Water Security for Food Security: Gaps, Needs and Potential for Growth in Sub-Saharan Africa

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Abstract

Sub-Saharan Africa (SSA) is faced with deep rooted poverty, malnutrition and inadequate food production. Key contributory factors include high population growth, low agricultural productivity, high natural and man-made tragedies such as climatic variability and change, conflicts and war. About 70% of SSA's economy is dependent on agriculture and the majority of the population is engaged in agriculture. This paper focuses on challenges and opportunities related to the development of physical capital, with special emphasis on the development of agriculture and water infrastructure in SSA. It also summarizes aspects with respect to communication, road infrastructure etc. Key challenges in relation to water supply and sanitation, agricultural productivity and its gap, influence of climate variability, water scarcity, and inadequate infrastructure are discussed. The paper further examines the potential and opportunities for infrastructure development to contribute to improving land and water productivity in agriculture. It points out that while SSA has adequate natural capital, productivity enhancement is constrained by relatively low levels of development of physical, human, financial and social capita; hence, the need for investment to improve access to domestic and agricultural water, energy generation, communication, road infrastructure, etc. It concludes that it is possible to achieve a green revolution in Africa, if through a judicious mix of expansion and intensification in agriculture through investments for improving agricultural water management, access to high yielding varieties and improved soil fertility management combined with policy and coping mechanisms against factors such as shocks associated with climate variability and climate change.

Key words: *physical capital, Africa, water infrastructure, water supply, irrigation, hydropower*

1. Introduction

Sub-Saharan Africa is the poorest region in the world – and getting poorer (NEPAD, 2003), a consequence of population growth outstripping the growth of both overall and agricultural GDP (World Bank, 2007a). Figures 1 and 2 and the issues discussed below illustrate this situation of poverty and food insecurity.

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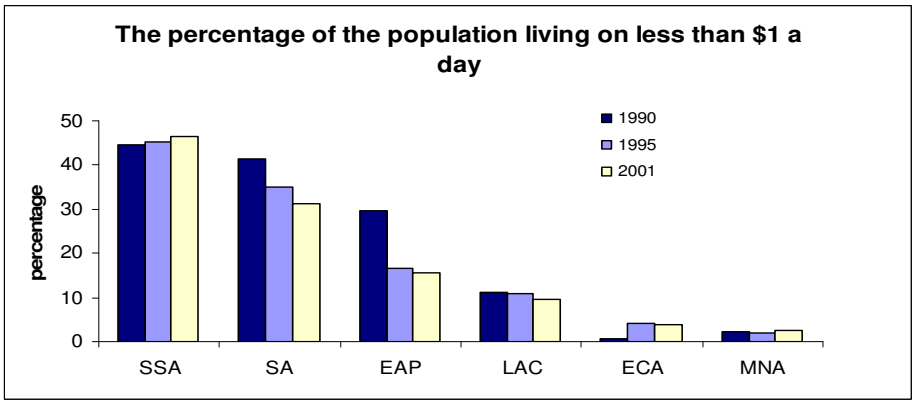

Figure 1. Sub-Saharan Africa is the poorest region in the world – and getting poorer (Source: AfDB et al., 2007).

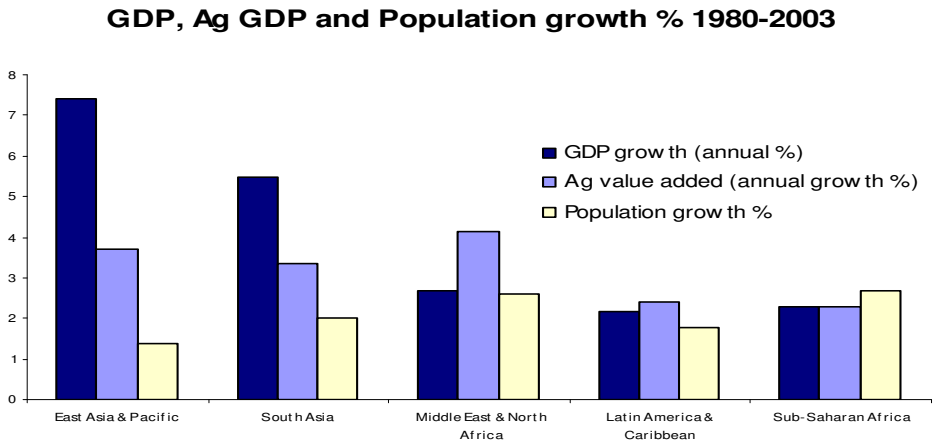

Figure 2. Population growth in sub-Saharan Africa has exceeded the growth of both overall and agricultural GDP, so that the population has become poorer (Source: AfDB et al., 2007).

African economy is heavily reliant on agriculture. A review of the importance of the agriculture sector, in terms of its contribution to GDP, export earnings and employment, reveals the unchallenged prominence of agriculture in the economies of most African countries.

Sub-Saharan Africa's population remains predominantly rural (70%), and poverty is widespread. Agriculture, providing 60 percent 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, still accounting for about 40 percent of the continent's hard currency earnings; and the main generator of savings and tax revenues. The agricultural sector is also still the dominant provider of industrial raw materials, with about two-thirds of manufacturing value-added in most African countries being based on agricultural raw materials. Agriculture thus remains crucial for economic growth in most African countries (NEPAD, 2003).

Despite the importance of agriculture in African economy, there is a huge potential for agricultural growth and improving agricultural productivity. The investments required to realize this potential have to be directed at enhancing five different types of 'capital': natural capital, social capital, human capital, financial capital, and physical capital. For successful and sustainable agriculture, all five capitals are needed in reasonable amounts. However, some of these capitals may already be present while one or two others maybe in short supply, which is where the proposed investments (both direct and indirect) should be the focused. When all capitals are present in reasonable amounts, production processes are more efficient and hence yield a higher return on investments than when one or more capitals are lacking. Furthermore, actions to augment 'natural capital' would be different from those needed to augment 'human capital', and the same for the other capitals. This is an important consideration for investment decisions. While the above is true, this paper specifically looks at physical capital.

Physical capital refers to any non-human asset made by humans and then used in production. While physical capital encompasses transport and market infrastructure, communication, water storage and distribution, irrigation systems and drainage works, mechanization and energy supply etc., the focus of this paper will be on the gaps, needs and potential for improvement of the physical capital related to water infrastructure. It specifically looks at water storage and distribution, irrigation and drainage systems, hydropower and energy production and also to some extent considers road networks, communication and transport.

2. Key Challenges and Situation Analysis

Inadequate and unreliable infrastructure services are a fact of life for the majority of rural communities in Africa. Many rural households do not have access to safe drinking water, electricity, good transportation, or modern communication services (Torero and Chowdhury, 2004). Infrastructure is critical to the achievement of social and economic goals as well as to ensure sustainability. Infrastructure development contributes to poverty reduction, and therefore it is a key factor to achieve the MDGs both directly through improving access to vital resources such as water and electricity, and indirectly by enabling access to other key resources such as schools, hospitals, and markets. Sub-Saharan African countries need more infrastructure development that is environmentally sound, socially acceptable, and financially sustainable. If Africa had enjoyed infrastructure growth rates comparable to those in East Asia in the 1980s to 1990s, its annual growth rate could have been about 1.3 percent higher (World Bank, 2007b).

Table 1 provides the coverage of water supply, sanitation, road and railway, telecommunication, electricity access, area under crops and proportion of irrigated land in Eastern Africa. The data is based on World Bank data (World Bank, 2006a).

Although there have been improvements in the various countries since the data period of 2004/2003, the table shows that there are still significant infrastructure gaps that need to be filled in the continent.

Table 1. Data extracted for East Africa from the World Bank Development Indicator 2006 (World Bank, 2006a). The data provided is for 2004 except indicated otherwise.

					Road network (km)			Telephone subscribers (per 1,000 people)						
	COUNTRIES	Internal fresh water resources per capita(m^3)	%population with sustainable water access	% of population with sustainable sanitation access	Total length (km)	Total national network (km)	Railway (km)	Total	Main telephone line	Cellular telephone	Electric power consumption (kWh per capita)	2003 permanent crop (1,000 ha)	2003 Land under cereal (1,000ha)	2003 Irrigated % of crop land
1	Burundi	555	79	36		4	478	12.5	3.4	9.1	18	365	211	1.5
2	Congo, DR	59,086	46	29		41453	4499	37	0.2	36.8	109.9	1,100	2,048	0.1
3	Djibouti		80	50				43.4	14.3	30.1				
4	Eritrea	683	57	9		18540	306	14	9.3	4.7	44.4	3	364	3.7
5	Ethiopia	1,603	22	6		8755		7.8	6.3	2.5	25.7	713	7,405	2.5
6	Kenya	627	62	48	63,942		2634	85	8.9	76.1	119.7	562	2,085	2
7	Madagascar	19,948	45	33				19.5	3.4	18.4	48.5	600	1,424	30.6
8	Rwanda	596	73	41		5408		18.2	2.6	15.6	19.9	270	324	0.6
9	Somalia	623	29	25				87.9	25.1	62.8	24.2	26		18.7
10	Sudan	894	69	34			4578	58.5	29	29.5	71.3	420	9,105	10.7
11	Tanzania	2,285	73	46	78891	67718	2600	32.2	4	43.6	67.8	1,100	3,410	3.6
12	Uganda	1,543	56	41	70746	10500	259	44.4	2.6	41.9	68.5	2,150	1,549	0.1

We shall now discuss some of the key challenges and gaps related to water infrastructure-agriculture-and economy in Sub-Saharan Africa:

2.1 Water Infrastructure is Needed to Curtail Africa's Top Killer and Achieve MDGs

The annual global burden of water-related diseases is estimated at 82 million Disability Adjusted Life Years (DALYs) in 2000. Burden of diarrhea alone in sub-Saharan Africa is 25 million DALYs. Annual diarrhea cases in SSA: 1.2 billion which leads to 769 000 deaths of children under 5. Ninety percent of deaths are children under 5. Diarrhoea and malaria are a greater burden than HIV/Aids (Lean, 2007; Rijsberman, 2006). Improved water supply and sanitation combined with hygiene education can have a great impact on reducing such effects.

As discussed in Winpenny (2003), water is one of the most important issues in the world today for a number of reasons: 1) access to water is a right and a basic need; 2) water is one of the vital MDG declarations and essential to fulfill the other goals such as poverty, education and gender equality; 3) water has been underemphasized and neglected in the past, compared to other sectors; 4) access to clean water and proper sanitation, and attention to wastewater disposal and treatment, has proven benefits to public health; 5) effective water resources development and management are basic to sustainable growth and poverty reduction, in several ways. Broad-based water resources interventions such as major infrastructure provide national, regional, and local benefits from which all people, including the poor, can gain.

2.2 Low Productivity of Agriculture

When we consider agriculture, the backbone of the SSA economy, its productivity is low and stagnant. Africa is the only region where per capita food production has fallen over the past forty years. SSA has yet to close the agricultural productivity gap as Asia and Latin America have done through the green revolution as shown in figures 3 (World Bank, 2003) and 4 (Molden, 2007). Therefore, there is an urgent need to improve productivity of agriculture in Africa.

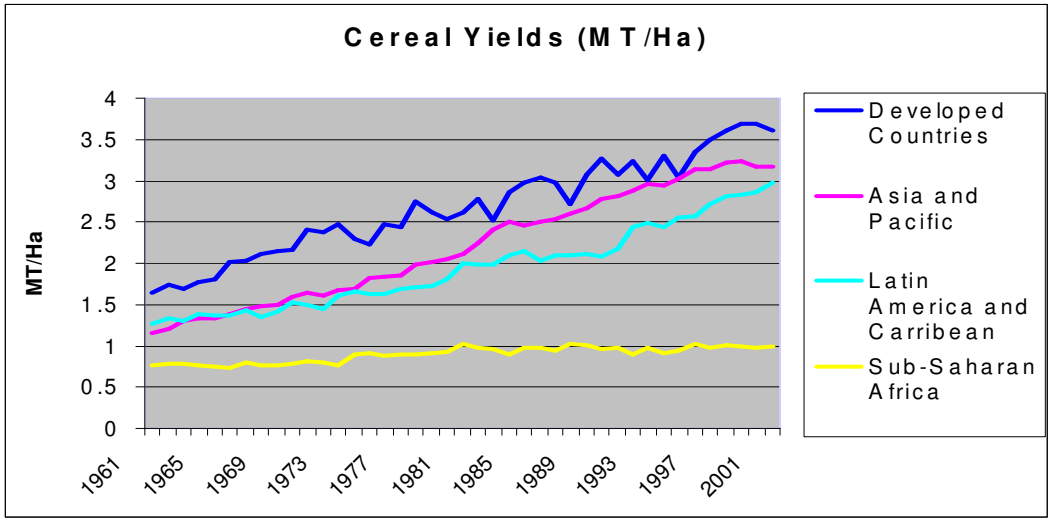

Figure 3. Comparative cereal yield of SSA

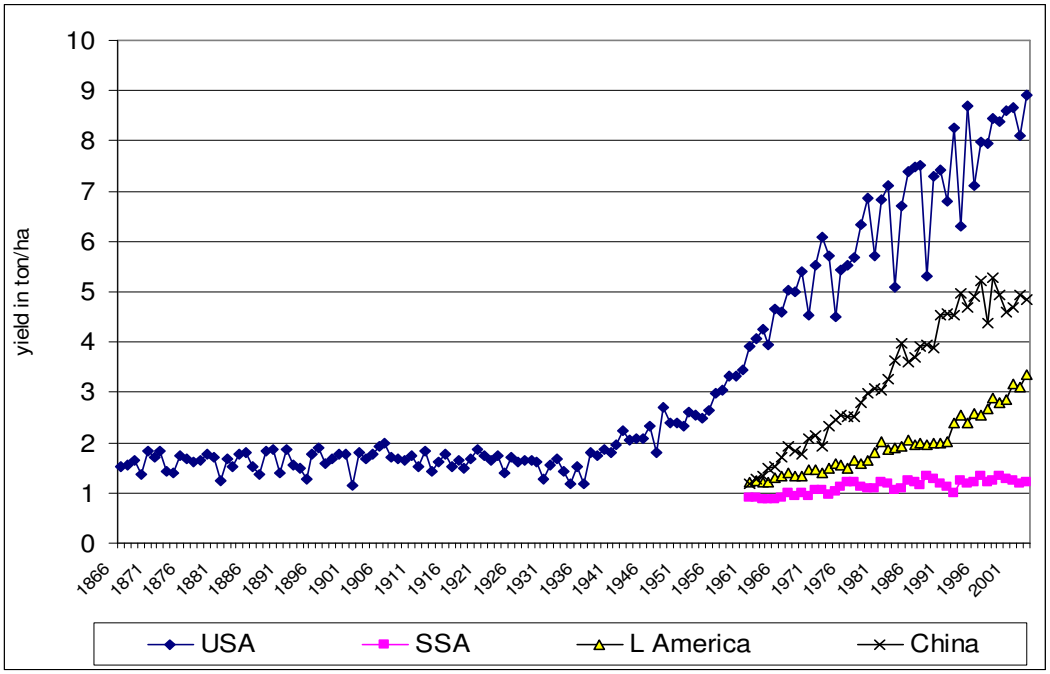

Figure 4. Comparative maize yield

2.3 African Agriculture and Economy are heavily influenced by Climate Variability

Due to lack of infrastructure, unmitigated variability of rainfall and hydrology agriculture, significantly affects the economy and livelihood of poor people in SSA. Africa has very high spatial and temporal variability in rainfall compared to other continents (FAO 2003; World Bank 2002; UN Millennium Project, 2005; Walling, 1996). 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).

Figure 5 for example shows the impact of rainfall variability on GDP and agricultural GDP in Ethiopia. The 2002/2003 drought caused negative 3.3% real GDP growth. Although the following years were positive at 11.9% and 10.6%, the growth over the three years averaged only 6.4% (MOFED, 2006). About 15 million people were obliged to seek food aid in Ethiopia alone and about 1,570,000 metric tons of food aid were needed. Figure 6 (EDPPC, 2006) shows the resulting related dependency on aid during last decade.

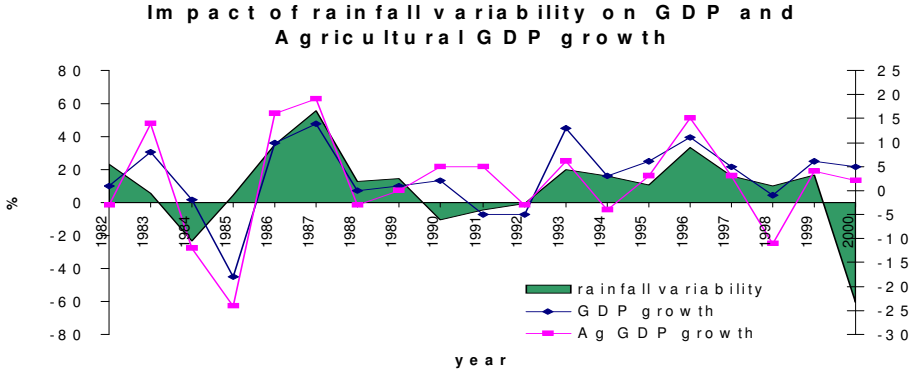

Figure 5. Impact of Rainfall variability on Ethiopian GDP and Agricultural GDP.

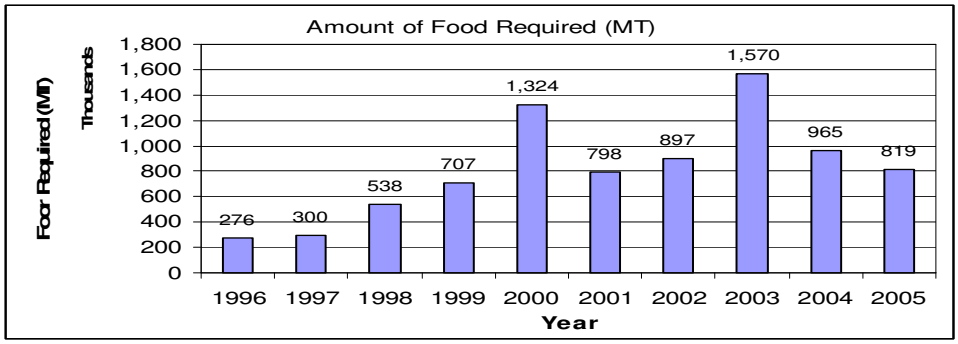

Figure 6. Drought and disaster related food aid import to Ethiopia.

The other extreme, the consequence of 2003 flood has cost Kenya about 2.4 billion USD (Grey and Sadoff, 2004), and recurrent drought and flood put millions of East African population dependent on food aid.

2.4. High economic scarcity of water

As shown in figure 7, most SSA countries are faced with economic water scarcity, lacking the financial or human capital to adequately develop their water resources (Molden, 2007).

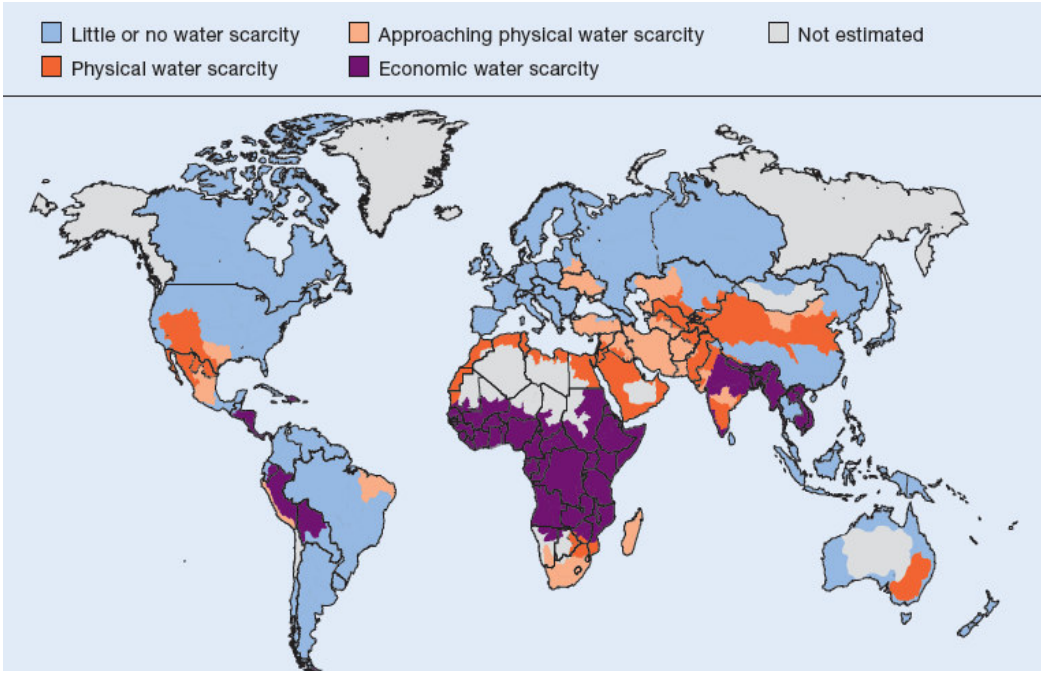

Figure 7. Water scarcity map of the world.

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 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 sub-Saharan Africa. Per capita water withdrawal in sub-Saharan Africa is the lowest of any region in the world, being just one-fourth of the global average. In fact, Lautze and Giordano (2007) point out that the region with the second lowest water withdrawal per capita, Southeast Asia and the Pacific, uses approximately twice the water per person while more developed regions such as North America and Europe withdraw more than five times as much. Africa also has the lowest levels of per capita storage (Sadoff and Grey, 2002), which limits its ability to withdraw water for beneficial uses in irrigation, hydro-electric power, municipalities and industry.

2.5. Inadequate and declining infrastructure and irrigation investment in Africa

No doubt that irrigation and investment in water infrastructure have transformed the socio-economy of many countries through increasing productivity, mechanization and modernization of agriculture, enhancing agro-industries, enabling green revolution, etc. The last 50 years have seen remarkable developments in water resources and in agriculture. Massive developments in hydraulic infrastructure have put water at the service of people. While the world population grew from 2.5 billion in 1950 to 6.5 billion today, the irrigated area doubled and water withdrawals tripled (Molden, 2007). Figure 8, obtained from the Comprehensive Assessment of Water Management for Agriculture (Molden, 2007), shows trends in irrigation investment by the World Bank, food price and overall irrigation development in the world. It must be pointed out that food prices are showing a worrying upward trend in the past few years.

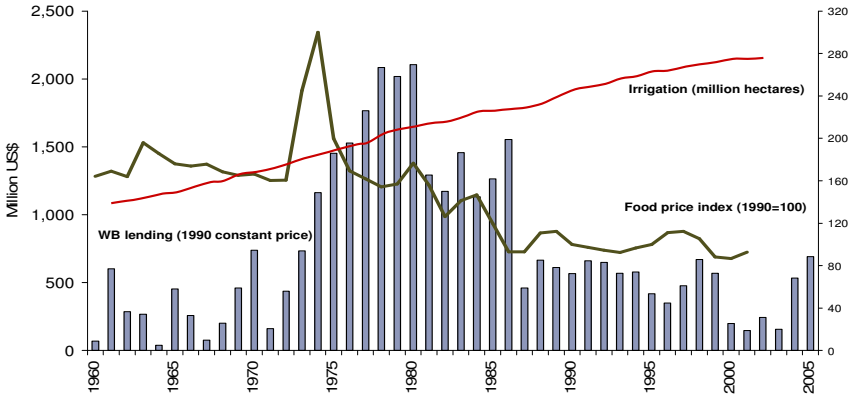

Figure 8. Expansion of irrigation and food prices (Molden, 2007).

Since the 1980s, the focus of investment has shifted from new infrastructure to rehabilitation and institutional reform. However, there is now a revival of interest in investments in agricultural water management in a broader, integrated framework that includes poverty reduction and natural resources management (World Bank, 2006c)

Sub-Saharan Africa never benefited from the Green Revolution of the 1960s and 1970s with high-yielding crop varieties, irrigation, fertilizers, and pest management (Rockstrom et al., 2007). Africa has missed the past opportunity during the major investment and many pessimist views argue that it is not possible to repeat a green revolution in Africa, which is not acceptable.

3. Potentials and Opportunities for Improving Water Infrastructure for Land and Water Management

3.1 General

Availability of sound infrastructure can make major contributions to uplifting African economies. Road and transport facilities to enable marketing of products; efficient communications; better access to improved energy sources to enable manufacturing, processing and value adding of products; better water infrastructure for improved water control and management not only to meet daily requirements, safe access and increase productivity but also to provide security against extreme and variable hydrological events (droughts and floods).

What should be new now among others is the emphasis on 'investments in water.' Although it will become clear quickly that there is no such thing as investing in 'water only', articulating it this way does help to focus upon the issue. Physical and economic scarcity of water is very common and is a growing problem in Africa. Although it is not a magical single-factor solution, investments in water combined with complementary policies (for example, to encourage private enterprises) and other infrastructure (roads and communications) can bring to the rural and peri-urban poor a significant improvement in household food security, poverty relief and economic growth. The impact of investments in water will also be far greater, if accompanied by investments in other sectors, (such as roads, communications and health and by appropriate policies effectively implemented) and vice versa.

Although there is no argument that Africa needs investment, it is important to look at the potential and scope of enhancing physical capital related to water infrastructure, and the following sections focus on three areas: upgrading rainfed systems, irrigation development and hydropower development as examples of physical capital related to some of the water infrastructures.

3.2 Potential for Upgrading Rainfed Systems

SSA agriculture is dependent on rainfed agriculture and is vulnerable to rainfall variability, with more than 90% of the food crops in SSA being rainfed. Better management of rainwater, soil moisture, and supplemental irrigation is the key to helping the greatest number of poor people, for three main reasons (Molden, 2007): it cuts the yield losses from dry spells, which claims one of every five harvests in SSA; it gives farmers the security they need to invest in other inputs such as fertilizers and high yielding varieties; it allows farmers to grow higher value market crops such as vegetable and fruits and to move away from low value staple foods. Management of rainfall and agricultural water in a holistic way is a key requirement for improvements in crop and livestock productivity under conditions of extreme rainfall variability.

Rainfed agriculture is upgraded by improving soil moisture conservation and providing supplemental irrigation. These techniques hold great potential for quickly lifting large numbers of people out of poverty and for improving water productivity in sub-Saharan Africa

(Molden, 2007). Thus, upgrading rainfed system requires proper management of rainfall in terms of capturing, storing, availing to crop, plan and other uses.

3.3 Potential for Irrigation Development

In addition to upgrading the rainfed system there are strong reasons to develop the irrigation sector in SSA. Irrigation can increase productivity of land and labor, can curtail expansion of agricultural land to marginal areas and minimize environmental and natural resources degradation. Irrigated systems also significantly reduce chronic poverty (Hussein, 2004). Without intensification of agriculture, such as through irrigated agriculture, many countries face huge challenges to cope with population growth. Irrigation reduces reliance on rainfall and mitigates the consequences of its variability; it also provides opportunities for high value crops and export markets, creates more job opportunities and fosters rural entrepreneurship and a more vibrant economy through forward and backward linkages.

A recent study by Inocencio et al. (2007) showed that irrigation is not uniquely expensive in Africa. Cost of irrigation in Africa can be comparable with those in Asia. Simply put, the average unit costs of "success" projects in sub-Saharan Africa are comparable with the averages for the non-SSA regions while the "failure" projects are significantly more expensive, so that they inflate the "average" for the region. The popular view that irrigation projects in sub-Saharan Africa are more expensive has to be properly understood and put into context if we are to move forward and develop sound and attractive irrigation investments.

Africa has a large untapped potential of irrigation. FAO (2005) shows that only a small share of the potentially irrigable area of 39.4 million hectares has been developed in sub-Saharan Africa. Overall, 185 million ha of area is under cultivation in Africa, of which 6% or about 12 million is under irrigation. This proportion is very much lower for SSA if the irrigation development of North African countries is not taken into account.

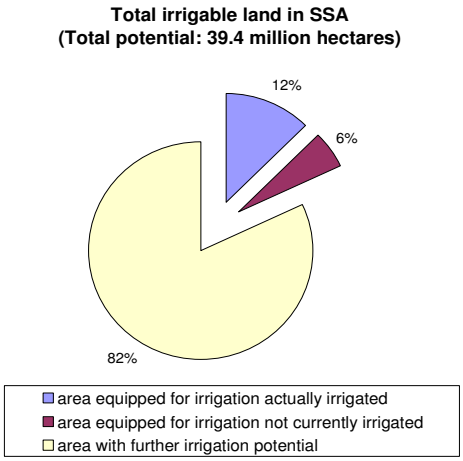

Figure 9. Total irrigable area in SSA (Source FAO, 2005).

In order to upgrade rainfed and irrigated agriculture in Africa, agricultural water management approaches ranging from field water conservation to full irrigation through improved water control and management supported by infrastructure.

3.4 Potential in Water-Energy Development

Africa has abundant energy resources (oil, coal, natural gas, hydro, biomass and other renewable sources) but these are unevenly distributed. While some countries are major exporters of oil and gas, access to energy services in sub-Saharan Africa is the lowest in the world: More than 600 million Africans still rely on traditional biomass as their main source of energy and are subject to the daily drudgery of fuel collection, health effects of smoke inhalation, as well other economic, social and environmental repercussions. About 500 million people in Africa have no access to electricity. The present trend is not encouraging: at current population growth rates, more than 60% of sub-Saharan Africans would still lack access to electricity in 2020 (BMZ, 2007a). Per capita electricity consumption in East Africa is as low as 18KWh per year in Burundi and reaches a maximum of 119.7 kWh in Kenya.

Rising fuel costs and increasing concerns over the effects of climate change are reinvigorating the policy-makers' interest in renewable energy sources such as hydropower and bio-energy. Development of any of these sources has the potential to generate positive economic and environmental benefits, yet, at the same time, they can cause negative food and equity impacts (McCornick et al., 2007).

Development of hydro-electric power, especially when combined with other sectors such as irrigation, flood protection, drought resilience, can yield attractive returns on investments in water infrastructure. The following figure (BMZ, 2007b) shows the hydropower usage as compared to the potential and the data for the 10 countries having the highest hydropower potential.

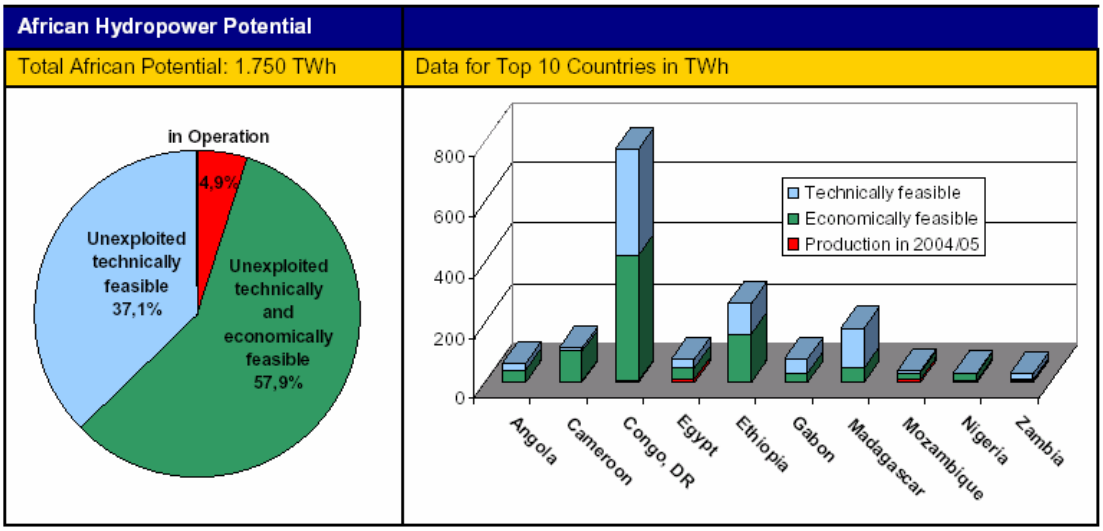

Figure 10. Hydropower outlook for Africa (BMZ, EUDEV, 2007).

For example, in Ethiopia, the economically exploitable hydropower potential is reckoned at 30,000 MW whereas actually developed capacity so far is only 667 MW (Beyene & Abebe, 2006). As a result, only 17% of the population, mainly in urban areas, has access to electricity. Low coverage and poor quality of power also cause heavy economic losses. For instance, during the drought of 2002-03, it is estimated that each day of lost service reduced the GDP for that day by up to 15% (World Bank, 2006b).

Equally serious are the environmental consequences of the present energy composition. Due to intensive biomass exploitation, for example in Ethiopia, it is reported that only less than 3% of the natural forest remains at present. Siltation from land degradations has led to the storage loss of Koka reservoir (World Bank, 2006) and to date, more than 30% of the total volume has been lost to sedimentation (Michael, 2004). Degraded catchments, on the other hand, have exacerbated the risk of extreme events (droughts and floods) and biodiversity loss (Taddesse et al., 2004). Recent developments on the other hand are encouraging in terms of transforming energy source from traditional to modern source and plans to increase access to rural populations, such as the recently launched Universal Electricity and Access Program and the start of three projects with a combined capacity of 1,180 MW. There are also ambitious plans to develop hydropower (and other energy sources) to both meet domestic needs, and to export electricity to Djibouti, Kenya, Sudan and Egypt (World Bank, 2006; McCornick et al., 2007).

An important precaution in regard to investment in infrastructure is to fully consider the possible environmental impacts. Large, capital-intensive infrastructure systems with high gestation period, in particular, unless properly planned can not only adversely affect the environment and the livelihoods of people but also diminish returns to investments.

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 dams are planned and managed in isolation from other developments occurring in a river basin.

4. Conclusions

Africa is endowed with a good natural resource base. Transforming the natural capital to appropriate physical capital and infrastructure to support sustainable social and economic growth also requires the development of other capitals and assets. Investment in physical capital is impossible unless there is financial capital to invest and human capital to enable the investment and manage the capital itself, and social capital to synergize the traditional norms, beliefs and practices with modern concepts and technologies.

Given the comparatively low levels of per capita water withdrawals and storage in sub-Saharan Africa, there is significant scope for investing in water infrastructure as a means of ensuring water and food security. Developing SSA's water resources offers opportunities to stabilize agricultural output, improve land and water productivity, mitigate the region's vulnerability to climate variability and the associated damage caused by extreme events (floods and droughts), and overcome its high and persistent levels of poverty. Improving poor people's access to water for domestic and productive purposes also uplifts levels of health and sanitation and brings the region closer to attaining the MDGs.

Investment in the development of appropriate physical capital, while necessary for improving SSA's water and food security, is not sufficient. In order to derive optimum returns, the infrastructure put in place has to be properly managed and maintained. The transboundary nature of much of the continent's waters sometimes poses special governance challenges in this regard. Moreover, water resources development alone will not resolve all the region's problems. Investments in transport infrastructure, market outlets, technology transfer, and human capacity building will enhance prospects for growth and economic development.

The disappointing results of many existing agricultural water investments resulted in a shift in investment policy in the last two to three decades, away from new infrastructure development towards initiatives favoring the improvements in the management and performance of existing investments. Greater emphasis on natural resources management and environmental conservation, notably on the part of donor countries and agencies, may have also contributed to a slowing down of water resources development in SSA.

While it is true that investment decisions in physical capital and infrastructure in SSA should benefit from experiences and lessons of the developed world, the value of local and regional priorities and concerns must also be recognized, especially in the context of the low levels of water development prevalent in SSA.

References

AfDB, FAO, IFAD, IWMI and World Bank. 2007. Investment in Agricultural Water for Poverty Reduction and Economic Growth in Sub-Saharan Africa: A collaborative programme. Synthesis report, August 2, 2007. 162 pp.

Africa Water Task Force. 2002. Water and sustainable development in Africa: An African position paper. Pretoria, South Africa: IWMI.

Beyene, T, and Abebe, M (2006) Potential and development plans in Ethiopia. Hydropower and Dams, Issue Six, 2006.

BMZ. 2007a. German EU Presidency – Commission Joint Background Paper on energy cooperation between Africa and Europe.

BMZ (Federal Ministry for Cooperation and Development). 2007b. Note to CODEV: Hydropower Outlook for Africa.
http://www.consilium.europa.eu/ueDocs/cms_Data/docs/pressData/en/gena/94068.pdf

EDPPC (Ethiopia Disaster Prevention and Preparedness Commission). 2006. Data on Population in need of food aid. Unpublished report.

FAO, 2005. Riddell, P.J., Westlake M. and Burke J.J. 2005. Demand for products of irrigated agriculture in sub-Saharan Africa. Rome. (Component report for Collaborative Program).

FAO, 2003. Bruinsma, J., ed. 2003. World agriculture: towards 2015/2030: An FAO perspective. London, Earthscan Publications Ltd.

Hussein, I. 2004. Pro-poor intervention strategies in irrigated agriculture in Asia: Poverty in irrigated agriculture. Realities, issues, options, and guidelines. India, Pakistan, Bangladesh, China, Indonesia, Vietnam. Colombo: International Water Management Institute.

Inocencio, A., Kikuchi, M., Tonosaki, M., Maruyama, A., Merrey, D., Sally, H. and I. de Jong. 2007. Costs and Performance of Irrigation Projects: A Comparison of Sub-Saharan Africa and Other Developing Regions. IWMI Research Report 109, 86 p.

Lautze, J., and Giordano, M. 2007. Managing transboundary waters in extreme environments: The role of international actors in Africa

Lean, G. 2007. Water Supply and Sanitation. Our Planet and http://www.ourplanet.com/txtversn/144/glance.html.

McCornick, P., Awulachew, S.B., Abebe, M. 2008. Water–food–energy–environment synergies and tradeoffs: major issues and case studies. Water Policy **2008 - 10 - 1 – SUPPL.** PP23-37. IWA Publishing

McCartney, M. and Sally, H. (2005) Managing the environmental impact of large dams in Africa. In: Lankford, B.A. and Mahoo, H.F. (eds). Proceedings of the East Africa Integrated River Basin Management Conference, 7th – 9th March 2005, Sokoine University of Agriculture, Morogoro, Tanzania. 151-159.

Michael A. (2004), Lesson Learned from Existing Hydro Schemes , Case Study: Koka Dam, First National Water Forum Conference Proceeding Paper (pp 49-58), Ministry of Water Resources, Addis Ababa , Ethiopia

MOFED (Ministry of Finance and Economic Development). 2006. Ethiopia: Building on Progress. A Plan for Accelerated and Sustained Development to End Poverty (PASDEP), Volume I: Main Text. Unpublished Report.

Molden, D. (2007). Comprehensive Assessment of Water Management in Agriculture. 2007. *Water for Food, Water for Life: A Comprehensive Assessment of Water Management in Agriculture.* London: Earthscan, and Colombo: International Water Management Institute.

Rockstrom, J. Lannerstand, M. and Falkenmark M. (2007). Assessing the water challenge of a new green revolution in developing countries, PNAS, April 2007. www.pnas.org#otherarticles.

New Partnership for Africa's Development (NEPAD). 2003. Comprehensive Africa Agriculture Development Program (CAADP). Midrand, South Africa: NEPAD.

UN Millennium Project. 2005. Halving global hunger: It can be done. Summary version of the report of the Task Force on Hunger. New York, USA: The Earth Institute at Columbia University.

Rijsberman, F. 2006. What Can Water Science and Technology do for Africa. International Water Management Institute

SAAP Support for African Agriculture Project, 2007. http://www.oecd.org/document/1/0,3343,en_2649_33797_37359297_1_1_1_1,00.html

Sadoff, C. and Grey, D., 2002. Beyond the river: the benefits of cooperation on international rivers, Water Policy 4, 389-403

Taddesse, G., P. G. McCornick, and D. Peden. 2004. Economic Importance and Environmental Challenges of the Awash River Basin in Ethiopia. Peer reviewed proceedings of Water Rights and Related Water Supply Issues, Water Management Conference (October 13-16, 2004), United States Committee on Irrigation and Drainage, Salt Lake City, Utah.

Torero, M. and Chowdhury, S. 2004. Increasing Infrastructure's Access to African Rural Poor, Assuring Food and Nutrition Security in Africa by 2020: Prioritizing Actions, Strengthening Actors, and Facilitating Partnerships," held in Kampala, Uganda,April 1-3, 2004.

UN Millennium Project. 2005. Halving global hunger: It can be done. Summary version of the report of the Task Force on Hunger. New York, USA: The Earth Institute at Columbia University.

Walling, D.E., 1996. Hydrology and Rivers. In: W. Adams, A. Goudie and A. Orme (Editors), The Physical Geography of Africa. Oxford University Press, Oxford. 103-121.

Winpenny, J. 2003. Financing Water for All. Report of the World Panel on Financing Water Infrastructure.

World Bank 2002. China Country Water Assistance Strategy.

World Bank. 2003. *Source book for agricultural investments*. Draft, December 2003.

World Bank 2006a. Africa Development Indicators 2006. International Bank for Reconstruction and Development. Washington DC

World Bank 2006b. Ethiopia: Managing Water Resources to Maximize Sustainable Growth: Country Water Resources Assistance Strategy. The World Bank, Washington DC.

World Bank 2006c. Reengaging in Agricultural Water Management: *Challenges and Options.* The International Bank for Reconstruction and Development, Washington, DC

World Bank, 2007a. Improving Irrigation Project Planning and Implementation Processes in Sub-Saharan Africa: Diagnosis and Recommendations, Synthesis Report. Washington DC.

World Bank, 2007b.Infrastructure: meeting an increased demand from developing countries, http://web.worldbank.org/WBSITE/EXTERNAL/NEWS/0,,contentMDK:20127296~menuPK:34480~pagePK:34370~theSitePK:4607,00.html