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ADAPTATION STRATEGIES TO CLIMATE VARIABILITY AND CHANGE AND ITS LIMITATIONS TO SMALLHOLDER FARMERS. A LITERATURE SEARCH

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Abstract

In sub-Saharan Africa, knowledge on adaptation strategies to climate variability and change are scattered and fragmented due to lack of standpoints adaptation framework. This paper intends to analyse differences in adaptation strategies across agro-ecological zones, and finding out factors dictating adaptation to climate variability and change to smallholder farmers. The paper is based on documentary review methodology in which journals and books on adaptation were used as the main sources of information. The collected information were analysed by using content analysis. This paper found that smallholder farmers use a variety of practices to adapt to climate variability and change. These practices include: crop management, livestock management, diversification of livelihood strategies and land use management. Availability of extension services, climate change information and membership to social networks were among the factors identified dictating smallholder farmers adaptation to climate variability and change. The paper recommends to the Government of sub-Saharan Africa and development partners to come up with adaptation framework that takes into consideration differences in geographical location. They are needed also to provide enabling conditions to smallholder farmers through strengthening farmers' supportive services to enhance their adaptive capacities.

Keywords: Adaptation, climate variability, climate change, adaptive strategies and smallholder farmer

1. INTRODUCTION

The agriculture sector has been playing a very significant role in providing food and income to majority of people in rural sub-Saharan Africa. It is the mainstay of the region economy by contributing substantially to export earnings and employs majority of total labour forces. The sector is now passing through difficult moment worldwide by being seriously affected by climate variability and change (CV & C). The impact of CV & C to agriculture sector is manifesting itself through increasing incidences of floods, droughts and unpredictable rainfall in most parts of the

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world that affecting crop production and management. These changes contribute to social, political and economic vulnerabilities of people and society (Ribot, 2010; Bardsley and Wiseman, 2012).

Although CV & C is global in nature, its potential changes are not globally uniform. The most vulnerable people to global CV & C are smallholder farmers living in the arid and semi-arid areas that experienced prolonged droughts. The areas are highly sensitive to changes in rainfall because only a small fraction of rainfall is converted to runoff and groundwater recharge is minimal (Adger, 2003; Nelson and Stathers, 2009; Madzwamuse, 2010). The impacts CV & C on agriculture are the principal factor contributing to poverty to the smallholder farmers by disrupting education, destroying assets, forcing the sale of productive capital and deepening the social differentiation among households. This state of affairs to the smallholder farmers is contributed by prospects of tragic crop failures, reduced agricultural productivity, increased hunger, malnutrition and diseases as a result of climate change (Kangalawe and Liwenga, 2005; Liwenga *et al.*, 2007; Mary and Majule, 2009; Dejene, 2011).

The current trends and the predictions in CV & C show a challenging future to the smallholder farmers in the sub-Saharan Africa. For example, some countries already face semi-arid conditions that make agriculture challenging by reducing the length of growing season. On the other hand, agriculture production is predicted to decline by over 50% at the region due to unreliable rainfall and increased in temperatures (FAO, 2010). In responding to the increasing impacts of CV & C in particular shortage of rain and increase in temperature on agriculture, smallholder farmers have been using various adaptation measures in sub-Saharan Africa (Reilly and Schimmelpfennig, 1999; Gbetibouo, 2009). Nevertheless, existing knowledge on available adaptation measures to CV & C by smallholder farmers is scattered and fragmented as attributed by lack clear adaptation framework standing point regional wise. Therefore, this paper aimed at analyzing common adaptation strategies to CV & C used by smallholder farmers in sub-Saharan Africa. Specifically, the paper intends to assess the differences in adaptation strategies used across different agro-ecological zones, and factors dictating adaptation to CV & V. The paper starts with a review of theory and framework that guide adaptation to CV & C. Adaptation strategies to CV & C and factors influencing adaptation are then discussed in more detail. The discussion in this paper is limited to rural environment to which agriculture sector is the main economic activity of poor people of which majority are smallholder farmers who are natural resources dependent for their livelihoods.

2. THEORY OF ADAPTATION TO CLIMATE CHANGE AND SUSTAINABLE LIVELIHOOD FRAMEWORK

The analytical study on smallholder farmers' common adaptation strategies to CV & C was guided by action theory and sustainable livelihood framework. The action theory of adaptation (ATA) was developed by Eisenack and Stecker (2011). In their theory, Eisenack and Stecker viewed that adaptation process to CC is the interface between environmental stimuli with three core adaptational functions of the actor namely exposure unit, receptors and operators. They argued that, potential impact of changes in meteorological variables such as rainfall and temperature on a given social system is the one that affects the exposure unit like individual, group of individuals and non human system and hence triggers the onset of adaptation process.

On the other hand, the theory identified operator groups which comprises individual or collective of actors who exercise the response towards adaptation to the impact of CV & C. As pointed out in the theory, action from the actors must be with the purpose of adapting to CV & C. The theory describes receptors as the actor that is the target of an adaptation. Examples of receptors in the adaptation process include crops of a farmer or farm household. However, it was pointed out by Eisenack and Stecker that implementation of adaptation by an operator needs resources such as access to financial, technology, legal power, social networks, knowledge or availability of

information. In the same vein, sustainable livelihood framework proposed by Corney (1998) shows that people's livelihood strategies are shaped by institutions, organizations, policies and legislation (Figure 1). The framework puts people's livelihoods and their interactions with their environment at the centre. He argues that, community and household assets such as financial capital; social capital, physical capital and natural capital are influenced by the institutions and organizations through types of policies and legislation that shape livelihood strategies of people.

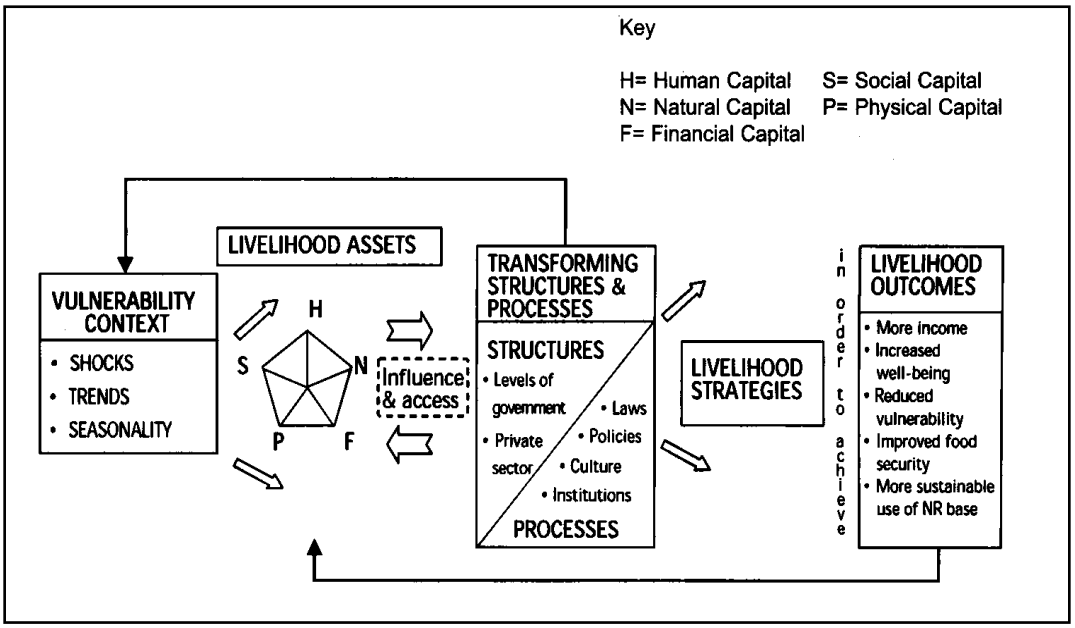

Figure 1: Sustainable livelihood strategies
Sources: Adapted from Department for International Development, 1998

In the framework, it is viewed that institution and organization processes operating from the household to the national level determine access to and control of assets, livelihood strategies (i.e. types of socio-economic activities) and vulnerability to CC induced droughts. Corney's approach observed that ability to pursue different livelihood strategies is dependent on how human capital such as skills, knowledge and good health; social capital such as membership to more formal social groups; ownership of natural resources such as land and forest; availability of physical assets such as basic infrastructures e.g. roads; and financial capital such as credit facilities enable people to pursue different livelihood strategies to mollify vulnerability caused by CV & C impacts.

3. STUDY METHODOLOGY

The methodology adopted in this paper was reviewing of the existing literature on adaptation to CV & C. The study reviewed various recorded information of smallholder farmers' adaptation strategies and factors that trigger such adaptation. It summarizes the secondary data from different journals, books and other literatures related to smallholder farmers adaptation strategies from different sources such as electronic websites. The appropriate key words such as CV& C, adaptation strategies and determinants for farmers' adaptation were used to search for the journals and books related to the subject. The collected information were analyzed by using content analysis in which all related information on CV & C, adaptation strategies and dictating factors for adaptation were sorted and organized ready for interpretation.

4. STRATEGIES AND FACTORS FOSTERING ADAPTATION TO CV & C AMONG SMALLHOLDER FARMERS

4.1. Strategies used to adapt to CV & C

Adaptation is a social response by individuals, a set of individuals or organizations directly or indirectly intended to change the way farmers are affected by stimuli arising from CV & C (IPCC, 2007). It reduces vulnerability to climate change by making smallholder famers better able to adjust to CV & C, moderating potential damages, and helping them to cope with adverse consequences. Studies by Liwenga *et al.*, 2007; Mary and Majule, 2009; Hassan and Nhemachena, 2008; Apata *et al.*, 2009; De Jonge, 2010; Deressa *et al*., 2009; Fosu-Mensah *et al*., 2010; Gbetibouo, 2009, have revealed that farmers adapt to impacts of CV & C on their agriculture activities. The adaptation strategies undertaken by smallholder farmers were discussed under practices of crop management, livestock management, land use management and livelihood strategies.

4.1.1. Crop management practice

Crop management practice is a common technique that is used by smallholder farmers in an effort to adapt to CV & C. The technique involves widespread strategies such as the use of improved crop varieties; change of planting date; diversification of crops. Nevertheless, the use of these strategies by farmers was found to vary from one agroecological zone to another due to changes in rainfall patterns and amount. For example surveys have shown the uses of improved crop varieties and changing planting date as the key adaptation strategies in semi-arid, temperate and humid agro co logical zones (Herrero, *et al.*, 2011; Majule, 2008). The findings by Thornton *et al.* (2007) in parts of East Africa indicated reduction in the length of the growing period has resulted in substitution of some crop species, for example, maize crop being substituted by sorghum and millet since they are more suited to drier environments. It was also noted that some famers due to increasing CV & C they are now planting early maturing crop varieties to reduce risks on crop productivity.

Farmers have also been using crop diversification in their farm as a vitally important adaptation strategy in the face of the uncertainties due to the implications of CV & C as well as resultant changes in crop pest and disease pressures. Report done by Woodfine (2009) have shown that in sub-Sahara Africa, farmers grow a diverse range of crop species and varieties, which ranges from annual crops such as cereals, legumes and oilseeds to perennial crops like cassava on their farms in order to adapt to CV & C.

4.1.2. Land management practice

Land management practice is another strategy that is found to be commonly used by smallholder farmers in adapting to the effects of CV & C. Much of the literatures have identified that smallholder farmers use crop rotations, fallowing, tillage practices, soil fertility management, irrigation, crop residue/mulching, ridges and furrows. The use of these strategies by smallholder farmers are found to differ from one agricultural area to another based on different agro-ecological zone of the farming activities. Several studies (Mary and Majule, 2009; Mahoo *et al*., 2007) have shown that in semi-arid zones, smallholder farmers found to use tillage practice, soil fertility improvement and irrigation practice. The use of tillage was found to improve infiltration rates of water and thus reducing surface runoff associated with short but heavy rains which are usually common semi-arid areas. Nevertheless, crop rotation strategy was found to be less practiced in arid and semi arid areas. In areas where crop rotation practices were used, smallholder farmers traditionally acknowledge that the practices are effective in maintaining soil fertility and health of arable land. However, the use of crop rotations practice in some parts of sub-Sahara African countries is constrained by increased population pressure.

On the other hand, review of literature has also found that smallholder farmers use crop residues/mulching techniques for soil moisture conservation in arid and semi-arid zones. The techniques were found to be used in situations where precipitation is low as the crop residues on the

soil surface protects the upper soil layer, reducing soil temperatures and hence water loss, both important factors for optimal plant growth as air temperatures increase. This strategy also helps to reduce the amount and speed of rainwater running off croplands and reduce soil erosion. This finding is in line with what was reported by FAO (2007) that a layer of mulch technique, reduces crop water requirements by 30 percent by reducing soil water loss through evaporation.

4.1.3. Livestock management practice

Livestock management is frequently cited as an important practice undertaken by smallholder holder farmers in sub-Saharan Africa in adapting to CV & C. Surveys done by FAO, 2008; Thornton *et al*. (2007) and Sidahmed, (2008) in the region indicated that famers use destocking (reduce number of livestock), supplement livestock feeds, rotational grazing, improved breeds and livestock migration. In all these strategies, livestock migration strategy seems to be more critical to the farmers that ensure survival of livestock in the period of harsh climatic condition occasioned by CV & C. This is normally done to save a core stock of breeding animals that together would be capable of reconstituting the herd after a drought. However, the expanding human population, urbanization, environmental degradation and increased consumption of animal source foods are likely to reduce effectiveness of some of these adaptation measures.

4.1.4. Diversification of livelihood strategies

Farming is a single major livelihood strategy for majority of smallholder farmers in rural parts of sub-Saharan Africa. The exposure of the strategy to CV & C has far reaching effects to the farmers' livelihoods, as the change in climate have severe impacts on food production, water availability, human health, natural resources and environmental impacts. In responding to these effects caused by CV & C, smallholder farmers have been diversifying their sources of livelihood. According to Urquhart (2008), more-diversified livelihood strategies can lead to both enhanced incomes and to spreading the risk for smallholder farmers, whose livelihoods are largely based on natural resources.

Diversification strategies are thus important in managing current climate risks, particularly for subsistence agricultural communities of which majority are smallholder farmers. For example, studies by (Urquhart, 2008; Mary and Majule, 2009; Herrero *et al.*, 2011) have shown that in some countries of sub-Saharan Africa smallholder farmers diversified their livelihood strategies from depending on farming activities only to off-farm income generating activities (IGAs). These livelihood diversification strategies have shifted some of the household income portfolio away from direct production of crops, of which the resulting income gains, allow for higher overall food consumption.

4.2. Factors fostering smallholder farmers' adaptation to CV & C

This part concentrates on the discussion on the factors that foster smallholder farmers' adaptation to CV & C. Adaptation as a process is the outcome of a combination of many forces and varies widely between countries and groups, as well as over time. There are several factors that influence smallholder farmers' adaptation to CV & C. Such factors categorized into five groups which include farmers/household characteristics; extension services; social networks; financial services, and technological factors. According to Rass (2006), these factors do not only affect smallholder farmers' adaptation to climate change, but they are the factors responsible for difference choices of adaptation strategies; they also behave differently in different countries and regions, particularly depending on the level of development. However, it is worth noting here that these factors are not independent to each other, nor are they mutually exclusive. The following sub-sections provide a detailed discussion on each of the factors and it is going to be explained in relation to how it influences smallholder farmers adapt to CV & C.

4.2.1. Farmer and/or household factors

Smallholder farmers' characteristics can influence decision on whether to adapt or not to adapt to the CV &. C. For example, many studies reveal that factors like experience in farming, gender, access and control over resources, education, marital status and intra household interaction can affect the choice of crop variety to be planted to adapt to the changes and variations to climate (Lockheed *et al.*, 1980; Hawaasi, 2006; Kilima *et al*., 2010). Differentiations in demographic variables such as age, gender, ethnicity, educational attainment are often cited in the literature as being related to the ability to cope with risk (1PCC, 2007). These variables can affect adaptation to the changes and variations to the climate in different ways. For instance, age can be an indicator of farming experience, which makes certain informational and search cost easier. According to Luh (1995), it is a widely accepted proposition in economics of production that there is a positive relationship between efficiency and accumulated experience. Similar findings were observed in studies by Nkumba (2007) and Hawaasi (2006). For example Nkumba (2007) found that household characteristics such as age of the farmers influence the adoption of new banana varieties in Kagera. But on the other hand, Lockheed *et al.* (1980) and Phillips (1994) in their studies had found that education level of the farmers influences productivity through the decisions to use purchased inputs and adoption of new varieties.

Other farm characteristics such as access and control over resources (e.g. land) can affect farmers' choice over certain crop varieties (Smale *et al*., 2001). Poor households are more likely to choose traditional crops varieties because of the associated costs to the new crop varieties. It is also very clear that poor farmers always farm for home consumption; therefore, they are likely to choose varieties that suit them rather than the market. As it was identified in Tanzania by Mpogole (2013), most important factors for maize variety choice were related to family's consumptions of maize rather than the suitability of the variety for the market sale.

4.2.2. Availability of extension services

In a country where majority of farmers are subsistent peasants, the role of extension services is indispensable. Extension officers are expected to offer more than just expert assistance in improvement of production and processing, but also enable flow of information and transfer of knowledge to practice. They are required to provide a wide range of assistance to farmers in helping them identify opportunities, tackle problems and provide needed advice, such as on crop diseases, adaptation to CV & C. According to Leeuwis and Hall (2013), extension service is expected to help farmers improving agricultural productivity through dissemination of knowledge, facilitating access to inputs, credit facilities and linking producers to researchers and policy makers. For example, studies by Namwata *et al*. (2010) and Mpogole (2013) had shown that contact with extension services was a major factor causing the variations in crop variety preferences among farmers. Similar results were found by Asrat *et al.* (2009) that the level of access to agricultural extension services affect farmers' private valuations of crop variety traits. Hence, farmers who receive extension or advisory services are more likely to choose improved varieties than those who do not.

4.2.3. Membership to social networks

Social network is an important source of knowledge for both individuals and groups as the knowledge about the universe is embedded in social ties and through it, individual and groups can learn about changes and variability on climate. Studies by Nombo 2007; Bodin and Crona (2009) and Prell *et al.* (2008) have confirmed that, social network can make people more resilient and adaptive to environmental change. It is also important resource when evaluating risk and vulnerability within communities as they serve not only to disseminate information, but also to shape the way individuals process and understand that information in a particular context (Morgan, 1986). The strong social networks can help the communities to have a strong supporting system which can enhance their adaptive capacity to respond to environmental shocks. As the matter of fact, Farmers who are members of certain organizations or cooperatives are expected to be more

informed and therefore be able to choose improved crop varieties compared to those who do not belong to such organizations. The studies done by Ortmun and King (2007) and Mpogole (2013), found that, being a member to the social networks and organizations have substantially increased likelihood to purchase improved and high yielding varieties.

4.2.4. Availability financial services

The design and delivery of financial services in many countries of sub-Sahara Africa greatly affects its accessibility particularly for the smallholder farmers. Financial institutions often require traditional forms of collateral property like land, house for which smallholder farmers frequently lack titles. Furthermore, complicated application procedures and documentation requirements prevent poor farmers with lower education and inadequate skills from applying. For example, studies conducted by Gabagambi (2003) and Olomi *et al.* (2009) had revealed that, commercial bank and other financial institutions are reluctant to lend to smallholder farmers because of associated risks. This is attributed by several factors like, the high risk associated with the main economic activity, rain fed agriculture, and the absence of traditional physical collateral normally required by the banking system (ADB, 2006). These situations have made the cost and risks associated with the delivery of lending services in rural areas to be high.

For example in Tanzania, reluctance of commercial banks and microfinance institutions to lend to small scale farmers led to the institutionalization of Savings and Credit Cooperative Societies (SACCOS). Most of the SACCOS were village and urban based and were expected to provide credits to their members. However, most of the rural SACCOS do not have adequate capital to provide loans to the members. Even when they do, the ability of the smallholder farmers to repay the loan has been very small. The SACCOS usually confiscate the properties including households 'appliances and land for those who fail to repay the loans. This confiscation of members' properties who fail to repay the loan has led to a negative attitude towards the SACCOS among smallholder farmers of which majority of them are women.

4.2.5. Climate change information

Smallholder farmers require different types of climate information during each stage of the agricultural production process in order to adapt to CV & C. The climate change information to smallholder farmers includes early warning signals, weather forecasts, pest attacks, input management, cultivation practices, pest and disease management, and prices (Thornton *et al*., 2006; IPCC, 2007; Aker 2011). A study by McOmber *et al.* (2013) revealed that, smallholder farmers obtained climate information from different sources such as extension agents, their own trial and error and from members within their social networks. However, in sub-Saharan Africa, sharing of information among climate change actors is limited and even worse in semi-arid environments due to many barriers such as poverty, poor infrastructure and illiteracy (O'Brien *et al.*, 2008). The use of different communication channels to reach the farmers with climate information can empower smallholder farmers to adapt to CV & C.

4.2.6. Technological factors

Lack of technology can impede seriously individual/household ability to implement adaptation options by limiting the range of possible responses. Availability, access and control to technology at various levels (i.e., from local to national) and all sectors is likely to cause adaptive capacity to vary. Many of the adaptation strategies identified for management of CV & C directly or indirectly involve the use of technology such as crop breeding and irrigation. Hence, a community's levels of technology and its ability to develop technologies are important determinants of adaptive capacity. Moreover, openness to the development and utilization of new technologies for sustainable extraction, use, and development of natural resources is a key to strengthening adaptive capacity.
Adaptive capacity will be greater if social institutions and arrangements governing the allocation of power in a nation assure equitable distribution and access to technology to the people (IPCC, 2007). The extent to which communities are entitled to draw on technology greatly influences the

adaptive capacity (Asante *et al*., 2012). As per Ludi and Bird (2007), adaptive capacity of smallholder farmers is a function of not only availability of technology, but also its accessibility. Lack or inadequate availability of technology within the community imposes constraints adaptation of smallholder farmers to CV & C.

5. CONCLUSIONS

This paper has described how smallholder farmers in rural environment setting overcome the impacts associated with CV & C. It has explored this by reviewing common strategies used by smallholder farmers in adapting to CV & C, and finding out factors that influencing adaptation. The paper found that smallholder farmers in rural parts of sub- Saharan Africa used a variety of adaptation practices which include: crop management; land management; livestock management and livelihood diversification strategies. However, it is worth to note here that the use of these practices is likely to vary from one agro-ecological zone to another. Also, the variations of selected practices can be attributed to smallholder farmer characteristics; availability of extension services and climate related information; accessibility to financial resources; social networks membership and accessibility of proper farming technology. Therefore the study recommends that the Government of sub-Sahara Africa and other stakeholders working in the agriculture sector to provide the necessary support to create enabling conditions that will help to strengthen smallholder farmers' adaptive capacities through their supportive services.

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