Chapter 6
The Threats of Climate Change: Implication for Food Crisis in Sub-Sahara Africa

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Abstract Food insecurity remains endemic in most of the Africa countries, with climate factors such as rainfall variability as a major cause. The significance of this variability is clear when we consider that in sub-Saharan Africa, agricultural production accounts for up to 90 % of food needs. Socio-economic conditions and the adverse impact of unpredictable weather on the agricultural production of communities in sub-Sahara Africa have long been recognized as an important cause of malnutrition in the region. The paper reviews the current state of knowledge related to the threats of climate to food crisis in sub Sahara Africa. Long-term climate change is linked to global warming. This increase is partly due to the influence of human activities on nature such as exhaust gas emissions from vehicles, coal burning for energy, and deforestation. Tackling these challenges of climate change will require the use of sophisticated surveillance and response systems. Therefore, mitigation policy that assures food security at all time is recommended to achieve the Millennium Development Goal 1 to reducing by half people suffering from hunger by 2015.

Keywords Climate change • Rainfed agriculture • Food crisis • Global warming • Sub-Sahara Africa

6.1 Introduction

Sustainable food security in a world of growing population and changing diets is a major challenge under climate change. Although estimates of food insecurity vary (Barrett 2010), the number of undernourished people already exceeds one billion and feeding this many people will require more than incremental changes (Federoff et al. 2010). Food production may need to increase by as much as 70 % by 2050

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when the global population will number nine billion (World Bank 2007; Royal Society of London 2009). Food security depends not only on gross production of staples, but also on agriculture's ability to provide a diverse and balanced food basket, socio-economic factors that determine whether poor people particularly women are able to purchase, store, prepare and consume sufficient food.

Sub-Saharan Africa is uniquely vulnerable to climate change because it already suffers from high temperatures, less predictable precipitation and substantially greater environmental stresses than other continents (IPCC 2001, 2008). According to the Food and Agricultural Organisation (FAO) of the United Nations, one in three people living in sub-Saharan Africa were chronically hungry in 2008. The region accounts for 25 % of the global figure of chronically undernourished. Despite a decades-long of governments' effort in the region to reduce hunger, trends show an overall increase in the number of undernourished people. In 1990–1992, 169 million people were considered undernourished, and that number jumped to 212 million in the 2003–2005 periods. Not only does this represent an increase in the absolute number of hungry people, but also an increase in the percentage of hungry people living in the region. Sub-Saharan Africa moved from having one fifth of the world's hungry in 1990–1992 to having one quarter of the world's hungry in 2003–2005 (FAO 2008). The food crisis of the past 2 years, brought on by rising fuel prices, severe weather conditions, an increase in the use of food crops for biofuels, and changes in diets had a devastating effect on less economically developed nations, including many in sub-Saharan Africa (Food and Water Watch 2008). In 2007 and 2008 price increases from between 30 and 150 % for staple foods have influenced the number of people going hungry (Oxfam International 2008). In 2007 alone, more than 24 million people became undernourished in Africa. The number of people that suffered from chronic hunger continued rising in 2008 and the projections that food prices will stay high through 2015 paint a bleak picture of the future (FAO 2008).

Agriculture is of great importance to most Sub-Saharan African economies, supporting between 70 and 80 % of employment and contributing an average of 30 % of gross domestic product (GDP) and at least 40 % of exports (Commission for Africa 2005). Majority of the poor resides in rural areas and depends on agriculture for their livelihoods. The failure of agriculture to take off in Sub-Saharan Africa has been attributed to the dependence on rainfed agriculture; low population densities; the lack of infrastructure, markets, and supporting institutions; the agro-ecological complexities and heterogeneity of the region; low use of fertilizers; and degraded soils (World Bank 2007). Running out of food is a very common phenomenon in sub Sahara Africa because crops often fail as a result of the effect of climate change (such as the unpredictable pattern of rainfall). This is an indication that climate change is already having a significant impact on Africa's food security.

A number of factors have led to sub-Sahara Africa being a region plagued with poverty and malnourishment. While there are many resource rich countries in sub-Saharan Africa, climate and geography in most of the equatorial countries does not lend itself to productive agriculture. Droughts, floods, and other severe

weather conditions have contributed in no small measure to food SSA food insecurity (Wermuth 2003). Climate change poses great risks to poor people whose livelihoods depend directly on the use of natural resources. In fact, many African countries have been coping for the past several decades with a "silent" crisis of climate variability whose impacts on food security have been devastating without always being highly visible. Global climate change poses great risks to poor people whose livelihoods depend directly on the use of natural resources. This situation has severe impact on cereal production, which relies mainly on rain-fed agriculture. Since the end of the 1980s, inter-annual gross cereal production in the Sahel has varied by 20 % on average. The significance of this variability is clear when we consider that in sub-Saharan Africa, agricultural production which accounts for up to 90 % of food needs of the region (Dembélé 2001). Socio-economic conditions and the adverse impact of unpredictable weather on the agricultural production of communities in sub-Sahara Africa have long been recognized as an important cause of malnutrition in the region. Understanding the potential implications of climate change for food systems requires evaluation of a complex set of climate, environmental, and socioeconomic factors. Sub-Sahara countries are particularly vulnerable to climate change because of their dependence on rainfed agriculture, high levels of poverty and other endowment. The United Nations Development Programme (UNDP) had observed that the progress in human development achieved over the last decade may be slowed down or even reversed by climate change, as new threats emerge to water and food security, agricultural production and access, and nutrition and public health (Ludi 2009).

Africa is the most vulnerable region to climate change because widespread poverty limits adaptive capacity. The impacts of climate change on agriculture could seriously worsen livelihood conditions for the rural poor and increase food insecurity in the region. The World Development Report 2008 (World Bank 2007) identifies five main factors through which climate change will affect agricultural productivity: changes in temperature, changes in precipitation, changes in carbon dioxide (CO_2) fertilization, increased climate variability, and changes in surface water runoff. Climate change will alter development strategy in ways that are not yet well-understood, with profound threats to agricultural production. Due to the sensitivity of agriculture to climate variability, climate change presents a significant potential threat to food security and economic growth and is likely to exacerbate the run up in global food and energy prices. The paper reviews the current state of knowledge related to the threats of climate to food production in sub Sahara Africa.

6.2 Impacts of Climate Change and Land Degradation on Sub-Sahara Africa

Sub Sahara African economies and communities are affected by climate change through increased extreme weather events, reduced crop yields and livestock productivity, drinking water shortages, reduced potential for hydroelectricity,

spread of diseases such as malaria, potential migration and social strife, increased cost of infrastructure maintenance and development, and increased pressure on service delivery and fiscal resources. Table 6.1 shows the number of people affected by disasters in sub Sahara Africa for example, Ethiopia 1995–2008 but data crosschecking shows some disparity in number of victims that may be attributed to underreporting by government officials. The difference in populations affected in between the study areas, mid and lowlands (Arsi-Negele, Shashamane Siraro and Shala) and predominantly highland areas (Kofale and Dodola) is shown in the Table. According to the country level study by Comenetz and Caviedes (2002) the successive drought in 1991–1992 and 1993–1994 has caused comparable affliction to that of 1980s. The 1994 heavy and unseasonal rain has also damaged crops. The damage incurred by 1997–1998 drought was estimated to 28 million dollars (a huge loss to poor countries like Ethiopia) that was again followed by catastrophic flooding in 1998 that compounded food shortages (ibid.). The drought in 2001–2002 has caused food and water deficit to 12.5 million Ethiopians (WFP Emergency Report 2003). Though 2005 and 2006 were relatively a good harvest season in West-Arsi zone, heavy rain mixed with hailstorm in 2006 has damaged ready to harvest crops in Dodola district, and latter followed by the notorious drought of 2007/2008 (total *Belg* rain failure). Similarly, the drought of 2007/2008 was followed by heavy *Meher* rain during the vegetative stage of the crops and latter followed by unseasonal rain during *Meher* harvest season.

The productivity of the natural resource base is likely to decline as a result of watershed erosion, loss of soil productivity, loss of woodlands and forests, desertification, coastal erosion, and loss of aquatic and terrestrial biodiversity with consequent effects on agriculture, forestry, and water resource-based economic activities, fisheries, urban and coastal infrastructure, and tourism. Land degradation processes may be exacerbated by climate change. More intense rainfall promotes soil erosion. Increasing temperatures increase evapo-transpiration rates that reduce soil moisture. Rainfall patterns affect vegetation patterns and the growing period for crops. Prolonged dry spells and erratic climatic conditions may lead to short-term coping strategies such as deforestation to increase livelihoods. They may also help to mitigate the immediate impact of a climatic event, but will prove to be maladaptive in the long term by having adverse consequences for watersheds, biodiversity, and provision of important ecosystem services.

The Fourth African Assessment Report on climate change released by IPCC highlights major issues related to potential impacts as a result of climate change (IPCC 2007). It indicates that Africa is one of the most vulnerable continents to climate change and climate variability. This is a result of the interaction of 'multiple stresses' including land degradation and desertification, declining run-off from water catchments, high dependence on subsistence agriculture, HIV/AIDS prevalence, inadequate government mechanisms and rapid population growth occurring at various levels, and low adaptive capacity due to factors such as extreme poverty, frequent natural disasters such as droughts and floods, and rainfall-dependent agriculture (Boko et al. 2007). The likely impacts of climate change will add to these existing stresses and exacerbate the effects of land degradation. Increased

Table 6.1 Populations affected by both manmade and natural disasters in Ethiopia 1995–2008

District	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Siraro and Shala	1,000	1,050		17,000		2,700		40,515	40,500				5,000	14,500
Shashamane				2,500		16,000		72,413	41,080				9,324	15,000
Arsi-Negele				10,030		18,000		17,230	53,100	5,808			7,000	18,260
Dodola													2,908	5,000
Kofale														5,500
Others													2,727	41,200
Total	1,000	1,050		35,530		61,000		130,218	130,600	5,808			26,959	99,400

Source: Oromiya Region New Zone Study Group. (2006).

temperatures levels are expected to cause additional loss of moisture from the soil, reduced and more intense rainfall and higher frequency and severity of extreme climatic events, such as floods and droughts. These factors are already leading to a loss of biological and economic productivity and putting drylands population at risk of short- and long-term food insecurity. There is considerable variability and uncertainty in climate change projections. Drought-prone areas inter alia are particularly deemed to suffer complex, localized impacts of climate variability/change. In the Sahel, for instance, changes in temperature and rainfall patterns have reduced the length of the vegetative period and make it difficult to continue the cultivation of traditional varieties of long and short cycle millets (Rosenzweig et al. 2007). Given the social, legislative, market and weather-based sources of vulnerability already prevailing in the region, reduction in agricultural productivity and land area suitable for agriculture, even if slight, would cause disproportionately large detrimental effects (IPCC 2007; Dietz et al. 2003).

6.3 Impacts of Climate Change and Challenges of Agricultural Productivity in Sub-Sahara Africa

Agriculture is often considered the most vulnerable sector to climate change. It is affected by the vagaries of climate, and contributes to increasing climate variability and change, directly and indirectly, through the emission of greenhouse gases. Potential impacts of climate change on agricultural production depend on the internal dynamics of agricultural systems, including their ability to adapt to the changes (IPCC 2007). The impacts of climate change on agriculture include: biophysical impacts and socio-economic impacts (Nyong 2008).

6.3.1 Biophysical Impacts

In Mid- to high altitude regions, moderate warming benefits cereal crop and pasture yields, but even slight warming decreases yields in seasonally dry and tropical regions. In mid- to high-latitude regions, temperature increases of between 1 and 3 °C across a range of CO_2 concentrations and rainfall changes, will likely have small but beneficial impacts on the main cereal crops for instance rice, wheat and maize. In the low-latitude regions, where most of the SSA countries (Sudan, Nigeria, Somalia, Ethiopia, Zimbabwe and Chad) are found, even moderate temperature increases are likely to result in declining yields for the major cereals. This could increase the risk of hunger in many parts of the world. Simulations for sub-Saharan Africa estimate that some countries in the region could lose cereal-production potential by 2080 across all emission scenarios (Fischer et al. 2005). These are countries where a large portion of the population depend on agriculture,

and where capacities (e.g. technologies, finances, investments, etc.), both at national and farm level to adapt to climate change, are lowest. In addition, most of these countries are currently experiencing conflicts that would further hamper agricultural production. However, global warming will also present opportunities for some countries to expand their agricultural potentials.

- Increases in frequency of climate change extremes may lower agricultural productivity beyond the impacts of mean climate change. Extreme events such as floods and droughts may also lower long-term yields by directly damaging crops at specific developmental stages. Heavy rainfall could precipitate soil erosion resulting in substantial agricultural loss.
- Elevated levels of CO_2 and climate change will have varied impacts on livestock production. Increased CO_2 and global warming will likely produce a dominance of unpalatable and invasive plant species, and could likely have detrimental effects on the nutritional value of extensive grasslands to grazing animals.
- Local extinctions of particular fish species are expected at edges of ranges. Fisheries could be affected by different biophysical impacts of climate change. It is likely that regional changes in the distribution and productivity of particular fish species will continue and local extinctions will occur at edges of range, particularly in freshwater species. In some cases, ranges are likely to increase, and decrease in some. A 1.5–2.0 °C rise in temperature could result in the loss in productivity on the fisheries in northwest Africa and the East African lakes. A simulation under a doubling of CO_2 indicates that extreme wind and turbulence could decrease global fish productivity by 50–60 % in the region.

6.3.2 Socioeconomic Impacts

Most models generally agree that global cereal production would increase by as much as 200 % by 2080 with global warming because of CO_2 fertilization (Fischer et al. 2005). More disaggregated regional models however have shown the disparity in cereal production at more localized levels. These detailed studies show an increasing gap in cereal production between developed and developing regions especially after 2020. There are disparities in cereal production at more localized level in sub-Sahara Africa and in some areas in South Asia where suitable arable land resources are limited. Several models project that climate change could cause a modest increase of between 2 and 20 % in the price of agricultural products in the short to medium term at the global level while temperature increase of up to 5 °C could result in higher output, a small decline in real world cereals prices and global mean temperature beyond that point could lead to a substantial increase in food prices (Easterling et al. 2007; Fischer et al. 2005). Studies have shown that some parts of sub Saharan Africa will experience a reduction in magnitude greater than what is predicted with global models (Boko et al. 2007).

6.4 Climate Change and Challenges of Food Production in Sub Sahara Africa

Climate change is a global warming, in part attributable to the 'greenhouse gases' generated by human activity. Global agricultural output per capita has grown at an average rate of 0.4 % per year since 1961. The negative effects of climate change on crop production are especially pronounced in Sub-Sahara Africa, as the agriculture sector accounts for a large share of GDP, export earnings, and employment in most African countries. The current global food crisis will worsen an already precarious food security situation most especially in developing countries including sub-Sahara Africa. In sub-Sahara Africa countries, especially in seasonally dry areas, crop and animal productivity may decrease significantly due to temperature increases of 2–3 °C, by 2020, climate change could cause, significant decreases in crop yields, declines of 40–90 % of grassland productivity, high levels of desertification and soil salinization in some areas and also lead to increasing water stress, particularly irrigated production systems (IPCC 2007).

Climate-related crop failures, fishery collapses and livestock deaths already cause economic losses and undermine food security, and these are likely to become more severe as global warming continues. A recent study estimates the annual costs of adapting to climate change in the agricultural sector to be over US$ seven billion (Nelson et al. 2009). Sub-Sahara Africa's agriculture and rural economy face challenges which could broadly be categorized into four such as production and productivity-related; infrastructure and market related; environment related; an institutional and policy related. The accumulation of greenhouse gases in the atmosphere has warmed the planet and caused changes in the global climate. Sub-Sahara Africa is the only region in which agricultural output per capita has not seen a sustained increase, with considerable variation over time and across countries. For example, sub-Saharan Africa produces less food per person today than it did three decades ago. The crop model indicates that in 2050 in Sub-Sahara Africa, average rice, wheat and maize yields will decline by up to 14, 22, and 5 %, respectively, as a result of climate change.

In 2001 the UN-sponsored Intergovernmental Panel on Climate Change (IPCC) reported that worldwide temperatures have increased by more than 0.6 °C in the past century and it also estimated that by 2100, average temperatures will increase by between 1.4 and 5.8 °C. IPCC also reported that sea levels have risen by between 10 and 20 cm and snow and ice covers have fallen almost worldwide, while the precipitation patterns characterizing land areas of the Northern Hemisphere have progressively changed. In the same report, IPCC estimated that sea levels would rise by an average 0.09–0.88 m between 1990 and 2100. Responses to climate change can either seek to reduce the level or rate of change (mitigation) or manage its consequences (adaptation). Mitigation of the adverse effects of climate change is

a high priority on the international agenda. Carbon trading, under the Kyoto Protocol as well as outside the protocol, is growing rapidly from a small base and is expected to increase dramatically under present trends. Long-term climate change is linked to an increase in global carbon dioxide, CO_2 concentration in the atmosphere, together with a few other greenhouse gases (GHG). This increase is partly the result of the influences of human activities on nature such as exhaust gas emissions from vehicles, coal burning for energy, and deforestation.

Recognizing the urgency of the situation, world leaders adopted the Rome Declaration on world food security and the challenges of climate change and bio-energy on 5 June 2008 and pledged to recognize food security as a priority national development policy. World Health Organisation informed the conference that adequate food intake is a fundamental determinant of health throughout the life course and highlighted the health implications of the current situation. The 2008 Group of Eight (G8) multi-industrialized countries summit also considered the recent rise in food prices which could jeopardize all nutrition programmes and adopted interventions to address the risks and consequences of malnutrition among vulnerable groups.

The food insecurity in sub Saharan Africa is high on the world development agenda. For example in 2005 the G8 summit with great fanfare announced a new aid and development deal for Africa. And yet a year latter instead of increasing aid by a promised 10 %, the reality turned out to be one where aid declined by more than 10 %.

Accompanying changes are likely to be both global, as with rising sea levels attributable to ice-melt, and local, such as changes in rainfall patterns. The impacts of climate change include sea level rise, droughts, heat waves, floods and rainfall variation which could, by 2080, push another 600 million people into malnutrition and increase the number of people facing water scarcity by 1.8 billion (UNDP 2008). It is estimated that 25 % of the population (approximately 200 million people) in Africa at present currently experience water stress, with more countries expected to face high risks as a result of climate change. This may, in turn, lead to increased food and water insecurity for at-risk populations, undermining growth. It is estimated that the net balance of changes in the cereal production potential of sub Sahara Africa (SSA) resulting from climate change will be negative, with net losses of up to 12 %. Overall, approximately 40 % of SSA countries will be at risk of significant declines in crop and pasture production due to climate change (Fischer et al. 2005; Shah et al. 2008). Climate change is expected to increase the number of undernourished people by between 35 and 170 million people in 2080, depending on projected development paths (Shah et al. 2008).

The food security depends on the ability of the world population to supply and distribute enough and quality food to poor households. Rice supply depends on global production, while its distribution depends on the distance from production sites to consumers' residences as well as on transportation systems and facilities.

6.5 Climate Change and Mitigations Policy

Sub-Saharan Africa with about 10 % of the world's population currently contributes some 2.4 % of CO_2 emissions and its share over the last 50 years of the world's cumulative CO_2 emissions is less than 2 %. The potential for mitigation through agriculture in the African region is estimated at 17 % of the global total, and the economic potential (i.e. considering carbon prices) is estimated at 10 % of the total global mitigation potential. Similarly, Africa's forestry potential per year is 14 % of the global total, and the avoided-deforestation potential accounts for 29 % of the global total.

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. Mitigating climate change requires identifying effective ways to reduce greenhouse gases produced and released to the atmosphere. Adaptation options for sub Sahara Africa are adaptation strategies that concentrate on the reduction of vulnerability to current climatic events and planning for long-term sustainable development.

Various mitigation options have been considered in the agricultural sector. These include: cropland management, grazing land management and pasture improvement, management of organic/peaty soils, restoration of degraded lands, livestock management, manure management, and bioenergy. Some of the recommended practices for better cropland management include:

- Agronomy: implementation of agronomic practices that give higher yields and residues, which can increase soil carbon.
- Nutrient management: This involves improving the efficiency of Nitrogen use by avoiding fertilizer over-applications.
- Tillage/residue management: Practices include low zero-tillage crop management practices, and the retention of residues on farms.
- Water management: This involves the improvement of yields through good and efficient irrigation practices, and better water management.

Increased climate variability and droughts will affect livestock production as well. Smallholders and pastoralists in Sub-Saharan Africa will need to gradually adapt and adopt technologies that increase the productivity, stability, and resilience of production systems (Faurès and Santini 2008). However, with the threats of changes in climate, exacerbating current trends of encroachment on grazing lands by agriculturists and other factors they may be forced to consider other livelihood options, including permanent migration, in order to cope with cumulative changes. Achieving sustainable food security in a world of growing population and changing diets is a major challenge under climate change. Successful mitigation and adaptation will entail changes in behaviour, technology, institutions and food production systems. These changes cannot be achieved without improving interactions among scientists, policy makers and civil society.

Agriculture and related activities also contribute to global warming, by generating greenhouse gas (GHG) emissions and altering the land surface. Agriculture is estimated to account for about 15 % of global GHG emissions and for around 26 % if the emissions from deforestation in developing countries where agriculture is the leading cause of forest conversion are included (World Bank 2007). Around 80 % of agricultural emissions, including deforestation, occur in developing countries (World Bank 2007). There remains much untapped technical potential to reduce agricultural emissions and increase agricultural mitigation of emissions from other sectors, notably through reduced deforestation via changes in land use and agricultural practices.

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. Potential agricultural management changes that have been proposed by FAO to increase agricultural production, as well as to decrease output variability due to climate variability and extreme climate events (many of which overlap with those proposed for adaptation to climate change): cropland management (e.g. improved varieties, reduced/zero tillage, agroforestry); water management (e.g. (supplementary) irrigation, water harvesting, watershed management); pasture and grazing management (e.g. forage quality, stocking rate management) and restoring degraded lands (e.g. re-vegetation, en-exclosures). However, it must be noted that there can be tradeoffs between short and long term benefits of interventions. Agricultural management practices, including those employed in organic and conservation agriculture capture carbon from the atmosphere and store it in agricultural soils. These practices involve increasing the organic matter in soils of which carbon is a main component. This, in turn, increases fertility, water retention and the structure of soils, leading to better yields and greater resilience.

Climate change mitigation measures include energy conservation measures, implementing land use plans, strengthening institutional and legislative mechanisms, energy efficiency measures, waste management, substituting fossil fuels with renewable energy sources and measures in the transport and agricultural sectors, as well as sequestering carbon biologically through reforestation or geo-physically (inside the earth's core). Certain incentives exist and more should be created to encourage developing countries to mitigate climate change in the agricultural sector. Such incentives for mitigation include:

- Carbon Trading: The emerging market for trading carbon emissions offers new possibilities for agriculture to benefit from land uses that sequester carbon, thereby enhancing carbon storage in soils and avoiding deforestation.
- Expansion of CDM to include aforestation and reforestation projects.
- Incentives for investment in science and technology for low-emission technologies.

6.6 Conclusion and Recommendations

6.6.1 Conclusions

There is a substantial body of work that shows that agricultural production is sensitive to climate change and variations in climate. There are also indications that, the potential effects of climate changes in future productivity are likely to be negative in regions that are already water-limited or positive in regions that are temperature limited. Climate change will have far-reaching consequences for agriculture and the poor and marginalized groups who depend on agriculture for their livelihoods and have a lower capacity to adapt.

The sustainable increase of agricultural production for food security will require efforts to enhance the capacity of crop production systems to adapt to global climate change as well as to mitigate the effects of food production on global warming. While adaptation strategies exist, considerable institutional and policy support will be needed to implement them successfully on the scale required. Technical options for adaptation and mitigation are available and could be further improved. Policy support to agricultural research and development to develop and transfer appropriate and efficient technologies, however, will be vital for the realization of such measures for sustainable food production.

6.6.2 Policy Recommendations

Agricultural development in sub-Saharan Africa faces daunting challenges, which climate change and increasing climate variability will compound in vulnerable areas. The livelihoods of many croppers and livestock keepers in Africa are associated with diversity of options which are likely to diminish because of these changes. Tackling these challenges will require the use of sophisticated surveillance and response systems as well as technologies and policy. In order to promote this transformational change in the agricultural sector, comprehensive action is not feasible without global cooperation, which requires an approach that is equitable, efficient and effective. Innovative ways of financing are needed from all sources, combined with capacity building and access to technology, knowledge and information on best practices. Therefore, policy that assures food security at all time is recommended to achieve the Millennium Development Goal 1 to reducing by half people suffering from hunger by 2015.

Appropriate climate-change policies are needed to unleash this huge potential for pro-poor mitigation investment in Sub-Saharan Africa. Such policies should focus on increasing the profitability of environmentally sustainable practices that generate income for small producers and create investment flows for rural communities. Pro-poor investments, community development, new research, and capacity building can all help to integrate agriculture and land-use systems of

developing countries into the carbon trading system, both generating income gains and advancing environmental security.

Agriculture appears to be the most vulnerable sector to the adverse impacts of climate change. To achieve sustainable development, efforts need to be stepped up to mitigate and adapt. Both strategies are very important and should be pursued concurrently. While climate change will likely affect development at various levels, the development approach chosen will also influence future emission of greenhouse gases as well as the adaptive capacity of individuals, communities and countries. It is therefore important that climate change be mainstreamed into developmental policies and plans.

In the agricultural sector, strategies should range from the development and deployment of early warning systems, better agricultural management systems, improved crop cultivars, better and more efficient irrigation systems and good grain storage systems.

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