

Reviewing Climate Change Related Shifts in the Agricultural System and Livelihood of the Farming Community

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Abstract

The threat of climate change is particularly in the areas of agriculture, land use, energy consumption, biodiversity, health and water resources. Poor people who depend on agriculture as a means of livelihood are the most vulnerable to the challenges stemming from climate change. The impacts of climate change will surely be felt in almost all the geographical location as well as sectors of the nation's development. Specifically it will manifest in the following ways; burning fossil fuels, deforestation and a growing world populations. There are four major causes of climate change namely; astronomical causes, volcanic eruptions, variations in solar output and changes in earth's environment as a result of human activity. The intergovernmental panel on climate change (IPCC) says that human activity is the main cause of the changes seen in climate. This it does through activities that cause emissions of greenhouse gases (mainly consist of carbon dioxide, water vapor, methane and nitrous oxide). Climate change impacts the four key dimensions of food security, namely food availability, food stability, food accessibility, and food utilization. Availability of agricultural products is affected by climate change directly through its impacts on crop yields, crop pests and diseases, and soil fertility and water-holding properties. It is also affected by climate change indirectly through its impacts on economic growth, income distribution, and agricultural demand. In addition, stability of crop yields and food supplies is negatively affected by variable weather conditions. Therefore, climate change mitigation can be partly achieved through the reduction of greenhouse emissions from agriculture by encouraging environmental friendly agricultural practices. The need for effective adaptive measures to changes in climatic condition cannot be overemphasized as the challenges posed by vagaries of climate has an adverse effect on food security, livelihood, labor productivity, poverty and the economy in general. It is recommended that policy measures on climate change adaptation should be very supportive of climatic information dissemination as successful adaptation to climate change depends on reaching the most vulnerable, who may not have easy access to and appropriate understanding of existing climate information.

Keywords: Climate change, Climate change effect, Livelihood, Farming community, Response mechanisms.

DOI: 10.7176/JBAH/11-5-05

Publication date: March 31st 2021

1. INTRODUCTION

Global climate change is one of the most critical challenges facing the international community today. Climate change is threatening to undo decades of development efforts due to its negative impacts on agriculture, health, environment, roads, and buildings especially in developing countries (GoU, 2007; IPCC, 2007; Mendelsohn *et al.*, 2006; Stern, 2007). From a food security perspective, sub-Saharan Africa (SSA) is arguably the most vulnerable region to many adverse effects of climate change due to a very high reliance on rain fed agriculture for basic food security and economic growth, and entrenched poverty (Dixon *et al.*, 2001; IPCC, 2007; Cooper *et al.*, 2008). Climate change is certain to amplify these vulnerabilities given projections of warming temperatures, potential for increased activity attributable to the ElNiño Southern Oscillation and trends of increased aridity in southern Africa and other regions within Africa (Christensen *et al.*, 2007; IPCC, 2007).

Climate change will have a significant impact on the livelihoods of the rural poor in developing countries. The Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) predicts that climate change is likely to have a significant effect on agricultural production in many African countries. Projected reductions in yield in some African countries could be as much as 50% by 2020, and net crop revenues could fall by 90% by 2100 (Boko *et al.* 2007). This amounts to a serious threat to food security and to the achievement of major developmental goals.

As the results presented in Nelson and van der Mensbrugge (2013) indicate, climate change is expected to have generally negative effects on developing-country agriculture, with concomitant implications for food security. Projections indicate that the impacts will increase over time, with socioeconomic development and trade much more important drivers of food security in the short run, but with climate change playing an increasingly important role after 2030. In the intervening years, however, climate shocks such as drought, flooding, and extreme temperatures are expected to increase in frequency and intensity, and that is already

occurring (IPCC 2012). In the absence of measures to reduce the vulnerability to, and impacts of, such extreme events, they can be expected to generate significant and negative impacts on food security (FAO 2010; Foresight 2011).

At present, some 70 percent of the food-insecure people in the world are rural and directly or indirectly dependent on agriculture for income as well as food (IFAD 2011). Rural poverty and hunger are concentrated in two locations: South Asia, with the greatest number of poor rural people, and Africa south of the Sahara (SSA), with the highest incidence of rural poverty. Those two areas are also where the bulk of future population growth is expected to occur. Some countries, mostly in SSA, could see population increases of 200 percent or more to the middle of this century, representing a substantial growth in absolute numbers (Nelson and van der Mensbrugge 2013). Such areas of growing populations, highly dependent on agriculture and with high rates of food insecurity, are also where climate change is expected to have the worst effects. Ericksen *et al.* (2011) indicate considerable overlap between areas of high poverty and food insecurity and “climate change hotspots,” partly due to projected impacts of climate change but also because poverty reduces coping capacity.

Reducing poverty and food insecurity in agriculture-dependent populations is thus also a key means of reducing vulnerability to climate change, increasing the urgency of addressing the challenge. How to accomplish that goal? Research has shown that gross domestic product growth originating in agriculture is almost three times more effective in reducing poverty than growth in other sectors of the economy due not only to the direct poverty reduction effect but also to its potentially strong growth linkage effects on the rest of the economy (FAO 2012b; De Janvry and Sadoulet 2010). Thus, the next 20 years are a critical window of time for accelerating the rate of agricultural growth in least-developed countries to achieve food security and development for agriculture-dependent populations.

Agriculture is an economic activity that is highly dependent upon weather and climate in order to produce the food and fiber necessary to sustain human life. Not surprisingly, agriculture is deemed to be an economic activity that is expected to be vulnerable to climate variability and change. The vulnerability of agriculture to climate variability and change is an issue of major importance to the international scientific community, and this concern is reflected in Article 2 of the UNFCCC, which calls for the: ...stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent serious anthropogenic interference with the climate system. Such a level should be achieved within a time frame sufficient to: (i) allow ecosystems to adapt naturally to climate change; (ii) ensure that food production is not threatened; and (iii) enable economic development to proceed in a sustainable manner.

Despite African's being highly vulnerable to rainfall variability and climatic shocks like droughts and floods (MoWE, 2002; GoU, 2007; GoU, 2010; MoWE, 2010), micro-level studies at the farm-level on how rural smallholder farmers perceive these changes are limited. Most studies assessing the potential effects of climate change on African agriculture are regional or national and yet adaptation is place-based and needs the use of place-specific strategies (Fischer *et al.*, 2002; Hassan & Nhemachena, 2008; Kurukulasuriya & Mendelsohn, 2008; Lobell *et al.*, 2008; Seo *et al.*, 2009; Deressa *et al.*, 2011). There is also limited knowledge on whether farmers perceive climate change and how they are responding to the effects of a changing climate. It is also important to note that local perceptions cannot be estimated by models and the need to document how the lives of the local people are affected by the recent changes in climate.

In countries like Senegal, China, Ghana, Nepal, Bangladesh, Nigeria, United States of America, farmers have been mentioned to perceive and even adapt to changes in the climate (Mertz *et al.*, 2009; Byg & Salick, 2009; Fosu-Mensah *et al.*, 2010; Maharjan *et al.*, 2011; Haque *et al.*, 2011; Salau, 2012; Arbuckle *et al.*, 2013). Socioeconomic and environmental factors have been demonstrated in various studies to influence farmers' perception and adaptation to changes in the climate (Deressa *et al.*, 2011), those include education, household size, livestock ownership, agro-ecological zone, farm size and access to credit among others. However, Gukurume (2013) reported that peasant farmers in Bikita district, Zimbabwe, had no adaptive capacity due to extreme poverty levels and reliance on basic technologies.

Coping strategies that have been recommended for instance in Ethiopia to lessen the negative impacts of climate change include encouraging livestock ownership, planting early-maturing and drought-tolerant crop varieties, investment in irrigation, and strengthening research institutions (Deressa & Hassan, 2009). In Ghana, Fosu-Mensah *et al.*, (2010) identified crop diversification and changing planting dates for crop plants as the two most common adaptation strategies used by farmers. In Zimbabwe, crop and livelihood diversification were the main coping strategies used to reduce the risk of crop failure and livelihood vulnerability (Gukurume, 2013).

2. WHAT IS CLIMATE CHANGE?

Climate change is one of the most outstanding challenges facing the global community and as such has been given different definitions by different authors according to their perception and the way it affects them.

The intergovernmental panel on climate change (IPCC) defines climate change as statistically significant variations that persist for an extended period, typically decades or longer. It includes shifts in the frequency and

magnitude of sporadic weather events as well as the slow continuous rise in global mean surface temperature. Ozor 2009 defined climate change as change in climate over time, whether due to natural variability or as a result of human activity and is widely recognized as the most serious environmental threat facing our planet today. This definition elicits the seriousness of the threat posed by climate change and the urgency of the need for countries to rise up to this urgent clarion call of combating the negative effects of climate change. The climate we know cannot be said to be static, but variations are very insignificant that it is only climatologists identify it. Over the years, the change becomes more pronounced and significant. This is as a result of earth's natural variations and man's activities which cause emissions of greenhouse gases thereby increasing global warming. This global warming is what actually induces the change in climate.

Scientists have noted that the average temperature of the earth has increased by 0.74 degrees Celsius over the past 100 years. And if nothing is done, there is going to be more rise in the earth's temperature to the extent that it will be difficult to cope with it.

2.1. CAUSES OF CLIMATE CHANGE

There are four major causes of climate change namely; astronomical causes, volcanic eruptions, variations in solar output and changes in earth's environment as a result of human activity. The intergovernmental panel on climate change (IPCC) says that human activity is the main cause of the changes seen in climate. This it does through activities that cause emissions of greenhouse gases (mainly consist of carbon dioxide, water vapor, methane and nitrous oxide). Studies of long-termed climate change have discovered a connection between the concentrations of carbon dioxide in the atmosphere and mean global temperature. Carbon dioxide is one of the more important gases responsible for the greenhouse effect. These greenhouse gases are able to alter the energy balance of the earth by being able to absorb long wave radiation emitted from the earth's surface. The net result of this process and the re-emission of long wave back to the earth's surface increases the quantity of heat energy in the earth's climatic system. Human activity is changing the amount of greenhouse gases in the atmosphere in three important ways, namely;

2.1.1. Burning fossil fuels

Carbon dioxide is one of the main greenhouse gases and contributors to the greenhouse effect. When fossil fuels like coal, oil and gas burn they release greenhouse gases. Anyadike, (2009) stated that through energy creating activities like heating homes and building, transportation and cooking food, traveling (for example, by car, plane, bus and train), treating water to make it drinkable, heating it and piping it into homes, manufacturing from fridges, gas flaring, bush burning etc. people induce the emission of carbon dioxide into the atmosphere. Since the industrial revolution which began in the 18th century, the amount of CO₂ in the atmosphere has increased by 35%.

2.1.2. Deforestation

Deforestation where forests are cut down faster than they are replaced is a major contributor to climate change. This accounts for 20 percent of the world's carbon emissions (more than the entire transport sector produces). Deforestation makes such a huge contribution to carbon emissions because trees absorb CO₂ as they grow. If there are fewer trees left to absorb CO₂, then CO₂ will build up in the atmosphere. The agriculture and industry that replace the forests do not only damage the earth's ability to absorb CO₂, they often cause an additional problem by producing carbon emissions of their own. In Nigeria, the primary tropical forest cover has been decimated by 97% mostly since 1990. The remainder is supposedly protected in Cross Rivers National Park and by a two year logging ban imposed in November 2008. The country's broader forest cover was estimated at just over 12% in 2005, being depleted at a rate of 3.3% per annum. The main cause is the demand for wood fuel. Therefore there is need for the country to educate its citizenry on the importance of the forest reserves as well as the need to avoid unnecessary cutting down of trees.

2.1.3. A Growing World Population

As the world's population grows, there are more people who need food, livestock and energy. This increased demand leads to increased emissions.

2.2. EFFECTS OF CLIMATE CHANGE

Globally, extreme weather is predicted to become more common and animals, plants and crops are all expected to be badly affected. The effects of climate change is expected not to stop at just affecting the crops and plants (i.e. the farmers), it will surely affect the lives and overall development of country. Eboh 2009 stated that the effects of climate change are projected to manifest through changes in land and water regimes, specifically, changes in the frequency and intensity of droughts, flooding, water shortages, worsening of droughts, worsening soil conditions, desertification, disease and pest outbreaks on crops and livestock. Anyadike (2009) stated that the general environmental effects of climate change include; rise in sea level due to melting of ice caps; changes in dates of onset and end of the rainy season; reduced rainfall amounts in some areas and increased rainfall amounts in others, leading to flooding and increase in intensity of atmospheric disturbances such as

thunderstorms and line squalls. He went further to state that climate change will deepen poverty both directly and indirectly. The direct impact he explained will manifest through the loss of lives, livelihoods, assets, infrastructure, etc from climate extreme events. The Third assessment report of IPCC (2001) stated that the poorest countries are more vulnerable to the risk of climate change and went further to identify a range of poverty-related climate change impacts as follows; reductions in crop yield (fall in agricultural productivity) in most tropical and subtropical regions due to decreased rainfall, changes in food security, employment, incomes and economic growth, displacement of people from coastal and densely populated low lying areas, salinisation of these fertile areas, exposure of millions of people to new health risks, especially from vector-based diseases like malaria and schistosomiasis, as well as water-borne diseases like cholera and dysentery and malnutrition from the reduction in crop yields.

The impacts of climate change will surely be felt in almost all the geographical location as well as sectors of the nation's development. Specifically it will manifest in the following ways;

2.2.1. Crop and animal production

As temperature increases and rainfall pattern becomes more unpredictable, crop yields are expected to drop significantly. Also extreme weather events such as thunderstorms, heavy winds and floods devastate farmlands and can lead to crop failure. Pests and diseases migrate in response to climate changes and variations. It is estimated that by 2100, Nigeria and other West African countries are likely to have agricultural losses of up to 4% of GDP due to climate change (Mendelson, *et al* 2000). Parts of the country that experienced soil erosion and operate rain fed agriculture could have decline in agricultural yield of up to 50% between 2000 – 2020 due to increasing impact of climate change (Agoumi, 2003; IPCC 2007).

Mowa and Lambi (2006); Rudolf and Hermann (2009) stated that even if there is sufficient rain, it irregularity can affect yields adversely if rain fail to arrive during the crucial growing stage of the crops. Also extreme weather leads to drying up of streams which are sources of irrigation water used by farmers during dry season crop production. Anyanwu (2008) in studying the farmer's perception of impact of climate change on food crop production identified the significant effects of climate change on crop production as; low yield of crop, stunted growth of crop, ease spread of pest and disease attack on crops, drying of seedling after germination and ineffectiveness of agricultural chemicals due to delay of rainfall. This agrees with the statement of Ozor (2009) that variations in rainfall pattern will affect crop production in varying ways depending on the location. He also went further to explain that changes in crop development and

phenology as a result of climate change can cause shortening or lengthening of crop cycles that could lead to decreases or increases in productivity. Structural changes he said especially in carbohydrate status of plants can also occur. This changes when they occur will surely affect the nutritional value, taste and storage quality of some fruits and vegetables. Also increases in CO₂ can also lower crop water requirements by reducing transpiration per unit leaf area.

On the side of Livestock production, Ozor (2009) stated that livestock production systems would be vulnerable to climate change in respect of anticipated decrease in rainfall and consequent reduction in the available pastureland. This he explained further by listing the various ways the anticipated decrease in rainfall will affect livestock as declining availability of surface water resources for animals, possible increase in salinity at water resources for animals, possible increase in salinity at watering points due to increase in temperature and evaporation in the face of reduced rainfall.

This is to say that further changes in rainfall and temperature will affect livestock production as well as availability of animal species. Some species might be unable to adapt quickly enough and habitats might not be available for them to move into. If global temperatures rise by 2 degrees Celsius, 30 % of all land-living species may be threatened by an increase risk of extinction. Though increase in temperature is generally seen to be destructive to the production of crops and human lives, FAO (2009) noted that livestock production could be boosted by temperature increase. Conversely, Deressa and Hassan (2009) found increasing temperature damaging to the Ethiopian agriculture; a situation that is not uniformly distributed across agro-ecological zones. Issa (2009) in agreement with the findings of Deressa and Hassan (2009) reported that commercial Livestock producers are negatively affected by rising temperature. This to say that varying climate has varying effects on crops and livestock depending on the agro-ecological location.

2.2.2. Fishery

Fish farming and the associated processes are becoming an important source of revenue and employment in World. Ozor (2009) stated that subtle changes in key environment variables such as temperature, salinity, wind speed and direction, ocean currents, strength of upwelling due to climate change could sharply alter the abundance, distribution and availability of fish production in the country. In the same vein, African Action (2009) stated that changes in ocean dynamics could lead to changes in migrating patterns of fish and possibly reduced fish landings especially in coastal fisheries. All these will directly and indirectly affect the livelihoods of fish farmers, their immediate families and their dependants. It will also affect the revenue sustenance of those who work or trade on fishery resources. Tubiello (2008) noted three major pathways through which climate change

will affect fisheries and aquaculture, as well as dependent communities and their economic activities as;

- Physical and chemical changes in oceans and fresh waters, including increase in water temperature and changes in salinity among others.
- Change in fish production, catch composition and species distribution resulting from a complex interplay of ecological changes and
- Physical changes to coasts, estuaries, wetlands, lakes and rivers caused by changing weather patterns, weather-driven natural disasters and sea-level rise. Fishery resources are known to be highly sensitive to marine environmental changes. Though they had always coped with these changes, future climate changes will likely be so extreme that it may be difficult for them to cope with. Therefore, identification of proper adaptation strategies is a high priority for the fishery sector.

2.2.3. Forestry

The forest reserves of the nation are not left out in the threat posed by climate change. Francesco, (2008) stated that climate change will affect agriculture and forestry through higher temperatures, elevated CO₂ concentration, precipitation changes, increased weeds, pests and disease pressure, and increased vulnerability of organic carbon pools. It is worthy to note that eleven out of the thirty-six states in the country referred to as the frontline states are gradually being swallowed up by desertification. As at 1985, deforestation claimed 1,544sq miles of the nation's forest land. Between 1983 and 1993 alone, Nigeria lost 20% of its forest and woodland areas. Nigeria's primary tropical forest in Cross River State has been decimated by 97%, mostly since 1990. The country's broader forest cover was estimated at just over 12% in 2005, being depleted at a rate of 3.3% per annum. The main cause is the demand for wood fuel. This depletion of the nation's forest reserves when critically looked at is not far from indirect effect of climate change. As a result of the drying up of village or communities forest which the dwellers depend on for firewood, they resort to the depletion of forest reserve as a means of getting wood fuel.

2.2.4. Sea levels

Globally, over the past century, the temperature of the atmosphere near the earth's surface has risen by 0.75 degree Celsius consequently sea level is expected to rise with the rising temperature, this would swamp some small, low lying islands states and put millions of people in all low-lying areas at risk of flooding. In Nigeria half of the 15 million population of Lagos lives less than six feet above sea level, including the wealthiest areas of Victoria Island and Lekki Peninsula. Also the Niger Delta may be the source of oil wealth but its low-lying terrain crisscrossed with water ways makes it extremely vulnerable to flooding. Bearing in mind the high population density (9th largest population in the world) of the country any displacement of this mass of people will be catastrophic especially as over 50% of this population lives below poverty lines. Therefore mitigating the impacts of climate change must be given priority if the nations Millennium development goals will ever be achieved.

2.2.5. Health of the people.

A healthy nation they say is wealthy nation. Climate change is expected to induce health problems directly and indirectly. The direct effects manifest in persistent and resistant to treatment as were never experienced before. Okhimamhe 2009, in studying the impacts and adaptation of climate change in Africa found out that diseases like persistent malaria, hypertension, ulcer, diarrhea, asthma and diabetes are new ailments that were ushered in by the changing climate, with malaria being the most widespread. She pointed out that thirty years ago, the people relied on local herbs for treating illnesses, but now, they have to go to nearby fairly functional clinics for treatment especially because the herbs are no longer able to stop diseases. In addition most of the herbs used are no longer available. Some diseases like tick-transmitted meningitis are infectious diseases that can be influenced by climate change. Also extreme weather events are known to facilitate some cardiovascular disease like asthma.

3. CLIMATE CHANGE AND AGRICULTURE

The threat that climate changes pose to agricultural production does not only cover the area of crop husbandry but also includes livestock and in fact the total agricultural sector. The impacts of climate change on agriculture can be classified into biophysical and socioeconomic impact (Khanal, 2009). The biophysical impacts include; physiological effects on crop and livestock, change in land, soil and water resources, increased weed and pest challenges, shifts in spatial and temporal distribution of impacts, sea level rise and changes to ocean salinity and sea temperature rise causing fish to inhabit in different ranges. The socio-economic impacts result in decline in yield and production, reduced marginal GDP from agriculture, fluctuation in world market price, changes in geographical distribution of trade regime, increased number of people at risk of hunger and food insecurity, migration and civil unrest. Direct effects of climate variables such as air, temperature, humidity, wind speed and other climate factors influence crop performance such as yield and animal performance such as growth, milk production, wool production and reproduction. Climate can also affect the quantity and quality of feed stuffs such as pasture, forage, and grain and also the severity and distribution of livestock diseases and parasite (Niggol and Mendelsohn 2008). According to FAO (2008), Climate change variables influence biophysical factors, such

as plant and animal growth, water cycles, biodiversity and nutrient cycling, and the ways in which these are managed through agricultural practices and land use for food production. However, climate variables also have an impact on physical/human capital such as roads, storage and marketing infrastructure, houses, productive assets, electricity grids, and human health which indirectly changes the economic and socio-political factors that govern food access and utilization and can threaten the stability of food systems.

4. IMPLICATION OF CLIMATE CHANGE ON FOOD SECURITY

Climate change impacts the four key dimensions of food security, namely food availability, food stability, food accessibility, and food utilization. Availability of agricultural products is affected by climate change directly through its impacts on crop yields, crop pests and diseases, and soil fertility and water-holding properties. It is also affected by climate change indirectly through its impacts on economic growth, income distribution, and agricultural demand. In addition, stability of crop yields and food supplies is negatively affected by variable weather conditions. Physical, economic, and social access to food would be affected negatively by climate change as agricultural production declines, food prices rise, and purchasing power decreases. Last but not least, climate change poses threats to food utilization through effects on human health and the spread of diseases in geographical areas which were previously not affected. By 2080, agricultural output in developing countries may decline by 20 percent due to climate change, while output in industrial countries is expected to decrease by 6 percent. Also due to climate change, yields in developing countries could further decrease by 15 percent on average by 2080 (FAO, 2008). Climate change will also affect the ability of individuals to use food effectively by altering the conditions for food safety and changing the disease pressure from vector, water, and food-borne diseases.

5. IMPLICATION OF CLIMATE CHANGE ON LIVELIHOOD

Agriculture provides the means of livelihoods to a larger proportion of peoples either directly or indirectly and therefore, the need to combat climate change for the purpose of sustaining livelihoods cannot be overemphasized. Climate change worsens the living conditions for many who are already vulnerable, particularly in developing countries because of the lack of assets and adequate insurance coverage. Agriculture-based livelihood systems such as small-scale rain fed farming, pastoralism, inland and coastal fishing/aquaculture communities, and forest-based systems that are already vulnerable to climate change face immediate risk of increased crop failure, loss of livestock and fish stocks, increasing water scarcities and destruction of productive assets (FAO, 2008). These unfavorable conditions are likely to have an adverse effect on the income, standard of living and health status of agrarian households. The livelihood status of agricultural as well as agro-allied firms will also change if centers of agricultural production shift or methods of production become less labor-intensive in response to climate change. All wage earners face new health risks that could cause declines in their productivity and earning power. Changing climate conditions and rising sea levels are also likely to make many places uninhabitable unless concerted and effective adaptation measures are taken, which could displace many vulnerable people with devastating consequences for their livelihoods and social relations. It is worth noting that climate change will affect livelihood of people differently depending on such factors as landownership, asset holdings, marketable skills, gender, age and health status.

6. RESPONSE MECHANISMS OF CLIMATE CHANGE

It has been established that climate change could result in adverse agricultural as well as environmental effects leading to food insecurity, poor livelihood, widespread poverty, high disease incidence, unemployment and poor economic growth which calls for well thought-out measures of adapting to climate change as a means of mitigating the adverse effects of climate change.

6.1 Mitigation strategies

Mitigation refers to elimination or reduction of frequency, magnitude or severity of exposure to environmental, economic, legal, or social risks, or minimization of the potential impact of a threat or warning. Climate change mitigation measures recognize that the amount of greenhouse gases in the atmosphere will influence the rate and magnitude of climate change. Therefore it is within the capacity of humans to influence their exposure to change. Climate change mitigation measures contributing to reduce disaster risks by reducing expected climate change impacts.

- Energy efficiency and conservation measures through substituting fossil fuels with renewable energy sources such as solar, wind and hydro powers.
- Implementing land use systems.
- Designing appropriate natural resources utilization policy and strengthening institutional monitoring and legislative mechanisms.
- Proper waste management.

- Using environmental friendly and sustainable measures in the transport and agricultural sectors.
- Sequestering carbon biologically through reforestation or geo-physically (inside the earth's crust)

6.2 Adaptation strategies

Adaptation: IPPC (2001) defines adaptive capacity as the ability of a system to adjust to climate change (including climate variability and extremes) to moderate potential damage, to take advantage of opportunities, or to cope with the consequences. Whereas 'mitigation' refers to tackling the anthropogenic causes of climate changes, 'adaptation' focuses on reducing negative effects of climate change by modifying systems to take in to account new/anticipated climatic conditions.

Adaptive coping mechanisms are strategies that have evolved over time through peoples lengthy experience in dealing with the known and understood natural variation that they expect in terms of seasons, combined with their specific response to a season as it unfolds. While adaptive strategies are longer –term (beyond a single season) strategies that are needed for people to respond to a new set of evolving conditions (biophysical, social and economic) which they have not previously experienced. The extent to which communities are able to successfully respond to a new set of circumstances will depend upon their adaptive capacity.

Adapting to climate change involves managing risk by improving the quality of information and its use, providing insurance against climate change risk, adopting known good practices to strengthen the resilience of vulnerable livelihood systems, and finding new institutional and technological solutions (FAO, 2008). Most agricultural system shave a measure of in-built adaptation capacity known as autonomous adaptation but the current rapid rate of climate change will impose new and potentially overwhelming pressures on existing adaptation capacity. This is particularly true given that the secondary changes induced by climate change are expected to undermine the ability of people and ecosystems to cope with, and recover from, extreme climate events and other natural hazards. It is for this reason that the IPCC encourages planned adaptation; that is deliberate steps aimed at creating the capacity to cope with climate change impacts (IPCC, 2007). A key component of climate adaptation involves building resilience, where resilience is the capacity of a system to tolerate disturbance without collapsing into a qualitatively different state that is controlled by a different set of processes. According to FAO (2008), Additional action areas that can strengthen resilience of agriculture-based livelihood systems include: research and dissemination of crop varieties and breeds adapted to changing climatic conditions, promotion of agroforestry, integrated farming systems and adapted forest management practices and improved soil management practices. At the grass root level, some of the adaptive measures taken by small scale farmers in the face of changing climate include alteration of planting dates, mixed cropping, tree planting, prompt weeding, changes in harvesting dates, mulching, irrigation, minimum tillage, culling of infected animals and decrease in stocking rate of animals.

7. SUMMARY

The threat of climate change is particularly in the areas of agriculture, land use, energy consumption, biodiversity, health and water resources. Poor people who depend on agriculture as a means of livelihood are the most vulnerable to the challenges stemming from climate change. Agriculture is not only affected by climate change, but also contributes to it through emitting greenhouse gases. Therefore, climate change mitigation can be partly achieved through the reduction of greenhouse emissions from agriculture by encouraging environmental friendly agricultural practices. The need for effective adaptive measures to changes in climatic condition cannot be overemphasized as the challenges posed by vagaries of climate has an adverse effect on food security, livelihood, labor productivity, poverty and the economy in general. It is recommended that policy measures on climate change adaptation should be very supportive of climatic information dissemination as successful adaptation to climate change depends on reaching the most vulnerable, who may not have easy access to and appropriate understanding of existing climate information. This implies that vulnerable groups such as farmers should have regular information on current issues of climate change adaptation which can be achieved through the strengthening of the nation's extension services in disseminating farm- level adaptation measures and other relevant climate information to farmers.

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