Journal of Resources Development and Management
ISSN 2422-8397 An International Peer-reviewed Journal
Vol.26, 2016

Farmers' Perception, Impact and Adaptation Strategies to Climate Change among Smallholder Farmers in Sub-Saharan Africa: A Systematic Review

Seid Sani Tamiru Chalchisa
Department of Agricultural Economics, College of Agriculture and Natural Resource, Assosa University, P.O. Box, 18, Ethiopia

Abstract
Climate change remains the major threat for smallholder farmers in Africa that undermines sustainable development efforts towards achieving the sustainable development goals. This paper reviews the empirical literature on farmers' perceptions of climate change, its adverse effects on farmers' livelihood and adaptation strategies in sub-Sahara Africa. It is evident that the majority of farmers in sub-Sahara Africa are aware of climate change which manifests itself as changes in temperatures and precipitation patterns. To cope up the adverse effects of climate change, farmers have adopted crop diversification, planting different crop varieties, changing planting and harvesting dates to correspond to the changing pattern of precipitation, irrigation, planting tree crops, water and soil conservation techniques and switching to non-farm income activities. However, choice of adaptation strategies differs between countries, regions, and households. At household level, most of the empirical evidence revealed that age, gender of household head, farming experience, household size, years of formal education, access to credit facilities, distance from market, access to extension services and access to off-farm income generating activities are the most important factors influencing farmers' decision regarding climate change adaptation and choice of adaptation strategies. Improving adaptation capacity of farmers in the region calls for support from African governments to improve farmers; access to non/off-farm income sources, training, information, extension services, among others. Governments and non-government organizations need to promote investment on climate smart and resilient practices such as agro forestry, conservation agriculture, etc.
Keywords: climate change, farmers' perceptions, impact, adaptations, sub-Saharan Africa

1. INTRODUCTION

Climate change is a global concern as it severely affects the livelihoods of the world community in general and agricultural production and food security of the farming community in particular. It could have an adverse effect on various biophysical and economic activities like agriculture, water resources, forestry, human health, biodiversity, and wildlife. Its consequences are severe in developing countries in which agriculture is the primary source of livelihood (World Bank, 2008).

Climate change affects agriculture and agriculture also affects climate change. The impact of climate change on agriculture in developing countries has been increasing. Higher temperature and changing precipitation levels caused by climate change depress crop yields. This is particularly true in low-income countries, where adaptive capacities are perceived to be low (IPCC, 2007). Many African countries which have economies largely based on weather-sensitive agriculture are vulnerable to climate change. However, the rapid pace of climate change, along with increasing socioeconomic pressures, threatens to overwhelm their ability to cope. It is worrisome that Africa is especially vulnerable to climate change and variability because large proportions of the population are poor and depend on agricultural activities, which is highly sensitive to rainfall variability and change in temperature (The World Bank Group, 2010).

Even though climate change is not a new Phenomenon, it continues to strongly impact agriculture in Sub-Saharan Africa, where smallholder farmers dominate the agriculture sector and are most vulnerable to adverse effects of climate change. The fact that climate change will adversely affect agriculture in the region has become a challenge for sustainable development on the continent (Juana *et al.,* 2013). Generally, losses in the agriculture sector due to climate change have economy wide consequences, like the decline in GDP, a decline in the income/consumption; hence, a general deterioration in households' standard of life. To reduce the adverse impacts of climate change, there is a need for farmers to adopt different adaptation strategies (Temesgen *et al*., 2008). Adaptation to the adverse impacts of climate change could be viewed from two distinct perspectives; i) the awareness of the impact of climate change and their capacity to adapt to climate change and ii) how adaptation can be carefully planned and implemented to reduce the possibility of mal-adaptation (FAO, 2007). However, the planning and implementation of any climate change policy requires adequate knowledge about the vulnerability status of farmers', the existing knowledge the population has about their exposure to climate change associated risks, the adaptation practices used, the existing capacity to adapt and the perceived barriers to adaptation (Madisson, 2006). To address these issues and concerns, there is a need for a critical and comprehensive assessment of the impact of climate change, farmers' perceptions and adaptations to climate change in Sub-Saharan

Africa.

Different studies have been conducted in different countries to assess climate change impact, perceptions, adaptations and adaptation strategies and adaptation barriers. However, the studies have concluded that different countries have different exposures to the risks of climate change. There is a need to synthesize these different studies and compare differences in climate change impacts, perceptions and adaptation in sub-Saharan African countries. Therefore, this study documents the existing literature on the perceptions of farmers about, and adaptations to climate change in Sub-Sahara Africa. Specifically, the study was designed to:

- Assess the existing knowledge that farmers have on, and the different levels of climate change risks perceived by farmers in sub Saharan Africa;
- Identify the major adaptation strategies farmers adopted to cope with the consequences of climate change;
- Identify the perceived barriers to climate change adaptation strategies;
- Explore the socio-economic determinants of farmers' adaptations to climate change in the region; and
- Recommend plausible policy interventions that match farmers' perceptions, experiences, adaptation strategies and coping mechanisms in the region.

2. DISCUSSIONS

2.1. Impacts of Climate Change in Sub-Saharan Africa

Climate change which manifests itself as a change in rainfall patterns and temperature adversely impacts the economic and social survival of the majority of the population in Africa and particularly in sub Saharan Africa. The major sources of livelihood for rural poor in Africa such as water resources, agriculture (crop production and animal husbandry), health, ecosystems and biodiversity, forestry and coastal zones are the most vulnerable areas or sectors to climate change. Climate change remains a major threat for food security and sustainable management of natural resources. Studies indicated that if adequate measures are not taken to cop up the impacts of climate change in sub-Sahara Africa, there will be a predicted loss of 2-7% of GDP by 2100 in parts of sub-Sahara Africa; 2-4% and 0.4-1.3% in West and central Africa, and northern and southern Africa respectively (FAO, 2009).

Sub Saharan Africa is among the most vulnerable regions to climate change impacts due to the fact that the majority of the population highly dependent on rain-fed agriculture for their economic activities as well as for sustenance of their livelihood (Juana *et al.,* 2013). The poor performance of the agriculture sector and rapid population growth, in combination with the adverse impacts of climate change causes the large segment of the sub-Sahara African population to live in abject poverty. If the current trend continues to lead to significant long term changes in rainfall patterns and temperature, which affect agriculture, it is highly likely that this situation will lead to significant reduction in food security, worsening water security, increase in animal and crop pests and disease infestation, among others (African Partnership Forum, 2007).

The impact of climate change on agricultural production is not uniform across regions of the world; low latitude and developing countries are expected to suffer more, reflecting their disadvantaged geographic location, greater agricultural share in their economies, and limited ability to adapt to climate change (Zhai and Zhuang, 2009; Newton *et al.,* 2010). It affects agricultural production and productivity both directly and indirectly. It directly affects agriculture by affecting the weather variables such as temperature, solar radiation, rainfall, wind speed and humidity (Deschenes and Greenstone, 2006; Sowunmi and Kintola, 2009) and indirectly through disease and pest outbreak as well as favoring the development of climate related diseases like malaria that affect the workforce (Ngigi, 2009). Newton *et al.,* (2010) also indicated that climate change affects the complex interactions between crop and pathogens leading to increased outbreaks of pests and diseases. The concern of food security and climate change in the developing world would be threatened due to anticipated to experience significant change in temperature and rainfall patterns, their developing economy heavily relays on climate sensitive business and they totally depend on agriculture as a source of food, which seriously affected by climate change (Newton *et al.*, 2010).

In addition, different empirical studies have shown that while agriculture is the most vulnerable sector, other sectors in the economy are also affected because of the induced effect from the agriculture sector. For example, as to Juana *et al.,* (2012) finding, which is cited in Juana *et al.,* (2013) showed that 20% reduction in water availability in South Africa due to climate change, will lead to a 12% decline in agricultural output. Because of the backward and forward linkages between agriculture and the other sectors of the economy, this 12% decline in agricultural output will lead to about 8% decline in gross sectoral output. The same authors also confirmed a 10% loss in agricultural output in Botswana due to drought will lead to about 8% decline in total sectoral output. Kurukulasuriya and Mendelsohn (2006) study results also showed that an increase in temperature was associated with losses of US$23 billion for dry land and US$16 billion for all African cropland. Furthermore, an increase in precipitation and irrigation were associated with a gain of $97 billion and $1 billion per year in most African cropland. Similarly, Molua and Mlambi (2008) revealed that a 2.5°C and 5°C increase in temperatures, reduced farm level net revenues by $0.5 and $1.7 billion, respectively. It was also found that a 7% decrease in precipitation decreased net revenues by $1.96 billion. The study concluded that precipitation and temperature remained the

dominant determinants of cultivatable farming practices in Cameroon.

Rowhani *et al.,* (2010) also depicted the impacts of precipitation on household crop yield in Tanzania. The study findings pointed that 20% increase in precipitation reduced agricultural yields by 3.6%, 8.9%, and 28.6% for maize, sorghum and rice, respectively. Benhin, (2006) found similar results in South Africa, where he assessed the economic impact of climatic change on crop farming. It was depicted that an increase in temperature reduced net revenue by U$2637 and U$880 between irrigated and dry land areas of South Africa, respectively. On the other hand, increase in precipitation, improved net revenue of dry land areas by U$22 from US$10. These studies show that the impact of climate change leads to general deterioration in households' welfare, but that poor or rural households who depend primarily on agriculture for their economic or livelihood sustenance are the most vulnerable population group.

In addition, a study conducted by Thurlow *et al.* (2009) in Zambia revealed that climate change and variability costs the country 4.3 billion US dollar over a 10-year period and might reach as high as $7.1 billion in a worst-case rainfall scenario. The same study pointed out that the impacts of climate change and variability are more pronounced in the southern and central regions of Zambia, where food insecurity is most vulnerable to climate shocks. Moreover, Bezabih *et al.,* (2011) also indicated that in Tanzania the projected effect of overall climate change on agricultural productivity is relatively limited to begin with, but becomes progressively worse. However, the long time periods involved and the low starting point of the economy leave ample time for factor substitutability, which allows adaptation measures to replace reduced land productivity with increased use of capital and labor.

Generally, the farmers have experienced increased pests and crop diseases, increased crop water requirements, leading to crop failures, reduced crop production in countries or regions where arable farming is predominant (Gbetibuou, 2007; Yesuf *et al.,* 2008; Nyanga *et al.,* 2006; Apkonikpe *et al.,* 2009; Gandure, 2012; Nzeadibe *et al.,* 2011). Livestock farmers reported that the climate change and climate variability have led to decreased livestock weight and an increase in livestock death. These imply loss of farm income and livelihood for the majority of the rural population; hence, a general deterioration in their welfare (Mengistu, 2009; Sofoluwe *et al.,* 2011; Mandleni & Amin, 2011; Mertz *et al.,* 2009).

2.2. Trends of Climate Change in Africa

The historical climate trend in Africa shows warming temperature of approximately 0.7°C and over most of the continent during the twentieth century, a decrease in rainfall over large portions of the semi-arid region south of the Sahara and an increase in rainfall in east and central Africa (Juana *et al.,* 2013). Over the twenty first century, these trends are expected to continue and be accompanied by a rise in sea level and an increased frequency of droughts and floods (IPPC, 2001). The same study conveyed that in all the regions of sub-Sahara Africa the temperature has shown an increasing trend and the precipitation pattern showed a 2% increase in West Africa and 7% increase in East Africa, but a 4% decrease in southern Africa.

Other studies have predicted a general decrease in precipitation and water availability. Between 1970 and 1995, Africa has experienced a 2.8 times decrease in water availability, and since 1970, average discharge of West African rivers has dropped by 40-60% (Shiklomanov, 1997). Arnell (2004) predicted that about 370 million African people will experience increases in water stress by the year 2025, while about 100 million people are likely to experience a decrease in water stress by the year 2055 as a result of a likely decrease in precipitation. In the Nile region, many studies on water availability estimate a decrease in river flow up to more than 75% by the year 2100, with implications for agriculture, conflict and livelihoods of poor (Nyong, 2005). In addition, a study conducted by seid (2016) in western Ethiopia indicated that the average annual temperature increases by about 0.096^{o}C each year. The same study witnessed that the total amount of annual rainfall in the study area decreases by about 46.75 mm each year.

2.3. Farmers' Perception of Climate change

Farmers in developing countries have been and are living in harmony with climate change. Therefore, they are the right people to tell about climate change and its impact on their livelihood. It has been said that awareness or knowledge about climate change is a pre-condition for mitigating or adapting to its adverse effects (Maddison, 2006; Juana *et al.,* 2013).

Different empirical studies indicated farmers' perception about climate change. Gandure *et al.,* (2012) revealed that farmers in South Africa have perceived increase in temperature, and indicated that summer temperatures were warmer while winter temperatures were colder. The same study also pointed out that warmer temperatures in the area are associated with high evaporation and increased crop water requirements. The farmers also reported that there has been a perceived decrease in rainfall or precipitation. Another study conducted by Acquah de Graft (2011) in Ghana, indicated that 60% of the farmers reported that there has been a noticeable increase in temperature and 49% reported a decrease in rainfall. Acquah-de Graft and Onumah (2011) also analyzed perceptions of climate change in western Ghana, the majority of the farmers in the study area perceived

an increase in temperature and decrease in precipitation.

The majority (more than 75%) of farmers in Osun State of Nigeria perceived increase in temperature and decrease in precipitation pattern (Sofoluwe *et al.,* 2011). Mandleni and Anim (2011) also pointed out that about 86% livestock farmers in the eastern cape of South Africa were aware of the increase in temperature pattern and that weather conditions in the province was dominated by drought. Moreover, a study conducted by taking samples from Benin, Burkina Faso, Ghana, Niger and Togo indicated that most of the respondents reported a decrease in rainfall, change in rainfall pattern with delayed rains and early cessation and a significant increase in temperature characterized by an increase in the number of hot days (Akponikpè *et al.,* 2010).

A study conducted by Mertz *et al.,* (2009) showed that farmers in savanna zone of Senegal were aware of climate change and variability, and identified intensive wind and occasional excess rainfall as the most destructive climatic factors. The study also figured out that households in the area noticed a decreasing trend in overall rainfall and increased temperatures throughout the year and that cold periods have become shorter and hot periods longer. Apata *et al.,* (2009) also analyzed arable food crop farmers' perceptions about climate change and adaptation strategies in southwestern Nigeria and the results of the study indicated that about 89% of the farmers perceived a significant increase in temperature, 72% perceived higher evapo-transpiration rates, 68% indicated that there has been violent rain and hailstorms and 65% experienced delayed rainfall and early cessation.

Other empirical studies also found that the temperature and humidity in Ethiopia have significantly increased over the years (Deressa *et al.,* 2008; Yesuf *et al.,* 2008). Nhemachena and Hassan (2007) also examined farmers' adaptation strategies in South Africa, Zambia and Zimbabwe and reported that most farmers perceived long-term increase in temperature and that the region was getting drier, with changes in the timing of the rains and frequency of droughts. Maddison (2006) conducted a survey covering seven African countries and reported that significant numbers of farmers believe that temperature has already increased and that precipitation has declined in the countries.

2.4. Determinants for Farmers` Perception of Climate Change

Although there are a number of empirical studies on patterns of climate change in sub Saharan Africa, few of these studies tried to study factors influencing farmers' differences in perception and detection of climate change.

A study conducted by Gbetibouo (2009) in South Africa argued that farmers with access to extension services are more likely to perceive changes in the climate because extension services provide information about climate and weather. Consequently, it also indicated that awareness and perceptions of changes in climatic conditions shape action or inaction on the problem of climate change. Households wealth represented by farm and non-farm income and livestock ownership increases the likelihood of climate change awareness (perception) (Yesuf *et al.,* 2008). Farmers with the greatest farming experience were more likely to notice changes in climatic conditions which, according to the study are consistent with farmers engaging in Bayesian-updating of their prior beliefs (Maddison, 2006). Moreover, a study conducted by Aemro *et al.,* (2012) in eastern Ethiopia pointed out that sex of household head, distance from market center, frequency of extension contact, agro ecological zones, access to farmer-to-farmer extension and access to information on climate change were the significant factors that explain farmer's perception of climate change.

2.5. Adaptations to Climate Change

Most studies have proposed specific studies and technologies to address climatic change impacts and household adaptation in specific locations (Aggarwal *et al.,* 2010; Kato *et al.,* 2008; Deressa, 2006). The adaptation strategies and coping mechanisms adopted by arable farmers in sub-Sahara Africa include:

I. Most farmers in sub-Sahara Africa, especially those in regions with reduced precipitation have switched from planting high water-requirement to low water-requirement crops (De Wit, 2006; Yesuf *et al.,* 2008; Nhemachena & Hassan, 2007; Gandure *et al.,* 2012; Deressa *et al.,* 2008), while crop farmers in regions where flooding is frequent plant short duration crops and have changed the planting and harvesting times to avoid crop growing and harvesting during the intensive rainfall period (Acquah & de Graft, 2011; Acquah de Graft & Onumah, 2011; Forsu-Mensah *et al.,* 2010).

II. Generally, farmers have switched to planting diversified crops, changed planting dates to correspond to the change in the precipitation pattern, planting tree crops, mixed cropping and off-farm income generating activities (Maddison, 2006; Deressa *et al.,* 2008; Fosu-Mensah *et al.,* 2010; Kurukulasuriya & Mendelson, 2006; Mertz *et al.,* 2009; Sofoluwe *et al.,* 2011, Gandure *et al.,* 2012; Acquah de Graft & Onumah, 2011; Seid *et al*.,2016; Nyanga *et al.,* 2006; Gbetibuou, 2007).

III. Farmers in southern Africa and parts of East Africa, where most countries are water stressed, have developed water conservation methods such as water harvesting, waste water re-use in agriculture and crop irrigation (Nyanga *et al.,* 2006; Mengistu, 2009; Deressa *et al.,* 2008; Gbetibuou, 2007; Mertz *et al.,* 2009; Yesuf *et al.,* 2008; Gandure *et al.,* 2012; Seid *et al*.,2016), while farmers in West Africa, where most countries experience short intensive rainy season plant short duration crops, practice upland farming

(as opposed to swamp farming) and soil conservation methods (De Wit, 2006; Acquah de Graft, 2011; Apata *et al.,* 2009; Sofoluwe *et al.,* 2011; Kurukulasuriya & Mendelson, 2006). Some farmers, especially in southern and some parts of East Africa have switched from arable to livestock farming (Kurukulasuriya & Mendelson, 2006; Mengistu, 2009; Deressa *et al.,* 2008).

IV. To cope with or adapt to climate change in sub-Sahara Africa, livestock or pastoral farmers have dug more boreholes in drier regions, switched to off-farm income generating activities and have reduced the number of livestock, by slaughtering and/or selling them during extended drought periods and restocking after the drought (Mandleni & Anim, 2011; Deressa *et al.,* 2008; Mertz *et al.,* 2009; Gandure *et al.,* 2012). Some other livestock farmers have switched to livestock that can withstand water stress and hot temperatures (Mandleni & Anim, 2011; De Wit, 2006; Nzeadibe *et al.,* 2011).

2.6. Determinants of Adaptation and Choice of Adaptation Strategies for Climate Change

Different studies conducted in sub-Saharan Africa have used various empirical methods to analyze the determinants of adaptations to climate change and choice of climate change adaptation strategies.

Different empirical findings confirmed that different demographic factors (such as gender, age of farmers, years of farming experience, household size and years of education) as well as institutional factors (such as access to credit facilities, access to extension services and off-farm income generating activities) were identified as significant determinants of climate change adaptation strategies (Acquah-de Graft & Onumah, 2011; Deressa *et al.,* 2008; Fosu-Mensah *et al.,* 2010; Kurukulasuriya & Mendelson, 2006; Mandleni & Anim, 2011; Mertz *et al.,* 2009). Other studies showed that households with large family size will be more willing to choose the adaptation options such as soil conservation techniques, chemical treatments that are labor intensive (Aymone, 2009; Temesgen *et al.,* 2008). Experience in farming increases the probability of uptake of adaptation measures to climate change (Maddison, 2006; Hassan and Nhemachena, 2008; Aymone, 2009; Temesgen *et al*., 2009).

As to Maddison (2006) finding, educated and experienced farmers are expected to have more knowledge and information about climate change and the agronomic practices that they can use in response. In addition, the same study found that farmers' awareness of changes in climate attributes (temperature and precipitation) is important for adaptation decision making. Moreover, Temesgen *et al*. (2008) conveyed that education significantly increased soil conservation and changing planting dates as adaptation strategies. Furthermore, almost all of the marginal values of education are positive across all adaptation options. Various studies have shown that the sex is an important variable affecting adaptation decision at the farm level. Temesgen *et al*. (2009) found that male-headed households adapt more readily to climate change. In contrary to this, Nhemachena and Hassan (2007) found that female headed households adapt more readily to climate change than male headed household heads.

Large-scale farmers are more likely to adapt to climate change because they have more capital and resources (Hassan and Nhemachena, 2008; Aymone, 2009). Productive resources such as capital, land and labor serve as important factors for coping with and adapting to climate change. The choice of the suitable adaptation measure depends on factor endowments (i.e. family size, land area and capital resources) at the disposal of farming households (Hassan and Nhemachena, 2008). Temesgen *et al*. (2008) found that farm income of the households has a positive and significant impact on conserving soil, using different crop varieties, and changing planting dates. In addition to farm income, nonfarm income also significantly increases the likelihood of planting trees, changing planting dates, and using irrigation as adaptation options.

Many researchers have indicated that access to credit increases the likelihood of adaptation (O'Brien *et al*., 2000; Temesgen *et al*., 2008; Aymone, 2009; Temesgen *et al*., 2009). O'Brien *et al*. (2000) also pointed out that, despite numerous adaptation options that farmers are aware of and willing to apply, the inadequate access to financial resources to purchase the necessary inputs and other associated equipment (e.g., purchasing seeds, acquiring transportation, hiring temporary workers) is one of the significant constraints to adaptation. Furthermore, the majority of the farmers in Limpopo basin of South Africa cited lack of financial resources as the main constraint to adaptation (Aymone, 2009).

Many studies have confirmed that having better access to extension services increases the probability of adopting different adaptation measures (Aymone, 2009; Temesgen *et al*., 2009). Farmers with better extension services access are more likely to be aware of changing climatic conditions and expected to have good knowledge about different types of adaptation measures in order to reduce climate change impact or to exploit the advantages. Information on climate change impact also increases the likelihood of using different crop varieties as an adaptation measure. Having access to farmer-to-farmer extension increases the likelihood of using different crop varieties and planting trees (Temesgen *et al*., 2008).

Aemro *et al.,* (2012) showed that the sex of the household head, age of the household head, education of the household head, family size, livestock ownership, household farm income, non/off-farm income, access to credit, distance to the market center, access to farmer-to-farmer extension, agro ecological zones, access to climate information, and extension contact have a significant impact on choices of climate change. In addition, Belaineh *et al.,* (2013) identified that sex, plot size and frequency of extension contacts have a significant and positive

impact on crop based diversification coupled with soil and water conservation practices while family size, non/off-farm income and training have significant negative impacts. On the other hand, plot size, livestock holding (TLU) and frequency of extension contacts are significantly and positively associated with integrated crop-livestock based diversification while family size, non/off-farm income and training are significantly and negatively associated. Similarly, plot size and frequency of extension contacts are significantly and positively associated with rainwater harvesting whereas off-farm income have a significant and positive relation.

Seid *et al.,* (2016) also pointed out that sex of the household head, literacy status, farming experience, family size, land holding, access to credit, access to media, extension contact, farmer to farmer extension, farm income, off/non-farm income, livestock ownership, market distance and access to training have a statistically significant impact on climate adaptation strategies. Generally, the determinants of adaptation and choice of adaptation strategies differ from region to region as well as from time to time.

2.7. Barriers to Effective Adaptation

Generally, education and awareness about climate change impacts and therefore adaptive capacities were found to be very low among sub-Saharan Africa farmers. This was due to weak institutional coordination and support, lack of information and low level of income. The barriers to adaptations to climate change included lack of access to early warning information and the unreliability of seasonal forecast. As to Gandure *et al.,* (2012) finding, lack of access to adequate cropland was a barrier for farmers to adapt to climate change. Other studies indicated that insufficient access to inputs, lack of knowledge about other adaptation options, no access to water, lack of credit, lack of information about climate change, high cost of adaptation and insecure property rights were the main climate change adaptation constraints (Acquah de Graft, 2011; Acquah-de Graft & Onumah, 2011; Sofoluwe *et al.,* 2011; Deressa *et al.,* 2008; Nhemachena and Hassan, 2007).

Furthermore, different studies confirmed that information asymmetry, irregularities of extension services, poor government attention to climate problems, inability to access available information and improved crop varieties/seeds, ineffectiveness of indigenous methods, no subsidies on planting materials, limited knowledge on adaptation measures, low institutional capacity, and absence of government policy on climate change were the main factors that prevent farmers from adapting to climate change impacts (Nzeadibe *et al.,* 2011; de Wit, 2006; Maddison, 2006).

3. CONCLUSION AND RECOMMENDATION S

This article synthesizes the available literatures on Farmers' perceptions, impact and adaptations to climate in sub-Sahara Africa. The review found out that most farmers in sub-Sahara Africa are aware that the temperature and precipitation or rainfall patterns have changed. However, changes in precipitation patterns are different for different regions in Africa. In addition, the review indicated that the impact of climate change is severe as it highly affects the agriculture sector, which is the primary source of livelihood in the region. Important adaptation options being pursued by farmers in sub-Saharan Africa countries include diversification of crops, adjusting planting and harvesting dates, increased use of irrigation, planting tree crops, increased use of water and soil conservation practices, and diversifying activities from farm to non-farm activities.

Different empirical studies showed that the gender of the farmers, age of farmers, farming experience, family size, years of education, access to credit facilities, access to and frequency of extension services, access to information, access to climate related trainings, distance from market center, agro-ecological zones and off-farm income are among the significant determinants of implementing different climate change adaptation measures. These findings have both public and private (farm-level) policy implications.

At the public policy level, sub-Sahara African governments should include climate change adaptation policies in their development agenda. This should include supporting farmers in increasing these adaptation measures through improving their access to different kinds of livelihood assets to enable them to enhance their adaptive capacity. There is also the need for governments and other concerned bodies to invest in climate resilient projects such as improving on existing or building new water infrastructure and building or improving on climate monitoring and reporting stations. Furthermore, to improve on the existing knowledge on climate change there is the need to conduct further research at local, regional or country levels. The implementation of any climate change policy requires substantial empirical research evidence of the potential costs and benefits of such policy. Therefore, advanced or extensive climate change research is the key to the implementation of regional, national and local climate policy.

REFERENCES

ACCCA. (2010). Farm-level climate change perception and adaptation in drought prone areas of Tigray, Northern Ethiopia: in improving decision-making capacity of smallholder farmers in response to climate risk adaptation in three drought prone districts on northern Ethiopia, *IDRC Project No093*.

Acquah-de Graft, H. (2011). Farmers' perceptions and adaptation to climate change: a willingness to pay analysis.

Journal of Sustainable Development in Africa, 13(5), 150-161.

Acquah-de Graft, H., & Onumah, E. (2011). Farmers' perceptions and adaptations to climate change: An estimation of willingness to pay. *Agris, 3*(4), 31-39.

Aemro Tazeze, Jema Haji and Mengistu Ketema, 2012. Climate change adaptation strategies of smallholder farmers: the case of Babile district of East Hararghe zone of Oromiya regional state of Ethiopia. *Journal of Economics and Sustainable Development,* 3 (14): 1-12.

AFP, (2007). Climate Change and Africa. *8th Meeting of African Partnership Forum*, Berlin, Germany, 22-23 May, 2007.

Akponikpe, P., Johnston, P., & Agbossou, E. K. (2010). Farmers' perceptions of climate change and adaptation strategies in sub-Sahara West Africa. *2nd International Conference on Climate, Sustainability and Development in Arid Regions, Fartaleza-Ceara, Brazil.*

Apata, T. G., Samuel, K. D., & Adeola, A. O. (2009). Analysis of climate change perceptions and adaptation among arable food crop farmers in South Western Nigeria. *Contributed paper presented at 23rd Conference of International Association of Agricultural Economists, Beijing, China, August 16-22, 2009*.

Arnell, N. W. (2004). Climate change and global water resources: SRES emissions and socio-economic scenarios.*Global Environmental Change, 14*(1), 31-52.

Aymone, G., 2009. Understanding farmers' perceptions and adaptation to climate change and variability: The case of the Limpopo basin, South Africa. IFPRI Discussion paper 00849, *International Food Policy Research Institute*: Washington DC.

Belaineh Legesse, Yared Ayele and Woldeamlak Bewket, 2013. Smallholder farmers' perceptions and adaptation to climate variability and climate change in Doba district, west Hararghe, Ethiopia. *Asian Journal of Empirical Research* 3(3):251-265.

de Wit, M. (2006). The perception of and adaptation to climate change in Africa, *CEEPA discussion Paper No. 10, CEEPA, University of Pretoria.*

FAO. (2009). *Climate Change in Africa: The Threat to Agriculture*. Retrieved from ftp://ftp.fao.org/docrep/fao/012/ak915e/ak915e00.pdf.Accessed on 25/12/2012

FAO. (2007). *Food and Agricultural Organization of the United Nations*. Retrieved from www.fao.org/nr/water/aquastat/countries/botswana/index.stm.

Fosu-Mensah, B., Vlek, P., & Manschadi, M. (2010). Farmers' Perceptions and Adaptations to Climate Change: A Case Study of Sekyedumase District in Ghana. *A contributed paper presented at World Food Systems Conference in Tropentag, Zurich: 14th -16 September, 2010*.

Gandure, S., Walker, S., & Botha, J. J., (2012). Farmers'perceptions of adaptation to climate change and water in a South African rural community. *Environment Development.* Retrieved from http://dx.doi.org/10.1016/j.endev.2012.11.004.

Gbetibouo, G. (2009). Understanding Farmers' Perceptions and Adaptations to Climate Change and Variability, the Case of the Limpopo Basin, South Africa: IFPRI Discussion paper 00849.

IPCC. (2007). Summary for Policymakers. In M. L. Parry, O. F. Canziani, J. P. Palutikof, P. J. van der Linden, & C. E. Hanson (Eds.), *Climate Change 2007: Impacts, Adaptation and Vulnerability.* Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge, UK and New York, NY, USA: Cambridge University Press.

IPCC. (2001). Climate Change 2001: Impacts, Adaptation and Vulnerability. In J. J. McCarthy, O. F. Canziani, N. A. Leary, D. J. Dokken, & K. S. White (Eds.), *IPCC Working Group II, Third Assessment Report*. Cambridge University Press.

Juana, J. S., Makepe, P. M., & Mangadi, K. T. (2012). Empirical analysis of the impact of drought on the Botswana economy, Presented at the *AERC/UNU-WIDER Climate Change Workshop, Helsinki, 25-29 September, 2012*.

Juana J., Z. Kahaka and F. Okurut (2013). Farmers' Perceptions and Adaptations to Climate Change in Sub-Sahara Africa: A Synthesis of Empirical Studies and Implications for Public Policy in African Agriculture. *Journal of Agricultural Science; Vol. 5(4):121-135*.

Kurukulasuriya, P., and Mendelson, R. (2006). *Crop Selection: Adapating to Climate Chnage in Africa.* IFPRI, Environment and Production Technology Division. Washington, DC: International Food Policy Research Institute.

Lovejoy, T. E. (2005). Conservation with a changing climate. In T. E. Lovejoy, & L. Hannah (Eds.), *Climate Change and Biodiversity*. New Haven & London, UK: Yale University Press.

Maddison, D. (2006). The perception and adaptation to climate change in Africa. *CEEPA. Discussion paper No.10. Centre for Environmental Economics and Policy in Africa*. Pretoria, South Africa, University of Pretoria.

Mandleni, B., & Anim, F. (2011). Perceptions of Cattle and Sheep Framers on Climate Change and Adaptations in the Eastern Cape Province of South Africa. *Journal of Human Ecology, 34*(2), 107-112.

Mengistu, D. K. (2011). Farmers' perception and knowledge of climate change and their coping strategies to the

related hazards: Case study from *Adiha*, central Tigray, Ethiopia. *Agricultural Sciences, 2*(2), 138-145.

Mertz, O., Mbow, C., Reenberg, A., & Diouf, A. (2009). Fermers' Perceptions of Climate Change and Agricultural Adaptation Strategies in Rural Sahel. *Environmental Management, 43*(2009), 804-816.

Newton, A.C., S.N. Johnson, and P.J. Gregory, 2010. Implications of climate change for diseases, crop yields and food security. A paper presented in BGRI 2010 Technical Workshop, 30-31- May 2010, St Petersburg, Russia.

Ngigi, S.N., 2009. Climate change adaptation strategies: Water resources management options for smallholder farming systems in sub-Saharan Africa. Columbia University: New York.

Nhemachena, C., & Hassan, R. (2007). *Micro-level Analysis of Farmers' Adaptations to Climate Change in Southern Africa.* IFPRI, Environment and Production Technology Division. Washington, DC: International Food Policy Research Institute.

Nyanga, P., Johnsen, F., Aune, J., & Kahinda, T. (2011). Smallholder Farmers' Perceptions of Climate Change and Conservation Agriculture: Evidence from Zambia. *Journal of Sustainable Development, 4*(4), 73-85. http://dx.doi.org/10.5539/jsd.v4n4p73.

Nyong, A. (2005). Key Vulnerabilities to climate change in Africa: in Global warming: Looking beyond Kyoto. Yele Centre for Study of Globalization 21-22 October, 2005. Retrieved from http://www.ycsg.yale.edu/climate/forms/Nyong_Yale.pdf. Accessed 13/12/2012.

Nzeadibe, T. C., Egbule, C. L., Chukwuone, N., & Agu, V. (2011). Farmers' Perceptions of Climate Change Governance and Adaptation Constraints in Niger Delta Region of Nigeria. *African Technology Policy Network,* Research Paper No. 7.

O'Brien, K., L. Sygna, L.O. Naess, R. Kingamkono, and B. Hochobeb, 2000. User responses to seasonal climate forecasts in southern Africa. Report 2000:3, Center for international climate and environmental research: Oslo.

Parry, Martin *et al.* (2007). Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge, UK: Cambridge University Press.

Seid S. (2016). Farmers' Perception of and Adaptation to Climate Change and Variability: The Case of Assosa District, Western Ethiopia. *Journal of Natural Sciences Research*: *Vol.6 (17):117-122*.

Seid S., H. Jema and G. Degye, (2016). Climate Change Adaptation Strategies of Smallholder Farmers: The Case of Assosa District, Western Ethiopia. *Journal of Environment and Earth Science: vol. 6(7):103-109.*

Shiklomanov, I. A. (1997). Assessment of Water Resources and Water Availability in the World. *World Meteorological Organization*.

Sofoluwe, N., Tijani, A., & Baruwa, O. (2011). Farmers' Perception and Adaptations to Climate Change in Osun Satte, Nigeria. *African Journal of Agricultural Research, 6*(20), 4789-4794.

Sowunmi, F.A. and J. Kintola (2009). Effect of climatic variability on maize production in Nigeria. *Research Journal of Environmental and Earth Sciences,* 2 (1): 19-30.

Temesgen Deressa, R.M. Hassan, Tekie Alemu, Mahmud Yesuf and C. Ringler (2008). Analyzing the determinants of farmers' choice of adaptation methods and perceptions of climate change in the Nile Basin of Ethiopia. IFPRI Discussion Paper, September, 2008.

Temesgen Deressa, R.M. Hassan, C. Ringler, Tekie Alemu and Mahmud Yesuf (2009). Determinants of farmers' choice of adaptation methods to climate change in the Nile Basin of Ethiopia. *Global Environmental Change,* 19: 248-255.

Yesuf M., Di Falco. S., Deressa, T., Ringler. C., & Kohlin. G. (2008). *The Impact of Climate Change and Adaptation on Food Production in Low-Income Countries: Evidence from the Nile Basin, Ethiopia, EDRI.*

World Bank (2008). World Development Report 2008: Agriculture for development. Washington DC: World Bank.

World Bank Group (2010). Economics of adaptation to climate change, Ethiopia country study. Washington DC. Available at http://climatechange.worldbank.org/content/ethiopia economics adaptation climate change study.

Zhai, F. and J. Zhuang (2009). Agricultural impact of climate change: A general equilibrium analysis with special reference to Southeast Asia. ADBI Working Paper 131. Tokyo: Asian Development Bank Institute. http://www.adbi.org/workingpaper/2009/02/23/2887.