Green Water Re-capitalization for Optimizing Agricultural Productivity in Eastern & Southern Africa

Bancy M. Mati & Nuhu H. Hatibu
Soil & Water Management Network of ASARECA (SWMnet)
b.mati@cgiar.org

Abstract

Failure to "manage" water has been identified as the major problem associated with poor agricultural productivity in Eastern and Southern Africa (ESA) region. Out of a total of 38 million ha of cultivated farmlands in the region, 18 million have been identified as suitable for managed water systems (usually irrigation and drainage) but only 3 million have been developed. The problems of insufficient management of water for agriculture are affecting mostly smallholder land users (farmers, pastoralists), who form about 85% of the total rural poor in the region. The most vulnerable zones being: the arid, semi-arid and dry sub-humid areas, which occupy about 69% of the land area in the region. Here, climate-induced risks to crop and livestock production persist, resulting in very poor yields, usually less than 1 t ha-1 of grain staples, and increasingly crop/pasture failures and thus food insecurity, famines and poverty. Agricultural drought is usually the real problem rather than meteorological drought, caused by the failure to make use of available rainfall optimally. Even in the well-endowed wetter areas of the ESA, high poverty (54%) among smallholder farmers persists, while land degradation is also a common problem.

The place of agricultural water management to alleviate food insecurity and poverty among smallholder producers in Africa has been well articulated in various documents and forms core tenets of the Millennium Development Goals and NEPAD's CAADP. That water, and in particular rainfall, is the premier resource associated with vulnerability among smallholder farmers is well known, including the fact that the main limitation is that the water is not distributed spatially and temporary in such a way as to make it naturally available to farmers whenever they need it. What is needed, therefore, is identification of more innovative and deliberate actions, to optimize on the utilization of all forms of water, especially rainfall, which is water at its purest form. In the past, sectorized approaches that encouraged channeling of resources, research and extension messages in such a way that the different components of water management compete rather than complement each other have not served farmers well. In addition, much of the targeted effort and investment on water for agriculture has previously gone to developing the use of "blue flows" such as rivers and lakes at great cost, while ignoring the vast potential of the "green" flows, which includes rainwater re-capitalization. It has been argued that over 90% of irrigation water in the ESA region is used to compensate for losses and/or inefficiencies in the management and utilization of rainfall. This paper therefore advocates for the green water paradigm, i.e. the deliberate actions towards institutionalizing the management and utilization of water held as green flows (harnessing rainfall, its storage and utilization, reduction of evaporative losses, optimization of soil moisture and water stored in green biomass). It calls for increased investment in holistic management of water for agriculture, with a view to enhancing agricultural productivity and environmental services especially in fragile ecosystems.

Introduction

The Eastern and Southern Africa (ESA) region has certain common features in terms of natural biophysical and socio-economic conditions that make it possible to treat the region as a block. The 21 countries (the data quoted here excludes the Democratic Republic of Congo, Sudan, Djibouti and Somalia) of the ESA have a total population of about 350 million, of which about 260 million (73%) live in rural areas. The ESA has one of the highest poverty rates in the world, averaging 56% in the rural areas. About

85% of the rural poor people derive their livelihoods from small scale agriculture (IFAD, 2002). In general, low agricultural productivity and rural poverty are most evident in arid, semi-arid and sub-humid areas, which occupy 69% of the land area in the ESA (FAO, 1999). In the past, poor harvests, food insecurity and famines were confined to the Horn of Africa countries, especially Ethiopia, Kenya and Somalia, but more recently, several countries from southern Africa have joined the list of those depending on relief food. For instance, the FAO estimated in February 2006 that 11 million people in East Africa were on the brink of starvation due to drought affecting Ethiopia, Kenya and Somalia, and some parts of Eritrea, Djibouti, Tanzania, Burundi, southern Sudan, Uganda and Rwanda due to failure of the short rains in 2005. Thus cattle, sheep, goats, wildlife and even camels died, some people had died and for instance, 70% of cattle in Wajir District of Kenya died. In some districts, not only food aid but also relief water was necessary to alleviate suffering. In most parts of the Eastern and Southern Africa (ESA) region, the most pressing constraint to smallholder agriculture may not be access to land, as much as access to water for crops and livestock (IFAD 2002). Thus the optimal management of water for agriculture forms an entry point towards alleviating suffering and improving livelihoods for smallholder producers in the region.

Agricultural water management (AWM) is not necessary new in the ESA. Rather, there is the question of how much targeted actions are applied as opposed to allowing natural phenomena to run their own course. The main problem is that the region has seen declining crop yields and recurrent crop failures associated with 'drought', yet the real problem lies not with the amount of rainfall received, but with inappropriate management of the water. Moreover, subsistence-based agronomic practices have resulted in the "mining" of the natural resource base in the process of crop production and livestock husbandry due to the need to produce more from the static and declining land areas. Since land is inelastic, innovative ways that allow higher productivity will have to be adopted to meet the growing food gap. For instance, at global scales (World Bank 2005), it has been recommended that over 40% of the extra food required to meet the growing food demands by 2025 will have to come from intensified rainfed farming, for which improved water management is essential. Within the sub-Saharan Africa region, 75% of the agricultural growth required by 2030 will have to come from intensification (62% from yield increases, 13% from higher crop intensities) rather than extensification of agriculture (FAO, 2000). It has been argued that smallholder agriculture may be the major cause of, and potential solution for poverty reduction and economic growth in Africa (DFID, 2002). In this respect, management of water under smallholder agriculture is the target of the Millennium Development Goals on hunger (Sanchez et al, 2005), and is seen as one way of increasing food security and reducing poverty among poor people in SSA.

Figure 1. Eastern and Southern Africa Region showing additional countries in IMAWESA

It has been estimated that this will require developments in water for agriculture by at least 10% of the potential, targeting improvements by 25% in water productivity of irrigated agriculture alone by the year 2015 (Donkor, 2003). Both rainfed and fully irrigated systems are expected to contribute to these improvements.

Biophysical factors and agricultural productivity in the ESA

The ESA region (Figure 1) broadly covers 25 countries in eastern, central and southern Africa to include Angola, Botswana, Burundi, Comoros, Democratic Republic of Congo, Djibouti, Eritrea, Ethiopia, Kenya, Lesotho, Madagascar, Malawi, Mauritius, Mozambique, Namibia, Rwanda, Seychelles, South Africa, Somalia, Sudan Swaziland, Tanzania, Uganda, Zambia and Zimbabwe. In this paper, the data provided (IFAD 2002) excludes the Democratic Republic of Congo, Djibouti, Sudan, and Somalia. The ESA is a diverse region and compared to other tropical and sub-tropical regions of the world, the natural resource base for agriculture is relatively marginal. Mean annual rainfall ranges from less than 100 mm in desert zones to over 1500 in humid mountainous areas (FAO, 1993). In addition, the soils are generally highly weathered, easily erodible and having little organic matter contents. With about 36% of the land area in the ESA being desert, arid or semi-arid, poor resource base and climatic variability have been blamed for the declining agricultural productivity and rural poverty. Furthermore, the dry sub-humid climate zones include vast savannahs at varying altitudes, where rainfed cereal production dominates. At altitudes 1000 m or more, the savannahs provide relatively cool temperatures (for the tropics) allowing maize-based mixed farming systems. These take large tracts of Angola, Kenya, Lesotho, Malawi, Mozambique, Swaziland, Tanzania,Zambia and Zimbabwe. About 32% of the region's poor people live in these maize-based systems. It is here that declining soil fertility and poor investments in inputs and machinery, and lack of targeted agricultural water management have seen agricultural production plunge down to subsistence levels. The high-rainfall and potentially highly productive areas include more than half of Uganda and Rwanda, and quite large areas in Ethiopia, Kenya and Madagascar, covering about 31% of the total land area. However, even with the high production potential, poverty prevalence in these zones is quite high, and about 54% of the region's poor live here.

Climatic variability resulting in prolonged dry spells and sometimes droughts is associated wit poor agricultural productivity on the ESA. Even then, climate and natural resource base are not entirely to blame for the poor status of agricultural production by smallholder farmers. It has been shown that agricultural productivity within the same geographical region, same crop, same climate, remains much lower under smallholder agriculture as compared to on-station research and large-scale farms (Falkenmark and Rockström 2003; SIWI, 2002).

Table 1 Agro-climatic zones and rural population in Eastern and Southern Africa (FAO databases)*

Climate Zone	Area km^2 (million)	Population (million)	Share of area	Share of population
Arid & semi-arid	3.7	36	38%	14%
Dry sub-humid	3.0	76	31%	30%
Moist sub-humid & humid	2.9	148	31%	56%
Total	9.6	260	100%	100%

* Urban population and areas are excluded

For instance, in Zambia, the gross national average of maize yield on smallholder farms is about 1.3 t ha-1, but farmers with slightly larger holdings and good managerial skills obtain 4.5 t ha-1. In comparison, trials with highbrid varieties, fertilizers and timely planting and under the same rainfed systems yield 9 - 13 t ha-1 (IFAD, 2002). Similarly, in western Kenya, maize yields under research yield over 6 t ha-1 compared to less than 1 t ha-1 recorded under smallholder farms and 0.5 t ha-1 for beans (Mati and Mutunga, 2005). It has been stated that low crop productivity is affected more by management aspects (of water, soils, agronomy) than by natural resource base (Place et al, 2005). Moreover, this difference shows widest gaps in areas prone to climatic variability, especially semi-arid and sub-humid areas where agricultural production cannot solely depend on the natural endowments of the land. Tackling the natural limitations to production will require access to information about technologies and approaches through which smallholders themselves can establish profitable operations, optimizing the impact of their investments, particularly labor, which is the more available resource.

Green Water re-capitalization and AWM

Green water is the portion of rainfall that finds its way back to the atmosphere, through both direct evaporation and evapotranspiration. In terms of benefit to agriculture and therefore livelihoods, green water is a water resource, usually stored as soil moisture generated from direct rainfall infiltration, before it vaporizes as evapotranspiration from plants. Green water can therefore be partitioned as (i) Green water flows, which is the total evapo-transpiration from soil moisture, (ii) Productive green flow, which is the transpiration of plants of beneficial use to people, and (iii) non-productive green flow which is direct evaporation flows from water bodies and soil surface. The balance of the rainfall therefore forms blue water which can be partitioned as (i) blue water flow, which is the surface runoff and base flow, and (ii) blue water resource, which is water stored as groundwater, lakes, reservoirs, wetlands and other bodies (Fallenmark, 1995). The importance of green water flows to agricultural productivity is linked to the fact that plant biomass is created when water is taken up from the soil, and utilized in evapotranspiration.

The green water paradigm requires an understanding that water is rarely truly scarce, but the main problem is that losses and extreme variability. Therefore, maximizing rainfall storages and infiltration as well as water uptake capacity of plants is the key to unlocking existing potentials. The reduction of non-beneficial green flows are important components of green water re-capitalization. In addition, there is need for attention to scale interactions of water functions, such as water and livelihoods, land use and degradation, carbon sequestration and water services provided through land management.

In its ultimate form, green water re-capitalization is achieved through holistic agricultural water management (AWM). Agricultural water management has been defined (FAO, 1995) as "any kind of human action that influences the natural flow of water to farmers' crops, or any form of agriculture that takes advantage of naturally rising or falling water levels for crop production". Thus, AWM is a broad term encompassing irrigation, drainage, water harvesting, water conservation, utilization of high water tables, as well as control of unnecessary evaporation, reduction of seepage losses, improving efficiency in water application, conveyance and utilization, and all aspects where water benefits the crop, livestock and ecosystems. "Management of agricultural water" is a better term describing the deliberate human actions, which ensure optimization of all types of water resource use for agricultural production. AWM ultimately leads back to green water re-capitalization. At the regional scale, AWM is visualized to be achievable through the following actions: (i) Working towards food security and virtual water trade, (ii) water resource development to meet competing demands (noting that rainfall is water), (iii) strategic and integrated public investments in holistic approaches to agricultural water, (iv) response to climate variability, including short-term shocks such as prolonged dry spells, (v), linking farmers to markets, enabling AWM contribute to poverty reduction, (vi) making every crop, high value,

(vii) opportunities pull rather than push by potential, and (viii) managing water wisely (integrated approaches for crop, livestock and ecosystems). Thus, since agriculture is about producing plant biomass, then AWM should enable production of more useful biomass per mm of water depleted which with appropriate market linkages should lead to higher net per drop. As most of the irrigation water in the ESA is used to compensate for losses in conveyance, application, and/or inefficiencies in the management and utilization of rainfall, managing rainwater is the missing link to optimizing productivity of green water.

Importance of green water re-capitalization in the ESA

Even with the physical presence of semi-arid zones, the untapped potential for green water re-capitalization and ultimately holistic agricultural water management in the ESA is enormous. There are about 38 million ha in the low income countries of the region classified as cultivated lands (Table 2). The total potential for targeted AWM in these countries is about 18 million ha, of which only 3 million ha are already under some form of water management (IFAD, 2002). Of these, about 2 million ha are under irrigation with full or partial control, while the remaining 1 million ha are under traditional wetland and valley bottom management systems. Madagascar, with about 1 million ha under full or partially controlled irrigation, accounts for about 50% of the total land area under controlled irrigation in the region. The share of irrigation in the other countries is less than 5%. For instance, aggregate annual runoff in Ethiopia is estimated at 122 billion cu m and ground water potential as 2.6 billion cu m (IFAD, 2002). However, only 5% of the irrigation potential is utilized, accounting for 3% of total food crop production, while a similarly small fraction of the runoff potential is utilized. It should be noted that in characterizing land as suitable or not for AWM, the estimates are based on the availability of land and water, usually available “blue” flows. It and does not take account of possible sources and the huge potential for green flows, such as road runoff harvesting, flood harvesting from surfaces, and rarely includes ground water potential.

Thus, substantial potential for targeted water management remains largely unknown and thus un-developed in the ESA region.

Another important aspect is the role of rainfed agriculture, which is the dominant from of crop production in the ESA region and is set to remain so in the foreseeable future. With the exception of Madagascar, Mauritius and Swaziland, rainfed agriculture accounts for over 95% of all croplands in each of the countries of the ESA (World Bank, 1999). However, while the potential for improving production and income from rainfed systems is considerable, there are risks associated with rainfed agriculture that must be mitigated with targeted interventions. The most vulnerable people to climate-related disasters are poor smallholder farmers, especially those in marginal rainfall areas. This is partly due to their inability to access cutting edge knowledge, afford inputs or utilize appropriate machinery and technologies that can mitigate natural disadvantages. In particular, there is need for alternative approaches to the development and maintenance of small-holder water management systems and major increases in investment in exploitation of the irrigation potential.

Agricultural productivity in the ESA could be improved further, through the integrated management of the water under rainfed systems, which includes some level of irrigated agriculture. In the past, sectorized approaches to both rainfed and/or irrigated agriculture have promoted initiatives like soil and water conservation (SWC) or rainwater harvesting (RWH) with some level of success. Examples of these are scattered throughout the region and have formed the foundation of many development projects with agriculture and land

Table 2: Cultivated area and water management potential (‘000 ha) (FAO 1995)

Country	Cultivated area	Total potential for water mgt.	Area of controlled irrigation	Area under other water mgt.	Total water managed area	Remaining potential
Angola	2 900	6 700	75	350	425	6 275
Burundi	800	185	14	60	74	111
Comoros	78	0	0	Na	0	0
Eritrea	439	Na	28	Na	28	Na
Ethiopia	6 000	3 637	190	Na	190	3 447
Kenya	3 738	352	67	6	73	279
Lesotho	209	13	3	Na	3	10
Madagascar	2 580	1 500	1 087	Na	1 087	413
Malawi	2 106	162	28	62	90	72
Mozambique	3 600	3 300	107	Na	107	3 193
Rwanda	825	160	4	156	160	0
Tanzania	6 300	828	150	Na	150	678
Uganda	5 028	202	10	Na	10	192
Zambia	1 030	520	46	100	146	374
Zimbabwe	2 750	331	117	20	137	194
Total	38,382	17,890	1,926	754	2,680	15,210

Na = Not available

management on theiragendas (Reij et al., 1996; Lundgren, 1993; Hurni and Tato, 1992; WOCAT, 1997). In particular RWH systems have been applied over wide range of conditions in areas where average annual rainfall is insufficient to meet the crop water requirement, with seasonal rainfall as low as 100 to 350 mm (Oweis et al., 2001; SIWI, 2000). Indigenous and innovative technologies in SWC, RWH and soil nutrient management abound in the ESA (Mulengera, 1998; Reij and Waters-Bayer, 2001, Mati, 2005, Negassi et al., 2000; Hamilton, 1997; Hatibu and Mahoo, 2000). Most of these technologies are also easily replicable. In addition, successful cases of smallholder water management have been documented in which farmers have overcome different kinds of obstacles, not only to achieve food self sufficiency, but also increase their incomes and move out of poverty (Mati and Penning de Vries, 2005; Penning de Vries et al, 2005). However, there has been little common meeting ground between what is perceived as “rainfed” with “irrigated” agriculture. The focus should be how to reduce poor people’s vulnerability to climatic variability, especially water risks associated with both floods and droughts, including both agricultural and meteorological droughts (Sally et al, 2003). The challenge is how to deal with declining crop yields and recurrent crop failures associated with ‘drought’, yet the real problem lies not with the amount of rain that is received, but inappropriate management of the water. Neither water nor know-how hinders success. The real gaps are in policy, awareness, and capacity and institution building. Policy and legal frameworks for fair and reliable allocation of water, surface and groundwater to a range of users and to the environment.

Impact of Policies

Several questions have been asked regarding the role of policy and legal framework in the ESA region (IFAD, 2000). Such questions as government policies with regard to water rights, cost recovery on water supplied for agriculture to the poor, the roles of private and public sectors, risk management, environmental legislation, incentives for conservation etc. To date, these questions still demand answers. Even then, all the countries in the ESA have policies that touch on water, environment, agriculture, natural resources, rural development and macro-economic policies (OED 2003, FAO 2003). Most of the policies focus more on drinking water with little mention of agricultural water management succinctly. Rather, the policies are split between irrigation, drainage, flood control, water harvesting, soil and water conservation disjointedly. Since most of the countries in the ESA are in the process of formulating and implementing various components of their PRSPs, contemporary policies on AWM in most countries of the ESA are either in draft stages or not well tested to allow for balanced critique of their efficacy. An analyses of both existing and proposed policies across the countries of the ESA can be summarized as follows (OED 2003, FAO 2003; FDRE, 2002; IMAWESA, 2006; Government of Malawi, 2002; URT, 2001; Government of Kenya, 1999); most of the policies tackle (i) the development of water resources on equitable and sustainable basis, (ii) allocation and apportionment of water resources based on comprehensive and integrated plans, (iii) management and mitigation of drought s and floods, (iv) efficient allocation, redistribution, transfer, storage and use of water resources (v) adherence to optimum allocation principles that incorporate efficiency of use, equity of access, and sustainability of resource, and (vi) conservation and protection of water resources and aquatic environment on sustainable basis.

There is therefore a need to overcome several obstacles in these policies due to overlapping jurisdictions, laws and regulations that sometimes contract each other. In addition, it is sometimes not clear as to who should enforce what regulation. Other obstacles include an unjustifiably large body of legislation, incompatibility between customary law and national law, lack of an agreed position on key policy issues such as in areas of land tenure, appropriate methods of tackling land degradation and an agreed position on the question of the harmonization of legal and administrative approaches to AWM. Of great interest is whether or not policies that address AWM tacitly are to be found in the national plans, legislations and programmes. There is also the question of the role of regional and international policies in affecting actions at national and local levels. However, good policies are necessary for successful promotion of land husbandry, but they are not sufficient in themselves to bring about sustainably productive local resource management. Policy simply provides a framework and gives farmers the latitude to manage their resources for the long run. It is just a first step towards local resource management for sustainable production. National AWM policies should cover land tenure, equity, rights to natural resources and the legal framework for land and water management.. Policy reform is therefore necessary to address agricultural water management in all its components. There efforts from various quarters, as with the IMAWESA project.

Contribution of the IMAWESA project

The Improved Management of Agricultural Water in Eastern and Southern Africa (IMAWESA), is a three-year project supported by the International Fund for Agricultural Development (IFAD), through the Association for Strengthening Agricultural Research in Eastern and Central Africa (ASARECA) in partnership with the International Crops Research for Semi-Arid Tropics (ICRISAT) and being implemented by Soil and Water Management Network of ASARECA (SWMnet). IMAWESA operates indirectly in all 25 countries of the ESA for the knowledge management component, and directly in 15 countries, which includes Burundi, Eritrea, Ethiopia, Kenya, Lesotho, Madagascar, Malawi, Mauritius, Mozambique, Rwanda, Swaziland, Tanzania and Uganda, and including the Democratic Republic of Congo and Sudan. The overall goal of the project is to enable poor producers in Eastern, Central and Southern Africa to increase their incomes through improved management of agricultural water. In order to achieve this goal, the purpose of the project is to enhance the development impact of public and private investments in smallholder agricultural water management. The project has four planned outputs which include:

- Enhancing engagement in policy dialogue relative to smallholder management of agricultural water within the ESA region,
- Enhanced understanding of key issues, in order to contribute to guiding future investments in management of agricultural water actions in the region
- Capacity strengthening for program management and implementation for management of agricultural water in the region, and
- Developing a robust knowledge management approach to ensure more systematic capture, synthesis, exchange and eventual utilization of experiences and lessons relative to management of agricultural water with emphasis on linking and networking those with experiences and expertise at both implementation and planning levels into a community of individuals and organizations, which will share knowledge and learn from each other, during and beyond the project period.

Though project implementation has just started in January 2006, IMAWESA had a six-month inception phase during which a baseline study of policies, policy makers and policy making processes associated with AWM in the ESA. In addition, IMAWESA has been documenting key stakeholders (managers and implementers of program and projects, researchers, policy makers, extension workers, the media) who influence decision on AWM in the ESA region. Preliminary findings have revealed major gaps to be filled by further research, as well as the fact that there is quite a good but varied human resource capacity for targeted AWM action in the region. The major problem is that of poor interaction, knowledge management and weak linkages between and across the various stakeholders, within their countries and across the region. IMAWESA intends to catalyze action, first through policy dialogue, capacity strengthening, communication and knowledge sharing, and hopefully development of viable communities of practice in AWM in the ESA.

Conclusions

The concept of green water management is not new, even to the ESA region. The green water paradigm involves activities which optimize the management and utilization of water held as green flows such as rainwater harvesting, storage and utilization, reduction of water losses by evaporation, enhanced storage of water as soil moisture and in green biomass. However, what is new is the need to raise enough consciousness about its importance, so as to influence the knowledge, attitudes and practices of all stakeholders to its immense potential impacts on agricultural productivity in the region. The difference between green water re-capitalization and conventional forms of AWM is that green water directly affects plant biomass production, which is the essence of all agriculture, including livestock production. Even though the ESA region is on average water scarce, the green water potential that has not been fully utilized, yet it is capable of closing the gap between food deficits and food security, as well as alleviating suffering resulting from crop failures caused by climatic variability. The paper thus advocates for increased focus on the “green water” component which comprises 57% of rainfall flows in the ESA. It has been pointed out that the prevailing policies in most of the countries in the ESA are not succinctly sensitive to AWM, but are fragmented between ministries and departments. Sometimes the policies contradict each other. There is therefore need for targeted policy reform to address agricultural water management, more succinctly. The technological options are available and the main challenge is to put knowledge into practice.

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