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Utilizing ICTs in Climate Change Resilience Building Along Agricultural Value Chains in Sub-Sahara Africa

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A R T I C L E I NFO

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ABSTRACT

This study, reviewed the challenges faced by agribusinesses in improving their value chains while under risks of climate change and variability in SS Africa. The study is anchored on the The study is anchored on Motivational Model (MM) and Uses and Gratification Theory.It identified challenges facing them as they attempt to adopt ICT. These ranged from poor access to ICT infrastructure, poor rural infrastructure, poverty, illiteracy, market failures, poor governance/institutional barriers and behavioural barriers among others. We also observed that some ICT tools (e.g. GIS, use of wireless communications, early warning systems and E-resilience development) are capable of boosting agricultural productivity of African's smallholder along value chain even when under climate variability. We documented other adaptation measures farmers were adopting to cope with climate change and variability which include altering of production patterns, adopting new technologies and other climate smart agricultural practices from across SSA. The study also identified options available to African agribusiness and authorities to build resilience against climate change risks such as GIS, E-Governance, Wireless Communications and Early Warning Systems. Such ICT tools can raise the agricultural productivity of African's smallholder farmers across the produce value chain under climate variability in various ways. Based on the findings, the provision of ICT infrastructure, capacity building of farmers and authorities; formulation of appropriate policies that can improve the resilience and productivity of agriculture with ICT tools were some of the key recommendations.

1.0 Introduction

Over the recent years Information and Communication Technology (ICT) has become a very useful tool available for use by both individuals and institutions in mitigating and prevention of harsh impacts of various forms of shocks and emergencies that can affect both economic and physical well-being (World Bank, 2012). Agriculture, the most significant livelihood activity to most of the citizens of Sub-Sahara Africa (SSA) is under the threat of climate change. Even though agricultural activities (which engage about 70 percent of SS Africans) serves as both a mitigating industry and at the same time a major source of carbon sequestration. It is also a major source of global biofuel supplies. According to FAO (2003) in SSA where the level of dependency on agriculture for job creation and provision of household incomes is very high agricultural transformation remains one of the best approaches in developing the local food supply and availability. Unfortunately, credible institutions are warning about impending negative impacts of climate change with some degrees of positive impacts in some areas especially in SSA (Inter-Governmental Panel on Climate Change, IPCC, 2001a, 2001b, 2001c).

Of late, climate variability unarguably continued to influence temporal fluctuations recorded in SS African agricultural production and other low income economies of the world. The most serious threat, according to IPCC (2001a) is drought. A fluctuation of that nature could be reversed through investment in irrigation or via import of foods. However, these options are very difficult for low-income economies as SSA countries. Any level of decline in the quantity and quantity of available agricultural resource to the farmers can spell a significant negative effect on their livelihoods (especially food security).

So far, the responses to these threats have largely been confined to boosting economic growths and diverting economies from over reliance on agricultural resources that are vulnerable, developing new resilient technologies capable of adapting to the varying ecological conditions and climate change. So far, at the regional, national and local levels, many new policies have been formulated to facilitate uptake of resilient practices including a host of innovative financing mechanisms aimed at insulating farmers from the negative effects of climate change. Unfortunately, there are no sufficient documentation on how such innovations have worked or how they can be up-scaled for improved agricultural productivity and resilience building across the Sub-Sahara African agricultural value chains.

For instance, while identifying the key the UN Economic Commission for Africa (UNECA) (2014) identified the major, comprehensive options Africa could adopt in responding to various climate change scenarios predicted for the current and projected periods left out the use of ICT. This assertion was corroborated by Ospina and Heeks (2010) who regret that a review of literature on ICTs and climate change showed that "not only is the literature, overall fairly limited to date", but were seriously deficient in discussion of contemporary country priorities and climate change adaptation. The issue of small scale farmers in developing economies who remained locked out of access to critical information needed to build up their agricultural productivities were insufficiently addressed. Meanwhile, if given access to the right information and conditions, these farmers can attain the frontier of their productivity growth (Plechowski, 2014). FAO (2003) offered hope when it observed that progress in scientific knowledge and technology which we now have could potentially help in improving crop productivity. It is therefore surprising that even in this present information age, not much is known about how ICT can be effectively utilized in building resilience against shocks related to climate change and variability. Just like agricultural market information, climate information can help farmers, agricultural policy makers, commodity consumers and traders, researchers and other agricultural stakeholders in African agricultural value chain to take an informed course of action that will result in value addition to agriculture. Since current options in ICTs have not been well explored by policy makers and stakeholders in African agriculture as earlier noted, this study therefore comes as a timely response to this gap.

1.1 Research Aim and Objectives

The broad objective of this research therefore, is to review the options available in literature amenable to the use of ICT for disseminating climate information which can strengthen the entire agricultural value chain in SSA. Specifically, the following objectives were explored, to:

(i) describe the climate change related challenges faced by farmers in their attempts to improve their value chains in SSA;

(ii) explore options available to African agribusiness firms to build resilience against climate change risks that face different aspects of agricultural value chain in SSA.

(iii) describe the major challenges faced by farmers in improving productivity along value chains of agriculture in SSA.

1.2 Theoretical Frameworks

The study is anchored on two major theories of innovation and technology adoption : Motivational Model (MM) and Uses and Gratification Theory. The Motivational Model, a theory proposed by Davis, Bagozzi and Warshaw (1992) holds that use of any system is explained by two major factors: intrinsic and extrinsic motivation. The extrinsic motivation is a perception which holds that users or adopters of technologies (or innovation) are goaded to carry out a given activity as a result of their perception that the activity will be instrumental in attaining some valued outcomes that are distinct from the activity itself, such as improved productivity of their production system. On the other hand, the users of the technology or innovation may like to embark on some activities with no vivid reinforcement besides the process of adopting the technology or carrying out the activity per se. Davis et al (1992) idndicate that while percieved usefulness may be a perfect example of an extrinsic motivation, perceived enjoyment or gratification is an example of an intrinsic motivation. Thus, in general the *quality of output and users' perceived ease of use exerts major impact on the perceived enjoyment and usefulness of adoption of the technology.*

Taherdoost (2017) reviewed the Uses and Gratification Theory (U&G Theory) as proposed by Grellhesl(2010) and Chen et al (2015). The theory analyses the factors that drive people's involements in communication medium compared to others. This use of media has gained much from gratifications. The U&G Theory focuses more on the social and psychological dimensions of users' use as they seek for motivation and satisfaction. The theory constitutes of three major aspects: constructs, motivations, behavioural utilization and gratification or satisfaction. They see motivation as the general dispositions which exerts effects on individuals for their requirements. Accroding to Terhdoos (2017) the U&G model is applicable in media environment for communicaation purposes and can also be used where the media is used for work process (such as agriculture in our case) or games.

2.0 Literature Review

2.1 Climate Change and its Impacts on Agriculture in Sub-Sahara Africa

IPCC (2001a) defined climate change narrowly as "the statistical description, in terms of the mean and variability of quantities such as temperature, precipitation and wind over a period of time ranging from months to thousands of years." However, IPCC noted that, based on Meteorological Organization (WMO), the norm is 30 years. The term "Climate" differs from "weather" which refers to atmospheric conditions in a given place at a specific time. According to Wilkinson (2006) climate change connotes a major statistical variation in either the mean level of an area's climate or a variation in its variability over a long period of time, usually in decades or beyond. According to Morton (2007), some key climate risks affecting households include drought, flood, market shocks, crop and animal disease. According to the IPCC Fourth Assessment Report, temperature rises will surpass the expected global mean increase of 2.5^{o}C in every regions of SSA (Christensen et al., 2007 and TerrAfrica, 2009). In addition, global warming was expected to be intensive around the central semi-arid tropical fringes of the Sahara and the central southern Africa. In all, the subtropics were projected to get drier, with the tropics probably witnessing a slight increase in precipitation (Christensen et al., 2007; Cline, 2007 in TerraAfrica, 2009).

2.2 ICTs and Climate Information in Agricultural Value Chains

Minischetti (2013) defined ICTs as "any product that can store, retrieve, manipulate, transmit or receive information. Examples, personal computers, television, radio, email and mobile phones." Other types of ICTs found to be adoptable in agriculture, according to Minischetti, included Mobile Agriculture also known as mAgri); services related to provision of knowledge exchange networks and other information services for agricultural production such as: (i) mobile facilitated payment systems, (ii)financial services (e.g. electronic cash transfer services), (iii) weather forecasts, (iv) weather index, (v) market information services and (vi) agronomic information services. All these can help build the agricultural value chain as they link farmers to input providers, buyers, other farmers, meteorological agencies and financial institutions which will in the end help them boost their productivity across their commodity value chains.

With increasing popularity of mobile phone technology in developing economies, including SSA, ICT utilization for agricultural development is gaining ground faster than previously imagined. ICTs have been used for projects, such as for Projects involving monitoring water points, provision of cash transfers using mobile phones and applications (Apps) are forms of use of ICTs in farming. Livelihoods markets-based programmes, especially in rural and agrarian communities are now benefitting from some organizations who are adopting ICTs for strengthening their pro-poor service deliveries. Such programmes improve rural livelihoods through provisions of access to information like finding the best prices available at the nearest areas for farm inputs and products, locating transportation or vehicles that will convey their farm produce or help them travel around (e.g. Uber services), provision of weather forecasts and e-payment services, credit or insurance (Minisetti, 2003).

Small holder farmers too have the opportunities to raise their incomes by effective participation in commercial agricultural supply chains. However, Sen and Choudhary (2001) noted that a lot of challenges abound in attempting to include them in the highly commercialized agribusinesses systems. One reason they gave is that, for instance, for agribusinesses, high transaction and monitoring costs required to ensure quality, safety, and timely delivery are usually involved when other commercialized agribusinesses are interacting with a large group of small-scale farmers. These farmers may not be able to pay.

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Participation of the small holder farmers can pose high risks as there are other additional needs which they may not be able to meet up. For instance, there are further needs for access to inputs and training to satisfy stringent quality requirements which also attract costs. ICTs, while facilitating exchanges and flows of useful agricultural information between different parties all along the agricultural supply chain can equally aid in managing financial transactions, arranging logistics, and ensuring that quality specifications are well understood by the farmers before they supply the required goods by the consumers. However, when the right conditions are provided, agribusinesses can provide incentives, capacity, and necessary resources to provide and utilize appropriate technologies that can support inclusion of the small scale farmers too. Government at different levels have significant roles to play through relevant supportive policy formulation and implementation , forging public-private partnerships that can develop ICT applications. They can also do more by building and utilizing their own ICT applications for farmers too.

Markets do have strong roles to play in reducing farm households poverty in SSA and strengthening the agricultural value chains. However, there are a lot of constraints along the value chain that need to be surmounted for the smallholder agriculture to benefit from agricultural markets. These challenges range from -- problems of inadequate infrastructure, poor policies and weak institutions to poor provision of capacity building of farmers and inadequate access to technologies (including use and access to ICTs) as well as capital (ICRISAT, 2014). Miller and Jones (2010) defined value chain as a group of actors (including service providers, the public and private) and the various steps of value-adding activities encompassed in moving a product from production phase to the final consumer (or consumption). This is akin to what is referred to in agriculture as a ‘farm to fork’ group of processes and flows (Miller and da Silva, 2007 as cited in Miller and Jones, 2010). Paradoxically, value chain analysis also involves evaluation of the various agents and factors which significantly impacts on the performance of an industry, the relationships existing among its participants to proper identification of what constraints drive growth in efficiency, productivity and competitiveness of the industry, and how such challenges may be overcome (Fries, 2007 as cited in Miller and Jones, 2010).

Islam (2010) asserted that effective management of knowledge is said to have occurred "only if knowledge and information are conveyed to the right individual at the appropriate time in a user-friendly manner that is within reach thus helping the recipients to perform their jobs efficiently." They identified the outcome of effective knowledge management as including improved productivity of the agricultural sector's value chain. ICT has the capacity of penetrating the value chains to boost the knowledge and capacity of the value chain and thus raising farm productivities.

2.3 Challenges Facing Sub-Sahara African (SSA) Farmers in Improving their Value Chains Under Climate Change and Variability Risks

Approximately 80 percent of Africans south of Sahara reside in rural areas and depend on agriculture as their means of livelihoods, yet since 1991 there has been a declining trend in investment to agriculture by the governments of many African countries (UN Economic Commission for Africa [UNECA], 2011). Thus, over the years Agricultural productivity had declined significantly while poverty had increased owing to persistent increase in cost of agricultural inputs, prevalent market failure, inadequate access to farm credit, and rising cost of efficient irrigation in rural areas. To worsen the situation, many African countries failed to integrate climate change adaptation strategies (including building e-resilience e.g. use of ICT) into their national agricultural and economic development policies. The dearth of suitable policy frameworks to enhance such integration had largely resulted in the recorded decrease in investments in the agricultural and rural sector over these periods in contention. All these render agriculture in Africa significantly vulnerable to the negative effects of both short-term variability in climate and long-term change in climate.

The Fourth Assessment Report of the IPCC (1PCC, 2007) showed that temperature increase had been lingering since 1960s on the continent, though dotted with significant pockets of variations at different regions. These could potentially increase spoilage of foods in store, induce disease infestation and pests outbreak due to incidence of migrating insects and other pests. ICTs also hep in building knowledge on crops' projected responses to climate change in future through modelling of some crops' responses to climate change from controlled agronomic experiments using crop growth simulation models (Hassan, 2008). Such model have earlier shown projected poor yields and productivity which paints a worrying level of exposure to agricultural production risks in the entire agricultural value chain in Africa. Worsening the vulnerability of the agricultural value chains are factors such as too much reliance on rain fed agriculture, decay in the poor existing rural infrastructure, high poverty rates and poor status of physical and human capital development. The entire scenario compounds the problem of poor access to agricultural inputs and factor markets Therefore, to develop SSA agriculture would require radically new policies which will factor climate change into the development programmes and policies so as to stimulate the right investments from the public and private sectors in agriculture.

According to the International Food Policy research Institute (IFPRI) (2013), there had also been a steady increase in water scarcity and quality loss which have been attributed to increase in economic activities, population increase, negative impacts of climate change and inappropriate management of water resources. These reduce productivity in agriculture across various value chains too either in livestock production or in staple or cash crop production. For instance, livestock grazing grounds or ranges will be depleted or reduced in acreage as water scarcity deepens thus reducing even the available water for the livestock consumption. This will definitely affect the productivity of livestock in SSA.

With respect to increase ICT adoption in SSA, Productivity Commission (2012) identified the following major barriers : inefficient market systems, poor regulatory regimes, poor governance, weak institutions and behavioural barriers to adoption of ICT in agriculture. With respect to inefficient market system or market failures, we can see this when there are conditions that work against the attainment of optimal and efficient allocation of agricultural resources in the production process. For example, in the absence of appropriate information on climate change impacts useful for agricultural commodity consumers or for either private or public sector required for making well informed decisions on adaptation, a barrier to adaptation will occur. This then can worsen the problem of poor access to climate related information as well as poor market information system. This is where ICT can play a major role in providing information. Poor regulations such as inability to integrate building and town planning regulations can potentially hamper adaptation to climate change for instance where environmental hazards (which could be a consequence of this poor regulation) can result in flooding. Weak governance and institutions could become barriers when governance plans which are not in sync with best practices impede attempts to coordinate governments and agencies for instance leads to reduction in accountability or rather cause authorities to be assigned responsibilities for which they do not have any capacity to effectively execute. For instance, this can be seen when the present legal liability of councils is not known with certainty while making land use decisions related to a land that is vulnerable to future risk of climate change (Productivity Commission, 2012). With respect to behavioural adaptation, this implies how people assimilate and process information and make decisions with it and by so doing possibly constitute hinder effective adaptation. For instance, when given a projection on possible climate change impacts, an individual may be unable to assess the costs and benefits of decisions to be taken to adapt on a long term. This may result in such entities responding poorly to the real and uncertain impacts of climate change through deferment of needed adaptation decisions which could have been done in their own best interest.

Other barriers in adopting ICT in building resilience along agricultural value chains were equally documented for Ethiopia by UNDP (2012) as a case study for SSA. Davis et al (2010) as cited in UNDP (2012) noted that budgetary shortfalls, poor infrastructure as well as localized technical information were the major constraints to agricultural extension services in Ethiopia. Poor access to electricity and poverty which is exemplified by lack of electronic equipment such as TVs and computers that information workers and farmers needed to effectively discharge their works largely constrained their productivities. Owing to the fact that some schools in Africa do not have modern teaching equipment such as computers and access to the internet, it would be important to build capacities of teachers who can train young and old farmers whenever authorities concerned provide these facilities.

2.4 Available Options to Build Resilience Against Climate Change's Risks in SSA Agricultural Value Chains

According to IPCC (2007) resilience implies the ability of a system (ecological or social) to take in disorder without losing its fundamental composition and ways of operating. Resilience, as a concept extends to elements of transformation to better states. There have been a lot of practices and technologies adopted in the past and present in SSA and other places to build resilience in agricultural value chains against shocks of climate change. Some of these practices can be referred to as adaptation practices. Any adjustment by human or natural systems as a response to real or anticipated climatic stimulus or their impacts, which reduces harm to its minimum level or take advantage of rewarding opportunities is called *adaptation* (IPCC, 2001a, 2001b). The adaptation types could be anticipatory or reactive; planned or autonomous; public or private. The IPCC also referred to it as "the ability of a human or natural system to minimize potential damages, to take advantage of opportunities or to cope with the outcomes."

There are many other adaptation strategies applied by Sub-Saharan African farmers. These in specific terms include improving crops and agricultural practices, biofortification, erosion reduction and other use of climate smart agriculture to enhance resilience to climate shocks (United Nations Systems Standing Committee on Nutrition, 2014).Some of adaptation measures to climate change identified by Kaliba and Rabele (2009) included irrigation, mulching, crop rotation, terracing, contour planting, intercropping, cropping along flood plains, bonding, changing timing of planting, planting early maturing crop varieties etc. Empirical work of Kalibba and Rabele (2009) indicated that the most common adaptation strategy utilized by the farmers in building resilience against climate change and related environmental problems were crop rotation, fallowing, construction of waterways, vegetable cover, contour farming, sandbag construction and interplanting. Onyeneke and Nwajiuba (2010) in an empirical research found that diversification of crops planted, soil conservation measures, changing planting dates, planting of trees, irrigation and rainwater harvesting were the most common forms of adaptive strategies to the harsh effects of climate change by the crop farmers in Eastern Nigeria. Some other resilience building approaches related to livestock production include improved livestock management practices, rearing of disease resistant and hardy stocks of livestock as well as adoption of mixed farming.

On the policy side, earlier in this report, it was hinted that UNECA (2014) proposed a multifaceted options to Africa in responding to climate change scenarios whether it is the projected or current levels. These include applying appropriate policies; domestic and foreign mobilizing foreign finance; adoption of climate research for development (i.e. CR4D); investments on clean energy, irrigation and promotion of green economy.

Another way of building resilience that is yet to be largely explored in SSA is what is now referred to as building e-resilience. Ospina and Heeks (2010) defined "e-resilience" as "a property of livelihood system to adapt to the effects of climate change." E-resilience, they observed, more generally aimed at facilitating the process of identification, incorporation and analysis of ICT's potentials with respect to its contribution to climate change adaptation. This should be a part of the complex set of linkages and interactions already existing within the context They equally noted that with the use of geographic information systems (GIS), use of computer applications including positioning and modelling software, ICTs would be able to improve the physical readiness of livelihood systems for climate change related extreme events. These, then can subsequently improve the design of the defences and also determine their best location; and by so doing, enhancing the robustness of the livelihood system.

Sen and Choudhary (2011) noted that modern ICTs and their applications significantly affected smallholders' inclusion in commercial supply chains. Through the use of ICT applications, especially when guided by sound business logic, inclusion of small scale farmers can be enhanced through one or more of the following interventions in the agricultural supply chains: i) reduction of coordination costs. ii) enhancement of transparency in inter partners decision making process; iii) reduction of transaction costs; iv) dissemination of market demand and price information; v) transmission of weather related, pest infestation or outbreak and risk management information for more proactive decisions; vi) dissemination of best practices that can meet high quality and certification standards; vii) collection of management data from the farm or field; and viii) ensuring traceability. Such interventions, they noted, have were erstwhile driven by both private and public sectors. Due to a slight variation in their focus and resource base, the nature and sustainability of ICT applications they propound also varies.

An ICT tool called Supply-chain management (SCM) software running on networked computers and handheld devices typically can also be applied in African agribusiness firms to boost productivity under any conditions of uncertainty (including climate change and variability). This software has been discussed extensively in Payne (2010), and Sen and Choudhary (2011). Sen and Choudhary (2011) noted that the software performs some or all of the following functions: (1.) Stores data about suppliers. In the context of sourcing agricultural products from smallholders, this function would allow a food processing company to know which farmers grow what, as well as other information, such as farmers' names, locations, previous transactions, and previous performance. Such a database makes it much easier to deal with a large base of smallholders; (2) Allows the company to pass on an order to farmers. The order would stipulate what is required, when it will be collected, and how much will be paid for it; (3) Preferably, lets production to be monitored, making it possible to manage quality and incentivize high performing suppliers or support poorer performers.

(4) The software could also provide answers to queries such as which farmers are on schedule, which are behind, and how much product has already been collected from each farmer. If connected to the bank accounts or mobile transaction accounts of the procurer and supplier, such software might also transfer payments when orders are fulfilled. (5) Lastly, SCM software might track the transport of goods from the farm gate to the warehouse or retailer. Such tracking can give an explanation or data about what damage that could have hindered effective movement of agribusiness product from farm to the market probably because of risk of climate change related risks such as flooding or erosion which could have destroyed the roads on which the commodity were transported. The above functions can enable an agribusiness build financial resilience against climate change effects. For instance, it was noted that the software could provide answers to queries such as which farmers are on schedule, which are behind, and how much product has already been collected from each farmer. If the farmer is behind as a result to late arrival of rain occasioned by climate variability or change such data can be retrieved from the software later and used for policy making against climate change and variability that can impede growth of the agricultural value chain. Farmers suffering from delays occasioned by delayed planting dates or other climate change related risks which have led to untimely delivery of commodity to suppliers, may be traced using GIS mapping with barcodes but is typically done by physically marking the items

2.5 Strategies Adopted by Some African Countries in Upgrading their Authorities' and Farmers' Capabilities using Various ICT Tools

Evidence abounds on current increasing ICT penetration in Africa. For instance, World Bank (2012) asserted that growth in access to and use of ICT across the developing world had been exponential. This, they noted included the entire range of telecommunications networks, information technologies (IT), and electronic services (e-services). There is no doubt that ICT has been growing stronly lately in Africa. A study, the report noted, found that between 2002 and 2008, while the French telecom market grew at an annual rate of 7.5 percent and the Brazilian market at a rate of 28 percent, the African market experienced 49.3 percent annual growth. Within the same period, the African continent's mobile phone use grew at an annual rate of 65 percent, which was twice the global average. Internet penetration, they also noted, even though was still low in Africa, registered the world's highest growth rate at 9 percent in 2009, with public-sector institutions fast embracing the use of internet in their daily operations. Farmers suffering from delays occasioned by, for instance delayed planting dates or other climate change related risks which have led to untimely delivery of commodity to suppliers, may be traced using GIS mapping with barcodes but is typically done by physically marking the items. Even though this study noted that not much emphasis has been placed by policy makers in adopting ICT as a tool for building resilience of farmers in various agricultural value chains in SSA, there are some few and remarkable success stories of adoption of ICT policy frameworks and technologies in some SSA countries. An exposition on such attempts can serve as lessons for up-scaling such successful strategies in other parts of SSA countries. This is the rationale that informs the discussion in this sub-section. One of such documented cases is a report from Magrath (2008) who noted that in Uganda, a country highly vulnerable and affected by climate variations and shocks, iPods and podcasts were being used in marginalized communities to access creatively-packaged content relevant to their livelihoods. The content includes generic agricultural improvement information but it could also include changing seed/crop choices and changes in agricultural practices. Kairo et al (2002) observed that remote sensing and GIS technology have been applied to map, rehabilitate and sustainably manage mangrove forests in Kenya. In the same vein, Kelly and Adger (2000) indicated that, given mangrove's role in reducing storm damage, the technology had aided in enhancing coastal defences and made these areas more robust even under the threat of climate events such as increased cyclone intensity. The World Bank (2012) reported that in a bid to refine ICT's role in the public sector, Mozambique had since long embraced policies aimed at leveraging ICT as a poverty reduction based on its ability to render better service and much offer of transparency in public sector institutions. Based on such policy framework and in a bid to enhance safety nets for cities and urban citizens, Mozambique started upgrading its local governments' capabilities using various ICT tools such as Geographic Information Systems (GIS), E-Governance, Wireless Communications, and Early Warning Systems. However, as the country made progress towards applying ICT in this direction, the World Bank report noted that the impact on the poor was not known. This therefore begs for proper study that can involve poverty and social impact analysis (PSIA) to be conducted for the purpose of gaining insights into the extent of impact of ICT related interventions on building of e-resilience against climate change and variability in Africa. USAID's Trade and Investment Program for Competitive Export Economy (TIPCEE) in Ghana was innovative in its use of ICTs to enable fruit and vegetable exporters to become sufficiently competitive to link with international value chains. There are lessons to learn from this project with respect to building resilience against climate change risks in agricultural value chains in Africa too. The project used barcodes, GPS, and geographical information system (GIS) to ensure that produce could be traced to the smallholders who grew it, a major requirement to participate in the target export markets (Sen and Choudhary, 2011). GPS readers communicate with global positioning satellites to specify the exact location of a place on the earth's surface through latitude and longitude coordinates. These coordinates can be collected from the boundaries of a particular farm and fed into a GIS application on a computer, which can map the location of the farm, often with great precision. After a farm is mapped electronically, a product from that farm can be traced back easily to the source if the product is marked with the coordinate information, which can be done with barcodes but is typically done by physically marking the items. By so doing, GIS maps can, in conjunction with barcodes, ensure traceability. Once such farmers are traced (and assuming their problem of delayed supply came as a result of climate change risks) they can be assisted to build resilience through capacity building after being identified. This is one way GIS can help in building farmers' capacities especially in building resilience against climate change risks in agricultural value chain. Naburo (2000) documented the use of ICT in effective land use management which can boost agricultural productivity by demonstrating how integration of remote sensing and GIS could improve or boost land use planning for sustainable natural resource management within the mount Cameroon region, Central Africa. A UNDP (2012) report which studied the adoption of ICT in agricultural production in Ethiopia noted that Information and communication technology (ICT) can play a critical role in facilitating rapid, efficient, and cost effective knowledge management. Meanwhile, ICT in Ethiopia still trailed behind other African countries. It was also noted by UNDP (2012) that in several SSA countries, small scale farmers were accessing technology related counsels in addition to location-specific market information related to farm inputs and outputs via ICT kiosks.

These were in addition to mobile telephone services which they used to deliver agricultural information to users. It was equally noted that in Ghana, Esoko, a local company, implemented Cocoalink, a pilot programme which provided cocoa farmers with useful information on how to improve their farm practices such as better farm safety measures, disease control and prevention in farms, postharvest processing and production, and farm produce marketing. In this programme farmers were given information and specific answers to questions at no cost via voice and SMS messages in their local language or English. In Kenya farmers were provided with agricultural insurance products through mobile phones. Three organizations: UAP Insurance, Syngenta Foundation for Sustainable Agriculture and Safaricom had developed a product called pay as you plant insurance. This insurance scheme assists farmers to hedge risks in agricultural inputs against severe weather conditions such as drought or flood. To be covered under the scheme, farmers were only required to pay an extra 5% for a bag of seed, fertilizer or other farm inputs. In a similar way, in Mozambique, a company called Agricultural Marketing Service (SIMA) collected and disseminated nation-wide and provincial data on market prices, product processing and availability using a variety of media including text messages, email, internet, national and rural radios, television and newspapers. The report added that a study conducted in selected countries in Sub-Saharan Africa (Tanzania, Malawi, Mali, Mozambique, Ghana, and South Africa) indicated that rural radios with innovative programmes, including dramas and radio forums tailored to local communities, were very effective way of communicating agricultural messages. In Nigeria, there was a provision for an extensive publicity campaign to popularize projects and stimulate participation in the nation's National Agricultural Investment Plan using ICT as a tool (Federal Republic of Nigeria, 2010) . The use of Information-Communication-Technology (ICT) mechanism was being developed to support the process, the report stated. Most NAIP projects (particularly those with bias for crop production) offer farmer support as well as capacity building . They also develop groups, build marketing access opportunities, offer agricultural finance services, development of rural infrastructure and improvement off-farm livelihood activities. The Nigerian Federal Ministry of Agriculture and Rural Development (FMARD) also distributed mobile telephones to a score of farmers who were duly registered as a way of targeting them for fertilizer distribution and provision of useful information for their farm production. A few examples of ICT use in Africa lately to build resilience in agricultural production are as follows: First is the case of use of ICT on intensive basis for increased irrigation efficiency. According to e-Transform Africa (no date), the increased utilization of ICT could have a positive effect on irrigation efficiency. The report indicated that Egypt depends almost exclusively on the Nile River for its water supply out of which 85 per cent is used for irrigation. One of the two cases of ICT use in the case of Egypt irrigation is exemplified here. The case in view is the Integrated Water Resource Management Action Plan which the Ministry of Water Resources and Irrigation in Egypt had been reportedly implementing in response to the increasing demand for water while the options for increasing supply remained limited. It is being implemented on more than 2,000 km in the Nile Delta, covering the command of two main canals, Mahmoudia and Mit Yazid. The project, according to Levidow, Zaccaria, Vivas and Todorovic (2014) focused on improving irrigation and drainage management and increasing the efficiency of irrigated agriculture water consumption and services in the site. The plan was aimed at improving irrigation and drainage systems and the water management institutional structure, the report noted. According to e-Transform Africa (no date) the first phase of the project had resulted in crop yield increases of 20 per cent, with drainage estimated to account for 15-25 per cent of this increase. A further benefit, it noted is the re-use of drainage water. The second application is the use of ICT as a tool for increased traceability of livestock. This is another initiative where ICT is deployed in Africa successfully for livestock production. According to e-Transform Africa (no date) livestock production remains the most widespread and generally practised agricultural activity in Africa. Given that, as a result of intensified use of ICT in livestock and meat production efficiency improvement is attained in selected African countries, significant increases in production are could be attained at affordable cost. Besides, these methods are relatively easy to replicate in areas with diverse natural landscapes, the potential for general increased wealth creation in all parts of the continent could be massive. The Namibian Livestock Identification and Traceability System (NamLITS), was studied by the report. In this system official identification was done through the use of animal identification devices as required by international standards. Other technologies being used include use of Radio frequency identification (RFID) particularly when automated data input as well as visual plastic ear tag that supports remote pastoral production in the face of limited technological support. To backup the system, branding of animals is continuing. Eligible cattle were given tags as part of a specific campaign after which further tagging took place during annual vaccination campaigns or community visit-based surveillance activities. Where there were no handling facilities or where they could be in a state of disrepair, mobile crush pens were normally used. Besides the above uses, the e-Transform Africa report (e-Transform Africa, 2012) noted that ICTs could be used when conducting spatial analysis or targeting of programmes; in improved risk management; improved financial services delivery for farmers. It could also be used in e-Education and for Virtual aggregation of small stakeholders for policy making.

2.6 ICT For Enhancement of Agricultural Value Chains' Productivities

FAO (2013) observed that information services provided data that were tied to helping farmers boost their productivity, yields and profitability along the various agricultural value chains. Such information systems, if adopted in Africa can enhance the productivity of the various value chains in SSA agriculture. Information services, according to FAO (2013) are one of the most common ICT-related categories for inclusive agricultural value chains. The FAO (2013) manual broke down these ICT-related information for value chain productivity enhancement into sub-categories of information services that involve short-term and long-term productivity enhancements; those that minimize the harsh effects such as informing farmers on how to protect crops from freezing weather in the short term; and those that could improve field-based risk management.

3.0 Conclusion

This study reviewed the potentials of ICT in developing African agricultural value chains. It was evident that the potentials were enormous and SSA cannot continue to relax while other regions of the world are accelerating their agribusiness resilience against climate change impacts. The study, after charting a theoretical frameworks for the research focus, reviewed the major challenges facing SSA agribusiness in their bid to boost their value chains under risks of climate change; explored feasible options in available to SSA in building resilience against climate change’s risks in agricultural value chains after which it documented the various strategies that were adopted by some SSA countries in upgrading their authorities’ and farmers’ capabilities using various ICT tools. The researchers found several challenges ranging from poor access to ICT infrastructure, poor rural infrastructure, illiteracy, market failures, poor governance/institutional barriers and behavioural barriers among others. The researchers also noted that ICT tools such as GIS, E-resilience, wireless communications, and early warning systems can raise the agricultural productivity of African's smallholder farmers across the produce value chain under climate variability while we also identified other adaptation measures farmers were adopting to cope with climate change and variability in Africa. Based on our findings it is hereby recommend that African governments should take advantage of the potential role that ICT can play in enhancing the productivity of their agricultural value chains by implementing robust ICT programmes in their countries in collaboration with their ministries of agriculture and rural development in order to harness and turn the potentials into real development benefits. African governments, NGOs, international donors and other stake holders in SSA agriculture need to help address the issue of poor access to ICT infrastructure and services, as well as power supply problem in many SSA countries. Lessons from other few African countries implementing new programmes to build e-resilience in their agricultural value chain such as success stories from Ghana, Kenya, Malawi and South Africa in this aspect need to be up scaled by other African policy makers. For instance it will be agriculturally rewarding to embark on establishment of rural ICT kiosks, establish and strengthen community radios, integrate ICT at all levels of education, and make ICT hardware affordable to the users especially those in agriculture. With mobile phone platforms a veritable opportunity now presents itself for reaching out to farmers and knowledge intermediaries. Therefore use of mobile phone platforms' use in disseminating knowledge and information should be well explored and utilized. The use of ICT in intensifying irrigation efficiency is another practice that, if adopted in irrigation projects in Africa where there are problems of drought and aridity crop productivities can be raised to a higher level. Proper study that can involve poverty and social impact analysis (PSIA) needs to be conducted to gain insights into the extent of impact of ICT related interventions to build e-resilience against climate change in Africa. There is also an urgent need to elevate the position of African agriculture in international climate change negotiations. Such interventions should be based on win-win technological options that improve land use efficiency and increase crop and livestock productivity. In addition, appropriate policies need to be developed along crop and livestock production value chains that enhance the viability of agriculture as an economic activity.

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