Integrated Watershed Management: Towards Sustainable Solutions in Africa

A. Bahri[1], H. Sally[2], R.E. Namara[1], M. McCartney[3], S.B. Awulachew[3], B. van Koppen[2], and D. van Rooijen[1]

International Water Management Institute (IWMI) www.iwmi.org

[1]IWMI Regional Office for Africa, IWMI Ghana, PMB CT 112, Cantonments, Accra, Ghana

[2]IWMI Sub-Regional Office for Southern Africa, Private Bag X813, Silverton 0127, Pretoria, South Africa

[3]IWMI Sub-Regional Office for Nile Basin and Eastern Africa, P.O. Box 5689, Addis Ababa, Ethiopia

(a.bahri@cgiar.org), (h.sally@cgiar.org), (r.namara@cgiar.org), (m.mccartney@cgiar.org), (s.bekele@cgiar.org), (b.vankoppen@cgiar.org), (d.vanrooijen@cgiar.org)

Abstract

Water availability and access are critical issues for the social and economic development of sub-Saharan Africa where most of the countries suffer from economic water scarcity. Water resources development and management are limited by the lack of capital investment and/or appropriate institutions to manage existing water infrastructure. Innovative ways of managing land and water including policy and institutional reform are needed to accompany efforts to develop water infrastructure and improve agricultural productivity to overcome the growing economic and physical scarcity of water, compounded by climate variability and climate change, rising prices of food and energy, and the imperatives to respect critical social considerations and ecological functions to sustain such developments. This paper highlights selected examples of research carried out in Africa to support the planning, design and implementation of integrated land and water resources management and of institutions for managing shared water resources on the continent. The quantity, quality, policy and institutional challenges in dealing with different spatial and

temporal scales, reconciling demands of different uses and users to a finite resource, and assessing possible impacts of planned interventions are highlighted, together with some of the approaches being developed and tested to address these issues.

I. INTRODUCTION

Water is a critical input in agricultural growth and pivotal in agrarian livelihoods. But most sub-Saharan African countries are faced with economic water scarcity, lacking the human, financial or institutional capital to adequately develop and use their water resources. Under-investment in water infrastructure, including provision for maintenance of existing facilities, is often compounded by poor governance and ineffective institutions, especially in poorer countries.

The recently concluded study by the Comprehensive Assessment of Water Management in Agriculture (CA) (2007) points out that improving land and water productivity is a critical contributing factor to achieving the Millennium Development Goals (MDGs) with regard to poverty, hunger and environmental sustainability. The need for integrated land and water resources management to reduce poverty and food insecurity especially in semi-arid Africa, where over 80% of rural livelihoods depend on land and water resources, cannot be overemphasized. The New Partnership for Africa's Development (NEPAD) has called for a 6% annual growth in agricultural output if the continent is to achieve food security by 2015. Furthermore, the World Bank and other development organizations recognize broad-based agricultural development as the engine of economic growth (FAO, 2006a, IFAD, 2007; World Bank, 2008).

Fortunately, renewed and vigorous responses to water scarcity, including investments to develop water infrastructure, intensifying agricultural production and improving its productivity together with the associated institutional reforms, are increasingly driving Africa's water agenda. Innovative ways of managing land and water are therefore called for in the face of growing economic and physical scarcity of water, compounded by rising costs of new developments, climate variability and climate change, increased prices of food and energy, and the imperatives to respect critical social considerations and ecological functions to sustain such developments. This paper first presents the challenges facing sub-Saharan Africa (SSA) from the land, water and livelihoods perspective; it then develops the trends and challenges of integrated watershed management, illustrated by selected examples of collaborative, inter-disciplinary research carried out to support decision-making regarding integrated land and water resources management. Finally, some policy implications are proposed to accompany implementation of some of the lessons learned.

II. LAND, WATER & LIVELIHOODS CHALLENGES IN SUB-SAHARAN AFRICA

Sub-Saharan Africa is the poorest region in the world (40-60% of SSA population is below $1/day) – and getting poorer (NEPAD, 2003), a consequence of population growth outstripping the growth of both overall and agricultural GDP (World Bank, 2007). Sub-Saharan Africa's population remains predominantly rural (70%), poverty is widespread and 33% of its people is undernourished with a constant low average calorie intake per person around 2000 kcal/p/d. Forty to fifty percent of the population has no access to safe drinking water and adequate sanitation. And there are very high rates of infant mortality, malaria, diarrhea, HIV/AIDS, and child malnutrition.

Agriculture, providing 60% of all employment, constitutes the backbone of most African economies. In most countries, it is still the largest contributor to GDP; the biggest source of foreign exchange, accounting for about 40% of the continent's hard currency earnings; and the main generator of savings and tax revenues. Agriculture thus remains crucial for economic growth, poverty reduction and food security in most African countries (NEPAD, 2003). But agricultural productivity is low and stagnant in SSA. Sub-Saharan Africa is the only region where per capita food production has fallen over the past forty years. More than 90% of food crops in SSA are grown under rainfed conditions; this renders SSA agriculture vulnerable to rainfall variability and in turn affects the livelihoods of the poor and also the national economy. At the same time, SSA also has a large untapped potential of irrigation. FAO (2006b) has reported that only a small share of the potentially irrigable area of 39.4 million hectares has been developed in SSA. Overall, 183 million ha of area are under cultivation in Africa, of which 5% or about 9 million ha is under water management and 7 million ha are equipped for full or partial irrigation. Only about 70% (5 million hectares) of the equipped area is operational (World Bank, 2007).

Africa has very high spatial and temporal variability in rainfall as compared to other continents (FAO, 2003; UN Millennium Project, 2005; Walling, 1996; World Bank 2002). The coefficient of variation in annual rainfall ranges from 200% in desert areas to 40% in semi-arid areas, and 5-31% even in humid areas (Africa Water Task Force, 2002). In several African countries, there is a strong correlation between GDP growth and the country’s highly erratic rainfall. For example, the 2003 floods have cost Kenya about 2.4 billion USD (Grey and Sadoff, 2004), and recurrent drought and flood made millions of people in East African dependent on food aid.

The amount of water withdrawn in Africa for agriculture (85%), water supply (9%), and industry (6%) amounts to only 3.8% of internal renewable water resources, a reflection of the low level of water resources development, especially in SSA. Per capita water withdrawal in SSA is the lowest of any region in the world, being just one-fourth of the global average. Africa also has the lowest levels of per capita storage (Sadoff and Grey, 2002); thereby highlighting the fact that provision of storage infrastructure should constitute a vital element of the water development agenda in sub-Saharan Africa. Water infrastructure is needed for providing services to urban, industrial, irrigated and rural areas or the natural environment, ranging from storage (rainwater harvesting systems, dams, ponds, etc.) to abstraction, conveyance, distribution, sanitation, to reuse/recycling and disposal. Development of hydropower, especially when combined with other sectors such as irrigation, flood protection, and drought resilience, can enhance returns on investments in water infrastructure.

The current phenomenon of rising food and energy prices should also lead us to rethink approaches to agricultural land and water management in SSA. While agricultural growth in SSA in the past has been mainly achieved through area expansion and provision of irrigation facilities (the use of "blue" water), there is growing realization that the reliability of agricultural water supply can also be assured by improving land and water management on rainfed areas (i.e. by harnessing more "green" water). Low-cost technologies such as rainwater harvesting, soil moisture conservation, etc. can help stabilize and increase crop yields and farmer incomes in rainfed agriculture by encouraging hitherto risk-averse farmers to invest in inputs (fertilizers, improved varieties,) and adopt improved management practices. Promoting awareness about and access to such technologies can also help unlock the potential of smallholder farming and uplift rural livelihoods. In this regard, it is worthwhile highlighting that in SSA, women are in charge of up to 80% of food production (FAO, 2003); more than elsewhere in the world, gender is central for equity and productivity in agriculture and agricultural water management. Hence, it is important to ensure that, both for productivity and equity reasons, all farm decision-makers, whether men or women, are included in programs of public support and investment. Irrigation development will also have to play a major role if the ambitious NEPAD targets for agricultural growth on the continent are to be met. Irrigation in SSA has suffered from declining investments over the past two decades due to results falling short of expectations and disappointing returns. The hydrology and pedology are partly responsible for that but there was also a popular view that irrigation projects in SSA are more expensive than elsewhere.

However, a recent analysis (Inocencio *et al.,* 2007) of over 300 irrigation projects world-wide showed that irrigation is not uniquely expensive in Africa.

Africa has 63 transboundary river basins – more than any other continent – implying very high water inter-dependence. Seventy-seven percent of the human population lives in these basins which contain 93% of the total water, and cover 61% of the surface area. Integrated planning and management of international river basins has seldom proved straightforward in Africa. Developing these basins requires agreements, institutions, information sharing and human resources (Wright *et al*., 2003). The way water is developed and managed has social, economic and environmental consequences. Integrated approaches to the development, management and use of water resources will help foster a more balanced and inclusive approach to water decision-making that emphasize social equity, environmental sustainability along with economic efficiency.

III. INTEGRATED APPROACH TO WATERSHED/RIVER BASIN MANAGEMENT

3.1. Trends and challenges of integrated watershed/river basin management

Historically, water management was equated with the development and operation of water systems and structures, largely for irrigation. From the mid 1990s, water management was placed into the overall context of river basins and to examine the interlinking hydrologic, socio-economic and environmental aspects of water management at multiple scales. It is now widely accepted that water can be efficiently managed within a river basin or watershed/catchment[1] area and that this approach helps to achieve a balance between resource use and protection (Ashton, 1999).

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[1] According to the CA (2007), "river basins are the geographic area contained within the watershed limits of a system of streams and rivers converging toward the same terminus, generally the sea or sometimes an inland water body. Tributary sub-basins or basins more limited in size (typically from tens of square kilometers to 1,000 square kilometers) are often

Several closely-related concepts have been proposed to develop and manage natural resources. These include Integrated Water Resources Management (IWRM), Integrated River Basin Management (IRBM), Integrated Natural Resources Management (INRM), Integrated Watershed Management, Integrated Catchment Management, etc. IWRM is defined by the Global Water Partnership (GWP-TAC, 2000) as "a process which promotes the coordinated development and management of water, land, and related resources in order to maximize the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems[2]". IWRM and IRBM are complementary and interrelated concepts but they differ in the sense that some policy decisions can be taken only at the national level (Jønch-Clausen, 2004). Clarifying in detail the similarities and differences among these concepts is beyond the scope of this paper. However, the common features of these concepts are that they are: holistic, integrated, and participatory in their approaches; and are based on hydrological and bio-geophysical units rather than politico-administrative units with the over-arching goal of developing and managing different sources of water (rainwater, surface water, underground water, return flows (runoff, drainage, wastewater, etc.)) to serve the needs of multiple users for multiple purposes (agriculture, industry, drinking water, sanitation, power generation, navigation, flood protection, and the environment).

Watershed management and river basin management concepts have evolved in parallel. Watershed management has evolved from a narrow perspective mainly based on soil and water conservation projects aiming at stopping land degradation, improving agriculture and natural resources management and securing downstream water-related services towards a more holistic approach recognizing the importance of the human element and the interconnection of ecosystems (CA,

called watersheds (in American English), while catchment is frequently used in British English as a synonym for river basins, watershed being more narrowly defined as the line separating two river basins*."*

[2] River basin governance functions include (CA, 2007; GWP-TEC, 2008): planning water resources development, collecting data, allocating water between competing uses, preventing flooding, monitoring and enforcing water quality standards, coordinating water-related decision-making among sectors, and mobilizing financing to support basin development and management activities. Social, economic, environmental and cultural values and institutional and political factors need to be taken into account as well and should support water management decisions.

2007). The watershed area became the appropriate spatial integrator unit for managing land and water resources and to take into account the upstream-downstream relationships. A variant of the concept has emerged in the 1990s as "participatory integrated watershed management" with a more complex mix of strategic concerns (German *et al*., 2006) very much on line with the river basin governance principles. It is aimed at promoting sustainable development of water and land resources, building partnerships with communities on the ground in a search for equitable and environmentally sustainable change. Principles guiding watershed approach development include equity, sustainability and local empowerment. Dimensions that characterize watersheds are biophysical, hydrologic, socio-economic (including poverty and gender), policy and institutional. Figure 1, adapted from Kirkby (In CPWF, 2003), illustrates the interplay among hydrologic, socio-economic and environmental aspects across multiple scales that must be considered when assessing trade-offs and options in integrated watershed management.

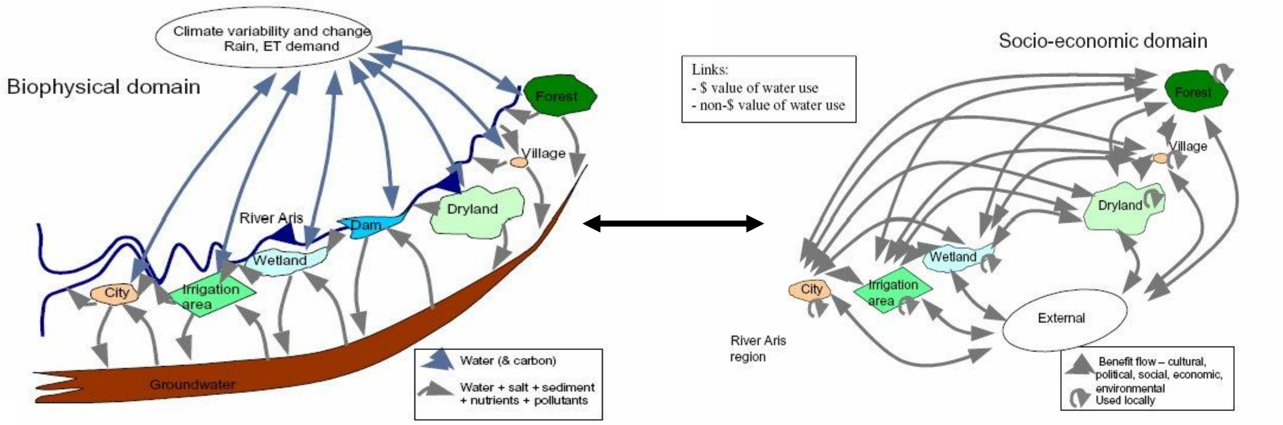

Figure 1. Conceptual model of upstream-downstream interactions (Kirkby, In CPWF, 2003).

Implementation of these approaches is still a challenge especially as regards to the institutional arrangements that have to be put in place at different scales and the need for coordination across scales and institutions. A key requirement for success is to have institutions open to the principles of integrated natural resources management taking account of the multiple objectives of the society.

The challenge is also to achieve a balance between values such as economic benefit, equity, sustainability and public participation when in practice there are often trade-offs between them.

3.2. Integrated watershed/river basin management in Africa

In Africa, the river basin concept goes back to ancient civilizations such as the Nile and the Niger that have long supported diverse populations of farmers, herders, crafts people and traders and that are the cradle of some of the earliest civilizations, the Sudannic and the ancient Egyptians. Indigenous irrigation systems, some based on complex gravity canal irrigation systems, have been developed in Northern Africa, West Africa, in the Nile Valley, and in the East African Rift Valley in Kenya and Tanzania (Adams, 2001). The most extensive and complex transformations of river flows at international scale in Africa on record were on the Nile, mainly in Egypt and Sudan. Four decades ago a few countries like Nigeria, Ghana and Egypt have reactivated the idea of river basin development to restore equitable balance between rural and urban economic development. National and international river basin authorities were established in the sixties and their most important products were the construction of dams (Aswan on the Nile, Akosombo on the Volta River, Manantali and Diama on the Senegal River, etc.) and irrigation schemes (Gezira in Sudan, Office du Niger in Mali, etc.). In some cases, these developments have had some negative impacts on livelihoods and ecosystems (loss of land, endangered livelihoods, social disturbances, health risks, clam fishery downstream of the dam in the lower Volta in Ghana). McCartney and Sally (2005) argue that past experience shows that construction of large dams without full understanding of the social and environmental consequences can have devastating impacts for the livelihoods of many poor people. Very often negative impacts arise as a result of lack of foresight and because water infrastructures are planned and managed in isolation from other developments occurring in a river basin.

Equally serious are the environmental consequences of intensive biomass exploitation in upper watersheds. Siltation from land degradation leads to storage loss and to environmental and socio-economic impacts downstream while degraded watersheds exacerbate the risk of extreme events (droughts and floods) and biodiversity loss. For example, sedimentation has had significant impacts on the utilization of the Nile Basin water resources, ranging from watershed degradation, sediment deposition in reservoirs to management difficulties of irrigation canals networks in the Gezira scheme. According to Ahmed (2003), the sediment load of the Blue Nile at El Diem is 140 million tons per year. The cost of sedimentation includes loss of hydropower potential and more importantly loss of agricultural production. In Sudan, the sediment clearance from the irrigation canalization system costs more than 60% of the total costs of the operation and maintenance. Among potential negative effects of large dams and irrigation schemes is intensified transmission of malaria and schistosomiasis, resulting from changes in environmental conditions that increase vector abundance. Such problems are not only associated with large infrastructure, but with small reservoirs and irrigation schemes as well.

It must be remembered that the large majority of water users in the continent use water “informally” for both domestic and productive uses. Most central governments lack even basic data about large-scale users, let alone the millions of small-scale users. In rural areas, indigenous natural resource management arrangements around traditional authorities continue to have a great influence on land tenure, but also on the way in which (a) individuals are authorized to engage in new water uses, (b) groups come together to jointly invest in communal infrastructure like wells, dams or river abstractions, (c) priorities between uses and users are set and enforced during droughts, and (d) pollution is prevented, etc. (van Koppen *et al*., 2007).

Actually, almost all African countries and more particularly those with large inland drainage systems have agreed to engage in watershed management and in IWRM, i.e. to establish river/lake basin development units as multipurpose use systems and to manage their water resources at the basin level rather than within the administrative and political boundaries; thus, involving in the planning, development and management of water-related activities relevant actors and stakeholders through various partnership arrangements among riparian countries in the continent's major river basins, and among local communities within the basins and watersheds. Some countries have however moved to a state-wide approach, in some cases after going through a river basin development and management stage. In Tunisia, for example, piped water systems that cross the country from North to South or from inland to the coast try to put in equation principles of equity along with efficiency and sustainability.

Despite the formal commitments by many countries after the 2002 World Summit to the ideas and principles of sustainable development, the implementation of policies and strategies that manage water resources for people, while maintaining functioning ecosystems, are however confronted with several difficulties, particularly in water stressed basins, or when administrative or political boundaries differ from the watershed limits, or when there are competing interests. The issue of how much water should be allocated to agriculture and other uses, and how much should remain for environmental uses is still a subject of debate and should probably be resolved on a basin by basin basis (Molden *et al.,* 2007).

According to AfDB (2007), eight of the continent's nine largest international basins have basin authorities that have been ratified by the states sharing the river basin. However, except the South African and the Senegal River Development Organizations (OMVS), most of these international basin organizations are ineffective, being "beset by bureaucratic inefficiencies and financial and capacity constraints" (AfDB, 2007). In addition, as they are not always able to keep up with science based water management innovations, they lack key techniques for water allocation, development, and distribution. Furthermore, issues of treaties/agreements regarding the use of international waters remain largely unresolved and national interests tend to prevail over shared interests. Differences in countries' needs and development stages should also be considered such as in the case of the Incomati River shared between South Africa, Swaziland and Mozambique. Some countries are focused on how to attain the MDGs (reducing poverty, hunger, diseases and environmental degradation including halving the number of people without access to water and sanitation) while others can afford to have a stronger focus on environmental protection and restoration. The question of how an integrated watershed/river basin management can help reconcile difficult trade-offs in the achievements of these goals has still to be worked out (Jønch-Clausen, 2004). The Nile River Basin is a good example of common resources, which can only be harnessed through effective cooperation across countries.

IV. CASE STUDIES

The examples presented hereafter illustrate the approaches adopted and the tools used in carrying out interdisciplinary collaborative work across scales (field, watershed, basin, and transboundary), involving researchers, basin or watershed organizations, farmers' organizations, local communities, NGOs and government agencies. The first case study analyzes trade-offs between water allocations to different sectors in determining river basin water management plans taking into account customary arrangements and promoting stakeholder dialogue. The second example looks at up- and downstream implications of rural-urban watersheds development. The third case study assesses the results of attempts made to create institutions for developing and managing international transboundary river, and the impacts of upstream watershed interventions and allocation on downstream users, using the Blue Nile Basin as an example.

4.1. Balancing inter-sectoral water demands

In situations of growing water stress, there is a need to improve water resources management to secure and maximize the benefits from water to the different users. In a watershed where agriculture is the principal anthropogenic use of freshwater, sufficient improvements in irrigation efficiency and productivity can provide adequate water for other sectors and downstream needs. Wetlands fulfill critical ecological functions and also make important contributions to sustaining rural livelihoods in Africa via a wide variety of uses such as crop production, livestock rearing, domestic water use, brick making and harvesting plants for crafts and medicinal purposes (Kashaigili, 2003). Making optimum use of their productive potential while minimizing adverse ecological effects, requires management strategies based on an understanding of a range of issues such as hydrology, climatic variability, availability of labor and other inputs, customary arrangements for land and water access, and the existence of a sound policy and institutional framework. The contribution of multidisciplinary research to support decision-makers to develop strategies and intervention packages that strike a balance between production and protection will be illustrated through the following example of the Usangu wetland located in the Rufiji Basin in Tanzania.

Tanzania, in compliance with current widely accepted notions of best practice, and in common with many other African countries, has focused largely on the development of more integrated watershed-wide approaches to water management. The New National Water Policy (MWLD, 2002) provides a framework for integrated management of water resources. Adopting the river basin as the principal unit for management and regulation, it embraces concepts such as full-cost recovery, water rights and water fees, and stakeholder participation in water resources management (Mutayoba, 2002; van Koppen *et al*., 2004).

The Rufiji Basin is one of three basins in Tanzania where the new policy is being pilot tested. The Great Ruaha River (Figure 2), a major tributary of the Rufiji, is one of Tanzania’s most important waterways. The watershed (83,979 km^2) contains one of the country's main rice growing areas, 50% of the countries installed hydropower capacity, as well as an important National Park and Ramsar sites. Since the mid-1990s, the Great Ruaha River, which in the past was perennial, has ceased flowing in the dry season every year. This has occurred because water levels in a large wetland, located on the Usangu Plain (close to the headwaters of the river) have dropped below a critical level and outflows from the wetland have ceased. This drying is largely as a consequence of diversions to rice irrigation upstream of the wetland. It is estimated that up to 95% of households living on the Usangu Plains benefit in some direct way from the wetlands. Upstream water withdrawals are causing considerable environmental degradation of both ecosystems. Between 1970 and 2004, irrigation on the Usangu Plain, increased from 10,000 ha to 45,000 ha.

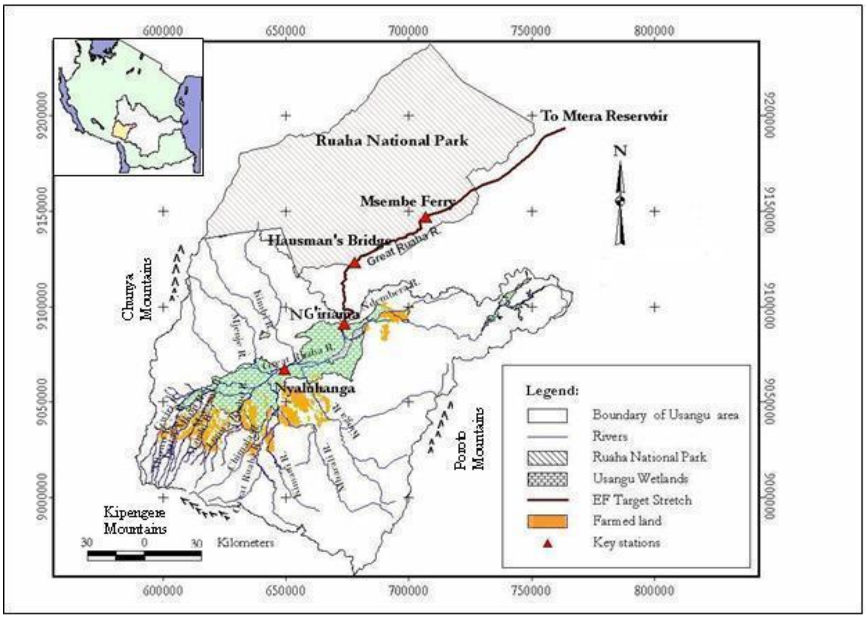

Figure 2. Map of the Great Ruaha River.

Over a 5 year period (2002-2007), a multi-disciplinary study was conducted to investigate the effectiveness of the new water management being implemented in the Rufiji and specifically the Great Ruaha Basin. Key components of the study were to determine: i) the flow requirements downstream of the Usangu wetland and how much water needs to flow into the wetland to maintain this flow, ii) the scope for improving irrigation efficiency and productivity in order to release sufficient water for downstream uses, iii) the role that economic valuation of different water uses should play in determining water allocation in the watershed, iv) if the formal water management systems being introduced would be effective in returning the Great Ruaha River to year round flow, and v) how are different types of decision-support systems best used to improve water management and the decision-making process (McCartney *et al.*, 2007).

Utilizing hydrological and water resource models, the study found that environmental flow requirements through the Great Ruaha National Park (located downstream of the wetland) require an average annual allocation of 635 Mm^3 (equivalent to 22% of the mean annual runoff) and an absolute minimum dry season flow of 0.5 m^3s^{-1} (Kashaigili *et al.,* 2007). To maintain the dry season flows requires a 65% reduction in current dry season abstractions, from 4.25 m^3s^{-1} to 1.50 m^3s^{-1}. Although there is significant potential to increase water-use efficiency in the irrigation schemes, which would free water for the wetland and downstream flows, current management systems are largely failing to reduce diversions. Although the water rights and fees system was intended to provide economic incentives to reduce water waste, it was found to be largely ineffective in the absence of ways to monitor and enforce compliance. Some withdrawals were found to be up to twice the legal water rights and even where water rights were not exceeded, considerable volumes of diverted water were wasted (Mehari *et al*., 2007; Rajabu *et al*., 2005). The average values of water for irrigated paddy were estimated at \$ 0.01 and 0.04 per m^3 for abstracted and consumed water respectively. For hydro-electric power, the values were relatively higher (\$ 0.06-0.21 per m^3 for gross and consumed water respectively). These figures provide an indication of the relative value of water use in the two sectors. Consequently, if based simply on criteria of economic efficiency, water would be allocated away from irrigation to the downstream hydropower schemes. However, paddy production from the Usangu area alone contributes about 14-24% to national production and supports about 30,000 agrarian families in Usangu with average gross income per family of US\$ 912 per year (Kadigi *et al.,* 2005). In deciding allocations, these benefits need to be considered, including equity and pro-poor returns as well as the implications for national food security. Ultimately, in this instance, water allocation is a difficult political choice.

At local level, as part of efforts to organize water users into WUAs, building upon traditional water allocation approaches based on water sharing (i.e., *Zamu*) led to improvement in village-level water management and reduced intra-scheme conflicts but did not reduce abstractions. Given the importance of diversions for livelihoods, proposed solutions included active water management within the wetland (i.e. to reduce evaporation) and perhaps even managing trade-offs between the wetland and the downstream National Park (i.e. a small reduction in the size of the wetland to ensure water flows to the National Park). Different types of participatory decision support tools such as the River Basin Game and the Ruaha Basin Decision Aid can assist water resource managers to make rational decisions about water allocation and facilitate the involvement of non-specialists stakeholders in the decision-making process.

4.2. Water management in urban watersheds

Urban population growth and economic development may exacerbate inter-sectoral and upstream-downstream competition for water and have effects on drinking water quality, wastewater and stormwater management. Urban development is changing the quantity and quality of water flows that extend beyond the urban watershed. Cities generate increased volumes of wastewater and other wastes whose disposal has a negative impact on a wider range of ecosystems. Poor sanitation facilities and lack of wastewater treatment have created wastewater flows downstream onto agricultural fields and into surface water bodies. On the other hand, if properly treated and managed, these wastes may promote different water uses and users across urban-rural-environmental gradients. These upstream-downstream interactions of cities with non-urban uses and the environment are explored through analyses of two cities in SSA, Accra and Addis Ababa, categorized in three groups: inter-sectoral competition over water, wastewater induced pollution and health risks and urban flood risks.

In urban watersheds, competition between urban water demands and those for agriculture and industries is increasing due to urban expansion and political priority given to cities. Fast growth of cities in sub-Saharan Africa and rises in livelihoods standards are exerting more pressure on water and land resources. With the political and economic centers of gravity located in the cities, urban water use tend to be prioritized over other users and other regions (Molle and Berkoff, 2006). Northern Ghana and Burkina Faso stand in competition for water resources with the urbanized society of Southern Ghana (Giesen *et al.*, 2001).

Cities are generating large volumes of wastewater that are a source of health risks and pollute the environment, when the scale of treatment is low. The near absence of actual treatment of domestic (5% or less in Addis and Accra) and much less industrial wastewater is putting a burden on the environment as well as posing a risk to human health. In Accra, of the total volume of water used (excluding 25% physical losses) about 80% or 80 MCM year^{-1} returns as wastewater. Another fraction is collected from septic tanks by trucks and dumped into the ocean or released into ponds with possible connections to the ocean. The various pathways of microbiological infection from wastewater to humans are posing a daily risk to many of Accra's inhabitants (Lunani, 2007). Wastewater (raw or mixed with underground or storm-water) is being used for irrigating mainly vegetables in Accra and Addis, which entails a health risk to irrigators within and downstream of the cities. In the case of Addis Ababa, heavy metal-polluted river waters from various factories are used to cultivate vegetables that pose serious health hazards to producers and consumers. Untreated or poorly treated domestic wastewater poses health risks to irrigators within and downstream of cities (Bayrau *et al.*, 2008; Obuobie *et al.*, 2006). Consumers of raw vegetable crops that are grown in the city (61% in Addis and 90% in Accra) are exposed to the risk of getting sick as well, when these food items have not been properly disinfected.

Research on the urban-rural linkages in terms of food, nutrient and water flows is providing knowledge on how cities in Africa stand more and more in interaction with their rural hinterland (Awulachew, 2007; Drechsel *et al.,* 2007). Empowering end-users to “add” their knowledge and perception of progress to the process as in the case of the SWITCH project, where local stakeholders are brought together to jointly discuss, learn and set priorities for improvement or all aspects of urban water in their city (Accra, in this specific case) may help reaching at a more sustainable management of water in cities.

The gradual conversion of land use from permeable to impermeable or paved areas in urban watersheds has changed the behavior of storm water flows. Poor drainage, inadequate and undersized drains, dumping of refuse into drains, and choking of gutters with plastics increase risks of flooding mainly in the flood-prone areas of Accra (Twumasi and Asomani-Boateng, 2002). In addition, seasonal floods pose health risks due to the mixture with wastewater.

4.3. The Blue Nile – an example of multi-national water management

The management of the Nile is unique in Africa for its long history, great technical complexity and its international scale. The first systematic modern attempts to understand and make plans about them were on the Nile (Waterbury, 1979; Collins 1990). Until the twentieth century the only major hydrological developments in Africa were confined to the Nile Valley. Within SSA, only the Sudan had developed irrigation on any scale before the sixties, Gezira Scheme being the first large scale irrigation scheme in SSA in 1926.

The basin is identified as a critical region where the interconnections between water, food, poverty and urbanization are enormous. Recognizing the importance of the Nile River and the increasing pressure on its use, efforts have been made to create legal instruments for the equitable and sustainable use of the basin's water. Fifteen bilateral treaties and agreements dated from 1891 to 1993 are available (Adams, 2001). However, all of these legal instruments were negotiated on strictly bilateral basis and the one party to the treaty was always Great Britain, except in the case of 1959 Nile Water Agreement signed between Egypt and Sudan. The treaties neglect the interests of other riparian countries and therefore many are unrecognized by one or more of the riparian countries.

Hence, there was a demand for formulating basin wide treaties or agreements to facilitate cooperation among riparian countries. Sadoff and Grey (2002) have identified four possible cooperation types on international rivers ranging from cooperation solely focusing on improving the environmental and ecological conditions of the river to cooperation intended to integrate regional infrastructure, markets and trade. Whittington *et al*. (2005) have attempted to quantify the benefits of full cooperation among the Nile River riparian countries. They showed that Nile basin wide cooperative development of hydropower and irrigation system would generate US$4.94 billion annually, more than the total economic benefits realized from the status quo conditions for the whole basin (Figure 3).

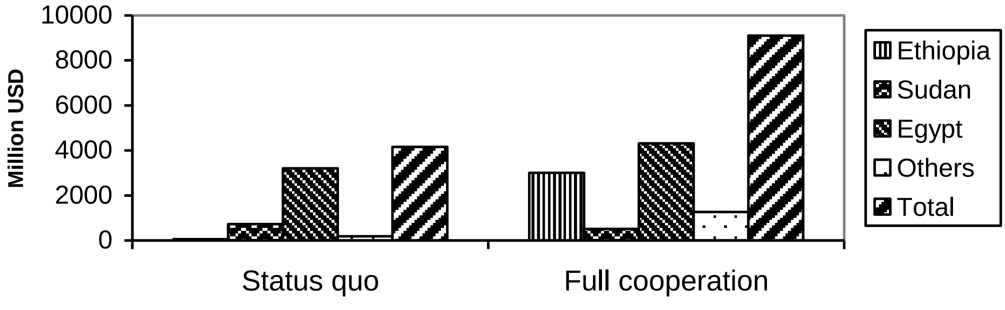

Figure 3. Economic value of cooperation: status quo versus full cooperation.

Recently, the World Bank has taken an active role in promoting cooperation in the Nile basin by helping to establish the Nile Basin Initiative (NBI) in 1999. The NBI represents a transitional institutional mechanism, an agreed vision and a basin wide framework, and a process to facilitate substantial investment in the Nile basin to realize regional socio-economic development. To translate the shared vision into action, the NBI has launched a Strategic Action Program, which includes two complimentary components: a basin wide shared vision program creating a basin wide enabling environment for sustainable development and subsidiary action programs. There are two Subsidiary Action programs: one for the Eastern Nile region and the other for the Nile equatorial lakes region.

The Eastern Nile Subsidiary Action Program (ENSAP) currently includes the countries of Egypt, Ethiopia, and Sudan. The long-term program objectives of ENSAP are to (a) ensure efficient water management and optimal use of the resources through equitable utilization and no significant harm; (b) ensure cooperation and joint action between the Eastern Nile countries seeking win-win goals; (c) target poverty eradication and promote economic integration; and (d) ensure that the ENSAP results in a move from planning to action. To realize these objectives, the ENSAP has sub-projects including flood preparedness and early warning, Baro-Akobo multipurpose water resources development, Ethiopia-Sudan transmission interconnection, Eastern Nile power trade investment program, irrigation and drainage and watershed management sub-projects. The Eastern Nile power trade investment program was developed based on the expectation that multipurpose dams on the Blue Nile in Ethiopia and elsewhere in the Blue Nile watershed could manage the Blue Nile flood and enable water resources managers to mitigate both the considerable inter- and intra-year variations in the flow of the Blue Nile. The construction of such dams could generate hydropower income for Ethiopia and positive downstream externalities for Sudan and Egypt in terms of drought, flood and sedimentation control. Such control structures could also allow water managers to operate the system in such a way that the total flow of water available to the riparian countries would increase (Whittington *et al*., 2005). Recent estimates of flood damage along the Blue Nile in Sudan amounted to USD 527 million for a 1-in-100-year flood event. This translates into damage of USD 52 million per year on average (Cawood, 2005). The watershed management sub-project targets selected watersheds along six rivers in Ethiopia and Sudan.

There is visible knowledge gap regarding the run-off, sedimentation, erosion, hydrological, hydraulic and institutional processes in the Blue Nile watersheds. To fill this knowledge gap, a research project, "Improved water and land management in the Ethiopian highlands and its impact on downstream stakeholders dependent on the Blue Nile", which aims at improving the understanding of these processes and to overcome constraints to up-scaling promising management practices and technologies within the watershed, is underway. The work includes hydrological and water allocation modeling, watershed management and policy and institutional studies at various levels. The specific activities of the project include *inter alia* micro-watershed and watershed level analysis of rainfall-runoff-sediment processes; analysis of sub-basin level impacts of water management interventions; evaluation of sediment management impacts on water infrastructure such as micro-dams; basin and transboundary level analysis of the impacts of upstream interventions on major reservoirs. Figure 4 demonstrates the schematization adopted for watershed management modeling at micro-watershed, watershed, sub-basin and basin levels (Awulachew *et al.*, 2008).

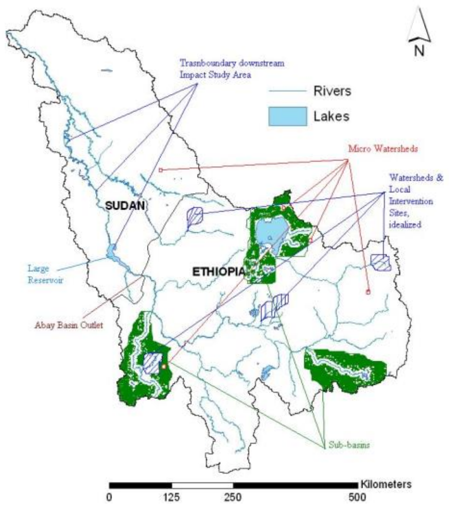

Figure 4. Schematization of Blue Nile for erosion and sediment modeling.

The schematization of the Blue Nile, major tributaries and the amount of tributary water derived from each sub-basin including the major lakes and reservoirs provides the necessary platform for a detailed understanding of the watershed (available water, potential, water allocation, and access) and analysis of the impacts of interventions. Such information provides a solid scientific base for informed negotiations among the up- and downstream countries regarding future development and management of the basin resources.

V. CONCLUSIONS AND POLICY IMPLICATIONS

The paper has shown that integrated watershed/river basin management in SSA should include a balanced portfolio of measures for managing economic water scarcity. The portfolio should include interventions meant to (a) minimize farmers' vulnerability and improve food security (water infrastructure development and management, soil and water conservation technologies, inter- and intra-basin water transfers, etc.), (b) manage upper watershed agro-ecosystems to minimize downstream externalities, (c) increase the productive use of water in different agro-ecosystems (irrigated, rainfed and wetland), (d) enhance the integrated management of urban watersheds, and

(e) identify effective policies, institutional arrangements and management strategies that both protect vital ecosystem services and reduce poverty at different scales, and that foster cooperation among riparian countries and benefit sharing from international rivers. Given the diversity of the various social, political and economical development trajectories and stages in Africa, different approaches are needed to address the critical development and management issues.

Integrated watershed/river basin management is a process whose implementation in SSA, is confronted with a range of challenges: inter-sectoral competition for water, dealing with trade-offs related to developmental and economic objectives on one hand and equity and conservation considerations on the other, integration across scales and reconciling hydrological boundaries with administrative and political boundaries. Addressing these issues not only requires knowledge, skills and expertise but also a political and institutional climate capable of providing the technical, financial and organizational support to deliver meaningful solutions.

Integrated watershed management is very much about decision–making in a multiple-use and multiple-user context to improve water productivity and derive optimum benefits for all relevant stakeholders. It has been shown that where water withdrawals are vital for livelihoods and poverty alleviation, managing trade-offs between different ecosystems is necessary. Such trade-offs need to be based on detailed understanding of the consequences of water management decisions for ecosystem services and their role in supporting livelihoods; such decision-making can be enhanced using tools that promote stakeholder dialogue and take into account existing local-level traditional arrangements.

In urban watersheds, comprehensive understanding of the entire urban water system is required considering various levels and modes of interactions such as watershed spatial scale, upstream downstream and socio-economic domains. Innovations and investment interventions in technological, institutional change and sociological learning are needed. Urban water supply, sanitation and environment need to be addressed across different scales, i.e. city watersheds and districts, with a watershed/basin perspective applying an integrated urban watershed management approach.

Transboundary coordination is needed to foster major win-win opportunities. Overcoming constraints to up-scaling promising management practices and technologies within the watershed/river basin will result in significant positive benefits for both upstream and downstream communities reducing win-lose scenarios.

Policies for integrated watershed management should aim at (1) integrated management of all sectors of the watershed/river basin in order to optimize benefits, (2) integrating rural and urban development, (3) involving stakeholders in the development and management of watershed/river basin from the planning to implementation stages.

i. The adoption of the ecosystem approach will ensure watershed/river basin-wide perspectives to development and management and make for social equity.
ii. The multipurpose use concept in integrated watershed/river basin development and management may provide the most equitable option on which watershed/river basin-wide plans may be based.
iii. Governments, experts and other stakeholders should think more in terms of agricultural water management rather than (separately) about irrigated or rainfed agriculture. It is necessary to improve management capability and skills/capacity of all role-players, including farmers and water user associations.
iv. Water, wastewater, non-point source pollution, and water reuse should be managed in an integrated way. Policy makers should start recognizing and acknowledging urban

development processes with their demographic and socio-economic causes and implications for watershed/basin management. Better legislation for health risk reduction can make wastewater irrigation downstream cities more acceptable.

v. In water allocation decisions, consideration of equity, food security, poverty reduction and development needs should be as well taken into account. Sustainable water resource management requires that water is treated as both an economic and a social good.

vi. The relevant boundaries for interventions are not necessarily the hydrological boundaries, in rural or urban watersheds. While a hydrological watershed would be most relevant for addressing water quantity and quality problems and applying pollution control and monitoring measures, both watershed and administrative or social/cultural boundaries will need to be considered.

vii. It is important to develop an adequate and effective institutional framework to manage and develop watershed/river basin resources. Nested institutional structures should be set up to manage large scale upstream-downstream interactions. A special challenge would be to create a framework that includes the large numbers of informal small-scale water-users. Adopting a pragmatic mix of new and existing management arrangements through active consultation can help to improve services and reduce conflicts.

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