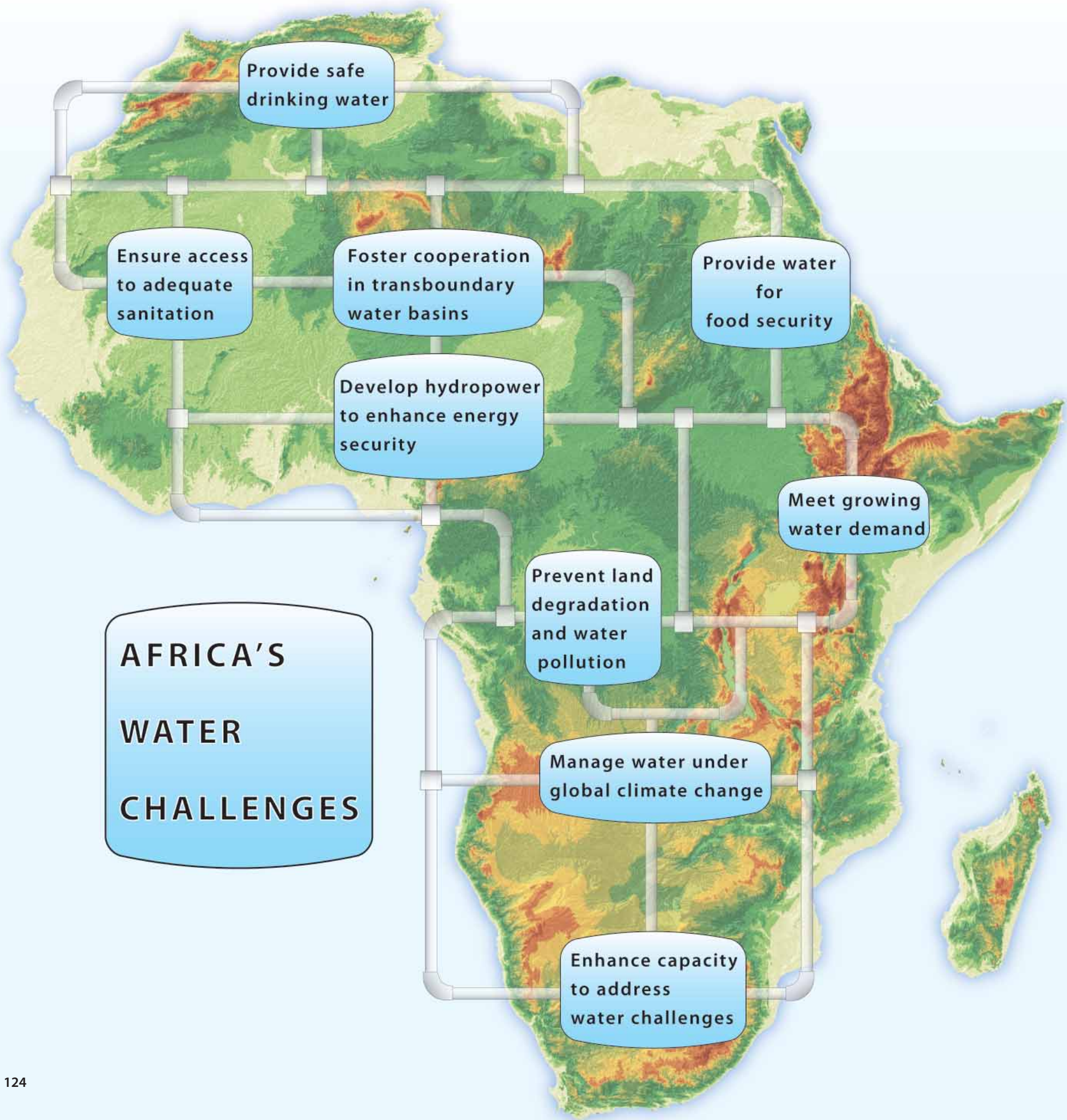
Improving the Quantity, Quality and Use of Africa's Water

Africa faces mounting challenges in providing enough safe water for its growing population, especially for the huge numbers of people migrating to peri-urban areas, where municipal water services are often non-existent. Many African nations will fail to achieve the Millennium Development Goal's safe water target to reduce by half the proportion of the population without sustainable access to safe drinking water by 2015, and many more will miss the sanitation target that stipulates that by that date, they reduce by half the proportion of the population without sustainable access to basic sanitation. Other challenges include avoiding potential conflicts over water in the 63 water basins on the continent shared by two or more countries; adapting to the impacts of climate change on water resources, which will be greater than most other regions because Africa already suffers from extreme rainfall variability; and developing water resources that are adequate for local needs but that are unavailable due to political and economic constraints.

On the other hand, there are clear opportunities for Africa to overcome these and other water-related challenges. One of them is the huge opportunity to develop its untapped water resources. In 2005, only about five per cent of the development potential of these resources—irrigation, industry, tourism and hydropower—was expected to be utilized (UNECA and others 2000). This chapter proposes exciting potential solutions to some of Africa's other water challenges, including revolutionizing toilets so they are as desirable as mobile phones, promoting a greener Green Revolution, investing in small hydroelectricity developments and fostering the greening of the Sahel.

This chapter underscores the following nine major challenges that Africa faces in addressing its water resource issues:



CHALLENGE 1

PROVIDE SAFE DRINKING WATER

The Challenge: *Attain the MDG water provision target: By 2015, reduce by half the proportion of the population without sustainable access to safe drinking water.*

The Situation: *Africa as a whole is not expected to meet this MDG drinking water target; of its 53 countries, only 26 are on track to meet it. The high incidence of water-related and waterborne diseases related to the lack of safe drinking water is a drain on human and financial resources.*

The Constraints: *Exploding peri-urban and slum areas; economic growth and higher demand; geographical isolation; dearth of public utilities and regulation; and high costs of water provision.*

The Opportunities: *Improve financing; encourage privatization through concessions; subsidize connections; target informal settlements; institute or improve regulation; target rural communities; and employ simple solutions.*

The Challenge

The Millennium Development Goal's safe water target is to reduce by half the proportion of the population without sustainable access to safe drinking water by 2015.

The Situation

- *Africa as a whole will not reach the MDG drinking water target*: Worldwide, 884 million people have no access to drinking water from improved sources (Figure 3.1.1). Sub-Saharan Africa accounts for more than third of that number, with about 330 million people without access to safe drinking water. Africa's progress towards the MDG drinking water target is slow and uneven, and the continent as a whole will not reach the goal. Although the proportion of people in sub-Saharan Africa using improved sources of drinking water increased by 14 per cent from 1990 to 2008, only 60 per cent of its population had such access by the end of that period (WHO/UNICEF 2010). Based on current trends, sub-Saharan Africa will not reach the MDG water target until 2040 (UNDP 2006a). A recent survey revealed a bleak future in which only two countries (Kenya and South Africa) are estimated to have more than 75 per cent of what is needed to achieve the sanitation target, and five countries are estimated to have more than 75 per cent of what is needed to achieve the MDG target for drinking water (WHO and UN-Water 2010).
- *There are large disparities in the provision of safe water*: sub-Saharan Africa has by far the lowest coverage rates of piped water among world regions (50 per cent) (WHO/UNICEF 2010). The increase in numbers of people with access to other improved sources of drinking water was 3.5 times higher than the rise in people with piped water on premises. Only five per cent of the rural population receives piped water in their homes compared to 35 per cent of urban dwellers (WHO/UNICEF 2010).

Figure 3.1.1: Number of people without access to an improved source of drinking water (millions) (Source: WHO/UNICEF 2010)

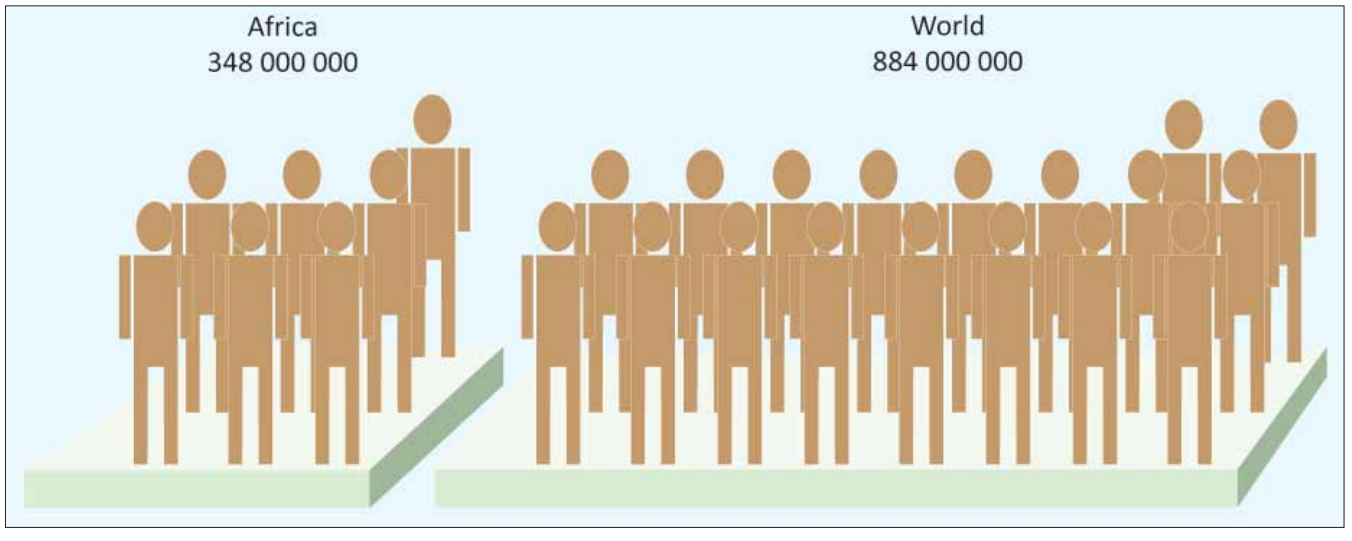


Figure 3.1.2: Percentage loss in GDP due to diseases and productivity losses linked to water and sanitation (Source: UNDP 2006a)

- *Limited access to water means that Africa has a high incidence of water-related disease:* The incidence of water-related and waterborne diseases such as cholera, malaria, Guinea worm and river blindness is high in Africa, mainly due to limited access to water and sanitation. Schistosomiasis (or bilharzia) is endemic in a total of 46 countries (Boelee and Madsen 2006). During the wet season in 2005, 14 303 cases of cholera were diagnosed and 252 people eventually died in Guinea-Bissau alone (Bordalo and Savva-Bordalo 2007). The World Health Organization (WHO) estimates that there are 0.75 cases of diarrhoea per person worldwide every year. This rate varies between regions. Sub-Saharan Africa has the highest rate, with 1.29 cases per person annually. In contrast, rates in Europe and the United States are 0.18 and 0.07 cases per person per year, respectively (Lewin and others 2007) (Figure 3.1.3).
- *The lack of safe water is debilitating to the economy:* In economic terms, the lack of proper water and sanitation services in developing countries translates into the loss of revenues and the inability to generate and sustain livelihoods, due in large part to the debilitating effects of water-related disease (Figure 3.1.2). In addition, the time and energy lost in hauling water from long distances, predominantly undertaken by women and girls, deprives them of time to engage in livelihood generating activities and attending school.

The Constraints

There are many reasons for the lack of progress in providing the people of Africa with safe drinking water, including the following:

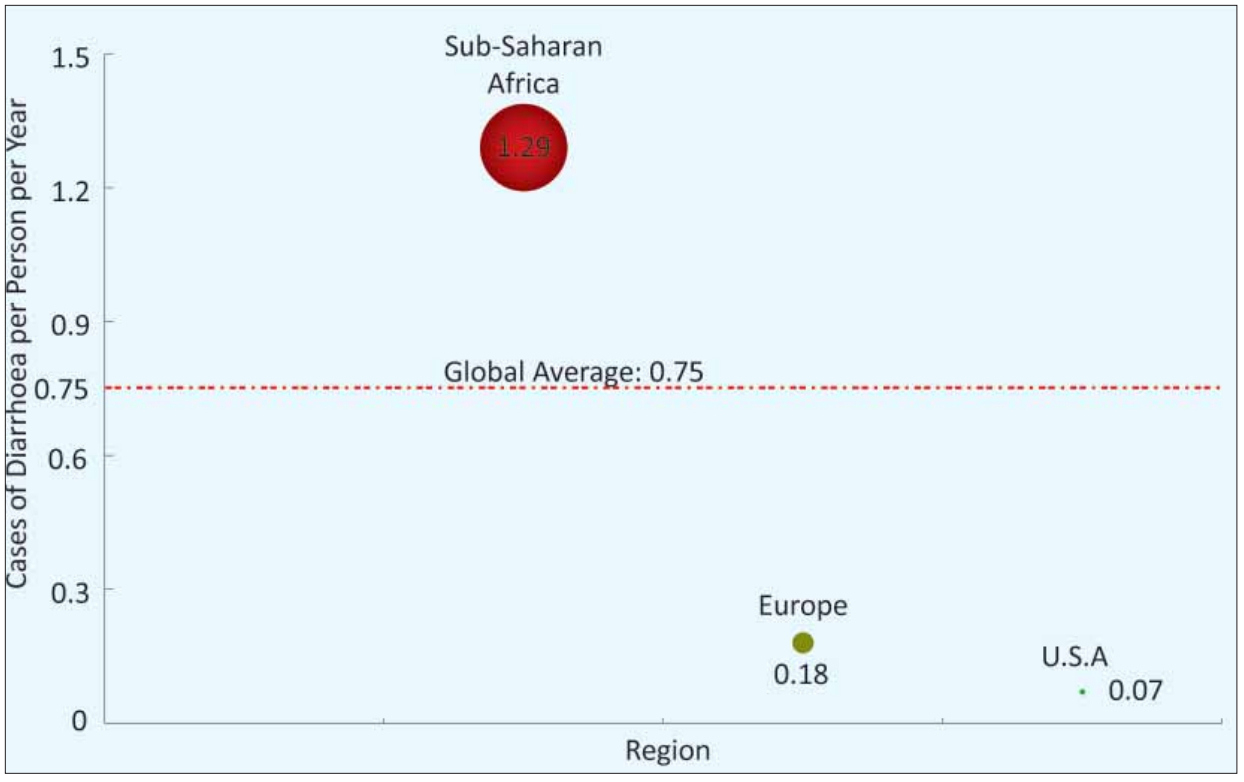
- *Exploding peri-urban areas and more affluent consumers:* In some regions, growing populations have caused the ranks of the destitute to swell. In Cairo and other large cities on the continent, sprawling city limits and rapidly growing populations (from both natural growth and in-migration from rural areas) have created extensive squatter settlements or slums, challenging the abilities of water management institutions to provide adequate water and sanitation infrastructure. On the other hand, as some city dwellers become more affluent and industrial development expands with economic growth, the demand for better and more water services also grows. Consequently, water scarcity is not entirely a natural phenomenon. It can also be attributed to low levels of investment in water resources services and the inability to cope with the growing demand for water in response to population growth and economic development (Mwanza 2003).
- *Lack of access, regulation and public utilities:* Throughout Africa, there are areas where water and sanitation services are more easily accessible than others. This can be due to geography, climate and the economic and political history of the countries. In poor and conflict-prone areas, water services are meager and most areas have no infrastructure at all. This dilemma has been recognized as a major

African Countries with Human Schistosomiasis

- ***Northern**: Algeria, Egypt, Libya, Morocco, Tunisia, Sudan*
- ***Western**: Burkina Faso, Chad, Gambia, Mali, Mauritania, Niger, Senegal, Benin, Côte d'Ivoire, Ghana, Guinea, Guinea-Bissau, Liberia, Nigeria, Sierra Leone, Togo*
- ***Central**: Angola, Cameroon, Central African Republic, Congo, Democratic Republic of Congo, Gabon*
- ***Eastern:** Burundi, Ethiopia, Kenya, Rwanda, Uganda, Somalia*
- ***Western Indian Ocean Islands:** Comoros, Madagascar, Mauritius*
- ***Southern**: Tanzania, Botswana, Lesotho, Malawi, Mozambique, Namibia, South Africa, Swaziland, Zambia, Zimbabwe*

(Source: Boelee and Madsen 2006)

Figure 3.1.3: Cases of diarrhoea per person per year (Source: Lewin and others 2007)

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challenge to South Africa's Department of Water Affairs and Forestry, for example (Dungumaro 2007). Small-scale private providers (that is, excluding community or publicly operated water schemes) supply 50 per cent of the urban population in Africa. High prices per unit of water supplied, poor water quality and difficulty in regulating the providers are important issues that challenge progress in safe water provision.

- *High cost of water provision*: The financial cost to users is a less obvious barrier to the provision of safe drinking water. The per capita costs of providing clean water are highest in urban areas and in sparsely populated rural areas; on average, however, expanding coverage costs less in rural areas than in high-density urban areas. In much of sub-Saharan Africa, higher-income households with connections to utilities derive the greatest gains from water sold at prices far below the level needed to cover operations and maintenance costs. People living in the slums of Kenya pay five to ten times more for water per unit than those in high-income areas, and more than consumers pay in London or New York. In Benin, Kenya and Uganda, connection fees for access to water provision from formal network providers exceeds US$100 (UNDP 2006a).

In 2008, aid commitments for large sanitation and drinking water systems was US$4.6 billion, compared to US$1.2 billion in aid to basic systems. Basic drinking water systems are defined as drinking water supply through low-cost technologies such as hand pumps, spring catchment, gravity-fed systems, rainwater collection, storage tanks and small distribution systems. Basic sanitation systems are defined as latrines, small-bore sewers and on-site disposal. Large drinking water systems include treatment, drinking water conveyance and distribution and large sanitation systems include sewerage collection systems and wastewater treatment plants (WHO and UN-Water 2010).

The Opportunities

In spite of the situation and formidable challenges, there are opportunities to improve safe water availability in Africa and lessons can be learned from some African countries that have seen the most progress. The strongest performers in terms of piped water-service expansion are Benin, Burkina Faso, Chad, Ethiopia, Mali and Senegal, all showing growth rates of four to eight per cent per year (Banerjee and others 2009). While rural populations continue to lag behind urban populations globally, countries as diverse as Morocco and Uganda have sustained rapid increases in rural coverage (UNDP 2006a).

- *Improve financing:* According to the 2006 UNDP Human Development Report, governments need to spend about one per cent of GDP on water and sanitation. Additionally, increased international aid would play a very crucial role in catalyzing access to improved water sources. More funding from tariffs, taxes and transfers, in the right mix, can help meet national goals for sustainable water access (Hashimoto Action Plan 2010).

- *Encourage concessions in privatization schemes:* Private investment by domestic and foreign companies that assume responsibility for financing and operating water systems can improve efficiency, reduce water losses, increase supply, extend meters and revenue collection and enlarge coverage. In Morocco, which created four concessions between 1997 and 2002, coverage increased as did consumer satisfaction scores (UNDP 2006a). In 1995, another programme to supply water to rural areas called PAGER was established in Morocco, which required public participation in its planning and implementation. Access to drinking water increased from 14 per cent before PAGER, to 16 per cent in 1995 and to 61 per cent in 2004 (Tortajada 2006). The crucial consideration in the introduction of any system, however, is the need to be sensitive to customer's needs, a lesson learned by the failure of some water-privatization schemes (Grimond 2010).

- *Subsidize connections for the poor*: Subsidising connections for poor households and implementing innovative payment strategies may remove an important barrier to expanding the water-supply network. In Côte d'Ivoire, for example, a Water Development Fund surtax is included in bills, with about 40 per cent of the proceeds used for connection subsidies (UNDP 2006a).

- *Target informal settlements:* Some utilities have shown an unwillingness to extend services to households lacking legal title, fearing that it could jeopardize their revenue collection. Using creativity to deal with this dilemma may solve water access problems for people in these settlements. For example, a utility in Manila has extended underground water lines to the perimeter of slums and allowed households to make above-ground connections through small plastic pipes linked to meters that are maintained by residents associations and non-governmental agencies. Such arrangements can improve equity; efficiency increases also by reducing the revenue losses associated with illegal connections. In Manila, for example, it reduced water costs by 25 per cent in the slum areas now being served (UNDP 2006a).

- *Institute or improve regulation:* Regulatory authorities are important to ensure that providers are managed in a way that secures both equity and efficiency independent of politics. Where administrative capacity and regulatory institutions are lacking, citizens can take a pro-active role, pressing for more information and publicizing underperformance by water utilities (UNDP 2006a).

- *Target rural communities:* Opportunities in rural communities include adoption of free-standing small-scale systems capable of treating water; recovering wastewater for re-use and capturing resulting gases as a source of energy for power, lighting and cooking—support to community-level projects on water resources management, water supply and sanitation in over 30 countries has demonstrated this. In Rajasthan, India, such support aided in the construction of 7 500 community water harvesting structures in the form of dams and ponds to eliminate water shortages in the area (UNDP 2006b).

- *Encourage entrepreneurship for simple water purification techniques:* Solutions using local ingenuity and simple tools and mechanisms have been shown to improve access to safe drinking water. For example, a Swiss-pioneered water-disinfection program is being used all over the world to provide drinking water for about four million people. The main components of the system are discarded plastic bottles, which are filled with any water that is not too murky and then placed on a piece of metal in full sunlight. In six hours, the UVA radiation is able to kill viruses, bacteria and parasites in the water, making it safe to drink. Since the beginning of the program in Tanzanian schools, promising results include less absenteeism due to diarrhoea (Jenkins 2010). There is now a large market for water purifiers and many entrepreneurs are inventing more affordable models to bring safe water to the poor. Subsidies may be required to initiate new programs, but a local commercial incentive by private enterprise is needed to grow and sustain the adoption of simple and efficient water purification systems (Grimond 2010).

Water for Sudan/Flickr.com

CHALLENGE 2

ENSURE ACCESS TO ADEQUATE SANITATION

The Challenge: *Attain the MDG sanitation target: By 2015, reduce by half the proportion of the population without sustainable access to basic sanitation.*

The Situation: *Africa as a whole is not expected to meet this MDG sanitation target; of its 53 countries, only nine are on track to meet it. The high incidence of water-related and waterborne disease related to unsanitary conditions is debilitating to African economies and human livelihoods and well-being.*

The Constraints: *Exploding peri-urban and slum areas; economic growth and higher demand; geographical isolation; dearth of public utilities and regulation; and high costs of water provision.*

The Opportunities: *Recognize the potential to generate revenues from sanitation technologies; revolutionize toilets so they are as desirable as mobile phones; learn from the extraordinary expansion of mobile phones; encourage and support simple solutions from entrepreneurs; introduce urban water tariffs; increase sanitation's share in total aid; adopt system financing; build partnerships between the government and civil society for educational campaigns; and seek international funding.*

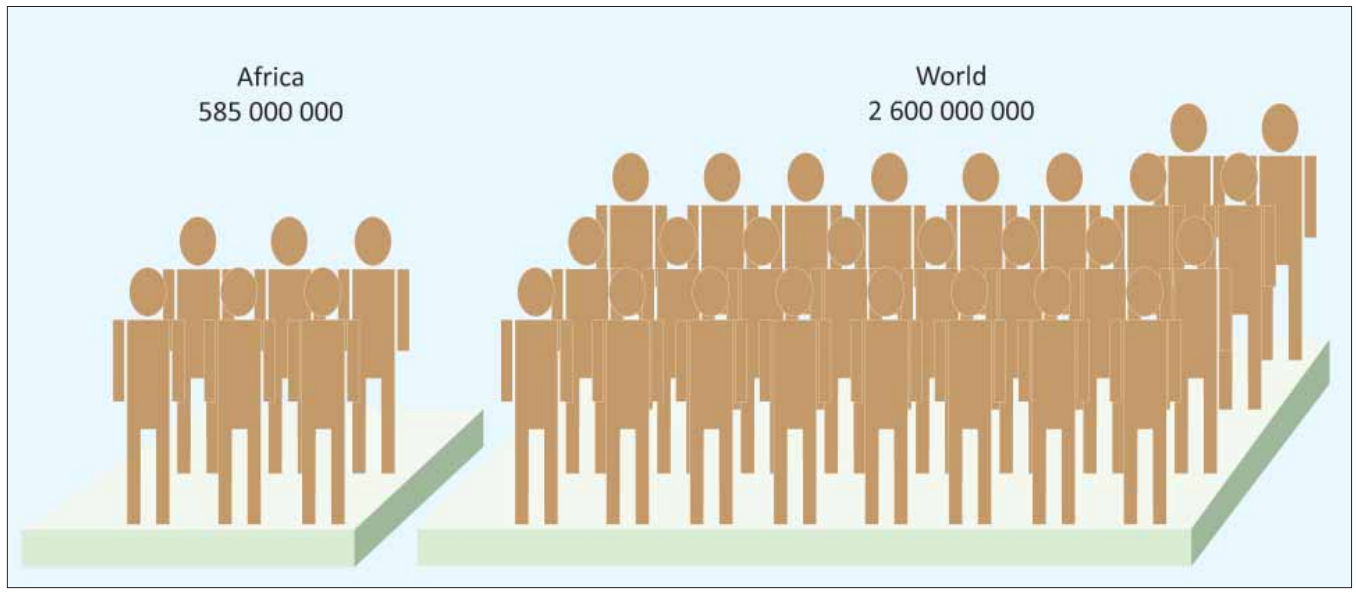
The Challenge

The Millennium Development Goal's sanitation target is to reduce by half the proportion of the population without sustainable access to basic sanitation by 2015. Increasing people's access to water will help Africa reach this target, while ensuring that water sources are not contaminated by sanitation facilities will help it to reach the MDG safe drinking water target.

The Situation

- *Africa as a whole will not meet the MDG sanitation target:* There are about 2.6 billion people in the world who do not have access to improved sanitation facilities of which about 585 million people are in Africa (Figure 3.2.1). Less than half of the people living in 35 African countries do not have such access. Use of improved sanitation facilities in sub-Saharan Africa is very low, at an overall 31 per cent, with great disparities between urban and rural areas. The MDG target requires that 63 per cent of the region's population has access to improved sanitation by 2015. That amounts to 370 million more people than the estimated 242 million who were using such facilities in 2006 (WHO/UNICEF 2010). Most African countries will not meet the target. Only nine countries (Algeria, Morocco, Tunisia, Libya, Rwanda, Botswana, Angola, South Africa and Egypt) of the 53 in Africa will achieve the MDG target for basic sanitation (WHO/UNICEF 2010). The 2006 Human Development Report predicts that under a business-as-usual scenario, it would only be possible to reduce the population using unimproved sanitation facilities by half by 2076 (UNDP 2006).
- *Access to sanitation is rising in Africa, but there are large disparities in its provision:* The coverage rates for sanitation are far lower than those for water, even in higher-income groups. The proportion of the population using improved sanitation facilities, however, is increasing in all the developing regions (UNDP 2006). Notable increase in the use of improved sanitation facilities has been made in North Africa, but

Figure 3.2.1: Number of people without access to improved sanitation facilities (Source: WHO/UNICEF 2010)



throughout the continent, regional disparities are still very apparent. Sub-Saharan Africa is the only region where more than half the population still does not have any access to better sanitation, with a striking contrast between urban areas, which are better served, and rural ones (WHO/UNICEF 2010). Even so, less than ten per cent of the urban population is connected. In Zambia, for example, only three-quarters of the richest quintile of households have access to a flush toilet (UNDP 2006).

- *Although sanitation coverage is rising, population growth is outpacing provision efforts:* Although Africa had one of the world's lowest sanitation coverage rates in 1990, the number of people using improved sanitation facilities in sub-Saharan Africa has improved over the years. The sanitation coverage in sub-saharan Africa as a whole increased from 28 per cent in 1990 to 31 per cent in 2008. The number of people without access to latrines and toilets in sub-Saharan Africa, however, increased by 194 million people during the same period. Similarly, the proportion of people practicing open defecation declined by 25 per cent, but population growth has meant that the absolute number increased from 188 million (in 1990) to 224 million (in 2008) (WHO/UNICEF 2010). Efforts to reach the MDG sanitation target have been unable to catch up with the population growth.

- *Lack of sanitation is a cause of waterborne disease:* Cholera epidemics are a major risk in areas with high concentrations of people and poor sanitation. Heavy rains can flood latrines, contaminating water and exposing populations to cholera bacteria. Groundwater can also become contaminated by improper sanitation. In Côte d'Ivoire, and in Dar es Salaam, Tanzania, for example, groundwater contaminated by inadequate sanitation facilities has caused cholera outbreaks and other water-borne diseases in informal settlements around these areas (Dagdeviren 2009). In 2005, West Africa suffered more than 63 000 cases of cholera, leading to 1 000 deaths. Senegal was severely affected following rainy season flooding in Dakar. During the first half of 2006, one of the worst epidemics to sweep sub-Saharan Africa in recent years claimed more than 400 lives in a month in Angola (UNDP 2006).

- *Economies and human livelihoods suffer from the lack of sanitation:* Lack of sanitation hurts local economies when resulting poor health leads to lost working days, school absenteeism and increased time to take care of the sick. A cost-benefit analysis by the WHO demonstrated an estimated economic return of between US$3 and US$34 for every US$1 invested in water and sanitation (WHO and UN-Water 2010).

The Constraints

The obstacles to providing proper sanitation facilities are the same as those faced in the provision of safe drinking water: exploding peri-urban and slum areas, economic growth and higher demand, geographical isolation, dearth of public utilities and regulation, and the high costs of water provision. In addition, talking about toilets is taboo, making it difficult for people, especially women who lack a voice in Africa, to demand better services.

- *Lack of financial and technical resources:* Sanitation investments have lagged behind water supply by almost a decade. Poor economic performance and associated financial and technological limitations continue to be at the root of the slow progress in supplying adequate sanitation services, which suffers from

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chronic under-funding. Public spending on water and sanitation is typically less than 0.5 per cent of GDP. The infrastructure for an effective nationwide water and sanitation system—from water pipes to pumping stations to sewerage works—requires investment on a scale beyond what the poorest countries can begin to afford. Moreover, it requires large upfront investments as well as longer-term maintenance costs. Given the high proportion of people in developing countries that lack access to water and sanitation and survive on less than U$1 a day, it is not feasible to meet these upfront costs through user fees (UNDP 2006).

The Opportunities

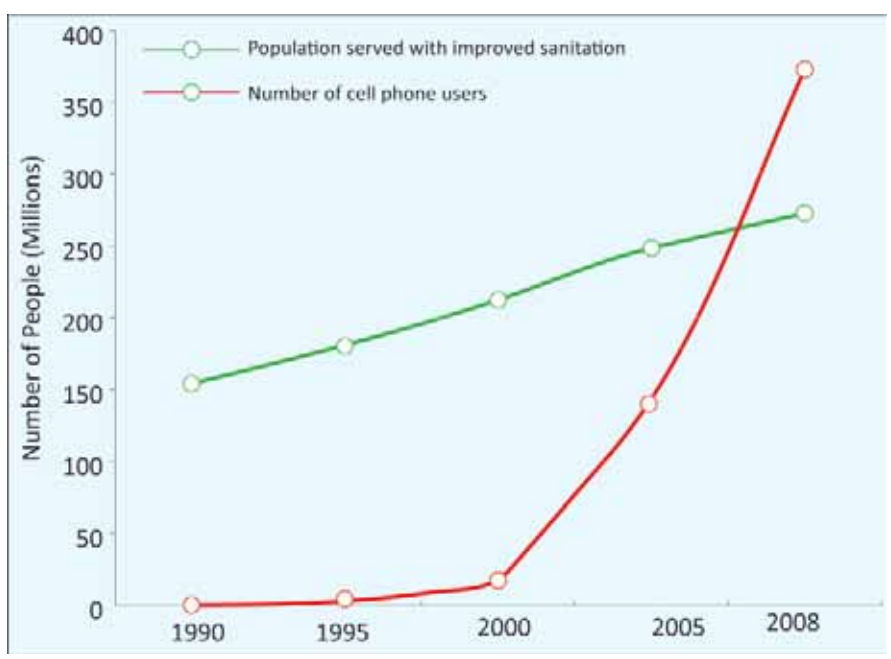
The improvement of sanitation services is inextricably linked to the improvement of water provision. Thus, the same opportunities outlined in the previous section apply here and there are lessons to be learned from countries that have made the most strides in increasing sanitation coverage. As well, the vast improvements being made in access to communications technologies provides an example of how innovation and entrepreneurship in sanitation technologies could also reap economic benefits in addition to improving health and well-being. The World Toilet Organisation (WTO) offers an alternative and radical approach to accelerate progress towards the MDG sanitation target by encouraging the perception of toilet ownership as a status symbol.

- *Recognize the potential to generate revenues from sanitation technologies:* The business opportunities afforded by investing in sanitation is now being recognized and Africa could benefit by market-based approaches (Lane 2010). The World Toilet Organisation (WTO) offers such an approach, arguing that businesses that provide affordable toilets can make profits (WTO 2010). The products of properly composted human faeces can also be a commercial commodity rather than a waste product, as has been demonstrated by the Chinese for centuries (Lane 2010).

- *Revolutionize toilets so they are as desirable as mobile phones:* The WTO also promotes a sanitation revolution in which toilets will become as desirable as mobile phones, simply by selling them—"Once people have invested some of their own money in a loo, they will use it" (Grimond 2010). Since the poor have not been motivated to invest in toilets through promotion on health grounds, the WTO aims to emotionally connect with the poor by branding toilets as a status symbol and an object of desire (WTO 2010).

- *Learn from the extraordinary expansion of mobile phones:* The number of mobile phone users in Africa has grown exponentially, while sanitation adoption has only increased mathematically. The number of mobile cell phone subscribers in Africa reached 448.1 million in 2009, representing an increase of 75 million new users since the previous year and a growth of 20 per cent in the customer base since 2008. The adoption of improved sanitation, on the other hand, has grown at a much slower rate (Figure 3.2.2).

Figure 3.2.2: Number of cellphone users against the population served with improved sanitation (Source: UNSD 2009, WHO/UNICEF 2010)



Public-private partnerships have helped to drive the recent exponential growth of mobile phone subscribers in Africa. The combination of the public sector's knowledge and expertise in development with the technical expertise and innovation of private companies has fostered the rapid, efficient

and sustainable communications business (Aker 2008). Improving sanitation can also provide an opportunity for such partnerships. Marginal costs can be reduced by the private sector's innovation for cheaper alternatives to improved sanitation facilities while the public sector can be responsible for equity and inducing behavioural changes.

- *Encourage and support simple solutions from entrepreneurs*: Entrepreneurs are increasingly bringing out low technology and affordable toilets. In Tanzania, for example, a concrete slab to install above pit latrines is now available for about US$5.00. A Swedish company is manufacturing a hygienic, single-use personal toilet bag of biodegradable plastic that breaks down the contents into marketable fertilizer (Grimond 2010).The most efficient way of designing integrated water and sanitation projects, especially for remote rural areas, is to use plug-in technologies that are flexible, compact, mobile and solar powered. More importantly, these technologies should be easily transferable to local communities so that local stakeholders can be responsible for maintaining and operating these facilities themselves. This local approach is suitable whereas large-scale solutions to the sanitation crisis are not practical due to lack of capacity in engineering, business development and fiscal management; it is also more donor-friendly for funding cycles of one-to-two years (UNU 2010).
- *Introduce urban water tariffs:* A study in Egypt showed that if urban water tariffs were raised to cover operations and maintenance costs, enough financial resources could be freed up to finance urgently required investment in sanitation infrastructure (UNDP 2006).
- *Increase sanitation's share in total aid:* Aid for sanitation and drinking water is increasing in absolute terms, but its share of total aid decreased from eight per cent in 1997 to five per cent in 2008 (WHO and UN-Water 2010). If water and sanitation targets were achieved, sub-Saharan Africa would save about US$2 per capita—equivalent to about 12 per cent of public health spending. Reduced spending would release resources for other priorities, including addressing HIV/AIDS (UNDP 2006).
- *Adopt system financing:* This opportunity is especially relevant if national plans include clear funding estimates for attaining their targets. All financing ultimately comes from government budgets (a category that includes aid) or users. The appropriate mix between the two varies. In low-income countries with limited coverage and high levels of poverty, a benchmark indicator is public spending on water and sanitation of about one per cent of GDP (depending on per capita income and the ratio of revenue to GDP), with cost-recovery and community contributions providing an equivalent amount (UNDP 2006).
- *Build partnerships between the government and civil society for educational campaigns:* There is an opportunity to increase capacity building through stronger partnerships between the government and civil institutions. For example, ten years ago Bangladesh's rural areas had one of the lowest levels in the world of access to proper sanitation. Despite being one of the world's poorest countries, it is now on target to achieve nationwide sanitation coverage by 2010, thanks to a "total sanitation campaign" promoted by NGOs and local authorities. The campaign appeals to three drivers of change: disgust, self-interest and a sense of individual responsibility for community welfare (UNDP 2006). An example from Burkina Faso in the mid-1990s demonstrates the success of an educational campaign conducted in partnership between the Ministry of Health and community groups related to sanitation: In Bobo-Dioulasso, children were still at risk from poor hygiene despite the presence of pit latrines in most households. The partnership promoted behavioural changes that reduced the incidence of diarrhoea—for example, by encouraging mothers to wash their hands with soap and water after changing diapers. Over three years, the programme averted some 9 000 diarrhoea episodes, 800 outpatient visits, 300 hospital referrals and 100 deaths—at a cost of US$0.30 per inhabitant (UNDP 2006).

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CHALLENGE 3

FOSTER COOPERATION IN TRANSBOUNDARY WATER BASINS

The Challenge: *Reduce potential conflicts over water resources by enhancing cooperation in transboundary water basins.*

The Situation: *Africa has 63 shared water basins. There is a potential for conflict over shared water resources; but there are already at least 94 international water agreements in Africa to cooperatively manage them.*

The Constraints: *Population growth is diminishing shared water supplies; climate change threatens to stress shared waters; water is declining in shared aquifers; there are seasonal differences in water supplies, and inadequate joint management laws and conflicting national interests stress joint management capacities.*

The Opportunities: *Recognize and build on water as a binding factor between otherwise hostile states; and learn from successful transboundary cooperation efforts and agreements among African states.*

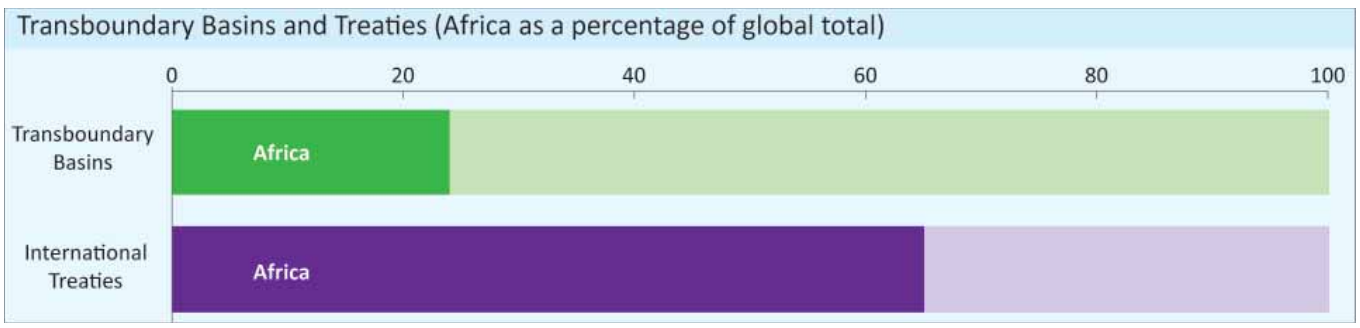
The Challenge

Given the many watersheds shared by numerous African nations and the potential for discord over water management in them, there is a need and an opportunity to avoid conflict by cooperating in transboundary water basins.

The Situation

- *Africa has a large number of shared watersheds:* There are 263 international river basins covering almost one half of the total land surface of the globe and affecting 40 per cent of the world's population. Of these, Africa has 63 shared basins covering about 64 per cent of the continental area (Figure 3.3.1). Africa has more rivers shared by three or more countries than any other continent. Every country in Africa has at least one international river, with the Congo basin shared by as many as 11 countries (Sadoff and others 2002).
- *There is a potential for conflict over water resources*: There are a number of ways in which disagreements over water use can arise among parties that share the resource: where one country transfers or threatens to transfer water outside the basin (for example, there is a planned project to transfer water from the Ubangi River to Lake Chad); when activities in upstream sections of a basin threaten downstream users and vice-versa (in the Okavango Transboundary watershed, for example, there is the potential for disputes between users in Angola and Namibia in the upper part of the river and those in Botswana downstream); where development outside a river basin threatens the river's water availability or quality, or vice-versa (for example, urban and industrial developments outside the Congo basin watershed make demands on the basin's waters); where there is competition for the same water among different economic sectors both within and between countries, including irrigation, hydroelectricity, industry, navigation, tourism, mining, etc.; and finally, when richer countries or large corporate development projects threaten water use by poorer users in another part of the basin (Roy and others 2010).

Figure 3.3.1: Number of transboundary basins and international treaties worldwide and in Africa (Source: UNEP 2006, OSU 2007)



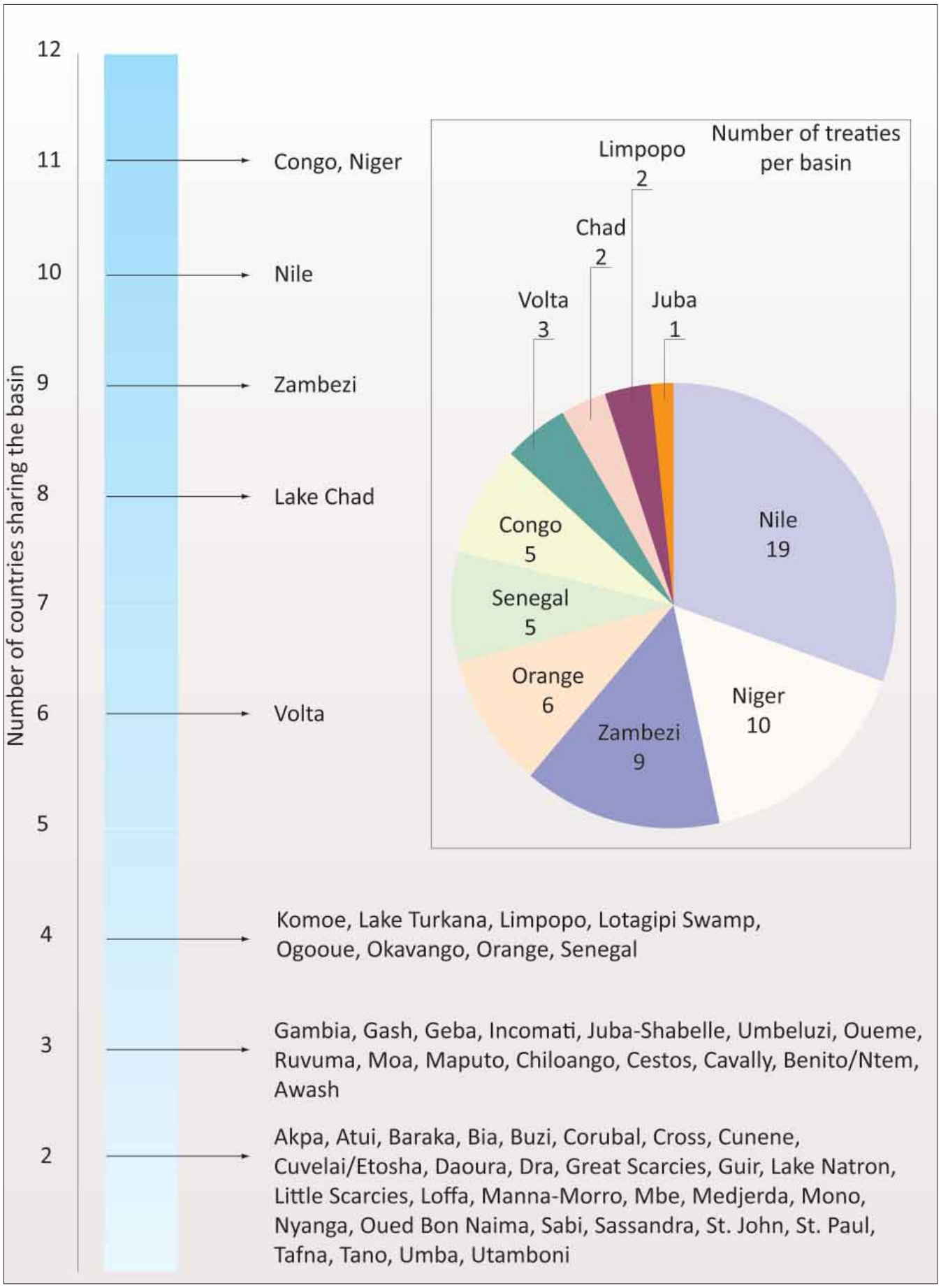
- *There are at least 94 international water agreements in Africa:* Worldwide, about 3 600 international waters treaties have been signed between 805 AD and 1984. Out of 145 international agreements signed between two or more states sharing water-basins in the last century, about 94 occurred in Africa, dating back from late 1800s (Wolf 1998). Figure 3.3.2 shows the number of countries sharing river basins in Africa's top shared basins and the number of transboundary treaties in those watersheds. It also illustrates the number of treaties in each of Africa's major basins.

The Constraints

- *Population growth is diminishing shared water supplies:* Perpetual population growth and existing hydro-political complexities in Africa's international river basins will inevitably place high stress on shared water resources and on the agreements that govern them (Turton 2008a). Africa's ever-growing population will certainly increase the demand for water. As demand increases and water supply decreases, the possibility for conflicts between transboundary nations could rise. For example,

"**Water conflict**" *refers to any disagreement or dispute over or about water, where external social, economic, legal, political or military intervention is needed to resolve the problem. A* "**water war**" *is an armed conflict that is fought between countries with the sole or primary purpose of gaining access to water, or where water forms the central weapon of offence in the arsenal of an aggressor (Ashton 2007).*

Figure 3.3.2: Number of countries in top-most shared basins and number of treaties for each of the major basins (Source: Wolf and others 2005, OSU 2007; Source 2 (for treaties): Number of treaties by Africa's major basins. Source: UNEP 2006, UNEP 2002, OSU 2007)



there is unprecedented demand for water in the Okavango River Basin, in part due to the increase in returning refugees and renewed commerce and trade as a result of the Angola peace process; water scarcity in the future could severely constrain economic development and possible elevate the issue of how to manage water to a national security issue (Roy and others 2010).

- *Climate change threatens to stress shared waters:* Predicted climate changes may have negative impacts on supply and demand, and may further exacerbate situations in which water is shared among countries (Cooley and others 2009).
- *Water is declining in shared aquifers:* Africa's aquifers contain large amounts of fossil water, which is thousands of years old. Their recharge rate is now much less than the withdrawal rate (UNEP 2006). A drop in groundwater levels or a decline in its quality may threaten the political stability of the region, especially where numerous countries share the resource (Turton 2008b).
- T*here are seasonal differences in water supplies:* Conflicts can also occur between upstream and downstream users due to large seasonal variations in water flows and periodic droughts and floods that are characteristic in Africa (Turton and others 2006).
- *Inadequate joint management laws and conflicting national interests stress joint management capacities*: Given that Africa's national boundaries are not aligned with water bodies, water resource management needs to include regional considerations rather than just national objectives (Ashton 2007). Vague or inadequate international laws regarding joint management of shared waters, however, make it hard for riparian states to manage both a single basin with other states and multiple basins in the same state. The water needs and economic situation in each country also varies (Turton 2008b). Conflicting interests and inequity in capacities between riparian states further constrain negotiations on international watershed management (Van der Zaag 2007). The Southern African Development Community (SADC) and the Senegal River Development Organization (OMVS) are the only two organizations that operate basin-wide shared water management (Kliot and others 2001). Issues among other organizations include lack of legitimacy and effectiveness, a "not-invented-here" syndrome (referring to models not developed in Africa) and inadequate consideration of the realities and needs of the local people (Merrey 2009). A mixture of these issues can lead to tense relations among riparian countries and increased potential for conflict. The "War of the Well" in Somalia is one example. Two clans clashed over the control of a water well, leading to the killing of 250 people over a period of two years as drought gripped the region (Jarvis 2006).

The Opportunities

International water cooperation presents an opportunity to deal with these challenges and constraints through negotiated basin sharing for both withdrawal and in-stream water uses. The sustainability of water available within a river basin that crosses two or more countries may be assured and even increased via transboundary agreements. Such agreements help ensure equity in the provision of water for all and help maintain peace and security. There are several examples of transboundary water agreements and other sharing mechanisms that have been successful in helping riparian African nations

negotiate equitable water sharing and that illustrate the potential for such agreements to be a catalyst for wider political cooperation.

- *Recognize and build on water as a binding factor between otherwise hostile states:* Although water has generally been described as a cause of political tension and armed conflicts, in reality, water has seldom been the primary cause of a transboundary war. Contrary to common perceptions, water has been a binding factor between otherwise hostile states. The Indus Water Treaty, for example, has survived three wars between India and Pakistan and Iraq gave Kuwait water "in brotherhood" without compensation. In Africa, confrontation between Swaziland, South Africa and Mozambique on water sharing within the Incomati River Basin because of competing interests ended after negotiations between 1964 and 2002. The deadlock was broken when the management of the adjacent Maputo River Basin was included so that some of the benefits were tradable between the parties (Van der Zaag 2007, Van der Zaag and Carmo Vaz 2003). A case study of competition and cooperation in the Incomati water issue concluded that: "The hypothesis that water drives peoples and countries towards cooperation is supported by the developments in the Incomati basin. Increased water use has indeed led to rising cooperation" (Van der Zaag and Carmo Vaz 2003).

  In the case of transboundary groundwater, conflicts are often attributed to the lack of information about the boundaries of the physical resource, resource capacity and conditions that suggest water quality. Yet, with all of these potential triggers for conflict, there are no documented cases where intensive groundwater use in a medium or large-sized aquifer has caused serious social conflicts (Jarvis 2006). Thus, there appears to be no historical reason to suggest that the problem of sharing water among riparian countries is likely to be a cause of future conflict in Africa or elsewhere; rather, it can be the catalyst for cooperation.

- *Learn from successful transboundary cooperation efforts and agreements among African states:* Successful transboundary water distribution is inherently dependent on political cooperation between the involved riparian states. In the absence of strong rules and laws, treaties are the best form of formal river basin management. These regimes define implicit and explicit principles, norms, rules and decision-making procedure to help meet actors' expectations. The formation of such institutions, including liability and sanctions in case of non-compliance, can help shift "negative peace" (absence of war) into "positive peace" (cooperation and confidence) (Turton 2003). Such cooperation in managing shared or competing interests in common water basins can promote many benefit-sharing possibilities, including international trade in water. For example, Lesotho and South Africa entered into a multi-billion-dollar water transfer and hydropower project on the Orange/Senqu river basin called The Lesotho Highlands Project (see page 91). It includes mechanisms such as direct payments for water, purchase agreements and financing arrangements and has enabled Lesotho to earn valuable foreign exchange from the water it sells to South Africa (Ashton 2000, Roy and others 2010). In the case of the Senegal River, a burden-sharing formula enabled Senegal, Mali and Mauritania to agree on how to share the development costs and benefits of infrastructure they jointly operate on the river. There has been a decided change from top-down to cooperative management approaches to managing transboundary water resources in Africa, as illustrated by the formation of OKACOM in the Okavango River Basin, which brought the riparian nations together under the slogan "Three Nations, One River" in a new model of water sharing (Roy and others 2010).

  Other examples of successful water-sharing bodies or mechanisms in Africa that hold lessons in cooperative management are the Nile Basin Initiative, in which ten riparian nations have met amicably for more than a decade, and the Senegal River group, including Mali, Senegal, Guinea and Mauritania, which refuses to argue about water entitlements in favour of distributing projects equitably such that a dam may be built in one country but the electricity generated is distributed elsewhere in exchange for another benefit (Grimond 2010).

  Common interests in transboundary rivers and basins, like water quality, supply, flood control, effects of climate change, etc., are potential arenas in which to build institutional capacity through collaboration among co-riparian states. Joint efforts in collecting data, understanding impacts and improving socio-economic models can bring the actors together and thus avoid potential conflicts. Transboundary cooperation can broaden the knowledge base, enlarge the range of measures available for prevention, preparedness and recovery, develop better responses and offer more cost-effective solutions.

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CHALLENGE 4

PROVIDE WATER FOR FOOD SECURITY

The Challenge: *Provide African agriculture with enough water to ensure long-term food security.*

The Situation: *Agricultural growth is the mainstay of most African economies; agriculture is the greatest user of water in Africa; there is inadequate water use for sustainable food production; Africa suffers from food insecurity and 30 per cent of the population lives with chronic hunger.*

The Constraints: *Per capita food intake is rising; food production is not increasing; green water efficiency is very low; and irrigation capacity is underdeveloped.*

The Opportunities: *Learn from the 1960-1990 Green Revolution; promote a greener, Green Revolution in Africa; increase irrigation to increase food security; avoid the pitfalls of over-irrigation; invest in simple and inexpensive irrigation technologies; tie irrigation development to issues of social equity and environmental sustainability; secure sustainable investment for the Green Revolution; invest in targeted breeding of drought tolerant varieties.*

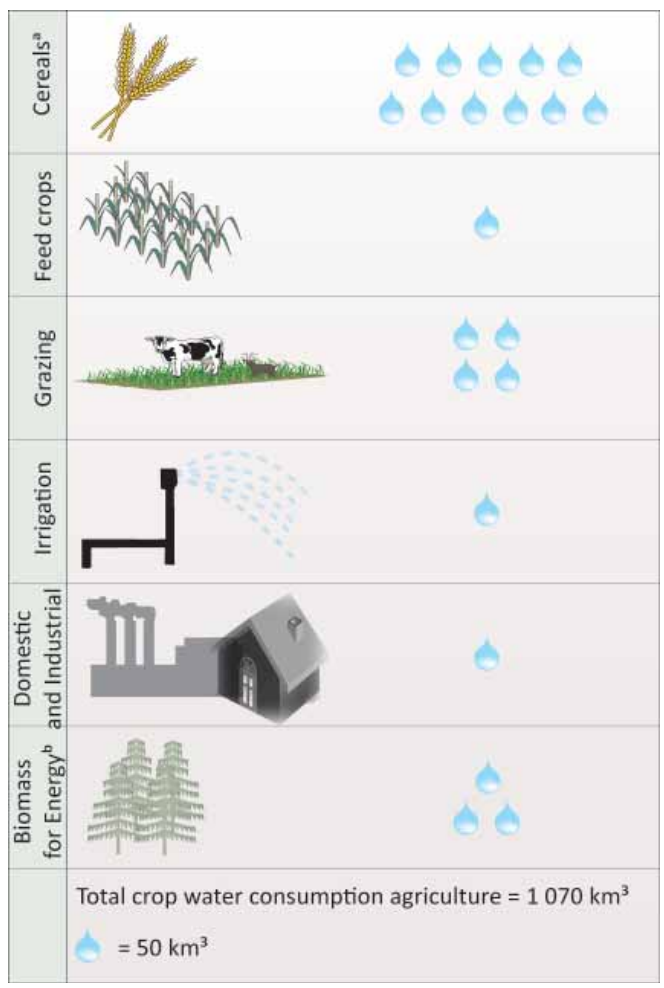
The Challenge

With a growing population, Africa needs more food and must secure the water needed to ensure its supply at the same time as water resources are becoming scarcer. How can Africa squeeze more food out of each drop of scarce water?

The Situation

- *Agricultural growth is the mainstay of most African economies:* Farming is the source of livelihood for about 70 per cent of Africa's population that are rural-based. In sub-Saharan Africa, mostly small-scale farming represents about 30 per cent of GDP and at least 40 per cent of export value. In a number of Africa's smaller nations, agriculture plays a much greater role, accounting for 80 per cent or more of export earnings (Nwanze 2010). Studies have shown that other economic sectors on the continent tend to perform well when there is positive growth in the agricultural sector (Wik and others 2008).

Figure 3.4.1: Water depletion from main agricultural activities for sub-Saharan Africa (Source: Adapted from de Fraiture and Wichelns 2010) [a]Includes cereals used for feed; [b]includes all biomass (mostly firewood)



- *Agriculture is the greatest user of water in Africa:* Globally, agriculture accounts for 70 per cent of water consumption (UNEP 2008) but in Africa, as much as 86 per cent of total annual freshwater withdrawal goes to agriculture (Frenken 2005). Thus, the demand for food is the most important driver of water use in Africa. Figure 3.4.1 shows the amount of water used for various agricultural activities in sub-Saharan Africa.
- *There is inadequate water use for sustainable food production:* Inadequate water for food production continues to compromise the well-being and economic productivity of Africa's people, thus curtailing their ability to generate revenue required for improving the availability and access to water for food.
- *Africa suffers from food insecurity and 30 per cent of the population lives with chronic hunger:* Lack of water contributes to the situation of food insecurity, a situation in which people lack adequate physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active healthy life (Mwaniki 2006). Economic water scarcity is a contributing factor to food insecurity, especially in sub-Saharan Africa (see Challenge 9). This refers to a condition in which water resources are abundant relative to water use, with less than 25 per cent of water from rivers withdrawn for human purposes, but malnutrition exists (UNEP GRID/Arendal 2008). In sub-Saharan Africa, overall per capita agricultural yields declined from 1970 to 1980,

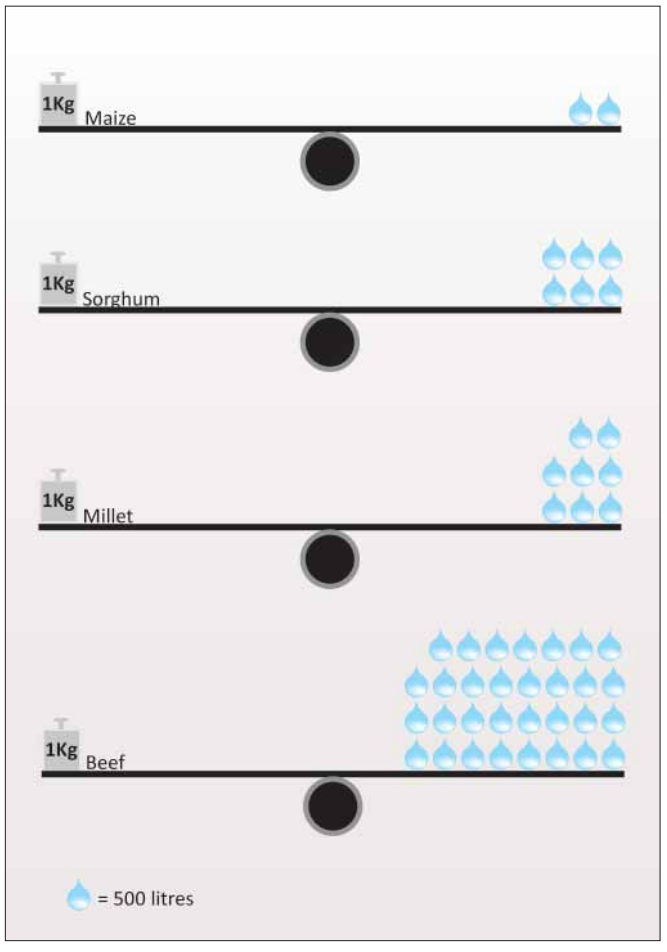
and since then have stagnated. The number of poor people is increasing, 30 per cent of the population lives with chronic hunger, and similar levels of malnutrition in children under the age of five persist (IAASTD 2009). Sub-Sahara Africa alone accounts for 25 per cent of the undernourished people in the developing world and it has the highest proportion (one-third) of people suffering from chronic hunger (World Bank 2008). In East and Southern Africa, the number of food-insecure people almost doubled from 22 million in the early 1980s to 39 million in the early 1990s. Furthermore, no single sub-region in Africa can attain food security without recourse to food imports or external food aid (UNECA 2006).

The Constraints

- *Per capita food intake is rising:* As Africa's population rapidly becomes more urbanized (UNFPA 2009), increasingly large amounts of water are needed to meet food requirements. Not only are there more people to feed in cities, but urbanization is also generally accompanied by a rise in personal income and an increase in per capita food intake. In addition, people tend to shift away from staples towards richer diets containing products that require more water to produce such as meat, fruits, vegetables, sugars and oils (Pingali 2007) (Figure 3.4.2).

- *Food production is not increasing:* About one-third of the continent's people live in drought-prone areas, and the rising population and increasing affluence and demand for different foods has not been matched by a corresponding increase in food production.

Figure 3.4.2: Water requirements of selected agricultural products (Data sources: Hoekstra and Chapagain 2008, Water Footprint n.d.)



- *Green water efficiency is very low:* A large portion of water for crop production in Africa comes from rainfall that is eventually transpired by crops as soil moisture (green water), while 68 km^3 or around six per cent is from surface and groundwater sources (blue water). Green-water use efficiency is still very low, with studies showing that only 15 per cent of the terrestrial rainwater is used by plants for the production of food, fodder and fibre in sub-Saharan Africa, partly due to excessive losses caused by poor land management practices (Rockström and others 2009, Stroosnijder 2009).

- *Irrigation capacity is underdeveloped:* There is underinvestment in water infrastructure for irrigation across the continent, with only seven per cent of cultivated land equipped for irrigation in 2005 (FAO 2005). In sub-Saharan Africa, the proportion was only 3.8 per cent of arable land. By comparison, 28.7 per cent of the Near East and North Africa's cultivated land was irrigated, and in South Asia, the proportion was as high as 39 per cent (Figure 3.4.3). Water-managed areas in national agriculture vary from less than one per cent of cultivated land in such countries as the Democratic Republic of the Congo, Comoros, Ghana, Togo and Uganda to 100 per cent in the most arid countries such as Egypt and Djibouti where agriculture is impossible without irrigation (UNECA 2006). The lack of investment in irrigation in most countries contributes to the expansion of rain-fed agriculture on to marginal lands with uncertain rainfall. This is forcing millions of impoverished people to farm in ecologically fragile areas. Without adequate water, farmers have little incentive to invest in quality seed and inputs (FAO 2002).

Water and food insecurity in Africa: some statistics

• The depth of water across Sudan, Africa's largest country by land area, is 43 cm, which is equivalent to the amount consumed annually by crops on the continent (De Fraiture and Wichelns 2010).

• Africa's irrigated area of over 13 million hectares represents six per cent of its total cultivated area, compared to 35 per cent in Asia and 11 per cent in Latin America (FAO 2009).

• Two-thirds of sub-Saharan Africa's over six million hectares of irrigated land is found in only three countries: Madagascar, South Africa and Sudan (AfDB and others 2007).

• At least US $4.7 billion is required per year to ensure food security in Africa (AfDB 2006).

The Opportunities

- *Learn from the 1960-1990 Green Revolution:* There are lessons to be learned for Africa from the Green Revolution, which saw the yield of major cereals (rice, wheat and maize) more than double during the period 1960-1990 in Asia and Latin America, arresting the threat of famine and lowering the prices of staple crops (FAO 2005). By focusing on small farmer-based agriculture, countries that were food deficit 40 years ago are now food exporters. National governments controlled their own agricultural policies and the main focus of agricultural research was to promote local and appropriate technologies. Although there are natural, social and economic differences, the Asian food crisis at that time was described in the same breadth and in terms used for Africa today: high population growth rates, widespread poverty, hunger and malnutrition.

- *Promote a greener, Green Revolution in Africa:* By initiating a green (ecological friendly), Green Revolution, Africa has an opportunity to grow more food from the same amount of water or grow the same amount of food using less

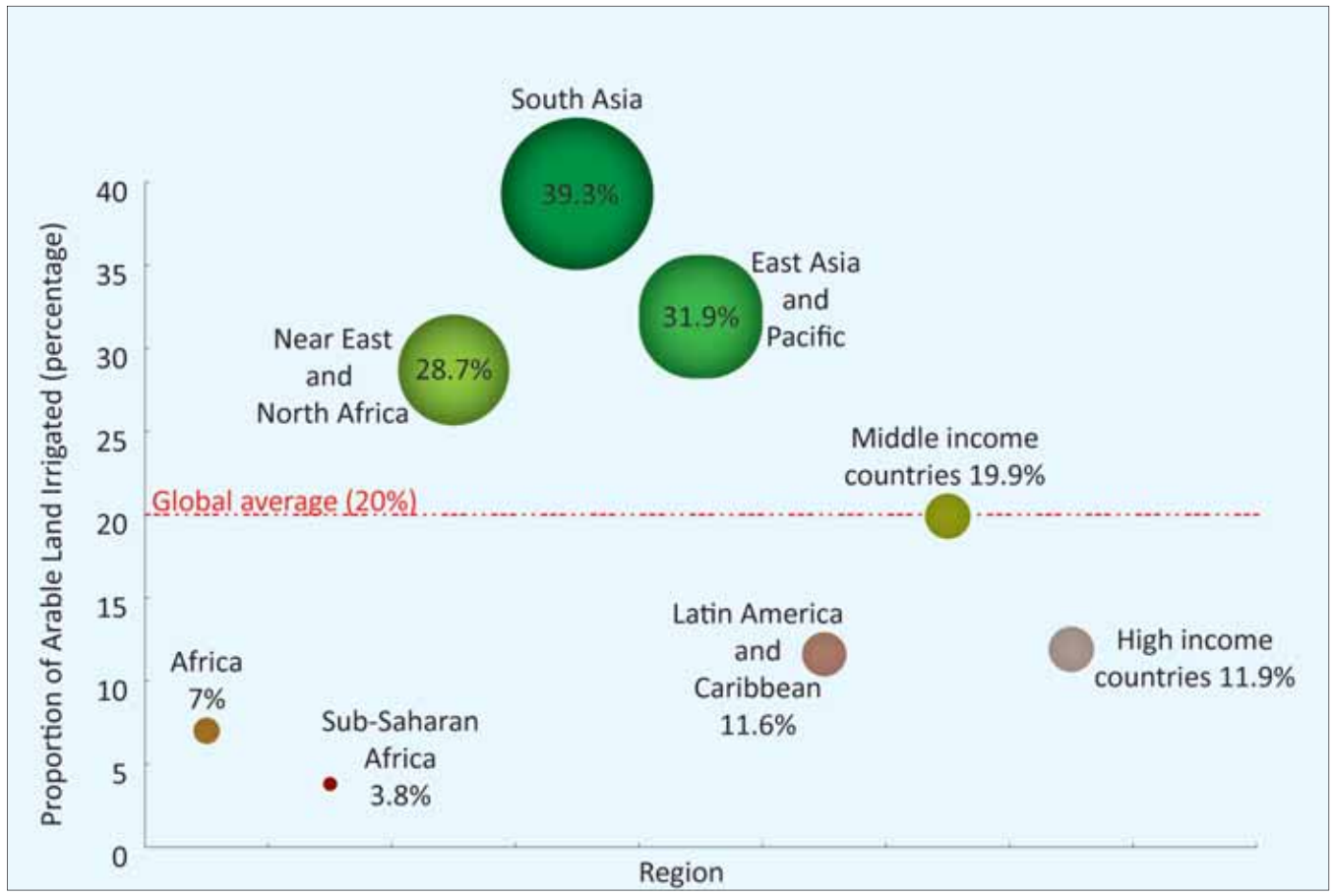


Figure 3.4.3 Proportion of arable land irrigated—regional and global (Data Source: FAO 2005)

water. The use of irrigation, synthetic fertilizers, chemical pesticides, early maturing and high yielding dwarf seed varieties (the dwarf varieties of rice and wheat were less susceptible to falling over, enabling the application of large amounts of water and fertilizer to boost yields) were critical components of the Green Revolution technology package in Asia (Ringler and others 2010). Record yields were realized but higher rates of poisonings from the chemical pesticides were also recorded in many areas, in addition to intense eutrophication of aquifers and waterways (Bai and others 2008, Jhamtani 2010). In Asia, the ecological costs of the Green Revolution have risen and a growing number of farmers are turning back to non-chemical or less-chemical agriculture (Jhamtani 2010). Alternative sustainable farming practices include agroforestry and intercropping cereals with legumes to improve nitrogen deficient soils and reduce reliance on synthetic fertilizers and pesticides. Increasing productivity on existing cropland is fundamental if Africa is to avoid destroying vital ecosystems such as its biodiversity-rich wetlands and rainforests. Africa can avoid the environmentally damaging aspects of such a revolution by focusing on a green, Green Revolution.

- *Increase irrigation to increase food security:* The estimated rate of agricultural output increase needed to achieve food security in Africa is 3.3 per cent per year. The potential for meeting this estimate exists, since two-thirds of African countries have developed less than 20 per cent of their agricultural production and less than 5 per cent of the cultivated area is under irrigation in all but four countries (UNECA 2006). Without investment in irrigation, it will be difficult to increase food production, reduce the financial burden of agricultural imports and increase food security. Irrigation increases yields of most crops by 100 to 400 per cent. In sub-Saharan Africa, only four per cent of cropland is irrigated (Figure 3.4.4), so farmers need to make significant investments in irrigation to increase their productivity. Irrigation makes it possible to:
  - Control soil moisture and therefore exploit an extended cropping season to boost agricultural yields and outputs;

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Figure 3.4.4: Map of Irrigated Areas (Source: FAO 2006)

- Supplement unreliable rainfall, and grow a wider range of crops, including high value crops for the export market;
- Maintain food production levels and contribute to price stability through control over production levels;
- Achieve food security at local levels through increased income and improved health and nutrition; and
- Bridge national gaps between production and demand of food crops (Ringler and others 2010).

• *Avoid the pitfalls of over-irrigation:* Irrigation development was an important component of the Asian Green Revolution, used to double yields by supplementing unreliable rainfall. Critics argue that over-irrigation led to steep drops in the water table, while thousands of hectares of productive land have been lost to salinization and waterlogged soils. A typical example is India where dams and canals constructed by the government and tube wells drilled by individual farmers saw the net irrigated area increase from 21 million ha in the 1950s, to 39 million ha, or roughly 20 per cent of the world's irrigated land in 1980 (Fitzgerald-Moore and Parai 1996). This expansion resulted in not only higher agricultural production, but also excessive groundwater depletion, waterlogging and salinization of formerly productive cropping areas (Ringler and others 2010).

- *Invest in simple and inexpensive irrigation technologies:* These offer the best advantages for increasing irrigation for food production, but they must be managed carefully to avoid environmental damage, which is already extensive, and the spread of water-borne diseases. Parts of sub-Saharan Africa have large untapped reserves of groundwater and there is great potential for harvesting water runoff and for farming lowlands and valley bottoms that catch it naturally (Figure 3.4.5). With investment, this potential could be unleashed (FAO 2002). Other water conservation techniques include switching from surface to "smarter" irrigation techniques like micro-irrigation and mulching and using cover crops to minimize the loss of available green water.

Increases in the level of irrigation can come from both surface and ground water, drawing lessons from within and outside the region on viable small to medium scale irrigation techniques that require limited infrastructural development and can reach many farmers. Methods such as pumping from rivers on an individual and small group basis, and locally manufactured drip systems are still to be fully exploited (IAASTD 2009).

Surface irrigation is easy to operate and maintain, and can be developed at the farm level with minimal capital investment, with an indicative field application efficiency of around 60 per cent. Most energy requirements for surface irrigation systems come from gravity, and the systems are less affected by climatic and water quality characteristics (FAO 1989a, 1989b).

Sprinkler irrigation has a high irrigation field application efficiency of around 75 per cent, and is easy to design and simple to install and operate. It can be adapted for all types of soils, many kinds of field crops and small irregular plots, and is less expensive than many other modern irrigation systems (FAO 1989b, 2007a). Drip irrigation is the most advanced irrigation method with the highest field application efficiency of around 90 per cent. Water is applied to each plant separately in small, frequent, precise quantities through dripper emitters. Switching from sprinkler irrigation to drip systems has resulted in a reduction in water use by 30-60 per cent (FAO 1989b, 2003, 2007a).

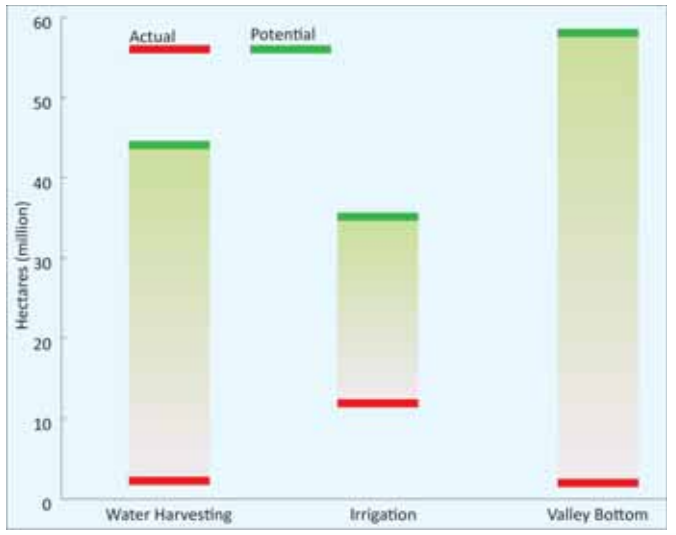


Figure 3.4.5: Water management potential in Africa (area in millions of hectares) (Source: FAO 2010)

Box 3.4.1: Small-scale irrigation projects bring multiple benefits

A recent study of selected small-scale irrigation projects in Burkina Faso, Mali and the United Republic of Tanzania shows the potential for these initiatives to increase farm productivity. Small dams, wells and canals built in the villages increased agricultural productivity and generated income that allowed people to cope better with "hungry periods" of the year. The projects included nonagricultural activities such as nutrition education. The benefits extended beyond increased agricultural productivity, giving women time to start market gardens and helping families reduce debt, increase school attendance,

limit seasonal migration for work and earn cash to pay for health care.

Source: FAO 2002

- *Tie irrigation development to issues of social equity and environmental sustainability:* The large-scale irrigation schemes of the past have lost favour because of their social, environmental and financial costs. Now, project planners are seeking the participation of farmers in designing and managing irrigation plans. In implementing small-scale irrigation projects, there are opportunities to extend benefits to enhance social and environmental sustainability (Box 3.4.1). One of these benefits should be providing opportunities for rural women; given their central role not only as mothers and caregivers, but also as farmers, they hold the key to food security (Nwanze 2010).

- *Secure sustainable investment for the green, Green Revolution:* Technologies such as the development of underutilized irrigation potential, and the development of high yielding and more drought tolerant varieties can work for Africa if there is good investment (World Bank 2008). African farmers can reduce reliance on food imports and protect against the import of low-price grains. Governments in Africa are taking ownership of their own agricultural policies through initiatives such as the Comprehensive Africa Agriculture Development Programme (CAADP), which provides the framework for supporting the design and implementation of national agriculture and food security strategies (MDG Africa Steering Group 2008). This initiative presents an opportunity for development partners and the private sector to support national governments, and to reduce donor fragmentation so that financing can be channeled to effectively support the implementation of national-scale agriculture strategies within the framework.

- *Invest in targeted breeding of drought-tolerant varieties:* For example, the AfDB funded and African Rice Initiative coordinated project contributed to a six per cent increase in the continent's rice output during 2007 (World Bank 2008). Such targeted breeding can produce crop varieties that are higher yielding, more drought tolerant, utilize fertilizers more efficiently, and are more resistant to pests. It is important to note that genetically modified organisms (including crops) are still considered an emerging issue in Africa since they present the following concerns and uncertainties in light of increasing cooperation and trade:

- The issues of bio-safety;
- The impact of GMOs on the environment;
- Trade with non-GMO partners;
- Ethics issues;
- Intellectual property rights; and,
- Access to seeds by small-scale farmers (SADC and others 2008).

CHALLENGE 5

DEVELOP HYDROPOWER TO ENHANCE ENERGY SECURITY

The Challenge: *Develop Africa's water resources for hydroelectricity to boost energy security.*

The Situation: *Hydroelectricity supplies 32 per cent of Africa's energy; electricity consumption in Africa is the lowest in the world; access to electricity is uneven; electricity supply is often unreliable; wars have destroyed existing electricity service in some areas; and Africa's hydro potential is underdeveloped.*

The Constraints: *The capacity to generate hydropower is unequal across the continent; climate change will exacerbate rainfall variability and hinder hydro potential; and hydro dams will need to avoid the environmental and social impacts historically characteristic of large dam developments.*

The Opportunities: *Recognize that Africa has enormous hydroelectricity potential; develop hydropower because it will boost the economy and human well-being, invest in hydroelectricity rather than fossil fuels, which makes sense in an era of climate change; learn from the many African countries that have developed hydropower successfully; learn from and copy successful regional power pools; and develop small-scale hydropower projects to avoid the environmental and human costs associated with large dams.*

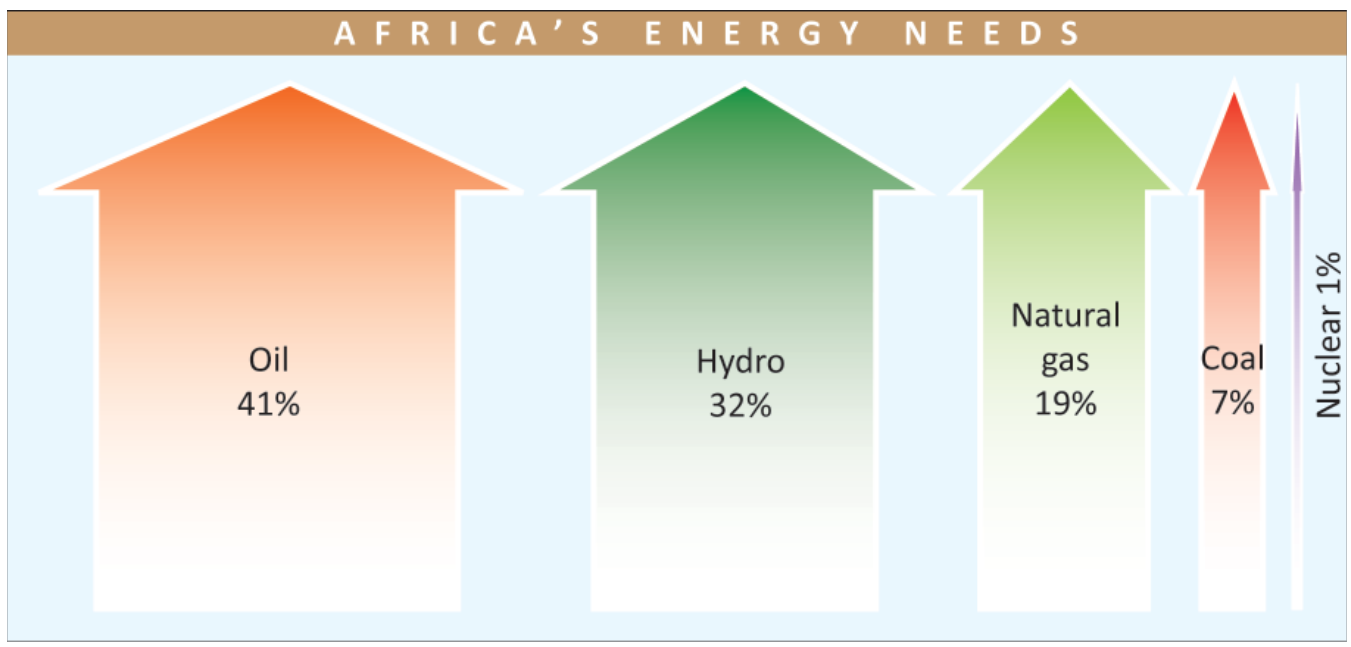
The Challenge

Africa has plentiful water resources for hydroelectricity and can boost energy security by increasing hydro development.

The Situation

- *Hydroelectricity supplies 32 per cent of Africa's energy* (Figure 3.5.1);
- *Electricity consumption in Africa is the lowest in the world:* Although Africa has the second-largest population after Asia, it has the lowest energy consumption per capita of any continent (Figure 3.5.2, next page). Many African nations have a per capita electricity consumption of less than 80 kWh/yr (Figure 3.5.3, next page), compared to 26 280 kWh/yr in Norway, 17 655 kWh/yr in Canada, and 13 800 kWh/yr in the United States (Bartle 2002).
- *Access to electricity is low and uneven:* More than 90 per cent of the rural population relies on biomass energy sources that include wood, crop waste, charcoal and manure for cooking and heating, and candles and kerosene for lighting (Bartle 2002, Tshombe and others 2007). Only one in four people in Africa has access to electricity, and this figure is barely 10 per cent in rural areas (MDG Africa Steering Group 2008). There are major disparities in levels of electrification between North Africa (93.6 per cent) and sub-Saharan Africa (23.6 per cent) (Kauffman 2005).
- *Electricity supply is often unreliable:* Even where access to electricity is available, it does not necessarily mean that electricity is available on demand. People frequently have to cope with unreliable supply and this disrupts economic activity at all levels and hampers progress. There are many reasons for the frequent and extended

Figure 3.5.1: Hydro contribution to Africa's primary energy needs, 2002 (Source: Kalitsi 2003)



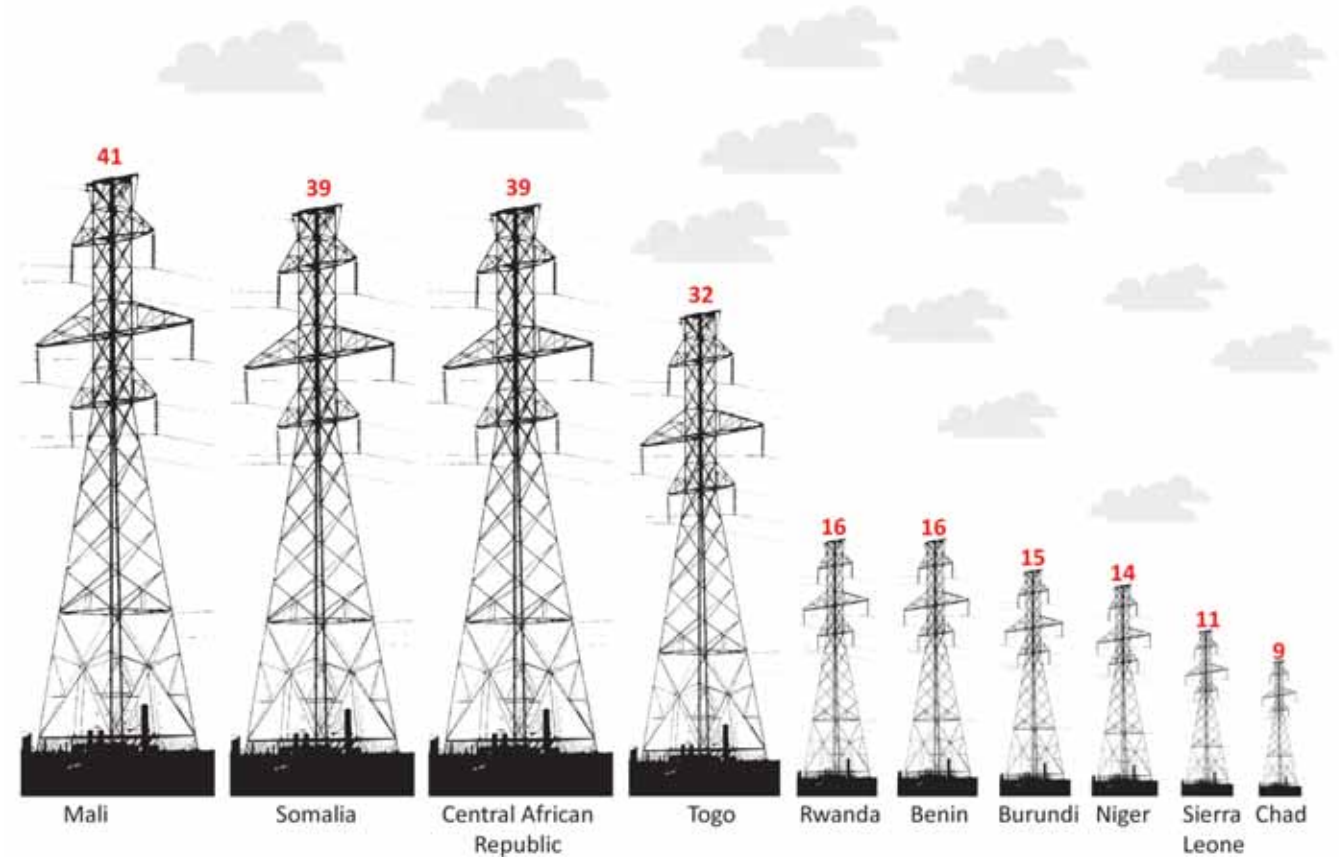


Figure 3.5.3. African countries with less than 80 kWh per capita electricity consumption (Source: Adopted from Bartle 2002)

interruptions, including conflicts that have damaged infrastructure, lack of government funds or treating hydro as a low priority, and aging equipment. Nigeria, for example, operates at about one-third of its installed capacity due to aging facilities. In addition, unpredictable and variable climatic conditions affect the constancy of electricity supply. The 1999-2000 East African drought had a serious impact on hydroelectric facilities, especially in Kenya and Ghana (MBendi n.d.). Rising demand is another reason. In 2007, frequent and extended electricity interruptions affected nearly two-thirds of the countries in sub-Saharan Africa, and although conflict and drought were to blame in several instances, electricity supplies failing to keep pace with growing demand was the cause in most cases (IMF 2008).

- *Wars have destroyed existing electricity service in some areas*: Infrastructure for electricity distribution and transmission has been

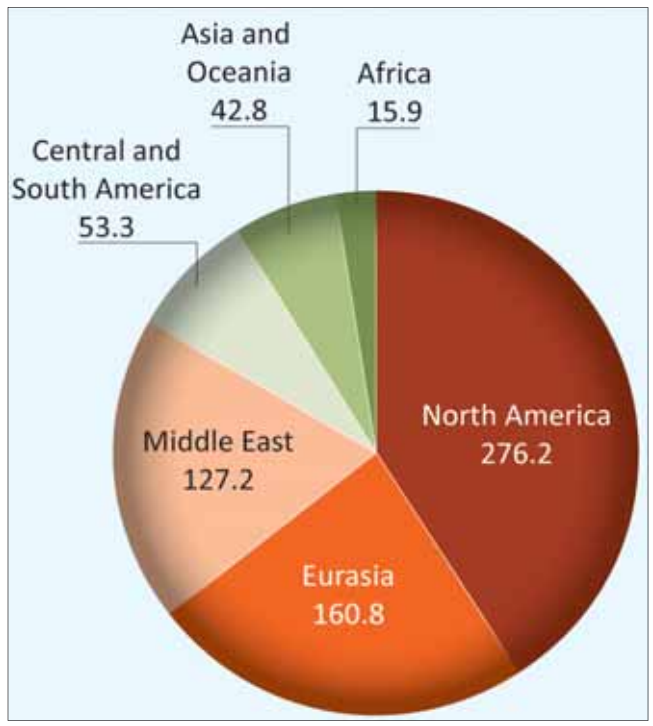


Figure 3.5.4: World per capita total primary energy consumption, 2006 (Million Btu) (Source: IEA 2008)

Africa is the "underdammed" continent. Only three per cent of its renewable water is used, against 52 per cent in Asia. So there is plenty of scope for an African dam-building boom.

—The Economist 2010

The Egyptian Wikimedia Commons

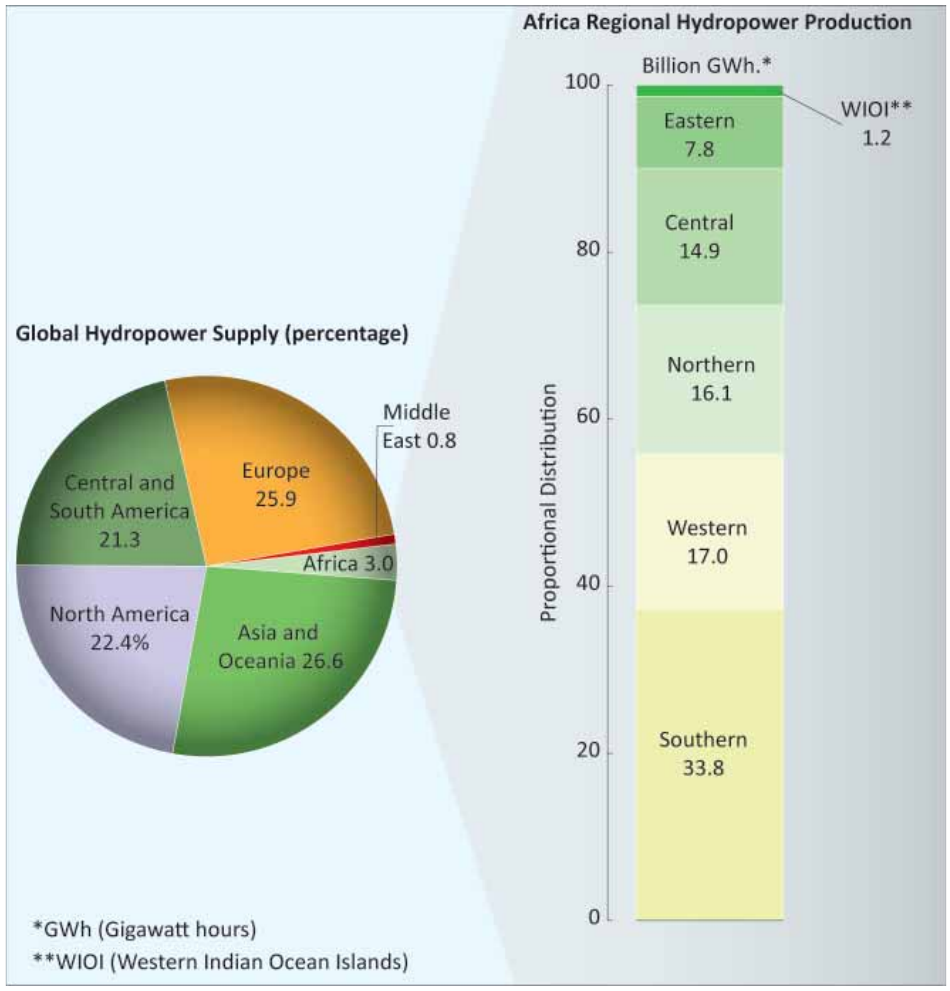


Figure 3.5.4: Regional shares in hydropower supply, 2004 (Data source: IEA 2007)

destroyed by war in countries such as Angola, Congo, Côte d'Ivoire, Chad and Sudan. According to the IEA (2008), it is more costly to restore service than the average cost of serving new customers in a stable environment.

- *Africa's hydro potential is underdeveloped:* Only three per cent of its renewable water resources are exploited for hydroelectricity, compared to an average of 45 per cent in OECD countries and 21 per cent in Latin America (Figures 3.5.4 and 3.5.5, and Box 3.5.1).

Box 3.5.1: How much hydro potential has Africa developed?

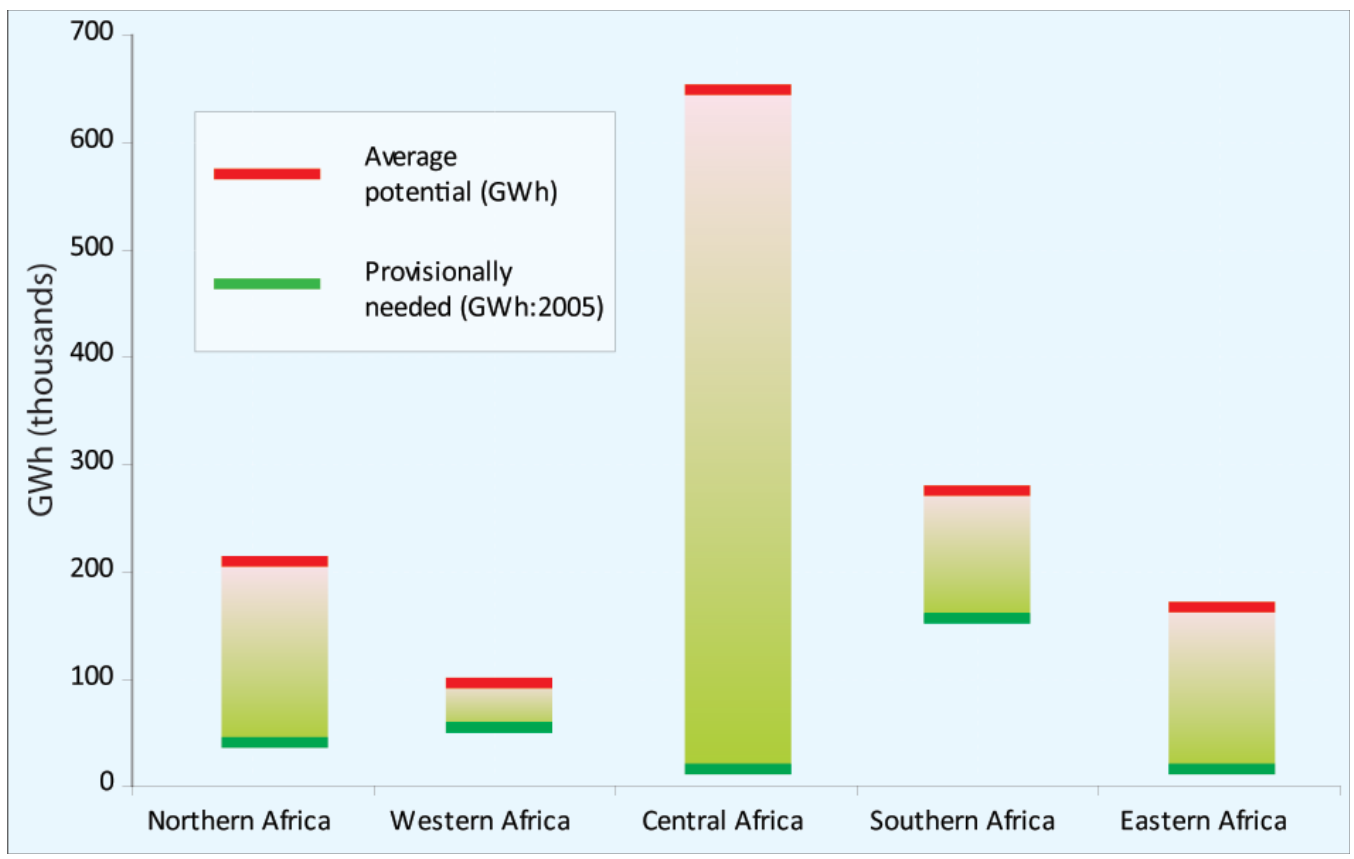
Various estimates regarding the extent of hydropower development in Africa have been given by different sources in the last decade. Despite these variations, as shown in this box, one underlying message is clear: Africa's vast hydropower potential is yet to be tapped.

Capacity Developed	Source
4 per cent	Bartle (2002); Blyden and Akiwumi (2008)
8 per cent	World Bank (2010a)
Less than 8 per cent	AfDB (2006)
4 per cent**	World Water Assessment Programme (2009)
7 per cent	AfDB (2006)

*Figure provided as "renewable water use", which covers other sectors in addition to hydropower.

**Figure covers annual renewable flows for irrigation, food production and hydroelectricity for sub-Saharan Africa only.

Figure 3.5.5: Regional development of economically feasible hydropower potential (Source: Modified from Hammons 2006)



The hardest bit is hydrology. Rainfall estimates are often wrong. Some countries must rent costly diesel generators to boost hydropower in years of drought. Climate change makes hydrology trickier still. Reservoir water sometimes falls too low to turn the turbines

—The Economist 2010

The Constraints

Constraints to hydropower development in Africa include the unavailability of suitable sites, large capital requirements, long lead times to develop, concerns over social and environmental impacts, political instability, and the impacts of climate variability on water resources (World Bank 2010). Low demand and dispersed populations also hinder rapid exploitation as well as the increase in demand from population and economic growth that challenge the ability of countries to provide increased power (Kalitsi 2003, MBendi n.d.).

- *The capacity to generate hydropower is unequal across the continent:* Across Africa, available sites for hydro development are unevenly distributed. For example, the average potential in North Africa is 41 000 GWh compared to 653 361GWh in Central Africa (Figure 3.5.6). In spite of its enormous hydroelectric potential, the Central Africa sub-region is the least electrified with only 2.6 per cent power production, while the Southern Africa sub-region is the most electrified (MDG Africa Steering Group 2008).
- *Climate change will exacerbate rainfall variability and could hinder hydro potential in some areas:* Challenge 8 outlines how and where climate change is expected to affect Africa's water resources.
- *Hydro dams will need to avoid the environmental and social impacts historically characteristic of large dam developments:* Africa has over 1 270 large dams (WCD 1999). In most cases, they brought considerable hardship to the local communities who reaped few benefits, but often sacrificed their land and livelihoods to make way for the projects. Such were the impacts of large hydro dams in Sudan, Senegal, Kenya, Zambia/Zimbabwe and Ghana. In most cases, benefits are inequitably shared and the dams feed centralized power grids that benefit industry and elite groups. Africa faces the challenge of developing hydro facilities that do not inflict damage on the environment or people's lives (Hathaway and Pottinger 2010).

Figure 3.5.6. Regional power production in Africa (Source: Hammons 2006)

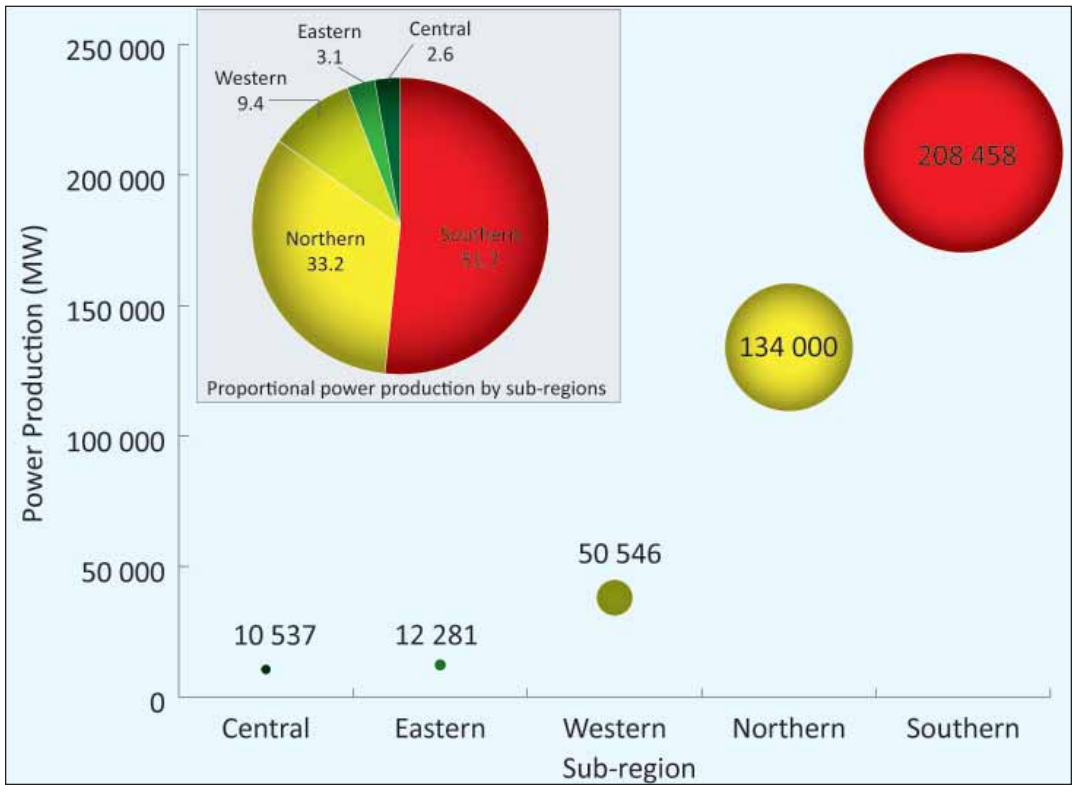


Table 3.5.1: Overview of proposed hydro developments in selected African countries. (Sources: Bartle 2002, Kalitsi 2003, Export-Import Bank of the United States 2008, Hydroworld website 2010, World Bank 2010)

Country	Proposed Developments
Benin	Hydro supplies 80 per cent of electricity; planning to increase country's installed capacity by more than 100 per cent to improve on 49 kW h annual per capita electricity consumption.
Niger	Per capita consumption is 25 kW h/yr; planning for first hydro plant, Kanadji, with a capacity of 125 MW.
Chad	Per capita consumption 14 kW h/yr; only 11 MW of 32 MW national capacity in service; planning for 6 MW capacity first hydro plant.
Burkina Faso	Water management programme for the Nakanbe river to lead to further hydro-development, regarded as a high priority for socio-economic development.
Mali	Detailed financial studies conducted for four of several medium-sized projects at the feasibility stage; Up to 800 MW new hydro-capacity planned for the long-term.
Ghana	Hydro is the main priority in economy; 400 MW Bui scheme under construction and scheduled for 2012 completion.
Liberia	Most power facilities damaged or destroyed due to long-term civil war; Large hydro-potential development regarded as basis for economic recovery.
Democratic Republic of the Congo	Largest potential in Africa with technically and economically feasible potential around 419 TW h/yr; and future plans include La Grande Inga, with capacity between 6 and 39 GW. Many more medium scale (40–100 MW) and small schemes planned; More than 3 000 MW expected from refurbishing existing plants.
Sudan	4 800 MW technically feasible hydro projects identified; two medium-scale schemes at the feasibility study stage.
Ethiopia	Exploitation of potential in the Nile basin regarded a priority; Nearly 200 sites identified for hydro-development; 18 proposed and two projects, Gilgel Gibe and Tis Abbay II, recently completed. Gibe III under construction.
Nigeria	5 000 MW planned for the medium and long-term, including the Zungeru (950 MW) and Mambila (3 900 MW) projects.
Mozambique	2 000 MW planned for implementation.
Tanzania	180 MW of capacity construction; Seven future schemes at the feasibility study stage; Stigler's Gorge (1 400 MW) the largest; others are 40–250 MW capacity.
Zambia	Two major binational schemes planned with Zimbabwe; Batoka Gorge to include 181 m-high dam and twin 800 MW power plants for each country; Devil's Gorge to provide 600 MW each. Major refurbishment schemes completed at Kafue Gorge, Kariba and Victoria Falls.
Zimbabwe	Two major binational schemes planned with Zambia; Batoka Gorge to include 181 m-high dam and twin 800 MW power plants for each country; Devil's Gorge to provide 600 MW each.
Cameroon	Hydro a major priority for rural electrification; Plans for several hundred megawatts of new hydro-capacity, and refurbishment of several schemes.
Kenya	Several new schemes totaling 460 MW planned.
Malawi	Could implement 365 MW of hydro-capacity, including the 90 MW Lower Fufu scheme.
Uganda	Hydro provides 99 per cent of electricity; Several private schemes planned, including the 290 MW Bujagali scheme on the Nile, now going ahead; Extension of Owen Falls project completed; Four more capacities 180- 642 MW in the longer term.
Egypt	Installing about 200 MW hydropower at its Nile barrages; Power sector capacity has doubled in the last few years.
Sierra Leone	Plans have been delayed by civil war.
Eritrea	Development impeded by economic difficulties; has ideal conditions for hydro schemes but lacks the necessary infrastructure.

The Opportunities

- *Recognize that Africa has enormous hydroelectricity potential:* Africa has vast hydropower potential—enough to meet all the continent's electricity needs (Lubini and others 2006), and even to export to Europe (Tshombe and others 2007). In fact, this is illustrated by the many proposed hydro developments in numerous African countries (Table 3.5.1).
- *Develop hydropower because it will boost the economy and improve human welfare*: Energy supply is vital for economic growth, stability and human welfare. As a factor of production, it directly affects the prices of other goods and services and hence, the competitiveness of businesses (Tshombe and others 2007). None of the Millennium Development Goals can be attained without more energy development (Hathaway and Pottinger 2010). Greater access

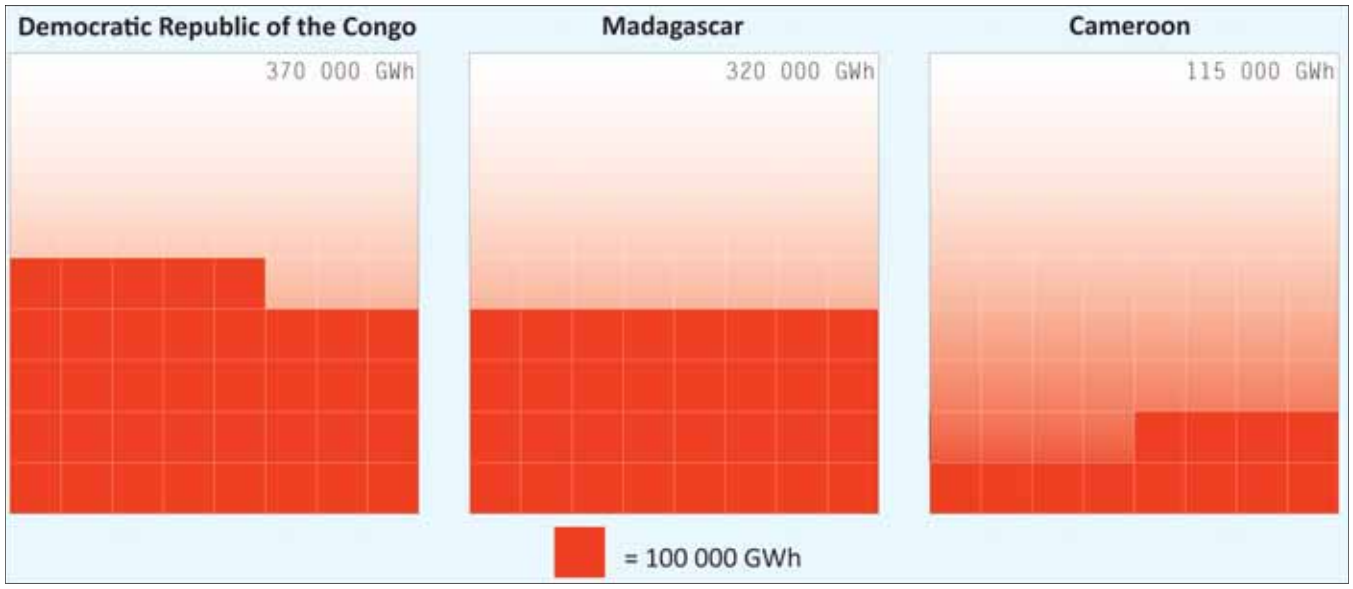


Figure 3.5.7: Top three potential electricity generating nations (Source: Tshombe and others 2007)

to energy will improve food security and health through refrigeration, while electric lighting promotes educational development and lengthens working hours. Improved access to energy also increases economic development through industrialization and communications technologies, among other benefits. The advent of electricity in rural homes reduces the human costs of fetching wood for fuel, freeing women's and girl's time for more productive and educational pursuits (Kauffman 2005).

- *Invest in hydroelectricity rather than fossil fuels, which makes sense in an era of climate change:* Fuel shares of world total primary energy supply were 10 345 Mtoe (Million tonnes of oil equivalent) in 2004. The global energy market is currently dominated by fossil fuel consumption. Concern about global warming is one of the major drivers behind recent interests in renewable and clean sources such as hydropower and biofuels (Ringler and others 2010). According to the World Bank (2010), regional hydropower trade could offer Africa the least-cost energy supply with zero carbon emissions.
- *Learn from the many African countries that have developed hydropower successfully:* Despite the low level of exploitation of technically feasible hydro potential, many African countries have shown that it is possible to develop that potential: hydroelectricity contribution is more than 50 per cent in 25 countries, and greater than 80 per cent in Angola, Benin, Burundi, Cameroon, Central African Republic, Congo, Democratic Republic of Congo, Ethiopia, Guinea, Lesotho, Malawi, Mozambique, Namibia, Rwanda, Tanzania, Uganda and Zambia (Bartle 2002) (Figure 3.5.7).

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Box 3.5.2. Regional power pools and the Grand Inga Project

A regional power pool is a "framework for pooling energy resources and power exchanges between utilities in a given geographic area base in an integrated master plan and pre-established rules." Such pools are meant to allow countries to secure their own power supply while they reduce costs, foster mutual help when power systems fail, bring social and environmental benefits, and strengthen relationships among nations (Hamad 2010). Africa's regional power pools are at very different stages of development, both technically and institutionally. The South African Power Pool (SAPP) was the first operational power pool in Africa, sponsored under the authority of the Southern African Development Community (SADC). The political process is also well advanced in the West African Power Pool (WAPP), supported by political agreements at the head of state level through the Economic Community of West African States (ECOWAS). The pools, particularly the SAPP and WAPP, have facilitated significant cross-border power exchanges.

Inga Hydroelectric Plants (Source: Tshombe and others 2007)

Element of Hydropower	Inga 1	Inga 2	Inga 3 Planned	Grand Inga Planned
Number of unit	6	8	7	5
Total installed capacity	351 MWh	1 424 MWh	1 344 MWh	244 000 MWh
Height of water head	50 metres	58 metres	60 metres	150 metres
Gross energy capacity	2 400 GWh	10 400 GWh	9 900 GWh	324 900 GWh

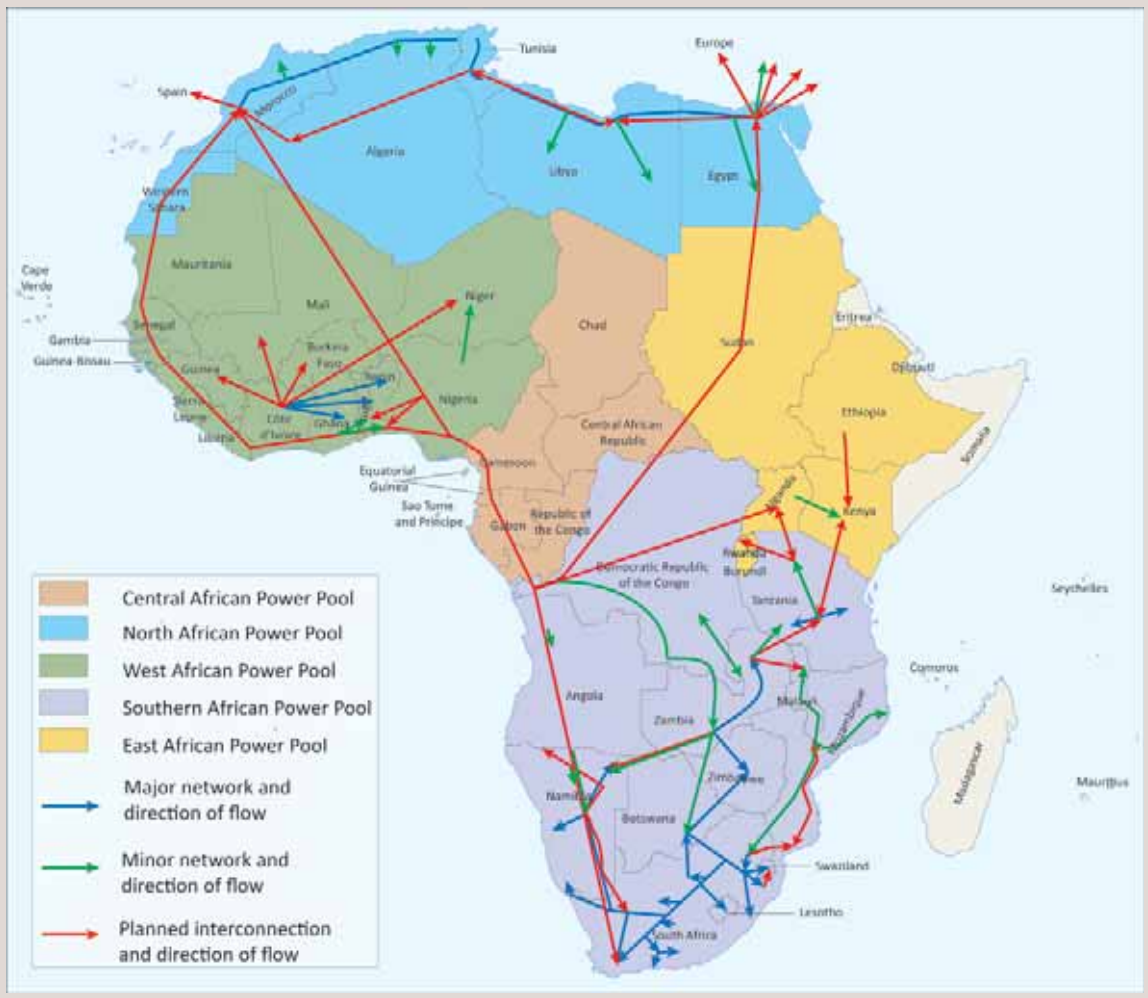
Regional power pools are able to reduce costs and improve conditions on the supply side. Operational costs are lower, due to investment in least-cost power generation plants on a regional basis. Benefits on the supply side, all contributing to increased reliability, include reduced coincident peak loads on the regional power pool, compared with the sum of the individual peak loads for each national power grid; shared power generation reserves for the interconnected power grids; and increased robustness to deal with local droughts or other unexpected events.

The Grand Inga dam in the Democratic Republic of Congo (DRC) is one of the key projects that will support regional pools. The project is estimated to cost US$80 billion and to have a total installed capacity of 44 000 MWh. Difficulties associated with the project include an absence of political consensus and legal harmonization. Nigeria is expected to be the largest consumer. The carbon-emission reduction potential is expected to help attract necessary investment.

Most of the power will be used for industry or for export. Inga 1 and Inga 2 were commissioned in 1972 and 1982, as part of an industrial development scheme in the DRC. The two dams currently operate at only 40 per cent capacity because they have never received maintenance. The World Bank is partially financing a project to rehabilitate these dams. When Inga 2 was built, a 1 800-km transmission line was also built to transport the power to state-owned copper mines in the Katanga province, bypassing nearly every city and village underneath. A component of the Grand Inga project could be expanded for household electricity access, particularly in the DRC, where access is estimated to be 13 per cent in urban areas and only three per cent in rural areas.

Sources: Tshombe and other 2007, IEA 2008

Africa's Regional Power Pools: CAPP, EAPP, SAPP and WAPP (Source: SAPP n.d.)



Box 3.5.3: The Tungu-Kabiti hydro scheme

A 1998 pilot project initiated by Practical Action (previously Intermediate Technology Development Group (ITDG) and the Kenyan Ministry of Energy (MoE), with funding from the UNDP, illustrates the potential for small hydro projects to boost electricity supplies in Africa in a sustainable manner. About 200 members of the Tungu-Kabiti community 185 km north of Nairobi formed a company to own, operate and maintain the plant, with each member buying a share in the company and contributing to building the plant. Community ownership has been central to the project's success. The project generates 18 kW of electricity that is generally sold to users for micro-enterprizes, such as a welding unit, a battery-charging station and a beauty salon. The project demonstrates that communities are willing to invest in improving energy generation and delivery and that micro hydropower can effectively meet poor, off-grid community energy needs.

Sources: UNEP 2006, Hydro4Africa n.d.

- *Develop small-scale hydropower projects to avoid the environmental and human costs associated with large dams:* With the current global financial crisis making it difficult to raise financing for large-scale hydropower that require large capital requirements, and considering the environmental and social impacts of large dams, small hydropower (generally less than 10MW of installed capacity) has been touted as an attractive proposition, especially in the rural areas of Africa. The technology can be connected to the main grid, isolated grids or as a stand-alone option, or combined with irrigation systems (Klunne 2007). Box 3.5.3 is a case study example of such a project.

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CHALLENGE 6

MEET GROWING WATER DEMAND

The Challenge: *Meet Africa's growing demand for water in a time of ever-scarcer water resources.*

The Situation: *More than 40 per cent of Africa's population lives in the arid, semi-arid and dry sub-humid areas; the amount of water available per person in Africa is far below the global average and is declining; groundwater is falling; and rainfall is also declining in some regions.*

The Constraints: *Demand for water is increasing with population growth and economic development; development of water resources is inadequate; prices to access water are generally distorted; and water provision is highly inefficient.*

The Opportunities: *Further develop and manage water resources sustainably; improve water use productivity; improve urban planning for better water provision; rationalize water prices; and protect Africa's water towers.*

The Challenge

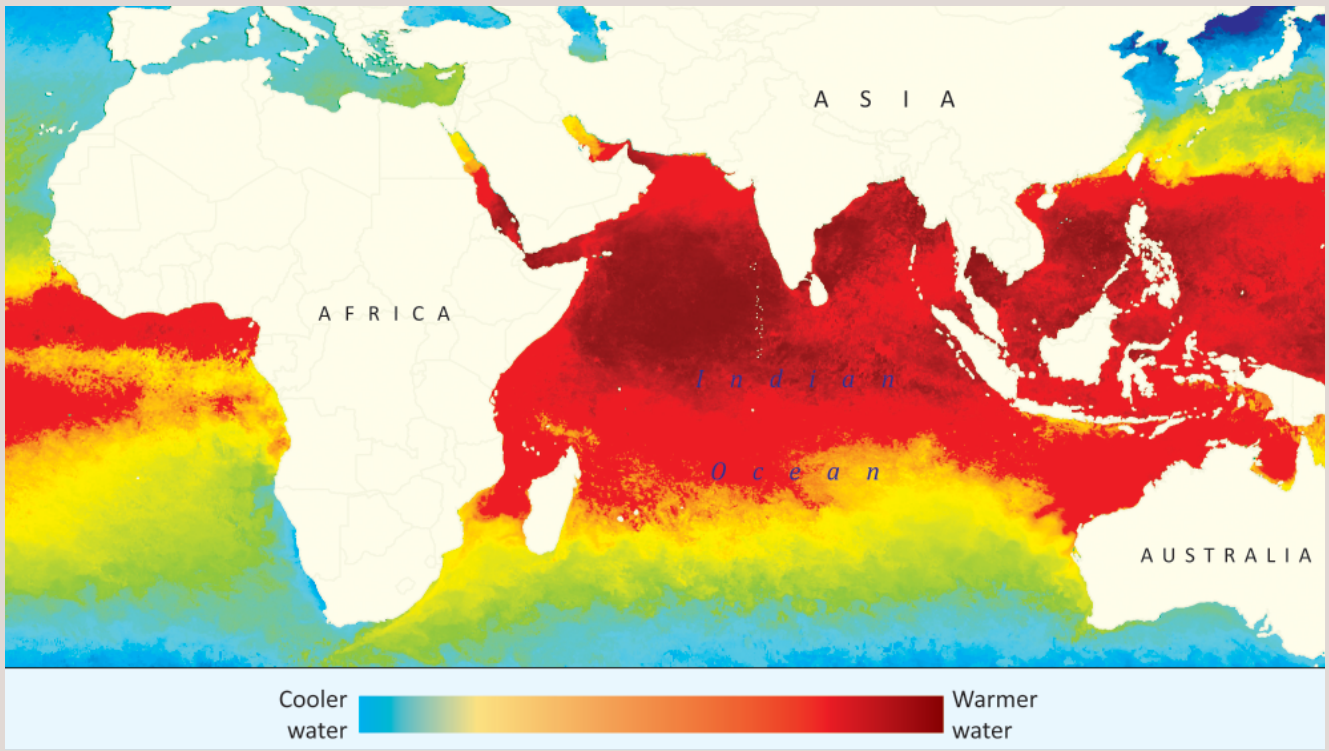
Africa faces the challenge of providing enough water for its people and ecosystems in a time of growing demand and increased scarcity. How can it ensure that access to water does not remain a pipe dream for millions?

The Situation

Chapter 1 provides the background water situation in Africa—the physical, meteorological and socio-economic conditions that contribute to making water so scarce on the continent. The main points are outlined below and in the following section that underscores other constraints Africa faces in meeting its growing demand for water.

- *More than 40 per cent of Africa's population lives in arid, semi-arid and dry sub-humid areas:* In these areas, annual rainfall reliability is low (de Rouw 2004, Sultan and others 2005). The uncertainty of water supplies has implications for Africa's people in terms of food security and public health, seasonal and permanent rural-to-urban migrations, and political instability and conflicts over scarce water resources (le Blanc and Perez 2008).
- *The amount of water available per person in Africa is far below the global average and is declining:* The continental annual average water availability per person is 4 008 m^3/capita/year, well below the global average of 6 498 m^3/capita/year (FAO 2009). Annual per capita water availability has declined from 37 175 m^3 in 1750 to 4 008 m^3 in 2008. It has been predicted that the proportion of the African population at risk of water stress and scarcity will increase from 47 per cent in 2000 to 65 per cent in 2025, affecting 18 countries (Bates and others 2008).
- *Groundwater is declining*: Some of Africa's important aquifers are losing more water than the rate of recharge. Water withdrawal in North Africa has greatly surpassed the rate of natural replenishment of aquifers from precipitation and countries will not be able to support current irrigation rates.
- *Rainfall is also declining in some regions:* Rainfall during the growing season is declining in Southern and Eastern Africa and research indicates that it is associated with warming in the Indian Ocean (Box 3.6.1).

"Scratching" for water. Muddy seep in a dry river bed in rural Chikomba District, Zimbabwe. Due to growing water scarcity, people end up scouring river beds to find water for drinking and for their livestock.



Visualization of sea-surface temperatures over the Indian Ocean, created with data from 1994 to 2005 from the Pathfinder satellite dataset

Source: NASA Earth Observatory 2010

Box 3.6.1: Warming Indian Ocean associated with rainfall decline in Southern and Eastern Africa

A study of sea-surface temperatures and rainfall has linked anthropogenic warming in the Indian Ocean to decreasing growing-season rainfall in eastern and southern Africa. The link to anthropogenic global warming implies that rainfall decreases are likely to continue or intensify, contributing to increased food insecurity in the region.

According to the study, the combination of evidence from models and historical data strongly suggests that human-induced warming of the Indian Ocean leads to an increase in rainfall over the ocean, which, in turn, adds energy to the atmosphere. The added energy then creates a weather pattern that reduces the flow of moisture onshore and brings dry air down over the African continent, which decreases rainfall.

The study observed that rainfall in eastern and southern African countries decreased about 15 per cent since the 1980s and reports that rainfall over the Indian Ocean would likely continue to increase through the year 2050, with impacts on moisture movement on the continental shelf. This disruption would reduce much needed continental rainfall by around 15 per cent every 20-25 years.

The Constraints

- *Demand for water is increasing with population growth and economic development:* With population projected to reach nearly two billion people by the year 2050 (UNFPA 2009), water supplies will be stretched to provide adequately for all uses. Africa's average population growth rate between 2005 and 2010 was 2.3 per cent, the highest in the world (UNFPA 2009).
- *Development of water resources is inadequate:* Water scarcity in Africa is partly a consequence of the very low level of development and exploitation of its water resources, which combined with physical water scarcity, deprives millions of people in Africa of adequate access to water. The growth in water demand is not being matched by a corresponding development of water resources at both national and transboundary levels, mainly due to lack of financial resources (AfDB 2009). Africa has the world's lowest per capita water withdrawal at about 170 m^3, due not only to poor water resource availability but also to underdeveloped water infrastructure and inefficient water management (AICD 2009). For example, less than 25 per cent of Africa's average annual river runoff is being utilized for human developmental activities (Couet and Maurer 2009), and total annual withdrawals for the three major water-use sectors of agriculture, municipalities and industries is only 5.5 per cent of internal renewable resources (FAO 2005). Agriculture is mostly rain-fed and less than 10 per cent of the continent's cultivated land of 185 million ha or 6 per cent of the total land area is irrigated. Nevertheless, agriculture is the largest user of water, accounting for about 85-88 per cent of total water use. This is believed to be due, in part, to the very low levels of technology and efficiency in agricultural production (UNECA n.d.). Similarly, Africa has exploited less than ten per cent of its low-cost hydropower potential even though it suffers from chronic shortages and high power costs (AICD 2009).
- *Prices to access water are generally distorted:* Access to water often remains free of charge, even to the rich, and in places where people

are charged for water, the poor pay more for it than do the rich (IWMI 2008). In some instances, the poor, who spend labour time and cash to access water, pay ten times as much as the rich. Distorted prices are also evident in agriculture. For example, farmers in Gauteng province, South Africa, pay a high price for water to grow export crops for Zambia, where water costs far less and similar crops could be grown. In addition, the cost of water access and long-run marginal costs continue to grow (Grey 2000).

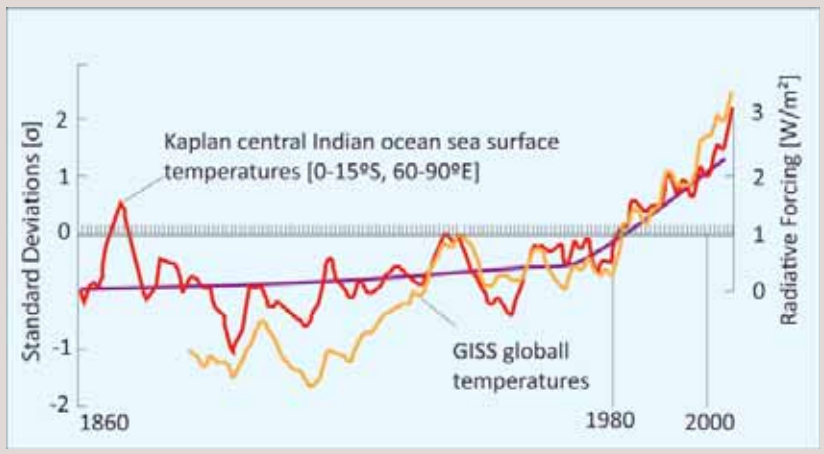
- *Water provision is highly inefficient:* One of the constraints in providing people of Africa with adequate and sustainable water supplies is the high level of water wastage through leakages in all major water-use sectors: agriculture, municipalities and industry. Most of the losses are due to delayed maintenance of infrastructure resulting from funding constraints (Frenken 2005). In some cities, as much as 40-60 per cent of the water introduced into distribution systems cannot be accounted for (Gumbo 2004). Water availability is also constrained by the pollution of existing water due to the lack of comprehensive wastewater management to treat the huge volumes of domestic wastewater generated by fast-growing urban populations (UNEP 2002, IWMI 2006). Water wastage is also encouraged by the use of contumacious or perverse incentives—water pricing mechanisms that do not promote a culture of saving; an example is the provision of subsidies for irrigation water.

The Opportunities

- *Further develop and manage water resources sustainably:* Given the presence of ample available water resources and their underdevelopment, one of the opportunities for addressing Africa's water scarcity is to further develop and manage its water sustainably (UNECA 2006). Economic development is needed to ensure a sustainable flow of funds for water infrastructure. There is also considerable scope for improved agricultural production and food security through irrigation and rain-fed agriculture, which does not necessarily lead to increased demand for water (UNECA n.d.). The African Water Vision specifically recommends an increase in the development of water resources potential by five per cent in 2005, 10 per cent in 2015, and 25 per cent in 2025 to meet increased

Box 3.6.2: Global surface temperatures and Indian Ocean temperatures, 1860-2000

Analyses show a negative relationship between seasonal continental rainfall and precipitation over the Indian Ocean. The analysis of historical seasonal rainfall data over the Indian Ocean and Africa's eastern seaboard from 1950 to 2005 showed that declines in rainfall in Ethiopia, Kenya, Tanzania, Zambia, Malawi and Zimbabwe were linked to increases in rainfall over the ocean, and that the trend was likely to continue.



Although differing in approach, the study's broad conclusions generally agree with those of the IPCC's Fourth Assessment Report finding that semi-arid Africa may experience water-stress and yield reductions by 2030. The IPCC assessment, however, anticipates precipitation increases over the Eastern African region, highlighting the fact that climate models are still not yet able to make precise predictions.

The same study showed that modest increases in agricultural capacity could reduce the number of undernourished people by 40 per cent by the year 2030. The challenge for Africa is to determine how best to mitigate the impacts of the likely increased water scarcity through investments in water for food and in agricultural development.

Sources: Funk and others 2008, Hansen 2008


David Trainer/Flickr.com

"The consequences of doing nothing, or waiting too long, can lead to situations where physical and economic resource scarcities converge, including geopolitical hotspots….."

– Bergkamp 2009

demand from agriculture, hydropower, industry, tourism and transportation at national levels (UNECA n.d.). "Hard" water development requires infrastructure such as dams, weirs, interbasin transfer pipelines, aqueducts and centralized treatment plants (Gleick 2003).

- *Improve water-use productivity:* In addition to developing more water resources, Africa will need to follow the "soft" path in water resource development, management and use by improving water-use productivity as opposed to seeking more sources of new supply (Gleick 2003). In this instance, water is acquired through a combination of Integrated Water Resources Management (IWRM) measures that include managing by water basin rather than within national boundaries; conserving water through efficiency approaches; making decisions at the appropriate level of public participation; investing in technology that is suitable for targeted communities; protecting aquatic ecosystems; pricing water appropriately; improving governance, including the operation of farmers markets; training people to maintain their own water infrastructure; managing aquifers more efficiently; analysing what farmers grow and encouraging change if appropriate; implementing drip irrigation to save fuel and water; and harvesting water (Gleick 2003).
- *Improve urban planning for better water provision:* Africa's increasing population and the unreliability of its water resources presents an opportunity for forward planning and learning new adaptation mechanisms. An example is the facilitation of migration from rural to urban areas (World Bank 2010). The availability of long-term historical rainfall patterns and various scenario analyses means urban planners can already factor in future contingent measures to handle rural-to-urban migration well before water systems get overwhelmed.
- *Rationalize water prices:* Given the contradiction between adequate water supplies and the lack of acceptable access, the economic, social and environmental values of water need to be defined and reconciled (UNECA 2006). Improved water pricing is necessary to indicate rising water scarcity and its value, force water towards high-value uses, encourage investment and improve water services. Water access and rights for the poor must also be protected, since water is a social good. Economic instruments can be used to ensure water allocation is productive, equitable and environmentally sustainable (IWMI 2008). Rational pricing approaches can be implemented that help the poor to access water at the same time as reducing costs. For example, in South Africa a levy was used to finance rural water supply and sanitation upstream, in a scheme in which urban areas supported protection measures upstream with economic benefits for those downstream (Grey 2000).

CHALLENGE 7

PREVENT LAND DEGRADATION AND WATER POLLUTION

The Challenge: *Prevent water pollution, and address land degradation related to rainfall variability and the impacts of such degradation on water resources.*

The Situation: *The Sahel has been subject to enormous rainfall fluctuations. Over the last three decades, the Sahel has suffered from land degradation; groundwaters are being polluted by saltwater intrusion, and Africa's scarce water supplies are being polluted by point sources.*

The Constraints: *Lack of valuing of ecosystem services; political instability and conflict within and between countries; poor agricultural practices and farming on marginal lands that affect water use or water resources; and lack of structured water monitoring and governance.*

The Opportunities: *Maintain vital ecosystem functions; foster the greening of the Sahel by encouraging adaptation to drought; and support scientific assessments of both land degradation and water quality.*

The Challenge

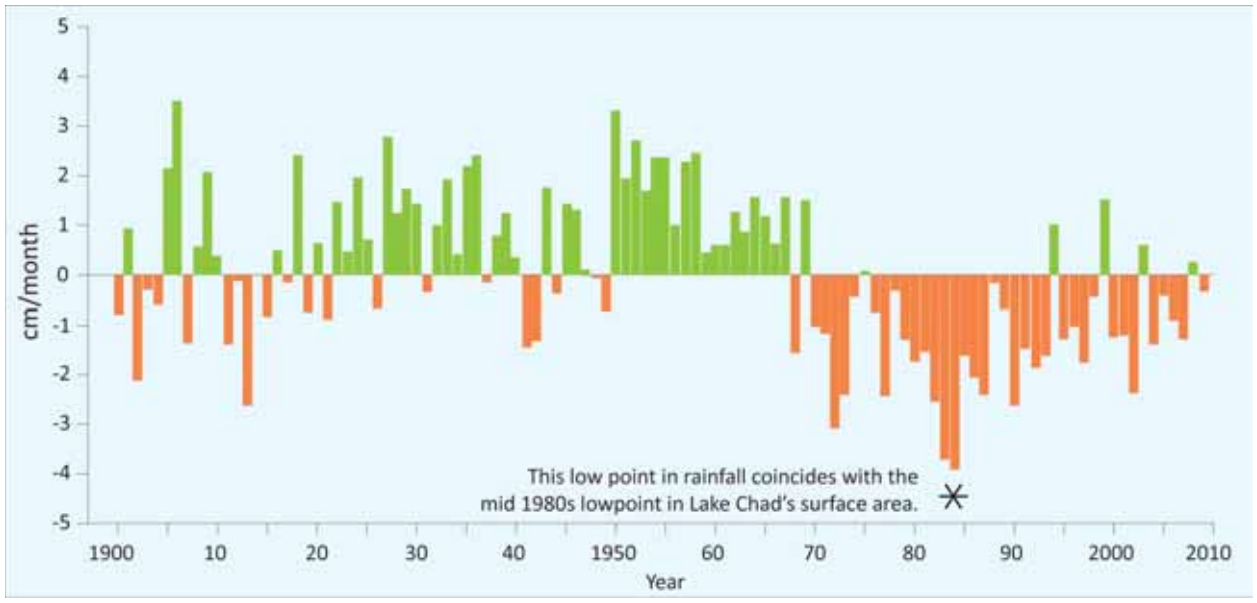
Rainfall variability, drought and land mis-management contribute to land degradation in Africa, while improperly managed water released to the environment can pollute land and water bodies; there are many opportunities for African countries to protect land and water resources from both.

The Situation

- *The Sahel has been subject to enormous rainfall fluctuations:* The Sahel is an arid to semi-arid ecoregion in northern Africa that spans 3 800 km from the Atlantic Ocean in the west to the Red Sea in the east, in a belt that varies from several hundreds to thousands of kilometres in width, covering an area of 3 053 200 km^2; it is sandwiched between the Sahara desert to the

Tim Braukmann/flickr.com

Figure 3.7.1: Rainfall index values in the Sahel, 1900-2004



The positive rainfall index values from more than a century of rainfall records in the Sahel show an unusually wet period from around 1950 to 1970. This period was followed by extremely dry years from the early 1970s to 1990, shown by the negative rainfall index values. Rainfall from 1990 to 2004 exhibited high inter-annual variability, but the levels were slightly below the 1898–1993 average (Sources: NASA Earth Observatory n.d., University of Washington 2009)

north and the wooded Sudanian savannas to the south (Frappart and others 2009). It includes parts of Senegal, Mauritania, Mali, Burkina Faso, Niger, Nigeria, Chad, Sudan, Somalia, Ethiopia and Eritrea, and is often referred to as the transition zone between the Saharan desert and the rainforests of Central Africa and the Guinean Coast (Held and others 2005).

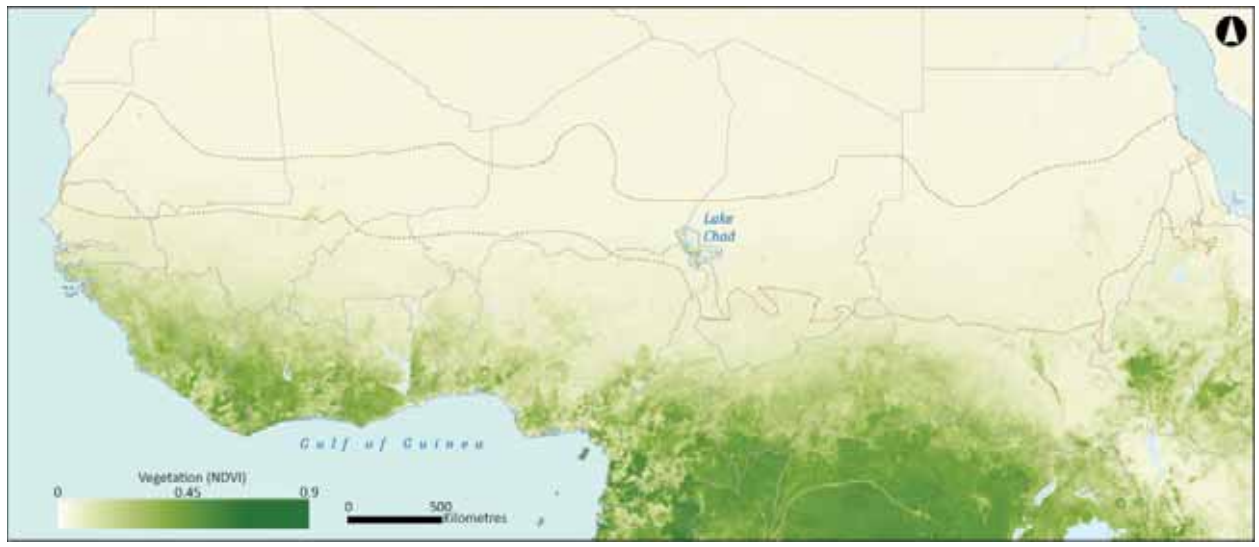
Historically, the Sahel has been subject to great rainfall fluctuations, characterized by extreme and prolonged droughts, especially during the last half of the 20th century (Figure 3.7.1). During the thirty-year periods between 1931-1960 and 1968-1997, mean rainfall declined by 25-40 per cent. Extreme differences occurred during the 1950s and 1980s, the wettest and driest decades, which affected the whole of Africa and point to large-scale general atmospheric circulation as the main driver of rainfall variability, albeit partially affected by variations in sea-surface temperatures. Dry conditions persisted from the late-1960s into the mid-1990s (Nicholson 2003). Patterns in the long-term human use of the land may have changed in response to rainfall variation. Substantial changes in climate conditions have seen the rainy season starting late and becoming shorter, forcing Sahelian farmers and pastoralist communities to adapt to declining water resources (Pedersen and Benjaminsen 2008, Biasutti and Sobel 2009). The drying trend has also been attributed to human factors such as increased aerosol loading and greenhouse gases (Held and others 2005). Both human and climatic conditions have contributed to land degradation in the Sahel, but satellite and ground data have not provided enough evidence for a consensus on the direction of change (ICRSE 2003). Figure 3.7.2 shows the extreme difference in vegetation between wet and dry periods, as illustrated in the Sahel.

Studies of global tropical carbon balance using a vegetation model are consistent with a recent trend toward a greener Sahel, showing that the region accumulated an average of 8.4 g C/m^2/y, or 50 million tonnes of carbon per year for the entire region for the period 1983-1999 (Olsson and Hall-Beyer 2008). Spatial

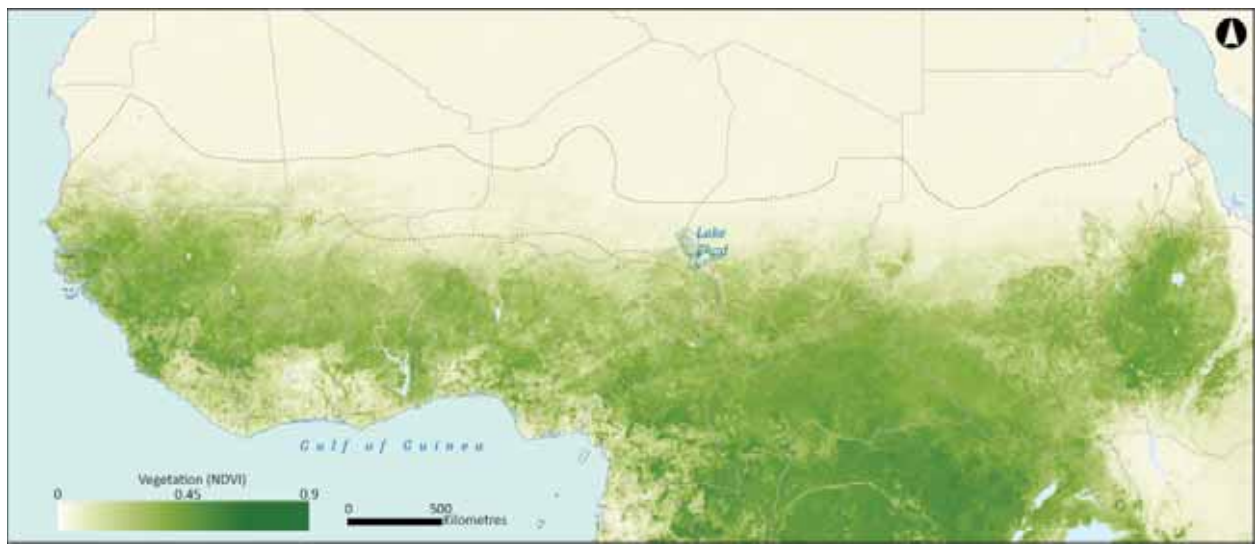
Radio Nederland Wereldomroep/Flickr.com

Figure 3.7.2: Dry and wet seasons in Senegal (Source: NASA Earth Observatory n.d.)

(a) March 2010 (Dry)



(b) September 2009 (Wet)



Vegetation in the Sahel region is generally coupled to seasonal rainfall and land use. In March, during the dry season, rainfall and lush vegetation do not extend north of the Gulf of Guinea (Figure 3.7.2a). September brings rain and vegetation into the Sahel as far north as the northern edge of Lake Chad (Figure 3.7.2b)

March 1984 (dry)

September 1982 (wet)

Vegetation in the Sahel region is generally coupled to seasonal rainfall and land use, as demonstrated by photographs from Senegal showing the difference in vegetation between the dry (left) and wet (right) seasons

vegetation patterns in the Sahel region, showing an increasing greenness, are an indication of variability of primary productivity (vegetation) in response to inter-annual rainfall variations (Hiernaux and Le Houérou 2006, Giannini and others, 2008, Mahé and Paturel 2009).

- *Over the last three decades, the Sahel has suffered from land degradation:* According to estimates by the Millennium Ecosystem Assessment (2005), 10-20 per cent of the world's drylands—an area more than twice that of India—have been significantly degraded. These include the Sahel region where the impacts of both rainfall variability and human uses have led to spatial and temporal changes and variability in landscape features such as tree-crop patterns and forest cover, and severe degradation of soils and fragile ecosystems (Sadio 2003). There are 500 million ha of moderately or severely degraded land in Africa, which represents 27 per cent of global land degradation (UNECA

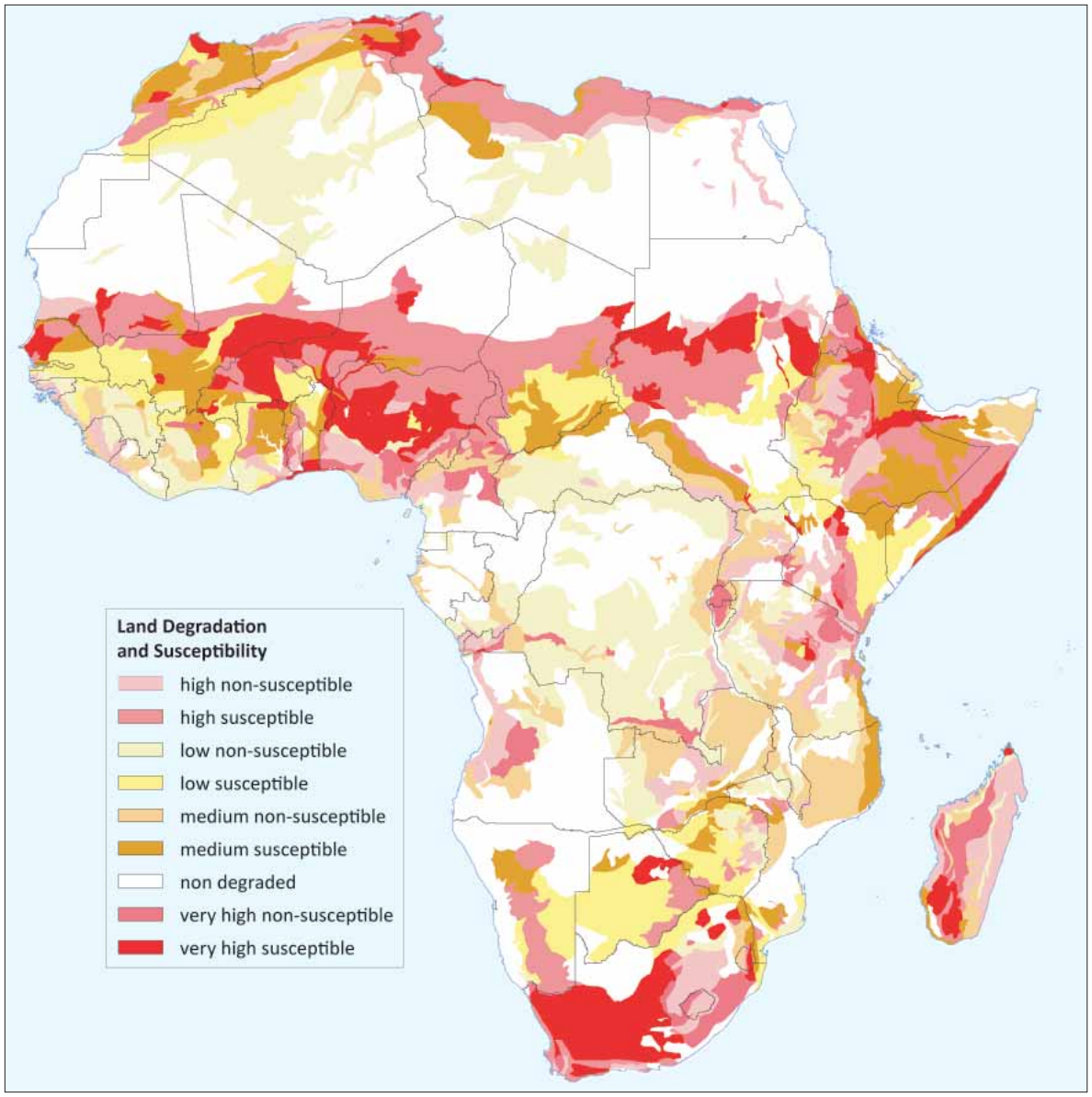
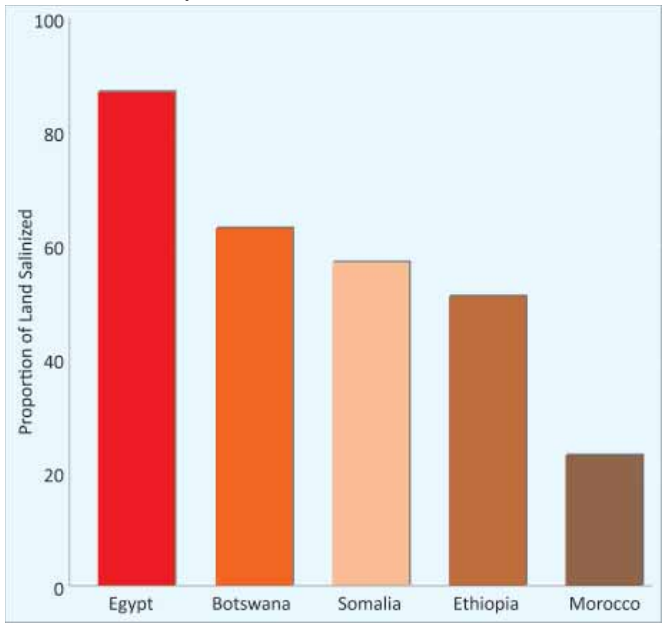


Figure 3.7.3: Land degradation susceptibility in Africa (Source: UNEP 2006)

2009) (Figure 3.7.3). "Land degradation is a long-term loss of ecosystem function and services, caused by disturbances from which the system cannot recover unaided" (UNEP 2007). Water contributes to land degradation through erosion (as a result of both human causes such as deforestation and poor agricultural practices, and from natural causes, such as flooding, often combined) and it suffers the consequences of land degradation in the form of the disruption of the water cycle, pollution and sedimentation. The degradation can reduce water availability and quality and alter the flows of rivers, all leading to serious downstream consequences (Barr and Mafuta 2007).

Figure 3.7.4: Salinization in African countries (Source: Barr and Mafuta 2007)



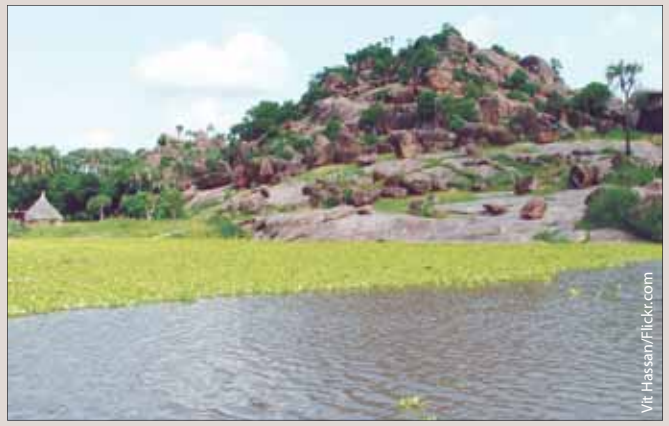
- *Groundwaters are being polluted by saltwater intrusion:* Agricultural production in Africa comes from predominantly rain-fed lands and irrigation. Inappropriate management of irrigation can result in land degradation in the form of waterlogging and saliniszation of formerly productive cropping areas (Figure 3.7.4).

- *Africa's scarce water supplies are being polluted by point sources:* Africa's available water and land resources are being increasingly polluted through people's actions that include discharge of industrial effluent, poor sanitation practices, release of untreated sewage, disposal of solid wastes, release of liquid from refuse dumps and the discharge of food-processing waste. These actions are affecting water quality and quantity and leading to an increase in the cost of developing water resources. Many water bodies receive waste at rates that are much higher than their natural ability to assimilate it and as a result there are widespread water-borne and water-related diseases. Water quality in sub-Saharan Africa is especially threatened. There are unacceptable levels of toxic substances such as heavy metals, persistent organic pollutants and biological contaminants in many important water bodies that provide drinking, sanitation and irrigation water for local people (PACN 2010).

Box 3.7.1: Environmental reserves in South Africa maintain the basic ecological functions of aquatic ecosystems

In 1998, South Africa established the National Water Act to set aside or allocate water of a certain quantity and quality to maintain the basic ecological functions of aquatic ecosystems. This amount of water is called an Environmental or Ecological Reserve. In other words, they protect the legitimate right of rivers and other ecosystems to their own water when water allocation decisions are made.

Although stakeholders sometimes interpret such protection or allocation as being in direct competition with human needs, the Environmental Reserve represents an opportunity to maintain the health of rivers and other ecosystems that provide water-related ecosystem goods and services



(maintaining water flows, for example) for the benefit of society. Sustaining various ecological functions through the Reserve in turn guarantees and prolongs the sustainability of ecosystems.

Sources: Republic of South Africa 1998, Van Wyk and others 2006, Digby and others 2007

The Constraints

The challenges Africa faces in addressing water issues related to land degradation include the impacts of the socioeconomic drivers already mentioned in other sections of this chapter, including rising populations, rapid growth of peri-urban areas and economic development, as well as improper or lack of sustainable water management practices. As the continent develops, for example, non-point sources such agricultural fertilizers and pesticides will rise with increased food demands from a growing population, while point sources from industries and municipalities will also increase. There are also risks of future threats to water from land-based activities such as petroleum refineries and tailing ponds from mining ventures (PACN 2010). Other constraints include the obvious rapid and often extreme rainfall fluctuations and continued change in the scientific debate about the causes (ICRSE 2003).

- *Poor agricultural practices and farming on marginal lands that affect water use or water resources:* Agricultural drought (drought in the root zone) is much more frequent than meteorological drought (a period when there is not enough water to grow crops because average rainfall is well below average) because most rainfall on cultivated land runs off the surface, and soil-water storage is diminished by soil erosion, resulting in poor soil structure, loss of organic matter, unfavourable texture and impediments to rooting. Farmers' field -water balances show that only 15-20 per cent of rainfall actually contributes to crop growth, falling to as little as five per cent on degraded land (UNEP 2007). Despite the reduced productivity of eroded soil, many African farmers are forced to continuously use the same land because of factors such as population pressure, inequitable land ownership and poor land-use planning. There is a strong relationship between population density and soil erosion (Barr 2007). The impacts of land degradation on water include the depletion of water availability through destruction of catchments and aquifers while increased siltation fills up dams and leads to flooding in rivers and estuaries. In Sudan, for example, the total capacity of the Roseires reservoir, which generates 80 per cent of the country's electricity, fell by 40 per cent in 30 years, due to siltation of the Blue Nile (Barr and Mafuta 2007).
- *Lack of structured water monitoring and governance:* Water pollution statistics are lacking because many African countries lack effective water quality monitoring programmes due to underinvestment and poor or absent water governance structures (PACN 2010).

The Opportunities

Maintain vital ecosystem functions: There is an opportunity in Africa for governments to set aside water for the environment in order to maintain ecological functions that contribute to water quantity and quality. Box 3.7.1 provides an example.

- *Foster the greening of the Sahel by encouraging adaptation to drought:* While rainfall has been deemed the primary driver of the

Box 3.7.2: Helping reverse land degradation in Africa

According to researchers at a meeting organized by the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) in Niger (23-25 September 2006), the degradation of drylands in Africa can be reversed. Rehabilitation does not necessarily lead to full land recovery, but it may restore the land to 50-75 per cent of its former productivity, depending on soil and economic conditions. Through rehabilitation by tree planting, sustainable farming practices and groundwater replenishment, the land can become more productive again. Farmer-led rehabilitation initiatives in the Sahel in the past 30 years have started paying dividends:

Niger: Three million hectares of severely degraded land were rehabilitated at the initiative of local farmers, resulting in 20 to 150 trees per hectare in areas where few trees could were growing in the mid-1980s. The farmers focused on actions such as protecting the re-growth of natural vegetation, which improved soil fertility and led to the breaking down of the hard crust that forms over soils. They also integrated agriculture, livestock and forestry, resulting in a significant increase in farm productivity. The initiative reversed the spiral of degradation that characterized the region in the 1970s and 1980s.

Burkina Faso: Farmers were able to improve the productivity of 200 000 ha of degraded land.

Ethiopia: Regrowth of vegetation occurred in the northern parts of the country, spurred by tree planting and soil conservation measures over a ten-year period. The farmers were reportedly earning extra income through selling wood.

Source: Hebden 2006

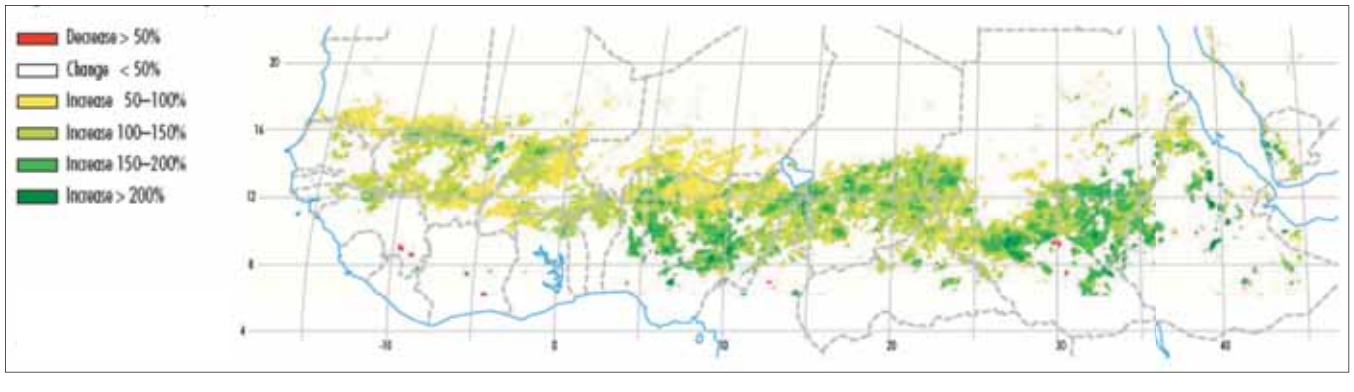
recent greening of the Sahel (Herrmann and Hutchinson 2005, Hickler and others 2005), the non-uniformity of greenness (greenness in certain areas but desertification in others) (Figure 3.7.5) suggests the interplay of factors in addition to rainfall, including land mangament practices, rural-to-urban migration and the displacement of people due to conflict (Mahé and Paturel 2009).

A number of studies (in Niger, Nigeria, Burkina Faso and Senegal) now indicate that some farmers and communities have improved the way they manage water in response to changes experienced during drought in the Sahel. When productivity and incomes rise as a result of the adaptive strategies, the farmers have been able to invest in more methods, such as inputs or crop diversification, that improve both their land and their livelihoods. Benefits have included higher cereal yields, tree densities and groundwater tables and reduced rural poverty and outmigration. These success stories suggest models that others may pursue. The emphasis on controlling land degradation could be changed to allow more focus on encouraging adaptation that would take advantage of good years and build up insurance against bad ones, since it is certain that drought will return (ICRSE 2003). Box 3.7.2 illustrates how degraded land has presented an opportunity to showcase what people can do on a local scale to rehabilitate degraded land.

To address land degradation by water and the impacts on water, it is necessary to manage freshwater resources from the moment rainwater hits the land surface. The type of soil management determines whether rain runs off the surface, carrying topsoil with it, or infiltrates the soil to be used by plants or to replenish groundwater and stream flows (UNEP 2007).

- *Support scientific assessments of both land degradation and water quality:* There is a need for both systematic global and national assessments of land degradation and desertification focusing on slow variables to understand long-term trends in land degradation and the potential for recovery. Such studies could allow the planning of effective responses to long-term drought (UNEP 2007). There is considerable knowledge and expertise among scientists in Africa to help plan and implement sustainable water strategies to address land degradation and pollution. Establishing centres of excellence staffed with African scientists networking with other water research and management experts would build Africa's capacity to monitor water quality, collect data and identify good water management approaches (PACN 2010).

Figure 3.7.5: Distribution of the greenness index in the Sahel, 1982-1999 (Source: Olsson and others 2005)



CHALLENGE 8

MANAGE WATER UNDER GLOBAL CLIMATE CHANGE

The Challenge: *Manage Africa's water under the impacts of global climate change.*

The Situation: *Global warming and its human cause are undeniable; warming patterns in Africa are consistent with global ones; Africa is already subject to important spatial and temporal rainfall variability; drought in Africa is common and some regions are becoming drier; Africa's repeated drought cycles kill thousands of people each event; and floods also occur regularly with severe impacts on peoples' livelihoods.*

The Constraints: *Africa is one of the most vulnerable continents to climate change and climate variability; the convergence of multiple stressors limits Africa's capability to address climate change impacts; increased rainfall variability contributes to Africa's economic limitations in adapting to climate change impacts; population growth in peri-urban areas will exacerbate flooding events; climate change will likely increase aridity, with important impacts on food production; climate change will increase water stress in Africa; climate variability and change could result in low-lying lands being inundated; climate change impacts in productive aquatic ecosystems will be costly economically and in terms of food supplies; and it is likely that climate change will affect disease vectors.*

The Opportunities: *Reinforce traditional adaptation mechanisms; provide early warning; introduce adaptation measures informed by a more reliable system of seasonal predictions; support public-private partnerships that develop innovative adaptation measures; and improve physical infrastructure.*

The Challenge

The impacts of climate change will be felt in Africa more than in most other regions, while its resources to adapt are much more limited. Africa faces the enormous challenge of managing increasingly uncertain water supplies as the global climate changes.

The Situation

- *Global warming and its human cause are undeniable:* The International Panel on Climate Change (IPCC) confirms that warming of the climate system is unequivocal. Furthermore, it confirms that human emissions of greenhouse gases are the primary cause. There is increasing evidence of a rise in global average air and ocean temperatures (Figure 3.8.1), widespread melting of snow and ice (Box 3.8.1) and an increase in global average sea level (IPCC 2007a). The impacts are expected to have great risks for environmental, social and economic well-being in both developed and developing world-regions. In developing regions, especially Africa, they are likely to reverse decades of development efforts.
- *Warming patterns in Africa are consistent with global ones:* The continent of Africa is warmer than it was about 100 years ago (Hulme and others 2000). Warming throughout the 20th

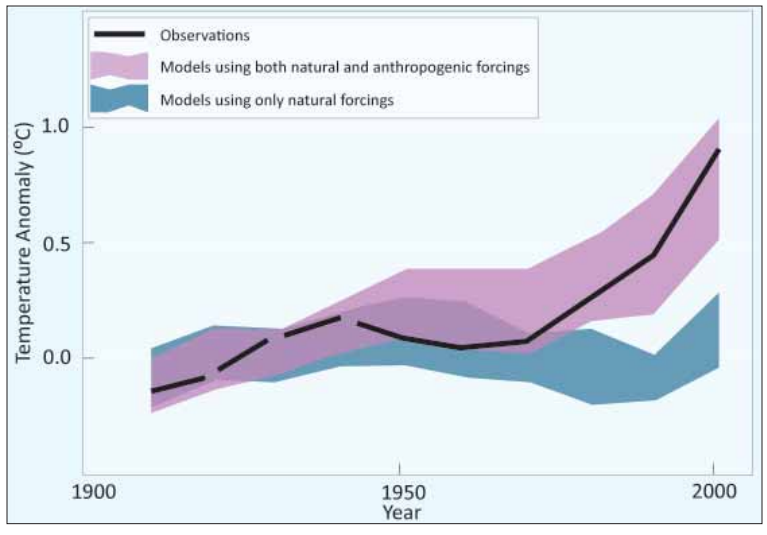
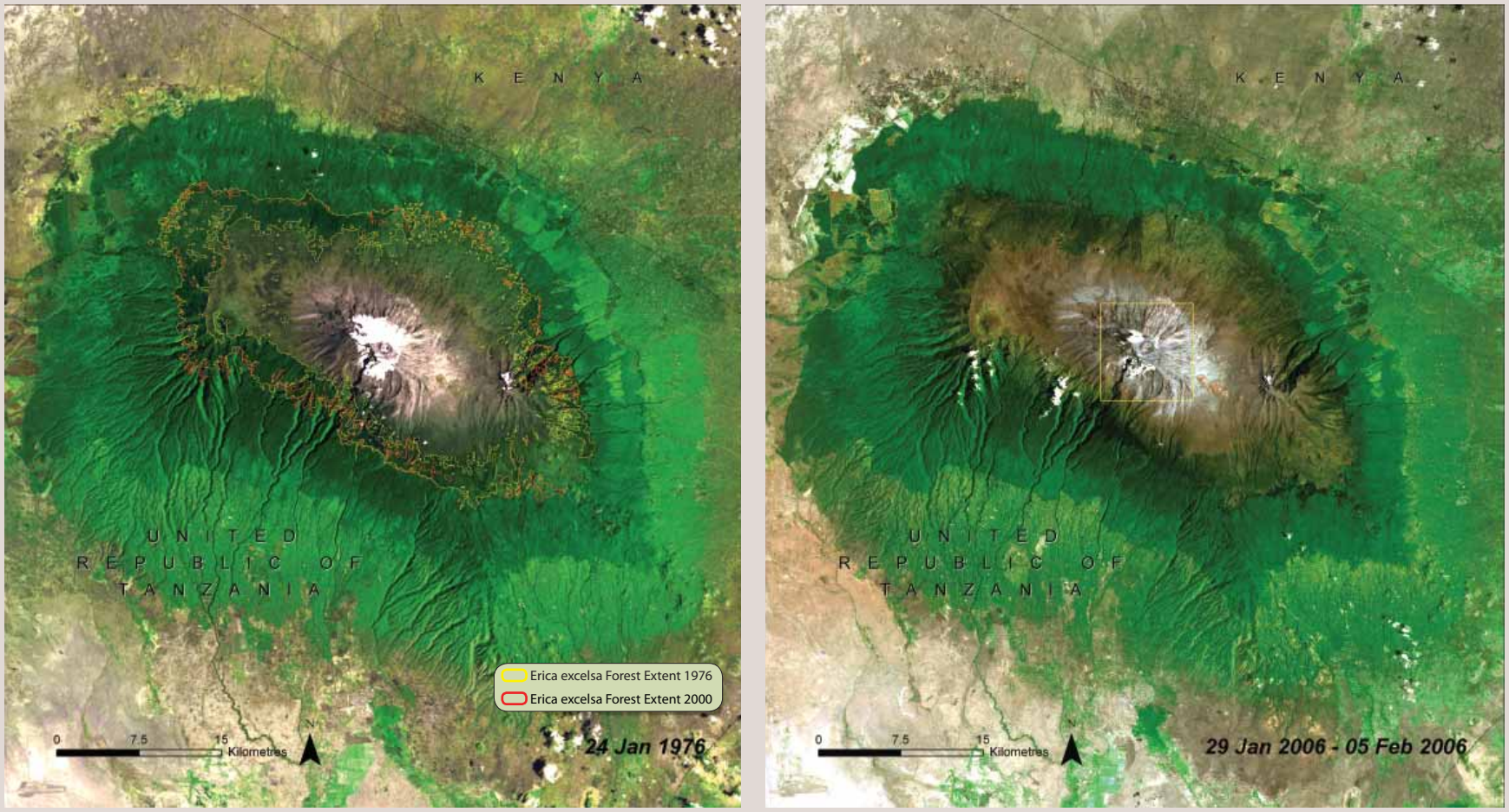


Figure 3.8.1 Comparison of observed continental-scale changes in surface temperature with results simulated by climate models using either natural or both natural and anthropogenic forcings. Decadal averages of observations are shown for the period 1906-2005 (black line) plotted against the centre of the decade and relative to the corresponding average for the 1901-1950. Lines are dashed where spatial coverage is less than 50 per cent. Blue shaded bands show the 5- 95 per cent range for 19 simulations from five climate models using only the natural forcings due to solar activity and volcanoes. Purple shaded bands show the 5- 95 per cent range for 58 simulations from 14 climate models using both natural and anthropogenic forcings (Source: IPCC 2007a)



Box 3.8.1: Mount Kilimanjaro's glaciers are melting

Glaciers on the summit of Mount Kilimanjaro have decreased in area by 80 per cent since the early 20th century. While glacial retreat globally has been linked to rising air temperatures, there is evidence that the decline of Kilimanjaro's glaciers (above images), along with changes in the boundaries of vegetation zones on the mountain, may be due in large part to a more local trend of decreasing precipitation that began in the 1880s.

It has also been found that water from the melting of Mount Kilimanjaro's glaciers provide little, if any, water to lower elevation streams. Most ice is lost through sublimation—water from the small amount of melting evaporates very quickly. A greater impact on the mountain's hydrology has resulted from increased burning under the drier conditions since 1880. The upper limit of the forest zone has descended significantly, as fire has destroyed nearly 15 per cent of Kilimanjaro's forest cover since 1976. In the 1976 image above, the upper limit of the Erica excelsa forest is shown in yellow. By 2000, the upper limit had moved noticeably downslope (red line) as a result of frequent fires. Changes in the hydrological and ecological functioning of Kilimanjaro affect a growing population living on and around the mountain.

Source: UNEP 2008

century has been at the rate of 0.5 degree Celsius/century, with slightly larger warming in the June-August and September-November seasons than in December-February and March-May. The warming patterns in Africa are similar to those globally, with the most rapid warming periods occurring in the 1910s to 1930s and the post-1970s (Hulme and others 2000). Although these trends seem to be consistent over the continent, the changes are not always uniform. For instance, decadal warming rates of 0.29°C in the African tropical forests and 0.1 to 0.3°C in South Africa have been observed. In South Africa and Ethiopia, minimum temperatures have increased slightly faster than maximum or mean temperatures (IPCC 2007a). Additionally, deep-water temperatures (which reflect long-term trends) of the large East African lakes (Edward, Albert, Kivu, Victoria, Tanganyika and Malawi) have warmed by between 0.2 and 0.7°C since the early 1900s (Bates and others 2008).

- *Africa is already subject to important spatial and temporal rainfall variability:* The situation is more complicated in the case of precipitation, with notable spatial and temporal variability. Inter-annual rainfall variability is large over most of Africa and multi-decadal variability is also substantial in some regions. In West Africa (4°-20°N; 20°W-40°E), a decline in annual rainfall has been observed since the end of the 1960s, with a decrease of 20-40 per cent noted between the periods 1931-1960 and 1968-1990. Increased inter-annual variability, however, has been observed in the post-1970 period, with higher rainfall anomalies and more intense and widespread droughts reported. In different parts of southern Africa, such as in Angola and Namibia, a significant increase in heavy rainfall events has also been reported, including evidence of changes in seasonality and weather extremes (IPCC 2007a).

Box 3.8.2: Late-twentieth-century warming in Lake Tanganyika unprecedented since AD 500

According to a study led by geologists at Brown University, Lake Tanganyika, the world's second-largest (by volume) and second-deepest lake after the Lake Baikal, has become warmer. The changes in temperature of Lake Tanganyika during the last century, which are considered to be unprecedented, have been attributed to anthropogenic climate change.

Tanganyika is a rift lake, situated in the Great Rift Valley in Eastern Africa, bordering Burundi, Tanzania, Zambia and the Democratic Republic of Congo. It is estimated that the lake provides 25-40 per cent of animal protein in the local population's diet. Fisheries employ around one million people.

The research team found that Lake Tanganyika experienced rising lake-surface temperatures throughout the past 1 500 years. However, it has only been in the past few decades that changes in the lake's temperature have surpassed natural variability.

Changes in the lake-surface temperature have affected its ecosystem, which heavily relies on nutrient recharge from the depths, the lake's base of the food chain. With rising temperatures at the surface, Lake Tanganyika becomes increasingly stratified, which diminishes this essential mixing of waters.

Lacking the basic nutrients, algae are unable to reproduce, which leads, in turn, to lower productivity of the lake, including fish stocks. If this trend continues, it will likely have major implications for the millions of people in the region that depend on these fish stocks.

Source: Tierney and others 2010

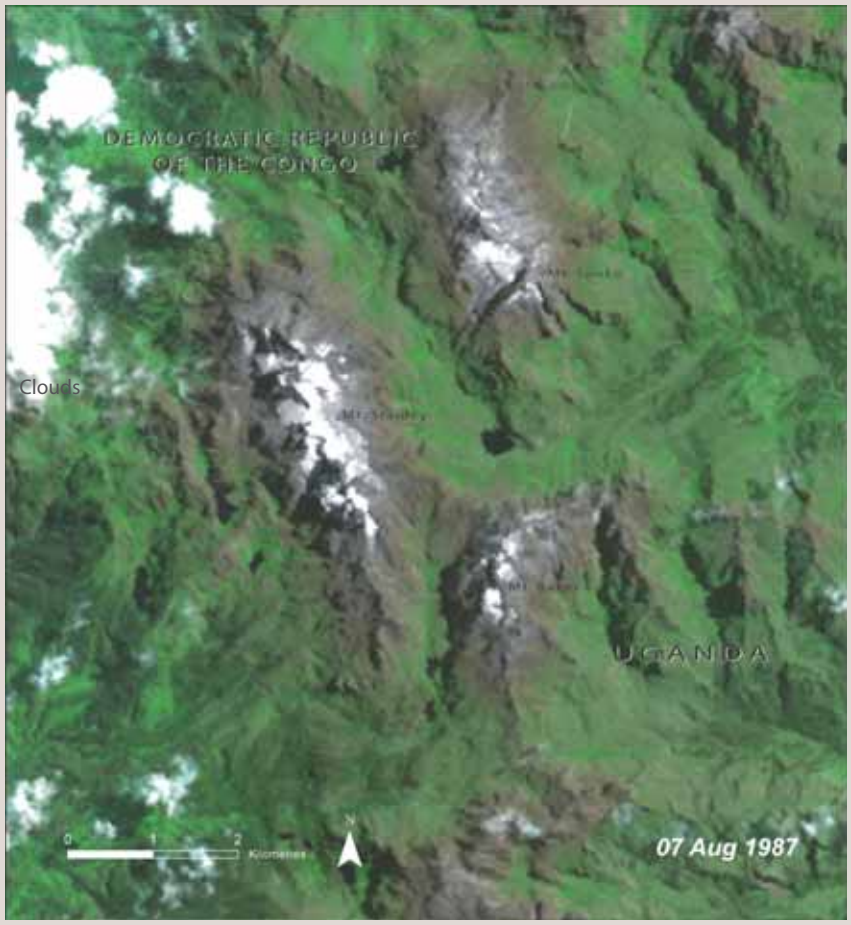
- *Drought in Africa is common and some regions are becoming drier:* Historically, the Sahel has experienced at least one severe drought every century. Since the 1950s, precipitation levels have decreased in the sub-tropics and tropics, making regions like the Sahel and Southern Africa even drier (Box 3.8.3).
- *Africa's repeated drought cycles kill thousands of people each event:* Drought is Africa's principal type of natural disaster, and in terms of number of people affected, Africa is second only to the world's most populous continent of Asia. Estimates suggest that one third of African people live in drought-prone areas and that around 220 million people are annually exposed to drought (UNFCCC 2006). Figure 3.8.2 (next page) shows the number of people killed and affected by Africa's most severe droughts. Droughts have particularly affected the Sahel, the Horn of Africa and Southern Africa since the end of the 1960s (UNFCCC 2006). The

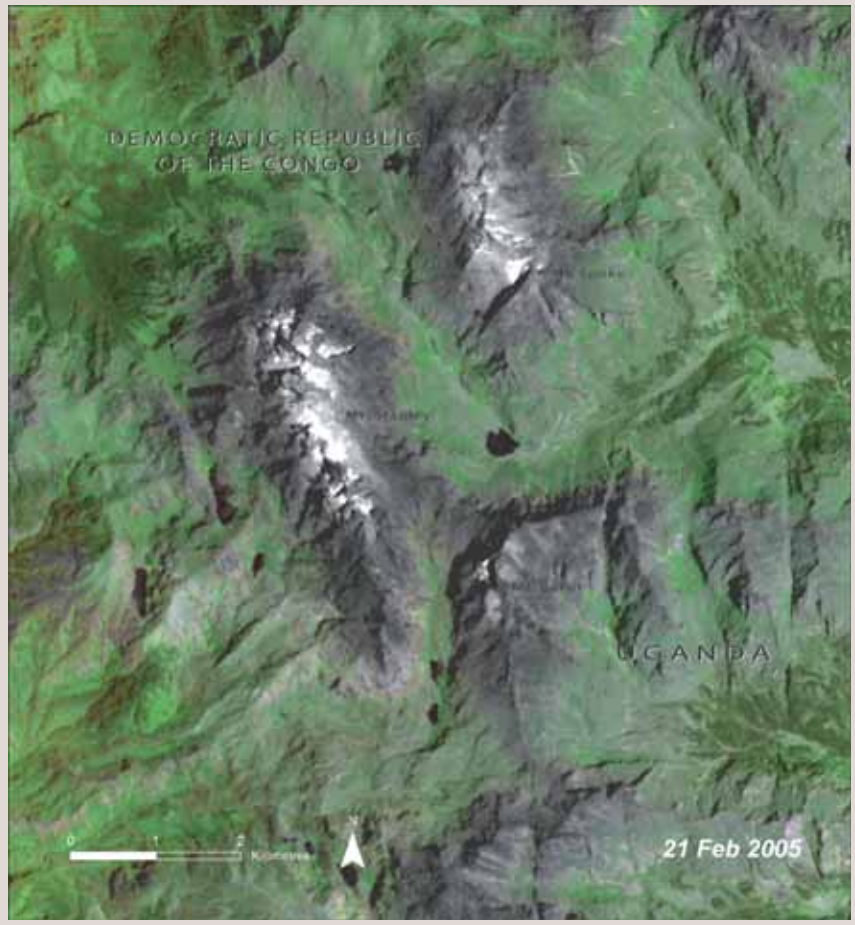
Box 3.8.3: The Sahel and Southern Africa are becoming drier

Historically, about 20 per cent of the earth's land surface experiences drought at any one time, but this has now risen to 28 per cent and will reach 35 per cent by the year 2020 (Calow and others 2010).

Since the 1950s, precipitation levels have increased in Africa's higher northern latitudes and decreased in the sub-tropics and tropics, making regions like the Sahel and Southern Africa even drier. Globally, very dry land areas have almost doubled since the 1970s, due to decreased El Niño-Southern Oscillation (ENSO)-related precipitation on land, which has been further augmented by surface warming. It is still not apparent if the recent multi-decadal droughts in the Sahel region are anomalous, or a part of a cyclic process. It has been argued that long-lasting intervals of dry and wet spells have been a feature of West African Monsoons for at least the past three millennia, and that this variability is associated with changes in circulation of the Atlantic. A much more severe drought than that witnessed by the African climate system in the last century occurred only 200-300 years ago. Hence, this recurring pattern of the hydrologic cycle suggests that there might be a gradual shift back into the period of centennial-scale drought of much greater severity, which would only be enhanced by rising temperatures (Trenberth 2005, Shanahan and others 2009). In the Sahelian region, warmer and drier conditions have reduced the length of growing seasons with detrimental effects on crops (IPCC 2007b).

Drought in the 1970s resulted in a dramatic alteration of the hydrological regime of rivers in the Sahel region due to land-use/cover change, while a rise in rainfall from the mid-1990s to the level of the 1970s caused an impermeable crust on the surface, resulting in less infiltration of water into the ground, and higher and earlier flood peaks in the rivers (Mahe and Paturel 2009).





Box 3.8.4: Glacial Recession in the Rwenzori Mountains

A comparison of satellite images from 1987 and 2005 shows a decrease in the extent of glaciers on Speke, Stanley and Baker peaks in the Rwenzori Mountains, which lie on the equator between Uganda and the Democratic Republic of the Congo. They are a major source of water for the lower plains like Kasese. Seasonal changes in snow and ice cover prevent simple visual analysis from conclusively measuring the decline of these glaciers. However, scientific findings from studies in 2003 and 2006 show that the glaciers at the tops of the Rwenzori Mountains are rapidly receding. The glaciers declined by 50 per cent between 1987 and 2003. This glacial recession is generally attributed to increased air temperature and decreased snow accumulation during the 20th century. It has recently been suggested that decreasing cloud cover during that same time period has contributed to a higher rate of sublimation (vaporization of ice without melting) of these glaciers as well. A century ago the glaciers of the Rwenzori Mountains covered nearly 6.5 km^2. If the glaciers continue to recede, as they have since 1906, researchers estimate they will be gone in the next 20 years.

Source: UNEP 2008

worst African drought in terms of fatality killed 300 000 people in Ethiopia in 1984, and the 1972 drought in Kenya caused severe damage to livestock and a 40 per cent decline in maize harvest (EM-DAT 2010).

- *Floods also occur regularly with severe impacts on people and livelihoods*: Floods recur in some African countries; even communities located in dry areas have been affected by floods (UNFCCC 2006). Unlike most of the tropics where the

Rick Scavetta/US Army Africa/Flickr.com

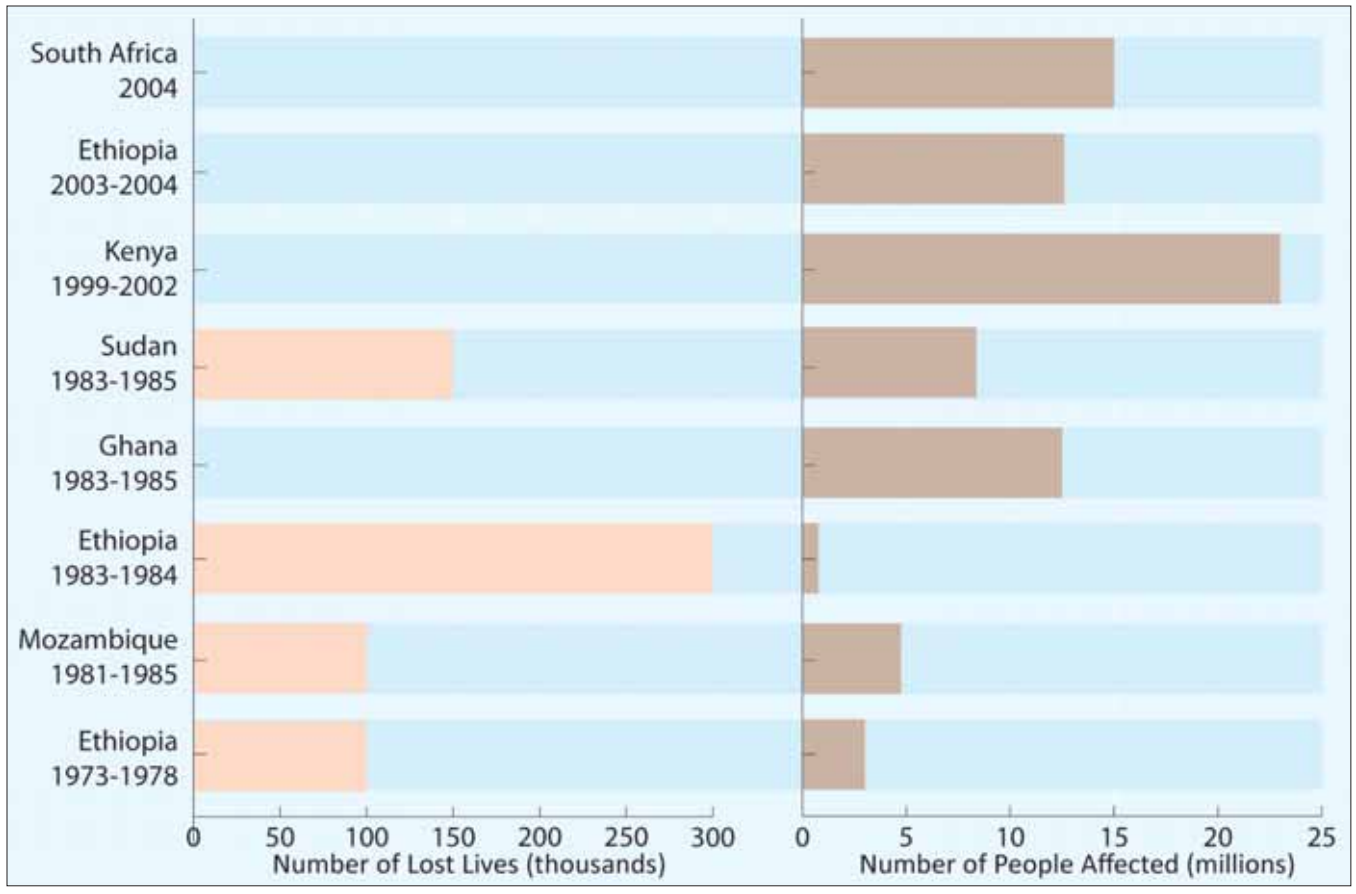
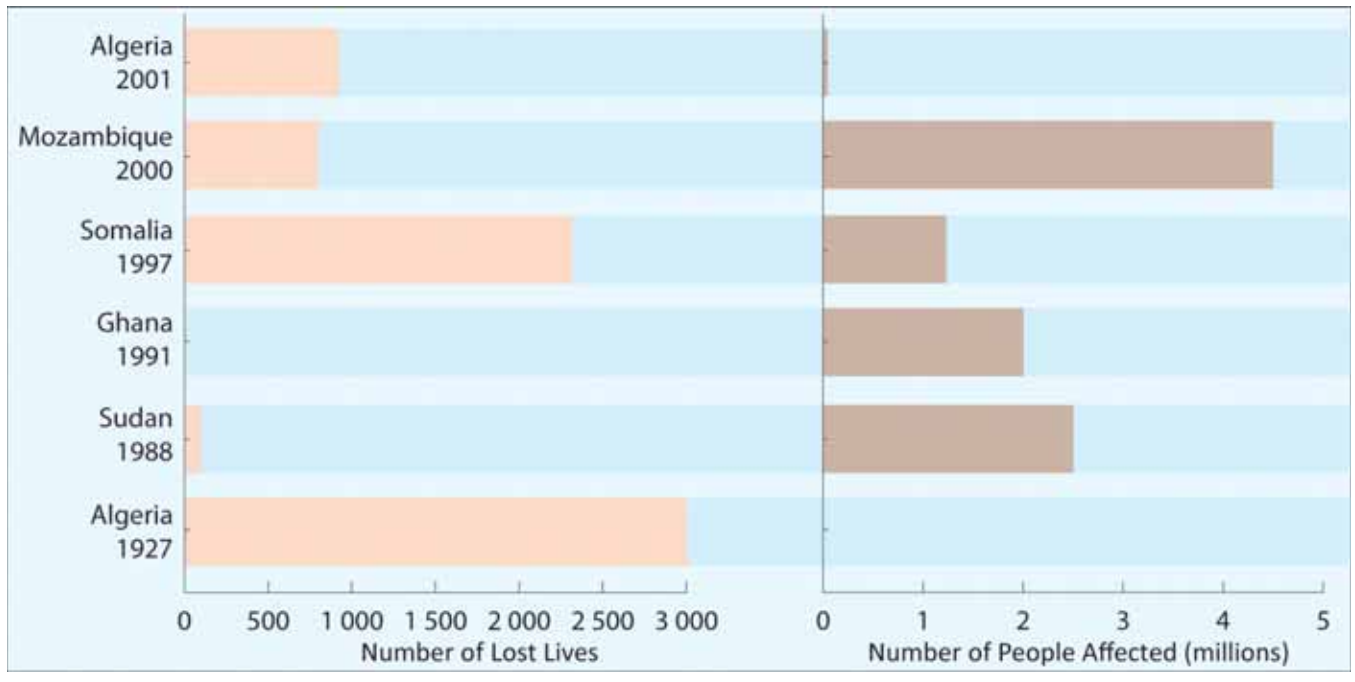


Figure 3.8.2: Number of people killed and affected by Africa's worst droughts (Source: EM-DAT 2010)

distribution and timing of floods is said to be dependent on the cycle of ENSO events, flooding in East Africa is mostly attributed to Indian Ocean Dipole (Behera and others 2005, Trenberth 2005). Floods have resulted in loss of life (Figure 3.8.3) and costly destruction of infrastructure on the African continent, with low-lying and densely populated coastal areas the most vulnerable.

The 1997-1998 floods in the Greater Horn of Africa caused extensive loss of life and property, and the loss of both field crops and food stocks in Somalia seriously affected food security in the region (Verdin and others 2005). In 2001, Mozambique was hit by both floods and drought in different parts of the country. In 2009, heavy and intense rainfall in western Africa set off massive flooding that affected 100 000 people, while torrential rain affected

Figure 3.8.3: Number of people killed and affected by Africa's worst floods (Source: EM-DAT 2010)



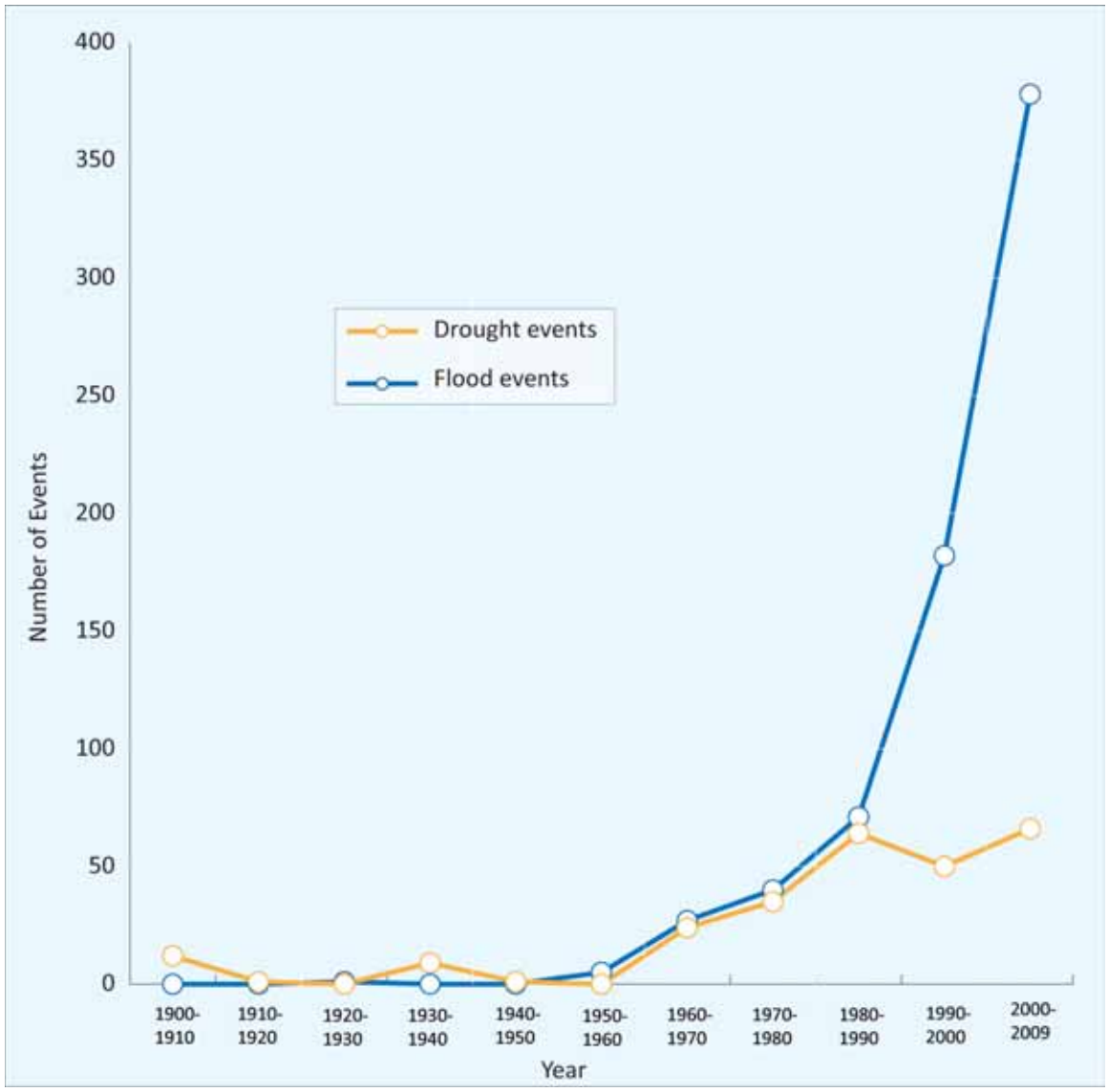


Figure 3.8.4: Trend in the number of recorded flood and drought events in Africa (Source: EM-DAT 2010)

about a million people in Zambia and Namibia (WMO 2009). Figure 3.8.4 shows a rising trend in the number of recorded flood and drought events in Africa.

The Constraints

A combination of various factors that include widespread poverty makes it difficult for most African communities to draw on financial, human, social, physical and natural capital to minimize their vulnerability to the impacts of climate change, including the possibility of more severe and frequent droughts and floods. Population growth is an additional strain on scarce resources to adapt to climate change impacts. Faced with existing low adaptation capacity, Africa will be further constrained by the direct and indirect impacts of climate change and a lack of the financial means to cope. These include increased water stress in some areas and inundation in others, a rise in food insecurity and the potential for an increase in water-related disease vectors.

- *Africa is one of the most vulnerable continents to climate change and climate variability:* This situation is aggravated by the interaction of multiple stresses, occurring at various levels (IPCC 2007a).

- *The convergence of multiple stressors limits Africa's capability to address climate change impacts:* The African continent contains the poorest and least developed nations of the world with low per capita GDP, low life expectancy and high infant mortality, weak governance structures and a low capacity to respond proactively to changes. A number of factors explain this very low adaptive capacity, including a deteriorating ecological base, widespread poverty, inequitable land distribution, a high dependence on the natural resource base, the ravages of HIV/AIDS and a reduced ability to cope with consecutive dry years due to less recovery and preparation time between events (UNFCCC 2006).

- *Increased rainfall variability contributes to Africa's economic limitations in adapting to climate change impacts:* A research study by Brown and Lall (2006) showed a statistically significant relationship between greater rainfall variability and lower per capita GDP and concluded that there is need for more infrastructure to secure water in the study's poorer countries, the majority of which are located in Africa. In Ethiopia, it found that the occurrence of droughts and floods reduced economic growth by more than one-third. Losses in Kenya due to flooding associated with El Niño in 1997-1998 and the La Niña drought in 1998-2000 caused annual damage ranging from 10 to 16 per cent of GDP during this period. The transport sector suffered the most damage, with 88 per cent of flood losses, while foregone hydropower and industrial production totaled 84 per cent of the drought losses (Brown and Lall 2006).

- *Population growth in peri-urban areas will exacerbate flooding events:* A surge in rural-to-urban migration in most areas of the continent has exerted pressure on urban areas, which are often not prepared to accommodate the extra numbers in the short term, resulting in informal settlements. About 72 per cent of Africa's urban population lives in such settlements that are quite frequently found in cities located in low-lying and poorly drained catchment areas, and thus most subject to flooding (GAR 2009).

- *Climate change will likely increase aridity, with important impacts on food production:* The IPCC (2007a) reports with high confidence that agricultural production and food security (including access to food) in many African countries and regions are likely to be severely compromised by climate change and climate variability. A number of countries in Africa already face semi-arid conditions that make agriculture challenging, and climate change will likely increase aridity and reduce the length of the growing season as well as force large regions of marginal agriculture out of production. Projected reductions in yield in some countries could be as much as 50 per cent by 2020, and crop net revenues could fall by as much as 90 per cent by 2100, with small-scale farmers being the most affected. This would adversely affect food security on the continent.

- *Climate change will increase water stress in Africa:* The IPCC reports with very high confidence that water stress currently faced by some countries is likely to increase, while some countries that currently do not experience water stress will become at risk. Even without climate change, several countries in Africa, particularly in northern Africa, will exceed the limits of their economically usable land-based water resources before 2025. About 25 per cent of Africa's population (about 200 million people) currently experience high water stress. The population at risk of increased water stress in Africa is projected to be between 75-250 million and 350-600 million people by the 2020s and 2050s, respectively (IPCC 2007a).

- *Climate variability and change could result in low-lying lands being inundated:* Climate change induced inundation will result in important impacts on coastal settlements (IPCC 2007a). Regionally, the most flood risk occurs in North, West and Southern Africa (Warren and others 2006). The numbers affected will be largest in the mega-deltas of Africa while small islands are especially vulnerable. Towards the end of the 21st century, projected sea-level rise will affect low-lying coastal areas with large populations.

- *Climate change impacts in productive aquatic ecosystems will be costly economically and in terms of food supplies:* Natural climate variability, coupled with human-induced changes, may affect ecosystems such as mangroves and coral reefs, with consequences for fisheries and tourism. The cost of adaptation could amount to at least 5-10 per cent of GDP (IPCC 2007a). Any changes in the primary production of large lakes will have important impacts on local food supplies. Lake Tanganyika currently provides 25-40 per cent of animal protein intake for the surrounding populations, and climate change is likely to reduce primary production and possible fish yields by roughly 30 per cent (Warren and others 2006).

- *It is likely that climate change will affect disease vectors:* Africa is already vulnerable to a number of climate-sensitive diseases (UNFCCC 2006). Climate change will no doubt alter the ecology and transmission of some disease vectors with links to water in Africa, and consequently the spatial and temporal transmission of such diseases. Most assessments of health have concentrated on malaria and there are still debates on the attribution of malaria resurgence in some African areas. There is a need to examine the vulnerabilities and impacts of future climate change on other infectious diseases such as dengue fever, meningitis and cholera, among others.

The Opportunities

With the knowledge that Africa will face significant impacts on its water resources due to climate change, the international community has begun to devote considerable attention and resources to climate change adaptability on the continent. It has identified many opportunities for managing water to overcome those impacts and the constraints in addressing them, some of which are highlighted below.

- *Reinforce traditional adaptation mechanisms:* Although Africa as a whole, especially its governments, have a low capacity for adaptation, many African communities in arid and semi-arid areas have developed traditional adaptation strategies to face great inter-annual climate variability and extreme events. An unusually persistent drought may increase people's vulnerability in the short term, but it can encourage adaptation in the medium to long term. This is particularly true for the drought-prone area in the Sahel region, which is susceptible to frequent climatic hazards (UNFCCC 2006).

- *Provide early warning:* It is as important for local communities to have early warning systems as it is to be supplied with relief, because at the onset of adverse environmental changes the critical decisions are made at the household level. Better forecasting and early warning systems are a prerequisite for adaptation, particularly to predict and prevent the effects of floods, droughts and tropical cyclones as well as for indicating the planting dates to coincide with the beginning of the rainy season and predicting whether there will be disease outbreaks in areas that are prone to epidemics (UNFCCC 2006). Improved early warning systems and their application will reduce vulnerability to future risks associated with climate variability and change (IPCC 2007a).

- *Introduce adaptation measures informed by a more reliable system of seasonal predictions:* Such measures include managing agriculture and water resources better, diversifying livelihoods and improving production efficiencies in arid lands and marginal areas by intensifying livestock densities, using natural fertilizers and practicing soil and water conservation, for example (UNFCCC 2006, IPCC 2007a). Improvement in present-day rain-fed agriculture can enhance resilience for future periods of drought stress through technological steps like water-harvesting systems, dam building, water conservation and agricultural practices, drip irrigation, and developing drought resistant and early-maturing crop varieties and alternative crop and hybrid varieties. Biotechnology research could also yield tremendous benefits if it leads to drought- and pest-resistant rice, drought-tolerant maize and insect-resistant millet, sorghum and cassava, among other crops (IPCC 2007a).

- *Support public-private partnerships that develop innovative adaptation measures:* Innovations for managing climate-related risks are being developed and deployed with private sector participation. In Malawi, for example, a private sector initiative that bundles insurance based on an established relationship between lack of rainfall and crop failure and a loan to help farmers purchase seeds and fertilizers has received strong support from farmers. With more variable and intense climate, weather-related crop insurance may have more limited prospects (APF 2007).

- *Improve physical infrastructure:* Improvements to physical infrastructure may improve adaptive capacity. Building improved communication and road networks for better exchange of knowledge and information, for example, gives people an opportunity to migrate more easily in case of extreme events due to climate change. On the other hand, general deterioration in infrastructure threatens the supply of water during droughts and floods (IPCC 2007a).

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CHALLENGE 9

ENHANCE CAPACITY TO ADDRESS WATER CHALLENGES

The Challenge: *Enhance Africa's capacity to address its water challenges.*

The Situation: *Africa faces a situation of economic water scarcity; and current institutional, financial and human capacities for managing water are lacking.*

The Constraints: *Inadequate and unsustainable funding arrangements for water resources management; insufficient knowledge base; lack of an effective research and technology base; and weak institutional arrangements and legal frameworks for the ownership, allocation and management of water resources.*

The Opportunities: *Reform water institutions; improve public-private partnerships; and improve the knowledge base through human capacity building.*

The Challenge

To address Africa's mounting challenge of economic water scarcity, it will need to strengthen and sustain financial, human and institutional capacities to effectively develop and utilize water resources.

The Situation

- *Effective institutional, financial and human capacities for managing water are lacking:* There is a lack of sustainable financing mechanisms for water-related investments, including transboundary water resources development, water supply, sanitation, hydropower and irrigation, among others and under financing of the water and sanitation sector in many countries has led to deterioration and potential collapse of infrastructure (Carles 2009). The situation is exacerbated by competition for public funding between sectors, and heavy public debt burdens in most countries (OECD 2010).

The Constraints

Insufficient knowledge base : There is generally a lack of data due to the underdeveloped human capacity for research, collection, assessment and dissemination of water resources data, and no motivation and retention of skilled staff. The planning and monitoring of water development activities need data, information, and managed knowledge. This is especially evident in the deficiency of climate change data on Africa, as identified in the G8 Gleneagles plan of action (2005), which is still relevant. It identifies the following gaps:

- Low institutional and human capacity levels.
- Limited comprehensive studies on vulnerability analysis.
- Equally limited studies on possible adaptation measures and their cost-benefit analysis.
- Lack of quantification of the different components of Africa's water balance. While estimates are available in the literature for continental average annual rainfall and evapotranspiration, research data are lacking for other components such as surface runoff, infiltration, groundwater storage and groundwater discharge, among others.
- Groundwater quantity and quality monitoring is very irregular in most countries due to a lack of expertise to collect and analyze the data for the continent's development.
- Wide gaps in ground and surface water information and knowledge in the water sector across Africa.
- Lack of earth observation systems and lack of in-country and regional capacity for analyzing and interpreting observational data.
- Data on economically exploitable small-scale hydropower potential is limited or not available for most African countries, and there are wide variations on how much hydropower potential has been exploited overall.
- Lack of decision-support systems and tools that are relevant to Africa's local water resources management needs.
- Lack of real-time data collection and transmission technology to facilitate sharing, such as through the Internet for meteorological and hydrological data.
- Lack of a coordinated, effective and financially sustainable continental system or database for data collection, assessment and dissemination for national and transboundary water basins, and for supporting strategic development decisions on the continent.
- Lack of commitment in the mobilization and leveraging of financial resources by African countries also affects the above data issues directly or indirectly. A typical example is the

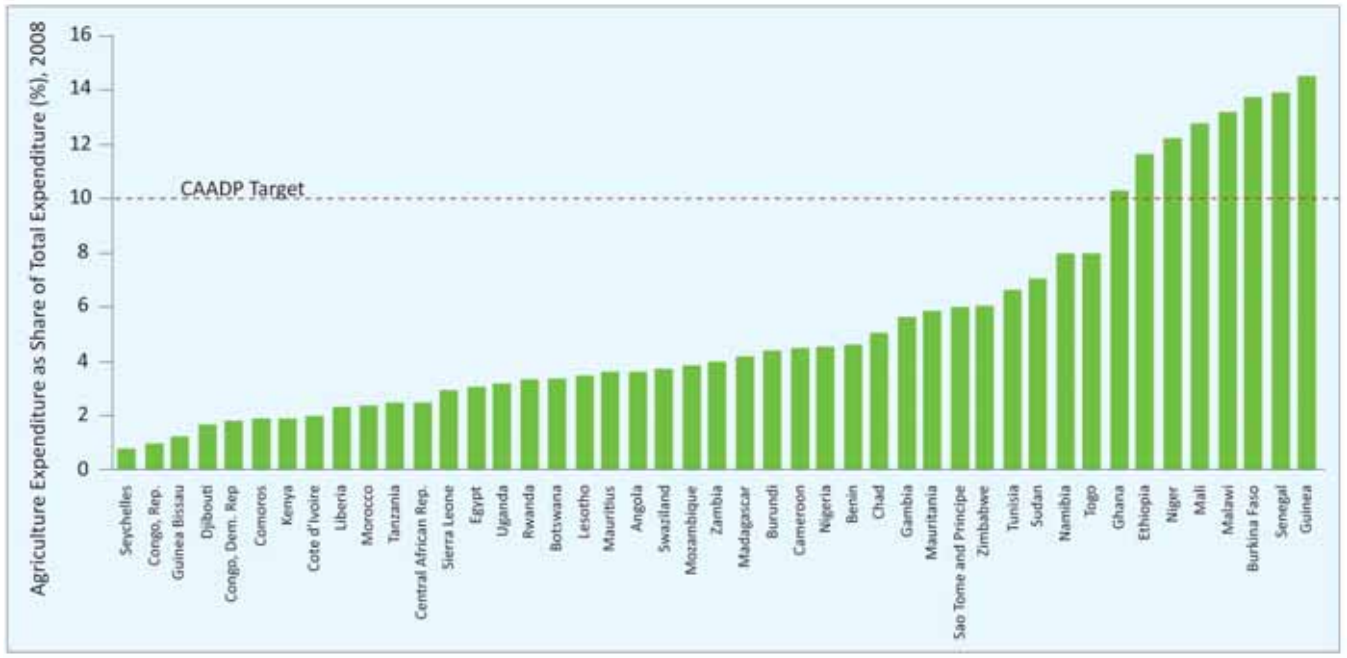

Figure 3.9.1: Agricultural expenditure (as percentage of total) compared to CAADP 10 per cent target, 2008 (Source: Bekunda 2010)

implementation of the 2003 Comprehensive Africa Agriculture Development Programme (CAADP), the Africa-owned and Africa-led initiative to boost agricultural production on the continent through irrigation and water management, among other measures. In 2003, member countries made a commitment to spend ten per cent of their total national expenditures on agriculture, but by the year 2008, only a handful of countries had implemented what they promised (Figure 3.9.1).

The Opportunities

Although there is a general lack of institutional, financial and human capacity to effectively manage water resources in Africa, at the individual country level, many African nations have made progress in improving water policies, strategies and institutional arrangements that highlight the opportunities to improve water management capacities in Africa. These include an increased awareness of, and political commitment to Integrated Water Resources Management (IWRM). Many countries are also increasingly committed to water-policy reform and the decentralization of water institutions. And many are taking steps towards financial sustainability in the water sector and recognize the importance of treating water as an economic good, while providing a safety net for the poor (UNECA 2006). Based on their progress and on recommendations from the Africa Water Vision, the following are some of the opportunities for African nations to improve their capacity to manage water resources.

- *Reform water institutions:* There is potential to enhance human resources and the capacity of water resource institutions, including the decentralization of water resource management activities to the most appropriate levels for stakeholders, as well as strengthening existing initiatives. Several countries, including South Africa and Namibia, reformed their water sectors and these initiatives provide lessons for establishing comprehensive water sector

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policy and strategy reforms and setting up appropriate legal frameworks, including those that protect the interests of the more vulnerable in society such as the poor. The capacity to manage water in Africa in an integrated and coordinated fashion can be improved through maintaining a centralized institutional structure that can better govern the complex and multi-disciplinary nature of water resources management and planning, especially given the challenges of pollution and environmental degradation (UNECA 2006). National water management institutions can be improved if their responsibilities include helping to unify perceptions about domestic water concerns, establishing a national water management framework, providing data to enable the forecasting of water demand and potential problems, cooperating with regional and international water bodies to manage shared water, and coordinating training programmes (UNECA 2006).

- *Improve public-private partnerships:* Governments have the opportunity to improve public-private partnership arrangements for the development of water infrastructure. The financial model of Public-Private Partnerships (PPPs) involves a sharing of risk and responsibility between the state and private firms, while the state retains control of the assets. Although such partnerships were expected to improve services without the disadvantages of privatization (unemployment, higher prices and corruption), they have fallen short of expectations; costs are often greater for the consumer, the private sector may not always be more efficient and big government contracts are often abused. If governments improve the system for dealing with the private sector by being disciplined and using highly transparent procedures, there is the potential for gains in efficiency and effectiveness in water management. There is evidence that PPPs in Africa have been most successful when planning, communication and commitment are strong, and when governments have implemented effective monitoring, regulation and enforcement. Governments must also perform thorough feasibility studies to examine affordability, value for investment and risk transfer. An example of a successful PPP is a 20-year concession contract between the government of Gabon and a private firm for the provision of water and electricity services; its relative success is due to the government's strong political commitment (Farlam 2005).

- *Improve the knowledge base through human capacity building*: Opportunities to identify training needs for water resources assessment and management, and to train a cadre of water professionals need to be fostered and acted upon to improve the level of information about Africa's water resources, uses and needs. Training should aim to ensure that staff is retained and that their knowledge and skills are frequently upgraded (UNECA 2009.). Governments need to ensure that information and education programmes are an integral part of the development process, and to provide water specialists with the training and means to implement IWRM (INPIM 1992). The proper policy frameworks for planning, developing and managing water resources that implement recent advancements in the science and technology of water management also need to be in place to take advantage of available knowledge and skills. This knowledge includes local and indigenous knowledge and wisdom about water resources (UNECA 2006). Box 3.9.1 illustrates the richness of indigenous knowledge of water that should not be lost.

Box 3.9.1: Indigenous Knowledge of Water

The Fulani of Mauritania have a detailed art of detecting groundwater. Their indicators are based on topography (e.g., shallow aquifers can be found near natural ponds or in depressions of mountains), on plant species (especially tap-rooted trees) and the health or vigour of the plants, such as the greenness of leaves during the year. Other indicators are based on fauna (e.g., wild boars only live where they can dig and find moist soil; other animals that prefer to stay around moist places are caimans, amphibious lizards, tortoises, bands of butterflies, some bird species, and many termite hills). The Fulani also are familiar with the geological strata in their area, and that they must dig through the whole layer of red or grey clayey soil and arrive at the sandy layer before finding ground water. A good quality ground water that is clear, sweet and has a good mineral content, is indicated by the presence of *Guiera senegalensis, B. rufescens*, termite hills, and deep-water wells (the deeper, the better the quality). The best quality natural ponds are indicated by the presence of water lilies, followed by *Acacia nilotica* and *Mitragyna inermis*. Bad, diseased water is indicated by the presence of the grass *Echinochloa pyramidalis*. Water quality is also tested by immersing a leather container in it. The best water leaves the leather intact, and as water quality deteriorates, the intensity and duration of the leather's colour will change to white, black, red or finally yellow/orange. Water quality is also evaluated by its effect on livestock, especially their behaviour after drinking (whether they are content or not) and the yield of milk.

Source: UNECA 2006

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4 WATER PROFILE OF COUNTRIES

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