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Background Note

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Climate change, water and food security

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The food price crisis of 2008 has led to the re-emergence of debates about global food security (e.g. Wiggins, 2008) and its impact on prospects for achieving the first Millennium Development Goal (MDG): to end poverty and hunger. On top of a number of shorter-term triggers leading to volatile food prices, the longer-term negative impacts of climate change need to be taken very seriously.

The United Nations Development Programme (UNDP) warns 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. The impacts of climate change – sea level rise, droughts, heat waves, floods and rainfall variation – 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).

Agriculture constitutes the backbone of most African economies. It is the largest contributor to GDP; the biggest source of foreign exchange, accounting for about 40% of the continent's foreign currency earnings; and the main generator of savings and tax revenues. In addition, about two-thirds of manufacturing value-added is based on agricultural raw materials. Agriculture remains crucial for pro-poor economic growth in most African countries, as rural areas support 70-80% of the total population. More than in any other sector, improvements in agricultural performance have the potential to increase rural incomes and purchasing power for large numbers of people to lift them out of poverty (NEPAD, 2002; Wiggins, 2006).

Climate change, however, is considered as posing the greatest threat to agriculture and food security in the 21st century, particularly in many of the poor, agriculture-based countries of sub-Saharan Africa (SSA) with their low capacity to effectively cope (Shah et al., 2008; Nellemann et al., 2009).

African agriculture is already under stress as a result of population increase, industrialisation and urbanisation, competition over resource use, degradation of resources, and insufficient public spending for rural infrastructure and services. The impact of climate change is likely to exacerbate these stresses even further.

The outlook for the coming decades is that agricultural productivity needs to continue to increase and will require more water to meet the demands of growing populations. Ensuring equitable access to water and its benefits now and for future generations is a major challenge as scarcity and competition increase.

The amount of water allocated to agriculture and water management choices will determine, to a large extent, whether societies achieve economic and social development and environmental sustainability (Molden et al., 2007).

This paper reviews current knowledge about the relationships between climate change, water and food security.

Small-holder agriculture, water and climate change

Smallholder farmers (including herders and fishers) make up the majority of the world's poor people. The International Fund for Agricultural Development (IFAD) (IFAD, n.a.) estimates that there are 1.2 billion people who cannot meet their most basic needs for sufficient

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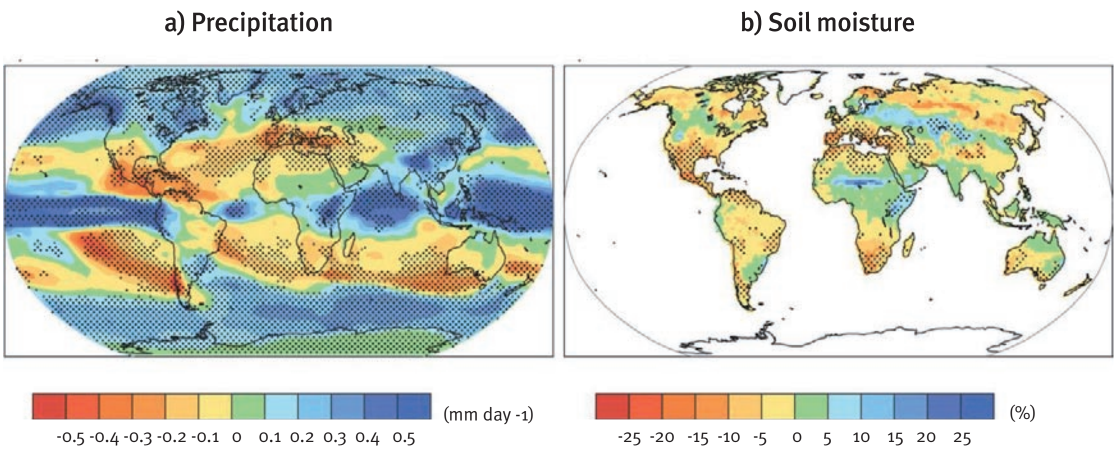
Figure 1: Multi-model mean changes in precipitation and soil moisture

Changes are for annual means for the scenario SRES A1B for the period 2080-2099 relative to 1980-1999



Source: Adapted from Bates et al. (2008).

food every day. Of these, the largest segment are the 800 million poor women, men and children, often belonging to indigenous populations, who live in rural environments and try to make a living as subsistence farmers and herders, fishers, migrant workers, or artisans. They often occupy marginal lands and depend heavily on rainfed production systems that are particularly susceptible to droughts, floods and shifts in markets and prices. Hence, strategies to reduce rural poverty will depend largely on improved water management in agriculture.

For both rainfed and irrigated agriculture, the spatial and temporal variation of precipitation is key. The short-term variability of rainfall is a major risk factor. Soil moisture deficits, crop damage and crop disease are all driven by rainfall and associated humidity. The variability in rainfall intensity and duration makes the performance of agricultural systems in relation to long term climate trends very difficult to anticipate. This is particularly the case for rainfed production.

Although the different climate change models are not clear with respect to rainfall and periods of drought, temperature projections are generally more reliable. Increased evaporation and evapotranspiration with associated soil-moisture deficits will impact rainfed agriculture (Bates et al., 2008). Recent estimates show that for each 1°C rise in average temperature dryland farm profits in Africa will drop by nearly 10% (FAO, 2008b). In addition, increased evaporation of open water storage can be expected to reduce water availability for irrigation and hydropower generation.

Despite considerable uncertainty related to the impacts of climate change in Africa, the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPPC) predicts decreasing rainfall in northern and southern Africa, increasing rainfall over the Ethiopian/East African Highlands and a considerable increase in frequency of floods and drought (Figure 1).

Food security concerns

Food security is defined as a ‘situation [...] when all people, at all times, have physical, social and economic access to sufficient, safe, and nutritious food that meets their dietary needs and food preferences for an active and healthy life’ (FAO, 2002). Food security is not narrowly defined as whether food is available, but whether the monetary and non-monetary resources at the disposal of the population are sufficient to allow everyone access to adequate quantities and qualities of food (Schmidhuber and Tubiello, 2007). All dimensions of food security are likely to be affected by climate change (Box 1). Importantly, food security will depend not only on climate and socio-economic impacts on food production, but also (and critically so) on economic growth, changes to trade flows, stocks, and food aid policy.

Water, food security and livelihoods

A number of countries in sub-Saharan Africa (SSA) already experience considerable water stress as a result of insufficient and unreliable rainfall, changing rainfall patterns or flooding. The impacts of climate change – including predicted increases in extremes – are likely to add to this stress, leading to additional pressure on water availability, accessibility, supply and demand. For Africa, it is estimated that 25% of the population (approximately 200 million people) currently experience water stress, with more countries expected to face high risks in the future. This may, in turn, lead to increased food and water insecurity for

Box 1: Climate change affects all four dimensions of food security

Food production and availability: Climate affects food production directly through changes in agro-ecological conditions and indirectly by affecting growth and distribution of incomes, and thus demand for agricultural produce. Changes in land suitability, potential yields (e.g. CO_2 fertilisation) and production of current cultivars are likely. Shifts in land suitability are likely to lead to increases in suitable cropland in higher latitudes and declines of potential cropland in lower latitudes.

Stability of food supplies: Weather conditions are expected to become more variable than at present, with increasing frequency and severity of extreme events. Greater fluctuation in crop yields and local food supplies can adversely affect the stability of food supplies and food security. Climatic fluctuations will be most pronounced in semi-arid and sub-humid regions and are likely to reduce crop yields and livestock numbers and productivity. As these areas are mostly in sub-Saharan Africa and South Asia, the poorest regions with the highest levels of chronic undernourishment will be exposed to the highest degree of instability.

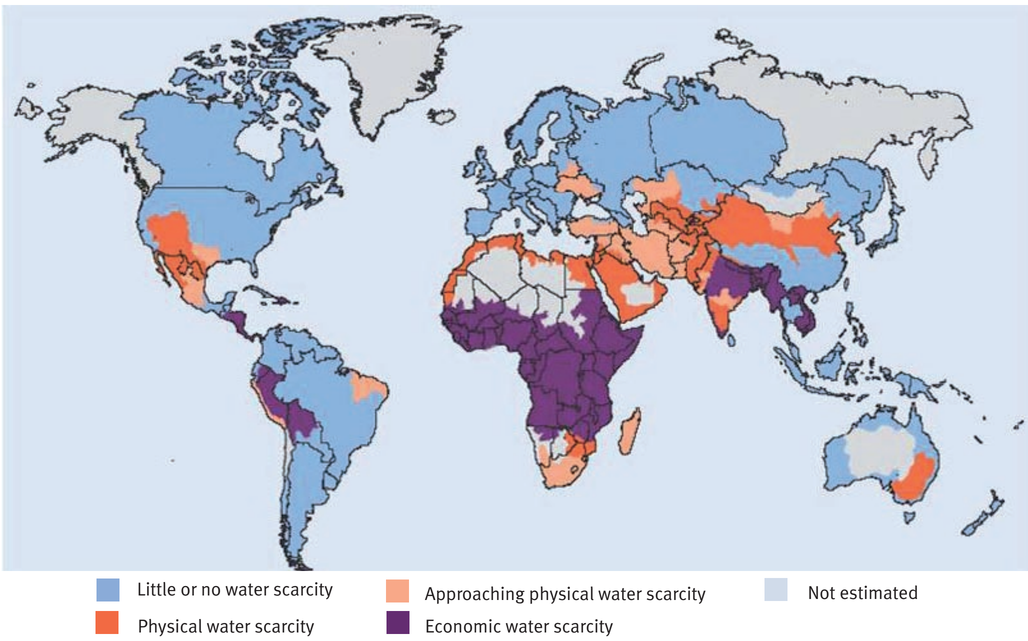
Access to food: Access to food refers to the ability of individuals, communities and countries to purchase food in sufficient quantities and quality. Falling real prices for food and rising real incomes over the last 30 years have led to substantial improvements in access to food in many developing countries. Possible food price increases and declining rates of income growth resulting from climate change may reverse this trend.

Food utilisation: Climate change may initiate a vicious circle where infectious diseases, including water-borne diseases, cause or compound hunger, which, in turn, makes the affected population more susceptible to those diseases. Results may include declines in labour productivity and an increase in poverty, morbidity and mortality.

Source: Schmidhuber and Tubiello (2007).

Figure 2: Water scarcity in major river basins

Physical scarcity: more than 75% of river flows are allocated to agriculture, industry or domestic consumption. Economic scarcity: water resources are abundant relative to human purposes but human, institutional and financial capital limit access to sufficient water and malnutrition in these areas.



Source: Adapted from Molden et al. (2007).

at-risk populations, undermining growth.

It is estimated that the net balance of changes in the cereal production potential of 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). FAO (2008a) estimates that in 2007 almost 850 million people were undernourished. 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).

In addition to farming areas, many of the world's rangelands are in semi-arid areas and susceptible to

Box 2: Insights from the field

Case studies carried out by RiPPLE (Research-inspired Policy and Practice Learning in Ethiopia and the Nile Region, see www.rippleethiopia.org) in rural Ethiopia point to the critical linkages between water and livelihoods, and to the value of water as a productive input.

Securing water for production – e.g. in the agricultural sector for small-scale irrigation or livestock, but also in the off-farm sector for activities such as brick-making or beer brewing – is integral to obtaining adequate food and the income necessary for food security. Water insecurity can affect wider household production and income earning opportunities than just agricultural production.

A survey carried out in Eastern Haraghe, Ethiopia, in 2007 showed that improved water supply has a strong association with increased volume of water consumed per household and a decrease in the average time spent fetching water, resulting in significant time saved for household members. Household members with access to an improved water source are more likely to participate in off- and non-farm employment. Households with access to improved water supply and productive water use (irrigation) have significantly lower overall and food poverty levels in terms of incidence, depth and severity. Access to an improved water source significantly reduces the probability of illnesses and leads to a significant reduction in household health expenditure.

Observers reported that during the 2007/08 drought in the Southern Nations, Nationalities and Peoples Region in Ethiopia people had to walk up to 25 km to fetch water and had to wait up to two days at the few remaining functioning water schemes to get water – time that could otherwise have been invested in productive activities – leading to substantial labour losses.

Sources: Calow et al. (n.a.); Desta Dimtse, personal communication (April 2008); Fitsum Hagos et al. (2008).

Box 3: Household Water Economy Approach (HWEA)

The Household Water Economy Approach (HWEA) builds on the analytical frameworks of the Household Economy Approach (HEA) developed in the early 1990s by Save the Children (UK).

HWEA is a tool that can be used to:

- Evaluate water access by different wealth groups;
- Characterise the nature of vulnerability of each wealth group to water-related hazards (e.g. access constraints vs. absolute water scarcity);
- Assess the impact of changes in access to water on food and income sources;
- Identify triggers for appropriate and timely water interventions and development programmes.

HWEA baseline data can be used for a variety of outcome analyses. In a pilot study carried out in Oromiya Region in Ethiopia under RiPPLE, HWEA and HEA data will be used to project the likely impacts of climate change and related geophysical shocks and hazards and likely impacts of climate change adaptation measures. Scenarios will address the following:

a) Impact of likely climate change hazards on water availability, access, and use; as well as food and income for different wealth groups in different livelihood zones;
b) Impact of climate change adaptation interventions on water availability, access, and use, as well as food and income;
c) Identification of policy options to mitigate negative climate change impacts and support positive developments and livelihood outcomes;
d) Identification of policy coordination needs and institutional mechanisms for climate change adaptation implementation and climate-proofing of national development policies and strategies.

Source: Coulter (2008); Holzmann et al. (2008).

water deficits; any further decline in water resources will greatly impact carrying capacity. As a result, increased climate variability and droughts may lead to significant livestock loss.

Food security and rural livelihoods are intrinsically linked to water availability and use. Food security is determined by the options people have to secure access to own agricultural production and exchange opportunities. These opportunities are influenced by access to water.

Making these water-livelihoods linkages is important for a more complete understanding of the nature of vulnerability of households to climate-related hazards such as drought, and the multi-faceted impacts that water security has on food and livelihood security. In order to highlight such linkages, there has been a move in recent years towards looking at water issues through sustainable livelihood frameworks (ie. Calow, 2002; Nicol and Slaymaker, 2003).

One main feature of climate change adaptation at local level is its attempt to increase the resilience of populations to climate-related hazards. This means assessing the populations at risk of water and food insecurity. Risk is determined by, first, the external hazard and, second, the characteristics of the population that increase or decrease their susceptibility to the harm caused by the hazard.

Vulnerability is dependent on the nature of the hazard. Vulnerability is not the same thing as poverty, nor is poverty the same as vulnerability. Similarly, risks overlaps with poverty, but they are not synonymous. All people face risks – the point is how people, especially the poor, are able to deal with them (Ludi and Bird, 2007).

Identifying populations that are vulnerable to current and future climatic hazards and conditions requires an understanding, therefore, of the climatic hazards that populations will most likely face; as well as an understanding of the specific livelihood capitals (or 'entitlements') that determine the 'internal' characteristics of the population.

Increasing the understanding of water use and livelihood strategies is key in the assessment of water stress and drought impacts and, as such, will be key in the assessment of climate change impacts. The concept of 'water security' is increasingly used to describe the outcome of the relationship between the availability of water, its accessibility and use. Water security is defined as 'availability of, and access to, water in sufficient quantity and quality to meet livelihood needs of all households throughout the year, without prejudicing the needs of other users' (Calow et al., n.a.).

Calow et al. (n.a.) distinguish three links between water, health, production and household income. First, lack of access to adequate water supply, both in quality and quantity, for domestic uses can be a major cause of declining nutritional status and of disease and morbidity. Second, domestic water is often a production input. Such production is essential for direct household consumption and/or income generation. Third, the amount of time used to collect water, and related health hazards, can be immense, especially for women and girls, and has been well documented (e.g. Magrath and Tesfu, 2006).

Climate change adaptation to enhance food and water security

Adaptation to climate change impacts should not be approached as a separate activity, isolated from other environmental and socio-economic concerns that also impact on the development opportunities of poor people (OECD, 2003). In countries where the majority of poor people depend on agricultural income, proposed climate change adaptation strategies centre around increasing agricultural productivity and making agriculture, including livestock, fishery and forestry, less vulnerable to climate stress and shocks.

Water management for agricultural production is a critical component that needs to adapt in the face of both climate and socio-economic pressures in the coming decades. Changes in water use will be driven by the combined effects of (i) changes in water availability, (ii) changes in water demand for agriculture, as well as from competing sectors including urban development and industrialisation, and (iii) changes in water management.

With regard to agricultural production and water, climate change adaptation may include (Bates et al., 2008):

- Adoption of varieties and species of crops with increased resistance to heat stress, shock and drought. For example, a private-public partnership under the leadership of the African Agricultural Technology Foundation called Water Efficient Maize for Africa (WEMA) intends to develop drought-tolerant African maize. This initiative, though, is not uncontested as it uses biotechnology besides conventional breeding and marker-assisted breeding techniques (www.aatf-africa.org);
- Modification of irrigation techniques, including amount, timing or technology (e.g. drip irrigation systems);
- Adoption of water-efficient technologies to 'harvest' water, conserve soil moisture (e.g. crop residue retention, zero-tillage), and reduce siltation and saltwater intrusion;
- Improved water management to prevent waterlogging, erosion and nutrient leaching;
- Modification of crop calendars, i.e., timing or location of cropping activities;
- Integration of the crop, livestock, forestry and fishery sectors at farm and catchment levels;
- Implementation of seasonal climate forecasting;
- Additional adaptation strategies may involve land-use changes that take advantage of modified agro-climatic conditions.

Water-related adaptation strategies will also affect the livestock sub-sector. Adaptation strategies include improved rotation of pastures, modification of times of grazing, changing animal species and breeds, integration of the crop and livestock systems, including the use of adapted forage crops, and provisions of adequate water supplies.

Land users and rural communities already adapt autonomously their land management practices to a number of political, economic, social, environmental

Box 4: The Ethiopian Climate Change National Adaptation Plan (NAPA)

The Government of Ethiopia/UN Framework Convention on Climate Change (UNFCCC) NAPA process identified arid, semi-arid and dry sub-humid areas of the country as being most vulnerable to drought. Agriculture was identified as the most vulnerable sector and, in terms of livelihoods, small-scale rain-fed subsistence farmers and pastoralist were identified as the most affected. The NAPA process has identified and prioritised 11project areas that address the immediate climate change adaptation needs in the country, focusing on: human and institutional capacity building; improving natural resource management; enhancing irrigation agriculture and water harvesting; strengthening early warning systems and awareness raising, of which the following are directly relevant to the water and agricultural sectors:

- Promoting crop insurance;
- Strengthening and enhancing drought and flood early warning systems;
- Development of small-scale irrigation and water harvesting schemes in arid, semi-arid and dry sub-humid areas;
- Improving and enhancing rangeland resource management practices in pastoral areas;
- Community-based sustainable utilisation and management of wetlands;
- Realising food security through at least one multi-purpose large-scale water development project;
- Community-based carbon-sequestration project in the Rift Valley system; and
- Promotion of on-farm and homestead forestry and agro-forestry practices in arid, semi-arid and dry sub-humid areas.

Source: FDRE (2007).

and climatic changes. Depending on perceived or real changes in climate, they will continue to do so. Part of this adaptation, however, is likely to be maladaptation such as: clearing forest land to gain additional arable land; increasing the cultivation of marginal land such as steep slopes leading to increased soil erosion; adoption of unsustainable cultivation practices as a result of dropping yields; introduction of new (exotic) plant and animal species; or more intensive use of chemical inputs leading to pollution. All of this may increase land degradation and endanger biodiversity, possibly reducing the ability to respond to increasing climate risk in the future.

It is widely believed – and many Climate Change National Adaptation Plans (NAPAs) emphasise (see Box 4 on the Ethiopian NAPA) – that irrigation will be a major adaptation approach in the agricultural sector. The problem with this strategy, however, is that adaptation practices that involve increased irrigation water use may place additional stress on water and environmental resources on the one hand, and will be influenced by changes in water availability resulting from climate change on the other.

The IPCC (Bates et al., 2008) concludes that, if widely adopted, adaptation strategies in agricultural production systems have a substantial potential to offset negative climate change impacts and can even take advantage of positive ones. At the same time, they can contribute to an increase in agricultural production sustainably.

They further conclude, however, that not much is known about how effective and widely adopted the different adaptation strategies really are. Reasons for this include complex decision making processes; the diversity of responses across regions; time lags in implementation; and possible economic, institutional and cultural barriers to change. Government support that would help poor smallholders to adapt is very limited. On top of this, developing countries have received less than 10% of the money promised by rich countries to help them adapt to global warming (Vidal, 2009).

Policy attention, by national governments and trans-national bodies will, increasingly, have to focus on the coordination of water uses across transboundary river-basins and across different sectors, and arbitration in increasing conflicts over water.

If precipitation decreases, and the demand for additional irrigation water is to be satisfied, then other demands (e.g. manufacturing, industry, urban consumption, etc.) will become much more difficult to satisfy. Climate change and increased water demand for agriculture in future decades is anticipated to be an added challenge to transboundary framework agreements, increasing the potential for conflict.

Unilateral measures for adapting to climate-change-related water shortages by, for example, increasing storage capacity upstream, increasing investment in irrigation infrastructure and efficient water-use technologies, or revising land tenure and land use arrangements, can lead to increased competition for water resources. Regulation at national and trans-national levels needs, therefore, to be enhanced to deal with the unintended consequences of increased consumptive water use upstream, resulting in downstream users being deprived of the water on which they depend for their livelihoods.

Conclusions

A number of adaptation options in agriculture face a dilemma. Increasing water availability and increasing the reliability of water in agriculture, i.e. through irrigation, is one of the preferred options to increase productivity and contribute to poverty reduction. However, as a result of the predicted climate change, semi-arid and sub-humid tropical areas that would greatly benefit from increased irrigation may see water availability changing temporally and spatially and rainfall not only declining, but also being more erratic and unfavourably distributed over the growing season, so that irrigation in the long term might not be a viable option.

In addition, the interrelations between adaptation and mitigation need to be carefully considered (Bates et al., 2008). At best, adaptation and mitigation strategies exhibit synergies. Positive examples include many carbon-sequestration practices involving reduced tillage, increased crop cover, including agroforestry, and use of improved rotation systems. These lead to production systems that are more resilient to climate variability, thus providing good adaptation in view of increased pressure on water and soil resource. In the worst case, they are counter-productive. In relation to water, examples of adaptation strategies that run counter to mitigation are those that depend on energy to deliver water and, therefore, produce additional greenhouse gas emissions. On the other hand, some mitigation strategies may have negative adaptation consequences, such as increasing the dependence on biofuel crops, which may compete for water and land resources, reduce biodiversity and increase mono-cropping, increasing vulnerability to climatic extremes.

Short-term plans to address food insecurity, provide access to water resources, or encourage economic growth must be placed in the context of future climate change, to ensure that short-term activities in a particular area do not increase vulnerability to climate change in the long term. Policy attention is needed in the following areas:

1. Developing long-term water policies and related strategies, taking into account country-specific legal, institutional, economic, social, physical and environmental conditions (FAO, 2008c). Policies and strategies will also need to integrate the different sectors depending on water – rainfed and irrigated agriculture, livestock, fisheries, forestry, nature and biodiversity protection, manufacturing and industry, and municipal water use. Water policies need to address such issues as upstream-downstream competition over water resources and equitable allocation of water across regions and generations;
2. Increasing water productivity by promoting efficient irrigation and drainage systems;
3. Improved watershed and resource management, integrating the different natural resources – water, soil, flora and fauna – through, for example, the promotion of Integrated Water Resources Management (IWRM) processes;
4. Enhancing water availability through better use of groundwater storage, enhancing groundwater recharge where feasible, and increasing surface water storage. Given the current economic situation of many water-stressed countries, however, managing demand is equally important: reducing water consumption and improving water use efficiency;
5. Institutional and governance reforms that balance demand and supply across sectors and that mainstream climate change adaptation;
6. Enhancing stakeholder participation in water development and climate change adaptation;
7. Improve information and early warning systems to provide land and water users with timely and adequate information and knowledge about availability and suitability of resources to promote sustainable agriculture and prevent further environmental degradation. Information exchange and dialogue between the agriculture, water and climate communities is vital (FAO, 2008c), not only at national levels but also at trans-boundary river basin level;
8. Human resource, capacity and skills development of policy makers and end-users to help them deal with new challenges;
9. Increase investments in agriculture and rural development. The 2003 Maputo declaration called for African governments to target 10% of their national budget to the agricultural and rural development sector. This is clearly justified, given the overwhelming environmental, economic and social importance of agriculture in SSA, the anticipated impacts of climate change on agriculture (especially in semi-arid and sub-humid areas) and the role agriculture has to play in climate change adaptation and mitigation.

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