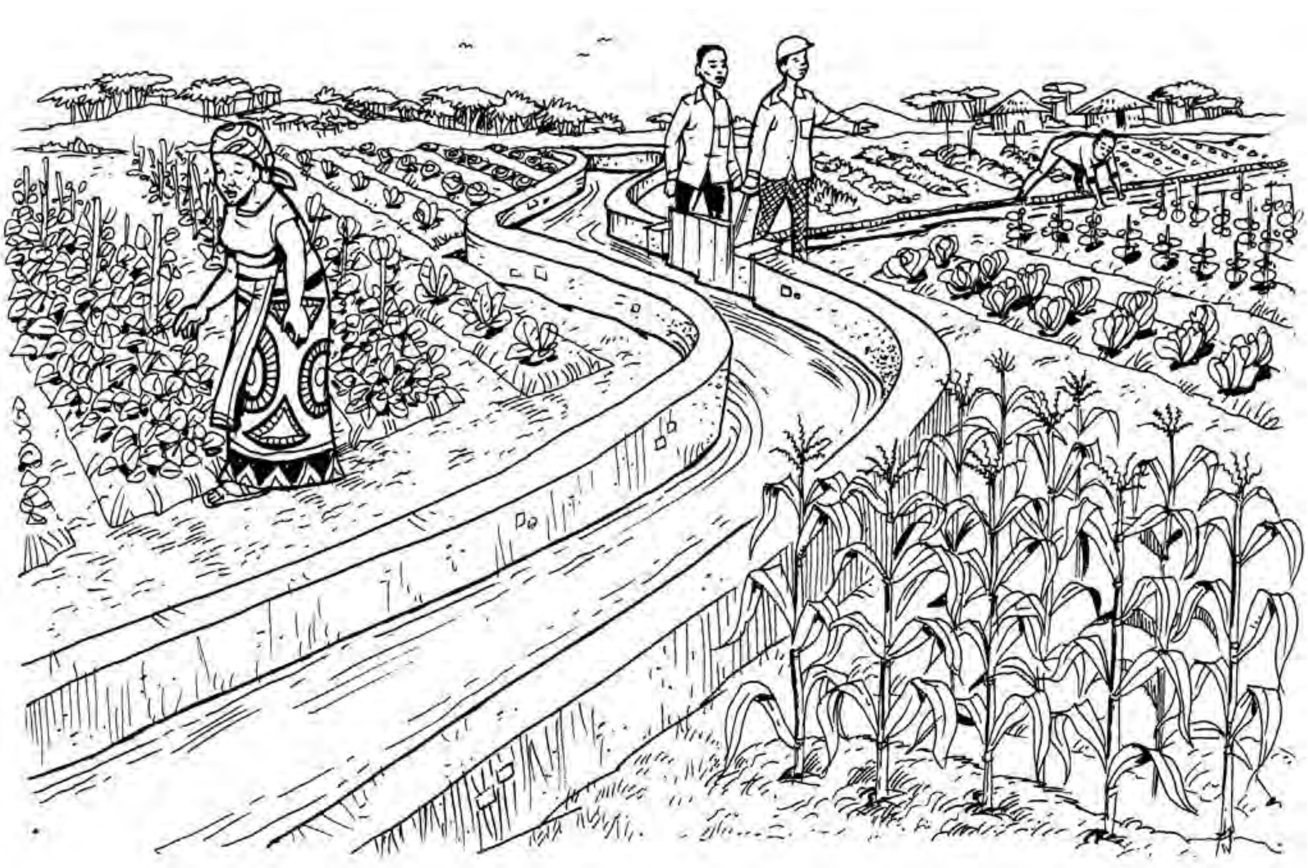
Water Resource Management Options for Smallholder Farming Systems in sub-Saharan Africa



Agriculture and climate change are inextricably linked. Nelson (2009) stated that "Agriculture is part of the climate change problem, contributing about 13.5% of annual greenhouse gas emissions (with forestry contributing an additional 19%), compared with 13.1% from transportation. Agriculture is, however, also part of the solution, offering promising opportunities for mitigating emissions through carbon sequestration, soil and land use management, and biomass production. Climate change threatens agricultural production through higher and more variable temperatures, changes in precipitation patterns and increased occurrences of extreme events like droughts and floods."

The challenges of water resources development in sub-Saharan Africa (SSA) will be aggravated by the ensuing climate change, with serious implications on socioeconomic development. IPCC (2001) noted that "these challenges include population pressure, problems associated with land use such as erosion/ siltation and possible ecological consequences of land use change on the hydrological cycle. Climate change—especially changes in climate variability through droughts and flooding—will make addressing these problems more complex. The greatest impact will continue to be felt by the poor, who have the most limited access to water resources." In the savanna regions, the incidence of seasonal flow cessation may be on the increase, as shown by some streams in Zimbabwe (Magadza, 2000). Southern Africa has experienced more recurrent drought and flood episodes in recent times. Drought periods now translate into periods of critical water shortages for industrial and urban domestic supplies (Magadza, 1996). The frequent droughts and floods in most parts of SSA—leading to severe food shortages, food insecurity, water scarcity, hunger/famine, and acute shortage of hydropower—signify the region's vulnerability to climate change. Reduced hydropower also affects energy supply for pumping water.

There is a general consensus that the African continent is particularly susceptible to the onset of climate change (Boko *et al.,* 2007). A variety of factors exacerbates susceptibility to the effects of climate variability but, in focusing on strictly physical elements, the range of ecosystems present on the continent poses particular challenges in developing mitigation and adaptation mechanisms. FAO (2008b) identified 16 distinct ecosystems (agroecological zones [AEZs]) in which various farming systems exist and which would be affected differently by climate change. However, according to Greenfacts2, over the past 40 years, some general climatic trends have emerged on a more regional scale.

The IPCC Fourth Assessment Report noted that, since the 1960s, the African continent has experienced a general warming trend with certain regions experiencing more warming than others (Boko *et al.,* 2007). Since 1900, warming has occurred in Africa at approximately 0.5 ^{o}C per century (Hulme *et al.,* 2001). Precipitation is also highly variable across the continent, although much of the continent has experienced decreases in annual precipitation. An increase in interannual variability has been noted with the indication that extreme precipitation events (floods, droughts) are on the rise (Boko *et al.,* 2007). Notwithstanding the inconsistency of predictions about climate change, the effects of the phenomenon are being experienced throughout SSA, especially in areas typified by variable rainfall shifting growing seasons (IPCC, 2001). Most African farmers, particularly those working in rainfed agriculture, have been affected in one way or another.

It is important to delineate expected regional differences in determining and assessing mitigation strategies for future water stresses resulting from the onset of climate change in Africa. Some African countries are much more economically dependent on agriculture, leaving them more vulnerable than others (Kurukulasuriya *et al.,* 2006). The precarious state of water resources in Africa is such that water stress (use exceeds renewable supply) is relatively high for the majority of the continent's population. Yet, nearly two-thirds of Africans rely on limited water sources prone to high yearly variability (Vorosmarty *et al.,* 2000). In total, about a quarter of the continent's entire population lives in water-stressed regions (UNEP, 1999).

Because the amount of available freshwater is relatively finite, increases in population result in corresponding decreases in per capita water supply, while rising temperatures exacerbate an already alarming situation in Africa (Human Impact Report, 2009). In terms of freshwater, annual runoff and water availability are projected to increase by 10–40% at high latitudes but to decrease by 10–30% over some dry regions at mid-latitudes and in the dry tropics (Falkenmark 2007). This means that drought-affected areas will likely increase in extent. Agricultural production is projected to be severely compromised in many regions by these trends (UNFCCC, 2008).

Agriculture accounts for more than 70% of global water use (FAO, 2008a; World Bank, 2006). According to projections, there will be increasing challenges in terms of increased water stress and areas suitable for agriculture along the margins of semiarid and arid areas are expected to decrease significantly (Falkenmark, 2007).

Seasonal variability in water availability is also critical for agricultural production. For instance, a comparatively small decrease in rainfall during one season may have more severe consequences than a much larger precipitation decrease in another season. Although many past studies have revealed different climate change scenarios in Africa (Christensen *et al.,* 2007), here are some of the expected climate changes that would affect water resources for agriculture:

- Warming is very likely to be larger than the global annual mean warming in all seasons, with drier subtropical regions warming more than the moister tropics.
- Annual rainfall is likely to decrease in much of Mediterranean Africa and the northern Sahara, with a greater likelihood of decreasing rainfall toward the Mediterranean coast.
- Rainfall in southern Africa is likely to decrease in much of the winter rainfall region and western

margins, leading to longer dry seasons and more uncertain rainfall.

- An increase in annual mean rainfall in East Africa is likely.
- A warmer and drier environment is expected in the Sahelian region (Falkenmark, 2007).

IPCC 2007 stated that "Africa is one of the most vulnerable continents because of multiple stresses and low adaptive capacity. The multiple stresses may arise from current climatic hazards, poverty and unequal access to resources, food insecurity, globalization trends, social and political conflicts, and incidences of diseases such as malaria, tuberculosis, and HIV/AIDS." Nevertheless, the overall climate will largely be defined by the change in precipitation corresponding to what appears to be a marked increase in temperature. This will lead to extreme rainfall events with dire consequences to agricultural production, especially for the vulnerable smallholder farmers. The impact of climate change on agricultural water management (AWM) will be aggravated by demographic change. In eastern and southern Africa, climate change vulnerability is heightened by the large number of people who depend on the already marginalized natural resource base for their livelihoods (Ziervogel *et al.,* 2008). Moreover, within the next 15–20 years, the area considered to have relative water security in Africa will fall from 53 to 35% (Ashton, 2002). Therefore, due to the current population growth, many SSA countries are expected to experience a severe increase in water stress, with or without climate change. Population changes could, in fact, nullify any increases in precipitation/available water. The situation will be aggravated by overdependence on natural resources (Raleigh and Urdal, 2007). Overdependence on surface water, especially for irrigation, will aggravate the impacts of climate change and variability on agricultural development.

The predicted impacts of climate change must be introduced into development planning, including land use planning, natural resource management, infrastructure design, and measures to reduce vulnerability in disaster reduction strategies. According to Falkenmark (2007), the array of adaptation options is very large, ranging from purely technological measures to managerial adaptation and policy reform. For developing countries, availability of resources and adaptive capacity building are particularly important. Based on anticipated climate change and impacts on water resources in Africa, IPCC (2001) identified four necessary adaptive strategies.

a. Adaptive measures. Measures should be adopted that would enhance flexibility, resulting in net benefits in water resources (irrigation and water reuse, aquifer and groundwater management, desalinization), agriculture (crop changes, technology, irrigation, husbandry), and forestry (regeneration of local species, energy-efficient cook stoves, sustainable community management).

b. Risk sharing. A risk-sharing approach between countries will strengthen adaptation strategies, including disaster management, risk communication, emergency evacuation, and cooperative water resource management.

c. Enhancement of adaptive capacity. Local empowerment is essential in decisionmaking in order to incorporate climate adaptation within broader sustainable development strategies. Most countries in Africa are particularly vulnerable to climate change because of limited adaptive capacity as a result of widespread poverty, recurrent droughts, inequitable land distribution and dependence on rainfed agriculture.

d. Diversification. To minimize sensitivity to climate change, African economies should be more diversified, and agricultural technology should optimize water usage through efficient irrigation and crop development.

Why focus on smallholder farmers?

Smallholder farmers are particularly vulnerable to changes in the climate that reduce productivity and negatively affect their weather-dependent livelihood systems. For instance, in Malawi, frequent droughts and floods have eroded assets and knowledge, leaving people more vulnerable to disasters (Gandure and Alam, 2006) such as water and food insecurity, diseases, and land degradation. Evidence strongly suggests that increased droughts and floods may be exacerbating poverty levels, leaving many rural farmers trapped in a cycle of poverty and vulnerability to diminishing resources (Phiri *et al.,* 2005). Water scarcity is already a major problem in arid and semiarid areas of SSA (Rijsberman, 2006)

—areas mainly inhabited by smallholder farmers in both agropastoral and pastoral communities.

Climate change and increasing population contribute to water scarcity and limit its availability for irrigation (Turner, 2006) and other productive uses. Although the potential to invest in irrigation in much of Africa is high, poor performance of large-scale irrigation schemes in Africa and competition for diminishing water resources suggest that smallholder irrigation is preferable. Smallholder farmers must develop water conservation and water-harvesting systems in order to maximize rainfall use efficiency on their own farms. Beside lower investment costs and higher rates of returns, smallholder irrigation development is easier to manage and operate than large-scale, centrally managed irrigation schemes. However, in spite of the low development cost and high rate of returns, there have been inadequate investments, mainly due to misplaced government priorities, declining external support, poor marketing infrastructure, and nonconducive policy and institutional frameworks. However, as the potential of irrigated agriculture continues to gain recognition as an adaptation strategy to climate change, the pattern appears to be changing.

Virtually all large-scale irrigation schemes in SSA have been undertaken by government agencies. While some farmer groups have grown more active in operating these projects, government agencies have largely been responsible for maintenance and operation, often with little cost recovery (Peacock *et al.,* 2007) and poor performance. The experience of Mali irrigation parastatals like the Segou Office for Rice Development and similar government-controlled schemes in SSA attest to this. In such government-controlled schemes, farmers rarely pursue an active role in improving these irrigation systems. Some reasons include insignificant incentive for individual users, lack of cohesion among users, isolation and poor means of communication, and reforms that often reduce subsidies and increase individual expenses (Aw and Diemer, 2005). However, reforms in government-controlled schemes, which give farmers more responsibility in water management, operation, and maintenance, have shown positive results. A good model is the case of the Mwea Irrigation Scheme in Kenya (Blank *et al.,* 2002). In Mali, reform of the Office du Niger irrigation scheme over a period of 20 years led to a quadruple increase in rice yields, a sixfold increase in total rice production (Aw and Diemer, 2005).

In addition to low costs and high economic impact, many factors support additional investments in smallholder irrigation development over large-scale irrigation projects.

Smallholder irrigation systems have strong local community governance, are relatively free of political intervention, have relatively low operation and maintenance cost (FAO, 2008a), and sometimes constitute a means of poverty alleviation. Water management is also improved by the relatively low number of users and the diverse options for water sources (small streams, shallow wells, boreholes, rainwater storage, etc.), many irrigation technological options (surface irrigation methods like the furrow and small basin methods, and pressurized systems (sprinkler and drip, both high-head and low-head systems), and water-lifting technologies (gravity, manual and motorized pumps, wind and solar pumps).

The potential is high for rehabilitation and improvement of existing smallholder irrigation systems, some of which have been initiated by farmers on their own but have fallen into disarray. According to FAO (2005), about 2 million ha of land equipped for irrigation are unused. This potential farmland could be developed, along with approximately 13 million ha of additional land with irrigation potential, of which about 9 million ha are in West Africa (FAO, 2008a). Given smallholder farmers' vulnerability to climate change, the low development costs and high economic performance of smallholder irrigation schemes underscore the need for investments in these AWM farming systems.

Recommendations

The study identified and recommended feasible AWM interventions that can be promoted by development agencies to enhance smallholder farmers' strategies for coping with climate change and variability in SSA. The following are some of the promising AWM interventions that should be considered:

1. Smallholder irrigation development includes rehabilitation of existing schemes to improve water use efficiency and productivity. This covers both gravity-fed (most preferable, where applicable, due to low organization and maintenance cost) and pumped schemes (from either groundwater or surface water sources (rivers, dams, etc.).

2. Upgrading rainfed agriculture through in situ rainwater harvesting systems—farming practices that retain water in crop land (terraces, contour bunds, ridges, tied ridges, planting pits, conservation agriculture, etc.).

3. Supplementary irrigation systems—farming practices that supply water to crops during critical growth stages. They are appropriate where irrigation water is inadequate for full irrigation or where crops are grown under rainfed conditions and only irrigated during intraseasonal dry spells or in case of early rainfall cessation.

4. On- or off-farm water storage systems—rainwater harvesting and management systems that allow the farmers to store runoff in ponds (unlined or lined). For communal land or farmers with appropriate sites, large storage structures such as earth dams or water pans can be considered. Water can be supplied to crop land either by gravity or pumping and applied to crops either by surface irrigation (furrow or basin) or pressurized (especially low-head irrigation systems). Other rainwater-harvesting structures such as sand dams, sub-surface dams and rock catchment systems fall under this category.

5. Spate irrigation—flood diversion and spreading into crop land is appropriate in areas where flash floods occur, especially in lowlands adjacent to degraded or rocky catchments.

6. Micro-irrigation systems—these include various technologies, among which low-head drip irrigation kits are most appropriate. Low-head drip kits can use many different water sources. They are mainly used for irrigating high-value crops such as garden vegetables and orchard fruits, and for green maize production at times.

7. Land drainage, wetland management, and flood recession are appropriate for areas with excess soil moisture and should therefore be considered where necessary.

Adaptive strategies are needed to promote these AWM interventions and must include overcoming barriers that hinder adoption by smallholder farmers. They must also provide the focus for replication and upscaling of best practices in SSA. The identified strategies can be implemented in most SSA countries, since most of them target smallholder farmers who are already experiencing similar problems and constraints to socioeconomic development. To ensure adoption, replication, upscaling, and sustainability, the study identified the following prerequisite measures that should be considered to enhance adoption and sustainability of proposed AWM interventions.

1. Capacity building and awareness creation at different levels (from farmers to policymakers)

    - Training of middle-level professionals working with different organizations and government—launching a regional training program with local universities.

    - Building capacity of smallholder farmers and extension staff, including NGOs and civil society organizations (CSOs), to adopt and promote integrated AWM interventions.

    - Policymakers—campaign to raise political and public awareness on climate change to influence development and implementation of appropriate and adaptive policies and strategies focusing on both legislative bodies and district development institutions.

    - The need to enhance capabilities and scientific strengths of African countries to address integrated AWM and climate change adaptation, while addressing immediate societal needs. This includes MSc and PhD training on AWM and adaptation to climate change to enhance capacity at local training and research institutions and government departments.

    - Enhancing the sharing of expertise and networking among African professionals—establishing exchange programs within SSA (South-South technology exchange).

    - Institutional support to regional centers of research and policy advocacy in AWM and adaptation to climate change: one each in eastern, southern, and west and central Africa to be based at the relevant CGIAR centers or other strong regional organizations (e.g., the regional MDG centers based at Nairobi and Bamako).

    - Support for the development and implementation of comprehensive national plans and strategies for adaptation of smallholder agriculture to climate change —these plans should be government-led, multistakeholder efforts, the results of which serve to inform national development policies and plans.

2. Research, technology development, and information dissemination

    - Assessing the potential for sustainable water resource development (both surface and groundwater extraction) at local and national levels.

    - Farmer-based demonstrations/piloting on plot and adaptive research on promising best practices for climate change adaptation in a range of agroecological zones and farming systems. The focus should be a district or hydrological unit where a wide range of feasible adaptation interventions, policies, and institutional arrangements are piloted. These districts or units serve as models for best practices. Special emphasis is placed on assisting women farmers in adapting to climate change.

    - Analyzing the yield gap, including cost-benefit of alternative irrigation interventions, to ascertain the appropriate systems for bridging yield gaps.

    - Establishing climate change adaptation tools for monitoring early warning systems and adaptive coping strategies. To effectively monitor adaptation strategies and impacts, a stakeholders' coordination forum will be necessary to build synergies and partnerships.

    - Support for applied research and policy dialogue to determine the agronomic and socioeconomic potential for adopting AWM interventions, especially in countries that depend on rainfed agriculture for food security and rural livelihoods.

    - Support for applied research and policy dialogue to better understand how best to address the effects of climate change on major transboundary river basins (e.g., the Nile, Zambezi, Limpopo and Niger rivers, which are already experiencing water stress due to climate change.

3. Appropriate policy and institutional reforms

    - Support for a professional, public and political awareness campaign that raises the profile of AWM and adaptation to climate change.

    - Support development of comprehensive national investment plans for promoting the adoption of rainwater harvesting and low-cost smallholder irrigation schemes.

    - Reforms that support investments in AWM and partnership among actors/stakeholders.

    - Reforms that improve water governance and water users' involvement in the decisionmaking process (i.e., empowerment of farmers).

    - Mainstreaming gender issues targeting women and vulnerable groups.

    - Strengthening climate communication and information networks to enhance delivery of timely weather information to intended users.

4. Farmers' support services to promote adoption and adaptation of integrated AWM systems

    - Establishment of rural service centers to provide technical advice and information on viable AWM options and other services to farmers.

    - Microcredit/revolving grants to farmers, especially to women who form the backbone of smallholder farming systems in SSA.

    - Crop insurance, where applicable, to reduce farmers' risks of crop failure.

    - Contract farming (farmer-private sector partnership).

    - Value addition (processing and storage) and marketing infrastructure.

    - Crop diversification—introduction of high-value crops for irrigated lands.

Increased investments in all of these areas are urgently needed. The aggregate requirements across the continent are much greater than the financial and managerial capacity of a single development partner. The question is how to create maximum impact and leverage through collaboration and building synergies among different development partners and investors in SSA. To enhance sustainability, a participatory, integrated, and multisectoral approach is recommended, in which different stakeholders will collaborate and work together to implement different aspects of the proposed interventions—improved AWM. Development partners and investors should target strong collaborative linkages among communities/farmers (CBOs), self-help groups, NGOs/CSOs, the private sector, agricultural research institutions, and relevant government departments (e.g., ministries of water, agriculture, irrigation).

Programs and projects should target an integrated and multisectoral approach—the entire production and market chain (i.e., market-oriented production process). Programs/projects that integrate the needs of smallholder farmers (bottom-up approach), participatory action research, demonstrations, development, training on feasible AWM interventions, information dissemination, and networking should be prioritized.

The MVP model is a good learning lesson that can be adopted by development partners and investors. The 14 MVP clusters in 10 countries in SSA have already developed AWM strategies, which should be the basis for funding consideration. The AWM strategies can be converted into smallholder farming business development plans to widen the scope of funding opportunities, and especially to attract social investments in SSA.

Finally, it is clear that opportunities for smallholder farmers to adapt to water shortage induced by climate change are attainable (especially integrated AWM interventions). Addressing climate change adaptation for smallholder farmers is a prerequisite to a sustained green revolution in Africa. However, for this to be achieved, increased investment, adaptive research, and capacity building are needed. This visionary investment requires a pooling of resources and building synergies among various stakeholders.

Source

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