MOBILE PHONE USE IN ACCESSING RICE INFORMATION FOR ADAPTATION TO CLIMATE CHANGE IN KILOSA AND KILOMBERO DISTRICTS, MOROGORO, TANZANIA

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ABSTRACT

The study aimed at determining the use of mobile phones in accessing rice information for adaptation to climate change in Kilosa and Kilombero Districts in Morogoro Region. The study involved 400 rain fed-rice farmers owning mobile phones. The study adopted a cross-sectional research design to collect data using a semi-structured questionnaire, focus group discussions and key informants interview. Statistical Package for Social Sciences (SPSS) was used in the data analysis. Quantitative data were analysed using frequency, percentages, chi-square, binary logistic regression and poisson count regression. Qualitative data were analysed through content analysis. The study found that socio-demographic factors influenced respondents' use of mobile phone for accessing rice information for adaptation to climate change were sex, age, education level, marital status, farm size, farming experience, radio ownership and off-farm incomes. In addition, access to market location was statistically significantly influenced use of mobile phones for accessing rice information for adaptation to climate change at $p \leq 0.02$. Moreover, few, 99 (24.8%)of the respondents used mobile phone to access strategic rice information while 105 (26.3%) of the respondents used mobile phone to access tactical rice information for adaptation to climate change. Furthermore, use of mobile phones for accessing rice information for adaption to climate change among study districts was low and did not differ at $p \leq 0.08$. Voice calling was most used application compared to other application. Moreover, type of rice variety, type of herbicides and weather forecast information was the major rice information for adaptation to climate change accessed by respondents through mobile phone. The study concludes that socio-demographic and institutional factors influence use of mobile phones for accessing rice information for adaptation to climate change. It can also be concluded the respondents' use of mobile phones to access rice information for adaptation to climate change in study areas was low.The study recommends that Kilosa and Kilombero Districts council through DAICO's should train

farmers in using mobile phones in accessing rice information for adaptation to climate change through campaigns, workshop and seminars

DECLARATION

I, **Nicholaus Mwalukasa,** do hereby declare to the Senate of Sokoine University of Agriculture that this thesis is my own original work, done within the period of registration and that it has neither been submitted nor being concurrently submitted in any other institution.

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This work is dedicated to my beloved late father Amoni Mwalukasa, my mother Tungulilege A. Mwamlima, my wife Elizabeth Landa and my beloved sons Clement and Cliff.

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LIST OF ABBREVIATIONS AND ACRONYMS

ANOVA	Analysis of Variance
AEA	Agricultural Extension Agent
AEAS	Agricultural Extension and Advisory Services
DAICO	District Agriculture, Irrigation and Cooperative Officer
GDP	Gross domestic Product
FAO	Food and Agriculture Organization
FFSs	Farmer Field Schools
FGD	Focus Group Discussions
ICT	Information and Communication Technology
IPCC	Intergovernmental Panel on Climate Change
ITU	International Telecommunications Union
MAFC	Ministry of Agriculture, Food Security and Cooperatives
SPSS	Statistical Package for Social Science
SUA	Sokoine University of Agriculture
TAM	Technology Acceptance Model
TCRA	Tanzania Communications Regulatory Authority
TMA	Tanzania Meteorology Authority
URT	United Republic of Tanzania
USDA	United States Department of Agriculture
UTAUT	Unified Theory of Acceptance and Use of Technology
VEO	Village Executive Officer
VIF	Variance Inflation Factor
WAEO	Ward Agricultural Exension Officer
WLO	Ward Livestock Officer

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background of the Study

1.1.1 Mobile phones

A mobile phone (also known as a handphone, cell phone, or cellular telephone) is a small portable telephone. It can be used to communicate over long distances without wires. A mobile phone typically operates on a cellular network, which is composed of cell sites scattered throughout cities, country sides and even mountainous regions (Lunden, 2018). It does so by connecting to a cellular network provided by a mobile phone operator, allowing access to the public telephone network. The first company to produce a mobile phone was Motorola in 1973 (Clark, 2013).

Mobile phones are among the most rapidly growing new information communication technologies in the world (Vashist *et al*., 2015). They are used for a variety of purposes, such as keeping in touch with family members, conducting business, keeping records and in order to inform colleague on emergence event. Some people carry more than one mobile phone for different purposes, such as for business and personal uses. Mobile phones have shifted from being just voice device to a multimedia communication tool capable of downloading, uploading text, can be used as a wallet, calculator, television, alarm clock, camera and many more (World Bank, 2011). Elsewhere, mobile phones have been used to deliver information to users on various issues (Duncombe, 2016; Tadesse, and Bahiigwa, 2015), and this helps users in lowering the cost of accessing information. Baumüller (2015) reports that mobile phones have significantly reduced communication and information costs for the rural poor in developing countries. Han *et al*. (2016) emphasize that mobile phones do not just provide access to information; they also facilitate communication among members of a community and across communities.

The ancient types of mobile phones support limited services such as, calling, sending messages and very few for taking pictures. However, the modern mobile phones supports a very wide range varieties of other services apart from making and receiving calls. A smartphone is a mobile phone that does more than other phones (World Bank, 2011). They work as a computer but are small enough to fit in a users' hands. The smartphone enables access to services such as voice communication, audio and video playback, web browsing, short-message and email communication, media downloads, gaming and more (Carroll and Heiser, 2017). They have stronger hardware capabilities and extensive mobile operating systems, which facilitate wider software, internet (including web browsing over mobile broadband), and multimedia functionality (including music, video, cameras, and gaming), alongside core phone functions such as voice calls and text messaging (Divya and Kumar, 2016).

1.1.2 Use of mobile phone in agriculture

Worldwide, the importance of mobile phone use in agriculture in rural areas has increased. Similarly, in developing countries, mobile phone are increasingly becoming an important driver of agricultural production (Yaseen *et al.*, 2016; Ward, 2014; Ali, 2012; Mittal *et al*., 2010). For example, in India fewer than 10% of farmers reported receiving information about agricultural technologies from public extension agents through mobile phones (Ward, 2014). One potential alternative to minimize cost individual extension agents going from village to village is to deliver agricultural information to farmers via low-cost information and communications technologies (ICT) like mobile phones (Jain and Kumar, 2017). Ward (2014) and Mittal *et al.* (2010) in India found that there was a positive economic impact of mobile phones use by agricultural extension agents, for they provided, easy, timely, and convenient access to customized content. The study found that there was an increasing number of farmers using mobile-enabled solutions in agriculture (Fu and

Akter, 2016). In additional, Panda (2018) found that mobile phone technology has the potential to link smallholder farmers with other communication channels using their local languages.

Studies in Africa (Sekabira and Qaim, 2017; Asa and Uwem, 2017; Bravo *et al.*, 2017; Sousa *et al.*, 2016; Baumüller, 2015; Haruna *et al*., 2013) show that there is a rapid adoption of mobile phones in accessing agricultural information by farmers. For instance, In Nigeria, Banmeke *et al*. (2017) found that mobile phones provided exciting new ways through which extension workers can reach farmers in rural areas who in the past, it was very difficult to contact them. Additionally, Asadu *et al*. (2018) found that mobile phones have been effective means of disseminating information on climate change. Again, mobile phones enable farmers to access timely climate change information which eventually enables them to take necessary measures to avert with impending impacts of climate change.

Similarly, Kaske *et al.* (2017) in Ethiopia found that mobile phones play an important role as an information media in agricultural extension services. Farmers in Ethiopia use mobile phones to consult extension workers to get advice, access information on agricultural inputs, on markets information, get agricultural emergency security information (e.g. weather forecast information, disease/pests outbreak, disaster early warning, financial transactions etc.).

In East Africa, smallholder farmers have reported a number of benefits resulting from mobile phone use in agricultural businesses (Engotoit *et al.*, 2016; Wyche and Steinfield, 2016). This includes removal of travel costs, saving of time and improving access to market and getting a good price of produce. Chhacchar and Hassan (2013) and Bukenya

(2016) studies in Uganda show that mobile phones saved the time of farmers, and eventually improved their income by providing an opportunity to communicate directly with market brokers and consumers for selling their products at good prices. Moreover, Makau *et al*. (2018) in Kenya found that mobile phone enabled farmers to get connected to new knowledge and information sources not previously available with the possibility of real-time, highly tailored information delivery.

In Tanzania, the dissemination of agricultural information through mobile phones in agricultural development is well documented (Sanga, 2018; Nyamba, 2017; Sanga *et al*., 2016; Mlozi *et al.,* 2015; Churi *et al.* 2013; Sanga *et al*., 2013; Nyamba and Mlozi, 2012). For instance, in order to increase the agricultural technology uptake, research institutions and information providers have been disseminating agricultural information through mobile phones (Sanga, 2018). Furthermore, Mlozi *et al*. (2015), Sanga *et al*. (2014) and Sanga *et al*. (2013) developed the web-based and mobile-based farmers' advisory information systems. The system allows a farmer to ask a question and receive an answer through a mobile phone. Mobile phones can be used by farmers in coordinating access to agricultural inputs; including agricultural training, seeds, livestock and pesticides from local dealers, governmental, non-governmental organizations, agriculture extension agents and community members without any physical contact and access to the market (Martin and Abbott, 2011). In the past, individuals would travel to seed dealers only to find all seeds had been sold, but today, individuals call or send short message service (SMS) and make appointments before travelling and payments can be made through mobile money services provided by telephone companies (Obong *et al*., 2018).

1.1.3 Rice production

Rice (*Oryza* sativa) is an important cereal crop grown by both smallholder and large scale farmers as a food and cash crop all over the world. In 2017, rice world production was about 482 million metric tonnes and leading producing countries are China and India with the former producing 215.7 and the latter producing 161.3 million metric tons (USDA, 2017a). Africa produces an average of 30.8 million metric tonnes of rice per year (FAO, 2017). Nevertheless, the use of local production systems, environmental constraints as well as low investment in production technologies, only 60% of the consumer demand is met through local production and the rest is imported (Zenna, 2016).

Tanzania produces 2.6 million metric tonnes of rice per year, and imports 2.0 million metric tons of rice to meet its local demand of 4.6 million metric tons (USDA, 2017b). In Tanzania, rice is mostly produced in five regions of Mbeya, Morogoro, Mwanza Shinyanga and Tabora, which produce over 60% of national production, Morogoro region being the second largest producer (URT, 2014). Rice is mostly grown by smallholders under rain-fed conditions (URT, 2017a). Unfortunately, rain-fed rice farming is vulnerable to the impacts of climate change due to irregular patterns of rainfall (Tumbo and Sanga, 2015; URT, 2014). Thus, farmers need appropriate adaptation measures to avert the impact of climate change.

1.1.4 Farmers' problems in accessing agricultural information

Poor access to agricultural information has been one potential explanation for the stagnating growth of agricultural performance in developing countries and has made farmers vulnerable to several risks. This has constrained efforts to improve agricultural development. Governments and international organizations have attempted to overcome some of the perceived information failures related to lack of access to agricultural information through the use of public agricultural extension services. For instance, in India public agricultural extension agents are the major sources of agricultural information (Gupta and Shinde, 2013). However, due to widely dispersed farmers and their information needs vary considerably, it is hard to reach them (Ferroni and Zhou, 2012). This is because extension agents are few (Mukherjee and Maity, 2015). As a result, this severely limits their ability to increase their productivity and income and thereby reducing poverty.

In addition, Asayehegn *et al*. (2012) in Ethiopia found that most of the agricultural extension agents use individual extension methods (farm or home visits and use of contact farmers) to communicate and to disseminate agricultural technologies to farmers. Also, their study explains that agricultural extension agents are also working under areas characterized by lack of infrastructure such as transportation (Ishida *et al*., 2018). Furthermore, Achora (2015) study in Uganda found that access to agricultural information by rural farming communities is one of the major constraints to agricultural development because of inadequate extension service delivery. This is a result of lack of enough extension agents to visit all the farmers for providing information when they need it (Sousa *et al*., 2016). For example, Danielsen *et al*. (2015) found that in Uganda one extension worker served about 3,189 farmers and the extension workers were not well facilitated to reach the sparsely distributed and uncoordinated farmers. This limited farmers' access to agricultural extension services from agricultural extension workers. In addition, Odini (2014) study in Kenya found that despite the agricultural technologies that have been generated through research in Kenya, the impact of such technologies has been felt by most smallholder farmers owing to inefficiency in communicating and sharing of agricultural knowledge. This has limited agricultural development efforts for improving agricultural productivity and production.

In Tanzania, the major source of agricultural information is the use of public agricultural extension workers who disseminate knowledge and skills on good rice production practices, but these are inadequate (Msuya and Wambura, 2016; Daniel *et al*., 2013). In 2017, the number of extension workers available in the villages was 11 073, while the required number was 15 853 (URT, 2017b), hence there was a deficit of 4 780 agricultural extension agents. As such, the extension-farmer ratio when high means that most farmers cannot access extension services from village agricultural extension agents. The advancements in ICTs provide an opportunity for developing countries to harness and utilize information and knowledge to improve productivity in various sectors including agriculture (Mutunga and Waema, 2016; Baumüller, 2015; Aker and Mbiti, 2010; Lwoga, 2010). Unfortunately, resource poor farmers are mainly affected by the digital divide which is a gap between groups or individuals in their ability to access information due to lack of income (Badiru and Akpabio, 2018). Nevertheless, the emergence of low-cost ICTs such as mobile phones may bridge the digital divide (Evans, 2018; Aker and Ksoll, 2016). This implied that mobile phones can bridge the information gap of the large part of rural farmers.

1.1.5 Strategic rice adaptation to climate change

Adaptation to climate change indicates processes taken to enable communities to have the ability to survive with the state of climate change (IPCC, 2007). Other Studies (Bounoua**,** 2015; Ford *et al*., 2014; IPCC, 2014; FAO, 2011) have reported that farmers' adaptation to climate change in African countries is low. This is greatly attributed to a lack of appropriate information to enhance farmers' decision on the adaptation to climate change. The importance of information related to farmers' adaptation to climate change has been emphasized by several studies (Churi *et al*., 2012; Mittal *et al*., 2010). The information enables farmers to make informed decisions regarding their choice of practices in order to make appropriate adaptation measures. The adaptation made by farmers involves response to both long term change of weather parameter (strategic adaptation) and short term change to weather parameter (tactical adaptation).

Strategic adaptations refer to changes in the farm operation that would apply for a subsequent season, or a longer term (Bradshaw *et al*., 2004). Strategic adaptations to climate change are adaptations made by farmers based on climate and other signals over multiple years. These include use of drought resistant varieties, use of organic manures, reduce use of inorganic fertilizers, adopt tillage practices and use of herbicides (Mligo and Msuya, 2015; Bryan *et al.,* 2013; Mugula, 2013; Churi *et al*., 2012; Gwambene *et al*., 2010). Strategic rice information for adaptation to climate change refers to various types of information and messages that are relevant to rice farming as a response to long term change on climate parameters. It includes information on the use of drought resistant and early maturity varieties, reduced use of inorganic fertilizers and use of herbicides. At the farmers' level, access to information is important to enhance famers' adaptation to climate change (Umunakwe *et al*., 2014).

In india, Hochman *et al*. (2017) found that strategic adaptation measure opted by rain fed rice farmers included the use of drought resistant rice varieties, change in cropping pattern and calendar of planting. Climate change adversely affects crop production through long-term alterations in rainfall resulting in changes in cropping pattern and calendar of operations. Thus farmers required to change their planting dates. Use of drought resistant rice helps in reducing vulnerability to climate change. In addition, Srivastava *et al*. (2017) reported that farmers opted for direct-seeding. Direct seeding of rice over transplanting enhances fast, easier sowing, reduce labour. Again, it minimizes cost of water and labour, which is inevitable to avoid in the conventional transplanted rice.

Similarly, Kusmana *et al*. (2016) study in Indonesia found that adaptation strategies opted by rain-fed rice farmers were direct planting. Direct planting (zero-tilled) saves water and at the same time shortens the growing period, so that they can gain early harvest, giving them more flexibility for the next planting. Furthermore, Sarker (2013) study in Bangladesh found that farmers adopted a variety of adaptation strategies including supplement irrigation, direct seeded rice, use of short-duration rice varieties, changing planting, harvesting dates, conversion of paddy land into mango orchards, agro-forestry, using different crop varieties, cultivation of various pulses and the cultivation of jute and wheat.

In the similar vein, in Nigeria, Kim *et al.* (2017) study revealed that rain-fed rice farmers used the following climate change adaptation strategies: use of climate tolerant varieties, early planting of rice, diversification into non-farm activities, mulching of paddy fields, use of zero tillage, use of early maturing rice variety and application of organic fertilizers. Mugambiwa (2018) study in Zimbabwe reported that to adapt to climate change, farmers used irrigation, diversified to drought-resistant crop varieties, diversified to other crops and changed the timing of planting period to coincide with the onset of the rains. Tambo (2016) study in Ghana found that the most common adaptation measure most practiced was changing the planting dates, use of droufgt resistant rice varieties and use of zero tillage.

In East Africa, farmers have reported adapting to climate change through water conservation, use of drought resistant crops, use of trees to protect soil erosion (Bagamba, 2012). Furthermore, Mburu *et al*. (2015) study in Kenya found that small scale farmers engaged themselves in various adaptation strategies to climate such as engaging in off-farm activities, rainwater harvesting and planting drought tolerant crops. In Tanzania, several studies (Mligo and Msuya, 2015; Bryan *et al.,* 2013; Mugula, 2013; Churi *et al.*

2012; Gwambene *et al*., 2010) found that strategic adaptation measures opted by rice farmers included the use of use drought resistant varieties, use organic manure, reduced use of inorganic fertilizers and herbicides.

1.1.6 Tactical rice adaptation to climate change

Tactical adaptations refer to changes made by farmers based on weather and other short term signals (Bradshaw *et al*., 2004). Tactical adaptations to climate change include adjustments made by farmers within a season that involves dealing with a climatic condition in the short term. These are made by the farmers while the season has started. Tactical adaptations to climate change are usually regarded as short-term responses to avert immediate threats (Huq and Reid, 2004). They reduce the impact of climate change on short time. Tactical rice information on climate change adaptation refers to information that enhances farmers' adaptation to climate change as a response to short-term change. For example, when there is a delay on initial rainfall, and when there is little rainfall after flowering. It includes information on weather forecasting, early mature seed variety and on the use of drought tolerant seed varieties. Weather forecasting information enables farmers to change their planting patterns and farming calendar due to climate change (Feleke, 2015). Seasonal rainfall forecasts are thus crucial for the provision of early warning information to be used by farmers. Bryan *et al*. (2013) revealed that, despite other factors influencing climate change adaptation, information triggered and enhanced farmers' ability to adapt to climate change. This can be achieved, if there are information sources that effectively disseminate it to rice farmers.

In addition, Hochman *et al*. (2017) study in India found that tactical adaptation opted by rain-fed rice farmers included change to another crops such as maize and cotton, reduce an area for rice cultivation and use of supplement irrigation and late planting. Farmers change to another crop types other than rice which require less amount of water and which are effective against the incidence of substantial pest and insect attacks. Kagopinath and Narsimulu (2017) reported that farmers apply foliar spray, use supplemental irrigation (at panicle initiation) in rice. Foliar spray provides a fast and effective way to address nutrient deficient. The foliar spray enables plant to get nutrient which enhances growth. Furthermore, the study found that farmers use stress-tolerant rice varieties. This is because rice is severely damaged by drought stress at the reproductive stage, especially during flowering, although stress at other stages can also lead to significant yield reductions. Srivastava *et al*. (2017) study in India revealed that farmers responded to perceived changes in the climate by irrigating their farms. This involves the use of supplement irrigation during the flowering stage. Furthermore, Sarker (2013) study in Bangladesh found that farmers adopted variety short-duration rice varieties with supplementary irrigation.

In Ghana, farmers adopted a range of tactical adaptation strategies, such as change to another crop and irrigation practices as a result of increasing incidence of climate-related shocks and stress during the growing season (Tambo, 2016). Similarly, Mugambiwa (2018) study in Zimbabwe found that tactical adaptation measures that are used include the planting early maturing crop varieties and switching to another drought tolerant crop. Furthermore, Waongo *et al.* (2016) emphasized that change in the time of farm operations was used by farmers as strategy adaptation to climate change. Also, it was used to respond to delayed onset of rains; majority of farmers in the Sahelian areas of Burkina Faso and Niger delayed their sowing dates to match the delay in rainfall during the growing season (Akponikpè *et al.*, 2010).

In Kenya and Uganda, studies by (Challinor *et al*., 2016; Opiyo *et al*., 2016; Ochieng *et al*., 2017) found that farmers adapt to climate change by using early maturing variety, mixed cropping, reduce plant population and change to another crop, late planting, use of supplemental irrigation and replanting. Ochieng *et al*. (2017) study in Kenya found that among adaptation measures employed by rain-fed rice farmers were mainly risk-reducing, such as planting early-maturing crop varieties and early planting.

1.1.7 Socio-demographic factors influencing the use of mobile phones for accessing agricultural information

Despite the importance of using mobile phones to access agricultural information, its adoption is influenced by multiple factors including socio-demographic factors. These are the factors that characterize the individual or group within the social structure. They include factors such as sex, age, marital status, education level, household size, number of mobile phones owned, owning smartphone, cost of mobile phone, experience of owning mobile phone, number of chips owned, land ownership, area under rice, farming experience, household ICTs assets ownership, and off-farm incomes.

Ali (2012) study in India found that socio-economic characteristics of farmers like age, level of education and farm size are significantly influenced farmer's use of mobile phone to access agricultural information. Increase in education, awareness increases and need to access different information sources arises. Furthermore, Rathod *et al*. (2016) study in India reports that land size was the factor which influenced farmers' use of mobile phone in accessing agricultural information. Large farmers are more resourceful and have a larger market surplus and are more aware and connected with all the available sources of information unlike most of the small farmers who mainly produce to meet their subsistence needs. Ganesan *et al*. (2015) study in India found that farm size, age and education of the farmers influenced the use of mobile phone in accessing agricultural information. In Bangladesh, similarly, Alam *et al*. (2018) study found that respondent' age, education and farm category statistically significant influenced mobile phone adoption. However, the study found that income did not influence mobile phone adoption for accessing agricultural information. Furthermore, Tomar *et al.* (2016) study in India revealed that the socio-demographic profile characteristics such as level of education, total family income, mass media exposure, information seeking behavior influence farmers use of mobile phone for accessing agricultural information. It found further that farmers with high educational status, income and exposure had high usage of mobile phones for accessing agricultural information. In addition, Manalo and Eligio (2011) study in Phillipine found that multiple social issues do influence the use of mobile phone by farmers such as illiteracy, socio-economic status and willingness and conditions to participate in ICT training are legitimate concerns.

Studies in Africa revealed that socio-economic characteristics influence farmers use of mobile phone in accessing agricultural information. For example, Akinola (2017) study in Nigeria found that socio-economic factors influence farmers' use of mobile phones for agricultural information. It was revealed that family size, and farm size had a positive significant influence on farmers' use of mobile phones in accessing agricultural information while age range, gender, marital status, farming experience had negative influence respectively. Rogers (2003) corroborated this by suggesting that those who are higher in socio-economic status are able to adopt innovation than those with a lower level. Kabbiri *et al*. (2018) study in Ghana found that socio-economic characteristics influenced significantly perceived ease of use, which subsequently influenced mobile phone use. Furthermore, Amir *et al*. (2016) study in Ethiopia shows that household characteristics (age, sex, household size and education level) and farm characteristics (farm size and off-farm income) influence farmers' use of mobile phone in accessing agriculture information.

Similary, Obong *et al*. (2018) study in Uganda found that age, education level, income influence farmers' decision to use mobile phones in accessing agricultural information. The study elaborates that farmers with higher incomes are more likely to use mobile phones than their counterpart. In addition, Okello *et al*. (2014) study in Kenya asserted that sex and age were among the factors which influence the use of mobile phone in communicating agricultural information. Furthermore, Mwombe *et al*. (2014) study in Kenya showed that age, gender, income and farm size influence the intensity of use of mobile phones, as a source of agricultural information for smallholder farmers. Moreover, Tata and Mcnamara (2018) study in Kenya found that socio-economic factors like gender, age, and education influence the use of the mobile phone for accessing agricultural information.

Studies (Nyamba, 2017; Nyamba and Mlozi, 2012) in Tanzania found that socio-demographic characteristics of the respondents such as sex, age, household size, income, level of education, marital status, land ownership, and farming experiences influence farmers' use of mobile phone in accessing agricultural information. This implied that success of the use of mobile phone by farmers among other factors, it is influenced by socio-demographic factors.

In additional, Venkatesh and Davis (2000) found that the use of mobile phones to access agricultural information and its adoption is influenced by multiple factors including performance expectancy, effort expectancy, social influence and facilitating conditions. Performance expectancy, effort expectancy and social influence are the indirect determinants of new technology usage, while facilitating conditions are direct determinants of usage behaviour. These factors are moderated by socio-demographic characteristics of the respondents such as age, sex and experience (Venkatesh *et al*., 2003). Serenko *et al*. (2006) assert that moderators can potentially increase the predictive validity of models. Rosen (2005) and Kripanont (2007) opted for adding or dropping some of the moderators while others retained the same variables as those in the original UTAUT model. Studies by Yaseen *et al*. (2016); Nyamba and Mlozi (2012); Okwu and Iorkaa (2011); Ali and Kumar (2010), found socio-demographic characteristics of the respondents such as sex, age, household size, income, level of education, marital status, land ownership, and farming experiences influenced farmers use of mobile phone in accessing agricultural information. Furthermore, there are conflicting results on the factors influencing the use of mobile phones in accessing agricultural information. Therefore, it is important to determine the socio-demographic factors influencing the use of mobile phones in accessing rice information for adaptation to climate change by rain-fed rice farmers.

1.1.8 Institutional factors influencing the use of mobile phones in accessing agricultural information

Success of mobile phone to enhance farmers' access to agricultural information is also related to institutional factors (Okello *et al*., 2014). Institutions are defined differently by different scholars. According to Helmke and Levitsky (2004), institutions are rules and procedures (both formal and informal) that structure social interaction by constraining and enabling actors' behaviour. Distinguishing institutions from organizations, North (1990) describes institutions as "rules of the game" and organizations as "the players". Institutions are necessary to enhance farmers' access to information from various information sources (Okello *et al*., 2014). Institutional arrangement plays a pivotal role for service delivery systems (Tata and McNamara, 2016). It enhances farmers' awareness on the use of ICTs to access agricultural information. Evidence suggests that the use of mobile phones by smallholder farmers is also influenced by the institutional factors (Nyamba, 2017; Okello *et al*., 2014; Nyamba and Mlozi, 2012).

Murugan *et al*. (2018) study in India found that, mobile phones positively affected rural livelihood outcomes for enhancing access to agricultural information due to supportive ICT regulations and policies, as well as adequate infrastructure. Furthermore, Rathod *et al*. (2016) study in India revealed that 'distance to veterinary institution and animal healthcare centre, have been associated with the use mobile phone in accessing agricultural information. Furthermore, Tomar *et al*. (2016) study in Bangladesh found that extension contact influences the use of mobile phones in accessing agricultural information. Agricultural extension workers can explain to the farmers on how to use mobile phone to access agricultural information on various mobile application as well as some difficult terminologies. They create awareness on different farmers' advisory information which allows farmers to call a hotline, ask questions, and receive responses from agricultural experts through mobile phones.

In addition, Ogunniyi and Ojebuyi (2016) study in Nigeria found that ICT infrastructural development, cost of broadcast equipment, cost of access, interconnectivity and electricity were amongst the factors that influence the use of mobile by farmers. Furthermore, Asenso-Okyere and Mekonnen, (2012) study in Ethiopia reported that the use of foreign language was among the factors which hindered the use of mobile phones to access agricultural information. This is due to the fact that some farmers can not understand or interpret information written in a foreign language, and this can lead to the possible misuse of the available information (Schalkwyk *et al*., 2017). Moreover, Nwaobiala and Ubor (2016) study in Nigeria report that network coverage influences farmers' use of mobile phones. Good coverage of networks is important to enhance the use of the services. Tadesse and Bahiigwa (2015) study in Ethiopia found that farmers access to market or cooperative influences the use of mobile phones for information searching. Farmers living closer to markets might have a high chance of using mobile phones to access agricultural information as they might have better social ties with traders and institutions in the market than distant farmers. Also, Amir *et al*. (2016) study in Ethiopia found that institutional arrangements such as access to social participation, access to farmers' group membership, distance from farmer training center, influences farmers use of mobile phone for accessing agricultural information.

Inadequate infrastructure that hardly supports network communication system is another impediment facing the use of mobile telephones to access farming information. Ifeoma and Mthitwa, (2015) study in Zimbabwe shows that obstacles which influenced farmers use of mobile phone include network communication. Comperativery, a study by Munyua *et al*.(2009) on ICT use in agriculture in Botswana, Ghana, Kenya and Uganda shows that low capacity and inadequate infrastructure were major challenges to ICT use in agriculture.

Similarly, Obong *et al*. (2018) study in Uganda found that access to market influences farmers' use of mobile phone to access agricultural information. On the one hand, Duncan (2016) in Uganda found that training on mobile phones usage influences farmers' use of mobile phone in accessing agricultural information. Through training farmers become aware on various ways of using mobile phones. On the other hand, Nyamba (2017) study in Tanzania identified institutional factors like access to market, access to extension and advisory services as factors influencing the use of mobile phones in accessing agricultural information. The study found further that stakeholder such as input suppliers, traders and agricultural researchers, the Tanzania Meteorological Agency (TMA) and Tanzania

Communications Regulatory Authority (TCRA) enhanced farmers use of mobile phones to communicate agricultural information. For example, TCRA enhances the provision of communication services in the country through certification and control of mobile phone telephone company, while TMAs collaborates with agricultural researchers, extension agents, farmer organizations and private sectors by providing agricultural information including weather information. Proper institutional arrangements can enhance the efficiency of technology transfer from bodies that search for and validate knowledge on the one hand, and those which use such knowledge to increase farmers' productivity and welfare (Krammer, 2015). However, farmers face different accessibilities to institutional factors in their own settings, which are likely to cause differences in the use of the available information sources. This implies that respondents in different geographical locations can be influenced by different institutional factors.

Other studies by Nyamba (2017); Kiberiti *et al*. (2016) and Sanga *et al*. (2016) done in rural communities in Kilosa and Kilombero Districts indicated that farmers used mobile phone in accessing agricultural information. These studies found that mobile phones enabled access to appropriate information and a technique on time for the smallholder farmers. Moreover, studies such as Sanga *et al*. (2013); Sanga *et al*. (2014) and Mlozi *et al*. (2015) reported that the web-based and mobile-based farmers' advisory information systems have been developed and piloted in Kilosa District. The system allows farmers to get advice on various agricultural issues such as agronomic practices, post-harvest operations, livestock husbandry, forestry, veterinary services, community development and market. Kiberiti *et al*. (2016) study in Tanzania found that mobile phones offered an affordable solution to farmers' information needs and information requirements. However, these studies did not reveal institutional factors influencing the use mobile phone in accessing rice information for adaptation to climate change by rain-fed rice farmers.

1.2 Problem Statement and Justification

1.2.1 Problem statement

Within the development discourses, various scholars shows that mobile phone technology has a wide range of applications in business activities and in agricultural sector(Panda, 2018; Sanga, 2018; Jain and Kumar, 2017; Bravo e*t al*., 2017; Nyamba, 2017; Amir *et al*., 2016; Misaki *et al.*, 2016; Mittal, 2016; Mittal and Mehar, 2016; Sanga *et al*., 2016; Mlozi *et al*., 2015; Ward, 2014; Ali, 2012; Nyamba and Mlozi, 2012). Information received through mobile phones plays a complementary role to the existing extension activities, and has a greater impact than other one-way information sources like radio, television, newspapers (Mittal, 2012; Sanga *et al*., 2014). However, many ICT-based solutions for agriculture are not adopted by most Tanzanian farmers (Barakabitze *et al*., 2017). This means that regardless of the long term efforts to promote the use of ICTs in accessing agricultural information, the situation in terms of dependence on traditional sources of information is still little to change. Thus, smallholder farmers in Tanzania still suffer from inadequate and untimely access to agricultural information and knowledge (Ngoepa *et al*., 2016; Misaki *et al*., 2016; Daniel *et al*., 2013). Lack of timely access to information and knowledge are among the constraints to farmers' adaptation to climate change (Ndamani and Watanabe, 2017; Zamasiya *et al*., 2017; Umunakwe, 2014).

In view of access to information on climate change using mobile phones in rural communities, other studies for example Churi (2013) and Churi *et al*. (2012) assessed the communication strategies for managing climate risks in rural communities; Moreover, Tumbo *et al*. (2018) assessed information seeking behavior of farmers' in information related to climate change adaptation through mobile phone. However, they did not establish the factors influencing the use of mobile phone in accessing information for climate change adaptation. In addition, these studies did not rigorously establish the influencing factors on the use of mobile phone for accessing information on adaptation to climate change. This study, therefore, has been undertaken to establish the use of mobile phone in accessing rice information for adaptation to climate change by rain-fed rice farmers in Kilombero and Kilosa Districts.

1.2.2 Justification of the Study

There have been efforts by public and private sectors to disseminate agricultural information in rural areas through public agricultural extension agents. However, most of rural communities in Tanzania lack access to timely agricultural information (Ngoepa *et al*., 2016; Elly and Silayo, 2013). Studies (Misaki *et al*., 2016; Daniel *et al*., 2013; Mwakaje, 2010) found that among the factors affecting access to agricultural information was poor coverage of extension services. Thus, ICTs such as mobile phones can be used to increase the effectiveness and efficiency of agricultural extension work (Fu and Akter, 2016). Also, Mittal and Mehar (2016); Nyamba (2017) underscores the importance of considering socio-demographic and institutional factors when designing sustainable ICT-based information delivery system. This implies that successful use of mobile phones enhances farmers' access to information for adaptation to climate change, and this can be achieved if their socio-demographic characteristics and institutional factors are considered. Also, the use of mobile phones for accessing tactical and strategic rice information for adaptation to climate change has not been thoroughly studied. Moreover, factors influencing farmers' use of mobile phones in accessing rice information for adaptation to climate change have not been established by the previous studies.

This study provides the missing information on the use of mobile phone in accessing rice information for adaptation to climate change, factors that influence the use of mobile phones in accessing rice information for strategic and tactical adaptation to climate change.

Above all, the results from this study will assist information providers, policy makers, academicians, researchers, agricultural extension agents, and other stakeholders when designing and disseminating information for climate change adaptation.

1.3 Objectives

1.3.1 Overall objective

The general objective of the study was to investigate farmers' use of mobile phones in accessing rice information for adaptation to climate change in Kilosa and Kilombero Districts in Morogoro Region.

1.3.2 Specific objectives

The specific objectives of the study were:

i. To determine socio-demographic factors influencing the use of mobile phones in accessing rice information for adaptation to climate change.
ii. To determine institutional factors influencing the use of mobile phones in accessing rice information for adaptation to climate change.
iii. To examine the use of mobile phones for accessing strategic rice information for adaptation to climate change.
iv. To assess the use of mobile phones for accessing tactical rice information for adaptation to climate change.

1.3.3 Study hypotheses

Based on the above objectives the following hypotheses were tested.

$Ho_{1:}$ There is no statistical significantly influence of socio-demographic factors on the use of mobile phones in accessing rice information for adaptation to climate change

Ho_2: There is no statistical significantly influence of the institutional factors on the use of mobile phones in accessing rice information for adaptation to climate change.

Ho_3 There is no statistical significantly influence of the use of mobile phones for accessing strategic rice information for adaptation to climate change.

Ho_4: There is no statistical significantly influence of the use of mobile phones in accessing tactical rice information for adaptation to climate change.

1.4 Theoretical Framework

Many theories and models have been used to explain the adoption to Information Technology(IT). This study is informed by three theories, Diffusion of Innovation, Technology Acceptance Model (TAM) and the Unified Theory of Acceptance and Use of Technology (UTAUT), which are explained below.

1.4.1 Diffusion of innovation theory

Diffusion of innovation has been used since 1950s and Rogers (1995, 2003) introduced the current well-known theory which is an advancement of diffusion innovation theory. An innovation is an idea, practice, or object that is perceived as new by individuals or a social system (Rogers, 2003). Here "the attributes of an innovation that influence adoption and acceptance behaviour are relative advantage, complexity, compatibility, trialability and observability" (Rogers, 1995). Relative advantage is the degree to which an innovation is perceived as better than the idea it supersedes (Rogers, 1995). Relative advantage indicates the benefits and costs resulting from adoption of an innovation and is one of the best predictors of an innovation's rate of adoption.

Compatibility is a key factor for all innovations, even those with a high relative advantage. If the idea seems morally irreconcilable, then the innovation will not be adopted. To be adopted, an innovation must be considered socially acceptable. It is expected that if the use of mobile phone in accessing rice information for adapation to climate change is compatabile with their lifestyles and values farmers will adopt the use of it to access information.

Complexity refers to the adopters' perception on the degree of difficulty to understand and use an innovation. The perceived complexity of an innovation is, generally related to its rate of adoption in a negative direction. Some innovations are easily understood by most members of a social system and will be adopted quickly, whereas others may be more complicated and will be adopted more slowly (Tondeur *et al*., 2017). The study assumes that if the use of mobile phone to access rice information for adaptation to climate change is simple to use then farmers will be willing to accept and adopt this innovation.

Trialability is the degree to which an innovation may be experimented with a limited basis. Thus, the perceived trialability of an innovation is usually positively related to its rate of adoption (Abbasi, 2011). The trialability is more important for earlier adopters than later ones, because earlier adopters have no precedent to follow when they adopt, while later adopters are surrounded by peers who have already adopted the innovation, and these peers act as a kind of vicarious trial for later adopters. The study assumes that if the use of mobile phones in accessing rice information for adaptation to climate change is trialable then farmers will be willing to accept and adopt this technology. Observability is a process of seeing results. The easier individuals can see the results of an innovation, the more likely they are to adopt it (Sonnenwald *et al*., 2001). The perceived observability is related to the rate of adoption in a positive direction. Therefore, the innovations that are perceived by individuals as having greater relative advantage, compatibility, trialability, observability, and less complexity will be adopted more rapidly.

1.4.2 Implications of the diffusion of innovation theory on the use of mobile phone in accessing rice information for adaptation to climate change

The Diffusion of innovation theory is important and relevant in analysing factors influencing the use of mobile phone in accessing rice information for adaptation to climate change. Diffusion of innovation theory seeks to explain how, why, and at what rate new ideas and technology spread. In diffusion of innovations theory, user perceptions of an innovation may be examined to understand the adoption of mobile phone for accessing rice information for adaptation to climate change. In addition, predictions may be made on the relationship between the innovation attributes and the technology adoption. The term adoption of technology is defined as the acceptance and interest for continued use of mobile phone for accessing rice information for adaptation to climate change.

Use of mobile phone in accessing information is the new innovation source agricultural information. The predominant source of information in most of the developing countries is a public extension service which helps in disseminating knowledge regarding the technology, and cropping system relevant for specific geographical areas and by recommending the appropriate use of inputs, farm practices and market information. Furthermore, past farmers obtained information from their farmer neighbourhood, input dealers, produce buyers/middlemen and traditional media sources like television, radio and newspaper. These modes have successfully penetrated to even remote regions but were restricted as they provide generic information, and could not target specific issues of the farmer, and also could not provide much scope for farmers to interact with the information provider. The use of innovative sources of communication such as mobile phones enable farmers access to information from anywhere at any time (Aker, 2011) and these are able to meet the growing information needs of farmers, relating to crop and technology choice, processing, utilization, storage and marketing of their produce. The underlying logic behind this study is that, if farmers perceive that mobile phones provide relative advantages, are compatible with their lifestyles and values, are simple to use and trialable, then farmers will accept and use mobile phones in accessing rice information for adaptation to climate change.

1.4.3 Limitation of diffusion of innovation theory

Despite being a strong framework in analysing factors influencing the adoption of the technology, it has been criticised for excluding the possibility of the influence of institutional factors on the adoption of the technology (Lee and Cheung, 2004). Furthermore, the theory is criticized for its exclusion of socio-economic characteristics of an individual on adoption of the technology. Rogers (2003) pointed that characteristics of adopters which include socio-economic status are among the factors which determine length of time it takes an innovation to diffuse through society. To address such criticism for the sake of maximizing results, this study is complemented with the technology acceptance model and unified theory of acceptance and use of technology which provides more insights in addressing the shortcomings of the diffusion of innovation theory.

1.4.4 Technology acceptance model (TAM)

TAM suggests that the three factors which influence adoption of technology are perceived usefulness (PU) and perceived ease of use (PEU) and behavioral intention (BI). Perceived usefulness refers to the degree to which a person believes that the use of the technology will enhance his or her performance whereas perceived ease of use is the degree to which a person believes that using the system will be free of effort (Roy *et al*., 2018). The attitude towards adoption depicts the prospective adopter's positive or negative orientation and/or behaviour towards adopting a new technology (Venkatesh and Davis, 2000). Usage could also be influenced by an individual's perception of the ability to use the technology (Yen and Wu, 2016). User attitude determines actual system use, and is influenced by two major beliefs (PEU and PU). PEU has a direct influence on PU. At first, PEU and PU were hypothesized to be directly influenced by the system designed characteristic as has been illustrated in Figure 1.

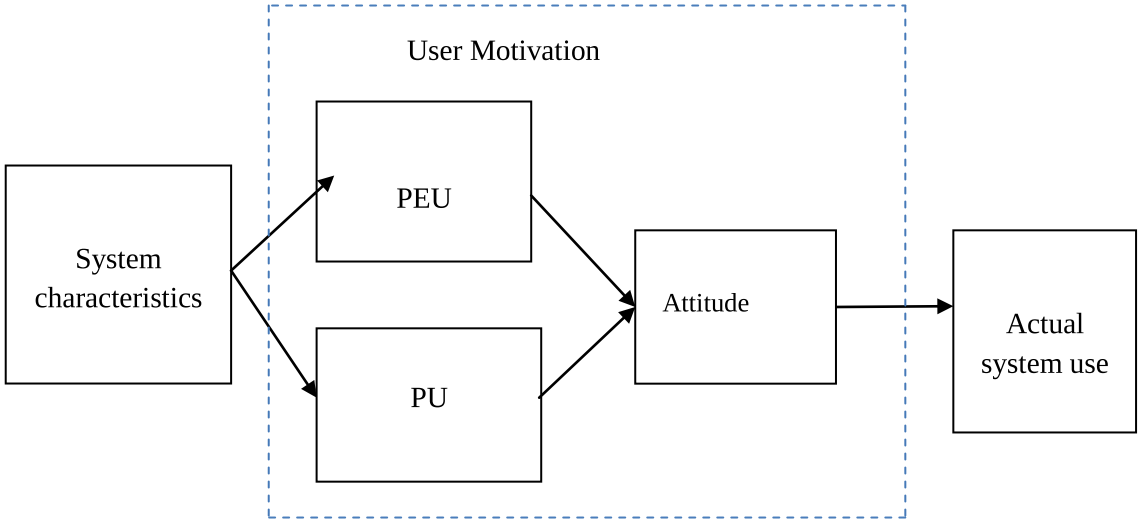

Figure 1: First version of TAM as proposed by Fred Davis (Davis, 1986)

The first version of TAM has been modified several times (Schepers and Wetzels, 2007). The first modified version of TAM is developed by adding behavioral intention (BI) to use as a new variable. It is assumed that there might be cases in which a given system's perceived usefulness by an individual motivates him/her to form a strong BI to use the system without any need to form a specific attitude towards the system. It means that, in some cases, people may not form a positive attitude towards a system, but because they perceived it to be useful, they directly form intention towards its use (Davis *et al.*, 1989). The extended TAM found that there is a direct significant correlation between BI to use and system's actual use, while PU and PEU has a direct influence on BI, which eliminates the need for attitude (Chuttur, 2009). The attitude has been omitted and excluded in many studies because of its primary limiting mediating effect (Sun and Zhang 2006) (Figure 2).

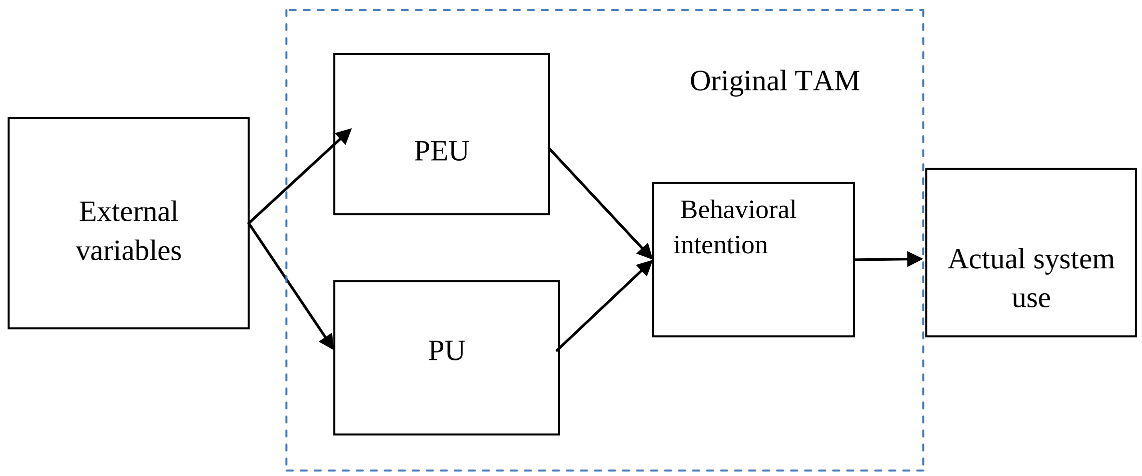

Figure 2: Last version of TAM, extended TAM (Venkatesh and Davis, 1996)

Underlying assumption of TAM is based mainly on an individual as a main decision maker (individual-based decision) on the issues concerning behavioural outcome (acceptance and use), which limit the model applications over group effect (neglect the role subjective norms and social influence). The model overlooks the importance of the group and social aspects. Also, TAM overlooks the direct link and indirect link (moderator/mediator) between essential external beliefs and BI because it postulates that the effect of external variable(s) on BI is only possible with mediation of PU and PEU (Davis *et al*., 1989). This assumption limits the model capability to add factors that may directly influence BI (such as FCs). Furthermore, TAM excludes the possibility of influence from institutional, social, and personal control factors. In response to this, a number of modifications and changes to the original TAM models have been made. The most prominent of these is the Unified Theory of Acceptance and Use of Technology (Venkatesh *et al*., 2003).

1.4.5 The unified theory of acceptance and use of technology (UTAUT)

The UTAUT model provides a refined view of how the determinants of intention and behaviour evolve over time and assumes that there are three indirect determinants of intention to use the technology (performance expectancy, effort expectancy, social influence) and direct determinants of usage behaviour (facilitating conditions). This model provides a useful tool for determining the likelihood of success for technology introduction as well as understanding the drivers of technology acceptance (Venkatesh *et al*., 2003).

UTAUT model hypothesizes that performance expectancy, effort expectancy, and social influence are the indirect determinants of new technology usage while facilitating conditions are the direct determinants of usage behaviour (Venkatesh *et al*., 2003). Moderators such as sex, age and experience play specific moderating roles to the indirect and direct determinants of technology use behaviour (Tarhini, 2014; Ghalandari, 2012; Kripanont, 2007). According to UTAUT model, it is expected that individuals will build intention of using a technology if they hope it will enable them to improve their performance. This implies that unless the new technology improves efficiency or quality of individuals' activities, it will likely not attract their interest on it. However, the relationship between performance expectancy and intention is moderated by age and sex such that performance expectancy directly affects intention of technology usage and is stronger for men and younger respondents (Venkatesh *et al*., 2003). Farmers will use mobile phones if they only believe that mobile phones will help them to obtain new benefits to enable them to adapt to climate change. In the context of this study, performance expectancy suggests that farmers will find mobile phones useful, if it enables them to access and disseminate rice information on adaptation to climate change quickly, at a time and place of their convenience.

The model hypothesizes that individuals are likely to show interest in technology usage if that technology is easy to use (Venkatesh *et al.*, 2003). This implies that less complex technologies can easily attract usage intention of many users than complicated technologies. Age, sex and experience are considered to play significant moderating roles for effort expectancy toward technology usage behavioural intention (Tarhini *et al*., 2014). It is expected that farmers will use mobile phones to access rice information for adaptation to climate change, if it is easy to use the devices. That is to say, if the mobile learning system on the mobile phone is hard to navigate, farmers will find it hard to use mobile phone in accessing information. Some organizations provide some training on how to use mobile phone by farmers to access agriculture information.

Individuals' intention to use new technology is expected to be high if such individuals expect that technology to draw the attention of their peers. Behavioural intention of a person is influenced by subjective norms which in turn are influenced by the significance of referents' perception (or normative beliefs) and motivation to comply with those referents. Jain and Hundal (2007) in Punjub, India found that the rural people were influenced to use mobile phone by the neighbours' usage. Again, social influence is moderated by sex, age, experience and voluntariness of use of the technology. It is expected that if the colleagues, superiors, juniors around an individual have positive opinions or behaviours towards the use of mobile phone, it will influence farmers to use mobile phones in accessing rice information for adaptation to climate change.

Moreover, usage of technology is dependent on the availability of an enabling environment for its application. Venkatesh *et al.* (2003) define facilitating conditions as the degree to which an individual believes that an organizational and technical infrastructure exist to support the use of a system. However, the influence of facilitating conditions toward the usage of technology is moderated by age and experience such that its effect is higher for older person and those with more experience. It is expected that older people would be less willing in adopting the technology than would be the case with young one. An experienced person is expected to have higher adoption rate of the technology than an inexperienced one (Buabeng-Andoh, 2012; Venkatesh *et al*., 2003). Presence of an organization can scaffold the sustainability on the use of mobile phone by farmers. It is expected that presence of organization proving support on the use of mobile phone will enhance farmers to willing adopt the use of mobile phones in accessing rice information for adaptation to climate change.

Besides the determining factors, the model contains a set of mediating factors that influence the determining factors toward behavioural intention; to use a mobile phone is determining factor: perceived usefulness but lack of income (mediating factor) could hold back adoption. As such, mediating factors identified in the model are personal factors, like age, gender, education.. The model postulates that actual adoption and use are the outcome of the interplay of the mediating and determining factors.

1.4.6 TAM and UTAUT theories implications on the use of mobile phone in accessing rice information on adaptation to climate change

Technology is the application of scientific knowledge for practical purposes (Sismondo, 2010). Technology refers to methods, systems, and devices which are the result of scientific knowledge being used for practical purposes; technology has important effects on business operations. In this study the word ‘technology’ refers to the use of mobile phone in accessing rice information for adaptation to climate change. Mobile technology is mostly used in cellular communication and other related aspects. The mobile technology includes internet browsing and instant messaging tool. Based on the technology adoption theories, the use of mobile phone can be analysed at two levels. First, it is the adoption of the mobile phone devices for accessing information over other sources of information. Secondly, the adoption of using different mobile phone application to access rice information for adaptation to climate change. Through use of advanced mobile phones such as smartphone, farmers can install mobile application which can enable him/her to use different social media (Aungst, 2013). Social media is the most active platform for communication and networking allowing online users to receive latest news updates from various sources. Social media has transformed how people share information and knowledge in the society, and it has enhanced the preservation of indigenous knowledge; its expansion generates new opportunities for different sectors of the economy including agriculture (Owiny *et al.*, 2014). These sites (WhatsApp, Facebook, Twitter, Instagram and Youtube) have become increasingly popular with the rise of Web 2.0, providing improved teamwork and sharing among users through such applications. Social media can enhance access to rice information for adaptation to climate change through real-time interaction with farmers as well as many other potential agricultural stakeholders. Farmers are now able to access agricultural resources over the Internet or SMS either through their mobile phones or computers. This has been as a result of evolution of digital technologies which have stimulated dormant economies especially in Africa where there is progressive increase in agricultural productivity due to application of modern communication technologies in agriculture.

The discussed theories are integrated in the conceptual framework here under for the purpose of setting the study direction. The developed conceptual framework depicts the variables of the study and their relationships. As illustrated in Fig.3, the conceptual framework developed for this study consists of independent variables nested at three categories: individual factors, institutional factors and adaptation measures to climate change opted by farmers. There are also variables under each category. All these three categories of variables influence the fourth category which is the dependent variable, the final outcome variable, which is the use of mobile phones for accessing rice information for adaptation to climate change. This study included only individual and institutional factors because the reviewed literature has shown that socio-demographic characteristics of the respondents act as moderators of indirect (performance expectancy, effort expectancy) and direct determinants (intention and facilitating conditions) of technology use behavior (Venkatesh, *et al*., 2003; Kripanont, 2007; Ghalandari, 2012; Tarhini, 2014).

In addition, rice farmer adaptation to climate change is more likely to enhance their use of improved sources of information such as mobile phones to access information. Farmers having such behaviour will search for information to adapt the strategy. Therefore, it is expected to influence access to and utilization of agricultural information positively. This will increase the probability of adopting the use of ICT's such as mobile phone to access rice information for adaptation to climate change.

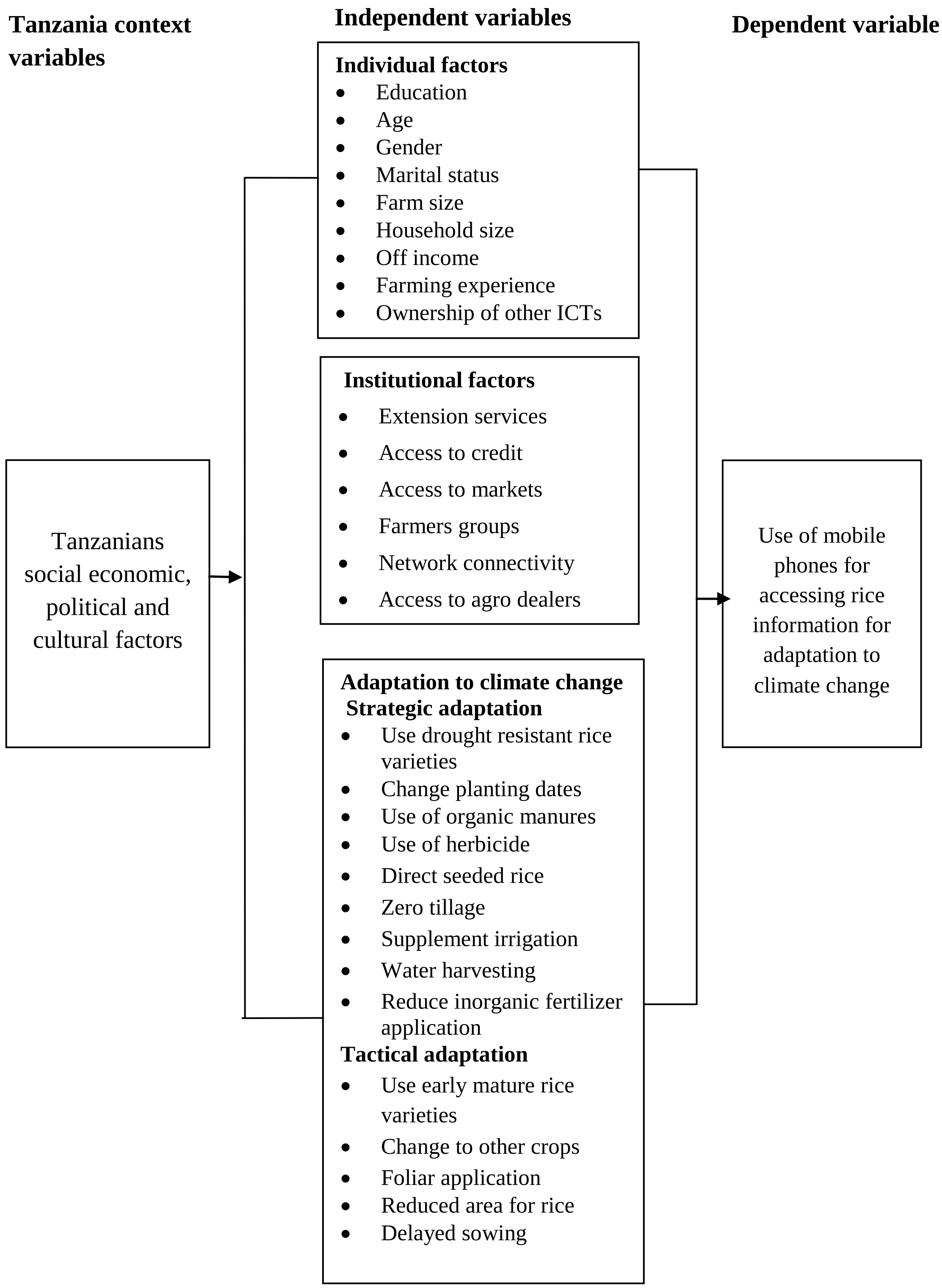

Figure 3: Conceptual framework on use of mobile phones in accessing rice information for adaptation to climate change.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 The Agriculture Sector in Tanzania

Agriculture accounts for 10% of Tanzania's GDP and provides employment to the majority of the nation's population (URT, 2018). Also, agriculture accounts for 30 % of export earnings and employs 75% of the labour force in the country (URT, 2017b). The main food crops in the country include maize, sorghum, millet, rice, wheat, beans, cassava, potatoes, and bananas, while cash crops are such as tobacco, cashew nuts, coffee, tea, cloves, cotton, and sisal. Rice is the second most cultivated food and a commercial crop in Tanzania after maize, with a cultivated area of about 681,000 ha, which represents 18% of the cultivated land (USDA, 2017a). In Tanzania, rice is mostly produced in five regions: Mbeya, Morogoro, Mwanza Shinyanga and Tabora, which produce over 60% of national production and Morogoro region being the second largest producer (URT, 2014a). In addition, 71% of the rice is grown under rain-fed conditions (USDA, 2017a), which is vulnerable to the impacts of climate change (Tumbo and Sanga, 2015; URT, 2014b). Farmer yields for rice are 2.0 tons/ha (URT, 2016a), while the estimated potential is between 4 and 5 tons/ha (MAFC, 2009). This low productivity per ha is due to following reasons: lack of adoption to technological innovations such as the use of improved seeds, fertilizers, herbicides, and low adoption to rainwater harvesting and post-harvest technologies (Msangya and Yihuan, 2016; Boniphace *et al*., 2015).

2.2 Agricultural Extension and Advisory Services in Tanzania

In Tanzania, the provision of agricultural extension and advisory services is done both by private and public sectors. The public extension officers are the major sources of agricultural extension and advisory services in the country (URT, 2016b). Agricultural extension and advisory services are services necessary for improving agriculture production. Realizing the importance of improving agriculture production through the application of improved agricultural practices, the country has various research stations under Tanzania Agricultural Research Institute (TARI) which is under the Ministry of Agriculture. Other institutions which develop agricultural technologies include academic and research institutions such as Sokoine University of Agriculture (SUA), University of Dar es Salaam (UDSM) and Nelson Mandela African Institution of Science and Technology (NM-AIST). The efforts of these stations and institutions are complemented by various international institutions such as AfricaRice and the International Rice Research Institute (IRRI).

Additionally, the national agricultural extension system in Tanzania is implementing a series of reforms which are intended to improve farmers' access to agricultural extension services. Currently, the provision of agricultural extension services delivery is decentralized from the Ministry Agriculture and Livestock Development (MALD) to the President's Office-Regional Administration and Local Government (PO-RALG) (Masanyiwa, 2014; URT, 2011). Komba *et al*. (2018) study in Arusha found that the decentralized agricultural extension information and service delivery do not significantly contribute in improving farmers' access to agricultural extension services. Several factors are attributing to this, and they include ineffectiveness of administrative de-linking on the accessibility of agricultural extension services, high cost of accessing agricultural extension services, limited number of agricultural extension workers, inadequate funding, and poor coordination and management of agricultural extension services.

Similarly, Daniel (2013) found that there are few extension agents compared to farmers and this leads to limited access to extension advice. High farmer-extension officer ratio of 1320:1, means that most farmers cannot access extension services from the agents. Some of these problems could be solved by using information and communication technologies such as mobile phones especially in accessing information for adaptation to climate change. The advancements in ICTs provide an opportunity to harness and utilize information and knowledge to improve productivity in various sectors including agriculture (Mutunga and Waema, 2016; Baumüller, 2015; Lwoga, 2010). Also, compared with other ICTs, mobile phones can be used with other ICTs like radio and television to access to various information such as weather forecasts, cropping options and market information (Loudon, 2009).

2.3 Mobile phone Coverage, Adoption and Usage in the World

Mobile phones have become the most popular way to communicate and access information with other individuals. Mobile-broadband subscriptions have grown more than 20% annually in the last five years and reached 4.3 billion globally at the end of 2017 (ITU, 2018). In sub-Saharan Africa, there is an increase of adoption to mobile phone coverage than other ICTs devices such as radio and television (Hampshire *et al*., 2015). The adoption of mobile phones has led to reduced communication costs, thereby allowing individuals and firms to send and to obtain information quickly and cheaply on a variety of economic, social, and political topics (Aker, 2010). Access to and use of mobile telephony in Africa has increased dramatically over the past decade. There are ten times as many mobile phones as landlines in sub-Saharan Africa and 60% of the population has mobile phone coverage. Mobile phone subscriptions increased by 49% annually between 2002 and 2017 (ITU, 2018).

2.4 Mobile phone Coverage, Adoption and Usage in Tanzania

Over the past decade, there has been an increase in mobile phone coverage and adoption in developing countries (Asongu and Nwachukwu, 2016). The number of mobile phones per

100 people in developing countries often exceeds access to other information communication technologies, such as landlines and radios (ITU, 2011). In Tanzania, the number of mobile phone subscribers rose to 43.6 million which is more than half of its total population (TCRA, 2018). This has created an opportunity to use mobile phones among most of the Tanzanians in both urban and rural areas. In areas where telephone service is available, studies show that a large percentage of the population makes calls regularly. Moreover, Short Message Service (SMS) where text messages sent via mobile phones is an added value service, and is cost effective. This is used by different mobile users, though literacy and the use of a language, which the technology supports in written form limit accessibility to some of the users (Wyche and Steinfield, 2016). Several studies (Mtega, 2018; Tumbo *et al*., 2018; Nyamba, 2017; Churi *et al.*, 2013; Churi *et al*., 2012; Nyamba and Mlozi, 2012) show that rural farmers in Tanzania use mobile phones in accessing various services including agricultural information. People use mobile phones to access information for improving their livelihood and general well-being, ranging from information about family members and information related to crop management (Aker and Mbiti, 2010).

2.5 The use of Mobile phones to Access Agricultural Information

The use of mobile phones increases the efficiency of farmers by affordable access to communication technologies in rural areas of developing countries (Duncombe, 2016). Several studies (Panda, 2018; Sekabira and Qaim, 2017; Yaseen *et al.*, 2016; Fu and Akter, 2016) have been carried out globally to establish the use of a mobile phone in communicating agricultural information to smallholder farmers. For example, Abraham (2007) study in South Western State of Kerala, India found that fishermen farmers used mobile phone to communicate with the buyers in advance and hence received good price. Furthermore, Islam and Grönlund (2011) study in Bangladesh revealed that mobile phone helps farmers to reduce information barrier of time to communicate with customers. In Swaziland, mobile phones have been reported to improve access to markets for livestock keepers by enabling them to sell their animal at a good price (Houghton, 2009). In addition, Donner (2006) study in Kigali District, Rwanda found that rapid growth of small business personnel used mobile phones to link between suppliers and their customers.

Furthermore, Tadesse and Bahiigwa (2015) study in Oromia Regional State, Ethiopia revealed that the use of mobile phones had been an important tool to farmers as it helped them to make marketing decisions. In additional, Baumüller (2015) study in Edoret, Kisumu, Kitale, Mombasa and Nairobi Districts, Kenya revealed that the use of mobile phone services that offered price information and market connections contributed in price reduction and ambiguity about expected profits, information asymmetries and market inadequacies. These examples explain the promotion of mobile phone in the agricultural sector worldwide in terms of communication and dissemination of agricultural information mainly for the smallholder farmers.

The use of mobile phones in accessing agricultural information by farmers is apparent in the Tanzanian context and elsewhere (Panda, 2018; Sanga 2018; Sekabira and Qaim, 2017; Yaseen *et al.,* 2016; Fu and Akter, 2016; Mlozi *et al*., 2015; Sanga *et al*., 2013; Nyamba and Mlozi, 2012). However, with regard to information for adaptation to climate change, previous studies focused on the use of mobile phones in accessing weather information (Etwire *et al*., 2017; Ogbeide and Ele, 2015; Chhachhar and Hassan, 2013; Churi *et al*., 2012; Okello *et al*., 2014). Other studies (Mittal, 2016; Caine *et al*., 2015; Churi *et al*., 2012) investigated the climate information accessed by farmers through mobile phones but they did not assess the socio-economic and institutional factors influencing use of mobile phones.

2.6 Socio-demographic Factors Influencing the use of Mobile phone in Accessing Agricultural Information

Literature in different parts of the world shows that various socio-demographic factors influence the use of mobile phones to access agricultural information (Alam *et al*., 2018; Tata and Mcnamara, 2018; Akinola, 2017; Kaatrakoski *et al*., 2017; Nyamba, 2017; Mittal and Mehar, 2016; Singh and Srivastava, 2016; Umar *et al*., 2015; Nyamba and Mlozi, 2012). The following section reviews these factors.

2.6.1 Education

Education has been valued as a means for increasing knowledge about innovation. An individual with education becomes critically aware of the need and scope for social change. Education is associated with a high level of comprehension of new skills and expands knowledge (Kaatrakoski, 2017). Education enables the individual farmers to know how to seek information on improved farm practices. This is because, as individuals get knowledge, they want to extend the scope of their experience through the modern sources of information. This means, education level is the factor that drives individuals to choose certain information sources. Adoption studies (Mittal and Mehar, 2016; Umar, 2015; Ali, 2012) showed a positive relationship between education level and the use of mobile phone. Studies in India (Tomar *et al.*, 2016; Ganesan *et al*., 2015; Ali, 2012; Mittal *et al.*, 2010) showed a positive and significant influence of education on the use of mobile phone in accessing agricultural information. These studies show that farmers with relatively better education rely less on traditional sources, and explore other information sources like modern ICTs such as mobile phones for accessing new information contents. Similarly, Studies in Africa (Sekabira and Qaim, 2017; Bravo *et al,* 2017; Haruna *et al*., 2013) showed that education level of the farmers influences farmers' use of mobile phone in accessing agricultural information. Furthermore, Nyamba (2017) study in Kilosa and

Kilolo District, Morogoro and Iringa Regions, respectively, Tanzania, found that education of the farmers influenced farmers' use of mobile phones for communicating agricultural information. However, a study by Churi *et al*. (2012) in Same District, Tanzania shows that education levels did not influence farmers' use of mobile phone in accessing agricultural information.

2.6.2 Age

Farmer's age is another characteristic or variable which determines the use of agricultural innovation. Young farmers are keen to get information than older farmers. Older farmers are more risk averse and less likely to be flexible than younger farmers and thus have a lesser likelihood of information utilization and the adoption of new technologies (Alam *et al*., 2018; Tata and Mcnamara, 2018). Ali (2012) asserts that older farmers are less likely to explore new sources of information, and thus less likely to depend on multiple sources. Studies (Ali, 2012; Mittal and Mehar, 2016) in India found that age significantly influenced farmer's use of mobile phone to access agricultural information. Alam *et al.* (2018) study in Bangladesh found a negative and significant influence of respondents' ages on the adoption to mobile phone for accessing agricultural information. Similarly, Obong *et al*. (2018) study in Uganda found that age influences farmers' decision to use mobile phones in accessing agricultural information. In Tanzania, Mtega (2012) study in Kilosa, Tanzania revealed that the younger respondents had high chances of using mobile phones in accessing agricultural information than the older ones. In fact, young farmers are quick to understand and accept new ideas, and are therefore more likely to adopt the use of mobile phone than older farmers.

2.6.3 Gender

Gender is another factor which has been found to influence the use of mobile phone in accessing agricultural information. In most developing countries, females are key players of the day-to-day agricultural tasks (Hammami, 2017). They are responsible for planting, weeding, watering, harvesting, transporting and storing crops. However, despite their crucial roles in agriculture, females have less access to agricultural extension services. They also have low adoption rates to new agricultural technologies (Amir *et al*., 2016). Mittal (2016) study in India found that gender influences respondents' use of mobile phone in accessing agricultural information. Furthermore, studies (Akinola, 2017; Okello, *et al*., 2014; Fadiji, 2011) in Africa showed that female have less adoption rate of using mobile phone for accessing agricultural information than their male counterparts. Low adoption of the use of mobile phone perhaps is because they are confronted with social norms and poverty. Men have reportedly continued to dominate farm decision making, even in areas where women are the largest providers of farm labour (Singh and Srivastava, 2016). The low level of women's education and cultural barriers prevent them from exposure to extension channels by their initiative. The male-dominated extension system also often restrains from contacting and working with women due to the strong taboos and value systems in rural areas. Thus, men are more likely of owning and using mobile phone to access agricultural information. However, some females headed households which are educated and wealthy are more likely to adopt the use of mobile phone in accessing information for adaptation to climate change.

2.6.4 Marital status

Marital status is also another factor influencing the use of mobile phones in accessing agricultural information. Married couples have a high chance of using mobile phone in accessing agricultural information. This is because married farmers are likely to be interested to produce more food for both family consumption and sale. Thus, their aspiration to produce more could be influencing seeking for agricultural information through modern technology such as mobile phones. Also, married respondents tend to share experiences on the use of various technologies among each other (Sell and Minot, 2018). Umar *et al*. (2015) study in Kaduna State, Nigeria found that the marital status of the respondents had a positive significant relationship with the utilization of ICTs for accessing agricultural information. The results showed that married respondents have high chance of using ICTs for accessing agricultural information.

2.6.5 Farm size

Farm size is also a variable which influences the use of mobile phone technology for accessing agricultural information by farmers. It has been recognized that, small and large farm operators differ in the speed in adopting and using mobile phone technology to access agricultural information. Mittal *et al*. (2010) argue that those farmers who own large farms enjoy a high socio-economic status, hence they have high rates of adopting the use of ICTs in accessing agricultural information. The higher the farm size farmers have, the more the propensity to seek agricultural information for increased agricultural production (Mwombe *et al*., 2014). Gasesan *et al*. (2015) study in Delta Zone of Tamil Nadu, India found that farmers with large farm sizes had higher chances of adopting and using ICTs for accessing agricultural information. Similarly, studies (Akinola, 2017; Amir *et al*., 2016) in Africa found that farm size of the respondents had a positive significant relationship with the utilization of mobile phones for accessing agricultural information. Furthermore, studies such as Nyamba, 2017; Nyamba and Mlozi, 2012 in Tanzania found that land ownership influences farmers’ use of mobile phone for accessing agricultural information.

2.6.6 Household size

Likewise, household size is another factor that influences the adoption of mobile technology. The household size includes the number of persons living together and capable of working. The presence of members who are capable of working in farms may encourage farmers to use mobile phone because it signals higher desired production hence investing in new technologies. Yaseen *et al.* (2016) in India and China found that there was an increase in the usage of ICTs as household sizes increased. In addition, Vosough *et al*. (2015) study in Iran found that the household size influenced positively the use of mobile phone. Similarly, Amir (2016) study in Haramaya District, Ethiopia and Sekabira *et al*. (2012) study in Mayuge District, Uganda, found that household size was a significant determinant of mobile phone usage for accessing agricultural information. However, household with high dependency ratio could have a negative influence on the use of mobile phone in accessing agricultural information. The presence of more dependents in households may discourage farmers to use mobile phone because it signals higher desired consumption instead of investing in new technologies or purchasing mobile phones and using them.

2.6.7 Off-farm incomes

The households' income is an important factor determining access to and utilization of agricultural information and different improved technologies. Off-farm (non-farm) income refers to the portion of an individual income obtained from off-farm activities, including non-farm wages, salaries, small business labourers, etc. Most farmers who earn an income from agricultural farming also engage themselves on other jobs to diversify household incomes. Households engaged in off-farm activities have better endowed with additional income (Elias *et al*., 2016). This additional income improves the households' financial position that in turn enables them to invest in purchasing the needed amount of farm inputs, especially fertilizers and improved seeds. Thus, farmers engage in non-farm activities to reduce the extensive dependence on agriculture, thereby reducing their vulnerability towards climate change. The income obtained from off-farm activities supports farmers to purchase farm outputs as well as other non-farms items such as airtime vouchers for mobile phones etc. Tomar *et al.* (2016) study in India reveals that total family income influences farmers use of mobile phone for accessing agricultural information. Furthermore, Amir *et al*. (2016) study in Haramaya District, Ethiopia found that off-farm incomes influenced farmers' use of mobile phones in accessing agricultural information. It was found that farmers with a high off-farm income had a high adoption rate of using mobile phone in accessing agricultural information. Mtega (2018) study in Kilosa District, Tanzania found that respondents' income influences farmers' use of mobile phone for accessing agricultural information.

2.6.8 Farming experience

Farming experience refers to the time a farmer has spent in the farming occupation since he/she started making independent production decisions. Longer farming experience implies accumulated farming knowledge and skill which can contribute to the utilization of agricultural technologies. Studies show that experienced farmers adopt new technologies early and switch to other alternatives than late adopters because of a high opportunity cost for their resources. Animashaun *et al*. (2014) study in Kwara State, Nigeria found that experienced farmers had low use of ICTs than inexperienced ones. Furthermore, Adegbidi *et al.* (2012) study in Dassa-Zoume and Glazoue Districts, Central Region, Benin, on factors influencing the adoption of mobile phone indicated a positive relationship of farmers experience and the number of mobile calls for agricultural transactions. It explains that farming experience conferred to farmer some skills in farming management, negotiation in input/output commercialization. Thus, these categories of farmers increased the number of mobile calls when making farming business. Nzie *et al*. (2018) study in Northwest Region, Cameroon found similar results.

Furthermore, Kirui *et al*. (2013) study in Kirinyaga (Central province), Bungoma (western province) and Migori (Nyanza province), Kenya found a negative relationship of farming experience with the adoption to mobile phone in accessing agriculture information. However, as farmers accumulate experience over time, they progressively switch from traditional agricultural technologies to improved technologies due to observed performance and learning by doing (Allahyari *et al*., 2016). Learning by doing depends on the release of new agricultural technologies. Thus due to climate change, it is expected farmers would be eager to learn new adaptation measures. This aspiration can influence farmers to access information for adaptation to climate change using improved sources such as mobile phones. Several studies (Nzie *et al*., 2018; Kirui *et al*., 2013; Adegbidi *et al.,* 2012) show that farming experience has both positive and negative relationship with use of the mobile phones. The implication drawn from these studies is that perhaps a non-linear relationship exists between the adoption of agricultural technologies and farming experience.

2.6.9 Ownership of ICT gadgets

Ownership of ICT gadgets shows the respondents access to information assets. Access to ICTs gadgets like radio and television is positively related to the use of modern ICT devices such as mobile phones. A farmer using radio and/or television for accessing information tends to be more likely to adopt mobile based information sources. Through radio and television farmers can be aware of various ways of using mobile phone in accessing agricultural information. Mittal and Mehar (2016) study in Indo-Gangetic States, India found that access to ICT gadgets like radio and television was positively related to the use of mobile phone in accessing agricultural information.

Literature shows that there have been various studies carried out to determine socio-demographic factors influencing the use of mobile phone in accessing agricultural information. These studies have focused on various factors such as sex, age, marital status, education level, household size, number of mobile phones owned, owning smartphone, cost of mobile phone, experience of owning mobile phone, number of chips owned, land ownership, area under rice, farming experience, but, these studies also give mixed findings about the socio-demographic factors influencing the use of mobile phones in accessing agricultural information. Therefore, there is a need to examine the social-demographic factors influencing the use of mobile phone for accessing information for adaptation to climate change by rain-fed rice farmers.

2.7 Institutional Factors Influencing the use of Mobile phone in Accessing Agricultural Information

Previous studies show that institutional factors have an influence on the use of mobile phone in accessing agricultural information (Asongu and Odhiambo, 2018; Akinola, 2017; Etwire *et al*., 2017; Otieno *et al*., 2016; Rathod *et al*., 2016; Sharma *et al*., 2016; Obisesan *et al*., 2016; Okello *et al.*, 2014). The following section reviews these factors.

2.7.1 Access to agricultural extension and advisory services

Agricultural extension and advisory services on the use of technology influence farmers' use of mobile phone to access agricultural information. Agricultural extension services enable farmers to recognize when information is needed and being able to efficiently locate and clearly access from various sources. Agricultural extension services enable farmers to gain skills and knowledge on the use of various mobile applications for accessing agricultural information (Mohanakumara and Biradar, 2018). Access to agricultural extension and advisory services facilitates understanding and the use of more advanced information technologies (IT) applications, as well as giving awareness to future IT-facilitated changes and development. Frequent access to agricultural extension services is crucial in order to make decisions to utilize mobile phone in the agricultural information. Akinola (2017) study in Yewa South Local Government, Ogun State, Nigeria found that access to extension services influenced farmers' use of mobile phone to access agriculture information. Furthermore, Nyamba (2017) study in Kilosa and Kilolo Districts, Tanzania found that training on mobile phone use was associated with respondents' ability to use mobile phones to communicate agricultural information. Similary, Sharma *et al*. (2016) study in Karnal District, India found that the rate and speed of adoption of technology is found to be higher where farmers received extension services in use of particular technology than otherwise.

Agricultural extension services can be carried out by different stakeholders including agricultural extension workers, researchers, agro-dealers, seed agencies. A major source of agricultural extension services in developing countries including Tanzania is the use of public agricultural extension agents who disseminate knowledge and skills on good agronomic practices to farmers (Mtega *et al*., 2016; Isaya *et al*., 2015; Daniel, 2013). Agricultural extension workers serve as a traditional link between agriculturalists and innovators. They are often partnered by other institutions, research institution and development projects to disseminate and monitor the adoption of agricultural innovation (Etwire *et al*., 2017). Agricultural extension workers are helpful in explaining complex terminologies, translating information from english to the local dialect or even assisting in the operation of a mobile phone (Anoop *et al.*, 2015). Hence, farmers who have access to agricultural extension workers are more likely to use mobile phone for accessing agricultural information.

Furthermore, studies (Etwire *et al*., 2017; Anoop, 2015) show that agricultural extension and advisory services enhance the use of mobile phone in accessing agricultural information. For example, Sokoine University of agriculture (SUA) in collaboration with agricultural extension workers in Kilosa District Council developed farmers' information advisory system called "UshauriKilimo" system. The system allows any actor in the agricultural sector (e.g. farmer, extension officer, policy maker, trader.) to ask a question on advisory services to an agriculture extension officer using either the web or a mobile phone (Sanga *et al*., 2013). The system is an integrated system, which has modules for mobile based farmers' advisory information system (M-FAIS) and web based farmers' advisory information system (W-FAIS). Both MFAIS and W-FAIS allow farmers to get advice on various agricultural issues such as agronomic practices, post-harvest operations, livestock husbandry, forestry, veterinary services, community development and market. A farmer can send a question in form of a text or Short Message Service (SMS) to a preferred mobile phone number, which is predefined to the system. After the question has been sent to a system, it is assigned to an expert (i.e. extension agent). The assigned extension agent has a role of answering the question from a farmer via his or her mobile phone. In case the question sent to extension agent is difficult, it can be re-assigned to a researcher from Sokoine University of Agriculture or to somebody else with similar experience (Sanga, 2018).

2.7.2 Access to credit

Access to credit has a significant influence in determining farmers' use of a technology. It helps in alleviating financial constraints as well as enhancing the use of technology packages. Different studies (Asongu and Odhiambo, 2018; Nkosana *et al*., 2016; Cant and Wiid, 2016) in Africa have shown that access to credit plays a significant role in enhancing the diffusion of ICT to small medium enterprises. Credits can enable farmers to buy agricultural inputs such as improved seeds, fertilizers, herbicides and thus it can demand them to access agricultural information through improved technology such as mobile phones.

2.7.3 Access to market

Distance to market is also another factor which influences the use of mobile in accessing agricultural information. Farmers living near to markets have a chance to interact with other farmers and other agricultural stakeholders and establish social capital. Market serves as forum for the exchange of goods but also constitutes an important place where agricultural information is exchanged (Katungi, 2006). Tadesse and Bahiigwa (2015) study in Oromia Regional State, Ethiopia found that farmers living close to the open market, cooperative, or the village center, have a higher probability of using mobile phones for information searching than farmers who are far from such centres. Nyamba (2017) study in Kilolo and Kilosa in Iringa and Morogoro Regions, respectively in Tanzania found that distance to market influences farmers use of mobile phone for accessing agricultural information.

2.7.4 Farmers' groups

In agriculture, farmer groups or farmers' network enhances opportunities for participation and ability to work together, creating social structures that enhance the exchange of information on improved technology (Wambugu *et al*., 2009). The importance of farmers group seems like willingness and ability to work together. Farmer groups play a significant role in facilitating farmers' decision in the use of ICTs based services. This is due to reasons that most rural interventions tend to target farmers that are organized into producer organizations (Shiferaw *et al*., 2011). Farmers' groups act as effective channels of new interventions relating to agricultural technology (Wambugu *et al*., 2009). Farmers who are members in farmers' groups and different cooperatives are more likely to be aware of new practices as they are easily exposed to information (Obisesan *et al*., 2016; Abayomi *et al*., 2008; Chilot *et al.*, 1996). Okello *et al*. (2014) study in Kirinyaga, Bungoma and Migori Districts, Kenya reported that membership to a farmer organization positively influenced the decision to use ICT-based market information services among the smallholder farmers.

2.7.5 Network connectivity

Network connectivity is another factor which influences the use of mobile. Among the major problem which hinders the use of mobile phone in developing countries is inadequate connectivity and network infrastructure (Otieno *et al*., 2016). A mobile phone signal is strength received by a mobile phone from a cellular network. It depends on various factors, such as proximity to a tower, any obstructions such as buildings or trees (Elechi and Otasowie, 2015). This notwithstanding, the probability of farmers using mobile phone to access agricultural information is higher in the village with a good mobile network as opposed to those farmers living in villages with poor mobile networks. Ogunniyi *et al*. (2016) study in Ogun, Osun and Oyo states, Nigeria found that poor mobile networks posed a challenge for mobile phone use in agribusiness by farmers.

2.7.6 Access to agro dealer

An agro-dealer is a locally-based entrepreneur who sells seeds, fertilizer and agro-chemicals to farmers (Chinsinga, 2011). It is another factor which can enhance the use of mobile phones to access agricultural information. Input supply companies seek to improve product quality, services and information to farmers, and expand distribution networks. ICT-enabled applications allow agricultural input supply companies and agro-dealer to improve operations and build capacity to expand outreach and meet farmer need. Nyamba (2017) study in Kilosa District, Tanzania found that Kilosa Rural Services and Electronic

Communication (KIRSEC) which is an agro-dealer in Kilosa District, Tanzania helped farmers to use mobile phones to communicate agricultural information. The study reported that KIRSEC had computers through which farmers registered their mobile phones numbers and received SMS of new agricultural inputs. Thus farmers were trained on how to use mobile phones to receive updates on agricultural inputs. Reviewed studies revealed that various institutional factors influenced farmers' use of mobile phones for accessing agricultural information.

The importance of rain-fed agriculture in rural communities in Tanzania provides challenges for accessing rice agricultural information. Therefore, this study investigated the influence of institutional factors on the use of mobile phones for accessing rice information for adaptation to climate change.

2.8 Farmers' Adaptation Strategies to Climate Change

As results of climate change, different adaptations strategies have been adopted to manage the impact of the climate change (IPCC, 2007). These include strategic and tactical adaptations measures (Churi *et al*., 2013; Bradshaw *et al*., 2004; Kandlinkar and Risbey, 2000).

2.8.1 Strategic adaptation to climate change

Strategic adaptations refer to changes in the farm operation or changes in enterprises or management that would apply for a subsequent season, or a longer term (Bradshaw *et al*., 2004). Strategic adaptations to climate change are adaptations made by farmers based on climate and other signals over multiple years (Bradshaw *et al*., 2004; Kandlinkar and Risbey 2000; Risbey *et al*., 1999). The following section reviews these strategic adaptations to climate change.

2.8.1.1 Use of drought resistant rice varieties

Use of drought resistant rice varieties is among the adaptation strategies to climate change that farmers opt. A drought resistant rice variety requires less water and hence tackles deficit of rainfall situations during the growing season. The use of drought resistant rice varieties is the best options for rain-fed rice cultivation as it provides a significant yield advantage when there is low rainfall over the traditional long duration rice varieties. Hochman *et al*. (2018) study in Mandals State in India found that rain-fed rice farmers used drought resistant rice varieties to adapt to climate change. Similarly, Churi (2013) study in Same District, Tanzania found that rain-fed farmer used drought seed varieties as adaptation measure to climate change. Furthermore, a study by Mwakaje *et al*. (2010) in Kasulu, District found that farmers used drought seed variety to adapt to climate change.

2.8.1.2 Changing planting dates

Change in the calendar of planting dates is another climate change adaptation strategy in rice farming. Changing planting dates shifts planting dates because of rainfall changes. Urama and Ozor (2011) study in Western and Central Africa found that farmers noted that the trend of uncertainties in extreme weather events had generally increased in the recent years. Thus farmers switched their planting dates due to onset and cessation of the rainy seasons. Dharmarathna *et al.* (2014) study in Kurunegala District, Sri Lanka, found that changing planting date by one month identified as a non-cost climate change adaptation strategy for rice production. The study found that there was an increase in rice yields due to change on planting dates. Similarly, Komba and Muchapondwa (2015) study in Iringa, Morogoro, Dodoma, and Tanga regions found that changing planting dates was among the adaptation strategies to climate change that smallholder farmers used. Furthermore, Kim *et al*. (2017) study in Benue, Nigeria found that farmers adjusted the planting dates to coincide with the onset of rainfall.

2.8.1.3 Use of organic manure

Use of organic manure is another climate change adaptation measures practiced by rain-fed farmers. Organic manure helps farmers to adapt to climate change because of high soil organic matter content which helps to prevent nutrient and water loss (Altieri and Nicholls, 2017). Also, soil carbon sequestration is enhanced through application of organic manures, which promote greater soil organic matter (and thus soil organic carbon) content and improve soil structure (Niggli *et al*., 2008). The use of organic manure is among the soil conservation techniques. Soil conservation techniques have been increasingly practiced in a number of countries to enable farmers to adapt to climate change. For example, Lema and Majule (2009) study in Manyoni District, Tanzania revealed that farmers ensure proper timing of different farming activities, bury of crop residues to replenish soil fertility, burn crop residues to enhance quick release of nutrients and allow livestock to graze on farmlands after harvesting crops so as to improve soil organic matter. Furthermore, Belay *et al*. (2017) study in Central Rift Valley, Ethiopia found that among other adaptation strategies used included soil and conservation practices using crop residues such as livestock feed.

2.8.1.4 Use of herbicides

Use of herbicide to control weeds on the rice fields is also a climate change adaptation measure that rain-fed farmers practice. Herbicides provide benefits of timely weed control at the critical time and low labour. Flooding rice paddies is one of the common measures used by farmers to control weeds in rice fields (Srivastava *el al*., 2017). On farms with reliable irrigation, water management is one of the most effective and lowest cost methods of controlling weeds. However, with rain-fed rice farming, it is difficult to control water due to unpredictable rainfall pattern, thus difficult to control water by continuous flooding of water on the rice fields and it necessitates the use of herbicides. Churi (2013) study in

Same District, Tanzania found that farmers used herbicide for weed control as adaptation measure to control weed in semi-arid areas. Similarly, Sugihardjo *et al*. (2017) study in Tamale Region, India found that rain-fed rice farmers used herbicides as an adaptation strategy to control weeds.

2.8.1.5 Direct seeding

Direct seeding of rice refers to the process of establishing a rice crop from seeds sown in the field rather than by transplanting seedlings from the nursery (Brunel-Saldias et al., 2016). The method eliminates the laborious process of planting seedlings by hand and greatly reducing the crops water requirements. This is appropriate for the rain-fed rice farming where availability of water during transplanting is not guarantees. Furthermore, in this method; plants are not subjected to stresses such as being pulled from the soil and re-establishing fine rootlets. Kumar and Sidana (2018) study in Punjab India found that rain-fed farmers opted for direct seeding to adapt to the impact of climate change. Similarly, Kim *et al.* (2017) study in Benue State, Nigeria, farmers used direct seeding under reduced-tillage as adaptation measure to climate change by rain-fed rice farmers.

2.8.1.6 Zero tillage

Zero tillage means planting of seed directly on no tilled soil after the harvest of the previous crop (Brunel-Saldias *et al*., 2016). This practice does not require large amount of energy and labour, but also it does not accelerate mineralization of organic matter, reduces soil fertility, lower water consumption, and do not damages the chemical and physical properties of the soil. Zero tillage leaves plant residues on the ground, which can help in keep the soil moist and protect against evaporation caused by sun and wind. In fields that are not tilled, when the plant residues decompose at a natural pace on the soil surface, many life forms increase in and on the soil. It enhances the soil conservation which promotes growth of the rice. Srivastava *el al*. (2017) study in India found that farmers opted for zero tillage to adapt to the impact of climate change. Similarly, Candradijaya *et al.* (2014) study in Sumedang District, West Java, Indonesia found that due to climate change the majority of smallholder farmers depending on rains directly sowed rice seeds. Also, Kusmana *et al*. (2017) study in Indonesia found that rain fed rice farmers opted zero tillage strategy to adapt to climate change.

2.8.1.7 Use of supplemental irrigation

Use of supplemental irrigation involves the addition of little amounts of water to improve and stabilize yields when rainfall fails to provide sufficient moisture for normal plant growth. It is an effective response to alleviating the adverse effects of soil moisture stress on the yield of rain-fed crops during dry spells. Supplemental irrigation, especially during flowering growth stages improves crop yields. However, use of supplement irrigation is costly, especially when the source of water is far. Mishra *et al*. (2013) study in Bengal Region, India found that rain fed rice farmers used supplemental irrigation on rice fields when there was a lack of rainfall during panicle initiation.

2.8.1.8 Water harvesting

Total annual rainfall is often unevenly distributed so that long dry periods are interspersed with periods of intense rainfall. In many cases, a crop is unable to get the required amount of water due to lack of water because of uneven distribution of rainfall during the growing season. Thus water conservation is essential for farming when rainfall is uncertainly (Niang *et al*., 2017). Among the rain water harvesting methods opted by rain-fed rice farmers is through bunded fields. Farmers divide the field into a closed rectangular basin here called *majaruba* which is into bunded fields for growing paddy rice. Bunding (the building of an earth embankment, or bund, around the field boundary) allows water to be stored, conserved and made available to the crop. Kenya *et al*. (2017) study in Mvomero District, Tanzania found that farmers constructed bunds as adaptation measure to climate change.

2.8.1.9 Reduce use of inorganic fertilizers

Another potential adaptation measure to climate change is through reduced use of inorganic fertilizers, which can lower input expenditures and can partly offset adverse effects on crop yield (Paudel and Crago, 2018). Inorganic fertilizers affect soil chemical properties, enzyme activities, microbial community and soil quality which lower the crop yields (Liu, 2017). Similarly, Brar *et al*. (2015) found that chemical fertilizers reduce the physical properties and microbiological activities of soil, whereas organic fertilizers support soil microbes. Sarker *et al*. (2013) concluded that in order to reduce the impact of climate change, it is important to reduce chemical fertilizers use and increase usage of organic materials in crop production. Thus to enable farmers to adapt to the impact of climate change, farmers need to reduce the use of inorganic fertilizers and increase the use of organic fertilizers. This is because organic manure increases water holding capacity of the soil (Mahmood *et al*., 2017). Organic manures enable a soil to hold more water and also help to improve the drainage in clay soils. They even provide organic acids that help to dissolve soil nutrients and make them available for plants (Sarker *et al*., 2013).

2.8.2 Tactical adaptations to climate change

In agriculture, tactical adaptations to climate change include adjustments made by farmers within a growing season. Tactical adaptations are made by farmers based on weather and other short-term signals (Bradshaw *et al*., 2004; Kandlinkar and Risbey, 2000; Risbey, 1999). These are adaptation measures made by the farmers while the growing season has started. Tactical adaptations to climate change are usually regarded as short-term responses to avert immediate threats (Huq and Reid, 2004). They reduce the impact of the climate change on a short-time. The following section reviews these tactical adaptations to climate change.

2.8.2.1 Use of early maturing rice varieties

Early maturing rice variety is a rice variety which matures for fewer days than the others (Srivastava *el al*., 2017). Early maturing rice varieties are suitable for delayed/deficit of rainfall**.** Early maturing varieties provide an effective drought avoidance strategy by increasing the probability of plants completing flowering, the most sensitive stage to drought, prior to the onset of drought and escaping terminal drought (Morris, 2001). Kim *et al*. (2017) study in Benue State, Nigeria found that due to low rainfall conditions, farmers preferred early maturing rice varieties. Similarly, Sarker (2013) study in Rajshahi District, Bangladesh revealed that farmers used short duration rice varieties to avert the impact of climate change, which shortens the growing season. Furthermore, Mugambiwa (2018) study in Mutoko Rural District, Zimbabwe, revealed that farmers used early maturing rice variety due to shortened rainy days on the growing season.

2.8.2.2 Change to other crops

Another adaptation measure involves switching to other crop varieties, which are more drought-tolerant. Changing variety or type of crop is beneficial because certain crops grow better in more adverse conditions. For example, a farmer facing an increased likelihood of drought may switch to a different crop that is more tolerant to low water availability. This includes planting crops which require less amount of water compared to rice. For example, wheat requires significantly less irrigation water compared to dry season rice. Churi (2013) study in Same District, Tanzania found that the use of drought-resistant crop varieties has been used by smallholder farmers as adaptation measure to climate change.

2.8.2.3 Foliar application

Foliar spray is one of the most effective ways to supplement nutrients needed by the plants through foliar feeding, or the technique of applying liquid fertilizer directly to the leaves, through the stomata where nutrient absorption takes place faster than that of soil fertilization. Foliar application mitigates the environmental stress in crop production (Dadhich *et al.*, 2015). Mohan *et al.* (2017) study in Maharashtra, Karnataka and Andhra Pradesh Region, India found that spraying foliar on the rice leaves under rain-fed increased the yield. Similarly, Meena *et al*. (2017) study in Uttar Pradesh, Bangladesh found that farmers used foliar spray on rice leaves to reduce the impact of water deficit stress due to climate change by rain-fed rice farmers.

2.8.2.4 Reduced area for rice cultivation

Rice production requires more water than most other crops; this renders it susceptible to climate change. Change to weather parameter makes rice farming more vulnerable due to irregular patterns of rainfall (URT, 2014). Thus to adapt to climate change farmers reduce the area which is used to grow rice and use it to grow other crops which require less water. Sugihardjo *et al*. (2017) study in Tamale Region, India found that farmers used a portion of an area used to grow rice for other crop varieties that have the ability to withstand extreme climate change.

2.8.2.5 Delayed sowing

Due to delay on onset of the rainfall during the growing season, farmers need to change the planting dates to coincide with the time when rain starts. Among the adaptation opted by farmers is delayed sowing. Delay of sowing dates helps plants to avoid too high or too low temperatures during critical development stages which can impede growth and thus reducing crop yields. Georgopoulou *et al*. (2017) study in Kentriki and Ditiki Region in

Macedonia show that delayed sowing of rice leads to promising adaptation measure. In additional, Rajwade *et al*. (2015) study in Kharagpur District, India found that delayed planting caused maximum grain yield reduction of the rain fed cropping system.

More importantly, the reviewed literature shows that there are various adaptation measures to reduce the impact of climate change by rain-fed rice farmers. However, adaptation to climate change could be influenced by farmers' access to appropriate information which will enable farmers to make informed decisions (Umunakwe *et al*., 2014). Timely access to information is critical for farmers to undertake the adaptation measures. Therefore, it is important to enhance access to adaptation to climate changes among farmers. This can be achieved through the use of effective communication channel. In Tanzania the major source of agricultural information is through agricultural extension agents.

2.9 Access to Agricultural iinformation for Adaptation to Climate change: Empirical Studies

Research studies were reviewed on access to agricultural information for climate change adaptation which was carried out in other parts of the globe especially developing countries and Africa. These studies were from India (Mittal, 2016), Bangladesh (Kashem, *et al*., 2010; Rahman, 2017; Christensen, 2018), Vietnam (Linh *et al*., 2016) and other parts of Africa (Baumülle, 2012; Churi, 2012; Umunakwe *et al*., 2014; Etwire *et al*., 2015; Nyasimi *et al.,* 2017).

Furthermore, Mittal (2018) study in Haryana and Bihar States, India, examined role of mobile phone-enabled climate information services in gender-inclusive agriculture. Interviews and questionnaires were used in the study. The findings of the study showed that information delivered through mobile phones contributed towards reducing information asymmetry among farmers. The results showed that the use of mobile phone enabled farmers to access weather-based agro-advisory messages which helped them in taking informed decisions about input use, thus leading to savings on irrigation and reducing the cost of other inputs such as pesticides and fertilizers.

Nyasimi *et al.* (2017) study in Lushoto, Northeast Tanzania assessed adoption and dissemination pathways for climate-smart agriculture technologies and practices for climate-resilient livelihoods. Focus group discussion structured individual interviews and structured questionnaires were used. The study findings showed that majority of farmers reported that they received agricultural information orally from a variety of sources including government extension workers, seed companies, researchers, traditional experts, neighbors, radio agricultural shows, religious groups, farmer groups, and family members. The results also indicated that the vast majority of farmers were not using scientific weather information due unreliability and inaccessibility of weather information as the main reason. Farmers reported a lack of adequate weather information to plan for their farming activities. While there are multiple initiatives that are aimed at producing and delivering climate information services for farmers in Tanzania (URT, 2014b; URT, 2013a URT, 2012), many challenges still remain in terms of accurate and timely weather and climate forecasts to support farmers efforts to adapt to a changing climate and increasing climate risks.

Moreover, Umunakwe *et al*. (2014) study in Owerri West Local Area of Imo State, Nigeria analyzed information needs for climate change adaptation among rural farmers. The study used both quantitative (questionnaires) and qualitative methods (interview schedule). Four villages were used as case studies. The findings from this study indicated that farmers in Nigeria needed information on mitigation issues for easy adaptation to climate change, obtained from diverse information sources. The study found that areas of information need for climate change adaptation include among other effects of climate change, causes of climate change, crops adaptable to climate change, sources of information on climate change, agroforestry practices, flood/ erosion control practices, afforestation practices and adaptation strategies. Similarly, Mupakati and Tanyanyiwa (2017) study in Chiredzi District, Zimbabwe revealed that farmers interviewed indicated that they needed information to assist them in planting different crops that are commonly grown, information on rainfall pattern, time of occurrence of the mid-season drought or dry spells and flooding and storm warnings. In response to these findings, this study suggested timely generation and dissemination of useful information on climate change to the people whose livelihoods are mostly affected.

Daniel *et al*. (2013) study in Kyela, Songea Rural, and Morogoro Rural Districts on assessing the agricultural extension services in Tanzania. The study findings revealed that the major sources of knowledge for small-scale farmers were agricultural extension officers, radio and fellow farmers. On the one hand, this finding was also found to be similar to many studies (Msuya and Wambura, 2016; Danielsen *et al*., 2015; Odini, 2014; Gupta and Shinde, 2013; Asayehegn *et al*. 2012) which found that most of agricultural extension officers and fellow farmers were major sources of agricultural and extension services. On the other hand, public extension services were not effective although they were the major source of information. Furthermore, farmers were not satisfied with the frequency of contact with agricultural extension officers.

Churi (2013) study in semi-arid Same District, Kilimajaro Region, Tanzania investigated a decision support system for improved crop productivity under climate change. Data were gathered through questionnaires from ten villages. The findings revealed that farmers rely heavily on radio and mobile phones as sources of climate information for their farm work. Similar observations were made in by Etwire *et al*. (2015) study Upper West Region of Ghana which found that farmers used mobile phone in accessing weather forecast information. Tumbo *et al*. (2018) study in Kilosa District, Morogoro, exploring information seeking behavior of farmers' in information related to climate change adaptation through ICT. The study found that information seeking behaviour of farmers differs when it comes to acquiring climate change adaptation information compared to acquiring other types of farming related information. The study found that farmers asked information on climate change, livestock husbandry, market information, forestry and crop farming using WFAIS and MFAIS. However, this study adopted the qualitative research method. Specifically, content analysis was used to analyse the qualitative data which are found on *UshauriKilimo* server.

2.10 Research Gap

The empirical findings regarding the use of mobile phone for accessing climate information for adaptation to climate change studies have been carried out in various developing countries (Churi, 2013; Mittal, 2016; Nyasimi *et al.* 2017; Rahman, 2017;). Most of these studies have focused on assessing mobile phone-based dissemination of weather information (Etwire *et al*., 2017; Ogbeide and Ele, 2015; Okello *et al*., 2014; Chhachhar and Hassan, 2013; Churi *et al*., 2012). Studies by Umunakwe *et al*, 2014; Churi, 2013 have attempted to analyse the role of mobile phones in accessing climate information, but did not attempt to examine the socio-economic and institution factors influencing the use of mobile phone for adaptation to climate change. Furthermore, these studies did not categorise tactical and strategic adaptation information accessed through mobile phones. Adaptations measure consists of several options that can be accessed independently and at different periods. In this regard, this study assessed strategic and tactical rice information for adaptation to climate change accessed through mobile phones. Likewise, it examined the socio-demographic and institution factors influencing the use of mobile phone for adaptation to climate change by rain fed rice farmers in Tanzania.

Furthermore, Tumbo *et al*. (2018) study in Kilosa District, Morogoro Region, Tanzania, used content analysis to analyse the qualitative data which are found on *UshauriKilimo* server. The study did not include the quantitative research design. Additionally, the study did not assess different ways of using mobile phones to access agricultural information such as voice calling, sending short message service and browsing on an internet. Furthermore, farmers' use of mobile phone is influenced by institutional factors. Institutional factors have not been well investigated by previous studies on how they influence the use of mobile phones to access information related to climate change.

Finally, previous studies investigated factors influencing the use of mobile phones by considering only one source (Nyamba, 2017; Etwire, *et al.*, 2017; Churi *et al*., 2012). However, farmers access information from different channels simultaneously (Mittal and Mehar, 2016; Ali, 2012) as they do not rely on a single source of information. As this is done, their choice to adopt different channel of information might be correlated. Therefore, this study investigated rice farmers' use of mobile phone for accessing ricel information on adaption to climate change, considering the possibilities of using different channels of information simultaneously.

Furthermore, Tumbo *et al*. (2018) study on exploring information seeking behavior of farmers' in information related to climate change adaptation through ICTs was not based on theoretical framework. In essence a theory or theoretical framework serve as the glue that hold the component of social research, and its absence makes the research design to fall apart (Ngulube, 2018; Ngai *et al*., 2015; Anfara and Mertz, 2006). Study by Churi (2013) assesses accessibility of the climate information and socio-economic status. However, the study did not use adoption theory on identifying the study variable. Furthermore, the study includes only age and wealth status. Thus, this study used UTAUT theory to investigate the use of mobile phones for accessing adaptation information for climate change.

CHAPTER THREE

3.0 RESEARCH METHODOLOGY

3.1 Essence of the Research

A research paradigm is a set of common beliefs and agreements shared between scientists about how research problems should be understood and addressed (Babbie, 2011; Patton, 2002). Examples of research paradigms are such as positivists, constructivist and pragmatists (Brierley, 2017; Lincoln *et al*., 2011). Positivists believe that there is a single reality, which can be measured and known, and therefore they are more likely to use quantitative methods to measure this reality. Constructivists believe that there is no single reality or truth, and thus, reality needs to be interpreted. As a result, they are more likely to use qualitative methods to get those multiple realities, while Pragmatists believe that reality is constantly renegotiated, debated, interpreted, and therefore, the best method to use is the one that solves the problem (Lincoln *et al*., 2011).

This study upholds the post-positivists research paradigm, which believes that a scientific method is the only way to establish truth and objective reality (Lincoln *et al*., 2011). Positivism contends that there is an objective reality out there to be studied, captured and understood, whereas post-positivists argue that reality can never be fully apprehended, only approximated (Panhwar *et al.*, 2017). Post-positivism relies on multiple methods of capturing reality as much as possible. At the same time, the emphasis is placed on the discovery and verification of theories. Post-positivist approaches show a much greater openness to different methodological approaches, and often they include qualitative, as well as quantitative methods. This allows for the development of alternative research strategies to find information in unlikely and creative ways (Bogdan and Biklen, 2003). Additionally, researchers in this paradigm normally believe in multiple perspectives from participants rather than a single reality (Creswell, 2003). Researchers begin with ideas, theories or concepts that are defined as they are used in the study to point to the variables of interest. The methodology used includes survey using questionnaire, interview and observation (Patton, 2002).

3.2 Description of the Study Districts

This study was conducted in Morogoro Region, Morogoro region was selected because it is among the top national cereal basket (Cochrane and D'Souza, 2015). The study was conducted in two districts namely Kilosa and Kilombero in Morogoro region, the districts were purposively selected based on their high rain-fed rice production figures. Furthermore, the two districts had good ICT infrastructure, which facilitate the uses of mobile phones. Also, these districts have been experiencing the effects of climate change (Vatn *et al*., 2017; Mutabazi *et al*., 2014).

3.2.1 Kilosa District

Kilosa District is located between latitude 5^{o} 55' and 7^{o} South and longitude 36^{o} 30' and 37^{o} 30' East, covering a total area of 12 393.7km^{2} (Kilosa District Council, 2016). According to the national 2012 census, there were 489 513 people living in Kilosa District and over 80% of the people were depending on agriculture (Kilosa District Council, 2016; URT, 2013). Kilosa District borders Mvomero District in the East, Kilombero District and Iringa Region in the South, Gairo District on the North and West respectively and Mpwapwa District in the West. The District is characterized by bi-modal rainfall patterns, short rains known as *vuli* that commence towards the end of November and fades away in January/February. The long rains known as *masika* start between March and May. The District's temperature is a typical representation of tropical climate ranging between 25^{0} C and 30^{0}C (Kilosa District Council, 2016).

The main economic activities in the District include crop cultivation, livestock keeping and commercial enterprises. Major crops grown include maize, rice, sorghum, millet, beans, coffee, bananas, sunflower, cotton, soya beans, sesame, onions, cabbages, tomatoes, egg plants, carrots, peppers, sugarcane, sisal, mangoes, oranges and lemons (Kilosa District Council, 2016). Most of the grown crops are used for both household consumption and trade (Mdangi *et al*., 2016). However, most of the farmers are subsistent, and they depend on rain-fed agriculture.

Rice is the second most important cereal crop in the district in terms of the planted area. More than 99% of the rice growing area in Kilosa District is under rain-fed conditions where rice is usually grown only once a year in the rain seasons. The number of households growing rice in Kilosa District during the long rainy season was 72 000 (DAICO Kilosa District, 2019). The production trend of rice and area under cultivation between 2013/14 and 2017/18 farming seasons are shown in Table 1. The production was steadily reduced from 89 600 tons in 2013/14 to 51 280 tons in 2017/18. Furthermore, the yield of rice has shown a gradual decline over the years since 2013/2014 (from 4.0 tons/ha in 2013/14 to 2.5 tons/ha in 2017/18). The key informant explained that this situation was caused mainly by a number of factors, which included lack of adoption of technological innovations such as the use of improved seeds, fertilizers, herbicides, appropriate and low adoption of rainwater harvesting and post-harvest technologies.

Table 1: Rice production 2013/14 to 2017/18 in Kilosa District.

Year	**2013/14**	**2014/15**	**2015/16**	**2016/17**	**2017/18**
Size(ha)	22 185.0	22 400.0	18 013.0	22 672.0	20 512.0
Production (tons)	88 740.0	89 600.0	54 039.6	68 086.0	51 280.0
Productivity (tons/ha)	4.00	4.00	3.00	3.00	2.50

Source: DAICO Kilosa District (2019).

The livestock keeping is another economic activity undertaken in the district, it includes keeping cattle, goats, sheep, pig and chicken. This activity is mostly done by Maasai and Sukuma tribes who migrate from other regions. The Maasai and Sukuma tribes had been moving from one point to another searching for green pastures for their cattle since 1980s (Poulton, 2018). These migrants moved out from their original regions and districts due to environmental destruction due to climatic change which then resulted in uneven rainfall distribution in the left regions as well in the districts (Selemani, 2014).

The study results show that there was 5880 livestock keeper in the district (DAICO Kilosa District, 2019). Cattle are the dominant livestock type in the district followed by goats, sheep and pigs. Cattle population in Kilosa District increased during the period of five years from 139 210 in 2013/14 to 208 279 in 2017/18. This trend depicts an annual positive increase rate of 49.61%. In addition, the number of goats in Kilosa District was 119 481. The overall annual increase rate of goat population from 2013/14 to 2017/18 was 11.34%. This positive trend implied that five years of population increase from 119 481 in 2013/14 to 133 029 in 2017/18 (Table 2). This implied that there is increased of demand for grazing and water sources for livestock. Key informants indicated that increase of livestock in the District lead to encroachment of water sources, forest and agricultural land by the pastoralist. Also key informants indicated that apart from inducing conflicts among herders and farmers, and local governments, the increase of livestock in the District also contributed to the deterioration of water resources in the basin.

Furthermore, the number of sheep was 21 953 in 2018. The overall annual increase rate of the sheep population for five years from 2013/14 to 2017/18 was estimated at 29.24% and the overall annual increase rate of pig population for the five years period from 2013/14 to 2017/18 was 31.97% (Table 2). During this period, the population grew from 4 730 to 6

242. Moreover, the poultry sector in Kilosa District was dominated by local chicken production, which was estimated at 2 100 861 chicken. The overall annual chicken population increase rate during the five-year period from 2013/14 to 2017/18 was 36.28%, and the local chicken population increased from 193 445 to 250 000.

Table 2 show that Kilosa District had 208 279 cattle, 133 029 goats and 31 079 sheep which require 457 585 ha of grazing area, current the total grazing area allocated was 119 236, hence, the District had a deficit of 338 349.00 ha. This contributes to frequency conflicts between farmers and pastoralists as pastoralists feed their cattle on the farmers' field with crops. Discussion with key informants revealed that proper land use plan is lacking in most of the studied areas in Kilosa District. It was reported that few of the wards have allocated land for crop farming and livestock grazing.

Table 2: Livestock population in Kilosa District

Name of livestock	2013/14	2014/15	2015/16	2016/17	2017/18	% change
Cattle	139 210	169 645	187 972	197 885	208 279	49.21
Goats	119 481	108 935	120 059	126 378	133 029	11.34
Sheep	25 953	25 314	28 049	29 525	31 079	19.75
Pigs	4 730	5 084	5 633	5 930	6 242	31.97
Donkeys	1 756	1 849	2 049	2 157	2 270	29.27
Local chicken	183 445	203 627	225 625	237 500	250 000	36.28

Source:Kilosa DAICO (2019).

3.2.2 Kilombero District

Kilombero District is situated in the Kilombero flood plain, and it covers an area of approximately 14 918 km^2 (1 491 800 ha) and its human population was 407 880 (URT, 2013b). It lies between latitudes 70º40′ and 9º21′ S and between longitudes 35º 20' and 37º 48' E, and has a size of 14 918 km^2. Most of the District‘s area lies along Kilombero valley (wetland) which supports both small and large scale farming. The District is located between the Kilombero River in the South-east and Udzungwa Mountains in the North-west, and is characterized by bi-modal rainfall patterns, short rains also known as *vuli* that commences toward the end of November and fades away in January/February (Kilombero District Council, 2016). The District is also characterized by long rains known as *masika*, which begin in March and ceases in May/June. The temperature of the District ranges between 26^0 C and 32^0 C.

The main economic activities of Kilombero District include crop cultivation, livestock keeping and commercial enterprises. The major crops are grown by smallholder farmers which include rice, cassava, maize, banana, sesame oil palms, sweet potatoes, beans, groundnuts, peas, sugar cane and fruits. More than 90% of the District's human population are smallholder farmers most of whom grow rice (Kilombero District Council, 2016). The District is most important for rice production in the region with a planted area of over 53 096 ha and the planted area per household is 1.2 ha, which is above average for the region of 1.16 ha (URT, 2016a). Rice production in Kilombero is practiced by both irrigating and rain-fed condition. The district has 2 064.30 ha of improved irrigation schemes and 45 563.00 ha of unimproved irrigation scheme (DAICO Kilombero District, 2019). More than 95% of the rice growing area in Kilombero District is under rain-fed conditions where rice is usually grown only once a year. Less than 5% of the area is under irrigated conditions, usually grown in the dry season. Table 3 shows rice production in 2013/14 to 2017/18 season in Kilombero District and the number of households growing rice in the District was 44 718, which represents 90% of the total crop growing households in the District (DAICO Kilombero District, 2019).

During the 2013/14 season, there was an increase in production of rice from 316 418 in 2013/15tons to 407 274 tons in 2014/15 (Table 3). The production dropped to 204 874 tons in 2015/2016 and production increased again to 353 696 tons in 2016/17 after which it sharply dropped to 305 388.0 tons in the following year. For example, one key informant explained that rice production had decreased mainly due to lack of technology, challenges of water control (both drought and flood), weed management and low soil fertility. In additional, another key informant elaborated that in the 2015/16 season there was an occurrence of insect-pests in the rice fields which destroyed hundreds of hectares and gradually lowered rice production.

Table 3: Rice production 2013/14 to 2017/18 in Kilombero District.

Year	2013/14	2014/15	2015/16	2016/17	2017/18
Size (ha)	113 006	116 364	81 951	101 056	105 306
Production (tons)	316 418	407 274	204 874	353 696	305 388
Productivity (tons/ha)	2.80	3.50	2.50	3.50	2.90

Source:Kilombero DAICO (2019).

Livestock keeping is another prominent economic activity and most livestock keepers are immigrants (pastoralists, agro-pastoralists) arrived in the 1980s (Kabuye, 2015). Since the 1970s, unreliable rainfall and competition for resources have driven some cattle-keepers to seek pasture for their animals in other parts of the country. Kilombero valley has received many migrant livestock keepers from Mwanza, Shinyanga, Arusha, and Manyara looking for pastures for their livestock because of environmental destruction in their areas of origin. Fishing is also undertaken along Kilombero River and in small swamps found in the Kilombero valley.

Table 4 shows the number of livestock kept in Kilombero District in the 2013/14 season to 2017/18. Cattle are the dominant livestock type in the district followed by goats, sheep and pigs. Cattle population in Kilosa District increased during the period of five years from 52 872 in 2013/14 to 98 428 in 2017/18 (DAICO Kilombero District, 2019). This trend depicts an annual positive increase rate of 86.16%, which had an impact on the demand of grazing land which increased conflicts on the use of the available land. The number of goats in Kilosa District was 119 481 and the overall annual increase rate of goats population from 2013/14 to 2017/18 was 32.69% (DAICO Kilombero District, 2019). This positive trend implied that five years of population increased from 6240 in 2013/14 to 8 280 in 2017/18, implied an increase of demand for grazing and water sources for livestock.

Table 4 also shows that the number of sheep was 10 818 and the overall annual increase for the 2013/14 to 2017/18 season was estimated at 49.42%. Pigs were few and the pig population increase rate for the five years period from 2013/14 to 2017/18 was 64.50%. During this period the population grew from 6936 to 11 410. During the interview, Key informant explained that pigs are kept under confinement, hence they do not invade crops. In addition, the poultry keeping in Kilosa District was dominated by local chicken, which were 848 400 chicken. The overall annual chicken population increase rate during the five-year period from 2013/14 to 2017/18 was 42.90%.

The total grazing area available for Kilombero District was 54 259 ha, the grazing area required for 98 428 cattle, 8 280 goats and 10 818 sheep was 204 630 ha of grazing area. Thus, the District had the deficit of 338 349.00 ha. For example, one key informant revealed that the District land use for various uses included pasture land. It was reported that land use plan in some wards has been undertaken in order to regulate the current influx of migrant pastoral communities in the District.

Table 4: Livestock population in Kilombero District

Name of livestock	2013/14	2014/15	2015/16	2016/17	2017/18	% change
Cattle	52 872	65 516	75 889	79 683	98 428	86.16
Goats	6 240	7 130	7 830	8 160	8 280	32.69
Sheep	7 240	8 140	9 032	9 840	10 818	49.42
Pigs	6 936	7 642	10 340	9 820	11 410	64.50
Donkeys	104	98	149	161	164	57.69
Chicken	593 700	635 800	746 500	789 600	848 400	42.90

Source:DAICO Kilombero District (2019).

3.3 Description of the Study Wards

3.3.1 Tindiga ward

Tindiga ward is located 12 kilometers from Kilosa town, it is located on a fertile plain with a perennial river crossing the ward agro-landscape. It borders with Masanze ward to the North, Kilangali to the South west and Mvomero District to the South East. The ward is made up of five villages namely: Tindiga A, Tindiga B, Malui, Malangali and Kwalukwambe. It has a population of around 13 291 people, of which 6513 and 6778 were males and females respectively. It had an average household size of 3.8 (URT, 2013b), and maize and rice were the major staples grown in the Ward. The Ward also produces a range of food crops such as beans, sesame and sunflower. Mangoes and banana are main fruits grown in the area. Villagers keep livestock mainly cattle, goats, sheep and chickens. Although the ward has livestock, there was no land that allocated for pastures. It was observed that lack of allocation of land for pastures, it leads to frequent conflicts which involve livestock feeding on field crops. In 2018, the ward had 11 500 farmers engaged in rice farming, but they also grew other crops such as maize and sunflower (Ward Agricultural Extension Officer [WAEO], 2019).

The results show that there was 34 livestock keepers in the Ward and the number of livestock kept in study Wards in the 2016/17 season to 2017/18 (WAEO, 2019). Cattle are the dominant livestock type in the Ward followed by goats, sheep and pigs. The total number of cattle in the ward was 4122 and cattle population in Ward increased from 3898 in 2016/17 to 4122 in 2017/18, and its annual with an increase rate was 5.7% (Table 5). This increase of cattle was below the districts' average annual increase of 5.3%. The overall annual increase rate of goat population from 2016/17 to 2017/18 was 12.7%. This positive trend implied goat population increase from 808 in 2016/17 to 911 in 2017/18. The number of sheep was 307, and the overall annual decrease rate of the sheep population from 2016/17 to 2017/18 was estimated at 32.2%. The poultry sector in Tindiga Ward was dominated by local chicken production, which was estimated at 2560 chicken. The overall annual chicken population increase rate during the period from 2016/17 to 2017/18 was 9.2% and the local chicken population increased from 2345 to 2560. This increase was above the districts' average annual increase of 5.3%.

Table 5: Rice production and number of livestock kept in the study Wards

District	Wards	Season	Rice production Size (ha)	Production (tons)	Productivity (tons/ha)	Livestock keeping Cattle	Goat	Sheeps	Pigs	Chicken
Kilosa	Rudewa	2016/17	999	3 496.5	3.5	2 200	631	326	177	23 220
		2017/18	4 326	1 2978.0	3.0	4 625	512	415	225	20 326
	Msowero	2016/17	700	1 750.0	2.5	9 714	31 085	82	43	3 328
		2017/18	719	1 795.8	2.49	9 815	30 089	79	41	2 928
	Tindiga	2016/17	423	1 269.0	4	3 898	808	453		2 345
		2017/18	423	1 057.5	2.5	4 122	911	307		2 560
	Kimamba A	2016/17	412	1 030.0	2.5	879	262	129	369	961
		2017/18	502	1 506.0	3	971	163	74	128	1 387
Kilombero	Signali	2016/17	6 200	18 600.0	3	3 211	321	1 100		25 512
		2017/18	6 500	19 500.0	3	3 333	451	1 107		26 212
	Sanje	2016/17	639	2 236.6	3.5	34	23	-	156	12 344
		2017/18	639	2 391.3	3.74	40	44	-	234	15 933
	Kiberege	2016/17	7 600	2 2800.0	3	4 211	421	1 110		30 510
		2017/18	7 600	2 2800.0	3	4 332	551	1 207		40 212
	Sawasawa	2016/17	5 729	20 051.5	3.5	77	54	9	132	17 912
		2017/18	5 729	17 187.0	3.0	100	64	9	147	18 040

Source:DAICO, WAEO and WLO (2019)

3.3.2 Msowero Ward

Msowero Ward is found in the main road entrance to the Kilosa District Council main office about 20 km from Dumila junction along the Morogoro to Dodoma highway. The ward borders the Dumila ward to the North, Gairo District to the North-West and Redewa ward to South. The ward is made up of four villages namely: Msowero, Mambegwa, Majaa and Mkobwe. According to the 2012 Tanzania national census, Msowero ward had 29 361 human population, of which 14 899 and 14 462 were males and females, respectively. It had an average household size of 4.4 persons (URT, 2013b). The ward had a land area of 554.1km^2 (DAICO Kilosa District, 2019). The ward had 6292 farmers engaging in rice farming, but they also grew other crops such as maize (WAEO, 2019). The Ward also produces a range of food crops such as beans, sesame and sunflower, and keep livestock mainly cattle, goats pigs and chickens. Although the ward has livestock, there was no land that was allocated for pastures. This creates frequent conflicts between pastoralists and farmers which involve pastoralists feeding their animal on farmers' farms. In 2019, the ward had 107 livestock keepers (DAICO Kilosa District, 2019).

Cattle are the dominant livestock type in the Msowero Ward. The total number of cattle in the ward was 9815 and cattle population in Ward increased from 9714 in 2016/17 to 9815 in 2017/189, and overall annual increase rate of cattle was 1.1% (Table 5). This increase of cattle was below the districts' average annual increase of 5.3%. The overall annual decrease rate of goat population from 2016/17 to 2017/18 was 3.2%. This negative trend implied that population decrease from 31 085 in 2016/17 to 30 089 in 2017/18. The number of sheep was 79. The overall annual chicken population decrease rate during the period from 2016/17 to 2017/18 was 19.1% and the local chicken population decreased from 2928 to 2345. This increase was above the districts' average annual increase of 5.3%.

3.3.3 Rudewa Ward

Rudewa Ward is one of the wards in Kilosa District, and is 20 km from Dumila junction along the Morogoro to Dodoma highway. It borders with the Msowero Ward to the North, Mvomero District to the North-East and Chanzuru Ward to South. The ward is made up of five villages namely: Rudewa, Ruaha, Mbuyuni, Peapea and Unone. In 2012, the ward had a total human population of 18 352, of which 9078 and 9274 were males and females, respectively, and it had an average household size of 4.3 (URT, 2013b). Agriculture is the main economic activity and most of the people engage in farming of both subsistence and cash crops of which the major food crops include rice, maize, beans and cash crops include sesame and sunflower. The major farming system includes maize-rice based and agropastoralism, but there was no land allocated for pastures. In 2019, the ward had 2398 farmers engaged in rice farming but also grew other crops such as maize (WAEO, 2019). The ward had 35 livestock keepers (DAICO Kilosa District, 2019). Cattle population in Ward increased from 2200 in 2016/17 to 4626 in 2017/18, and its annual increase rate of cattle was 110.2% (Table 5). This increase of cattle was above the districts' average annual increase of 5.3%, implied an increase of demand for grazing and water source for livestock. In addition, chicken population decrease rate during the period from 2016/17 to 2017/18 was 14.2%. This decrease was below the districts' average annual increase of 5.3%.

3.3.4 Kimamba A Ward

Kimamba A Ward borders the Chanzuru Ward to the North, Kimanba B to South. In 2012 census the ward had a total human population of 6079, of which 2986 and 3093 were males and females, respectively. It has an average household size of 3.5 (URT, 2013b). The ward is made up of three suburbs namely: Mkwajuni, Soko Msuya and Skutari. Agriculture is the main economic activity and most of the people engage themselves in farming for both subsistence and cash crops: food crops include rice, maize, beans, cassava and bananas, and major cash crops include sisal, sesame and sunflower. However, crops like rice, maize and beans were for food and sale. The ward had 825 farmers mostly engaged in rice farming, and also grew maize (WAEO, 2019). For example one, Key informant explained that there were few livestock keepers who kept their livestock under zero grazing, and there was no land allocated for pastures. However, there are pastoralists from nearby villages who fed their livestock on the crops of other farmers due to lack of pasture in their areas. In 2019, the ward had seven livestock keepers (DAICO Kilosa District, 2019). Cattle population in Ward increased from 879 in 2016/17 to 971 in 2017/18, and its annual increase rate was 10.5% (Table 5). This increase of cattle was above the districts' average annual increase of 5.3%. The number of goat was 163, while sheep was 74. The results showed that the overall annual chicken population increase rate during the period from 2016/17 to 2017/18 was 44.3% and the local chicken population decreased from 961 to 1387. This decrease was below the districts' average annual increase of 5.3%.

3.3.5 Signali Ward

Signali Ward was established in 2015 and is 18 kilometres from Ifakara District's headquarters, and borders with the Udzungwa National Park to the West, Kiberege Ward to the North . The ward is made up of three villages namely: Signali, Sululu and Saga. Rice and maize were crop grown in the ward and crops such as beans and finger millet. Villagers keep livestock mainly cattle, goats, pigs and chicken. One Key informant explained that the ward had 650 ha for rice farming, which made for farmers to buy and hire land for rice farming from outside the village. Furthermore, the ward allocated of 2290 ha for pastures and 10 800 farmers engaged themselves in rice farming (WAEO, 2019). In

2019, the ward had 141 livestock keepers (Ward Livestock Officer (WLO, 2019), and the major livestock kept were cattle, goat, sheep and pigs.

The overall annual increase rate of cattle population from 2016/17 to 2017/18 was 3.8%. This positive trend implied cattle population increase from 3211 in 2016/17 to 3333 in 2017/18 (Table 5). This increase of cattle was below the districts' average annual increase of 23.5%. The overall annual increase rate of the sheep population from 2016/17 to 2017/18 was estimated at 29.2%, and the number of goat was 451. During this period, the sheep population lowered from 1100 to 1110. Moreover, the poultry sector in Signali Ward was dominated by local chicken production, which was estimated at 26 212 chicken with annual increase of 3.9. This increase was below the districts' average annual increase of 7.4%.

3.3.6 Kiberege Ward

Kiberege Ward is 40 Kilometres from Ifakara which is the Districts' headquarter and it is borders with Kisawasawa Ward in the North part and Udzungwa Mountain Reserve in the North-West, while in the South and East, it borders with Kilombero River and Kisawasawa ward, respectively. The ward is made up of four villages namely: Kiberege, Nyamwezi, Mkasu and Bwawani. In 2012 census, the study ward had a total human population of 22 312, of which 11 075 and 11 237 were males and females, respectively with an average household size of 4.3 (URT, 2013b). Rice and maize are the major crops grown in the ward and produces a beans, vegetables and fruits. In 2018, the ward had 12 600 farmers growing rice and other crops such as maize (WAEO, 2019).Villagers keep mainly cattle, goats pigs and chickens. Cattle population in Ward increased from 421 in 2016/17 to 4332 in 2017/189, and annual increase rate was 2.8% (Table 5). This annual increase of cattle was below the districts' average annual increase of 23.5%. In 2019, the number of goat was 551, while sheep was 1207. The results showed that the overall annual chicken population increase rate during the period from 2016/17 to 2017/18 was 31.8% and the local chicken population increased from 30 510 to 40 212. This increase of chicken was above the districts' average annual increase of 7.4%.

3.3.7 Sanje Ward

Sanje Ward is 60 kilometres from Ifakara which is the District headquarters, and borders the Udzungwa mountain and Mkula in North-West and North. In the Southern and Eastern part is bordered with Mkula and Kidatu Ward. The ward is made up of three villages namely: Msolwa Ujamaa, Miwangani and Sanje, and in 2012 census, the study ward had a total human population of 11 041, of which 5485 and 5556 were males and females, respectively, with an average household size of 4.3 (URT, 2013b). Rice, maize and sugar cane being the main crops grown in the ward. The ward also produces beans, and vegetables. Few villagers keep livestock such as cattle, goats pigs and chickens. During an interview with key informant, explained that most of the cattle kept are for milking, which are kept under zero grazing, hence reducing conflicts with farmers due to livestock eating other farmers' crops. In 2018, the ward had 7400 farmers engaged in rice farming and other crops such as maize. In this ward, 565 hectare were used to grow rain-fed rice farming, while only 74 hectare was used for growing rice under improved irrigation (WAEO, 2019). In 2019, the Cattle population in the Ward was 40 (WLO, 2019). The number of goat was 23, while pig was 234 (Table 5). The results showed that the overall annual chicken population increase rate during the period from 2016/17 to 2017/18 was 29.1% and the local chicken population increased from 12 344 to 15 933, with annual increase rate of 29.07. This increase of chicken was above the districts' average annual increase of 7.4%.

3.3.8 Kisawasawa Ward

Kisawasawa Ward is 20 kilometre from Ifakara town which is the Districts headquarters, and it borders the Udzungwa National Park to the West and North-West, Mangula Ward to the North, Kiberege and Signali to South-West(Fig. 4). The ward is made up of four villages namely: Kisawasawa, Ichonde, Kanolo and Mpanga. In 2012 census, the study ward had a total human population of 9048, of which 4642 and 4406 were males and females, respectively, with an average household size of 2.6 (URT, 2013b). Rice and maize are major cereal crops grown in the ward. Observation shows that few villagers kept livestock such as cattle, goats, pigs and chickens. During an interview on livestock keeping, the key informant explained that most of the cattle were kept under zero-grazing for milk. This reduced conflicts between farmers and pastoralists due to livestock eating crops in the farms. In 2018, the ward had 3043 farmers engaged in rice farming and other crops such as maize and vegetables. In 2019, the ward has 20 livestock keepers (WAEO, 2019).

The overall annual increase rate of cattle population from 2016/17 to 2017/18 was 3.8%. This positive trend implied cattle population increase from 77 in 2016/17 to 100 in 2017/18. This increase of cattle was below the districts' average annual increase of 23.5% (Table 5). In 2019, the number of goat was 64 and sheep was 9. The overall annual chicken population increase rate during the period from 2016/17 to 2017/18 was 0.7%, and the local chicken population increased from 17 912 to 18 040. This increase of chicken was below the districts' average annual increase of 7.4%.

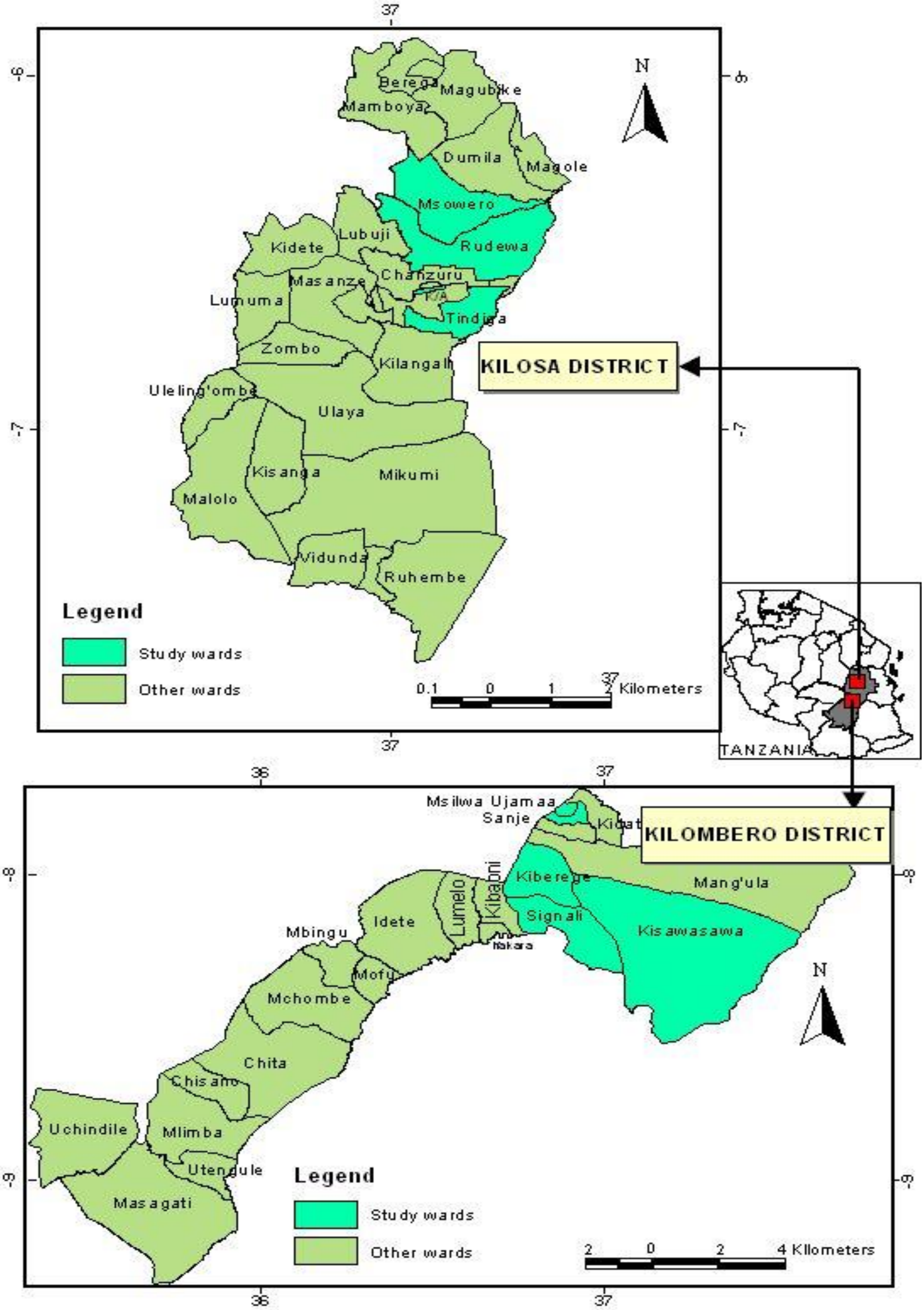

Figure 4: A map of Kilosa and Kilombero Districts showing study areas

3.4 Research Design

The basis for selecting a particular research design greatly depends on the kind of information that is to be collected. According to Stokes (2014), research design entails the arrangement of conditions for the collection and analysis of data in a manner that aims to combine relevance of the research purpose with economy of procedure. White and McBurney (2013) define research design as a plan of how a researcher conducts research. Hence, based on the nature of this study a cross sectional research design was adopted. Cross-sectional research design allows data to be collected at a single point in time to capture important aspects (Kothari, 2004).The design allows a combination of various survey methods for gathering both qualitative and quantitative data. The design also offers quick results at minimal cost.

3.5 Sampling Procedure

This study used a two stage sampling technique: firstly by selecting two study districts out of the seven in Morogoro Region. Then, selection of wards and villages with smallholder farmers who mostly grew rain-fed rice. The second stage involved the selection of the respondents.

3.5.1 Stage I: Selection of study districts, wards and villages

The study adapted a multi-stage sampling technique. Firstly, two districts were selected purposively. Purposive selection of the district was based on their high rice production figures in 2014/15 season. Kilombero District recorded the highest rice production in Morogoro Region with 407 274 tons (46.5%) and a crop yield of 3.5 tons/ha, followed by Ulanga with 185 983.8 tons (21.2%) with a crop yield 2.72 tons/ha and Mvomero have 160 836 tons (18.3%) with yield 5.0 tons/ha (Morogoro Regional Agricultural Office, 2019). On the other hand Kilosa District produced 89 600.00 tons (10.2%) with a crop yield of 4.0

tons/ha, followed by Morogoro Rural had 171 00.6 tons (1.95%) with crop yield of 1.00 tons/ha. Morogoro District had the lowest rice production of 15 018 tons (1.71%) with a crop yield of 2.12 tons/ha. However, Mvomero District was excluded due to the presence of an irrigated scheme covering 2060 ha, also Ulanga District because its closeness to Kilombero District in the Kilombero Valley.

Secondly was selection of wards, the selection of wards for the study was done in collaboration with agricultural extension officers at the DALDO's office in October 2015. Purposive sampling was also used to select eight wards which were included in the study based on farmers who mostly grew rain-fed rice. In Kilosa District: Tindiga, Rudewa, Kimamba A and Msowero, and in Kilombero Ditrict: Kiberege, Kisawasawa, Sanje and Signali. Then, in each ward, one village were selected based on similar criteria making a total of eight

3.5.2 Stage II: Selection of the respondents

The sampling frame included all rain-fed rice farmers in the study areas. An individual farmer with mobile phones formed a sampling unit of the study. From each participating village, the rain-fed farmers' roaster was developed in collaboration with Village Executive Officers and the Village Agricultural Officers in the selected villages. The roaster for all farmers in a particular village, were stratified into two categories of males and females. A stratified sample of 50 farmers per village (25 males, 25 females) was randomly selected producing a total of 400 respondents in the eight villages.

According to Singh and Masuku (2014), the formula provided by Cochran if population is unknown is $n=z^2pq/e^2$. Where "n" is the sample size, "z" level of confidence, "p"is the estimated proportion of the attribute that is present in population, q=1 –p and e is the desired level of precision. With the level of precision of 0.05, p of 0.5 and assuming 95% confidence level (thus z =1.96). The calculation gaves a sample size of 384 respondents. Calculated sample size was approximated to 400 to ensure equal number of respondents per selected villages.

In addition, eight FGDs with ten participants from each village, including five men and five women were conducted. The researcher also interviewed key informants who were likely to interact with farmers in the process of using mobile phones to access rice information for adaptation to climate change. This included ten out of seventeen agricultural extension officers, one agricultural extension officer at the DAICO from each district and eight village agricultural extension workers from the study village were purposively selected because their positions for enhancing farmers' access to agricultural information.

3.6 Data Collection Methods

The study used three main data collection methods, namely interviews with the respondents, key informants interviews, and focus group discussions. These methods were designed to complement each other in terms of analysis, and verification. Questionnaires were the main tool for data collection.

3.6.1 Questionnaires

This method of data collection is quite popular, particularly in case of big enquiries. Questionnaire can be sent (usually by post) to the people concerned with a request to answer the questions and return the questionnaire or it can be administered personally to the target groups. A questionnaire consists of a number of questions printed or typed in a definite order on a form or set of forms. The advantage of the questionnaire method is that it involves several respondents who answer a set of questions (Singh and Masuku, 2014). Additionally, questionnaires are relatively inexpensive to administer, hence enabling the researcher with inadequate funds to complete a study. Also, it has a fixed format, hence, eliminating variations in questioning. The questionnaire was developed based on the study objectives. It contained both closed and open-ended questions. Questionnaire was administered by the researcher and his assistants to avoid low return percentages of questionnaire and to provide guidance where it was needed in filling in and completing it.

3.6.2 Testing of the instrument

3.6.2.1 Validity

Questionnaire is one of the most widely used tools to collect data in especially social science research. The main objective of questionnaire in research is to obtain relevant information in most reliable and valid manner. Thus, the questionnaire should be validity to ensure that it is accuracy and consistency. Validity of the instrument is the extent to which the data collected truly reflect the phenomena being studied (Heale and Twycross, 2015). Validity tests how well an instrument that is developed measures the particular concept it is intended to measure (Sekaran, 2003; Neuman, 2006). Validity of the instrument was achieved in two ways. Firstly, the questionnaire was given to the two supervisors to read it and check the logical flow of the questions as per study objectives. Secondly, the prepared questionnaire was given to other experts to read it for clarity and correctness as per study objectives.

3.6.2.2 Reliability test

The worthiness of a questionnaire is judged in the course of the reliability. Based on this understanding the instrument was pretested to verify its reliability. Reliability refers to the extent to which a measure can give consistent and stable results in a measurement process

(Sekaran, 2003). A reliability test attempts to indicate the extent to which the research tool is without bias (error free) and hence offers consistent measurement across time and across the various items in the instrument (Carey, 2016). According to Kombo and Tromp (2006), pretesting of an instrument is required to ensure its reliability. The researcher pre-tested the reliability of the instrument using a random sample of 20 respondents drawn from Kidete village in Kilosa District before being used in the main sample. The village was selected because it had similar characteristics as those found in the study villages. The 20 respondents were chosen as suggestion by Kathuri and Pals (1993) that 20 cases is appropriate for pre-test of the research instrument. The collected data from this exercise was coded and entered in the SPSS and using the spilt-half reliability analysis using Spearman-Brown formula was run and yielded a reliability coefficient, which are expressed as Cronbach alpha correlation coefficient. In this case, pre-testing produced a reliability coefficient Cronbach alpha of 0.8, which according to Hair *et al*. (2010), a questionnaire with a correlation coefficient of Cronbach alpha 0.7 and above is considered ideal and reliable.

3.6.3 Focus Group Discussion (FGD)

This method of collecting data involves a discussion with some selected respondents. Newcomer *et al*. (2015) elaborate that a Focus Group Discussion (FGD) is a good way to gather together people from similar backgrounds or experiences to discuss a specific topic of interest. The group of participants was guided by a moderator (or group facilitator) who introduced topics for discussion and helped the group to participate in a lively and natural discussion amongst themselves. FGDs allows the participants to agree or disagree with each other so that it provides an insight into how a group thinks about an issue, about the range of opinion and ideas, and the inconsistencies and variation that exists in a particular community in terms of beliefs and their experiences and practices (Carey, 2016).

This method of collecting data involved a discussion with participants picked amongst sampling frame who did not participate on an interview through structured questionnaire. The discussion was led by the researcher based on the research objectives. Data were collected through eight FGDs, each one with 10 participants having both five male and five female respondents from each village. The criteria for selection of participants were based on being resident in the study area and their involvement in rice production with mobile phones for better representation of community members while observing gender balance. Important considerations to involve a member in a focus group interview included group homogeneity in terms of their socioeconomic characteristics and experience. They were considered knowledgeable to clarify issues raised in the surveys during the FGDs. The selection of respondents with similar characteristics also helped in elaborating hidden issues for ease convergence and comparison of quantitative and qualitative information.

3.7 Data Collection

3.7.1 Primary data collection

This study adopted the mixed research methodologies involving both quantitative and qualitative techniques. Mixed approach provides a better understanding of research problems than either approach alone (Creswell, 2003). Both quantitative and qualitative data were collected. Primary data were collected from 400 respondents using face-to-face interviews. In order to avoid the possibilities of low response rates caused by low levels of literacy as the case with self-administered questionnaire, face to face interviews were carried out verbally with individual respondents. Checklists for FGDs and key informant interviews were also used to discuss with various stakeholders on aspects of mobile phone use in accessing rice information for adaptation to climate change as per study objectives.

3.7.2 Secondary data

Secondary data were collected through reviewing different relevant documents relating to this study. These included data from the Regional Agricultural Officer, Regional Livestock Officer for data about districts rice production. Others were data on size of size of land used for rice production, size of improved and traditional schemes from the District Agriculture Irrigation and Cooperative Officer (DAICO), rice production number of rice farms, number of livestock at ward Executive office (WEO and VEO).

3.8 Data Analysis

3.8.1 Quantitative data analysis

Quantitative data collected from the 400 respondents was coded on the Statistical Package for Social Sciences (SPSS) version 20 spread sheet and analysed to yield descriptive and inferential statistics. Descriptive statistics such as frequency and percentages were analysed while inferential statistics such as chi-square tests and regression analyses were also performed to test for relationship between the variables.

3.8.1.1 Chi-square

Chi-square statistic is a non-parametric tool designed to analyse group differences when the variables are categorical. It tests for independence; it compares two variables in a contingency table to see if they are related (Onchiri, 2013). It tests to see whether distributions of categorical variables differ from each another. The chi-squared statistic is a single number that tells how much difference exists between observed counts and the expected counts expect if there were no relationship at all in the population. A chi-square test compares proportions which were actually observed in a study with the expectation of establishing whether they are significantly different.

3.8.1.2 Binary logistic regression

Logistic regression is useful for situations where the dependent variable is dichotomous (Garson, 2016). Logistic regression is well suited for describing and testing hypotheses about relationships between a categorical outcome variable and one or more categorical or continuous predictor variables (Ramirez and Shultz, 2000). Logistic regression coefficients estimate odds ratios for each of the independent variables in the model. The Binary logistic model was selected for this study because the dependent variable was a dichotomous in nature. The independent variables were measured as follows:

i. Age of the farmer was measured as respondent's age in number of years.
ii. Sex was measured as being male or female (coded as 1= Female, 0= Male).
iii. Education level was measured in terms of level of literacy (Coded as: 0 = No formal education, 1= primary education, 2= secondary 3= College education, 4= Graduate and above).
iv. Marital status was measured as to whether the respondent was single or married (Coded as 1= Married, 0 = Single).
v. Household size is the number of people living in a household.
vi. Farm size and rice grown area were measured in acres.
vii. Access to ICT gadgets captured farmers' ownership of radio and television (Coded 1 = Own, 0 = Do not own).
viii. Farming experience was measured as number of years the person had been engaged in rice farming.
ix. Experience of owning a mobile phone measured the number of years respondents had been using a mobile phone.
x. Off -farm income was measured in Tanzanian currency (Tsh).
xi. Number of chip owned was measured as numbers of Subscribed Identification Module (SIM) owned by respondents.

xii. Cost of mobile phone was measured in Tanzanian currency (Tsh) of highest value of mobile phones owned by the respondents.

xiii. Ownership of smartphone was measured whether the mobile phones owned is smartphone or not (Coded1 = Own, 0 = Do not own).

xiv. Number of mobile phone owned was measured as the number of mobile phones owned by the respondents.

xv. Access to agricultural advisory services on use of mobile phone was measured whether the respondents have or not (Coded as 1=Have access, 0=Not).

xvi. Access to credit was measured as whether the respondents received financial support for rice production in the form of credit on the growing season 2015/2016 from formal and informal institutions. (Coded as 1=Yes, 0=No).

xvii. Membership in farmers group was measured whether respondents is a member or non-member in different farmers group (Coded as 1= member, 0= Not a member).

xviii. Distance to market was measured based on distance from the residence of respondents to the nearby market (km).

xix. Access to agro dealer was measured respondents have access to agro dealer (Coded as 1=Have access, 0=Not).

xx. Network connectivity was measured in terms of perceived network connectivity of the mobile services on the study village (1=No network, 2=Weak, 3=Moderare, 4=High).

xxi. District it representing the study districts (1 = Kilosa, 0 = Kilombero).

The binary logistic regression model was as given below:

$$\log\left(\frac{pi}{1-pi}\right) = \alpha + \beta_1 X_1 + \beta_2 X_2 \ldots\ldots\ldots\ldots \beta_{21} x_{21} \ldots\ldots\ldots\ldots \text{I}$$

where

Pi is the probability the ith respondents using mobile phone for accessing rice information for adaptation to climate change. α is constant, β_1 to β_{21} are coefficients of the independent variables, X_1 to X_{21} are independent variables entered in the binary logistic regression model.

Prior to estimation of the model parameters, it is crucial to look into the problem of multicollinearity among the explanatory variables (Hair *et al*., 2010; Katrutsa and Strijov, 2017). In this study, Variance Inflation Factor (VIF) was used to detect multicollinearity among the independent variables. Furthermore, Pseudo R-squared namely Cox and Snell R^2 and Nagelkerke R^2 were used to measure the goodness-of-fit of the model. These indices explain the proportion of the variation in the dependent variable to that of the independent variables in the model (Peng *et al*., 2002). Additionally, Hosmer-Lemeshow was used to test if the model fits well to the data.

The odds ratio was converted into predicted percentage change of the independent variables in the use of mobile phone in accessing rice information for adaptation to climate change. This is because the numbers in the odds ratio show the odds change for a one-unit change in the independent variable while predicted percentage change expresses the effect of independent variables on dependent variable on percentages (Hair *et al*., 2010).

3.8.1.3 Poisson count regression model

Poisson Count Regression Model (PCRM) was run to analyze the influence of sources of information for accessing rice information for adaptation to climate change. PCRM was used in this study because the outcome variable was a total score of a respondent's access to information for climate change adaptation. Count data reflect the number of occurrences of a behavior in a fixed period of time, and therefore it is used in poisson regression model (Ramirez and Shultz, 2000). The model assumes that the dependent variable results from a counting of events using positive integer numbers. Moreover, the model has been adopted because the dependent variable do not follow normal or binomial distributions which is the requirement for multivariate statistical ordinary least squares models (Schmidt and Finan, 2018).

The respondents' use of various sources of tactical rice information for adaptation to climate change was measured by the respondents responding to a list of information channels of which they were asked to rate their access as: "regular," "occasional ," or "never,", which were later scored as 2, 1, and 0, respectively. To determine farmers' access to tactical and strategic rice information for adaptation to climate change, respondents were presented with a list of tactical and strategic rice information for adaptation to climate change. Then they were asked to indicate their level of access to such information, and supposed to respond as: "quite often," "rarely," and "never", which were later, scored as 2, 1, and 0, respectively. Each respondent's information score was obtained by summing up all the information access scores.

A Poisson model of a count variable was used to estimate the log of the expected count as

$$\text{Log } \lambda i=\alpha + \beta_1 X_{1+} \ \beta_2 X_2 + \ \beta_3 X_3 \ldots\ldots \text{ii}$$

where log λi is the expected value of the dependent variable for the ith observation, α is the constant, βi is parameter estimates of sources of tactical rice information for adaptation to climate change, denoted by the vector *Xi*. The independent variables were the three channels used by rice farmers for accessing rice information for adapation to climate change.

3.8.2 Qualitative data analysis

Qualitative information collected from the FGDs and Key Informants (KI) interviews were conceptualized, summarized using content analysis. The interviews were recorded and transcribed into practical themes by the researcher for discussion. The researcher sorted phrases and issues that recurred during discussion and established themes. Data which were subjected to content analysis through the following procedures as follows:

Step i: Data collected from focus group discussions and key informants were prepared in the form of a text;

Step ii: Categories and a coding scheme for all the responses were developed.

Step iii: Assessing reliability and validity of data.

Step iv: Generalization of the themes about the phenomena in question and interpret in the light of the available literature.

The detailed analysis of each specific objective is shown hereunder:

Objective i: This objective intended to determine socio-demographic factors influencing the use of mobile phones for accessing rice information to adaptation to climate change. In this objective, the quantitative data which were collected included sex, age, marital status, education level, household size, number of mobile phones owned, owning smartphone, cost of mobile phone, experience of owning mobile phone, number of chips owned, land ownership, area under rice, farming experience, household ICTs assets ownership, and off-farm incomes. These data were analysed using binary logistic regression. Prior to determine socio-demographic factors influencing the use of mobile phones for accessing rice information to adaptation to climate change, Chi-square was used to determine the association between the socio-demographic factors and study district.

Objective ii: This objective determined institutional factors influencing the use of mobile phones in accessing rice information for adaptation to climate change. In this objective, the quantitative data which were collected included access to agricultural advisory services, access to credit, access to agro-dealer, access to market, and mobile network connectivity. These data were analysed using binary logistic regression.

Objective iii: This objective sought to examine the use of mobile phones in accessing strategic rice information for adaptation to climate change. In this objective, descriptive statistics were determined and chi-square test was used to analyse data on different strategic adaptation measured opted on the study areas. Other data which were analysed through same methods included strategic rice information on adaptation to climate change accessed through mobile phones, sources of strategic rice information for adaptation to climate change. In addition, poisson count regression was used to analyse data on the use of mobile phones in accessing strategic rice information for adaptation to climate change. Qualitative data on the different strategic adaptation measures were collected from FGDs, KI were analysed using content analysis method.

Objective iv: This objective assessed the use of mobile phones for accessing tactical rice information to adaptation to climate change. In this objective, the quantitative data which were collected included tactical adaptation to climate change weather information, adaptation measure when initial rainfalls had delayed, when there was no rain after seed germination, and when there was no rain during flowering in the growing season. These were analysed using cross tabulation on the two districts, descriptive statistics such as frequency and percentages were used for data analysis. Moreover, chi-Square was used to determine association of different adaptation measure on the two districts. Furthermore, the study collected information sources were used to access tactical information on adaptation to climate change. These data were analysed using binary Poisson count regression to determine the influence of mobile phone in accessing tactical rice information for adaptation to climate change. Also, the study collected information on different ways in which respondents use mobile phones to access tactical information for adaptation to climate change. Qualitative data on the different tactical adaptation measure which were collected from FGDs, were analysed using content analysis method.

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

4.1 Socio-demographic Characteristics of the Respondents

Of the 400 respondents, 180 (45.0%) reported that they were aged below 36 years. Of these, more than half, 117 (58.5%) were from Kilombero District and 63 (31.5%) where from Kilosa District, and the variable was statistically significant at $p \leq 0.01$ (Table 6). This implied that Kilombero District had more youth involved in rice production than Kilosa District. This is similar to a study by Mtega *et al.* (2016) done in Kilombero District in Morogoro Region, Tanzania who found that majority of the rice farmers were younger farmers. These respondents were in the active age group and could influence on the use of mobile phone for accessing rice information for adaptation to climate change. Younger farmers would most likely be willing to spend more time to obtain information on improved technologies compared to old farmers (Alam *et al*., 2018).

Moreover, of the 400 respondents, 295 (73.8%) indicated that they had attained primary level of education and of these, majority, 152 (76.0%) and 143 (71.5%) were from Kilombero and Kilosa District, respectively. The difference in education levels in the two districts was highly statistically significant at $p \leq 0.01$. Similarly, the study by Nyamba (2017) in Kilolo and Kilombero Districts, Iringa and Morogoro Regions, respectively, Tanzania found that majority of farmers in rural areas had attained primary education. Education attainment could enhance efficient use of mobile phones for accessing rice information for adaptation to climate change as they can write messages or use various mobile phone applications. Furthermore, few of the respondents, 14 (3.5%) mentioned to have attained college education.

Table 6: Socio-demographic characteristics of the respondents

Variable	Kilosa (n=200)		Kilombero (n=200)		Total (n=400)		χ2	df	p
Age category	**n**	**%**	**n**	**%**	**n**	**%**			
20- 35	63	31.5	117	58.5	180	45.0	36.86	3	0.000
36 – 45	79	39.5	55	27.5	134	33.5			
46 – 55	39	19.5	26	13.0	65	16.2			
More than 55	19	9.5	2	1.0	21	5.2			
Marital status									
Married	150	75.0	157	78.5	307	76.8	20.50	3	0.000
Widowed	6	3.0	5	2.5	11	2.8			
Single	26	13.0	38	19.0	64	16.0			
Separated	18	9.0	0	0.0	18	4.4			
Education level									
Never been to school	18	9.0	0	0.0	18	4.5	26.88	3	0.000
Primary education	152	76.0	143	71.5	295	73.8			
Secondary education	26	13.0	47	23.5	73	18.2			
College education	4	2.0	10	5.0	14	3.5			
Household size									
One - Two	18	9.0	5	2.5	23	5.8	30.89	3	0.000
Three – Five	91	45.5	144	72.0	235	58.8			
Six – Eight	79	39.5	46	23.0	125	31.2			
More than 8	12	6.0	5	2.5	17	4.2			
Rice farming experience									
1 – 5 years	60	30.0	96	48.0	156	39.0	14.830	2	0.001
6 – 10 years	72	36.0	46	23.0	118	29.5			
More than 10	68	34.0	58	29.0	126	31.5			
Land ownership									
Do not own land	92	46.0	59	29.5	151	37.8	63.41	4	0.000
1 – 2 acres	65	32.5	30	15.0	95	23.8			
3 – 4 acres	9	4.5	46	23.0	55	13.8			
4 – 6 acres	5	2.5	30	15.0	35	8.8			
More than 6	29	14.5	35	17.5	64	16.0			
Annual income from off-farm activities									
Less than 5 000 000	103	51.5	96	48.0	199	49.8	0.719	2	0.689
5 000 001 – 10 000 000	4	2.0	3	1.5	7	1.8			
More than 10 000 000	93	46.5	101	50.5	194	48.5			

Of the 400 respondents, 307 (76.8%) reported that they were married and of these, most 150 (75.0%) and 157 (78.5%) were from Kilosa and Kilombero Districts, respectively. The difference on marital status of the respondents in the two districts were highly statistical significant at $p \leq 0.01$.The distribution of marital status confirms that rice farming activities in the study areas mostly attracted couples. Yet, over half of the respondents, 235 (58.8%) indicated to had 3 to 5 people per household. This household size was within the country‘s average household size of 4.8 (URT, 2013b). The above observation is important due to the fact that, some agricultural activities could be done by other household members. Hence, farmers with large family size might significantly adopt the agricultural technology in rice farming because of available labour. Furthermore, two thirds, 244 (61.0%) of the respondents reported that their farming experience was more than 6 years. Farming experience is an advantage for improving productivity, since it encourages rapid adoption to farm innovations (Allahyari *et al*., 2016). This could have an influence on the use of mobile phones for accessing rice information for adaptation climate change.

On the other hand, of the 400 respondents, 151 (37.8%) mentioned that they did not own land, and of these, 92 (46.0%) and 59 (29.5%) were from Kilosa and Kilombero Districts, respectively. Furthermore, few, 29 (14.5%) and 35 (17.5%) of the respondents from Kilosa and Kilombero Districts respectively reported that they owned more than 6 acres of land (Table 6). The differences in land ownership among respondents in the two districts were highly statistically significant at $p \leq 0.01$. Lack of land ownership was indicated by more than a third of the respondents 151 (37.8%) which implied that they either hired land or farmed with special agreements with land owners. Hence, this could limit their adoption to use of mobile phones for accessing rice information for adaptation to climate change. The study findings conform to a study by Mwatawala *et al*. (2016) in Mbalali District Mbeya Region, Tanzania who found that rain-fed rice production in Tanzania is managed by small-scale farmers with small size farm holdings.

Similarly, of all the 400 respondents, less than half, 99 (49.8%) reported to earn annual incomes of less than Tshs 5 000 000 from off-farm activities and of these 103 (51.5%) and 96 (48.0%) were from Kilosa and Kilombero District, respectively. Moreover, 93 (46.5%) and 101 (50.5%) of the respondents from Kilosa and Kilombero Districts mentioned that they earned more than Tshs 10 000 000 annual income from off-farm activities (Table 6). This variable was not statistical significant different at $p \leq 0.689$. Farmers with high off-farm income are likely to use ICT than those in full time farming (Mittal *et al*., 2010, Derso *et al*., 2014). Piya *et al*. (2012) found that, participating on off farm activities enables farmers to get money, which could be used to buy agricultural inputs such as seeds, fertilizers, pesticides and recharging mobile phones.

4.2 Aspects Related to Mobile phone Ownership

The study results in Table 7 show the distribution of the respondents' opinion on aspects related to mobile phones ownership. It includes the number of mobile phones owned, cost of mobile phones, ownership of smartphone, number of chips owned, sources of money for buying mobile phones and sources of power for charging mobile phones**.** Of the 400 respondents, majority, 373 (93.2%) indicated that they owned one mobile phone and of these, 186 (93.0%) and 187 (93.5%) were from Kilosa and Kilombero Districts, respectively. Few respondents, 14 (7.0%) and 13 (6.5%) mentioned that they owned two mobile phones, and these 14 (7.0%) and 3 (6.5%) were from Kilosa and Kilombero Districts respectively. This variable was not statistically significant at $p \leq 0.842$. This finding is contrary to a study by Tadess and Bahiigwa (2015) in Oromia regional state, Ethiopia who found that majority of the farmers owned at least one mobile phone. Furthermore, of the 400 respondents, 268 (67.0%) indicated that the mobile phones they owned were worth less than Tshs 50 000 (USD 21.74) and few 29 (7.2%) said their mobile phone were worth more than Tsh 100 000 (USD 43.48). In addition, of the 400 respondents, most, 337 (84.2%) indicated that their mobile phones were not smartphones. This meant that only 63 (15.8%) owned smartphones and of these 24 (12.0%) and 39 (19.5%) were from Kilosa and Kilombero Districts, respectively. This variable was not statistically significant at $p \leq 0.06$ (Table 7). Low ownership of smartphones implies that most of the respondents could not access and share information through some social media such as whatsApp and Youtube.

Again, more than half, 226 (56.5%) of the respondents indicated to had more than one mobile phone chip, and of these, less than half, 99 (49.5%) and 127 (63.5%) were from Kilosa and Kilombero Districts, respectively. The difference on number of chips owned was highly statistically significant at $p \leq 0.01$ (Table 7). This is in line with studies by Tadesse and Bahiigwa (2015) in Oromia regional state, Ethiopia and Nzie *et al*. (2018) study in Northwest region, Cameroon which found that majority of the smallholder farmers owned at least one mobile phone. Field observation revealed that respondents owned more than one mobile phone chip which enabled them to subscribe to more than one mobile phone networks to avoid inconvenience if network provider was down (Table 7).

Furthermore, of the 400 respondents, over half, 232 (58.0%) mentioned that they bought mobile phones using incomes obtained from selling rice, and of these, 94 (47.0%) and 138 (69.0%) were from Kilosa and Kilombero Districts, respectively. This variable was highly statistically significant at $p \leq 0.01$ (Table 7). Kilombero District had more respondents reported that they bought a mobile phone from income gained from rice farming as 90 percent of the smallholder farmers in Kilombero District engage themselves in rice production (Kilombero District Council, 2016).

Table 7: Aspects related to mobile phone ownership

Variable	Kilosa (n=200)		Kilombero (n=200)		Total (n=400)		χ2	df	p
Number of mobile phone owned	**n**	**%**	**n**	**%**	**n**	**%**			
One	186	93.0	187	93.5	373	93.2	0.04	1	0.842
Two	14	7.0	13	6.5	27	6.8			
Cost of mobile phone									
Less 50 000	137	68.5	131	65.5	268	67.0	18.031	3	0.000
50 000 – 70 000	39	19.5	32	16.0	71	17.8			
70 001 – 100 000	20	10.0	12	6.0	32	8.0			
More than 100 000	4	2.0	25	12.5	29	7.2			
Own smartphone									
Yes	24	12.0	39	19.5	63	15.8	4.239	1	0.060
No	176	88.0	161	80.5	337	84.2			
Number of chip owned		0.0		0.0					
One	101	50.5	73	36.5	174	43.5	12.432	3	0.006
Two	89	44.5	104	52.0	193	48.2			
Three	6	3.0	19	9.5	25	6.2			
Four	4	2.0	4	2.0	8	2.0			
Source of money to buy mobile phone									
Rice farming	94	47.0	138	69.0	232	58.0	33.790	3	0.000
Other crops	53	26.5	18	9.0	71	17.8			
Non farm produce	24	12.0	32	16.0	56	14.0			
Gift	29	14.5	12	6.0	41	10.2			
Experience of owning mobile phone									
One – Two	32	16.0	18	9.0	50	12.5	25.341	3	0.000
Three – Four	52	26.0	21	10.5	73	18.2			
Five – Six	61	30.5	75	37.5	136	34.0			
More than six	55	27.5	86	43.0	141	35.2			
Power source to charge mobile phone									
Electricity from TANESCO	58	29.0	185	92.5	243	60.8	169.3	3	0.000
Solar	137	68.5	15	7.5	152	38.0			
Generator and solar	4	2.0	0	0.0	4	1.0			
Generator	1	0.5	0	0.0	1	.2			
Radio									
Do not own	60	30.0	48	24.0	108	27.0	60	1	0.177
Own	140	70.0	152	76.0	292	73.0	140		
Television		0.0		0.0		0.0			
Do not own	188	94.0	145	72.5	333	83.3	188	1	0.000
Own	12	6.0	55	27.5	67	16.8	12		

In addition, of the 400 respondents, 243 (60.8%) reported that they charged their mobile phones using electricity from TANESCO, and of these, most, 185 (92.5%) and few, 58 (29.0%) were from Kilombero and Kilosa Districts, respectively. Furthermore, of all the respondents, 152 (38.0%) reported that they charged their mobile phones using solar panels, and of these, 137 (68.5%) and few 15 (7.5%) were from Kilosa and Kilombero Districts, respectively. This variable was highly statistically significant at $p \leq 0.01$ (Table 7). Kilosa District had more respondents charging their mobile phones using solar panels.

Of the 400 respondents, more than half, 292 (73.0%) indicated that they owned radio and of these, 140 (70.0%) and 152 (76.0%) were from Kilosa and Kilombero District, respectively and the variable was not statistically significant $p \leq 0.177$ (Table 7). Furthermore, few, 67 (16.8%) indicated to own television sets, and of these 12 (6.0%) and 55 (27.5%) were from Kilosa and Kilombero District, respectively. This variable was highly statistical significant at $p \leq 0.01$. Few respondents from Kilosa District reported to having television sets. This conforms to studies by Isaya *et al*. (2015) and Mtega *et al*. (2016) in Kilombero and Kilosa Districts, respectively, in Morogoro Region, Tanzania, and found high ownership of radios by the smallholder farmers.

4.3 Socio-demographic Factors Influencing the use of Mobile Phones in Accessing Rice Information for Adaptation to Climate Change

Table 8 shows a regression model of the selected socio-demographic factors influencing the use of mobile phones in accessing rice information for adaptation to climate change. Sixteen socio-demographic factors were included in the model: sex, age, marital status, education level, household size, number of mobile phones owned, owning smartphone, cost of mobile phone, experience of owning mobile phone, number of chips owned, land ownership, area under rice, farming experience, household ICTs assets ownership, and off-farm incomes. The study results show that the Variance Inflation Factor (VIF) for all variables in the model ranged from 1.40 to 5.63 and meets the VIF as stipulated by Yu *et al*. (2015) and Pallant (2011). According to Pallant (2011), independent variables have no multicollinearity if their VIF is less than 10. The -2 log likelihood improved from 56.98 for the model with constant only to 21.27 with explanatory variables. This implied that addition of the explanatory variables explained more of the variance in the outcome. Chi-square value was 445 with df of 23 and was highly statistically significant at $p \leq 0.01$ indicating that the independent variables had an influence on the dependent variable.

The Cox and Snell R^2 and Nagelkerke R^2 values in the model were 0.61 and 0.76, respectively. This implied that the predictors in the model accounted for at least 61 to 76% of the use of mobile phones in accessing rice information for adaptation to climate change. Furthermore, the Hosmer-Lemeshow test results were 0.62, with df of 8 and a p-value $p \leq 0.06$, and according to Canary *et al*. (2017), the p value should be greater than 0.05, implying that the fitting effect between the model and data was good.

The Wald Chi-square value ranged from 0.01 to 4.71.The walds coefficient for sex, age, marital status, education, land ownership, area under rice and off farm income, radio ownership were statistically significant at $p \leq 0.05$. This implied that their beta coefficients are significantly different from zero. Thus socio-demographic characteristics such as sex, age, marital status, education level, farm size, area under rice, off farm income and radio ownership contributes significantly in predicting the use of mobile phones in accessing rice information for adaptation to climate change.

Table 8: Factors influencing use of mobile phones in accessing rice information for adaptation to climate change

Variable	B	S.E.	Wald	Sig.	Exp(B)	Predicted % Change	VIF
(Constant)	.286	.376	.58	0.79	1.33	33.11	
Sex	-.438	.312	1.97	0.02	0.65	-35.47	5.63
Age	-.063	.034	3.43	0.04	0.94	-6.11	2.83
Marital status	.186	.383	.24	0.03	1.20	20.44	1.99
Education level	.201	.244	.68	0.04	1.22	22.26	3.08
Household size	.211	.12	3.09	0.13	1.23	23.49	4.20
Number of mobile phone owned	.312	.454	.47	0.08	1.37	36.62	3.16
Cost of mobile phone	.281	.208	1.83	0.54	1.32	32.45	1.40
Whether is smartphone	.12	.477	.06	0.09	1.13	12.75	5.07
Experience of owning mobile phone	.274	.234	1.37	0.09	1.32	31.52	2.68
Number of Chip owned	.234	.23	1.04	0.97	1.26	26.36	2.64
Farm size	.038	.018	4.46	0.01	1.04	3.87	2.43
Area grown rice	.267	.234	1.30	0.00	1.31	30.60	3.71
Farming experience	-.183	.034	28.97	0.03	0.83	-16.72	2.61
TV ownership	.257	.245	1.10	0.13	1.58	29.30	1.77
Radio ownership	.268	.256	1.10	0.03	1.97	30.73	2.06
Off farm income	.301	.23	1.71	0.01	1.35	35.12	2.34
Access to extension services	.267	0.123	4.71	0.03	1.31	30.60	3.32
Membership in social group	.016	0.256	0.01	0.57	1.02	1.69	1.23
Distance to nearby market	-0.11	0.034	0.01	0.02	0.89	-10.68	2.56
Network connectivity	.167	0.1	2.79	0.23	1.18	18.18	3.32
Access to credit	.003	0.134	0.03	0.56	1.02	0.33	1.34
Availability of agro dealer	.049	0.23	0.11	0.12	1.05	5.02	4.23
District	-.256	0.567	0.02	0.06	0.77	-22.59	4.07

-2 log likelihood = 21.27; Nagelkerke R2 = 0.76; Cox & Snell R2 = 0.61, Model Chi square=445;df=23, p=0.000;Hosmer and Lemeshow Test; chi square=0.62, df=8, p=0.063.

Table 8 shows a beta coefficient for females of-.438, and the variable was highly statistically significant at $p \leq 0.02$. This meant that females had a 35.47% less likelihood of using mobile phone in accessing rice information for adaptation to climate change than males. Male respondents had higher use of mobile phones for accessing rice information for adaptation to climate change and this could be influenced by the fact that men are the decision-makers with regard to agricultural production in most households. Women, on the other hand, are engaged in domestic chores and other productive activities, leaving them with little time to tune to the radio or watch television sets. Also, in many households, women were not decision-makers on issues related to agricultural production. This finding is in line with Amir (2016) study in Haramaya District, Ethiopia who found that males had high chances of accessing agricultural information using by mobile phones than female.

Similarly, Table 8 shows that, age had a beta coefficient of -.063 and was statistically significant at $p \leq 0.04$. This meant that as age increased by one year, it lowered the use of mobile phones for accessing rice information for adaptation to climate change by 6.11%. This implied that younger respondents had high chance of using mobile phone for accessing rice information for adaptation to climate change. Studies (Ganesan *et al*., 2015; Mittal and Mehar, 2016; Alam *et al*., 2018; Tata and Mcnamara, 2018) shows that older farmers are less likely to adopt modern sources of agricultural information than younger producers. This finding is in line with previous studies by Nyamba (2017) in Kilolo and Kilombero Districts, Iringa, and Morogoro Regions, respectively, Tanzania, and Akinola (2017) in Yewa South Local Government, Ogun State, Nigeria which found that young farmers had higher chances of using mobile phones in accessing agricultural information. Furthermore, farm size had a positive beta coefficient of .038 and was highly statistically significant at $p \leq 0.01$. This implied that farmers with large farm sizes had high chances of using mobile phone for accessing rice information for adaptation to climate change. This findings conforms to a study by Gasesan *et al*. (2015) study in Delta Zone of Tamil Nadu, India who found that farmers with large farms had higher chances of using ICTs to access innovative information for adopting agricultural technologies.

Furthermore, Table 8 shows that education levels attained by the respondents did influence their use of mobile phones for accessing rice information for adaptation to climate change.

It had a beta coefficient of .20 and was statistically significant at $p \leq 0.04$. This meant that a one unit increase in education produced 22.26% increase on the likelihood for using mobile phone for accessing rice information for adaptation to climate change. This implied that educated respondents had higher chances of using mobile phones in accessing rice information for adaptation to climate change. This could be explained by the fact that increases in education level increase people awareness on use of ICTs. This conforms to a study by Gasesan *et al*. (2015) study in Delta Zone of Tamil Nadu, India and Mittal and Mehar (2016) in Punjab, Haryana, Uttar Pradesh who found that farmers with higher education levels had higher chances of using mobile phone in accessing information. Furthermore, this study result is similar with study findings by Nyamba (2017) in Kilolo District and Kilosa District in Iringa and Morogoro Region, respectively, Tanzania who found that attainment of education levels influenced the use of mobile phones in accessing agricultural information by smallholder farmers in the study area.

A beta coefficient for cost of mobile phones was .281, meant that a one unit increase in the cost of mobile phone resulted in the increase of use of mobile phone by 32.45%. This implied that respondents with expensive mobile phone had high chances of using mobile phone for accessing rice information for adaptation to climate change. However, the variable was not statistically significant at $p \leq 0.54$ (Table 8). Furthermore, the results show that beta coefficient on owning smartphone is positive .012 and it was not statistically significant at $p \leq 0.09$. This implied that owning smartphones did not influence the use of mobile phone in accessing rice information for adaptation to climate change. Observation revealed that most of the respondents used mobile phones to call, receive and send messages and few used the advanced mobile applications. This study finding is contrary with Kailash *et al*. (2017) study in Nagaur, India who found that owning of smartphone among farmers influenced farmers' access to agricultural information.

In addition, the study findings shows that respondents' income earning from off-farm engagements did influence the use of mobile phone for accessing rice information for adaptation to climate change and the variable had a beta coefficient of .301. This variable was highly statistically significant at $p \leq 0.01$. This meant that one unit increase in off-farm earning resulted in 35.12% increase on using mobile phone in accessing rice information for adaptation to climate change. Farmers with secondary sources of income are in a better position to invest in innovative farm technologies. With this regard, they are more likely to look for appropriate sources of information including mobile phones to access agricultural information. This study finding is in line with those of Elias *et al*. (2016) in North West Ethiopia who reported that farmers with alternate, secondary sources of income had a high usage of mobile phone in accessing agricultural information. Similarly, Tomar *et al.* (2016) study in Uttar Pradesh states, India and Amir *et al*. (2016) study in Haramaya District, Ethiopia, found that farmers with high off-farm incomes had higher chances of using mobile phones in accessing agricultural information.

Table 8 shows that beta coefficient for household size was .211. The positive beta coefficient implied that one unit increase in household size increased 23.34% on the use of mobile phones for accessing rice information for adaptation to climate change. However, the variable was not statistically significance at $p \leq 0.13$. This implied that household sizes did not influence the use of mobile phone for accessing rice information for adaptation to climate change. This study finding is contrary to study by Yaseen *et al.* (2016) in Punjab Province and Hebei Province, India and China, respectively who found that there was an increase on the usage of ICTs as household sizes increased.

In addition, Table 8 shows that land ownership had a positive beta coefficient of .038, and was highly statistically significant at $p \leq 0.01$. This meant that one unit increase in land ownership resulted in 3.87% increase on the use of mobile for accessing rice information for adaptation to climate change, and the area under rice cultivation had a positive beta coefficient of .267. This variable was highly statistically significant at $p \leq 0.01$. This meant that one unit increase in area under rice cultivation resulted in 30.60% increase on the use of mobile for accessing rice information for adaptation to climate change. This implied that farmers who owned larger land had higher chances of using mobile phone in accessing rice information for adaptation to climate change. This study finding is in line with the previous study by Gasesan *et al*. (2015) in Delta Zone of Tamil Nadu India, who found that farmers with large farm sizes had higher chances of adopting use of ICTs in accessing agricultural information. Also Table 3 shows that farming experience had a beta coefficient of -.183. This variable was statistically significant at $p \leq 0.03$. This implied that one unit increase of the respondents' farming experience causes a 16.7% decrease on the use of mobile phone in accessing rice information for adaptation to climate change. These findings is in line with a study by Animashaun *et al*. (2014) who found that experienced farmers had low use of ICTs than inexperienced ones. Zongo *et al*. (2015) argue that farming experience is an indicator of age, meaning that older farmers with more farming experience are less willing to try out new innovations or take risks compared to younger farmers.

The beta coefficient for marital status was .186 and statistically significant at $p \leq 0.03$. This implied that married respondents had 20.44% higher chances of using mobile phones for accessing rice information for adaptation to climate change than single ones. Married farmers were likely to be under pressure to produce more not only family consumption but also for sale. The desire to produce more could lead to seek for agricultural information through modern technology including mobile phones. These study findings are in line with those of Ajijola (2015) in Afijio Local Government Area, Oyo State, Nigeria who found that, married farmers had higher usage of ICTs for accessing agricultural information.

Furthermore, the study results in Table 8 show that radio ownership influenced the use of mobile phone for accessing rice information for adaptation to climate change. It had a positive beta coefficient of .268 and was statistically significant at $p \leq 0.03$. This means that the respondents who owned radio had 30.73% likelihood of using their mobile phones for accessing rice information for adaptation to climate change than those who did not own radio. Radio plays a significant role in spreading information. It reaches larger percentage of the people irrespective of their location; it promotes the level of awareness of the people on various issues including the usage of mobile phones to access information (Mogambi, 2016). This study finding is in line with those of Derso *et al*. (2015) in Tole Wareda in central highlands, Ethiopia who found that farmers with ICTs devices had a high chance of using mobile phone to access agricultural information.

4.4 Summary of Key issues on Socio-demographic Factors Influencing the use of Mobile phones in Accessing Rice Information for Adaptation to Climate Change

It was expected that a successful use of mobile phones in accessing rice information for adaptation to climate change, among other things, is dependent on socio-demographic characteristics of the respondents. A binary logistic regression analysis identified a number of socio-demographic characteristics that influenced the use of mobile phones in accessing rice information for adaptation to climate change. These factors included sex, age, marital status, farm size, farming experience, radio ownership and off-farm incomes.

Male respondents have higher use of mobile phones for accessing rice information for adaptation to climate change than females. Results show that younger respondents had higher chance of using mobile phone for accessing rice information for adaptation to climate change than older ones. Furthermore, it was found that married respondents had higher chances of using mobile phones for accessing rice information for adaptation to climate change than single ones. Similarly, educated respondents had higher chances of using mobile phones in accessing rice information for adaptation to climate change. In addition, results showed that respondents with higher off farm income had higher chances of using mobile phones in accessing rice information for adaptation to climate change. Likewise, respondents who owned larger land had higher chances of using mobile phone in accessing rice information for adaptation to climate change. Finally, the respondents who owned radio had higher likelihood of using their mobile phones for accessing rice information for adaptation to climate change than those who did not own.

4.5 Institutional Factors Influencing use of Mobile phones in Accessing Rice Information for Adaptation to Climate Change

Table 8 shows a regression model of the institutional factors influencing the use of mobile phones in accessing rice information for adaption to climate change. These included access to agricultural advisory services, access to credit, access to agro-dealer, access to market, and mobile network connectivity. The study results show that the Variance Inflation Factor (VIF) for institutional factors ranged from 1.23 to 4.23 and meets the VIF as stipulated by Pallant (2011). According to Pallant *et al*. (2011), an independent variable has no multicollinerality if its VIF is less than 10. The walds coefficient for market location, access to agricultural extension, advisory extension services were statistically significant at $p \leq 0.03$ and $p \leq 0.02$, respectively. This implied that access to agricultural extension and advisory extension services and access to market contributed significantly in predicting the use of mobile phones in accessing rice information for adaptation to climate change.

Access to agricultural extension services had beta coefficient with a positive sign of .267 and was found to be statistically significant at $p \leq 0.03$. This meant that access to agricultural extension services on use of mobile phone caused a 30.6% increase in the use of mobile phone for accessing rice information for adaption to climate change**.** Agricultural extension personnel and researchers serve as a link between agriculturalists and innovators (Etwire *et al.*, 2017). They are often partnered by other institutions and development projects to disseminate and monitor the adoption of agricultural innovation. Agricultural extension services are helpful in explaining complex terminologies, translating information from English to the local language or even assisting in the operation of a mobile phone *(*Anoop, 2015). Farmers who have contact with agricultural extension services are more likely to use mobile phone to access adaptation information.

Furthermore, Table 8 shows that the beta coefficient for market location was -.11 .and was statistically significant at $p \leq 0.02$. The negative beta coefficient implied that one unit increase in distance to nearby market lowered on the use of mobile phone in accessing information on adaptation to climate change by 10.68%. Farmers residing near the market have higher chances of social interactions and exchange. They may have better social ties with traders in the market with whom they can share information, than distant farmers. This is consistent with the study of Tadesse and Bahiigwa (2014) who reported that farmers who were close to an institutional centre, be it the open market, cooperative, or the village centre, had a higher probability of using mobile phones for information searching than farmers who were far away from such centres.

In addition, the study finding shows that respondents' access to credit had a positive beta coefficient of .003. However, this variable was not statistically significant at $p \leq 0.56$, which implied that respondents' access to credit increased by 0.30 % in using of mobile phone to access adaptation information to climate change. Its non-significance may be due to lack of access to credit to most of the rain-fed farmers in the study areas. The results showed that only 26 (6.5%) of the respondents had access to agricultural credits. This study findings is contrary to those of Saqib *et al*. (2016) in Mardan District, India, who found that access to agricultural credit enabled farmers to utilize more costly sources of information such as use of ICTs.

The coefficient of respondents' participation in farmers groups had a beta coefficient of .016 and was not statistically significant at $p \leq 0.57$. The positive sign implies that respondents participation in farmers groups caused an increase of 1.69% likelihood of the respondents' to use mobile phone for accessing adaptation information. However, the variable was not significant. This finding is contrary to the previous study by Martin (2010) in Kamuli District, Uganda who found that members of farm groups were more likely to use mobile phones for agricultural-based purposes.

Furthermore, network connectivity had a beta coefficient of .17 and was not statistically significant at $p \leq 0.23$. The positive sign implied that one unit change on farmers response on network connectivity caused 18.18% increase on the use of mobile phone for accessing rice information for adaption to climate change. Non-significant of the variable is due to reason that most of the respondents 300 (75.0%) reported that the network connectivity in their areas was good. Also, Table 8 shows that access to agro-dealers had a beta coefficient of .049. This variable was not statistically significant at $p \leq 0.12$. This implied that access to agro-dealer caused a 16.7% increase on the use of mobile phone in accessing rice information for adaptation to climate change. These study findings are contrary to a study by Nyamba (2017) in Kilosa District, Tanzania who found that there was high interaction between farmers and agro-dealer using mobile phone.

4.6 Summary of Key Issues Regarding on the Institutional Factors Influencing the use of Mobile phones in Accessing Rice Information forAadaptation to Climate Change

Institutional factors are necessary to enhance farmers' access to information from various information sources including mobile phone. It enhances farmers' awareness on the use of mobile phone to access agricultural information. The study findings show that, access to agricultural extension advisory services on the use of mobile phone and market location influenced farmers' use of mobile phones in accessing rice information for adaptation to climate change. Furthermore, the study finding show that respondents with access agricultural extension services on use of mobilephone had higher use of mobilephone to access rice information for adaptation to climate change. In addition, farmers residing near markets had higher chance of using mobile phones for accessing rice information for adaptation to climate change.

4.7 Use of Mobile Phones in Accessing Strategic Rice Information for Adaptation to Climate Change

4.7.1 Strategic rice information for adaptation to climate change accessed through mobile phone

Of the 400 respondents, less than one third, 99 (24.8%) reported to use mobile phone in accessing strategic rice information for adaptation to climate change. Of these, about one quarter, 57 (28.5%) and 42 (21.0%) were from Kilosa District and Kilombero Districts, respectively. The differences in use of mobile phone to access strategic rice information for adaptation to climate change in the two districts were not statistically significant at $p \leq 0.08$. The results implied that use of mobile phone to access strategic rice information for adaptation to climate change among study districts was low and did not differ.

Furthermore, of the 99 respondents, majority, 78 (78.8%) indicated that they accessed information on the type of rice varieties, and of these, 38 (66.7%) and 40 (95.2%) were from Kilosa and Kilombero Districts, respectively. Again, of the 99 respondents, 62 (52.6%) mentioned that they used mobile phone to access information on the type of herbicides to use to control weeds in their fields, and of these, 30 (52.6%) and 32 (76.2%) were from Kilosa and Kilombero Districts, respectively (Table 9).

Furthermore, few, 26 (26.3%) of the respondents indicated that they used mobile phone to access the type of recommended fertilizer application, and of these, 10 (17 %) and 16 (38.1%) were from Kilosa and Kilombero Districts, respectively. Few, 28 (28.3%) of the respondents reported that they used mobile phone to access type of pesticides to use in their farm, of these, 12 (21.1%) and 16 (38.1%) were from Kilosa and Kilombero Districts, respectively. In addition, during FGDs sessions at Kimamba A village in Kilosa District one participant said:

> *"I have been calling extension agents asking them about the type of the herbicides and correct ratio of water and herbicides during mixing when there were weed infestations in the rice fields.*"

Table 9: Strategic rice information for adaptation to climate change accessed through mobile phone

Strategic rice information	Kilosa (n=57)		Kilombero n=42)		Total (n=99)		χ2	df	P
	n	%	n	%	n	%			
Type rice variety to plant	38	66.7	40	95.2	78	78.8	9.92	6	0.128
Seed treatment	3	5.3	0	0.0	3	3.0			
Type of fertilizer	10	17.5	16	38.1	26	26.3			
Type of herbicides	30	52.6	32	76.2	62	62.6			
Pest control	12	21.1	16	38.1	28	28.3			
Other drought tolerant crops	4	7.0	0	0.0	4	4.0			

4.7.2 Information sources contacted through mobile phone to access strategic rice information for adaptation to climate change

Table 10 show the information sources that the respondents contacted using mobile phone in accessing strategic rice information for adaptation to climate change. The results show that, of 99 the respondents, majority, 96 (97.0%) indicated that their main source of information were their fellow farmers. The difference in information sources contacted through mobile phones in the two districts were not statistically significant at $p \leq 0.264$, implying that fellow farmers were the main sources. This is in line with Faruk (2013) study in Munshiganj District, Bangladesh, who found that contact with fellow farmers were the most important sources contacted by smallholder farmers to access agricultural information using mobile phones. Sharma *et al*. (2016) found that interpersonal sources such as friends, family members and neighbours have all the time become the main providers of the agriculture information due to their availability and most of all; they are trusted by the rural community. However, major negative aspects of farmer to farmer contacts in relation to information flow are their social and personal characteristics and lack of formal education for delivering of agricultural information.

Table 10: Information sources contacted through mobile phone to access strategic rice information for adaptation to climate change

Information sources	Kilosa (n=57)		Kilombero (n=42)		Total (n=99)		χ2	df	P
	n	%	n	%	n	%			
Agricultural extension agents	20	35.1	16	38.1	36	36.4	7.63	6	0.264
Local government official	5	8.8	3	7.1	8	8.1			
Farm input/shop	5	8.8	8	19.0	13	13.1			
Fellow farmers	56	98.2	40	95.2	96	97.0			
Middlemen	33	57.9	23	54.8	56	56.6			
Mobile phone agricultural advisory services	7	12.3	4	9.5	11	11.1			

Of the 99 respondents, less than half, 36 (36.4%) reported that they contact agricultural extension agents, and of these, 20 (35.1%) and 16 (38.1%) were from Kilosa and Kilombero Districts, respectively. Low contact with agricultural extension agents is due to lack of enough agricultural extension agents in the study areas. It was observed in the study villages all has one agricultural extension agent. This makes them difficult to each majority of farmers through home visit. Similarly, study by Daniel (2013) in Kyela, Songea Rural and Morogoro Rural Districts, Tanzania found lack of enough village agricultural extension officers was among the challenges facing farmers on accessing agricultural extension services.

Furthermore, the findings show that of the 99 respondents, more than half, 56 (56.6%) reported that their other source was the rice buying middlemen and of these 33 (57.9%) and 23 (54.8%) were from Kilosa and Kilombero Districts, respectively. In addition, Middlemen play an important role by linking farmers to traders and final markets. They are the major sources of market information with regard to price and market of the rice produce. The study revealed that respondents also receive an advice on the type of drought and early maturing rice varieties to plant from the middlemen. However, the drawback of the middlemen is that they may lack information on appropriate rice varieties rather than the one with high demand which may not have high produce under climate change. Most of the respondents accept their advance because the middlemen have a strong bargaining position due to their knowledge of supply and demand conditions at the farm and in the market (Ranjan, 2017).

In additional, the findings show that of the 99 respondents, few, 8 (8.1%) reported that their other source was village leaders and of these, 5 (8.8%) and 3 (7.1%) were from Kilosa and Kilombero Districts, respectively. Similarly, the study by Feleke (2015) in

Central Rift Valley, Ethiopia, which found that few of the farmers accessed information on climate change from village leaders. It was observed that village leaders are involved on conveying various information including information for adaptation to climate change. Likewise, Mtega (2016) in Kilombero District, Tanzania found that the few rice farmers accessed agricultural information from the village leaders. Sharma *et al*. (2016) underscore the important function that opinion leaders fulfill in the diffusion process as that of passing on information to the villagers; interpreting outside information on the basis of own experience; setting an example for others to follow; and having an influence in changing group norms. This implies that opinion leaders play a crucial role in not merely relaying information, but also in the endorsement and of new ideas they want to have adopted including rice information for adaptation to climate change. However the village village leaders are concerned with most of day to day activities of the village could lack rice information for adaptation to climate change.

Furthermore, the results show that of the 99 respondents, few, 13 (13.1%) reported that their other sources were input supply and of these, 5 (8.8%) and 8 (19.1%) were from Kilosa and Kilombero Districts, respectively. It was observed that in Kilosa District, there is the Kilosa Rural Services and Electronic Communication (KIRSEC) which is an agro-dealer which helped farmers to use mobile phones to communicate agricultural information. During an interview in Kilosa District, one KI said:

> " *KIRSEC register farmers using their mobile phones numbers and give them information on new updates on agricultural input through SMS"*.

4.7.3 Mobile phone applications used to access strategic rice information for adaptation to climate change

Of the 99 respondents, all, 99 (100.0%) reported that they made voice calls to access strategic rice information for adaptation to climate change. Furthermore, the results show that, few, 11 (11.1%) used internet, while 17 (17.2%) used Short Messages services (SMS) to access strategic rice information for adaptation to climate change (Table 11). The differences on mobile phone application used in the two districts were not statistically significant at $p \leq 0.243$. This implied that voice calls were the most used mobile phone application compared to SMS and internet application. The findings are in line with a study by Crandall (2012) in Kiambu, Central Province, Kenya who found that most farmers tend to prefer making voice calls. This is because voice calls consume less money to get a final response compared to other application such as SMS which has much back and forth communication between sender and receiver. Similarly a study by Wyche and Steinfield (2015) in Bungoma, Homa Bay, Nyanza Province, Kenya, revealed that farmers preferred voice calling rather than sending SMS which results in an instant and assured interactions of information once the receiver answers the phone call.

Table 11: Mobile phone applications used in accessing strategic rice information for adaptation to climate change

Mobile applications	Kilosa (n=57)		Kilombero (n=42)		Total (n=99)		χ2	df	p
	n	%	n	%	n	%			
Voice calling	57	100.0	42	100.0	99	100.0	4.17	4	0.243
SMS	8	14.0	9	21.4	17	17.2			
Browsing	7	12.3	4	9.5	11	11.1			
Mobile agricultural advisory services	0	0.0	2	4.8	2	2.0			

4.8 Mobile phone as a Determinant of the Respondents' Access to Strategic Rice Information for Climate Change Adaptation

Table 12 show a regression model for examining the influence of the mobile phone as determinant of the respondents' access to strategic rice information for climate change adaptation. It also includes other channels used by the respondents to access strategic rice information for adaptation to climate change. This is because farmers access information from different channels simultaneously as they do not rely on a single source of information (Mittal and Mehar, 2016; Ali, 2012). The deviance test result was 162, with a chi square value of 163 with $p \leq 0.166$, which was not statistically significant. According to Pallant (2011), the p-value of a model should be greater than 0.05, implying that data fit the model well. Likelihood ratio chi-square value was 18.94 with df of 11 and was statistically significant at $p \leq 0.04$. This implied that at least one predictor variable regression coefficient was not equal to zero in the model. Furthermore, the study results show that the Variance Inflation Factor (VIF) for all variables in the model ranged from 0.22 to 3.04 meeting the VIF rule as stipulated by Pallant (2011). According to the Pallant (2011), independent variables have no multicollinearity if their VIF is less than 10. The walds coefficient for use of mobile phones were statistically significant at $p \leq 0.05$. This implied that their beta coefficients are significantly different from zero. Use of mobile phones contributes significantly in predicting respondent access to strategic rice information for adaptation to climate change.

Table 12: Mobile phone as a determinant of the respondents' access to strategic rice information for climate change adaptation

Parameter	B	Std. Error	Wald Chi-Square	Exp(B)	Predicted % Change	Sig.	VIF
(Intercept)	1.741	.0729	569.904	1.701	70.1	.000	
Mobile phone	.133	.0476	7.854	1.143	14.3	.040	1.22
Radio	.070	.0877	.633	1.072	7.2	.426	3.04
Television	.106	.1978	.289	1.079	5.91	.591	1.23
District	.076	.0448	2.906	1.112	7.9	.088	0.22

Deviance=162; Chi square=163; likelihood ratio of chi-square=18.94, df=11; p=.0.041

A beta coefficient for use of mobile phone of .133. This meant that one unit increase of using mobile phone to access rice information caused 14.3% increase in communication of strategic rice information to smallholder farmers in the study areas. This variable was statistically significant at $p \leq 0.04$ (Table 12). The results show that use of mobile phones had the highest impact on the likelihood of obtaining strategic rice information for climate change adaptation because of its high beta coefficient of .133 compared to other sources. Anand and Kumaran (2017) elaborated that mobile phones generates positive economic benefits, due to easy access, mobility, and time-saving or convenience. Mobile phone is a powerful medium in sharing relevant and timely agricultural information to farmers.

On the other hand, the study findings show that the respondents' use of radio influenced access to strategic rice information for climate change adaptation. The variable had a beta coefficient of .70 and it was not statistically significant at $p \leq 0.43$. This meant that one unit increase in use of radio resulted in 3.0% increase on the respondents' likelihood to access strategic rice information for adaptation to climate change. This is contrary to the study by Nkua (2017) in Babati District, Tanzania who found that radio enhanced rice farmers access to climate information. Radio has been acknowledged to be the cheapest and by far the most effective means of reaching rural targets with agricultural innovations (Mittal, 2012), compared to other sources of information. With this study, it can be inferred that radio available in the study area were minimally used as delivers of strategic rice information for adaptation to climate change.

Furthermore, Table 12 show that access to television had positive beta coefficient of .106 and it was not statistically significant at $p \leq 0.591$. This meant that one unit increase in access to television resulted in 5.9% increase on the likelihood of the respondents' access to strategic rice information for adaptation to climate change. Non-significant influence on use of television to farmers' access to strategic rice information for adaptation to climate change is due to lack of television sets among most respondents. The results show that few respondents owned television. Only 67 (16.8%) indicated to own television sets. However, the sessions do not deliver strategic rice information for adaptation to climate change. During the FGDs at Rudewa village in Kilosa District, one participant said:

> "*Telecasted sessions on television have little strategic rice information for adaptation to climate change and if there is it is too general and thus serving little value in any local context for enabling us to adapt to climate change*".

This is contrary to the study by Devkota and Phuyal (2018) study in Terai , Hilly Region, Nepalese, who found that farmers used television to access information on adaptation to climate change.

4.9 Strategic Rice Adaptation to Climate Change that the Respondents Opted

This section discusses adaptation measures that respondents used. The study findings show that, of all the 400 respondents, majority, 336 (84.0%) reported that they planted drought tolerant rice varieties and of these, 141 (70.5%) and 195 (97.5%) were from Kilosa and Kilombero Districts, respectively. Furthermore, few, 59 (29.5%) and 5 (2.5%) of the respondents from Kilosa and Kilombero, respectively reported that they planted other drought tolerant crops (Table 13). The differences in adaptation strategies opted in the two districts were highly statistically significant at $p \leq 0.01$. The results show that planting drought tolerant rice varieties was high in Kilombero District. This is similar to a study by Mligo and Msuya (2015) study in Kilombero District, in Morogoro Region, Tanzania who found that farmers used drought tolerant rice varieties as adaptation measures to climate change.

Table 13: Adaptation option opted by the respondents during drought periods

Adaptation measure	Kilosa		Kilombero		Total		χ2	df	P
	n	%	n	%	n	%			
Plant drought tolerant rice varieties	141	70.5	195	97.5	336	84.0	55.90	2	0.00
Change to other drought tolerant crops	33	16.5	0	0.0	33	8.2			
Plant drought tolerant rice varieties and other drought tolerant crops	26	13.0	5	2.5	31	7.8			
Total	200	100.0	200	100.0	400	100.0			

Furthermore, the study assessed the type of rice varieties that the respondents grew during drought periods in the study areas. Of the 400 respondents, two thirds, 254 (63.5%) reported that they grew local varieties, and the variable was highly statistically significant at $p \leq 0.01$. This implied that few respondents grew improved rice seed varieties of semi aromatic (SARO), WAB and Super Dakawa (Table 14). Similarly, Kashenge and Makoninde (2016) study in Kilombero District, Tanzania found that majority of smallholders' farmers used local varieties. Similar findings were revealed during FGDs at Signali Village in Kilombero District, one participant said:

> "*We grow local varieties because they have high marketability compared to improved varieties. The selling price of the local varieties is at higher price than the improved varieties.*"

Similary, study by Kihupi *et al*. (2007) in Kyela District, Mbeya Region found that marketability of rice was influenced by its aroma and quality.

Table 14: Rice varieties grown during drought period in the study areas

Rice variety	Kilosa		Kilombero		Total		χ2	df	P
	n	%	n	%	n	%			
Change to other drought tolerant crops	33	16.5	0	0.0	33	8.3	250.80	12	0.00
WAB	2	1.0	0	0.0	2	0.5			
SARO	52	26.0	59	29.5	111	27.8			
Berenge	18	9.0	11	5.5	29	7.3			
Super dakawa	27	13.5	0	0.0	27	6.8			
Super Mbeya	2	1.0	0	0.0	2	0.5			
MbawaMbili	3	1.5	54	27.0	57	14.3			
Super dakawa	63	31.5	0	0.0	63	15.8			
Lawama	0	0.0	38	19.0	38	9.5			
Kalimawangu	0	0.0	7	3.5	7	1.8			
India	0	0.0	3	1.5	3	0.8			
Kisengo	0	0.0	13	6.5	13	3.3			
Zambia	0	0.0	15	7.5	15	3.8			
Total	200	100.0	200	100.0	400	100.0			

Furthermore, the study assessed the different land adaptation options to climate change that the respondents used. Of the 400 respondents, two thirds, 250 (62.5%) indicated that they made bunds called *majaruba* and of these, 117 (58.5%) and 133 (66.5%) were from Kilosa and Kilombero Districts, respectively (Table 15). Only 144 (36.0%) of the respondents mentioned that they grew rice on flat land. The difference on land preparation measures adapted was highly statistically significant at $p \leq 0.01$. Majority of the smallholder farmers made bunds as an adaptation measure for water retention. This is in line with Churi (2012) study in Same District, Tanzania, who found that most of the farmers made water bunds to conserve water in their farms as an adaptation measure to climate change.

Of the 400 respondents, most 334 (83.5%) reported that they winnowed seed to get the best rice seeds for planting, and of these, 161 (80.5%) and 173 (86.5%) were from Kilosa and Kilombero Districts, respectively (Table 15). Furthermore, few, 39 (9.8%) of the respondents reported that they soaked seed in salt solution. The difference on seed treatment was not statistically significant at $p \leq 0.242$. Yet, the study results show that, of the 400 respondents, more than half, 237 (59.3%) mentioned that they sowed rice seed directly, and of these, 169 (84.5%) and 68 (34.0%) were from Kilosa and Kilombero Districts, respectively. This is in line with Candradijaya *et al.* (2014) study in Sumedang District, West Java, Indonesia who found that due to climate change majority of smallholder farmers depending on rains directly sowed rice seeds directly. Of the 200 respondents from Kilombero, 131 (65.5%) reported that they sowed rice seeds in nurseries and later transplanted them in fields, a practice which was not common in Kilosa District. The difference on ways of planting seeds in the two districts was highly statistically significant at $p \leq 0.01$ (Table 15). This is in line with Kumar and Sidana (2018) study in Punjab State, India and Kim *et al.* (2017) study in Benue State, Nigeria, who found that due to climate change majority of rain-fed smallholder farmers sowed rice seeds directly.

Of the 400 respondents, more than half, 240 (60%) reported that they sowed rice without following the recommended seed spacing, and of these, 163 (81.5%) and 77 (38.5%) were from Kilosa and Kilombero Districts, respectively. The differences on ways of sowing rice in the two districts were highly statistically significant at $p \leq 0.01$. This finding is contrary to a study by Gujja and Thiyagarajan (2010) in Tamil Nadu, India, who found that rain fed rice smallholder farmers adapted wider spacing as an adaptation measure to the impact of climate change.

Furthermore, few, 33 (8.3%) of the respondents indicated that they used inorganic fertilizers during rice sowing, and of these, 31 (15.5%) and 2 (1.0%) were from Kilosa and Kilombero Districts, respectively (Table 15). Yet, few, 129 (32.3%) of the respondents who reported using inorganic fertilizers for top-dressing, 193 (96.5%) and 78 (39.0%) were from Kilosa and Kilombero Districts, respectively. The differences in use of inorganic fertilizers in the two districts were highly statistically significant at $p \leq 0.01$. The most commonly used inorganic fertilizers were Minjingu Rock Phosphate (MRP) and

Di-Ammonium Phosphate (DAP) during sowing while UREA, Calcium ammonium nitrate (CAN) and Booster were used as top-dressing. Majority of the respondents, 367 (91.8%) and over two thirds, 271 (67.8%) indicated that they did not use fertilizer for sowing and top dressing, respectively (Table 15). This implied that there were low uses of inorganic fertilizers in the study areas. Mugula (2013) study in Wami-Ruvu basin, Tanzania, found similar results of low inorganic fertilizer use by rice rain-fed smallholder farmers.

Table 15: Respondents' adaptation measures used by respondents during drought periods

Adaptation measures	Kilosa (n=200)		Kilombero (n=200)		Total (n=400)		χ2	df	P
Land preparation	**n**	**%**	**n**	**%**	**n**	**%**			
Construct bunds e.g majaruba	117	58.5	133	66.5	250	62.5	6.46	2	0.039
Plant on flat land	82	41.0	62	31.0	144	36.0			
Low tillage	1	0.5	5	2.5	6	1.5			
Seed treatment									
Deep seed in salt solution and retain heavy settled seeds	24	12.0	15	7.5	39	9.8	2.84	2	0.242
Winnowing	161	80.5	173	86.5	334	83.5			
Buy from a shop	15	7.5	12	6.0	27	6.8			
Ways of planting seeds									
Direct sewing	169	84.5	68	34.0	237	59.3	105.80	2	0.000
Transplant seedlings	31	15.5	131	65.5	162	40.5			
Soaking seeds for 24 hours then drain and plant	0	0.0	1	0.5	1	0.3			
Plant spacing used									
25 by 25	4	2.0	46	23.0	50	12.5	83.69	2	0.000
20 by 20	33	16.5	77	38.5	110	27.5			
No spacing	163	81.5	77	38.5	240	60.0			
Inorganic fertilizer use									
During Planting									
MRP/DAP	2	1.0	31	15.5	33	8.3	27.77	1	0.000
Do not use fertilizer	198	99.0	169	84.5	367	91.8			
As top dressing									
UREA/CAN/Booster	7	3.5	122	61.0	129	32.3	151.3	1	0.000
Do not use fertilizer	193	96.5	78	39.0	271	67.8			
Weeding									
Thinning	70	35.0	53	26.5	123	30.8	3.95	2	0.138
Use herbicide	119	59.5	138	69.0	257	64.3			
Both thinning and weeding	11	5.5	9	4.5	20	5.0			
When rice harvested									
Grains on panicles are colored	176	88.0	188	94.0	364	91.0	4.39	1	0.036
Grain are colored and firm	24	12.0	12	6.0	36	9.0			

Furthermore, of the 400 respondents, few, 33 (8.3%) of the respondents indicated that they used inorganic fertilizers during rice sowing, and of these, 31 (15.5%) and 2 (1.0%) were from Kilosa and Kilombero Districts, respectively. Yet, few, 129 (32.3%) of the respondents who reported using inorganic fertilizers for top-dressing, 193 (96.5%) and 78 (39.0%) were from Kilosa and Kilombero Districts, respectively (Table 15). The differences in use of inorganic fertilizers between the respondents in the two districts were highly statistically significant at $p \leq 0.01$. The most commonly used inorganic fertilizers were MRP and DAP during sowing, while UREA, CAN and Booster were used as top-dressing. This implied that there were low uses of inorganic fertilizers in the study areas. This is explained by lack of information on use of recommended fertilizer on rice farming. During the FGDs at Rudewa village in Kilosa District, one participant said:

> "*Our farms still have enough fertility, hence they do not need to apply inorganic fertilizers*".

Again, of the 400 respondents, two thirds, 257 (64.3%), mentioned that they used herbicides for weeding, and of these, 119 (59.5%) and 138 (69.0%) were from Kilosa and Kilombero Districts, respectively. Furthermore, few, 123 (30.8%) of the respondents reported that they manually weeded rice fields (Table 15). The differences in weeding methods that they used in the two districts were not statistically significant at $p \leq 0.34$. This implied that there was low use of manual weeding in the study areas. Observation shows that manual weeding was done because few farmers could afford the cost of herbicides. Furthermore, of the 400 respondents, majority, 364 (91.0%) reported that they harvested rice when panicles had changed their colours from green to amber, and of these 176 (88.0%) and 188 (94.0%) were from Kilosa and Kilombero Districts, respectively (Table 15). This implied that majority of respondents harvested rice when it was ripe. The differences of harvesting rice in the two districts were statistically significant at $p \leq 0.04$.

Similarly, Herath and Thirumarpan (2017) study in Anuradhapura District, Sri Lanka found that majority of rice farmers harvested rice when it had changed its colour as an adaptation strategy to climate change.

Table 16 show the respondents response on various ways that the respondents used to control pest on rice particularly birds, rats and insect pests. Results show that, of the 400 respondents, most, 320 (80.0%) reported that they controlled birds by scaring them, and of these, 180 (90.0%) and 140 (70.0%) were from Kilosa and Kilombero Districts, respectively. This method of scaring birds involves using traditional noise making devices from 6am to 7pm till up to harvesting. Yet, few, 98 (24.5%) of the respondents mentioned that they hoisted frags of cloths in the farms to scare away birds. The differences in birds control methods adapted among the respondents in the two districts were not statistically significant at $p \leq 0.069$ (Table 16). Similarly, de Mey *et al*. (2012) study in Senegal River Valley, Senegal found that smallholder farmers used manual birds scaring methods. However, Nakamura (2011) study in Japan found that farmers cover the fields with nets, which can be costly and not feasible for majority of smallholder farmers in Tanzania.

Furthermore, of the 400 the respondents, few 122 (30.5%) indicated that they used chemicals to control rats in rice fields. Furthermore, few, 3 (0.8%) reported using wider bunds and big mud pots in fields. The differences in use of rat control measures in the two districts were not statistically significant at $p \leq 0.160$ (Table 16). This implied that in the study areas rats and rice insect pest infestation were not a major problem. These data were supported by one FGD participant in Msolwa Ujamaa village in Kilombero District who said:

> "*Rats and insect pests occurrences in our areas were rare. Whey they occur we spray chemicals on our rice fields to kill them*".

Table 16: Ways used to control rice pests

Bird control	**Kilosa (n=200)**		**Kilombero (n=200)**		**Total (n=400)**		**χ2**	**P**
	n	**%**	**n**	**%**	**n**	**%**		
Manual bird scaring	125	62.5	140	70.0	265	66.2	2.15	0.11
Putting flags on the farm	75	37.5	60	30.0	135	33.8		
Rat control measures								
Use chemicals	84	42	38	19	122	30.5	72.32	0.00
Construct wider bunds	0	0	3	1.5	3	0.8		
Use big mud pots immersed to half of its height	34	17	2	1	36	9.0		
No incidence	82	41	157	78.5	239	59.8		
Insect control measure								
Chemicals	29	14.5	10	5.0	39	9.8	12.06	0.00
Early planting	0	0	2	1.0	2	0.5		
No incidence	171	85.5	188	94.0	359	89.8		

4.10 Summary of Key Findings on use of Mobile phones for Accessing Strategic Rice Information forAadaptation to Climate Change

The study results have indicated that, less than one third of farmers used mobile phones to access strategic rice information for adaptation to climate change. Furthermore, results show that voice calling was major mobile phone application used by respondents for accessing strategic rice information for adaptation to climate change through mobile phone. The results show that, few respondents used internet and SMS to access strategic rice information for adaptation to climate change. Moreover, most of the respondents contacted their fellow farmers for accessing strategic rice information for adaptation to climate change. Furthermore, the study findings revealed that few respondent contacted agricultural extension agents and input supply through mobile phone to access strategic rice information for adaptation to climate change. Type of rice variety and type of herbicides to control weed on their fields was the major strategic rice information accessed by respondents through mobile phone. In additional, the regression model revealed that mobile phones had the highest impact on the likelihood of obtaining strategic rice information for climate change adaptation. The results show that most of the respondents planted drought tolerant rice varieties few respondents grew improved rice seed varieties of semi aromatic SARO and Super Dakawa. Most of the respondents sowed rice seed directly on the flat land. Furthermore, few, of the respondents used inorganic fertilizers. Results showed that most of respondents used herbicides for weeding while few respondents they manually weeded rice fields. Likewise the results revealed that in the study areas rats and rice insect pest infestation were not a major problem.

4.11 Use of Mobile Phone in Accessing Tactical Rice Information for Adaptation to Climate Change

4.11.1 Tactical rice information for adaptation to climate change accessed through mobile phones

Of the 400 respondents, less than one third, 105 (26.5%) reported to having used mobile phone in accessing tactical rice information for adaptation to climate change. Of these, about one quarter, 59 (29.5%) and 46 (23.0%) were from Kilosa and Kilombero District, respectively. The differences in use of mobile phone for accessing tactical rice information for adaptation to climate change in the two districts was not statistically significant at $p \leq 0.140$. These results implied that use of mobile phone to access tactical rice information for adaptation to climate change in the study districts was low and did not differ.

Furthermore, of the 105 respondents who reported to use mobile phone for accessing tactical rice information for adaptation to climate change, majority, 98 (60.3%) indicated that they accessed weather forecast information. Of these, 59 (100.0%) and 39 (84.8%) were from Kilosa District and Kilombero Districts, respectively. The different tactical rice information for adaptation to climate change accessed through mobile phones in the two districts was statistically significant at $p \leq 0.05$ (Table 17). This implied that most of the farmers from Kilosa District accessed weather forecasting information through mobile phones. During the FGD in Rudewa Village in Kilosa District, one participant said:

"We use mobile phones to search information on weather forecasting so that we can change our planting dates. We also ask our colleagues from nearby villages whether it has started to rain."

Yet, another FGDs participant in Msowero village in Kilosa District said:

"*With a mobile phone one can get weather forecast anytime unlike the radio where one can only get that information during news broadcasting hours.*"

Similarly, Etwire *et al*. (2015) study in Upper West Region of Ghana found that farmers used mobile phone to access weather forecast information. In addition, Umunakwe *et al*. (2015) study in Owerri West Local Area of Imo State, Nigeria found that farmers used mobile phones to access weather forecast information. Weather forecasting information enables farmers to change their planting patterns due to climate change (Feleke, 2015). Farmers mostly wanted to know the onset of the rains so that they could start to plant seeds.

Table 17: Tactical rice information for adaptation to climate change accessed through mobile phones

Tactical information for adaptation to climate change	Kilosa (n=59)		Kilombero n=46)		Total (n=105)		χ2	df	P
	n	%	n	%	n	%			
Weather forecast	59	100	39	84.8	98	93.3	8.52	5	0.04
Type of early maturing ice varieties	36	61.0	24	52.2	60	57.1			
Other drought tolerant crop	7	11.9	0	0.0	7	6.7			
Type of fertilizer to apply	7	11.9	11	23.9	18	17.1			
Disease control	9	15.2	12	26.1	21	20.0			

Furthermore, of the 105 respondents who used mobile phones to access tactical rice information for adaptation to climate change, more than half, 60 (57.1%) mentioned that they asked for type of rice varieties, and of these, 36 (61.0%) and 24 (52.2%) were from Kilosa and Kilombero Districts, respectively (Table 17). These findings are similar to those of Mitall (2018) study in Haryana and Bihar States, India who found that farmers used mobile phone to access information about appropriate agricultural inputs including type of seeds to plant. In additional, few, 18 (17.1%) of the respondents indicated that they used mobile phones to access information on fertilizer application, and of these, 7 (11.9 %) and 11 (23.9%) were from Kilosa and Kilombero Districts, respectively. Moreover, the findings show that, 21 (20.0%) of the respondents reported that they used mobile phone to access information on pesticides, and of these, 9 (15.2%) and 12 (26.1 %) were from Kilosa and Kilombero Districts, respectively (Table 17).

4.11.2 Information sources contacted through mobile phone to access tactical rice information for adaptation to climate change

The study results in Table 18 show information sources that the respondents indicated to contact to access tactical rice information for adaptation to climate change through mobile phone**.** The results show that, of the 105 respondents, most, 100 (95.2%) of the respondents reported that they contacted their fellow farmers. Furthermore, more than half, 56 (53.3%) of the respondents reported that they contacted middlemen, while few, 39 (37.1%) said that they contacted agricultural extension agents. The different information sources that the respondents contacted in the two districts were not statistically significant at $p \leq 0.26$. The results implied that information sources that the respondents contacted to access tactical rice information for adaptation to climate change through mobile phone among study districts did not differ. Fellow farmers were the main sources contacted to access tactical rice information for adaptation to climate change. This is similar to Zendera (2011) study in Baringo District in Kenya who found that majority of the farmers communicated with fellow farmers to get weather forecast information through mobile phones. During the FGD in Sanje Village in Kilombero District one participant said:

"I have been calling fellow farmers asking them about the types of rice varieties which perform better when climate changes as I have their mobile phone numbers of fellow farmers within and outside our village."

Also, another FGD participant said:

"I have been calling agricultural extension agents to ask about types of inputs such as seeds, and insecticides that I could use in my rice fields".

This is similar to a study by Kavi *et al*. (2018) in Edo State, Nigeria, who found that farmers used fellow farmers as a first-hand source for agriculture information. Also, Etwire (2017) study in Upper West in Ghana, found that fellow farmers were the major sources of climate information.

Table 18: Information sources contacted through mobile phone to access tactical rice information for adaptation to climate change

Information sources	Kilosa (n=59)		Kilombero n=46)		Total (n=105)		$\chi2$	df	p
	n	%	n	%	n	%			
Agricultural extension agents	20	33.9	16	34.8	39	37.1	7.66	6	0.26
Local government official	5	8.5	3	6.5	8	7.6			
Farm input/shop	5	8.5	8	17.4	13	12.4			
Fellow farmers	56	94.9	44	95.7	100	95.2			
Middlemen	33	55.9	23	50.0	56	53.3			
Mobile phone based agricultural information system	15	25.4	7	15.2	22	20.9			

Furthermore, the findings show that of the 105 respondents, more than half, 56 (53.3%) reported that their other sources was the rice buying middlemen, and of these 33 (55.9%) and 23 (50.0%) were from Kilosa and Kilombero Districts, respectively (Table 18). The study revealed that respondents also received advice on the type of early maturing rice varieties to plant from the middlemen. However, the drawback of the middlemen is that they may lack scientific information on the appropriate rice varieties that yield more under climate change.

Yet, few, 22 (20.9%) of the respondents reported that they had used mobile based agricultural advisory services and of these, 15 (25.4%) and 7 (15.2%) were from Kilosa and Kilombero Districts, respectively (Table 18). This is contrary to the study by Tumbo *et al.* (2018) in Kilosa District, Tanzania who found that farmers share agriculture information related to coping strategies for climate change adaptation through mobile phone. Also this is contrary to the study by Ganesan *et al*. (2015) in Kancheepuram, Erode and Dharmapuri Districts, India who found that most of the farmers used mobile multimedia agricultural advisory systems that enhanced farmers' access to agricultural information.

4.11.3 Mobile phone application used to access tactical rice information for adaptation to climate change

Of the 105 respondents, all indicated that they made voice call to access tactical information for adaptation to climate change. Few, 11 (10.5%) of the respondents reported that they used SMS while 39 (37.1%) reported that they used an internet services to access tactical information for adaptation to climate change (Table 19). The differences on mobile phone application used to access tactical rice information for adaptation to climate change in the two districts were not statistically significant at $p \leq 0.24$. This implied that voice calling was the major mobile application used to acess tactical information for adaptation to climate change. Similarly, Umunakwe *et al*. (2015) study in Owerri West Local Area of Imo State, Nigeria reported that farmers voice calling was the major way used by farmers on accessing weather information through mobile phone. Lack of use of internet on mobile phone was due to lack of mobile phone with internet function. Of all the 400 respondents, only 63 (15.8%) owned smartphones, and of these 24 (12.0%) and 39 (19.5%) were from Kilosa and Kilombero Districts, respectively. Similary, Lwoga *et al*. (2011) study in Karagwe, Kasulu, Kilosa, Moshi and Mpwapwa Districts in Tanzania found that few farmers used mobile phone application in rural areas due to lack of awareness about mobile phone application to use in agriculture. Observation showed that the ICTs infrastructure in the study areas was good for supporting mobile phone use, but there was low use of mobile phone for accessing tactical information for adaptation to climate change. During an FGD session in Kisawasawa Village Kilombero District, participant one participant said:

> "*One of the reasons hindering us to use mobile phones for accessing agricultural information is lack of awareness among farmers about different ways in which mobile phones can be used to access agricultural information. Most of us frequently use voice calling when accessing agricultural information*"

Similarly, Nyamba (2017) study in Kilosa District Tanzania found that farmers' use of mobile phones was constrained by lack of awareness, among other factors. Also, Tadess and Bahiigwa (2015) in Oromia, Ethiopia found that lack of appropriate knowledge was a major cause of low exploitation of mobile phones for information dissemination.

Table 19: Ways mobile phone used to access tactical rice information for adaptation to climate change

Mobile function	Kilosa (n=59)		Kilombero (n=46)		Total (n=105)		$\chi 2$	df	p
	n	%	n	%	n	%			
Voice calling	59	100.0	46	100.0	105	100	4.173	3	0.243
SMS	18	30.5	21	45.7	39	37.1			
Internet	7	11.9	4	8.7	11	10.5			

4.12 Mobile Phone as Determinant of the Respondents' Access to Tactical Rice Information for Adaptation to Climate Change

Table 20 shows a regression model for examining influence of the mobile for accessing tactical rice information for adaptation to climate change. It also includes other communication channels used by the respondents to access tactical rice information for adaptation to climate change. This is because farmers simultaneously access information from different channels as they do not rely on a single source of information (Mittal and Mehar, 2016; Ali, 2012). The deviance test result was 134.764, with a chi-square value of 134.76, which was not statistically significant at $p \geq 0.06$. According to Pallant (2011), the p-value of a model should be greater than 0.05 in a model, implying that the model fits well the data. The model had a likelihood ratio chi-square value of 89.376 with a df of 15 and was highly statistically significant at $p \leq 0.01$. This implied that at least one explanatory variable of the regression coefficient was not equal to zero in the model. Furthermore, the study results show that the VIF for all variables in the model ranged from 0.11 to 3.11, and meets the VIF as stipulated by Pallant (2011). According to Pallant (2011), independent variables have no multicollinearity if their VIF is less than 10. Furthermore, the Wald chi-square value ranged from 0.01 to 6.04. The walds coefficient for use of mobile phone and radio were statistically significant at $p \leq 0.01$. This implied that use of mobile phones and radio contributed significantly in predicting the respondents' access to tactical rice information for adaptation to climate change.

Table 20: Mobile phone as determinants of farmers' access to tactical rice information on climate change adaptation

Parameter	β	Std. Error	Wald chi-square	Exp (β)	Predicted % change	Sig.	VIF.
(Intercept)	.071	.15	.214	1.074	7.36	.00	.
Mobile phones	.494	.20	6.035	1.639	63.89	.01	0.11
Radio	.302	.12	6.325	1.353	35.26	.01	1.21
Television	.107	.87	.015	1.113	11.29	.99	3.11

Deviance=134.764; Chi square=134.76, df=383; p=0.352; likelihood ratio of chi-square=89.376; df=15; $p \leq 0.01$.

The respondents' use of mobile phone had a positive beta coefficient of .494, and was highly statistically significant at p≤ 0.01 (Table 20). This meant that one unit increase in use of mobile phone resulted in 64% increase on the respondents' likelihood to access tactical rice information for adaptation to climate change. The results show that the use of mobile phone had the highest impact on the likelihood of obtaining tactical rice information for adaptation to climate change. High predicted percentage change is because mobile phone allows two way communications and results in immediate and guaranteed exchanges of information once the recipient answers the phone (Mittal and Mehar, 2016).

Additionally, the study findings showed that the respondents' use of radio influenced access to tactical rice information for adaptation to climate change, and the variable had a beta coefficient of .302. This variable was highly statistically significant at p≤ 0.01 (Table 20). This meant that one unit increase in use of radio resulted in 35.3% increase on the likelihood of respondents' access to tactical rice information for adaptation to climate change. These results provide evidence that radio is among the reliable ICTs device for enhancing respondents' access to tactical rice information for adaptation to climate change in the study areas. This is similar to a study by Churi *et al.* (2012) in Same District, Tanzania, who found that farmers used radio as a source of climate information. Also, a study by Etwire *et al*. (2015) in Upper West Region, Ghana, revealed that farmers used mobile phones for accessing weather forecast information.

Furthermore, the study findings showed a beta coefficient for respondents' use of television as.107, and the variable was not statistically significant at p≤ 0.99 (Table 20). This meant that one unit increase in use of television resulted in 11.3% increase on the likelihood of respondents' accessing tactical rice information for adaptation to climate change in the study areas. This is contrary a the study by Jost *et al*. (2016) in Rakai

District, Uganda, who revealed farmers used television to access climate information. Low use of television to access tactical rice information for adaptation to climate change is due to lack of television set among most of the respondents. The results show that only 67 (16.8%) of all the respondents owned television sets.

4.13 Tactical Rice Adaptation Measures to Climate Change that the Respondents Opted

This section discusses tactical adaptation measures that the respondents used. Tactical rice adaptation measures that the respondents used were categorized in three occasions: when there was a delay of initial rainfall; when there was little rainfall after rice seed germination; when there was no rainfall during rice flowering and when there was too much rainfall during the growing season. Of all the 400 respondents, most, 371 (92.8%) reported that they planted short rice varieties, while few 29 (7.3%) indicated that they changed to another crop when there was initial rainfall delay (Table 21). This variable was highly statistically significant at $p \leq 0.01$. This results show that planting short rice variety was high in Kilombero District. Similarly, Churi (2013) study in Same District in Kilimanjaro Region in Tanzania reported that majority of smallholder farmers opted to plant short duration varieties when there was a delay in rainfall. Kim *et al*. (2017) study in Benue State, Nigeria found that due to climate change farmers plant early maturing varieties which are disease resistance while achieving high yields.

Furthermore, the study assessed the type of rice varieties that the respondents grew when there was a delay in initial rainfall in the study areas. Of the 400 respondents, about two thirds, 241 (60.3%) indicated that they grew local varieties, and of these 142 (71.0%) and 96 (48.0%) were from Kilosa and kilombero District, respectively. This variable was highly statistically significant at $p \leq 0.01$. The results show that planting local varieties was high in Kilosa District. Similarly, Kim *et al*. (2017) study in Benue State, Nigeria found that due to climate change, farmers used early maturing rice varieties. This is also in line with the findings by Sarker (2013) study in Rajshahi District, Bangladesh who revealed that farmers used early maturing rice varieties to avert the impact of climate change, which shortens the growing season.

In additional, of all the 400 respondents, over half, 238 (59.5%) indicated that they replanted rice in their fields and of these, 131 (65.5%) and 107 (53.5%) were from Kilosa and Kilombero Districts, respectively. Only 137 (34.3%) of the respondents mentioned that they irrigated their fields as an adaption measure when there was little rainfall after seeds had germinated (Table 21). Observation showed that the respondents' decisions to use supplemental irrigation in Kilombero District than in Kilosa District was due to availability of rivers near the rice fields in the former District. This variable was highly statistically significant at $p \leq 0.01$. Also, of all the respondents, two thirds, 247 (61.8%) reported that they did nothing when there were no rainfall during rice flowering period and of these, 138 (69.0%) and 109 (54.5%) were from Kilosa and Kilombero Districts, respectively. Few, 137 (34.3%) of the respondents mentioned that they irrigated their rice fields when there were little rainfall during the rice flowering period. This is contrary to the study by Mishra *et al*. (2013) study in Bengal Region, India who found that rain fed rice farmers used supplemental irrigation on rice fields when there was lack of rainfall during flowering.

Table 21: Tactical adaptation measures used by respondents (n=400).

Adaptation measures when rainfall delayed	Kilosa (n=200)		Kilombero (n=200)		Total (n=400)		χ2	df	P
	n	%	n	%	n	%			
Plant short rice variety	171	85.5	200	100.0	371	92.8	31.267	1	0.000
Change to another crop	29	14.5	0	0.0	29	7.3			
Rice varieties grown when initial rainfall delayed									
SARO	55	27.5	104	52.0	159	39.8	170.700	9	0.000
WAB	3	1.5	0	0.0	3	0.8			
Mbawambili	33	16.5	28	14.0	61	15.3			
Super Dakawa	8	4.0	0	0.0	8	2.0			
Berege	0	0.0	4	2.0	4	1.0			
Kabangala	77	38.5	0	0.0	77	19.3			
Kalimawangu	0	0.0	48	24.0	48	12.0			
India	0	0.0	6	3.0	6	1.5			
Kisengo	0	0.0	2	1.0	2	0.5			
Zambia	0	0.0	8	4.0	8	2.0			
Adaptation measures when little rainfall after seed germination									
Change to other crop	20	10.0	0	0.0	20	5.0	37.401	3	0.000
Apply booster fertilizer	3	1.5	2	1.0	5	1.3			
Replant rice	131	65.5	107	53.5	238	59.5			
Irrigate fields	46	23.0	91	45.5	137	34.3			
Adaptation measures when there was no rainfall during flowering									
Use supplement irrigation	46	23.0	91	45.5	137	34.3	34.186	3	0.000
Apply booster	5	2.5	0	0.0	5	1.3			
Change to another crop	11	5.5	0	0.0	11	2.8			
Did nothing	138	69.0	109	54.5	247	61.8			
When there too much rainfall during growing season									
Land preparation measures									
Construct earthed canals	35	17.5	52	26.0	87	21.8	4.245	1	0.039
Plant on flat land	165	82.5	148	74.0	313	78.3			
Ways rice seeds planted									
Direct planting	154	77.0	98	49.0	252	63.0	33.634	1	0.000
Transplant	46	23.0	102	51.0	148	37.0			

Adaptations options that the respondents used when there was too much rainfall during the growing season are shown in Table 21. Of the 400 respondents**,** most**,** 313 (78.3%) reported that they planted on flat land, and of these 165 (82.5%) and 148 (74.0%) were from Kilosa and Kilombero Districts, respectively. Few, 87 (21.8%) mentioned that they made furrows to allow runoff to flow outside their fields. The differences in land preparation measures was statistically significant at p≤ 0.04.

Further, during the FGDs in Tindiga village in Kilosa District, one participant said:

> "*If we knew that there were going to be too much rainfall in that season, we normally planted rice seeds before it started to rain because it is difficult to transplant when it starts to rain*."

Furthermore, of the 400 respondents, two thirds, 252 (63.0%) reported that they to planted rice directly in the field, and of these, 154 (77.0%) and 102 (51.0 %) were from Kilosa and Kilombero, respectively. Yet, few, 148 (37.0%) of the respondents reported that they transplanted rice seedlings. The differences in ways of planting rice seeds in the two Districts were highly statistically significant at p≤ 0.01 (Table 21). In the study areas, there are two ways of planting rice seeds: by broadcasting; and drilling seeds. Broadcasting uses more seeds and seed grow unevenly. Ishfaq *et al*. (2018) recommends that farmers should use line-seeding because rice plants receive soil nutrients and fertilizers evenly and weeding becomes easier compared to broadcasted seeds. Kumar and Sidana (2018) study in Punjab India found that farmers adapted direct seed planting as an adaptation strategy to the impact of climate change. This is also is supported by Kim *et al.* (2017) study in Benue State, Nigeria, who found that farmers used direct seeding as adaptation measure to climate change in rain-fed rice fields.

4.14 Summary of Key Findings on the use of Mobile phones for Accessing Tactical Rice Information for Adaptation to Climate Change

The study results have indicated that, less than one third of farmers used mobile phones to access tactical rice information for adaptation to climate change. Furthermore, results show that voice calling was a major mobile phone application used by the respondents for accessing tactical rice information for adaptation to climate change through mobile phone. The results show that, most of the respondents contacted their fellow farmers for accessing tactical rice information for adaptation to climate change. Furthermore, the study findings revealed that few respondents contacted agricultural extension agents through mobile phone to access tactical rice information for adaptation to climate change. Likewise, weather forecast information and type of rice varieties to plant were the major tactical rice information accessed through mobile phone. The results show that most of the respondents planted early mature rice varieties when initial rainfall delayed. Most of the respondents in Kilombero District mentioned that they irrigated their fields as an adaptation measure when there was little rainfall after seeds had germinated.

4.15 Theoretical Implication of the Study Findings

The author concluded that the use the Unified Theory of Acceptance and Use of Technology (UTAUT) was a viable in researching use of mobile phones technology for accessing rice information for adaptation to climate change. This model provides a useful tool for determining the likelihood of success for technology introduction as well as understanding the drivers of technology acceptance. The UTAUT model provides a refined view of how the determinants of intention and behaviour evolve over time and assumes that there are three indirect determinants of intention to use the technology (performance expectancy, effort expectancy, social influence) and direct determinants of usage behaviour (facilitating conditions). Moderators such as sex, age and experience play specific moderating roles to the indirect and direct determinants of technology use behaviour. The study findings conform to the UTAUT theory in the sense that, the use of mobile phone in accessing information for adaptation to climate change are influenced by different factors among them are socio-demographic and institution factors. The underlying assumption is that socio-demographic influence farmers' use of mobile phone in accessing information for adaptation to climate change. Moreover, regression results confirm that, socio-demographic factors namely, sex, age, marital status, education, farm size, radio ownership, off farm income were statistically significant with use of mobile phone in accessing information on adaptation to climate change. Furthermore, the theory hypothesizes that institutional factors influence use of technology. Under this assumption, institutional factors it enhances farmers' use of mobile phone to access rice information for adaptation to climate change. In the context of this study, institutional factors include various institutions and organizations, such as access to agricultural extension services, access to credit, participation on farmers groups, access to agro dealer and market location. Results indicated that, respondents access to agricultural extension and advisory services and access to market were statistical significant. This meant that the UTAUT adequately determine farmers' use of mobile phone for accessing rice information for adaptation to climate change.

CHAPTER FIVE

5.0 CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

This section present conclusions as per specific objectives, namely to determine socio-demographic factors influencing the use of mobile phones in accessing rice information for adaptation to climate change, to determine institutional factors influencing the use of mobile phones in accessing rice information for adaptation to climate change, to examine use of mobile phones in accessing strategic rice information for adaptation to climate change and to assess use of mobile phones in accessing tactical rice information adaptation to climate change. This study used a combination of methods to collect data for this study, including questionnaires which were administered by the researcher, Focus Group Discussions (FGDs) and key informants interviews.

The study concludes that socio-demographic characteristics influences the farmers' use of mobile phones in accessing rice information on climate change adaptation. In addition, socio-demographic characteristics of respondents such as sex, age, marital status, farm size, farming experience, radio ownership and off-farm incomes significantly influences respondent's use of mobile phones in accessing rice information on climate change adaptation. Older respondents tend to have less chance of using mobile phones to access rice information on climate change adaptation than younger ones. Besides, the respondents with high incomes earned from off-farm activities are more likely to use mobile phones in accessing rice information for climate change adaptation. Moreover, farmers with large farms under rice are more likely to use mobile phones in accessing rice information for adaptation to climate change. Furthermore, married respondents had higher chances of using mobile phones to access rice information for climate change adaptation than unmarried ones. Finally, respondents with higher education attainments are more likely to use mobile phones in accessing rice information for adaptation to climate change.

Moreover, this study assessed institutional factors influencing use of mobile phones in accessing rice information for adaptation to climate change of rain-fed rice farmers. The study findings conclude that market location influences use of mobile phone in accessing rice information for adaptation to climate change. Farmers located near to institutional centres such as markets research centre and small towns are more likely to use mobile phone in accessing rice information for adaption to climate change.

Furthermore, the study concludes that few respondents use mobile phones to access strategic rice information for adaptation to climate change. Voice calls are most used application compared to other application in accessing strategic adaptation information. The study indicates that the main sources of strategic information that the respondents used for adaptation to climate change are through use of mobile phones to fellow farmers and middlemen. The findings revealed that few respondents contacted agricultural extension agents and input supplies through mobile phone to access strategic rice information for adaptation to climate change. Type of rice variety and type of herbicides to use to control weed in rice fields are the major strategic rice information for adaptation to climate change accessed by respondents through mobile phone. Also, most of the respondents plants drought tolerant rice varieties and few grew improved rice seed varieties. Most of the respondents sow rice seed directly on the flat land, and, few, of the respondents indicated that they used inorganic fertilizers in the rice fields.

It can also be concluded the respondents’ use of mobile phones to access tactical rice information for adaptation to climate change by rain-fed farmers in study areas were low.

Voice calling is a major mobile phone application used that the respondents used for accessing tactical rice information for adaptation to climate change through mobile phone. The results indicate that, most of the respondents contacts their fellow farmers for accessing tactical rice information for adaptation to climate change. Few respondents use SMS and internet for accessing tactical information on adaptation into climate change. Furthermore, weather forecast information and type of rice varieties to plant are the major tactical rice information accessed by respondents through mobile phonse. In addition, use of mobile phone to access tactical rice information for adaptation to climate change do not differ among the two study districts.

5.2 Recommendations

Based on the conclusions, recommendations for enhancing the use of mobile phones in accessing rice information for adaptation to climate change are given below and could be achieved through a combination of strategies; thus, the study recommends the following areas.

1. Kilosa and Kilombero District Councils in collaboration with the DAICO's office should register all farmers to create a communication platform using their mobile phones numbers and give them information on new updates on rice information for adapation to climate change through SMS.
2. Kilosa and Kilombero District Councils in collaboration with the DAICO's office should train farmers in using mobile phones in accessing rice information for adaptation to climate change through campaigns, workshop and seminars.
3. TMA in collaboration with Kilosa and Kilombero District Councils in collaboration with DAICO's office should strengthen the information processing and communication capacities to ensure that climate information is communicated to agricultural extension agents and smallholder farmers.

5.3 Contribution of the Study to the Body of Knowledge

This study contributes to the existing literature on the use of mobile phone for accessing rice information for adaptation to climate change. The study found that the use of mobile phone for accessing rice information for adaptation to climate change was influenced by sex, age, marital status, farm size, farming experience, radio ownership and off-farm incomes. This information is important to different stakeholders when developing and designing relevant farmer's information mobile systems and consequently enhance farmers adaptation to climate change.

The review of the literature appears to indicate that there are inconsistencies among researchers on the socio-demographic and institutional factors influencing use of mobile phone by the farmers. The study included 21 factors, most of those (11) appeared to influence the use of mobile phone for accessing rice information for adaption to climate change. This study in itself is a contribution to the literature.

Furthermore, the farmers use various sources of information. Therefore, this study contributes to methodology approach on analyzing use of information sources to enhance farmers access to information. Theoretically, the study contributes to the UTAUT theory in that the socio-demographic factors influenced the use of mobile phone in accessing rice information for adaptation to climate change. Moreover, the study has further shown that not only the socio-demographic characteristics of the respondents' do influence the use of mobile phones but the institutional factors too are important. The study adapted three original UTAUT model moderators which are age, educationand sex and adds more factors.

5.4 Suggestions for Further Study

Since this study limited it to the use of mobile phone for accessing rice information for the rain-fed rice farmers. Then similar study be done to farmers involved in other crops such as maize to see how they have been using mobile phone to access information for adaptation to climate change.

5.5 Policy Implication

The farmer need information to make informed decisions on various adaptation measures about climate change. Provision of agricultural extension and advisory services involve policies and other measures, which need to be implemented by the government at different levels of administration and by the non-governmental organisations (NGO's) for increasing agricultural productivity. Therefore, policies in Kilosa and Kilombero District Councils should be in place to ensure that there is design, development and application of innovative ways to use mobile phones in the rural areas that focus enhancing farmers' access to information on adaptation to climate change.

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APPENDICES

Appendix 1: Questionnaire for farmers

Title: Assessment of use of mobile phones for accessing paddy information for adaptation to climate change: Case study of Morogoro Region, Tanzania

Introduction to respondents

I am Nicholaus mwalukasa a PhD student at Sokoine University of Agriculture doing a study on "Assessment of use of mobile phones for accessing paddy information for adaptation to climate change: Case study of Morogoro Region"

I would appreciate if you could spare a few minutes for an interview. The information provided will be treated confidentially.

General Information

Name of district 1. Kilosa 2. Kilombero [_]

Name of Ward______________________

Name of village______________________

Objective 1: To determine socio-economic factors influencing the use of mobile phones for accessing paddy information for adaptation to climate change

A1. Sex of respondent: 1. Male 2.Female [_]

A2.Age of respondent_____________Years

A3 .What is your marital status? 1. Married [ ] 2. Widowed [ ] 3. Divorced [ ]4. Separated [ ]

A4.What is your highest education level?1. Never been to school [ ] 2. Primary [ ]3. Secondary [ ].4 College[ ] 5. University [ ]

A6. How many persons live in your household?_____________

A7. How many mobile phones do you have? 1. One 2. Two 3. More than two [_]

A8.What is the cost of a mobile phones_______________Tshs

A9.What is the source of found used to buy mobile phone 1. Paddy farming 2. Other agricultural crops. 3. Non farm produce 4. Gift

A10. Is it a smartphone 1. Yes 2. No [_]

A11. How long have you owned your mobile phone?______years

A12. How many chips do you own? ________

A13**.** Name source of power used for charging your mobile phone.1. Electricity form TANESCO 2. Solar. [_]

A14. Do you have other person in your household who own mobile phones (1) Yes (2) No [_]

A15.If answered yes in question C8, who own mobile phone? 1. Farther 2. Mother 3.Children [_]

A16. What is your farm size that you own_______________acres
A17. What was the area under paddy last season__________________acres
A18. For how long have you been farming paddy? .... (years)

A19 .What is the type of paddy farming do you practice? 1. Rainfed 2. Irrigated 3.Both [_]

A20. Do you own a house? 1. Yes 2. No [_]
A21. If answered yes on QN A20. Provide information about the type of house you own (if you have more than one mention the information for main house)

Type of wall	1. Concrete block 2. Mud 3.Bunt block 4. unburnt block [_]
Type of floor	1. Soil 2. Cement 3. Other mention [_]
Type of roof	1. Thatch 2. Mud 3. corrugated iron 4.Coconut leaves [_]
Do you use electrical power in your house?	1. Yes 2. No [_]
If yes, what is the source of power?	1.Electrical from TANESCO 2. Solar power 3. Dry cells 4. other specify [_]

A22. Information about resources that you own

	Type of resources	Number	Value
1	Cows(cattle)		
2	Goats		
3	Sheep		
4	Pigs		
5	Chicken		
6	Car		
7	Lorry		
8	Tractor		
9	Motor cycle		
10	Bicycle		
11	Television set		
12	Radio		
13	Sofa set		
14	Land (acres)		
15	Others(mention)		

A23. What were the sources of income in last season from agriculture?

Source	Type of source	Amount produced	Amount sold	Price	Income
Crop	Paddy				
	Maize				
	Bean				
	Sugar cane				
	Cassava				
	Sunflower				
	Cowpeas				
	Sesame seeds				
	Other(mention)				
Livestock	Cattle				
	Goats				
	Sheep				
	Pigs				
	Chicken				
	Other(mention)				
Total income					

A26. Apart from agriculture, what other sources of income did you get in 2015/2016growing season?

Source of income	**Income(Tshs)**
Employment	
Labour	
Petty business	
Off farm	
Total	

Objective 2: To assess use of mobile phones for accessing strategic paddy information for adaptation to climate change

Indicate the level of access to information for adapation to climate change using 1-quite often, 2-rarely and 3=never

During drought

B1. What adaptation option did you adapt for paddy?	1. Plant a drought tolerant paddy variety [_] 2. Change to other drought tolerant crops [_] 3. Plant both drought tolerant paddy and other crop
B2. If you decided to plant drought tolerant paddy variety, which one did you plant?	1. NERICA [_] 2. Super Dakawa [_] 3. WAB [_] 4. Mbawambili [_] 5. Berege [_] 6. Other(mention [_]

B3.What was the source of paddy information on drought tolerant paddy variety,? (Rank the first five sources)

AEA	Mobile	Local	Farm input	Farmer	Farmer group	FFSs	G.Reseacher	U. Rese archer	Telecentre	Mid dlen	Radio	T V	M-FAIS

B4. What land adaptations measure did you adapt? (Go to C10)	1. Construct bands e.g Majaruba 2. Incorporate paddy stalk (residues) 3. Incoporate husk

B5. What was the source of paddy information on land adaptation measures did you adapt? (Rank the first five sources)

AEA	Mobile	Local	Farm input	Farmer	Farmer group	FFSs	G.Reseacher	U. Researcher	Telecentre	Middlen	Radio	TV	M-FAIS

B6.What kind of paddy seed treatment did you adapt?	1. Deep seed in salt water and collect heavy seeds settled at bottom of water [_] 2. Winnowing seeds [_] 3. No treatment [_]

B7. What was sources of information about seed treatment? (Rank the first five sources)

AEA	Mobile	Local	Farm input	Farmer	Farmer group	FFSs	G.Reseacher	U. Researcher	Telecentre	Middlen	Radio	TV	M-FAIS

B8. How did you plant paddy seeds?	1. Direct planting [_] 2. Transplant [_] 3. Soaking the seed for 24 hours and then drain for 24 hours in the shade [_] 4. Bought seeds

B9. What was the sources of information on how to plant paddy? (Rank the first five sources)

AEA	Mobile	Local	Farm input	Farmer	Farmer group	FFSs	G.Reseacher	U. Researcher	Telecentre	Middlen	Radio	TV	M-FAIS

B10. What seed spacing for paddy did you adapt?	1. Double row [_] 2. 30 by 30 [_] 3. 25 by 25 [_] 4. 20 by 20 [_]

B11. What was the sources of information on paddy seed spacing? (Rank the first five sources)

AEA	Mobile	Local	Farm input	Farmer	Farmer group	FFSs	G.Reseacher	U. Researcher	Telecentre	Middlen	Radio	TV	M-FAIS

B12.What paddy fertilizer application did you adapt?	During planting 1=Using Mijinga/DAP for planting [_] 2=Use FYM [_] 3=Do not use fertilizer [_] During top dressing 1=Use UREA [_] 2=Do not use fertilizer [_]

B13. What were the sources of paddy information on fertilizer application? (Rank the first five sources)

AEA	Mobile	Local	Farm input	Farmer	Farmer group	FFSs	G.Reseacher	U. Researcher	Telecentre	Middlen	Radio	TV	M-FAIS

B14. How did you weed paddy?	1. Uprooting weeds [_] 2. Use herbicide [_]

B15. What were sources of paddy information on weeding? (Rank the first five sources)

AEA	Mobile	Local	Farm input	Farmer	Farmer group	FFSs	G.Reseacher	U. Researcher	Telecentre	Middlen	Radio	TV	M-FAIS

B16.When did you harvest paddy?	1. Harvest paddy when grains on panicles are coloured [_] 2. Harvest paddy when grains in the lower part of the panicle are hard, not soft [_] 3. Harvest when grains are firm but not easily broken when squeezed between the teeth [_]

B17. What were source of paddy information on paddy harvesting? (Rank the first five sources)

AEA	Mobile	Local	Farm input	Farmer	Farmer group	FFSs	G.Reseacher	U. Researcher	Telecentre	Middlen	Radio	TV	M-FAIS

B18.What storage facilities did you use?	1. Store on “pic” [_] 2. Store on sack [_]

B19. What were sources of paddy information on paddy storage? (Rank the first five sources)

AEA	Mobile	Local	Farm input	Farmer	Farmer group	FFSs	G.Reseacher	U. Researcher	Telecentre	Middlen	Radio	TV	M-FAIS

B20. If you decided to change to another drought tolerant crop, which one did you plant?	1. Sunflower [_] 2. sorghum [_] 3. Cowpeas [_] 4. Beans [_] 5. Sesame Seed [_] 6. other(mention

B21. What were sources of paddy information on another tolerant crop? (Rank the first five sources)

AEA	Mobile	Local	Farm input	Farmer	Farmer group	FFSs	G.Reseacher	U. Researcher	Telecentre	Middlen	Radio	TV	M-FAIS

During pests infestation

B22. What bird control measures did you adapt?	1. Covering individual heads of ripening crops with grass or cloth [_] 2. Manual bird-scaring efforts. [_] 3. Putting flags on the farm [_]
B23.Rat control measures did you adapt?	1. Use chemical [_] 2. Construct wider bunds [_] 3. Reduce amount of cover along edges of paddy fields [_] 4. Clean spilled grain at harvest, [_] 5. use of the Trap Barrier System (TBS) [_] 6. Use big mud pots immersed to half of its height [_] 7. Use fresh cow dung is mixed with kerosene [_] 8. Other (specify)
B24. Insect control measure did you adapt?	1. Early planting [_] 2. proper spacing [_] 3. Use of early maturing varieties [_] 4. Removal of alternate host weeds [_] 5. Field sanitation/crop hygiene [_] 6. Ploughing after harvesting to bring eggs to surface and destroy them [_] 7. Other(specify)

B25. What was source of information on pests infestation? (Rank the first five sources)

AEA	Mobile	Local	Farm input	Farmer	Farmer group	FFSs	G.Reseacher	U. Researcher	Telecentre	Middlen	Radio	TV	M-FAIS

During too much rainfall in this area	
B26. What land adaptations measure did you adapt?	1. Construct earthed canals [_] 2. Construct lined canals [_] 3. Incorporate paddy stalk (residues) [_] 4. Incoporate husk [_]

B27. What was source of information on land preparation? (Rank the first five sources)

AEA	Mobile	Local	Farm input	Farmer	Farmer group	FFSs	G.Reseacher	U. Researcher	Telecentre	Middlen	Radio	TV	M-FAIS

B28. Which paddy variety did you plant?	1. NERICA [_] 2. Super Dakawa [_] 3. WAB [_] 4. Mbawambili [_] 5. Berege [_] 6. Other(mention [_]

B29. What was source of information paddy variety? (Rank the first five sources)

AEA	Mobile	Local	Farm input	Farmer	Farmer group	FFSs	G.Reseacher	U. Researcher	Telecentre	Middlen	Radio	TV	M-FAIS

B30. How did you plant paddy variety?	1. Surface seeding. [_] 2. Direct planting [_] 3. Transplant [_]

B31. What was source of information on how to plant paddy variety? (Rank the first five sources)															
AEA	Mobile	Local	Farm input	Farmer	Farmer group	FFSs	G.Reseacher	U. Researcher	Telecentre	Middlen	Radio	TV	M-FAIS	Elders	Print

B32.How often do you use the mobile phone for accessing strategic paddy adaptation information to climate change?

Contact with	Mode used 1-call, 2-sms, 3-Both, 4-social media eg whatsap, facebook	1-quite often, 2-“rarely 3=never
Agricultural extension agents		
Local government officials		
Farm input store/shop		
Fellow farmers		
Government researcher		
University researcher		
Middlemen		
M-FAIS,e,g Ushauri kilimo		
FM radio		

B33.What was your levelof access to the followingsources of information use(1-quite often, -rarely 3=never)

AEA	Mobile	Local	Farm input	Farmer	Farmer group	FFSs	G.Reseacher	U. Researcher	Telecentre	Middlen	Radio	TV	M-FAIS	Elders	Print

Objective 3: To assess use of mobile phones for accessing tactical paddy information for adaptation to climate change

When initial rainfall has delayed	
C1.When initial rainfall have delayed what adaptations measure would you adapt?	1. Plant short paddy variety 2. Change to another crop
C2.If you decided to plant short paddy variety, which paddy variety would you plant?	1. NERICA [_] 2. Super Dakawa [_] 3. WAB [_] 4. Mbawambili [_] 5. Berege [_]

	Other(mention [_]
C3. What sources of information on adaptation measures would you adapt when initial rainfall delayed? (Rank the first five sources)	1. Agricultural extension agents [_] 2. Mobile phone [_] 3. Local government officials [_] 4. Farm input store/shop [_] 5. Fellow farmers [_] 6. Farmer group [_] 7. FFSs [_] 8. Government researcher [_] 9. University researcher [_] 10. Tele-centre [_] 11. Middlemen [_] 12. Radio [_] 13. Print material-newspaper [_] 14. Print material-brochures [_] 15. M-FAIS,Tigo Kilimo [_] 16. Elders [_]
When there are no rain after seed germination	
C4.When there are no rains after seed germination what adaptation measures would you adapt	1. Change to other crop 2. Do not apply fertilizers 3. Apply booster fertilizer 4. Replanting 5. Reduce paddy population
C5. What would be the sources of paddy information on adaptation measures that you adapt when there were no rains after seed germination? (Rank the first five sources)	1. Agricultural extension agents [_] 2. Mobile phone [_] 3. Local government officials [_] 4. Farm input store/shop [_] 5. Fellow farmers [_] 6. Farmer group [_] 7. FFSs [_] 8. Government researcher [_] 9. University researcher [_] 10. Tele-centre [_] 11. Middlemen [_] 12. Radio [_] 13. Print material-newspaper [_] 14. Print material-brochures [_] 15. M-FAIS,Tigo Kilimo [_] 16. Elders [_]
When there are no rain during flowering	
C6. When there are no rains during flowering stage what adaptation measures would you adapt	1. Use supplement irrigation [_] 2. Do not apply fertilizers [_] 3. Change to another crop [_]

C7. What sources of information on adaptation measures would you adapt when there were no rains during flowering stage? (Rank the first five sources)

AEA	Mobile	Local	Farm input	Farmer	Farmer group	FFSs	G.Reseacher	U. Researcher	Telecentre	Middlen	Radio	TV	M-FAIS

C8.How often do you use the mobile phone for accessing tactical paddy information for adaptation to climate change?

Contact with	Mode 1-Call, 2-Sms, 3-Both, 4-social media eg whatsap, facebook	Frequency of mobile phone adaption per season
Agricultural extension agents		
Local government officials		
Farm input store/shop		
Fellow farmers		
Government researcher		
University researcher		
Middlemen		
M-FAIS,e,g Ushauri kilimo		
FM radio		

F. Objective 4: To examine institutional factors influencing the use of mobile phones accessing paddy information for adaptation to climate change

	Extension services	
D1	Did you receive advisory extension services on how to use mobile phone to access paddy information for adaptation to climate change?	1= Yes, 2=No [_]

D2If answered yes QN F1, what were the sources of information.
Rank them according to your accessibility

AEA	Mobile	Local	Farm input	Farmer	Farmer group	FFSs	G.Reseacher	U. Resea rcher	Telecent re	Middlen	Radio	TV	M-FAIS

	Social capital	
D3	Are you a member to any social	1= Yes, 2=No [_]
D4	If answered yes Qn F3, what type of social group?	1.Farmers' group 2. Farmers' association 3.Agricultural cooperative 4.Saving and Credit Cooperative (SACCOs) 5.Other (specify)
D5	Which year did you join the social group?	

D6	In your group have you ever learned on how to use mobile phones to access paddy information for adaptation to climate change?1= Yes, 2=No [_]	
D7	If you have meetings, how many meeting did you attend per year	
	Market	
D8	What is the distance to the nearest local market____________________km	
D9	Do you seek market information before you sell paddy? 1= Yes, 2=No	
D10	If answered yes to Qn D9 , How do you get market information?	1.Traders [_] 2. Brokers [_] 3. Relatives [_] 4.Nearby market post [_] 5. M-FAIS [_] 5.Others (specify)
D10	Do you use mobile phone to search for paddy market information? 1= Yes, 2=No [_]	
	Training	
D11	Have you ever attended any of the training on how to use mobile phone to access paddy information on climate change adaptation? 1=Yes 2=No [_]	
D12	If yes, who organised the training	1= NGO [_] 2=Agricultural extension workers [_] 3=Researchers [_] 4=Local government workers [_] 5=Religious institution e.g church, [_] mosque
D13	What is the frequency of attending those training per year?	
	Network connectivity	
D14	What is the level of mobile telephone coverage in your village (tick appropriate box)	1. No network connection [_] 2. Very weak network connection [_] 3. Moderate network connection [_] 4. High network connection [_]
	Access to credit (formal and informal)	
D15	Do you have any loan for use in paddy growing 1=Yes 2=No [_]	
D16	If yes, state the source of the loan	1. Commercial bank [_] 2. Micro-finance institution [_] 3. NGOs. [_] 4. SACCOS [_] 5. Informal [_]
D17	Did you use the loan to get paddy information for climate change adaptation using mobile phones? 1=Yes 2=No [_]	
D18	If yes Qn D17, how did you use it?	1. Buying the mobile phone device [_] 2. Recharging the mobile phone [_] 3. Both [_]
	Access to agro dealer	
D19	Do you have any agro dealer in your village? 1=Yes 2=No [_]	
D20	If No, where do you frequently get agricultural inputs?	1. From near by agro dealer [_] 2.From informal agro dealer [_]
D21	Do you use mobile phone to communicate with agro dealer? 1=Yes 2=No [_]	

D22	If yes, what kinds of paddy information for adaptation to climate change do you access using mobile phone?	1 Advice on how to use paddy inputs [_] 2.Get update on the agricultural input using mobile phone [_] 3 Price of agricultural input [_]
	Availability of FM radio	
D23	What is the level of FM radio coverage in your village *(*tick appropriate box*)*	1. No Coverage [_] 2. Very weak coverage [_] 3. Good coverage [_]
D24	Do you FM radio to access paddy information for adaptation to climate change?1=Yes 2=No [_]	
	Weather information	
D25	Do you use mobile phone to get weather information 1=Yes 2=No [_]	

Appendix 2:Key infortants Checklist

A: General information
1. Title of key informant: ………………………………………………
2. Sex: Male [__] Female [__]
3. District:____________________Ward

Experience (in years) with the work position?

B. Use of mobile phone to access rice information for climate change adaptation

4.In your opinion, do farmers use mobile phones rice information on adaptation to climate change to farmers? [__] YES [__] NO, if Yes how? Have you ever contacted farmers for agricultural information?

4. If yes, what kind of rice information on adaptation to climate change did you communicate with farmers

   ____

   ____

   ____

6.What ways do farmers use mobile phone to access rice information for adaptation to climate change____
____
____

7.What are the major sources of information do farmers contact to access rice information on adapation to climate change using mobile phone

____
____

8.What are the challenes limiting farmer to use mobile phone in accessing rice information for adapation to climate change

____

____

9.What are other major source of rice information for adaptaion to climate change on your area

Appendix 3: Focus Group Discussion checklist

1. What kind of rice information for adaptation to climate change do they communicate through mobile phones?
2. Whom do farmers contact for accessing rice information for adaptation to climate change through mobile phone?
3. What factors limiting use of mobile phone in accessing rice information for adaptation to climate change through mobile phone?
4. What are other sources of rice information for adaptation toclimate change?