What role for African agriculture under climate change?

Subsidiary Body for Scientific and Technological Advice (SBSTA) Submission

Agriculture for Impact
Imperial College London
23rd March 2015

SBSTA

"The SBSTA invited Parties and admitted observer organizations to submit to the secretariat their views on issues relating to the elements referred to in paragraph 3(a) and (b) by 25 March 2015: (a) Development of early warning systems and contingency plans in relation to extreme weather events and its effects on desertification, drought, floods, landslides, storm surge, soil erosion, and saline water intrusion; (b) Assessment of risk and vulnerability of agricultural systems to different climate change scenarios at regional, national and local levels, including but not limited to pests and diseases. "

About Agriculture for Impact

Agriculture for Impact (A4I) is an independent advocacy initiative based at Imperial College London, supported by the Bill & Melinda Gates Foundation and led by Professor Sir Gordon Conway. A4I encourages better European government support for productive, sustainable, equitable and resilient agricultural development in Sub Saharan Africa (SSA), focusing in particular on the needs of smallholder farmers. A4I convenes the Montpellier Panel, a group of European and African experts in the fields of agriculture, trade, ecology and global development, which publishes regular high-impact reports on topics related to improved agricultural and economic development in SSA. The last report "No Ordinary Matter: Conserving, Restoring and Enhancing Africa's Soils" was published in December 2014.

Introduction

Agriculture and smallholder farmers are particularly vulnerable to climate change. In many regions of the world the first impacts of climate change can already be felt. Erratic rainfall, shorter growing seasons and prolonged droughts mean that crop growth suffers, as do the livelihoods of those smallholder farmers who depend on these crops for food, nutrition, and income. To meet the demands of an increasing global population for more nutritious food, agricultural productivity has to be increased. However, this will have to be achieved with fewer resources and interventions that are climate-smart.

Early warning systems and contingency plans must be developed to reduce the onset of processes such as desertification and soil erosion, that are in part the result of poor land management practices, but will intensify under climate change. Sustainable land management practices can also improve global food security under climate change conditions and when combined with an array of economic, ecological and genetic based support mechanisms, build resilience to withstand extreme events such as drought, floods, storms and landslides. Ultimately, better land management practices will begin to sustainably reduce greenhouse gas (GHG) emissions from agriculture, provided farmers are given the incentives to do so.

For agricultural systems to feed the world, improve adaptation and contribute to a reduction of GHG emissions, five actions need to be undertaken:

- Sustainably increase food production, particularly in developing countries.
- Support smallholder farmers to adapt to the adverse impacts of and become more resilient to climate change.
- Reduce emissions from the agricultural sector by providing appropriate incentives.
- Promote climate smart soil management to reduce GHG emissions and to restore the lost carbon to the soil.
- Countries should include agriculture's adaptation and mitigation potential in their Intended Nationally Determined Contributions (INDCs) to catalyse action towards these aims.

The following submission sets out 1) why agricultural systems and smallholder farmers are especially vulnerable to climate change; 2) how global food and nutrition security is threatened by climate change; 3) examples of contingency plans that can reduce vulnerability and build resilience for both agricultural systems and smallholder farmers towards slow onset, but damaging ecological processes, extreme weather events and plant pest and disease; 4) how better land management practices offer opportunities for both adaptation and mitigation under these scenarios; and 5) why developing countries in particular should address agriculture's adaptation and mitigation potential in their INDCs.

1. Agricultural systems and smallholder farmers are especially vulnerable to climate change

Agricultural systems are especially vulnerable to climate change because crop plants and livestock are inherently affected by:

- Too much or too little water
- Temperatures that are too high or too low
- The length of the growing season
- Seasonal variation in rainfall
- Other climatic extremes

At the same time farmers are especially vulnerable to these weather events because:

- 500 million farmers in developing countries work with less than 2 hectares of land;
- Many of them are poor and live on less than USD 1 a day;
- They do not produce enough food or earn enough income from farming to feed their families; and
- They lack access to a variety of services and products that leave them highly vulnerable to extreme climatic events.

In developed countries, many farmers also struggle to make a living and are highly vulnerable to extreme climatic events. However, they can often rely on a safety-net of subsidy programs, insurance payouts, and agricultural research systems to withstand these stressors. Similar types of support are required in developing countries, and globally more sustainable land management practices are needed to mitigate the threats of climate change to global food production, and food and nutrition security.

2. Global food production and food and nutrition security are under threat from climate change

Approximately 1.5 billion people are engaged in smallholder agriculture across the world.[1] In some developing countries, agriculture accounts for more than half of gross domestic product (GDP) and around 75% of the labour force. In Liberia, for example, agriculture accounts for

[1] Ferris *et al.* (2014); Linking Smallholder Farmers to Markets and the Implications for Extension and Advisory Services, USAID and Catholic Relief

approximately three-quarters of GDP and 70% of the labour force; in Mali, agriculture accounts for almost 40% of GDP and 80% of the labour force. However, there are other countries, such as Gabon, Senegal or Lesotho, where agriculture's contribution to GDP is less than 15% yet 60%, 78% and 86% of the labour force, respectively, is employed in the agriculture sector.[2] This disparity between contribution to GDP and share of population, common in many other developing countries means that many farmers are also some of the world's poorest people whose food, nutrition, income, and livelihood prospects depend on agriculture.

Farmers in developing countries, particularly in Africa, are already experiencing the adverse impacts of climate change from:

- shorter growing seasons and erratic rainfalls;
- higher growing season temperatures;
- greater soil acidity; and
- higher levels of soil degradation.

Reduced food production

For Africa, the most serious consequences of climate change will arise from higher temperatures. An average increase in temperatures of more than 2°C by the end of this century compared with pre-industrial levels, or a rise of even 3° - 6°C predicted under some scenarios, will result in lower average rainfall and shorter wet seasons in many semi-arid regions.[3] For maize in Africa each degree day spent above 30°C reduces the final yield by 1% under optimal rain-fed conditions and by 1.7% under drought conditions.[4]

Agriculture will also suffer from a greater incidence and severity of extreme weather events such as drought and flooding. According to the International Panel on Climate Change (IPCC) (2014) the negative impacts of climate change will outweigh any positive effects – net global agricultural yields are predicted to decrease by up to 2% per decade. The International Food Policy Research Institute (IFPRI) estimates that by 2050 grain crop yields in SSA will shrink substantially: average rice, wheat and maize yields will decline by up to 14%, 22% and 5%, respectively.[5] These decreases will take place within the context of a rapidly rising global population, where demand for food in SSA is expected to increase by 14% per decade. There are also limits to adaptation, including upper limits to heat tolerance[6]. There are parts of Asia where current temperatures are already approaching critical levels during susceptible stages of the rice plant[7].

Threats to nutrition

There also exists a strong connection between the effects of climate change and undernutrition. Globally 2 million people suffer from micro-nutrient deficiencies and undernutrition is attributed as the underlying cause of nearly 45% of all child deaths.[8] Stunting and wasting, the most common physical impacts of undernutrition,

[2] CIA Factbook country profiles, retrieved 17.02.2015
[3] The Montpellier Panel (December 2014), No Ordinary Matter: conserving, restoring and enhancing Africa's soils
[4] Lobell *et al.* (2011), Nonlinear heat effects on African maize as evidenced by historical yield trials, Nature Climate Change Vol. 1
[5] International Food Policy Research Institute, (2009), Impact of Climate Change on Agriculture - Factsheet on Sub-Saharan Africa
[6] IPCC, 2014.
[7] Wassmann et al. (2009a, 2009b) in IPCC, 2014.
[8] UNICEF (2011), The impacts of climate change on nutrition and migration affecting children in Indonesia

also lead to irreversible cognitive deficiencies that result in large losses to productivity at the individual and country level.

The IPCC recognises that malnutrition linked to extreme-climatic events may be one of the most serious consequences of climate change.[9] Some of the most important crops to poor people's diets in developing countries, including wheat, barley, rice and beans, deliver far less nutrition when there are higher levels of carbon dioxide in the air.[10]

Furthermore, a study concluded that a delay in the onset of the rainy season beyond 20 days during the El Niño years had disrupted production significantly. A one-month delay in rainfall translated to an estimated 11% decline of wet-season rice yields in East Java and Bali. The same study also found that in a rice plot experiment in the Philippines for every 1% increase in average temperature during the dry season, rice yields decreased by 10%.[11]

Increases in Pests and Diseases

The results from emerging studies show that climate change, in interaction with other environmental and production factors, is also likely to intensify damage to crops and livestock from pests, weeds, and diseases. [12]

Warming in highland regions of eastern Africa could lead to an expansion of a range of crop pests into cold-limited areas:[13]

- In highland Arabica coffee-producing areas of eastern Africa, warming trends may result in the coffee berry borer becoming a serious threat.
- Temperature increases in highland banana-producing areas of eastern Africa enhance the risk of altitudinal range expansion of the highly destructive burrowing nematode; however, no detailed studies have assessed the impacts of this risk.
- Estimates[14] suggest that increasing minimum temperatures by 2020 would expand the suitable range of black leaf streak disease of banana in Angola and Guinea.
- Climate change may also affect the distribution of pests in lowland areas and drylands of Africa. For example, estimates[15] indicate that changes in temperature, rainfall, and seasonality will result in more suitable habitats for Striga in central Africa, whereas the Sahel region may become less suitable for this weed. Striga weed infestations are already a major cause of cereal yield reduction in sub-Saharan Africa.
- In the case of livestock, it has been estimated[16] that the distribution of the main tick vector species responsible for the East Coast fever disease in cattle could be altered by a 2°C temperature increase, and changes in mean

---

[9] International Panel on Climate Change (2007), Chapter 9, Africa

[10] Myers et al. (2014), Increasing CO_2 threatens human nutrition, Nature, 510, 139–142

[11] Natawaidjaja *et al.* (2009), Climate Change, Food Security and Income Distribution: Adaptations of small rice farmers, Policy Brief 9, Australia-Indonesia Research Partnership, Australian National University

[12] International Panel on Climate Change (2014), Chapter 22, Africa

[13] Ibid.

[14] Ramirez *et al.* (2011), Changing climates: effects on growing conditions for banana and plantain (Musa spp.) and possible responses. In: Crop Adaptation to Climate Change (Yadav, et al.)

[15] Cotter *et al.* (2012) Understanding the present distribution of the parasitic weed Striga hermonthica and predicting its potential future geographic distribution in the light of climate change. Julius-Kühn-Archiv, 2(434), 630-636

[16] Olwoch *et al.* (2008), Climate change and the tick-borne disease, Theileriosis (East Coast fever) in sub-Saharan Africa. Journal of Arid Environments, 72(2), 108-120.

precipitation resulting in the climatically suitable range of the tick shifting southward.

Threats to Livestock

At the same time, livestock systems in Africa will also come under more stress due to increasing rangeland degradation and shrinking availability of water in many regions directly impacting the food security, nutritional status and livelihoods of millions of pastoralists and smallholder farmers. The additional stresses that climate change will place on livestock systems in Africa include:[17]

- Increased rangeland degradation;
- increased variability of access to water; and
- fragmentation of grazing areas and changes in land tenure from communal toward private ownership leading to in-migration of non-pastoralists into grazing areas.

Loss of livestock under prolonged drought conditions poses a major risk to pastoralists and smallholder farmers, given the extensive rangeland area in Africa that is prone to drought. Regions that are projected to become drier with climate change include northern and southern Africa. Adequate provision of water for livestock production could become more difficult under climate change. The cost of supplying livestock water from boreholes in Botswana, for example, will increase by an estimated 23% by 2050 due to the number of increased hours required for groundwater pumping to meet livestock water demands.[18] Although small in comparison to the amount of water needed for feed production, drinking water provision for livestock is critical; livestock production and mortality will be directly affected by water scarcity through its impact on crop production and subsequently the availability of water and crop residues for livestock feeding.

Estimates show that maize stalks and waste availability per head of cattle will decrease by as much as 46kg (Tanzania) between 2000 and 2050 in several East African countries.[19]

As a result, livestock-keeping communities will become even more vulnerable. Malnourishment or higher mortality rates for livestock will translate into less food and less nutritious food for these communities. Overcoming existing barriers such as limited opportunities to diversify livelihoods, weak social safety nets, and insecure access to land, markets, and other resources will only become more difficult.

3. Contingency plans are required to increase resilience against the negative impacts of climate change

The impacts of extreme weather events on food production and consumption are well documented. For example, the 2010 extreme floods in Pakistan destroyed an estimated two million hectares of crops, killed 40% of livestock in affected areas, and delayed the planting of winter crops, causing the price of basic foods such as rice and wheat to skyrocket.[20] As a consequence, an estimated eight million people reported eating less food and less nutritious food over an extended period of time. However, it is not only extreme weather events that threaten global food security. More marginal shifts, including

[17] IPCC (2014)

[18] Masike and Urich (2008) Vulnerability of traditional beef sector to drought and the challenges of climate change: the case of Kgatleng District, Botswana. Journal of Geography and Regional Planning, 1(1), 12-18.

[19] Thornton *et al.* (2010) Adapting to climate change: agricultural system and household impacts in East Africa. Agricultural Systems, 103(2), 73-82.

[20] Oxfam (2014), Hot and hungry – how to stop climate change derailing the fight against hunger

seemingly small increases in temperature and changes in rainfall patterns, are already having major impacts on people's ability to provide food for their families.

Contingency plans and adaptation measures against the negative impacts of climate change, such as desertification, drought, floods, and soil erosion already exist, but need to be significantly scaled-up. Rather than reacting to crises after they occur, an anticipatory and proactive approach is urgently required. Whether large-scale or autonomous, adaptation actions need to be publicly supported and funded, drawing also on the expertise and financial support of private sector companies.

Examples of contingency plans that can be taken to scale, include:

- **Drought-tolerant Maize**. The African Agricultural Technology Foundation's (AATF) Water Efficient Maize for Africa (WEMA) programme shows how the agriculture sector can adapt to the negative impacts of climate change. WEMA is a public-private partnership that develops drought-tolerant and insect-protected maize using conventional breeding, marker-assisted selection, and biotechnology, with a goal to make these varieties available royalty-free to smallholder farmers in Sub-Saharan Africa through African seed companies
- **Livestock early warning systems.** The Pastoral Community Development Project in Ethiopia, a project, supported by the International Fund for Agricultural Development (IFAD) aims to improve the prospects of achieving sustainable livelihoods among herders living in arid and semi-arid lowlands. Engaging pastoral communities in development groups, decisions are made on their priorities for basic services and activities to pursue to improve the communities' livelihoods. The project has improved access to safe water sources and established animal health posts, local clinics and vaccination centres to increase the farmers' and their livestock's resilience to increased stresses under climate change.
- **Orange Fleshed Sweet Potato**. Through the process of biofortification, orange fleshed sweet potatoes are rich in beta-carotene, a building block of vitamin A, to address vitamin A deficiency. In 2011 the International Potato Center released 15 drought-tolerant orange fleshed sweet potato varieties in Mozambique. To accelerate farmers' access to the improved varieties, sweet potato voucher-based distribution centers that supply vines and other inputs to vulnerable households were opened across the country. Over the course of three years, more than 2,400 tons of disease-free planting material were produced and distributed, and more than 3,800 farmers – over half of them women – were trained in the production and multiplication of orange fleshed sweet potatoes.
- **Weather Index Insurance.** Risk is inherent in agriculture. Farmers face a variety of market and production risks that make their incomes unstable and unpredictable from year to year. In recent years, an increasing number of pilot programmes have tested an innovative idea for managing covariate risk in agriculture: index insurance. Weather index-based insurance is a financial product linked to an index highly correlated to local weather. The Weather Risk Management Facility[21], a joint undertaking of IFAD and WFP, reviewed a range of index insurance

[21] IFAD-WFP Weather Risk Management Facility (WRMF), http://www.ifad.org/ruralfinance/wrmf/, accessed 25.02.2015

programmes, analysing the key actors, features of the products, and their successes and challenges. It has been suggested that index insurance could not only provide an additional effective, market-mediated solution to promote agricultural development, but it could also make disaster relief more effective.

- **Public-private partnerships.** Kilimo Salama, is a project that offers low-cost micro insurance to maize and bean farmers in southern and western Rwanda, protecting them from financial loss if their crops are damaged by weather. The project is a partnership between Swiss Re Corporate Solutions, the Syngenta Foundation for Sustainable Agriculture, the Rwandan Ministry of Agriculture and Animal Resources, the One Acre Fund (OAF) and Rwandan insurer SORAS. Kilimo Salama bundles insurance with loans provided by OAF for seeds, fertilizer and extension services. The insurance premium is paid as part of the loan repayment. Eight weather stations, all equipped with transmission systems that broadcast weather updates and rainfall amounts, have been set up in the participating provinces. When a station detects rainfall levels that are below or above a particular crop's rainfall needs, a pay-out to One Acre Fund is triggered. In turn, the OAF either compensates the farmers participating in Kilimo Salama or forgives their loans.[22]

4. Better land management practices offer opportunities for both adaptation and mitigation.

Whilst agricultural systems and farmers are vulnerable to climate change, agriculture is also responsible in part for global GHG emissions and thus a main contributor to anthropogenic climate change. Agriculture is responsible for emissions of carbon dioxide (CO_2), but also nitrous oxide (N_2O) and methane. Emissions of nitrous oxide and methane (CH_4) originate from livestock and soil, which are nearly 300 times and 35 times more powerful than CO_2 respectively.[23] According to the IPCC (2007), N_2O emissions from soils constitute around 40% of non-CO_2 emissions.

Addressing these emissions is fundamental if the UNFCCC goal of limiting average global temperature increases to 2°C is to be achieved. Critically, agriculture itself can play an important role in the mitigation of climate change. Sustainable land management practices such as integrated soil management can increase farmers' resilience to the negative impacts of climate change, while creating climate-smart soils helps to minimise GHG emissions and restore the lost carbon to the soil. Soil is a precious resource that must be constantly conserved, enhanced and repaired where damaged. When improperly managed, land degradation reduces soil fertility and in turn leads to an increase in GHG emissions as well as reduced crop production and food insecurity. Currently, nearly one-third of the earth's land area is degraded.[24] In SSA 65% of arable land, 30% of grazing land and 20% of forests are already damaged affecting an estimated 180 million people and translating into an economic loss of USD 68 billion per year.[25]

To reverse these trends and achieve adaptation and mitigation benefits,

[22] Farming First, Kilimo Salama – Index-based Agriculture Insurance, http://www.farmingfirst.org/2013/09/kilimo-salama-index-based-agriculture-insurance/, accessed 25.02.2015

[23] IPCC (2013), Climate Change 2013: the Physical Science Basis

[24] Kirui and Mirzabaev (2014), Economics of Land Degradation in Eastern Africa. Working Paper. Bonn: Center for Development Research (ZEF)

[25] Nkonya et al. (forthcoming), Global cost of land degradation. In Nkonya et al., Economics of Land Degradation and Improvement. Springer, the Netherlands

implementing sustainable land management practices, such as Integrated Soil Management (ISM), will be indispensable especially in developing countries. ISM requires harnessing the skill and knowledge available in traditional farming together with ecological approaches and precision farming using modern inputs. While overuse of inputs such as fertiliser is a contributor to GHG emissions, farmers need to be supported to gain access the right nutrients for their soil types and learn how to use them appropriately.

Central to ISM is the selective choice of inputs, whether organic or inorganic, and their targeted use. This applies to fertilisers, biological nutrient absorption and also water. Microdosing – the application of very small quantities of fertiliser at the root of a young plant – reduces the amount of fertilisers applied and improves nutrient use efficiency by the soil and by plants. This method not only lowers emissions from reduced fertiliser use, but it supports the plant's root system so that it is capable of capturing more water and coping with stresses from higher temperatures and less water availability. Similarly, Urea Deep Placement in rice fields – the practice of placing urea briquettes near the plant root can lower the amount of nitrogen that escapes by simply using less. Microdosing of water can also assist farmers to adapt as water resources come under greater duress with climate change.

Soils can also be managed to retain current levels of carbon. There are about 1500 gigatons (gt) of Soil Organic Carbon (SOC) in the soil globally, more than double the size of the amount of carbon in the atmosphere and three times the pool in plants, animals and microorganisms. When land is converted to agriculture the SOC is depleted by as much as three-quarters in tropical regions. Plowing releases nutrients by destroying the humus. Over centuries farmers have mined humus to grow food and in the process released CO_2 into the atmosphere. The cumulative historic loss from agriculture is estimated to be between 50 – 78 gt.[26]

Furthermore, when more organic matter is added to the soil than decays, soils put 'lost carbon' back through carbon sequestration. . Plants take up CO_2 from the atmosphere and convert it through photosynthesis to organic matter, part of which remains in the soil as humus. A possible approach to carbon sequestration is conservation farming. In practice, no-till systems result in greater sequestration than under tilled crops. Sequestration is also encouraged when the soil is kept covered or when fallows are reduced or eliminated. In general, conservation farming systems can sequester up to 0.4 tons per hectare of carbon per year. Agroforestry systems – typically annual crops grown under trees – can accumulate carbon above and below ground in the range of 2-4 tons of carbon per hectare per year. Agroforestry systems not only store carbon stocks, they also provide better protection from carbon loss through soil erosion.[27]

As shown above, some technologies are already available for reducing emissions and enabling farming systems and farmers to better adapt to climate change through better agricultural practices. Realising the potential of agriculture to mitigate emissions, however, will depend upon more research and investments. Both are needed to scale-up these efforts as well as create incentives for farmers such as improved land rights and extension services in order to adopt these practices.

[26] Lal (2004), Soil Carbon Sequestration Impacts on Global Climate Change and Food Security. Science 304
[27] Montpellier Panel (December 2014)

5. **Agriculture should be addressed in countries' Intended Nationally Determined Contributions for its adaptation and mitigation potential**

Countries' INDCs need to reflect that agriculture is central to adaptation and mitigation. Following the December 2014 COP in Lima, Peru, all countries agreed to identify nationally appropriate contributions to adaptation and mitigation. Principally, countries will propose the steps they will undertake to reduce GHG emissions. Countries may also address other issues, such as how they plan to adapt to climate change impacts and what support they will need from—or will provide to—other countries to address these impacts.[28] For developing countries it will be of particular importance to identify adaptation options that also have co-benefits for mitigation. As identified above, sustainable land management practices provide multiple benefits for improved food security, enhanced adaption, and reduced emissions.

Recognising the pivotal role that agriculture plays in all of these processes, it is important that countries address not only options for adaptation in agriculture, but also agriculture's potential in mitigating climate change in their INDCs. If left unaddressed and no formal arrangement for addressing agriculture within the negotiations is reached, a critical opportunity to mitigate the negative impacts of climate change on vulnerable systems and populations will be missed.

Climate-smart agriculture approaches can help countries to achieve co-benefits of adaptation and mitigation. These approaches range from enhancing and protecting crop diversity, to efficient water management practices, and an improved management of grassland ecosystems to regenerate degraded lands.

- **Parque de la Papa, Peru:** Six Potato Park communities have established a collection of 1400 types of native potatoes (around 650 different scientifically recognised varieties), to reduce risk, increase farmers' resilience, provide options for adaptation and ultimately increase food security. These include drought and frost tolerant varieties, a virus tolerant strain, and a number of crop wild relatives. At the same time, these adaptation responses also contribute to mitigation efforts by planting native trees on or around the farms, to improve moisture, shade and income, store carbon and reduce pressure on forests.[29]
- **Domestic rain water harvesting, Cameroon**: Water resources in conventional rural water supply systems are among the first to be impacted by climate variability. Accessibility to potable water in the sudano-sahelian part of Cameroon is limited given that the population relies mainly on springs, wells and boreholes for the supply of water in rural areas. Rain water harvesting interventions such as terracing, deep tillage and pitting methods such as zaï, have been implemented to provide relief to the communities especially during the dry season.[30]
- **Farmer-managed natural regeneration (FMNR), Niger:** In 1984, the Maradi Integrated Development Project (MIDP) introduced FMNR, under which farmers allowed the stumps of their trees to regenerate, as part of a 'food-for-work' programme targeting 95 villages in

[28] WRI, http://www.wri.org/indc-definition, retrieved 19.02.2015

[29] Parque de la Papa, http://www.parquedelapapa.org/

[30] Global Water Partnership, http://www.gwp.org/Global/ToolBox/Case%20Studies/Africa/CS_460_Cameroon_full%20case.pdf, accessed 18.03.2015

Niger's Maradi region. A recent study by the World Agroforestry Centre shows that FMNR more than tripled yields of millet, from 150 kg/ha to 500 kg/ha.[31] Overall, the changes brought about by FNMR, including improved soil fertility and increased supply of food, fodder and firewood, have been estimated to be worth at least USD 56 per ha each year.

Conclusion

Ignoring the connection between dangerous levels of climate change, food insecurity and malnutrition will exacerbate challenges to economic growth and development of poor countries. To prevent the most serious consequences of climate change on agricultural systems, food and nutrition security and farmers' livelihoods, the following must be achieved through combined efforts of national governments, donors and the private sector:

- **Sustainably maintain and increase food production particularly in developing countries to achieve food security under climate change**. In Africa, a rapidly growing population will lead to large increases in food demand. Scarce productive resources such as land and water need to be properly managed to ensure that Africa's producers can meet this growing demand and reduce levels of poverty and malnutrition in the process.

- **Enable smallholder farmers to adapt to the adverse impacts of climate change and to become more resilient to climate change.** A variety of technologies and practices already exist to support smallholder farmers to adapt to climate change. These initiatives need to be scaled-up now to ensure that vulnerable communities, especially those physically disconnected from major roads and markets, are reached by information and support systems. Public support for vulnerable populations will improve resilience to long-term climatic stresses and weather shocks.

- **Sustainably reduce emissions from the agricultural sector by providing incentives to farmers to do so.** The right incentives are not in place to encourage smallholder farmers to make short-term investments (e.g. labour, materials, and equipment) whose benefits are only realised over time. For autonomous mitigation actions to be taken by farmers, they must be provided with adequate incentives such as secure land rights, affordable credit, training and capacity building or payments.

- **Promote climate smart soil management to reduce GHG emissions and to restore the lost carbon to the soil**. Climate smart soil management will help agricultural systems to better adapt to the adverse impacts of climate change while at the same time contribute to reduced GHG emissions and carbon sequestration. Governments, farmers and the private sector must protect soils to withstand existing and increasing stresses under climate change. Strong political leadership, institutions as well as dedicated policies and programs are essential to achieve this goal.

- **INDCs need to address agriculture's adaptation and mitigation potential.** Recognising agriculture's pivotal role as both a casualty and a contributor to climate change, it is important that options for adaptation and mitigation in agriculture are addressed. For developing countries it is of particular importance to identify adaptation

[31] World Agroforestry Centre (2013), The Quiet Revolution: How Niger's farmers are re-greening the croplands of the Sahel

options with co-benefits for mitigation, such as integrated soil management or agroforestry. INDCs offer a platform for catalysing efforts towards making the necessary investments for a sustainable and resilient agricultural system.