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May 2010

منظمة الأغذية والزراعة للأمم المتحدة | 联合国粮食及农业组织 | Food and Agriculture Organization of the United Nations | Organisation des Nations Unies pour l'alimentation et l'agriculture | Продовольственная и сельскохозяйственная организация Объединенных Наций | Organización de las Naciones Unidas para la Agricultura y la Alimentación

TWENTY-SIXTH REGIONAL CONFERENCE FOR AFRICA

Luanda, Angola, 03 – 07 May 2010

CLIMATE CHANGE IMPLICATIONS FOR FOOD SECURITY AND NATURAL RESOURCES MANAGEMENT IN AFRICA

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I. INTRODUCTION

1. The evidence indicating significant changes in global climate over the past century has been presented in the Intergovernmental Panel on Climate Change Fourth Assessment Report (IPCC, 2007). The report also indicates that variability and the risk of extreme events and abrupt changes in climate patterns may increase throughout the 21st century. It is likely that Africa will face some degree of climate change impacts over the next 50 to 80 years. As the economies of most African countries are rooted in agriculture and the bulk of the peoples of Africa are engaged in the agricultural sector, there are serious implications on food security for the continent. The presence of major non-climatic stressors that influence sensitivity to changes in climatic conditions, and the endemic poverty often associated with food production exacerbates the situation in Africa.

2. Climate change jeopardizes the economic progress achieved by Africa to date due to the substantial diversion of resources required to fund adaptation initiatives. Estimates predict economic losses as a result of climate change as up to 14% GDP if adaptation measures fail to be implemented (Clements, 2009; Nelson *et al*., 2009). If this were to occur, significant levels of investment would need to be diverted away from key rural development projects to responses to short term emergencies, in particular undermining the achievement of MDG1 and core Comprehensive Africa Agriculture Development Programme pillars. It is ironic that though Africa contributes the least to the Greenhouse gas (GHG) emissions it is likely to suffer the most, as increasing climate variability is already affecting crops, livestock, water sources, land, forest, biodiversity (Collier *et al*., 2008).

3. Forests and trees are major contributors of food security, through the protection of agricultural soils and water resources, income generation essential for the purchase of food, and direct provision of food, in particular for the most poor and vulnerable people. The IUFRO report on Adaptation of Forests and People to Climate Change (2009) concludes that forests in semi-arid to arid climatic conditions may decline to an extent that no longer supports forests or even trees. In such cases forest systems will become grasslands, savannas, or even deserts (IUFRO, 2009). Tropical forests are projected to increase their productivity wherever sufficient water is available. However, in seasonal dry or otherwise drier climates, tropical forests are projected to decline.

4. The primary objective of this paper is to serve as a background document for the 26th Regional Conference for Africa. It synthesizes the work already ongoing in FAO and other key players by reviewing the current state of knowledge on the vulnerability, impact and adaptation of African agriculture and natural resources to climate change. It presents a summary of the key issues and challenges that climate change will bring to African food security and indicates potential steps that need to be taken by African governments in order for agriculture to adapt to the climate change challenge.

II. CLIMATE CHANGE PROJECTIONS AND AFRICA

5. Recent climate variability in Africa, particularly Sub-Saharan Africa, has shown a marked decline in rainfall and hydrometric series leading to an observed average decline in discharge of some watercourses in the range of 40-60% since early 1970s (Niasse *et al*., 2004). This has resulted in a significant reduction in surface area of most natural wetlands in the region as exemplified by Lake Chad, whose surface area shrunk from 20 000 km^2 before 1970s, to 7 000

km^2 after 1970s. By the 1990s, the lake had become shallower leading to its splitting into two parts, with only the southern part maintaining water permanently (Niasse *et al*., 2004).

6. In the second half of the last century, mean annual temperatures in Africa rose approximately half a centigrade with some areas (Nile Basin countries increase by 0.2°C and 0.3°C per decade) warming faster than others (Rwanda increase by 0.7°C to 0.9°C over 50 years) (Eriksen *et al.,* 2008). This gradual heating meant more warm spells (days) and fewer cold days across the continent (Boko *et al.,* 2007).

7. The projections for climate change in Africa are clouded in uncertainty; the IPCC predicts that in the short-term the number of extremely dry and wet years will increase during the present century (IPCC, 2007). However, it is still uncertain how rainfall will change over this century in the Sahel, along the Guinean Coast, and in the southern Sahara (IPCC, 2007). It is likely that past climatic trends will continue, with semi-arid areas becoming more arid (Druyan *et al.,* 2008). The high variability in precipitation will continue, and it is possible that the mean level of rain will be a little higher, though it is still uncertain.

8. The IPCC long term predictions are that warming in Africa may be higher than the global average and persist throughout all seasons (IPCC, 2007). There are discrepancies between models regarding expansion or contraction of vegetation area: some models project significant drying of land, while others a general wetting and expansion of vegetation into the Sahara (IPCC, 2007; Hansen *et al*., 2008).

9. Boko *et al.,* (2007) predict that Africa is likely to warm across all seasons during this century (For a medium warming scenario, annual mean surface air temperatures are expected to increase between 3°C and 4°C by 2099, roughly 1.5 times average global temperatures. These average projections mask significant regional variations with warming likely to be greatest over the interior of the semi-arid margins of the Sahara and central southern Africa (Eriksen *et al*., 2008).

10. Projections in East Africa suggest that increasing temperatures due to climate change will increase rainfall by 5 - 20% from December to February, and decrease rainfall by 5-10% from June to August by 2050 (Hulme, 2001; IPCC, 2001; 2007). Drying in the Mediterranean and much of southern Africa is projected. Increase in East African rainfall will not necessarily benefit agriculture as it is likely to be sporadic and sometimes delivered in large rainstorms.

11. In areas where agriculture is heavily dependent on irrigated water from the Nile, climate change is projected to pose a major food security problem. Aquatic resources like fish stocks are also projected to see a drastic decline (Allison *et al.,* 2006). Africa is most vulnerable because of the heavy reliance on rain-fed agriculture, the poor level of water control and the poor replenishment of reservoirs. Climate induced change in flow regimes has resulted in reduced flow velocity in watercourses, temperature changes as well as deterioration in water quality, particularly in sub-Saharan Africa. This has often affected functioning of irrigation schemes, hydroelectric power generation and created very conducive conditions for the proliferation of aquatic weeds (Niasse *et. al*., 2004).

12. Sea level rise as a result of climate change poses major threat to coastlands, settlements, lagoons and mangrove forest areas of Africa. The cost adaptation could amount to at least 5-10% of Gross Domestic Product (GDP). Apart from the island states, countries likely to be affected

would include parts of Mozambique, Tanzania and Angola (DFID, 2004). Changes in coastal ecosystems will have a direct bearing on settlements, productivity fish stocks and coastal dwellers will have no alternative but migrate. Along the eastern shores of Ghana, for example, changes in ecosystem function in the aftermath of damming of the Volta River resulted in mass exodus of people to other parts of the country. The resultant shortage of labour in source areas and pressure on limited natural resources in destination areas resulted in many undesired outcomes.

13. Warm sea surface temperatures, extreme weather events and rise in sea level will lead to the destruction of coral reefs, which are crucial for coastal protection. Mangroves ecosystems in eastern and western shores of Africa also face a threat from extreme weather events and are most vulnerable to sea level rise and inundation (IPCC, 2001). Sporadic heavy down pours could bring about massive flooding of riverbanks and low lying farmlands as sometimes experienced in Northern Ghana (Brown & Crawford, 2007). The urban poor living in coastal cities and floodplains all over Africa also face increasing risks (FAO, 2008b).

III. THE VULNERABILITY OF AFRICA

3.1. Increased Vulnerability: Fragile ecosystems and Food Insecurity

14. Africa is considered the most vulnerable region in the world in terms of climate change, because some of its physical and socio-economic characteristic, for instance, the fragility of its economy, predisposes it to be disproportionately affected by adverse effects of climate change (Niasse *et al*., 2004).

15. Sub-Saharan Africa includes the mixed arid-semiarid systems in the Sahel, arid to semi-arid rangeland systems in parts of eastern Africa, the Great Lakes region of eastern Africa, the coastal regions of eastern Africa, and many of the drier zones of southern Africa (Thornton *et al*, 2006). Using future nutrition at the factor regions located in Ethiopia, Uganda, Rwanda and Burundi, south-western Niger, and Madagascar will likely remain 'hotspots' of food insecurity; while regions located in Tanzania, Mozambique and the Democratic Republic of Congo might face more serious under-nutrition (Liu *et al*, 2008).

3.2. Increased Vulnerability: Women and Children

16. Both rural women and men play complementary roles in guaranteeing food security, however, women tend to play a greater role in natural resource management and ensuring nutrition (FAO, 2003a; ELIAMEP, 2008). In Africa, women are often into subsistence agriculture whilst men are generally responsible for cash cropping and larger livestock. About two-thirds of women work in the subsistence agriculture in sub-Saharan Africa. They rely mainly on rain-fed agriculture and farm on marginal lands and have relatively less access to key productive assets and services such as land, labour, water, rural infrastructure, technology and information (World Bank, FAO & IFAD, 2008).

17. Despite being primary caregivers, many statutory and/or customary laws often restrict women's property and land rights and make it difficult for them to access credit and agricultural extension services (Brody *et al.*, 2008). Climate change is expected to exacerbate these gender inequalities with women being more affected by depletion of natural resources and reduced

agricultural productivity. African women therefore tend to have limited adaptive capacities, and are more dependent on climate sensitive resources such as local water and food supplies (IPCC, 2007). Due to these multiple responsibilities and inequalities, they tend to assume a disproportionate share of economic burden like food insecurity. Children will also have to walk longer distances in search of water, fuel wood and fodder. This will affect their education and in the long term ability to respond to the impacts of climate change, creating a vicious cycle.

3.3. Increased Vulnerability: Diseases, Migration and Conflict

18. A healthy population is key to high agricultural productivity and hence food security. As the majority of Africans employ labour intensive methods of food production, any changes in the health status of the community as a result of climate change is most likely to affect food security (Confalonieri *et al*., 2007). Health risks can be linked to changes in diseases from either increased or decreased precipitation, lowering people's capacity to utilize food effectively and often resulting in the need for improved nutritional intake (IPCC, 2007; FAO, 2008b). Impacts on food production and nutrition can lead to higher rates of malnutrition and susceptibility to other diseases such as HIV/AIDS, which affects agriculture through loss of labour, knowledge, and assets (World Bank, 2008).

19. Longer dry seasons are already driving African farmers to migrate to locations with better moisture conditions and higher soil fertility. This is currently being experienced in parts of some Sahelian countries where farmers have to internally migrate from the drier areas in the north to the wetter areas (Brown & Crawford, 2007). This is the result of rainfall scarcity, lack of fertile land, and low crop yield and/or food security problems in the north (van der Geest, 2006). There is, however, the fear that greater congregation of people in smaller fertile areas may increase competition for valuable land and accelerate environmental degradation (MECV and SP/CONEDD, 2006).

20. It has been suggested that climate change is associated with conflict over land resources in Africa (Nyong & McLeman, 2006; WBGU, 2007; Garcia, 2008). A UNDP report (UNDP, 2007) stated that the conflict in Darfur, for instance, had in part been caused by tension between farmers and herdsmen over the dwindling pasture and declining waterholes. The report therefore warns that there could be a succession of new wars across Africa if not much is done to contain the damage of climate change. In conflict prone areas, the most vulnerable group is the refugee community, the bulk of which are women and children (Nsiah-Gyabaah, 2005).

IV. IMPACT OF CLIMATE CHANGE ON AFRICA

4.1. Climate Change and Food Security in Africa

21. Projected climate change impacts and declining agriculture productivity may compound the risk of food insecurity in the African continent. Agricultural production and food security in many African countries and regions are likely to be severely compromised by climate change and climate variability (IPCC 2007). Currently, most African countries are net importers, with over 50% of North Africa's food requirement and between 25% and 50% in sub-Saharan Africa imported (FAO, 2006). Africa's cereal import bill, for example, estimated at about USD 21.748 billion in 2008 and USD 9.8 billion in Sub-Saharan Africa in 2008, represents a 30% and 35% increase over the 2007 level, respectively (Kamara *et al*., 2009).

22. FAO (2008a) defines the four main components of food security as food availability, food accessibility, food utilization, and food system stability – which implies affordability. Climate change will affect all the four dimensions of food security. The impacts of climate change on food availability will be experienced differently, depending on location. For example, moderate warming (increases of 1 to 3 ºC) is expected to benefit crop and pasture yields in temperate regions, while in African tropical and seasonally dry regions, it is likely to have negative impacts, particularly for cereal crops. Warming of more than 3 ºC is expected to have negative effects on production in all regions (IPCC, 2007). The supply of meat and other livestock products will be influenced by crop production trends, as feed crops account for roughly 25 percent of the world's cropland (FAO, 2008a).

23. Food accessibility is a measure of the ability to secure entitlements, which are defined as the set of resources (including legal, political, economic and social) that an individual requires access food. Climate change will affect food accessibility by influencing food allocation. Food is allocated through markets and non-market distribution mechanisms. For rural communities in Africa who produce a substantial part of their own food and also non-farming low-income rural and urban households, climate change impacts on food production may reduce availability to the point that allocation choices have to be made within the household (Mendany *et al*., 2006). Climate change will also affect affordability by affecting income and also ability of people to choose the food they want to eat (preferability) (FAO, 2008a).

24. Food utilization refers to the use of food and how a person is able to secure essential nutrients from the food consumed. Climate change will cause new patterns of pests and diseases to emerge, affecting plants, animals and humans, and posing new risks for food security, food safety and human health. Increased incidence of water-borne diseases in flood-prone areas, changes in vectors for climate-responsive pests and diseases, and emergence of new diseases could affect both the food chain and people's physiological capacity to obtain necessary. Food system stability is determined by the temporal availability of, and access to, food. Droughts and floods are particular threats to food stability and are expected to become more frequent, more intense and less predictable as a consequence of climate change.

25. Africa's poor agricultural incentives and infrastructure, inadequate trade and pricing policies, and weak capacity signify low investments in this sector, although more than 60% of its population depends directly on agriculture and natural resources (FAO, 2003b). With farming done mainly under rain fed conditions, increasing land degradation and low levels of irrigation, i.e. 6% in Africa compared to 38% in Asia (FAO, 2005), climate change can significantly reverse the progress towards poverty reduction and food security.

4.2. Impact of climate change on Agricultural Systems in Africa

26. Agriculture in Africa is important for food security in two ways: it produces the food people eat; and (perhaps even more important) it provides the primary source of livelihood for two-thirds of the working population in sub-Saharan Africa (ILO, 2008). If agricultural production in the low-income developing countries of Asia and Africa is adversely affected by climate change, the livelihoods of large numbers of the rural poor will be put at risk and their vulnerability to food insecurity increased.

27. In general, Africa's crop and livestock systems have evolved based on the availability and opportunities provided by the natural resource base, in addition to market systems (Morton, 2007). Farms tend to be small, under traditional or informal tenure, with diverse soil types and individual farmer management strategies. Padgham (2009) notes that vulnerability to the extreme events of climate change is determined by:

- The extent of abiotic and biotic stresses in the production system
- The ownership of land and livestock
- Land size and productivity
- Access to credit and markets
- Availability and affordability of agricultural inputs
- Access to cash income from off farm livelihood activities
- The state of village infrastructure
- Gender of household head
- Connection to family and social networks

These factors determine the sensitivity of household livelihoods, the sensitivities to variations in productivity and climate, and their capacity to respond to these impacts.

28. With climate change, the yields of some major crops may be reduced, for example, a decrease of 6.9% for maize by 2020 as compared to the drought resistant crop millet which would not be as affected (Brown & Crawford, 2007). In the recent decades, there have been some advances in improved varieties of maize, cassava, rice and beans that are more tolerant to drought and disease. The diverse mix of crops, the complex agro-ecological systems, the lack of supporting infrastructure, markets and supporting institutions, and gender differences in labour responsibility and access to assets have affected the adoption of new crop varieties in Africa (World Bank, 2008).

4.3 Animal Husbandry and Pastoralists

29. In the arid and semi arid zones of Africa are an estimated 50 million pastoralists and agro-pastoralists that constitute one of the poorest and most vulnerable population sub-groups (Rass, 2006). Pastoralists obtain more than 50% of their total gross income from mobile livestock rearing on communal pastures; and agro-pastoralists between 25% and less than 50% from livestock and more than 50% from cropping activities (Swift, 1988). In addition to the low but highly variable rainfall patterns and poor soils, the risks of epidemic diseases, exclusion from livestock export markets due to insufficient health standards, risks of violent conflict over natural resources, decreasing rangelands with increasing human and livestock populations, and widespread marginalization, further elevate their vulnerability to the potential impacts of climate change (Rass, 2006). The changes to crop production, availability of feed crops and grazing systems will have negative and permanent impacts on animal husbandry and the free range grazing of livestock.

30. Although pastoralists have developed resilient livelihood systems to deal with their harsh and unpredictable environment, the new dynamics introduced by global change will amplify potential impacts. The main factor in pastoral strategies, for example, is livestock mobility, i.e. moving herds to areas with better grazing conditions and securing access to critical resources during the dry season and in times of crisis (Hesse & Cotula, 2006). With climate change, the

number, distribution and productivity of permanent pastures and water points, which are so critical for livestock survival during the dry season, are bound to decline.

31. Dry lands used for grazing are fragile ecosystems, which are increasingly being degraded yet they are also very resilient towards disturbances (Janzen, 1988). The greatest danger is the potential to increase desertification because of resource management inefficiencies (Gonzalez, 2001). Recent droughts in Africa illustrate the potentially large effects of local and/or regional climate variability on livestock (IPCC, 2007). One obvious consequence would be rangeland degradation involving reduced forage productivity and quality, and lack of resilience to drought, which could lead to massive livestock loss (FAO, 2008b) (see Table 1).

Table 1 Impacts of droughts on livestock numbers in selected African countries, 1981 to 1999
(Source: IPCC, 2007 cited in FAO, 2008a)

Date	**Location**	**Livestock losses**
1981- 1984	Botswana	20 % of national herd
1982-1984	Niger	62 % of national cattle herd
1983-1984	Ethiopia (Borana Plateau)	45-90 % of calves, 45 % of cows, 22 %of mature males
1991	Northern Kenya	28 % of cattle; 18 % of sheep and goats
1991-1993	Ethiopia (Borana) 2002	42 % of cattle
1993	Namibia	22 % of cattle 41% of goats and sheep
1995-1997	Greater Horn of Africa (average of 9 pastoral areas)	20 % of cattle; 20 % of sheep and goats
1995-1997	Southern Ethiopia	46 % of cattle; 41% of sheep and goats
1998-1999	Ethiopia (Borana)	62 % of cattle

4.4 Agriculture and Land Degradation

32. It is estimated that about 65% of Africa's population and an area of about 16.1 million km^2 are currently affected by land degradation. The rate of agricultural production is reducing at 3% per annum. In addition, at least 4 million tons of nutrients are removed in harvested produce compared to the 1 million tons that is returned to the soil in the form of manure and fertilizers, thereby affecting soil fertility (FAO, 2008a). There is a growing fear that if the trend continues, in the face of climate change, two-thirds of the regions arable land could be lost by 2025 (TerrAfrica, 2006).

33. About half of Africa's cultivable land is arid and semiarid comprising mostly of desert soils, which have the least organic matter content, and is degraded (ECA, 2001). Land degradation is a serious problem throughout Africa, threatening economic and physical survival. An estimated 500 million ha of land have been affected by soil degradation since about 1950 (Clarke, 2000). Increasing soil erosion, declining fertility, salinisation as a result of poor

irrigation techniques, soil compaction, agrochemical pollution and desertification are major issues. The frequency, severity and duration of droughts, in addition to non-climate factors such as population growth and economic incentives, create pressures to intensify land uses, expand farming and grazing activities into marginal lands, and clear vegetation (Leary & Kulkarni, 2007). The combined effects of climate change and current anthropogenic activities influence land productivity and quality to reduce resilience of the land and soil fertility.

34. Cash crop farming requires the availability of vast amounts of arable land. However climate change is likely to affect land degradation processes by altering rainfall averages, variability and extremes and by increasing evaporation and transpiration of water from soils, vegetation and surface waters. In North Africa and the Sahel, increasing drought, water scarcity and land overuse could lead to a loss of 75% of arable, rain-fed land. The Nile Delta, for example, is at risk from both sea-level rise and salinisation in agricultural areas with estimates of 12 to 15% loss of arable land by 2050 affecting 5 million people.

4.5. Natural Resources

35. Africa is endowed with diverse and biologically important ecosystems namely tropical savannahs, tropical forests, coral reef, marine and fresh water habitats, wetlands and mountain ecosystems. The ecosystems yield a variety of land-based resources including soils, vegetation, wood products, and fauna, and constitute the basic capital to meet Africa's food, fuel, water and shelter requirements (FAO, 2008a). Climate change effects on ecosystems resources, as it relate to food security in Africa, will impact significantly on biophysical processes like plant and animal growth, biodiversity and nutrient cycling, and the way these processes are managed for food production in a sustainable manner (FAO, 2008b).

36. Biodiversity is an important resource for African people. It is used for both consumptive (food, fiber, fuel, shelter, medicine, wildlife trade) and non-consumptive purposes (ecosystem services and the economically important tourism industry). Bush meat and non-timber forest products in particular play a significant role in the diets of Africans (Ntiamoa-Baidu, 1997). Approximately 30 million people live in the forests of Central Africa, and they eat approximately 1.1 million metric tons of wildlife each year – the equivalent of almost 4 million cattle. The estimated annual value of the bush meat trade in West and Central Africa could exceed 1 billion US dollars (Nasi *et al.*, 2008). Considering the heavy dependence on natural resources in Africa, many communities are vulnerable to the biodiversity loss that could result from climate change.

V. ADAPTATION AND MITIGATION OPTIONS: CAPACITY AND STRATEGY

5.1. Adaptation and Development

37. McGray *et al.*, (2007) note that there are two roughly distinct perspectives that inform the approach to adaptation: one focuses on creating response mechanisms to specific impacts associated with climate change, and the other on reducing vulnerability to climate change through building capacities that can help address a range of challenges, including the effects of climate change. *McGray et al.*, (2007) also report on the different types of adaptation approaches that countries follow:

- ***"Serendipitous" Adaptation:*** Activities undertaken to achieve development objectives incidentally achieve adaptation objectives.

- ***Climate-Proofing of Ongoing Development Efforts:*** Activities added to an ongoing development initiative to ensure its success under a changing climate.
- ***Discrete Adaptation:*** Activities undertaken specifically to achieve climate adaptation objectives. Development activities may be used as means to achieve adaptation ends.

38. Climate change adaptation is the priority for most African countries and is fundamentally about sound resilient development. Some adaptation to current climate variability is taking place; however, this may be insufficient for future changes in climate (IPCC, 2007). The key areas of adaptation, which when sustained could bring development, are disaster risk reduction; sustainable land, water, and forest management; coastal and urban development; watershed management, increased agricultural productivity; health and social issues (IAASTD 2008 a, b; IAASTD, 2009; World Bank, 2009). Adaptation responses, however, have to be tailored to local conditions and needs, since the nature of risks and the affected livelihood groups vary from one ecosystem to another (MA, 2005).

39. Climate change adaptation could become an important development agenda for African countries when based on ecosystems approach (e.g., the FAO Ecosystem Approach to Fisheries). Protection of natural ecosystems like wetlands, floodplain forests, mangroves and other coastal vegetation could provide storm protection, coastal defenses, and water recharge, and act as safety barriers against natural hazards such as floods. This could complement or serve as a substitute for very expensive infrastructure investment to protect coastal and riverine settlements in times of extreme weather events. Wetlands protection in Africa as climate change adaptation could help to filter pollutants and serve as water recharge areas and nurseries for local fisheries (World Bank, 2009).

5.2. Adaptation Strategies and Traditional Knowledge

40. Africans have historically used several coping strategies especially in the water-stressed Sahelian zone to avert the effects of climate variability. Some of these strategies employed mostly in Mali, Niger and Burkina Faso involve building of anti-erosion small dykes to allow for sedimentation and particle deposits upstream of the dykes to reduce run-off and increase water percolation; the "*zai*" technique, which is also applied in the Sahelian zone, involves planting of crops in small, circular pits perpendicular to the slope to capture rainwater and retain soil moisture (Brown & Crawford, 2007; ECOWAS-SWAC/OECD 2008); and improved land clearing technique which involves leaving of tree stumps and trimmed shrubs and small tress to facilitate fast re-growth (ECOWAS-SWAC/OECD, 2008).

41. Adaptation options of smallholder and subsistence farmers are basically location specific and need to consider complexity in household crop and livestock productions and non market relations. Family labour, existing patterns of diversification and indigenous knowledge are, however, important resilience factors to help communities cope with crises (Morton, 2007). Participatory approaches that involve farmers in the early stages of plant breeding, and allow them to select and adapt technologies to social and economic conditions, using indigenous knowledge, have proven to be successful in improving agricultural yields (Walker, 2007).

42. Farmers are also often the repository for traditional and indigenous knowledge, expertise, skills and practices related to crop and animal production. These systems provide an invaluable resource for ensuring agricultural diversity, livelihood and food security in Africa (FAO, 2009a). Indigenous people have developed a wide array of coping strategies, and their

traditional knowledge and practices provide an important basis for adapting to or mitigating the potential impacts of climate change. The various plant and animal breeds used by indigenous and local communities have traits to adapt to the local environment and climate, resist pests and disease and satisfy cultural preferences to help ensure food security, improve livelihood and market participation. In addition, traditional knowledge applied by communities to previous climatic variations can help select the most appropriate adaptive and/or coping responses. Nevertheless, new investments and modernization are needed to promote improved adaptation strategies as traditional knowledge is gradually losing its significance under the changing physical and socioeconomic context.

43. Broad scale (regional or national) assessments that do not include the spatial heterogeneity of climate change impacts, households' access to resources, poverty levels and ability to cope, can miss out critical information important for community based efforts to increase local adaptive capacity (Thornton *et al*., 2009). Aid programmes to Africa must therefore carefully consider how they can help African farmers adapt to climate change, and such adaptation should vary geographically depending on conditions.

5.3. Role of forests in climate change adaptation and mitigation

44. Forests contribute to adaptation to and mitigation of climate change. Floods are recurrent in some countries of Africa. In 2007, for example, unprecedented flooding over the White Volta catchments created a tragic situation for nearby farming villages and beyond. It is expected flood-prone coastal regions would be even more dramatically impacted. Mangrove forests protect coastal zones from floods and forests reduce flooding by acting as sponges – that is, they trap water during heavy rainfall, and then release it slowly into streams, which lessen the severity of floods and maintain stream flows during dry periods.

45. Non-wood forest products (NWFP) are particularly important for the livelihoods of rural forest dependent communities, who often tend to be the poorest of the poor. NWFPs provide an available and accessible source of a diverse range of food and medicine for these communities for household use as well as for marketing to urban communities. NWFPs are often comparable, and in some cases superior in nutritional quality to cultivated varieties. Thus they significantly supplement the overall diversity and nutritional quality of rural people's diets. NWFPs also provide a "buffer food source" during climate induced droughts and flooding when other agricultural crops are not available.

46. Forests are the major source of wood fuels for cooking and heating. Wood fuels are a source of renewable energy and thus help in climate change mitigation. The Global Forests Resources Assessments (2005) estimates that 88% of wood removals in Africa are attributed to fuel wood. Fuel wood collection is one of the major drivers for deforestation and degradation of large forest areas in Africa. Currently several governments are working to mitigate this by mapping available wood energy resources to ensure proper management and utilization

5.4. Agroforestry – Adaptation and Mitigation Synergies

47. Agroforestry contributes to the provision of environmental services especially through diversified tree products, secured soil health, and enriched livestock feeds. Adaptation to climatic change and restoration of soil fertility is important for a sustainable future especially in the Sahel and other dry lands. Agroforestry, a combination of agriculture and forestry, is now recognised as

having high potential for sequestering carbon as part of a short-to-medium term mitigation strategy. Trees have an important role in reducing vulnerability, increasing the stability of farming systems, and buffering households against climate-related risks. Trees grown on farms can help improve soil conditions and give shade to crops and livestock. Forest products produced on farm are important for income diversification and spreading risk in times of crop failure or livestock disease. The cultural perceptions as well as traditional resource management methods used by communities may need to be modified towards adaptation to climate change.

48. In places where droughts recur, rural farmers have been practicing coping strategies and tactics and have developed their own ways of assessing the prospects for favourable household or village seasonal food production (Downing *et al*., 1989). The Economic Commission on Africa (ECA) notes that in some areas, locals have improved their adaptive capacity by using traditional pruning and fertilizing techniques to double tree densities in semi-arid areas. These help in holding soils together and reversing desertification (ECA, 2001). Other strategies include the reliance on forest products as a buffer to climate-induced crop failure in climatically marginal agricultural areas (Dube *et al*. 2005). Soil conservation and well-managed tree plantations are also important.

5.5 Reduced Emissions from Deforestation and Forest Degradation

49. Cheap reductions through the Reduced Emissions from Deforestation and forest Degradation (REDD) mechanism is key in mitigation to climate change (CIFOR 2009). The economic argument for REDD primarily centres on the financial opportunity costs of deforestation and forest degradation. Offering financial compensation to forest nations that reflect the value of the carbon stored in their forests to the world would be a fundamentally new and promising approach. In a long time perspective whole-landscape carbon accounting (combining REDD, A/R CDM, i.e., afforestation and reforestation of the Clean Development Mechanism, and the gaps in between) may provide a basis for investment in trees managed by farmers and rural communities.

5.6. Urban forests

50. In some cities, urban forests make an important contribution to family nutrition. Tree planting for micro-climate amelioration in cities attribute to cooling effect of trees (block afforestation of degraded hillsides, windbreaks, triple rows of trees along railways, and the lining of street sides). While the primary effect is energy saving (air conditioning), another positive impact is on the water cycle and water conservation for agricultural activities. The contribution of urban and peri-urban agriculture to urban food security and poverty alleviation is being given increasing attention by policy makers. Urban forests are also a major source of fuel wood and non-wood forest products for household use and many countries have actively managed these forests to preserve these resources.

5.7. Natural Resource Management as an Adaptation Response

51. Ensuring adequate food and water to all and achieving sustainable rural development and livelihoods for current and future generations all depend upon the sustainable natural resources management. Sustainable natural resource management is one of the key entry points to build adaptive capacity of vulnerable communities. Various measures exist so as to reduce climate risk to natural resources (WRI, 2009). These include:

- Development and implementation of systems for integrated management, e.g.:
  - Integration of climate risk into management planning
  - Updating/development of monitoring and observation systems
  - Creation of management processes/institutions where they do not exist
  - Frequent review of management plans and systems
  - Identifying synergies or conflicts between management needs of different systems (e.g. upstream/downstream issues, or effects of urban systems on neighbouring ecosystems)
- Systems for managing tradeoffs between natural resources management (NRM) and other priorities
- Systems for valuing ecosystems that account for their resilience-building function and provision of other key services
- Identification of risks to key sectors/regions/populations for which existing and/or new NRM practices may be an adaptation solution
- Comprehensive options analysis to address the climate risk(s) above, to consider:
  - Technology or infrastructure
  - Various nature-based solutions
  - A combination of technology/infrastructure and nature-based options
  - Costs of each option
  - Comparative effectiveness
  - Likely performance over both short- and long-terms
  - Synergies/trade-offs between the options
  - Synergies/trade-offs across sectors/regions/populations
- Prioritization of adaptation options based on the above assessment
- Provision of appropriate resources for adaptation option(s) above
- Implementation of selected adaptation options
- System for monitoring/review of steps taken

5.8. FAO Guidance to Best Practice

52. The FAO plays a key role for African countries in addressing the climate change challenge (FAO 2007; FAO 2009b, 2009c). It does this by providing a neutral forum for discussions, acts as a repository of data and information as well as custodian of models and methods. With the view to providing an evidence base for sector response strategies and assisting with emerging demands from countries, FAO has assembled the best available knowledge and tapped relevant networks through a series of Expert Meetings on:

- Climate change adaptation and mitigation
- Climate change, water and food security
- Climate-related trans-boundary pests and diseases, including relevant aquatic species
- Climate change and disaster risk management
- Bio-energy policy, markets and trade and food security
- Global perspectives and food and fuel security
- Climate change and fisheries and aquaculture
- Climate change and biodiversity

53. Each of these Expert Meetings examined the opportunities and constraints for the agriculture, forestry and fisheries sectors, including cross-sectoral linkages between food security,

rural development (including coastal and inland waters) and the environment, as well as related key areas for investment and research, methods and tools, capacity-building, regulatory frameworks, policy implications (at national and international levels), possible partnerships and available investment and financial instruments (FAO web site). These Expert meetings then feed into High Level Conferences e.g., the June 2008 meeting in Rome on Food Security, Climate Change and Bio-energy[1].

Core Principles that guide FAO's work on Climate Change

- Integrating climate change concerns into food security and development planning across all sectors and spatio-temporal scales
- Seeking a systems approach that build synergies in mitigation, adaptation and sustainable food production
- Working in a demand driven, location specific and participatory manner, considering gender specific needs as well as priorities of indigenous and other vulnerable communities
- Addressing adaptation and mitigation as an ongoing social learning processes that integrates local and scientific knowledge
- Promoting synergies between international conventions and agreements on climate change, desertification, biodiversity and forestry.

FAO's six priority action areas for climate change adaptation in agriculture, forestry and fisheries:

- Data and knowledge for impact assessment and adaptation
- Governance for climate change adaptation
- Livelihood resilience to climate change
- Conservation and sustainable management of biodiversity
- Innovative technologies
- Improved disaster risk management

FAO 2009 Profile on Climate Change

54. An example of best practice addressing the information needs facilitated by FAO is the Assessment of Impact of Climate Change on Agriculture in Morocco. This climate change impact assessment led by FAO, the World Bank and local partners in Morocco is now available with information on future yields of about 50 crops following two scenarios within six agro-ecological zones. Assessments at a fine local spatial resolution were made using special FAO software, showing that yields will remain relatively stable for most crops until approximately 2030. After this period, some major crops will show significant decreases: in 2080, rain fed sugar-beet would decrease by 40 percent in most favourable growing zones and barley by 30 percent. The study is part of a comprehensive programme covering the spectrum from climate change scenario projections to impacts on agriculture output and trade to lead to policy recommendations to adapt to climate change and its effects.

[1] FAO high level conference on "World Food Security: Challenges of Climate Change and Bioenergy" (http://www.fao.org/foodclimate/hlc-home/en/

55. The Forestry Divisions of FAO are very active in Climate Change related matters. The FAO also chairs the Collaborative Partnership on Forests (CPF) a consortium of 14 major forest-related international organizations, institutions and secretariats created in response to a resolution by the Economic and Social Council of the United Nations. They all have substantial programmes on forests and they work together to support the implementation of internationally agreed actions and sustainable forest management, for the benefit of people and the environment. The main thrust of activities is in Sustainable Forest Management by:

- Strengthening forest policy frameworks: national forest programmes
- Global and regional sector outlook studies
- Facilitating forest law compliance and good governance
- Implementing best practices for sustainable forest management
- Improving livelihoods through forestry
- Forest monitoring and assessment and reporting

VI. CONCLUSIONS

56. The main conclusion from the literature synthesis and the main message of this paper is that climate change will likely to reduce crop yields and exacerbate the risk of food insecurity in Africa. African governments need to prioritize and implement measures to develop agriculture and sustainable natural resources management to ensure food security for their people. The "business as usual" approach to the climate change problem will not reduce the vulnerability as this vulnerability is exacerbated by existing developmental challenges such as endemic poverty, complex institutional dimensions; limited access to capital, infrastructure and technology,; ecosystem degradation; and complex natural disasters and conflicts.

57. Climate change will affect poorer African countries disproportionately. The poorest people in those countries will suffer the greatest consequences. The African subsistence farmer is among the most vulnerable. Those least able to cope will be hit the hardest. Economic activity in these countries is principally rural-based, relying on agriculture, fisheries and forestry, which are vulnerable to the effects of climate change. It is they who will see the possibilities of escape from poverty become increasingly more difficult to achieve due to climate change brought about almost entirely by other, richer, people living elsewhere.

58. Climate change is accelerating the rapid depletion of Sub-Saharan Africa's natural resources and the genetic erosion of indigenous germplasm. The lack of comprehensive impact assessment and non availability of appropriate and sustainable adaptation practices compounds the problems. Adaptation thus should be the priority and well integrated with livelihood systems and development goals if it is to succeed. Bringing a climate-aware perspective to agricultural development is particularly important for investments with a long life span including infrastructure and national strategies – which should be adapted to the long term issues of climate change

59. African Governments and international agencies have always been aware of the risks associated with climate variability and change to the African farmer. Now real progress toward a comprehensive solution to the problem is foremost important. Some recent initiatives include the NEPAD 2006 Abuja Summit on Food Security in Africa; the 2007 Chennai Declaration on making Hunger History; the 2009 World Summit on Food Security, etc. The 2009 EU-US Summit Declaration Annex 1: Statement on Development Dialogue and Cooperation states "… *we will*

accelerate implementation of our commitments under the Paris Declaration and Accra Agenda for Action, with a strong focus on in-country implementation. We will focus our initial cooperative efforts on three common priorities: food security and agricultural development, climate change and the Millennium Development Goals."

60. Development policies are needed that target vulnerable groups (i.e., that include gender in adaptation policies as the burden on women's labour will increase with impacts on water and land resources). Policy is also needed to improve data access and knowledge dissemination, strengthen processes that support collective action as well functioning social networks enable communities to manage and recover better, include climate risk considerations in decentralization and property rights policies to avoid increasing the vulnerability of marginal groups (Padgham, 2009).

61. The promotion and protection of traditional and local food and agricultural knowledge can help in dealing with food insecurity in the face of climate change. This will require international, intercultural and interdisciplinary approaches, communication and cooperation. Coordination of indigenous and local communities' sustainable use, conservation and management of food and agriculture within and across ecosystems, landscapes and sea scapes will also require synergies that link food security, livelihood sustainability, poverty alleviation and food and agricultural productivity to rural development processes based on in and ex-situ conservation of food and agricultural genetic resources.

62. One-third of the African population lives in drought-prone areas. Six of the ten largest cities in Africa are located on the coast (Garcia, 2008). These are both areas susceptible to climate change. With climate change, food and water supplies may become unreliable, livelihoods and access to food insecure, and available arable land reduced, causing population movements by making certain parts of the world much less viable places to live (Brown, 2008). The so called 'environmental migrants' not only leave behind degraded farm lands and destroyed trees but also may increase conflicts in transit and destination areas.

63. There is increasing need to evolve adaptation and mitigation strategies at national and local levels in line with identified priorities. For instance, the International Workshop on Adaptation to Climate Change in West African Agriculture recommended putting forward the primordial role of weather and climate services and products in developing adaptation solutions to climate change[2]. Other priorities include documentation and dissemination of action oriented data base, impact assessments, facilitate better access to credit and agricultural inputs, improved water resource management, strengthen cooperation among academic and research institutions, establishing climate change and food security networks and developing comprehensive communication plan to share information with regard to climate change impacts, vulnerability, adaptation and mitigation.

64. There is an urgent need to promote and build capacity for the FAO initiative for Sustainable Land Management (SLM) in Africa. This knowledge based procedure helps integrate land, water, biodiversity, and environmental management including input and output externalities

[2] See Declaration of the International Workshop on Adaptation to Climate Change in West African Agriculture held in Ouagadougou from 27 to 30 April 2009 which clearly states what needs to be done to minimise vulnerability.
http://www.wmo.int/pages/mediacentre/news/documents/Ouagadougou_declaration.pdf

to meet rising food and fibre demands while sustaining ecosystem services and livelihoods (World Bank, 2006). SLM, if promoted by national governments, could reduce the region's dependence on natural factors like rain-fed agriculture and natural soil fertility which cannot withstand the pressures of climate change.

65. There is increasing potential for African countries to be involved in voluntary markets for carbon and international market mechanisms such as the CDM (Clean Development Mechanism). Knowledge and strategies to reduce carbon emissions through community based afforestation and reforestation projects, agro-forestry and reduced deforestation and degradation (REDD) are being generated, but need to be tested and adopted. These strategies have the potential to create synergies for increasing productivity and achieving the multiple functions of agriculture for the benefit of smallholders.

66. As more people congregate in the urban areas in Africa, there is the urgent need to promote peri-urban agricultural, where appropriate, using all available land resources to off-set anticipated short falls in relation to climate change. Farm units close to towns and cities have potential to operate intensive semi- or fully commercial farms to grow vegetables and other horticulture, raise chicken and other livestock, produce milk and eggs, and develop aquaculture fisheries. When carried out properly under safe conditions, this system of farming can contribute to food security by increasing quantity of food available especially during times of crisis, enhance the freshness of perishable foods on the urban market and offer opportunities for productive employment to the unemployed.

67. Finally, measures to reduce climate change impacts in Africa must be seen as additional to ongoing international development assistance, not as a substitute. There needs to be a harmonized approach in international joint efforts on actions that will help insulate the African farmer from the worst impacts of climate change by anticipatory adaptation. This would need policy coherence for aid effectiveness and accelerated implementation of commitments under the Paris Declaration, the Accra Agenda for Action, as well as use of the 2009 L'Aquila principles, with a strong focus on in-country implementation.

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