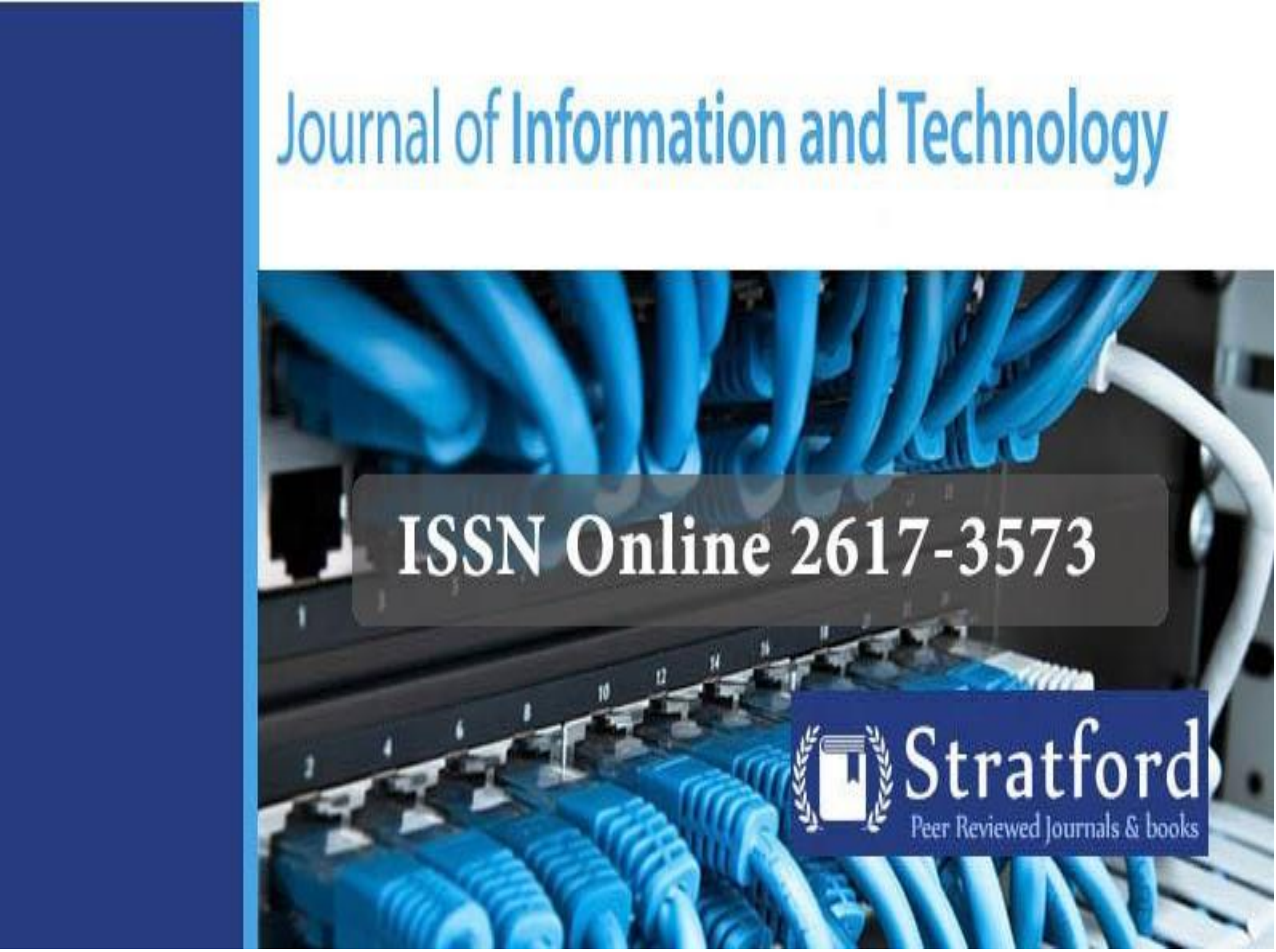

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Abstract

This study aimed to establish the influence of ICT weather forecasting on agricultural productivity in Kenya. The paper used a desk study review methodology where relevant empirical literature was reviewed to identify main themes and conclusion drawn based on the reviewed literatures. The study was guided by the following specific objectives; to establish the ICT weather forecasting practices used on agricultural production in Kenya, to establish the extent of use of ICT on weather forecasting in Kenya and to determine the challenges hindering ICT weather forecasting on agricultural productivity in Kenya. Agriculture in Kenya is an important fundamental in economic development; it contributes 35% of the gross domestic product (GDP) and constitutes 40% of the export earnings. Thus, weather forecast helps farmers on many fronts such as helping them make informed decisions. Weather affects the entire agriculture chain, whether it is determining which seeds are most effective in certain soil conditions, helping farmers decide how much water to use for crops, or deciding how many crops to raise based on weather conditions at various level. Precision agriculture based upon weather analytics is becoming even more important. Information and communication technology in agriculture (ICT in agriculture), has been developing and applying innovative ways to use ICTs in the rural domain, with a primary focus on agriculture on weather forecasting. The study concluded that climate uncertainty also has a negative impact on the providers of credit and markets for productive inputs and can make it difficult for smallholder farmers to benefit from agricultural markets. Climate information reduces uncertainty and can help farmers make better use of new seeds and technologies. The study recommended that meteorologists should consider linkages with end users of forecast information to develop user-oriented products, communicate the information in the user's local languages (particularly the pastoral communities), and develop techniques for raising the awareness of the user communities on the benefits of using weather information in agricultural practices decision-making. The study recommends that weather forecasts be devolved to the counties in developing informed agricultural decisions. It further recommends that language and communication of the weather information be improved in temporal and spatial scales with the use of new and emerging technology. KMS should enhance its efforts in awareness creation and public understanding of weather services

Key words: ICT, *Weather Forecasting, Agricultural Productivity & Kenya*.

1.1 Introduction

In Kenya, agriculture provides a livelihood for most of the 75 percent of the people who live in rural areas in Africa. At the same time, these areas have the largest concentration of poverty and food insecurity. Poverty as a result of low income is attributed to low productivity of agriculture. Agriculture in Kenya is key to the development of Kenya, contributing directly to over 35% of the Gross Domestic Product (GDP). A significant fraction of government revenue is allocated to achieving food security in the country, thus, agriculture is given special emphasis in national development policies and strategies, including the Poverty Reduction Strategy Paper and Kenya Vision 2030. According to Kanui, Kauti and Mwobobia (2016), attempts to reduce poverty should therefore pay special attention to transforming the agricultural sector, especially sustained improvement of land and labor productivity in the sector, facilitated by remunerative markets.

Extreme weather and climate changes are a big risk factor in agriculture in Kenya. In most cases, good rains are followed by warm sunny days that get hotter and drier (Henze & Ulrichs, 2016). One of the great challenges of weather and climate science is estimating the probability of the occurrence, severity and duration of weather events, as well when and where the event will take place. This uncertainty poses major threats to small-scale farming in Kenya where about 80% of the population depend on rain-fed agriculture (Sibiko & Qaim, 2017). The harsh effects of climate change have continued to exacerbate enormous difficulties among the poor households who are risk averse, leaving them more vulnerable and food insecure in many months of the years (Krone, Dannenberg & Nduru, 2016). A sure knowledge base from systematic observation and forecasting services is therefore essential to monitor climate; detect and attribute climatic change; improve the understanding of the dynamics of the climate system and its natural variability; provide input for climate models; and thus plan adaptation options (Tata & McNamara, 2018).

In order to help meet these challenges, more investment in disaster risk reduction is needed, including building the capacity to anticipate risks and as well as provision of relevant and accurate weather and climate information services as an early warning strategy (Birch, 2018). Skillful seasonal climate forecasts can also help to not only reduce climatic uncertainty, but also reduce livelihood risk to farmers and fishers only if the uncertainty associated with the forecast is accurately communicated, understood and integrated into the decision process (Duncombe, 2018).

1.1 Background to the Study

The Kenya meteorological Department (KMD) is the primary source of weather forecasts, as well as of historical weather data records that are needed for index insurance services (KMD, 2018). In recent years, free and open data initiatives for weather and agriculture have emerged to help national meteorological agencies and commercial weather companies provide better weather forecasts in the developing countries.

According to Bendre, Thool & Thool (2015), modern-day skillful weather forecasts are based on the numerical weather prediction approach, involving computer-based modelling from a set of initial atmospheric and environmental conditions. Weather forecasting involves the application of current technology and science to predict the state of the atmosphere for a future time and a given location (Chithra, 2015). Weather forecasts are made by collecting as much data as possible about the present state of the atmosphere, which includes temperature, humidity, wind, and the understanding of atmospheric processes to determine how the atmosphere will evolve in coming weeks. Weather forecast accuracy can be very sensitive to the reality of the specified initial conditions, highlighting the importance of high quality observational data and its geographical coverage, both horizontally and vertically (Gollin, Lagakos & Waugh, 2014).

Over the centuries, as farmers have adopted more technology in their pursuit of greater agricultural productivity, the belief that 'bigger is better' has come to dominate farming, rendering small-scale operations impractical. Effective adoption of Information and Communication Technologies (ICT) has proven record in many parts of the world and a demonstrated potential to attain significant economic, social and environmental benefits at local, national and global levels (De Janvry, Macours & Sadoulet, 2017). The past four decades have witnessed numerous attempts to understand the mechanisms of the adoption of technological innovation.

ICT in agriculture has been developing and applying innovative ways to use ICTs in the rural domain, with a primary focus on agriculture. ICT in agriculture offers a wide range of solutions to some agricultural challenges. It is seen as an emerging field focusing on the enhancement of agricultural and rural development through improved information and communication processes (Gollin, Lagakos & Waugh, 2014). In this context, ICT is used as an umbrella term encompassing all information and communication technologies including devices, networks, mobiles, services and applications; these range from innovative Internet-era technologies and sensors to other pre-existing aids such as fixed telephones, televisions, radios, machinery and satellites.

ICT in agriculture continues to evolve in scope as new ICT applications continue to be harnessed in the agriculture sector. ICT in agriculture involves the conceptualization, design, development, evaluation and application of innovative ways to use ICTs in the rural domain, with a primary focus on agriculture. Provisions of standards, norms, methodologies, and tools as well as development of individual and institutional capacities, and policy support are all key components of ICT in agriculture (Palis, 2017).

Despite occurrences of drought with attendant crop failure and occasional famine, flooding with the attendant loss of human life and destruction of property and the impacts of other phenomena on socio-economic development, there has been very limited research done to quantify the benefit of weather and climate information and services. This study sought to establish the influence of ICT weather forecasting on agricultural productivity in Kenya.

1.2 Statement of the problem

Agriculture in Kenya is an important fundamental in economic development; it contributes 35% of the gross domestic product (GDP) and constitutes 40% of the export earnings. Thus, weather forecast helps farmers on many fronts such as helping them make informed decisions (Kanui, Kauti & Mwobobia, 2016). Weather affects the entire agriculture chain, whether it is determining which seeds are most effective in certain soil conditions, helping farmers decide how much water to use for crops, or deciding how many crops to raise based on weather conditions at various level (Karanja, 2018). Precision agriculture based upon weather analytics is becoming even more important. Information and communication technology in agriculture (ICT in agriculture), has been developing and applying innovative ways to use ICTs in the rural domain, with a primary focus on agriculture on weather forecasting (Kibunja, Kihoro, Orwa & Yodan, 2014).

Almost every single activity in the modern world is becoming more dependent on the application of ICT for one use or another. Weather forecast accuracy can be very sensitive to the reality of the specified initial conditions, highlighting the importance of high quality observational data and its geographical coverage, both horizontally and vertically (Muriithi, Olago, Ouma & Oriaso, 2018). The predictability of weather conditions varies with time. Although Kenya Meteorological Services issues seasonal climate forecasts climate variability continues to affect life support systems on which small holder farmers depend, severely affecting not only households but also national food security and general social order in Kenya. However, it is complicated by the fact that the reaction of various agricultural plants to type and intensity of peculiar weather phenomena is different. This paper aimed to establish the practices in weather forecasting in Kenya and how it affects agricultural productivity where conclusions and recommendations are given.

1.3 Research Objectives

The study was guided by the following specific objectives;

i) To establish the ICT weather forecasting practices used on agricultural productivity in Kenya.
ii) To establish the extent of use of ICT on weather forecasting in agricultural productivity Kenya
iii) To determine the challenges hindering ICT weather forecasting on agricultural productivity in Kenya

1.4 Research Questions

The study was guided by the following research questions;

i) What are the ICT weather forecasting practices used on agricultural production in Kenya?
ii) What is the extent of use of ICT on weather forecasting on agricultural productivity in Kenya?
iii) Which are the challenges hindering ICT weather forecasting on agricultural productivity in Kenya?

2.1 Literature Review

In literature review, the study reviewed both the theoretical framework and the empirical review related to ICT weather forecasting and agricultural productivity.

2.2 Theoretical Framework

2.2.1 Theory of Technology Acceptance Model

Davis (1986) developed the Technology Acceptance Model that deals more specifically with the prediction of the acceptability of an information system. The purpose of this model is to predict the acceptability of a tool and to identify the modifications that must be brought to the system in order to make it acceptable to users. This model suggests that the acceptability of an information system is determined by two main factors: perceived usefulness and perceived ease of use. Perceived usefulness is defined as being the degree to which a person believes that the use of a system will improve his performance (Aubert, Schroeder & Grimaudo, 2012). Perceived ease of use refers to the degree to which a person believes that the use of a system will be effortless.

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Several factorial analyses demonstrated that perceived usefulness and perceived ease of use could be considered as two different dimensions.

Technology Acceptance Model postulates that the use of an information system is determined by the behavioral intention, but on the other hand, that the behavioral intention is determined by the person's attitude towards the use of the system and by his perception of its utility. According to Davis, the attitude of an individual is not the only factor that determines his use of a system, but is also based on the impact that it may have on his performance (Venkatesh, Thong & Xu, 2012). Therefore, even if an employee does not welcome an information system, the probability that he will use it is high if he perceives that the system will improve his performance at work. Besides, the Technology Acceptance Model hypothesizes a direct link between perceived usefulness and perceived ease of use. With two systems offering the same features, a user will find more useful the one that he finds easier to use.

According to Davis (1986), perceived ease of use also influences in a significant way the attitude of an individual through two main mechanisms: self-efficacy and instrumentality. Self-efficacy is a concept developed by Bandura (1982) which explains that the more a system is easy to use, the greater should be the user's sense of efficacy. Moreover, a tool that is easy to use will make the user feel that he has a control over what he is doing. Efficacy is one of the main factors underlying intrinsic motivation (Marangunić & Granić, 2015) and it is what illustrates here the direct link between perceived ease of use and attitude. Perceived ease of use can also contribute in an instrumental way in improving a person's performance. Because the user will have to deploy less effort with a tool that is easy to use, he will be able to spare efforts to accomplish other tasks.

The technology acceptance model theory is relevant as it specifies behavioral beliefs, perceived usefulness and perceived ease of use, as determinants of attitude towards behavioral intentions and IT usage behavior. In TAM, behavioral intention to use, leads to actual ICT usage behavior. Behavioral intention is determined jointly by attitude and perceived usefulness, where perceived usefulness also affects attitude directly. The theory assists to portray how technology adoption in agriculture could be used to bring out improved productivity.

2.2.2 Bob Doppelt Theory

Doppelt theory proposed in 2008 argues that global warming is not, at its core an energy, technology or policy problem. It is the greatest failure of thought in human history. He points out that global warming and today's other environmental, social and economic problems therefore cannot be resolved merely through more-efficient technologies or cap-and trade policies. Fundamental change in thinking and perspectives will be needed (Doppelt, 2017).

This theory holds that a sustainable development model focuses on economic sustainability, which involves the development of a healthy economy that supports and sustains people and the environment over the long-term. This theory shows that in a market driven economy, cost is a deciding factor in determining whether a project moves forward (Pike, Doppelt & Herr, 2013). To be sustainable, projects must not only provide environmental and social benefits but also offer economic value. This theory relates to this study in such a way that forecast application is highly dependent on how people think about it, the action taken and therefore the outcome. Based on these ideas, farmers‟ perception of any forecast is affected by their way of thinking (Doppelt, 2017). The actions taken in terms of response strategies to the forecasts are dependent on availability of the resources. This could either enhance forecast use or impede its application. This

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in turn has a greater effect on the outcome of any agricultural practice, there by influencing the food security situation in the region and in the country as a whole.

This therefore means that forecast application by farmers will be increased if information about how it should be used is downscaled to the poor rural small holder farmer. This could influence how they perceive it and therefore their willingness to use it in their farm level decision making. The economic value attached to it due to improved production, income and food security could eventually encourage farmers to be more willing to use the forecast in order to improve their productivity, food security and therefore income.

2.3 Empirical Review

The empirical literature was reviewed on ICT weather forecasting practices, extent of use of ICT on weather forecasting and the challenges hindering ICT weather forecasting.

2.3.1 ICT Weather Forecasting Practices

Kenya Meteorological Department (KMD) is the institution that is mandated to collect and store climate data in Kenya. Data collection is undertaken through the climate observing stations operated by the institution and also through collaboration with other institutions and volunteer observers (KMD, 2018).

The Numerical Weather Prediction (NWP) section of the Kenya Meteorological Department is one of the sections within the Forecasting Division of the Department. The computer models used for numerical weather prediction calculate the formation, growth, movement and decay of the systems within which weather events, including severe weather, are embedded. The models are complex and integrate fluid motion, thermodynamics and radiation on a rotating globe that includes topography, land and seas differences and the diurnal cycle. In addition, mathematical schemes for representing very small-scale processes, such as cloud and turbulence are included (KMD, 2018).

According to Masinde, Bagula and Nzioka (2013), extensive weather station networks are needed for monitoring key climate parameters such as wind speed, precipitation, barometric pressure, soil moisture, wind direction, air temperature and relative humidity. These parameters may be used both for forecasting and for decadal climate modelling. The technologies needed include weather satellites and both local and remote automated weather stations. Satellite observations include: visible spectrum cameras to detect storms and deforestation; infrared cameras to detect cloud and surface temperatures and sea level rise; particle detectors of solar emissions (KMD, 2018). The accuracy of climate (general circulation) models, is being continuously improved through better understanding of the basic science (including the impacts of clouds, for example); advances in the technology, as observed by Moore’s law, whereby the processing power of computers doubles every two years, and by more extensive data gathering through weather and environmental sensors connected to telecommunication networks. In order to make relevant information available to local communities these models are being extended to predict changes in regional and local weather and sea level extremes (KMD, 2018).

Ochieng, Recha and Bebe (2017) conducted to assess use of seasonal climate forecasts as strategies for securing pastoralists assets in arid and semi-arid lands (ASALs) of Baringo County. The study used five (5) study locations that were purposively picked to ensure that they fall within the ASAL agro-ecological zones, LM5 and IL6. The total sampled households from the five locations was 221. The study used data from household survey to establish barriers to use of seasonal climate forecasts, use of traditional climate information and enabling conditions. Mean comparisons and frequencies of ratings were generated to ascertain the use of traditional climate information among the respondents. Sensitivity analysis was useful in identifying the most significant barriers to uptake of seasonal climate forecasts and the best and most significant enabling conditions/institutions to the access and usage of climate forecasts. The study established that majority (72.4%) of the respondents relied on traditional climate forecast methods than scientific methods in decision-making. The factors with greater influence on uptake of seasonal climate forecast information were lack of information, access, diversified sources of income and insecurity/conflicts, illiteracy and culture. The institutions with large influence were knowledge dissemination linked to radio and extension services and local climate information.

In Kenya, many communities rely on indigenous knowledge for agriculture, food processing and storage, but indigenous forecast methods have not been ventured in as an important resource for enhancing agricultural production in most areas (Kanui, Kauti & Mwobobia, 2016). Kenya being an agricultural country that depends on rain-fed agriculture requires maximum use of seasonal climate forecast. The regional nature of seasonal forecast may limit their relevance for planning at national and local level. Finer scale forecast and more fine-tuned early warning systems, accompanied by a rapid delivery of information is needed (Gollin, Lagakos & Waugh, 2014). Kenya Meteorological Services (KMS) is responsible for monitoring and forecasting weather and climate in Kenya, including seasonal forecast. In spite of the slight improvement in forecasting accuracy, the present forecasting accuracy, which is 75%, is still not sufficient as challenges are still numerous due to the strong spatial and temporal variability nature of weather events. These scientific forecasts are formulated at a much larger scale, diverging with local needs.

Kenyan farmers have relied on traditional weather forecasting for generations. Some fear these methods will be discarded as climate change brings more extreme and unpredictable weather (Guthiga & Newsham, 2011). Others say that indigenous knowledge and methods remain valuable especially when used together with modern science. The Kenya Meteorological Department infers that traditional practices have something to offer. The Department now blends these forecasts with science-based predictions. The result is more accurate and better-received local weather forecasts in most regions of Kenya. The Department uses satellite technology and other modern methods to produce forecasts (Luseno, McPeak, Barrett, Little & Gebru, 2013).

In Kenya for example, localized flooding, droughts, and lightning strikes are observed in parts of the country almost every year. These extreme weather events in the country are often associated with very severe socioeconomic impacts that include lack of food, water, energy, and many other basic needs including destruction of infrastructure as well as loss of lives (Muriithi, Olago, Ouma & Oriaso, 2018). Such impacts have tended to retard socioeconomic growth of the country with the ultimate enhancement of poverty. Currently, majority of the rural communities live under dire poverty since agriculture on which they depend for their livelihood has become more and more sensitive to severe and extreme weather events (Sagero, Shisanya, Ongoma & Shilenje, 2016).

Different regions require different weather information. KMS produces various forecasts and early warning products (Gichangi, Gatheru, Njiru, Mungube, Wambua & Wamuongo, 2015). They include historical and past climate records, real-time and near-real-time weather information, now casting for airport services, short-range weather forecasts, medium- range weather, long-range weather forecasts, and climate predictions. KMS also provides climate change information and severe weather advisories. This information helps in identifying suitable activities for specific areas and period to reduce weather related risks.

2.3.2 Extent of use of ICT on Weather Forecasting

According to Daniel and Cheserek (2018), pastoral communities have used indigenous forecasting methods for a long time to predict seasonal climatic events. Some pastoral communities observe clouds, wind and lightning that likely have their origins in traditional understandings of what contemporary researchers recognize as atmospheric science. Others watch the behavior of livestock, wildlife and the local flora. Indigenous early warning signs of weather changes are not only limited to livestock-keeping communities.

According to Musembi and Cheruiyot (2016), most of the products of KMS are highly time sensitive and thus need to be disseminated to the users in the fastest modes possible. Faster communication of weather information has proved to be a major challenge to many weather organizations, although Kenya has developed a vibrant communication system. The channels used in the dissemination of the meteorological products in KMS include press releases, interaction with media personnel, radio and TV channels, email services, government line ministries, website, and social media. At the county levels where KMS has now decentralized its services, the information flow channels are offices of the county directors of meteorology, radio, and Internet communications project, Community Based Organizations, sub county development committee meetings, and chiefs' "barazas."

Shilenje and Ogwang (2015) finds that partnership between the Kenya Meteorological Department and community radio stations is bringing weather alerts to four parts of Kenya. The stations are operated by the Radio and Internet Communication System, or RANET. They broadcast to Kangema, Narok in the Rift Valley, Budalangi in western Kenya, and Kwale in the coastal region. However, many communities still rely on traditional forms of climate forecasting by mainly using environmental, meteorological and astronomical indicators. Local communities have developed intricate system of gathering, predicting, interpreting and decision making in relation to weather.

Liang (2017) finds that changes in weather patterns, coupled with the increased frequency and intensity of severe weather are resulting in fewer growing days rendering traditional farming methodologies increasingly less reliable. Local residents in most cases do not understand the meteorological forecast. Despite modernization and global change, indigenous methods used to predict weather still play an important role in decision making in rural livelihoods.

2.3.3 Challenges hindering ICT Weather Forecasting

According to the Kenya Meteorological Department (2018), weather forecasting for agricultural use faces various challenges. The observation network is not well distributed throughout the country. Such distribution is necessary in order to observe smaller scale climate conditions that are influenced by small scale features such as topographical variations among others. The optimum number requirement of synoptic stations is seventy seven. The Department is faced with inadequate funds to purchase consumables whose cost is increasing. For this reason upper air observations in Garissa and Lodwar are currently not active and the Dagoretti one operates only once a day instead of twice as required. There is an inadequate technical capacity for operation and maintenance of equipment. There is lack of necessary infrastructures such as electricity, or access roads in some important observing stations. The department is faced with insecurity in some of the areas where observation sites are located. Some of the equipment was installed a long time ago but there are inadequate funds for their rehabilitation or replacement. The Department does not have adequate personnel as required in order to efficiently carry out observation obligations.

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Data collected by volunteer observers is not collected on a regular basis as required perhaps because the observers have other commitments (KMD, 2018).

According to Mwaniki and Stevenson (2017), KMS lacks modern facilities for data analysis and integration of products necessary to overlay various products for realization of more accurate forecasts. There therefore is a need to improve and refine the weather models used and enhance the capacity in numerical weather prediction and dynamical modelling as well as the remote-sensing techniques. Ultimately, KMS should acquire modern facilities for data analysis and information presentation.

Karanja (2018) finds that there is limited clarity on what forecast formats are best suited to user needs although it is known that the optimal format may vary between applications. Use of information, once received, is not straightforward and if inappropriately used may lead to further difficulties. Production and delivery systems are somewhat fragmented and consequently it is sometimes difficult for forecasts to reach those end users who may have particular need for the information. End users often perceive a need for temporal and spatial detail (e.g., exact rainfall amounts, onset, and cession dates) in the prediction that currently cannot be achieved with much accuracy (Shilenje & Ogwang, 2015). Best method from the scientific perspective of delivering outlooks is through probabilistic approaches. Probability forecasts, however, are often viewed as being difficult to understand and act upon.

2.4 Conceptual Framework

The conceptual framework provides a diagrammatical illustration that shows the connection between the independent and dependent variables. The figure below depicts the relationship between ICT weather forecasting and Agricultural production as shown ion Figure 1.

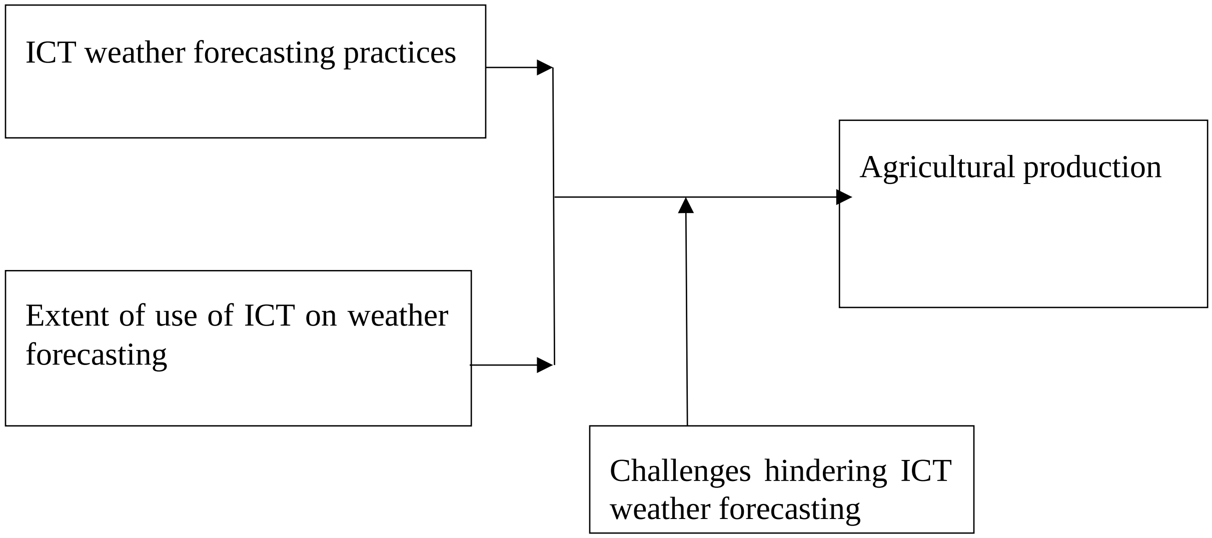

Figure 1: Conceptual Framework

3.0 Research Methodology

The study sought to establish the influence of ICT weather forecasting on agricultural productivity in Kenya. The paper used a desk study review methodology where relevant empirical literature was reviewed to identify main themes. A critical review of empirical literature was conducted to establish the influence of ICT weather forecasting on agricultural productivity in Kenya.

4.0 Results and Discussion

The socioeconomic wellbeing of the Kenyan communities is very sensitive to severe weather and extreme climate events. The country often experiences loss of life and destruction of property because of severe weather events such as floods and landslides, wind gusts, lightning, and prolonged droughts.

A large percentage of the rural communities within the country live below the poverty line since rain-fed agriculture, on which they rely for their livelihood has become more and more sensitive to severe weather that is now prevalent. Skillful and timely weather forecasts can help the government and communities mitigate the negative impacts of severe weather events through proper planning. This is the essence of an effective early warning system. The basic idea behind early warning is that the earlier and more accurately we are able to predict the likelihood of occurrence of natural and human induced hazards, the more likely we will be able to manage and mitigate a disaster's impact on society, economies, and environment. The warning lead-time should be sufficient to allow appropriate measures to be put in place.

Effective climate services rely upon locally relevant climate data tailored to farmers' needs. Under-resourced national meteorological services need support to be able to supply such information over large areas. Forecasts must reach remote rural communities in time for farmers to make use of them. Mobile phones and rural radio have been successfully used to convey weather information to a very large audience. Nevertheless, personal interactions are probably most effective for communicating complex climate messages.

Monitoring, prediction, and timely early warning of the aforementioned extreme events are favorable strategies for mitigating their negative impacts on humanity and property. This therefore calls for the existence of an effective and efficient early weather warning system. By definition, early warning provides timely weather information that allows individuals, organizations, or communities exposed to likely hazards take action that avoids or reduces their exposure to risks. An early warning system therefore involves data collection, information development, modes of dissemination, and action triggering mechanisms.

5.0 Conclusions

Climate uncertainty also has a negative impact on the providers of credit and markets for productive inputs and can make it difficult for smallholder farmers to benefit from agricultural markets. Climate information reduces uncertainty and can help farmers make better use of new seeds and technologies. Such information can be used to support complex and context-specific decisions about farm labour and resource allocation. Climate information should be accompanied by services that communicate, train and help users understand how to interpret and act on the information.

Changes in weather patterns, coupled with the increased frequency and intensity of severe weather are resulting in fewer growing days rendering traditional farming methodologies increasingly less reliable. Local residents in most cases do not understand the meteorological forecast. It was clear that despite modernization and global change, indigenous methods used to predict weather still play an important role in decision making in rural livelihoods. The study also concluded that farmers‟ perception of the forecast has an influence on how they would use these forecasts. Majority of the farmers rely on indigenous knowledge in weather prediction because of how they perceive it. They perceive indigenous methods forecasting methods to be more reliable than the scientific ones. Furthermore, the study revealed that socio-economic status of a farmer may impede or enhance the use of climate forecast information.

6.0 Recommendations

To overcome the challenges, meteorologists should consider linkages with end users of forecast information to develop user-oriented products, communicate the information in the user's local languages (particularly the pastoral communities), and develop techniques for raising the awareness of the user communities on the benefits of using weather information in agricultural practices decision-making. There is need for improvement of the modes of communication, for example, short messaging service (SMS) and common alerting protocol. Through collaborating with intermediaries, KMS is able to disseminate weather information services to county and sub county levels using modern technology available, that is, SMS at reasonable speed and cost.

The study recommends that weather forecasts be devolved to the counties in developing informed agricultural decisions. It further recommends that language and communication of the weather information be improved in temporal and spatial scales with the use of new and emerging technology. KMS should enhance its efforts in awareness creation and public understanding of weather services. This leads to increased uptake and confidence in applying the weather knowledge in agricultural planning and alleviating risks on societies. Partnerships between public and private sectors are enhanced by sharing lessons learnt and efforts being made to mitigate weather related hazards and protect crops.

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