New Issues in Security #5

CRITICAL ENVIRONMENTAL SECURITY: RETHINKING THE LINKS BETWEEN NATURAL RESOURCES AND POLITICAL VIOLENCE

Edited by

Matthew A. Schnurr and Larry A. Swatuk

Centre for Foreign Policy Studies
Dalhousie University
2010

CHAPTER 6
WATER AND HUMAN SECURITY IN AFRICA

*Larry Swatuk and Dominic Mazvimavi**

Introduction

Water plays a central role in promoting or impairing human security. "Reliable access to enough safe water at an affordable price … while maintaining the ecological systems that provide water and also depend on water" is the basis for each individual's ability "to lead a healthy, dignified and productive life." However, "when these conditions are not met, or when access to water is disrupted, people face acute human security risks transmitted through poor health and the disruption of livelihoods."[1] Today we face a growing world water crisis. Despite there being more than enough water to satisfy all human uses, and despite the fact that household water use constitutes less than 5% of total world water use, more than 1.1 billion people lack access to an improved water supply and more than 2.6 billion lack access to improved sanitation.[2] It is commonly said that 'water is life,' however, using water of poor quality is a deadly practice. More than 1.8 million children worldwide die each year from diarrhoea. Data shows that more than one-half of all people in developing countries suffer water and sanitation deficiency-related health problems, creating "lifecycle disadvantages."[3]

Comparative aggregate data show that access to sufficient water and sanitation varies directly with the economic wealth of states. High income Organization for Economic Cooperation and Development (OECD) states have universal coverage in both categories. Sub-Saharan Africa's (SSA) averages are 37% access to sanitation and 56% access to improved water supply, the latter figure actually below the average (59%) for all least-developed countries. Individual SSA states vary widely across these averages (see Table 1 below for a cross-section).

Table 1: Access to Water and Sanitation in Sub-Saharan Africa: Select Country Data

State	Human Development Index ranking (2006)	% access to sustainable improved sanitation (2004)	% access to sustainable improved water supply (2004)	Total Population (millions) (2004)	% population urban (2004)
Medium Human Development					
Cape Verde	106	43	80	0.5	56.6
Equatorial Guinea	120	53	43	0.5	38.9
South Africa	121	65	88	47.2	58.8
Botswana	131	42	95	1.8	56.6
Ghana	136	18	75	21.7	47.1
Congo	140	27	58	3.9	59.8
Swaziland	146	48	62	1.0	23.9
Low Human Development					
Kenya	152	43	61	33.5	20.4
Nigeria	159	40	48	160.9	23.4
Malawi	166	61	73	12.6	16.7
Ethiopia	170	13	22	75.6	15.7
Mali	175	46	50	13.1	36.5

Source: United Nations Development Program (UNDP), Human Development Report, 2006, Tables 5 and 7.

At current rates, it is estimated that SSA will reach its Millennium Development Goal targets of halving the number of people without access to both a sustainable source of water and a sustainable source of improved sanitation by 2040 and 2076 respectively, so condemning several more generations to both water and human insecurity.[4]

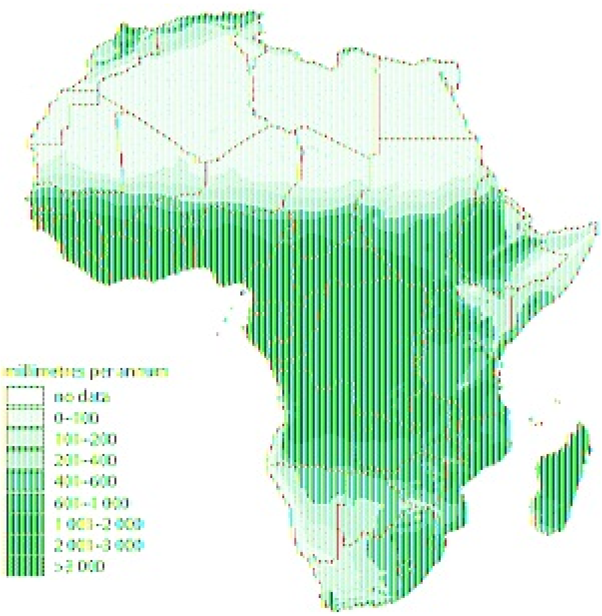
The complex and interrelated problems of water and human insecurities in sub-Saharan Africa are only partly a function of local and regional hydrological cycles. More significant, in our view, is the impact of the socio-political and socio-economic structures created and political choices made over the last 150 years.[5] This paper highlights contemporary challenges to achieving water security in SSA across several key issue areas.

The next two sections of this paper set the context, first by presenting an overview of water resources in Africa, and then by describing the historical legacy of water management on the continent. The next sections focus on key issue areas: water for cities; water for food; and the legal and institutional basis for water management on the continent. The final section presents the conclusion.

Water Resources in Africa

Water resources and their availability vary greatly both spatially and temporally across the length and breadth of the African continent. We can imagine the continent's dominant climate zones as a series of bands radiating outward from a central core (Figure 1). The central core (West/Central Africa) is the humid region with average annual rainfall greater than 1,600 mm/year and occurring throughout the year. Surrounding this core is the sub-humid region with distinct wet and dry seasons and average rainfall of 800 to 1,600 mm/year. Substantial rainfall in the rainy season(s) is offset by almost no precipitation during the dry season(s). Beyond the sub-humid region are the semi-arid regions (the savannas), with average rainfall of 400 to 800 mm/year. Rainfall has a high inter-annual variability with the coefficient of variation being greater than 30%. Africa is also home to extensive desert regions, or arid to hyper-arid zones: the Sahara in the north; and the Namib-Kalahari in the south. The extreme northern part of Africa and some of the areas at high altitude such as the Ethiopian highlands have a temperate climate.

Figure 1: Variation of Average Annual Rainfall (mm/year) in Africa



Source: Food and Agricultural Organization, available at http://www.unep.org/dewa/Africa/publications/aeo-1/032.htm.

The seasonal variation of rainfall in Africa is due to the annual north-south migration of the Intertropical Convergence Zone (ITCZ). Inter-annual variation of rainfall is partly explained by the occurrence of El Nino events. Warm El Nino events are associated with high rainfall in the equatorial east African region during the short October-November rainy season, and low (high)[6] rainfall in southern Africa during the November-February rainy season. There is evidence of multi-decadal variability of rainfall throughout Africa. Thus the 1950s were generally wet, 1960s generally dry, and the 1980s generally dry throughout Africa. Multi-decadal variability seems to be partly influenced by sea surface temperature in both the tropical Atlantic and Indian Oceans.**7** Years with generally wet conditions are associated with low sea surface temperatures, while warm temperatures tend to result in low rainfall.

Most parts of Africa are located within the tropical region, receiving large amounts of solar radiation, resulting in warm to high temperatures. This abundance of solar radiation and generally high temperatures, together with low humidity through most parts of Africa, results in very high evaporation rates. Annual average reference evapotranspiration rates vary from 1,000-1,400 mm/year in the humid equatorial region, 1,400-2,000 mm/year in the semi-arid region, to 2,000-3,000 mm/year in the arid regions. Evapotranspiration rates exceed rainfall during most of the months in the semi-arid region which restricts successful production of rain-fed crops. High evapotranspiration rates cause significant loss of water from surface water bodies. It is estimated that 80% of the rain falling over Africa returns to the atmosphere through evapotranspiration.[8] The combination of highly seasonal rainfall and high evapotranspiration rates results in most rivers drying up during the dry season, which limits the amount of water available for human and wildlife use. The proportion of rainfall forming runoff, the runoff coefficient, generally varies from 1% in the arid deserts, 5-20% in the semi-arid region, to 20-50% in the humid equatorial region.[9] Thus the annually renewable water resources are variable throughout Africa. The central African region in which the Congo River basin is located, has mean annual runoff equivalent to 359 mm/year and accounts for 48% of the surface water resources of Africa (Table 2), while north Africa has a very low mean annual runoff, 9 mm/year. The per capita annual renewable water resources for the North African region is 346 m^3/year. All the north African countries have internal renewable water resources of less than 500 m^3/capita/year (Figure 2) and are considered to experience absolute water scarcity. The Sudano-Sahelian region also has very low values of runoff at 19 mm/year. Countries in the Horn of Africa have internally renewable surface water resources of 501-1,000 m^3/capita/year and are considered to be within a water scarce category. The southern Africa region has a mean annual runoff of 57 mm/year, and the annually renewable water resources range from 1,000-2,000 m^3/capita/year for most countries (Figure 2).

Table 2: Surface Water Resources in the Sub-Regions of Africa

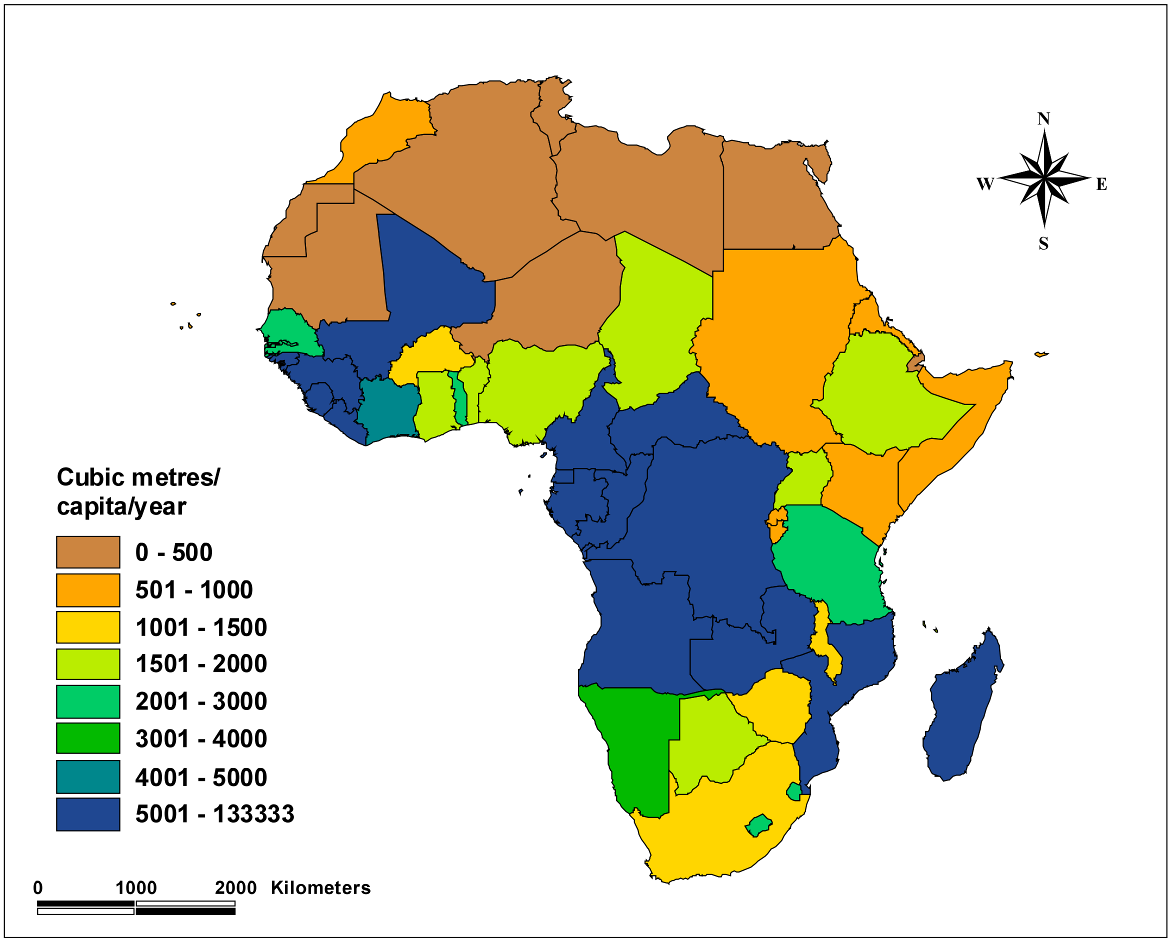
Region	Area (km^2)	Runoff (km^3/year)	% of Total Runoff	Runoff (mm/year)	Water/capita/ year
Central Africa	5,328,660	1,912	48	359	21,849
Eastern Africa	2,924,970	260	7	89	1,567
Gulf of Guinea	2,119,270	952	24	449	5,388
Indian Oceans Islands	594,270	345	9	581	18,533
Northern Africa	5,752,890	50	1	9	346
Southern Africa	4,738,520	271	7	57	2,653
Sudano-Sahelian	8,587,030	160	4	19	1,609
Africa	30,045,610	3,950	100	131	4,979

Source: Food and Agricultural Organization (FAO), 2003.

Groundwater is particularly important for water security in Africa where the majority of the population lives in small and dispersed settlements in rural areas. The provision of water to most of these dispersed rural populations from surface water bodies is not economically viable due to the costs of installing and maintaining water treatment and distribution systems. Groundwater, however, has several advantages with regard to the provision of potable water to rural populations in Africa. It generally lacks microbiological contamination and therefore does not require investment in water treatment systems. Furthermore, groundwater is often locally available to supply these dispersed rural population. During times of drought, groundwater is often the only available resource in rural areas. The availability of groundwater mainly depends on the nature of the geology of an area. The geological formations of Africa can be classified into the following categories for the purpose of describing the potential for groundwater occurrence:

1. Precambrian basement complex consisting of crystalline and metamorphic rocks;
2. volcanic rocks;
3. consolidated sediments; and
4. unconsolidated sediments.[10]

Figure 2: Availability of Internal Renewable Surface Water Resources per Capita per Year in Africa



Source: Produced from data obtained from Food and Agricultural Organization, 2003.

Crystalline and metamorphic rocks of the basement complex occupy about a third of Africa, and are generally inherently impermeable. Groundwater only occurs where these rocks have been weathered and fractured with the depth of weathering greatly determining the yield of aquifers. The depth of weathering tends to be a few metres in arid regions and as deep as 90 m in humid regions.[11] The amount of water available increases with the depth of weathering. Aquifers occurring within the basement complex are generally capable of supporting water supply systems for rural domestic water use and small-scale irrigation. Volcanic rocks occur in east Africa mostly in Kenya, Sudan and Ethiopia. Aquifers tend to occur in fractures zones between laval flows, and can support water supply for rural domestic use and small scale irrigation.

Consolidated sediments mainly comprise sandstone, limestone, siltstone and mudstone and occupy about 32% of the land area in sub-Saharan Africa.[12] The Karoo and Kalahari sediments in southern Africa are some of the important formations in this category. Sandstones generally contain aquifers with very large amounts of water. The Nubian sandstone aquifer underlies Chad, Libya, Sudan and Egypt, and is estimated to be two million square kilometres (km^2) in area and contains approximately 150,000 cubic kilometres (km^3) of fossil water, laid down 30,000 years ago during the last ice age.[13] Fractured limestone has the potential to store also large amounts of water. The most productive aquifers occur in unconsolidated sediments which occupy large areas of Chad, Democratic Republic of Congo, as well as the coastal areas of Nigeria, Namibia and Kenya.

The Historical Context

The negative impact of colonialism and imperialism on Africa's development trajectory should not be under-estimated. The role of the colonial state and the imperial project was to re-articulate African political economies to serve the needs and interests of Europeans.[14] The role of the colonial and indeed the post-colonial city was to facilitate extraction of resources through concentration of activities – at mining heads, trading posts and ocean ports. These interconnected nodes supplanted older African patterns of movement and interaction. Like water running in the vast majority of rivers, African resources rose in the interior and flowed toward the coasts. Unlike the hydrological cycle, wherein the rivers are perennially replenished, the resource-extraction cycle is largely non-renewable in the case of minerals, or erratic and unevenly spread in the case of cash crops. As with Africa's natural resources, so with its peoples: land alienation and forced migration through colonial taxation policies cleared early pathways to the colonial cities. Put differently, colonialism's primary impact was to turn pre-colonial African political economies inside-out, and to turn Africans into servants of budding European industrialization. Even as late as 1965, 95% of African exports were of primary commodities destined for Europe.[15] Ten years later, in 1975, 52.2% of all foreign direct investment (FDI) was invested in the primary sector, and 32.3% in the secondary sector compared to 26.5% of FDI in primary and 53.2% of FDI in secondary sectors in all developing states.[16] Thirty years later, Africa is undergoing yet another 'scramble' for its resources in the wake of Chinese industrialization.[17]

Not only were the natural resources of the continent extracted to serve inter-imperial rivalries; water and land were turned to European service, thus severing, or perverting, the historical connection of Africans to the very basis of their livelihoods.[18] Water from the continent was exported through cash-crop production. J. Anthony Allan describes this as trade in "virtual water," i.e., the amount of water used in agricultural production.[19] Through colonialism, Africa became a net exporter of water to Europe, which therefore became a net importer of water.[20] Traditional management systems were overturned by colonial officials, or deliberately subverted by African leaders supportive of colonial/post-colonial interests. Sierra Leone presents an extreme example of this. According to Robert July, Sierra Leone's mineral rich terrain led many in Europe to believe that it would become "a major centre for the apostles of modernisation."[21] To this end, in 1935 the Sierra Leone Selection Trust (SLST) mining company was awarded a concession that consisted of the entire country! This was later reduced to 780 km^2 in 1956, but included vast areas of river, stream and swampland that originally had been key resources in village livelihoods.

Alongside the export and privatization of the continent's water resources for European wealth-creation was the role of surface water in defining the boundaries of colonial 'rights.' Surface waters make convenient borders. Globally, more than 45% of Earth's surface lies within an estimated 275 river basins that cross national boundaries. These basins are home to approximately 40% of the world's human population, and account for 60% of the total flow of the world's rivers.[22] Much of Africa is included in these statistics. There are an estimated 61 shared river and lake basins in Africa, some of which are listed in Table 3 below.

Table 3: Selected Transboundary Rivers in Africa

River/Lake Name	**Number of Countries Sharing the Basin**	**Remarks**	**Management Structures**
Nile	10	Africa's longest river at 6,700 km; basin covers 3 million km^2	Permanent Joint Technical Committee; Nile Basin Initiative
Niger	10	4,100 km in length and with the basin area being 1.47 million km^2	Niger Basin Authority
Congo	9	3,100 km in length; basin area is 3.7 million km^2 and receives 30% of Africa's total rainfall.	
Zambezi	8	3,000 km in length; Kariba and Cahora Bassa dams important for hydropower generation in southern Africa.	Zambezi River Authority; Zambezi Watercourse Commission
Senegal	4	1,050 km in length; 0.5 million km^2	Senegal River Development Organisation
Gambia	4	The country of Gambia consists mainly of the lower portion of the river, so making it the ultimate 'downstream' riparian	Gambia River Basin Development Organisation
Volta	6	Lake Volta behind the Akosombo Dam is the largest reservoir by surface area in the world	Volta Basin Authority
Mano	3	Cote d'Ivoire soon to become fourth member joining Liberia, Sierra Leone and Guinea	Mano River Union

Kagera	4	Tributary of Nile through Lake Victoria; hydropower project planned at Rusumo Falls	Kagera Basin Organisation
Shebelle-Juba	3	The Shebelle flows from Ethiopia to Somalia, reaching the Juba in good rainy season years	
Lake Victoria	5	2nd largest freshwater lake in the world	Lake Victoria Basin Commission; Lake Victoria Fisheries Organisation
Lake Malawi/Nyasa	3	Most species-rich lake in the world	Lake Malawi/Niassa/Nyasa Basin Commission
Lake Chad	5	Has shrunk from 25,000 km^2 to roughly 1,250 km^2 due to human overuse and mismanagement	Lake Chad Basin Commission
Okavango	3	Basin covers about 1% of Africa's land surface but virtually pristine	Okavango River Basin Commission
Limpopo	4	Heavily utilized by South Africa	Limpopo River Basin Commission
Orange-Senqu	4	Covers 3% of Africa's land surface; heavily utilized by South Africa	Orange-Senqu River Basin Commission

According to data from Oregon State University, as of 2004, cooperative management initiatives were in existence or underway in only 15 shared basins, leaving 46 without any formal initiatives. This is not unusual. As recently as 2002, worldwide "158 international river basins lack[ed] any type of cooperative management framework."[23] According to Heather Cooley et al., "[a]n overwhelming 43 international river basins where transboundary floods were frequent during the period 1985-2005 lacked the institutional capacity for managing these events."[24] In Africa, many of the agreements that do exist are treaties made by and for colonial powers.

Given water's central place in social organization and economic development, the colonial impact on Africa's water resources has been calamitous. Without doubt, African decision-makers had a hand in this.

Water for Cities

Africa's early-modern cities were relatively small, neo-European enclaves designed to serve the interests of a limited number of European traders, settlers and administrators.[25] During the post-

World War II rush to 'prepare' Africans for independence, various 'big push' projects, in particular building large dams for hydropower and water supply to the newly created capital cities were undertaken. Yet no one could anticipate the scale of the influx into these small cities, with Lagos being the most dramatic case in SSA: from 5,000 people in 1800 to 42,000 in 1900, 300,000 in 1950, 5.68 million in 1991, to somewhere around 8 million today.[26] All African primary cities have undergone similar processes and face similar pressures today.

The number of people living in African cities increased thirteenfold between 1950 and 2000, from 33 million to 417 million. An estimated 42.4% of Africans lived in cities in 2000, in contrast to only 14.9% 50 years earlier.[27] The growth of cities derives from three trends: in-migration; natural increases; and expansion of the urban space into the surrounding hinterland. The increasing physical expansion of Lagos, Nigeria, over most of the 20th century from about 3 km^2 in 1900 to 300 km^2 today is indicative of rapid urban growth in Africa. This growth reflects the city's changing role from a small fishing village to a 15th century Portuguese trading post, to an administrative/trading centre under British colonial rule, to the economic nerve-centre of politically independent west Africa.[28] Lagos is SSA's largest city today, with a population projected to rise to about 15 million by 2030.

In 1900, Africa had no cities with a population of one million. In 1950, there were two, and by 2000 the number of million cities had increased to 35.[29] As shown in Table 4 below, urban rates of growth are significantly higher than Africa's overall growth rates across all regions.

Table 4: Demographic, Social and Economic Indicators

Demographic, social and economic indicators

World and regional data	Total population (millions) (2009)	Projected population (millions) (2050)	Ave. pop. growth rate (%) (2005-2010)	% urban (2009)	Urban growth rate (2005-2010)	Population/ arable & perm. crop land	Total fertility rate (2009)	% births with skilled attendants	GNI per capita PPP$ (2007)	Expenditures/ primary student (% of GDP per capita)	Health expenditures, public (% of GDP)	External population assistance (US$,000)	Under-5 mortality M/F estimates (2005-2010)	Per capita energy consumption	Access to improved drinking water sources
World Total	6,829.4	9,150.0	1.2	50	2.0		2.54	66	9,947			8,766,710	71 / 71	1,820	
More developed regions	1,233.3	1,275.2	0.3	75	0.6		1.64	99					8 / 7		
Less developed regions	5,596.1	7,875.0	1.4	45	2.6		2.70	62					78 / 78		
Least developed countries	835.5	1,672.4	2.3	29	4.1		4.29	38	1,171				138 / 126	309	
Africa	1,009.9	1,998.5	2.3	40	3.4		4.52	49				3,179,335	142 / 130		
Eastern Africa	318.8	711.4	2.6	23	4.1		5.17	35				1,790,256	131 / 117		
Middle Africa	125.7	273.0	2.6	42	4.2		5.53	63				122,771	200 / 176		
Northern Africa	209.4	321.1	1.7	52	2.5		2.94	73				96,553	60 / 52		
Southern Africa	57.5	67.4	1.0	58	1.9		2.59	89				455,307	80 / 66		
Western Africa	298.6	625.6	2.5	44	3.9		5.14	42				531,575	169 / 163		

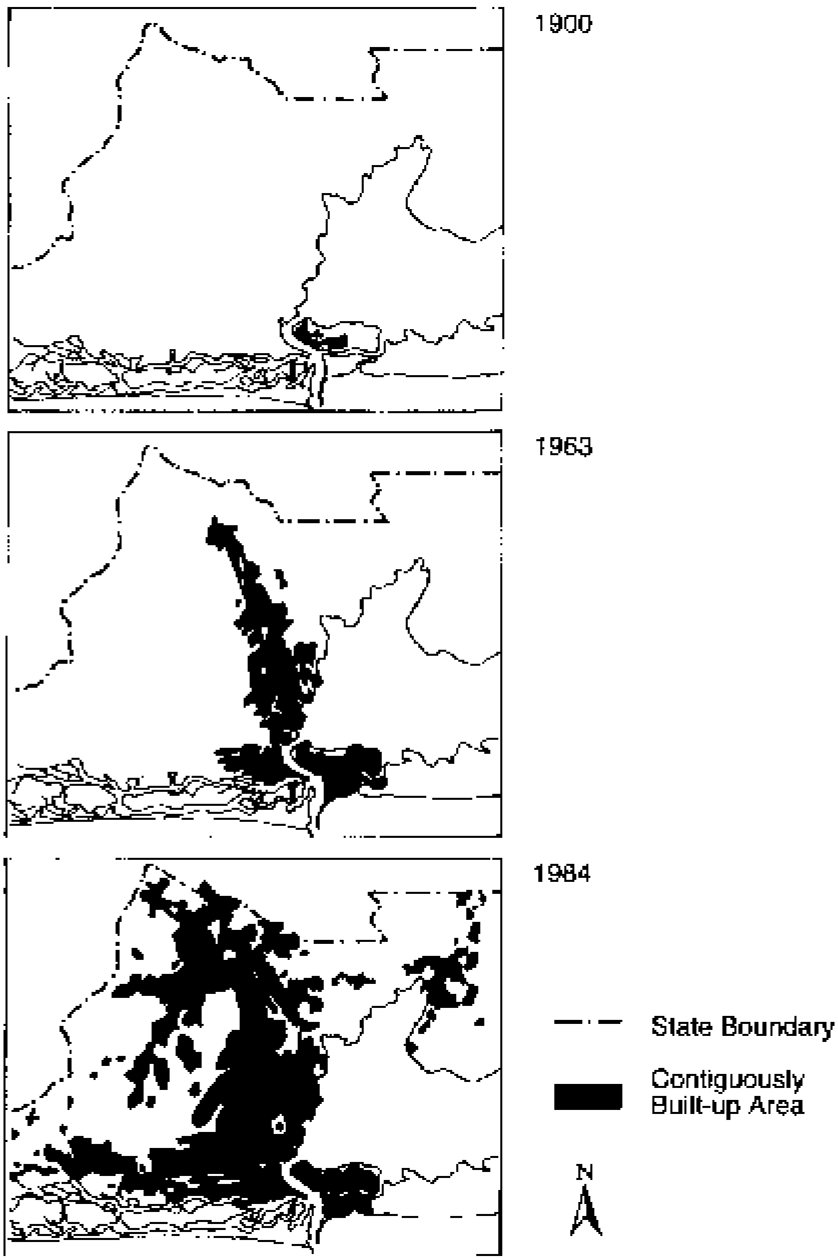
Source: UN Populations Fund, (UNFPA), "State of the World's Population," 2009, p. 91.

Africa's primary cities have extensive ecological footprints. They draw resources, capital and people from not only their own hinterlands, but from around the world. Without exception, Africa's capital cities account for between 33% (e.g., Accra, Lagos) and 100% (e.g., Banjul, Monrovia) of all manufacturing in their countries.[30] Many obtain their water and energy resources over long distances via complex systems of hydraulic infrastructure. These hydraulic works can dramatically alter social and environmental systems, as has happened in and around Africa's large dams. The general inability of cities to supply citizens with many basic services and the corresponding demand for fuel wood has led to localized deforestation, soil erosion, the siltation and pollution of surface and groundwater bodies and enhanced vulnerability to flooding.[31] As rural areas are deprived of the young and able-bodied, urban areas groan under the weight of their needs, so turning assets into potential liabilities through their everyday production of waste.

Part of the problem with water and other resource management issues in African cities is the fact that different residents are affected differently – not all people suffer equally, and water means very different things to different people. It is a common error to think that water flows solely along its hydraulic gradient, but more often than not, it flows toward money. In vastly unequal societies, where Gini coefficients of income inequality range between .45 and .64, water flows toward a fraction of the population. In a recent study, James Cullis and Barbara van Koppen demonstrate through the application of a Gini coefficient for water inequality in the Olifants River Basin of South Africa that water inequality almost perfectly mirrors income inequality.[32] Esther Dungumaro shows how income and access to water of sufficient quality and quantity vary directly.[33] Water is not an ordinary good – it exists in all things, transcending the very notion of 'sectoral' management.[34] Thus, water management is not easy in highly unequal societies where water itself is embedded in and facilitates such inequality. In settler societies, race-based economic development further complicated matters:

> Local institutional systems were designed to facilitate accumulation by capital, much of which was in foreign hands, by ensuring an environment conducive to business and the maintenance of lifestyles for European residents. This was achieved by infrastructure provision; by land-use planning in the parts of the settlement used for trade, administration, and European residence (and sometimes manufacturing); and also, in many settlements and by the public sector provision of housing for African residents. The urban spatial structure and built environment that resulted, reflected the underlying ideology of separate development, based on racially segregated residential areas and radically different standards of service provision and construction.[35]

Figure 3: Urban Sprawl in Lagos 1900 to 1984

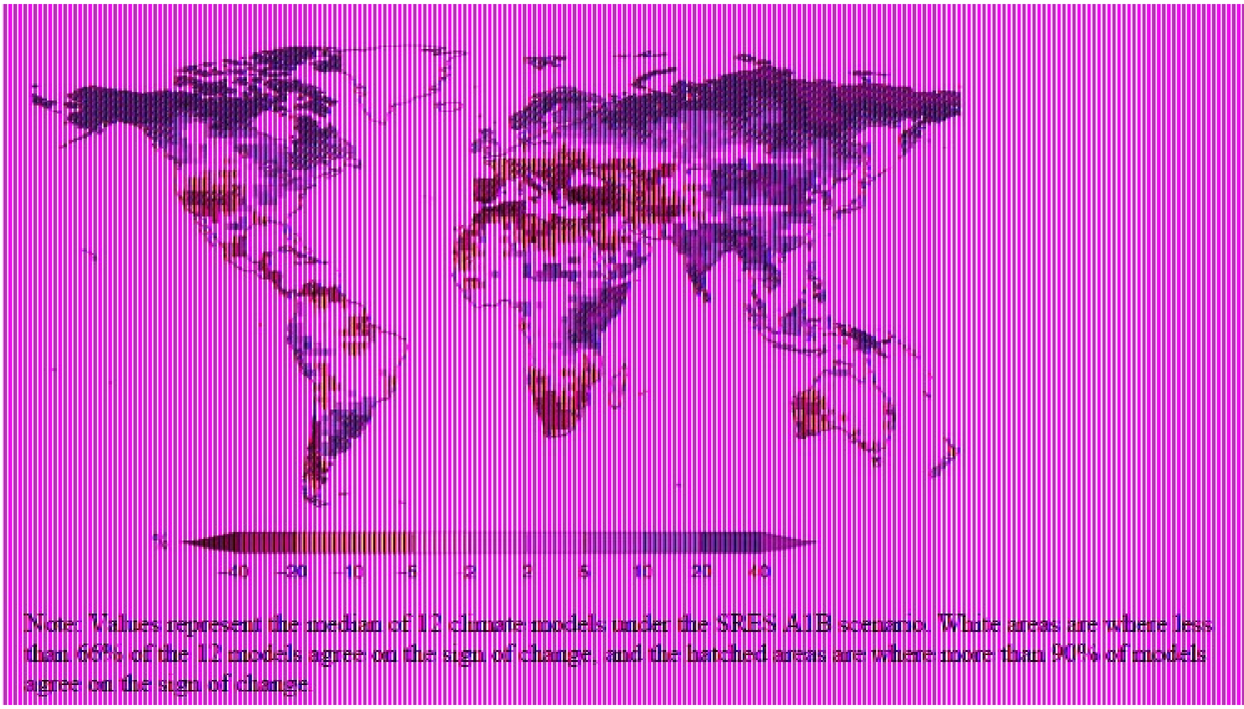


Source: Josephine Olu Abiodun, "The Challenges of Growth and Development in Metropolitan Lagos," in Carol Rakodi (ed.), *The Urban Challenges in Africa* (Tokyo: UN University Press, 1997), available at http://www.unu.edu/unupress/unupbooks/uu26ue/uu26ue0i.htm.

Across SSA, water and sanitation are presently adequate only in the low density suburbs, where both central and private systems of provision may be found.[36] Central Business Districts (CBDs) struggle to provide basic services for a number of reasons that vary from limited financial, technical and human resource capacity to illegal tapping of piped water and illegal, indiscriminate dumping of solid waste by both formal and informal businesses. Industrial parks generally enjoy regular (or as regular as possible) service but often flout a wide variety of laws thereby creating knock-on problems for themselves and others (e.g., by dumping untreated effluent into waterways).[37] The greatest problems of water and sanitation are experienced in the high-density areas of Africa's cities. Originally developed to house a limited number of urban workers, these areas are now densely filled with illegal buildings as add-ons to existing structures, and ringed by even denser squatter/informal settlements. For example, Sakubva is a high-density area built around 1910 to house labourers for the local industries of Mutare, Zimbabwe. At that time, a series of formal housing units (stand alone two- and three-room houses and one-room row housing) with public standpipes and toilet facilities were built for 3,000 or so people. By 2000 there were more than 50,000 people residing in this area, with all the attendant problems well-chronicled throughout the literature on urbanization in developing countries.[38] In many African cities, the story is the same, but the scale is more dramatic, often by a factor of 10 or 15: built environments designed for 30,000 people now hold half a million and more. Soweto, for example, is home to more than one million people.

Lastly, climate change poses extreme challenges to water resources management, not only in cities, but at the basin scale. Most of Africa's cities lie at either end of river systems: at coasts near the mouths of rivers, or in highland areas at river sources. Maarten De Wit and Jacek Stankiewicz show the dramatic potential effects of relatively small percentage changes in rainfall regimes due to climate change where, for example, a 10% decrease in rainfall would reduce total surface runoff by an estimated 22% in Johannesburg, South Africa, 19% in Harare, Zimbabwe, 36% in Dodoma, Tanzania, 48% in Dakar, Senegal and 25% in Algiers, Algeria.[39] Conversely, a 10% increase in rainfall would increase perennial drainage by 22% in Johannesburg, 19% in Harare, 36% in Dodoma, 48% in Dakar and 25% in Algiers. As shown in Figure 4 below, climate models tend to agree that by the end of this century a large percentage of Africa will be much drier, while significant parts of eastern Africa will see significant increases in rainfall. As cities continue to grow and as rural areas too suffer similarly under altered climatic regimes (so leading to further in-migration to major centres), the potential for large-scale social upheaval is real.

Figure 4: Large-Scale Relative Changes in Annual Runoff for the Period 2090-2099 Relative to 1980-1999



Source: Heather Cooley, J. Christian-Smith, P.H. Gleick, L. Allen, M. Cohen, *Understanding and Reducing the Risks of Climate Change for Transboundary Waters* (California: Pacific Institute, 2009), p. 12.

Water for Food

Africa's water-related challenges for food production span the continent's many biomes: rainfed and irrigated food crop production; freshwater fisheries management and aqua-culture; agro-pastoralism; forest and wetland food harvesting; and coastal fisheries management. Each of these activities competes with other uses – especially cash-crop production, industry, households and mining – for access to water resources of sufficient quantity and quality. Thus, the story of 'water for food' in Africa is inextricably tied to the story of development and underdevelopment, power and inequality, as partly described in the urban context above.

Irrigation uses the lion's share of water in the world. The world averages are in the order of 70-80% irrigation, 10-20% industry, 10-20% households in urban areas, with numerous variations such as Botswana, with very little arable land, which uses 43% of its withdrawn water for its towns and cities. Despite the extensive use of water in irrigation, "in 2003, 850 million people in the world were food insecure, 60% of them living in South Asia and SSA, and 70% of the poor live in rural areas. In SSA the number of food-insecure people rose from 125 million in 1980 to 200 million in 2000."[40] Women account for two-thirds of all food production in developing countries, yet face gender-based discrimination in terms of access to land, water, labour, capital, technical and other services.[41]

Where does all the water go? In Africa, much of the water goes to cash crops grown plantation-style for export: cotton, tobacco, groundnuts, cocoa, tea, sugar, coffee, fruits of all kinds. Ali Mazrui aptly characterized African economies as "beverage economies," growing the raw material that goes into beverages processed by and for the rest of the world.[42] All of these products are readily substitutable, all have high elasticities of demand whereby a small rise in price will send buyers running in search of cheaper producers, and consumers turning to other products. Yet most African economies remain wedded to these practices not for food or household or income security, but for debt repayment and national wealth creation. Thus, in the African case we find the paradox of increased efficiencies in agricultural production necessarily supported at the national level, but complicating the ability of Africans to feed themselves affordably and sustainably. This is not to suggest that individual farmers do not benefit from extensive cash-crop production. Data in David Molden et al., shows that in Kenya 47% of subsistence farmers are below the poverty line, compared to only 31% of cash-crop farmers.[43] In Malawi, the incomes of smallholder burley tobacco growers are more than two times greater than the incomes of food crop producers in the poorest regions.

Globally, "rain-fed farming represents 82% of cropland and the bulk of the world's agricultural production."[44] Yields expressed as metric tonnes/hectare (t/ha) vary greatly across rain-fed farming zones. In general, yields are greater in temperate zones (7-10 t/ha) where water is more reliable and soils more fertile and resilient, as opposed to humid, semi-humid, semi-arid and arid zones (often <1 t/ha) where soils are more fragile, drought and/or flood common occurrences, and rainfall regimes more erratic, intense and patchy. Savanna zones constitute the primary areas of rain-fed subsistence agriculture and water-dependent pastoralism practised in SSA.

African savannas are ecological adaptations to the following hydroclimatic characteristics:

- a pronounced climatic rhythm of wet and dry seasons;
- a rainfall range of 250-1500 mm/year with most being concentrated during one or two rainy seasons of 3-5 months;
- high potential evaporation (>1000 mm/year) and an average annual temperature above 18˚C;
- large [spatial and temporal] rainfall variability with high coefficients of variation which vary between 15 and 50 percent.
- high intensity rainstorms resulting in high risk for storm surface runoff.[45]

The challenges for those inhabiting savanna zones are several:

- a large proportion of the world's population inhabits savannas and, in many countries, these have the most rapidly growing populations of the world's biomes.
- ecosystems of the semi-arid tropics are extremely sensitive to over-exploitation, or inappropriate land use.
- the huge population and the high water requirement linked to agriculture in the semi-arid and dry sub-humid savannas present the major water-related environmental and development challenges of all ecosystems.
- poverty and environmental degradation are serious problems in these landscapes.

- food productivity is low at present and, in many regions (such as parts of the Sahel), even at a standstill.
- most of the population makes their living from agriculture, predominantly rain-fed land use.[46]

When "the rainfall during the growing season is considered, savannas exist in landscapes with at least 100 mm of rainfall per rainy month in the driest zone, and up to 250 mm per month on average in the wettest zone. This is substantially more rainfall than in most so-called wet temperate areas." Thus, "the ecohydrological challenge in savannas is not particularly related to lack of water. Rather, the main challenges are adapting to the huge fluctuations of rainfall over time and space, and adapting to the high evaporative demand of the atmosphere."[47] Put differently, the challenge is to encourage 'more crop per drop' through better use of *green water*, i.e., water used by plants through evapotranspiration.

There are numerous ways to achieve more crop per drop at the level of the individual smallholder farm. For example, high intensity rainstorms generate large volumes of surface water runoff. In addition, given high atmospheric demand for water, most of the water that falls as rain either runs quickly away or evaporates back to the atmosphere. Two key challenges for African farmers, therefore, are to capture runoff (e.g., through small-scale water harvesting and increased ground cover), and to slow evaporation (e.g., through minimum tillage and mulching). During the growing season, plants need the right amount of water at the right time, which can be achieved by supplemental irrigation. Harvested and stored water available to plants when needed can ensure a successful crop even in a drought year. In addition, proper crop choice, as well as removal of alien and opportunistic species, many of which are 'water hogs,' can ensure more productive green water. According to Molden et al:

> In developing countries rain-fed grain yields are on average 1.5 t/ha, compared with 3.1 t/ha for irrigated yields, and increases in production from rain-fed agriculture have originated mainly from land expansion.... Sub-Saharan Africa, with 97 percent rain-fed production of staple cereals such as maize, millet, and sorghum, has doubled cultivated cereal area since 1960, while yield per unit of land has barely changed.[48]

As suggested above, poor yields are not strictly a function of poor rainfall. Rather, "agricultural dry-spells and droughts … are due primarily to management-related problems with the on-farm water balance and are thus an indicator of large opportunities to improve yields through better water management."[49]

A major present-day barrier to sustainable water use in Africa is the historical appropriation not only of the majority of surface water (i.e., blue water) but of arable land (i.e., green water) by settlers for export crop development. John Keegan observed that wars are repeatedly fought over "zones of first choice," i.e., the world's most arable lands.[50] Clive Ponting describes how crop and livestock domestication led to agricultural surplus and ultimately the rise of civilization.[51] The fecundity of land is directly related to climate, wherein water plays a key role. Put this way, all wars are water wars – green water wars.

Legal and Institutional Basis for Water Provision: From Fragmented to Integrated

Given water's central place in economic development, the modern management systems devised for water resources in Africa reflect the twin legacy of colonial state-defined 'needs' and high-modern beliefs in man-over-nature styles of development. As the global social, economic and environmental costs of these unreflective behaviours are made obvious,[52] many observers believe that water management must return to more traditional forms of use and management. The twin message is that we attempt to live beyond the natural parameters set by the ecosystem, and abandon the strong foundations of indigenous knowledge at our peril.[53] As noted by Michael Niemann, this does not mean a return to "some romantically transfigured idealization of virtually any traditional element of water utilisation."[54] Rather, what is needed is some sort of hybridization, where appropriate forms of modern management and technology are linked with traditional approaches.[55] The landscape of Africa's human geography has dramatically altered over the last 100 years (see the changing face of Lagos in Figure 3 above), in many cases rendering indigenous knowledge obsolete. Technology – in many cases complicated and expensive – must be brought to bear to address the real and pressing water-related needs of the continent.[56]

Exogenous pressures, such as climate change, and endogenous pressures such as population growth and resource mismanagement, suggest that there will be no technical 'fix' to Africa's water 'crisis.' Presently and historically, sectoral and actor-specific interests dominate water access, use and management in Africa. Those with the most political and economic clout have had their way, with large dams and inter-basin water transfer schemes being telling examples. Under colonial rule, foreign legal systems displaced indigenous approaches to resource management, and privileged the articulated needs of 'modern' industry, urban 'civilisation' and settled plantation agriculture thus imparting a veneer of 'legality' to these actions. As in the 'developed' world, so in Africa: water was either taken for granted, or the key driver in industrial development. Thus planning for water use was fragmented across colonial and post-colonial government departments. Today it is widely recognized that if Africa is to achieve even a fraction of the targets set by the Millennium Development Goals, water resource use cannot continue in this way.

Over the last 15-20 years, we have moved toward a global consensus that integrated water resources management (IWRM) is the conceptual basis for environmentally sustainable, socially equitable and economically efficient water development and management.[57] IWRM requires politicians and water managers to wean themselves off of supply-side interventions as the primary basis for 'solving' water shortages. Rather, judicious supply-side projects should be complemented by vigorous water demand management.[58] IWRM is primarily about the scope, scale and processes of decision-making. This is particularly important in the African context where decisions have been taken mostly by central state actors about single-purpose interventions for ostensibly 'national development' purposes. IWRM, in contrast, argues in favour of participatory processes of decision-making, taken in view of all stakeholders' interests across the basin, with social justice (e.g., 'some water for all forever') and ecological sustainability as primary goals. This means, somewhat contentiously, that in international basins 'national' interests should be subordinate to the greater good of the basin itself, and in national settings, basic human needs and minimum ecological requirements should be satisfied before water is granted to other stakeholders for any other purpose.

In many ways, IWRM is the linchpin that draws and holds together actors and stakeholders across geographical and political levels. Stakeholder networks and organizations such as Global Water Partnership (GWP), the World Water Council and World Water Forum serve to facilitate discussion and debate regarding the ways and means of achieving IWRM. National, regional (e.g., Southern African Development Community (SADC), the East African Community, Economic Community of West African States (ECOWAS)), continental (e.g., African Union (AU), Economic Commission for Africa, New Partnership for Africa's Development (NEPAD)), resource specific (e.g., African Council of Water Ministers, Nile Basin Initiative, Volta and Niger Basin Authorities, Lake Victoria Basin Commission), intergovernmental organizations (e.g., United Nations Environment Program (UNEP)), international financial institutions (e.g., the World Bank, the African Development Bank), transnational and sub-national non-governmental organizations and civil society organizations regularly interface at these and related meetings to hammer out the ways and means of water for all. The 'international' character African water as a border-maker or border-crosser adds a further layer of complexity to what is already a highly complex situation. Understandably, this is by no means a harmonious process but its importance cannot be over-emphasised.

Across the continent, positive steps toward integrated planning and decision-making are underway. Numerous transboundary river basins commissions and initiatives have been or are in the process of being established (see Table 3 above). A wide variety of programs and projects, involving actors at all levels of governance, are being undertaken. New ways of thinking about water resources – e.g., 'virtual water,' 'green water,' storm water capture, artificial recharge of aquifers – are making it possible to reconsider current use practices among stakeholders across and within sectors (e.g., urban, agriculture, industry). Numerous tools of forecasting and measurement are also now available, making possible better predictions regarding particular constellations of decisions.

Most African states are undertaking water reforms that include *inter alia* national water master plans, revised and rewritten water laws, institutional reforms including significant roles for stakeholder participation and more transparent and inclusive forms of governance. Significant amounts of donor funding have been made available for all of these exercises. Meaningful progress has been made, especially where the interests of powerful actors intersect with those of donors and coincide with immediate need, e.g., in the wake of widespread drought and/or in the immediate post-revolutionary aftermath of shared nationalist struggle.[59] A significant degree of these activities may be understood merely as 'formalism,' i.e., good written laws and agreements with little or no implementation.[60] Even where intentions are good, African states vary in their human resource and financial capabilities. Most sub-Saharan African states fall toward the lower end of the Human Development Index scale, signifying not only problems of development delivery, but in some cases the central state's lack of intent. The rush to privatize water delivery and move toward full-cost recovery in urban areas shows two things about water governance in Africa: (i) how little influence African decision-makers have over the direction of the global discourse on water management; and (ii) how little affected they themselves are by such decisions. Water use across societies reflects how wealth is distributed within those societies.[61] Africa's leaders – like leaders everywhere – have adequate supplies of good, clean water. Thus, changing the way states manage water is akin to remaking the state itself.[62]

Conclusion

Water plays a fundamental role in human development. Inequality of access to the resource as well as its mismanagement reflect the historical and contemporary basis of Africa's underdevelopment. This paper highlights the fact that there is more than enough water for everyone on the continent. However, socio-political and economic dynamics set in train during the colonial/imperial era ensured that accessible water resources would serve the interests of a small urban elite, extractive resource industries (blue water) and plantation agriculture (green water). In the post-colonial era, these structures are still in place. Put differently, the most powerful actors on the continent will always have water. However, as shown above, Africa's urban spaces face massive challenges. These primary cities located at the top ends of watersheds or in coastal zones face issues of crumbling infrastructure, limited supply, point-source and diffuse pollution and sprawl. At the same time, large populations confined to marginally habitable land, suffer green water scarcity, so encouraging out-migration to the cities. Climate change models offer the spectre of more extreme events – none of which any African system of governance is equipped to handle.

The colonial prescription of rivers as borders combined with water's essentially fugitive nature ensures that no state today can proceed with unilateral water management. Thus, sustainable development for human security in SSA requires a collective vision. While moving toward socially equitable, ecologically sustainable and economically efficient water resource management requires a shared vision, it is important to note that improvements can proceed in piecemeal fashion. Water cannot be separated out of any human activity; thus, we must understand it holistically but improve its management when and where opportunities present themselves. Given the highly unequal condition of African states and societies, piecemeal progress is the only option.

Notes

* Larry A. Swatuk is in the Faculty of Environment, University of Waterloo. Contact: lswatuk@uwaterloo.ca. Dominic Mazvimavi is in the Faculty of Earth Sciences, University of the Western Cape, South Africa, Contact: dmazvimavi@uwc.ac.za.

1. United Nations Development Programme (UNDP), *Human Development Report* (New York: Oxford University Press, 2006), p. 3.
2. *Ibid*., p. 2.
3. *Ibid*., p. 5.
4. *Ibid*.
5. UNDP, *Human Development Report*, 2006, p. 2; United Nations (UN), *Water a Shared Responsibility. The United Nations World Water Development Report 2*, UNESCO and Berghahn Books: France and New York, 2006.
6. El Nino events are to be contrasted with La Nina events: cold ocean temperatures resulting in low rainfall in the equatorial east during the short October-November rainy season, and high rainfall in southern Africa during the November-February rainy season.
7. See Sharon E. Nicholson, "The Nature of Rainfall Variability over Africa on Time Scales of Decades to Millennia," *Global and Planetary Change*, Vol. 26 (2000), pp. 137-158.

8. Mamdouh Shahin, "Hydrology and Water Resources of Africa," *Water Science and Technology*, Vol. 41 (2002), Kluwer Academic Publishers, Dordrecht, The Netherlands.
9. *Ibid*.
10. A.M. MacDonald and J. Davies, "A Brief Review of Groundwater for Rural Water Supply in Sub-Saharan Africa," BGS Technical Report WC/00/33, British Geological Survey, Keyworth, Nottingham, United Kingdom, 2000; Shahin, "Hydrology and Water Resources of Africa."
11. MacDonald and Davies, "A Brief Review of Groundwater for Rural Water Supply in Sub-Saharan Africa."
12. *Ibid*.
13. See International Atomic Energy Agency, "Great Lakes Beneath their Feet: Probing North Africa's Oldest Water Treasures," no date, available at http://www.iaea.org/Publications/Booklets/Ssp/great_lakes.html.
14. Larry A. Swatuk and Peter Vale, "Why Democracy is not Enough: Security and Development in Southern African in the 21st Century," *Alternatives*, Vol. 24, No.3 (1999), pp. 361-389.
15. Carol Rakodi (ed.), *The Urban Challenge in Africa* (Tokyo: UNU Press, 1997), available at http://www.unu.edu/unupress/unupbooks/uu26ue/uu26ue0i.htm 1997.
16. *Ibid*.
17. Joshua Eisenman and Joshua Kurlantzick, "China's Africa Strategy," *Current History*, May 2006, pp. 219-224.
18. Joshua B. Forrest, "Water Resource Administration and Racial Inequality in South West Africa," in R. Coopey and T. Tvedt (eds), *A History of Water. Volume 2: The Political Economy of Water* (New York: I.B. Tauris, 2006), pp. 151-171; Fenda A. Akiwumi, "'Indigenous People Participation': Conflict in Water Use in an African Mining Economy," in T. Tvedt and T. Oestigaard (eds), *A History of Water. Volume 3: The World of Water* (New York: I.B. Taurus, 2006), pp. 49-77. David Gordon, "From Sacred Ownership to Colonial Commons: Water Tenure Systems in Central Africa," in T. Tvedt and T. Oestigaard (eds), *A History of Water. Volume 3: The World of Water* (New York: I.B. Taurus, 2006), pp. 18-37.
19. J. Anthony Allan, "IWRM/IWRAM: A New Sanctioned Discourse?" *Discussion Paper No. 50*, Water Issues Study Group, University of London, 2003.
20. UN, *Water a Shared Responsibility*, p. 393.
21. Robert W. July, *A History of the African People* (New York: Charles Scribner and Sons, 1980).
22. UN, *Water a Shared Responsibility*, p. 613.
23. *Ibid*., p. 613.
24. Heather Cooley, J. Christian-Smith, P.H. Gleick, L. Allen, M.. Cohen, *Understanding and Reducing the Risks of Climate Change for Transboundary Waters* (California: Pacific Institute, 2009), p. 15.
25. Alfred M. Crosby, *Ecological Imperialism: The Biological Expansion of Europe, 900-1900* (Oxford: Oxford University Press. 1986).
26. Tayo Odumosu, "When Refuse Dumps Become Mountains: Responses to Waste Management in Metropolitan Lagos," in M.K. Tesi (ed.), *The Environment and Development in Africa* (New York: Lexington, 2000).
27. UN, *Water a Shared Responsibility*, p. 90; see also Table 2.
28. Odumosu, "When Refuse Dumps Become Mountains," in Tesi (ed.), *The Environment and Development in Africa*.
29. For details, see Rakodi, (ed.), *The Urban Challenge in Africa*; Asit K. Biswas, "Water Management for Major Urban Centres," *Water Resources Development*, Vol. 22, No. 2 (2006), pp. 183-197; and UNFPA, "State of the World's Population 2007," available at http://www.unfpa.org/swp/2007/index.htm2007.

30. O'Connor quoted in Rakodi (ed.), *The Urban Challenge in Africa*.
31. See Munyaradze Chenje and Phyllis Johnson (eds), *Water in Southern Africa* (Harare/Maseru: SADC/SARDC/IUCN, 1996).
32. James Cullis and Barbara Van Koppen, "Applying the Gini Coefficient to Measure Inequality of Water Use in the Olifants River Water Management Area, South Africa," in Larry A. Swatuk and L. Wirkus (eds), *Transboundary Water Governance in Southern Africa* (Bonn: Nomos, 2009).
33. Esther W. Dungumaro, "Socioeconomic Differentials and Availability of Domestic Water in South Africa," *Physics and Chemistry of the Earth*, Vol. 32 (2007), pp. 1141-1147.
34. See Hubert Savenije, "Why Water is Not an Ordinary Economic Good, or Why the Girl is Special," *Physics and Chemistry of the Earth*, Vol. 27 (2002), pp. 741-744.
35. Rakodi, (ed.), *The Urban Challenge in Africa*.
36. Dumisani Dube and Larry Swatuk, "Stakeholder Participation in the New Water Management Approach: A Case Study of the Save River Basin, Zimbabwe," *Physics and Chemistry of the Earth*, Vol. 27 (2002), pp. 867-874.
37. See Gerry Goldblatt et al, *Water Demand Management. Towards Developing Effective Strategies for Southern Africa* (Harare: MG Printers for IUCN, 2000).
38. Azwidowi Mukheli, Gilbert Mosupye and Larry A. Swatuk, "Is the Pungwe Water Supply Project a Solution to Water Accessibility and Sanitation Problems for the Households of Sakubva, Zimbabwe?" *Physics and Chemistry of the Earth*, Vol. 27 (2002), pp. 723-732.
39. Maarten De Wit and Jacek Stankiewicz, "Changes in Surface Water Supply Across Africa with Predicted Climate Change," *Sciencexpress Report*, 2006, available at www.sciencexpress.org/2March2006/Page1/10.1126/science.1119929.
40. UN, *Water a Shared Responsibility*.
41. David Molden, Karen Frenken, Randolph Barker, Charlotte de Fraiture, Bancy Mati, Mark Svendsen, Claudia Sadoff, C. Max Finlayson, "Trends in Water and Agricultural Development," in David Molden (ed.), *Water for Food, Water for Life: A Comprehensive Assessment of Water Management in Agriculture* (London: Earthscan and Colombo: IWMI, 2007), p. 150.
42. Ali Mazrui, *The Africans: A Triple Heritage* (Boston: Little Brown, 1986.
43. Molden et al., "Trends in Water and Agricultural Development," in Molden (ed.), *Water for Food, Water for Life*, p. 283.
44. UN, *Water a Shared Responsibility*, p. 256.
45. Malin Falkenmark and Johan Rockstrom, *Balancing Water for Humans and Nature* (London: Earthscan, 2004), pp. 103, 109, 110.
46. *Ibid*., p. 104.
47. *Ibid*., pp. 110, 127.
48. Molden et al., "Trends in Water and Agricultural Development," in Molden (ed.), *Water for Food, Water for Life*, p. 318.
49. *Ibid*., p. 324.
50. John Keegan, *A History of Warfare* (New York: Random House, 1994).
51. Clive Ponting, *A Green History of the World* (Harmondsworth: Penguin, 1990).
52. UN, *Water a Shared Responsibility*; Mark Svendsen, Phillipus Wester and Francois Molle, "Managing River Basins: An Institutional Perspective." In: Mark Svendsen (ed.), *Irrigation and River Basin Management: Options for Governance and Institutions* (Cambridge, Mass: CABI, 2005).
53. Volker Boege, "Transboundary Water Governance in Regions of Weak Statehood," in Larry A. Swatuk and L. Wirkus (eds), *Transboundary Water Governance in Southern Africa* (Bonn: Nomos, 2009).
54. Michael Niemann, "Unstated Places: Rereading Southern Africa," in Peter Vale, Larry A. Swatuk and

Bertil Oden (eds), *Theory, Change and Southern Africa's Future* (Basingstoke: Palgrave, 2002), p. 195.

55. See Boege, "Transboundary Water Governance in Regions of Weak Statehood," in Swatuk and Wirkus (eds), *Transboundary Water Governance in Southern Africa*; Francis Cleaver, "Reinventing Institutions: Bricolage and the Social Embeddedness of Natural Resource Management," *The European Journal of Development Research*, Vol. 14, No.2 (2002), pp. 11-30.
56. See Peter van der Zaag and Alex Bolding, "Water Governance in the Pungwe River Basin: Institutional Limits to the Upscaling of Hydraulic Infrastructure," in Swatuk and Wirkus (eds), *Transboundary Water Governance in Southern Africa*.
57. Global Water Partnership (GWP), "Integrated Water Resources Management," GWP Technical Committee Background Paper 4, Stockholm: GWP, 2000; Lewis Jonker, "Integrated Water Resources Management: The Theory-Praxis-Nexus, a South African Perspective," *Physics and Chemistry of the Earth*, Vol. 32 (2007), pp. 1257-1263.
58. Goldblatt et al, *Water Demand Management*.
59. On the former see, Bekithemba Gumbo and Peter van der Zaag, "Water Losses and the Political Constraints to Demand Management: The Case of the City of Mutare, Zimbabwe," *Physics and Chemistry of the Earth*, Vol. 27 (2002), pp. 805-814. On the latter see, Maria Amakali and Larry A. Swatuk, "Different Approaches to Local Level Participation in River Basin Management in Namibia: A Comparison between the Kuiseb and Cuvelai Basins," in Swatuk and Wirkus (eds), *Transboundary Water Governance in Southern Africa*.
60. Akiwumi, "'Indigenous People Participation,'" in Tvedt and Oestigaard (eds), *A History of Water. Volume 3: The World of Water*.
61. See Cullis and van Koppen, "Applying the Gini Coefficient to Measure Inequality of Water Use in the Olifants River Water Management Area, South Africa," in Swatuk and Wirkus (eds), *Transboundary Water Governance in Southern Africa*.
62. See Larry A. Swatuk, "A Political Economy of Water in Southern Africa," *Water Alternatives*, Vol. 1, No. 1 (2008), pp. 24-47.