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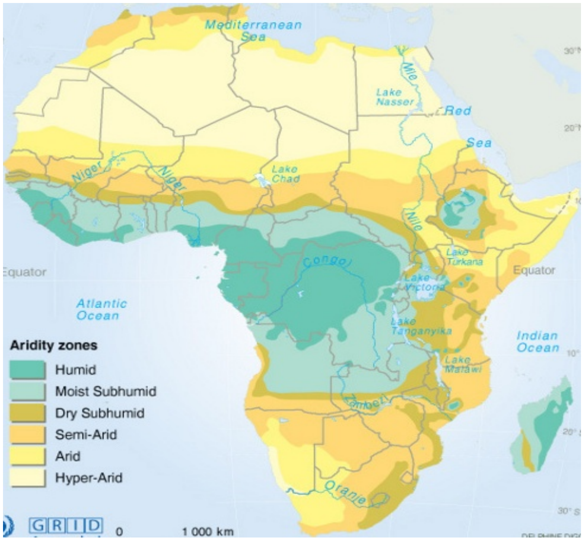
Water Adaptation in Africa



Africa is one of the world's most vulnerable regions to climate change. Potential impacts of climate change on the continent are multiple but are mostly connected through the medium of water. Historically the continent has unpredictable rainfall and climate patterns which are likely to be exacerbated by future climate change. This briefing discusses adapting water resource management to climate change.

Overview

- Africa already has significant rainfall variability within years, and across years and decades. Rainfall is likely to become more unpredictable under climate change, with an increase in intense events.
- The dominant issues for water governance in Africa are transboundary resources, managing resource use and improving storage. Adaptation measures can be implemented through existing initiatives.
- Adaptation measures could include improving information and monitoring systems on surface and groundwater resources, providing water managers with technical training, and applying a range of natural and built water storage solutions
- Climate change experts argue that water should be recognised and funded as a foundation for adaptation to climate change, and that water resource management is not currently given enough attention.

Rainfall and Climate

Rain in Africa is characterised by variability. As illustrated by the title image, rain falls very unevenly across Africa. For example, the humid region of Central Africa, which comprises 20% of the land area, receives 37% of total rainfall. In contrast, the arid region of North Africa, occupying a similar area, receives less than 3%[1]. In a year, seasonal variations in rainfall can be dramatic. Year-to-year, humid regions tend to have low levels of variability compared with arid regions which have higher levels. In a study for the Department for International Development (DFID), it was estimated that in humid regions the level of variation from average annual rainfall was 15% (or less)[2]. In arid areas, the level of variation was typically greater than 40%.

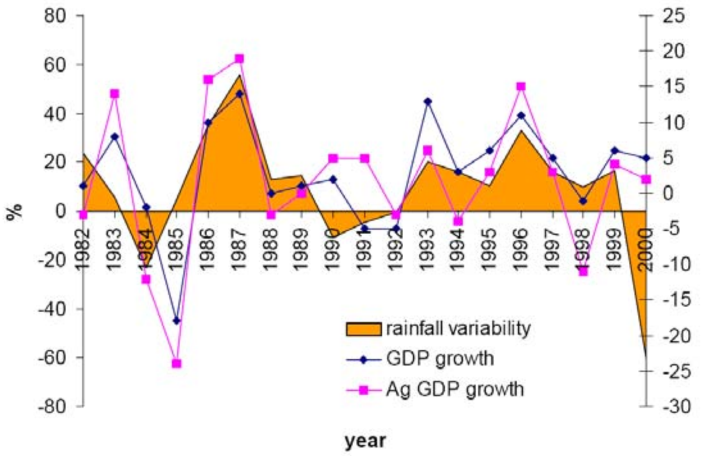
Rainfall variability in Africa can result in extreme events such as flooding and severe droughts over years, or decades. The Sahel, the semi-arid belt that lies across Africa south of the Sahara and north of the tropical regions, has experienced the greatest change in rainfall patterns anywhere in the world since measurements began. Over the period 1961-1990, annual rainfall was 20% to 40% less than during the period 1931-1960[3]. Other examples include the almost continent-wide drought of 1983-4 and severe drought in the southern African region during the early 1990s. A third of the African population reside in drought-prone areas. Over the past 100 years in Africa, there have been periods of stable temperatures as well as warming and cooling episodes. Against this backdrop of climate variability, there has been a net warming trend - the annual average temperature has increased 0.53ºC since 1895.

Impacts on Development

Africa's rainfall and climate variability has had serious impacts on social and economic development. Africa is highly dependent on rain-fed agriculture and fluctuations in rainfall can have significant impacts on food production and security. Ethiopia's rainfall variability correlates with fluctuations in both GDP and agricultural GDP, as shown in Figure 1[4]. A lack of rain results in reduced food production due to inadequate water management and storage.

In 2006, United Nations International Children's Emergency Fund (UNICEF) reported that nearly 8 million people were on the verge of starvation in the Horn of Africa due to severe drought[5]. The La Niña drought of 1998-2000 in Kenya resulted in $2.41 billion economic losses. Winter floods in Kenya in 1997-98 caused $2.36 billion infrastructure damage. Floods in Mozambique in February 2000 affected approximately 4.5 million people, GDP growth fell from 10% to 2%, and losses were approximately $500 million.

Figure 1: Ethiopia: Rainfall Variability, GDP and Agricultural GDP Growth[4]



Future Climate Change

Climate change is predicted to impact on the level and variability of Africa's rainfall according to the Intergovernmental Panel on Climate Change (IPCC) (Box 1). Even small changes in rainfall can lead to disproportionately large changes in water resources. In a study in Western Cape, South Africa, it was estimated that an 8% reduction in rainfall results in a 36% reduction in groundwater recharge, and 30% reduction in surface runoff[6].

Box 1 Climate Change Predictions

The consensus from the IPCC's models[7] is that:

- Average temperatures are likely to increase disproportionally in Africa with warming at 1.5 times the global mean;
- Mean annual rainfall is likely to decrease in southern Africa and the Sahara, and is likely to increase in west and east Africa. For the Sahel region the results are ambiguous;
- Rainfall will be less predictable, with an increase in the frequency of extreme events such as droughts and flooding.

Average temperatures are likely to rise under future climate change, which will increase evaporation. The combination of these changes is likely to affect the availability of water resources, and thus water security – the level of risk of insufficient quantity and quality of water being available for human wellbeing, economies and ecosystems. Such challenges in water management were discussed at the Davos 2011 World Economic Forum.[8]

Water resources in general need to be protected and they are the foundation for future development and the achievement of most of the Millennium Development Goals (MDGs). They are explicitly addressed under MDG Goal 7: 'Ensure environmental sustainability'; Target 10: 'Halve, by 2015, the proportion of people without sustainable access to safe drinking water and basic sanitation'.

Water Resources

Surface Water

Africa's surface water resources comprise a total of sixty international river basins, 62% of the land area,[1] and more than 160 freshwater lakes, each with catchment areas of more than 25 km^2. Most of the surface water resources are situated in the central and south eastern regions of the continent, reflecting the spatial pattern of rainfall. Around 50% of Africa's total surface water resources are generated in the Congo basin alone[9]. Surface runoff of water, which occurs when the intensity of rainfall exceeds the rate at which it infiltrates the soil, is much lower for the African continent than in any other populated region due to factors such as high rates of evaporation.

Surface water resources provide benefits ranging from hydropower generation, irrigation, inland fisheries, tourism and recreation, to water supply for domestic, industrial and mining operations. Countries exploit the resource to various degrees, depending on their level of development. For example, 98% of South Africa's surface water resources are already allocated.

Groundwater

Much of Africa is underlain by complex and unconnected groundwater resources, the majority of which are low yielding shallow aquifers (underground geological formations of porous, permeable, saturated rock). Groundwater provides reliable water to more than 100 million people in Africa[10], and is the resource of choice for developing rural water supplies. Among urban populations it is usually the very poorest who are dependent on groundwater, gaining access though shallow, hand-dug wells. Aquifers also play an important role for a high number of aquatic and terrestrial ecosystems, such as wetlands. Commentators suggest groundwater resources may be developed to provide increasing water supply for the population, taking withdrawal and recharge rates into consideration, but potentially not in volumes sufficient to support irrigation and industrialisation.

Water Resource Management

Africa's extreme hydrology presents many challenges. Investing in water management is necessary to protect resources for future generations. There are two dominant issues for water management in Africa, transboundary and integrated.

Transboundary Water Management

Surface water resources in Africa are predominantly transboundary. Approximately 90% of the river basins and lakes are transboundary, with the Congo, Niger, Nile and Zambezi basins and Lake Chad having boundaries shared by eight or more countries. Transboundary water management can be defined as management at the level of the river/lake basin. Since the 1960s, bilateral and multilateral agreements have been developed for some of the continent's major river basins, with a few resulting in the development of river basin level institutions of.

Groundwater management has historically received less attention than surface water. However, the importance of managing this resource is being increasingly acknowledged. Furthermore, in December 2008, the UN General Assembly adopted an international resolution on the "Law of Transboundary Aquifers". This resolution "encourages aquifer states to make appropriate bilateral or regional arrangements for the proper management of their transboundary aquifers."

The next step will be to translate the resolution into practical action.

The 1997 United Nations Convention on the Law of the Non-Navigational Uses of International Watercourses (defined as “a system of surface waters and groundwaters constituting by virtue of their physical relationship a unitary whole”) is seen as the most important landmark in international water law. This Convention acknowledges surface and groundwater resources as interconnected systems, and outlines three key principles for states that share transboundary water resources:

- ensuring equitable and reasonable use
- prevention of significant harm
- prior notification of planned measures.

The Convention has 21 contracting states to date, 14 short of the number required to enter into force. It has not yet been ratified by the UK government.

Integrated Water Resource Management (IWRM)

The concept of IWRM (Box 2) was first discussed in 1977 [11], and put on the international agenda in the early 1990s. Today the concept is supported by a wide range of international and national agencies, and IWRM is put forward as the best practice approach, although there is considerable debate about exactly what the approach entails. While some more radical approaches propose extensive participatory management and full integration of land and water development, the basic principles outlined in Box 2 are generally accepted.

Box 2 IWRM Principles

- Recognition of the interconnectedness of the water cycle, and taking a holistic approach to managing surface water, groundwater, and water quantity and quality.
- Adoption of a mix of “soft” solutions (effective institutions, stakeholder involvement and information management) with “hard” solutions (infrastructure).
- Co-ordination of water management and land management.
- Recognition that water management arrangements should be inherently adaptable, and evolve with societal changes.

Transboundary and integrated water resource management are complimentary to each other, and can be applied together where appropriate. For example, the Nile Basin Initiative uses both transboundary and integrated approaches (Box 3).

Box 3 Nile Basin Initiative (NBI)

This initiative, supported by donors including DFID, was launched in February 1999 by the ten countries sharing the Nile Basin. With a combined population of approximately 300 million people, all these states are exposed to water stress, with increasing competition over limited water resources.

- The process started by open, political dialogue between countries over several years to develop a “shared vision” on managing common resources.
- This led to the development of a Co-operative Framework Agreement, and established the NBI as a “transition” institution that would evolve into a permanent River Basin Commission.
- The NBI provides countries with a shared information system, enabling monitoring and management of the basin.
- Through the NBI, practical projects are implemented at a local level within the basin. Projects take an IWRM approach, and ensure co-ordination across sectors including power, trade, agriculture and irrigation, and water.

Adapting Water Management

Adaptation is defined as “actions that minimise the consequences of actual and expected changes in the climate”. Some of the key measures for adaptation in water management include both ‘soft solutions’ to monitor and manage use of water and ‘hard solutions’ to increase water storage infrastructure. The importance of incorporating adaptation projects and programmes into existing transboundary, and integrated, water resource management frameworks, where they exist, is acknowledged. This will ensure co-ordinated action in the protection of water resources at all scales, from international, through national, to the local level.

Soft Solutions- Information and Institutions

An absence of data on both surface water and groundwater reduces the ability to monitor and manage resources, and thus to adapt to climate change. Measurement of stream and river flows, as well as recording of water abstractions (the process of taking water for use), is declining at a time when the challenges to managing the resource are increasing (Box 5).

Box 5 Mainstreaming Climate Change into IWRM: Pangani Basin, Tanzania

Pangani is already a water stressed basin, with climate change predicted to result in a 6-10% decrease of annual river flow. Almost 90% of surface flow is allocated to irrigation and hydropower, and even at present this does not meet water demand levels for these activities. This project, funded by the EU and UNDP, has objectives including:

- Collecting baseline information on hydrology and developing a monitoring plan on water flow, water quality, and river changes through climatic conditions (particularly reduced flows).
- Training water managers in modelling river flow scenarios under expected climate change, and applying this information in their resource decisions
- Using a participatory approach to engage communities in IWRM and climate change adaptation processes, such as awareness on water allocations, or resolution of water user conflicts.

Groundwater resources provide natural water storage, buffering against surface water variability caused by climate change. These resources need to be adequately defined in the first instance by their location, quality and quantity, and recharge rate, so they can be managed and developed to guarantee water supply for future generations. In the absence of management, overexploitation and contamination can occur, leading to permanent basin or aquifer closures. In recent years, initiatives have gathered momentum to produce maps of aquifer distribution for Africa, although comprehensive information remains lacking. Developments in groundwater mapping and monitoring are further constrained by a shortage of local hydrogeologists (Box 6).

Box 6 Groundwater Resilience to Climate Change in Africa

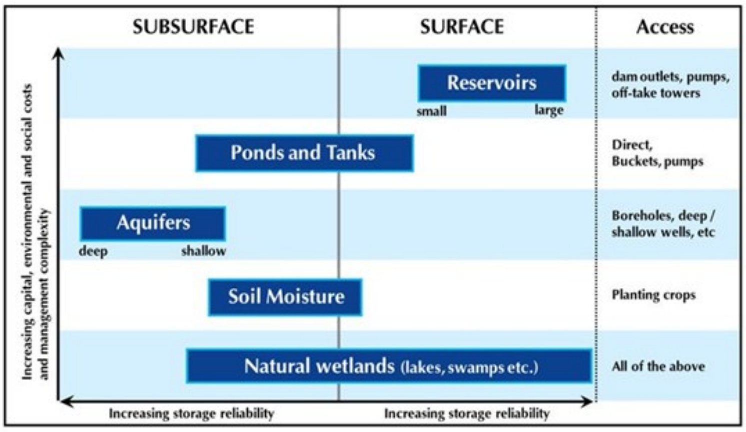
This DFID funded initiative is currently seeking to consolidate existing geological and hydrogeological maps to produce an aquifer map for Africa. It further aims to develop benchmarking for aquifer properties and recharge estimates, and will undertake two hydrogeological case studies of aquifer resilience to climate change.

Understanding rainfall dynamics from days to months would strengthen early warning systems and help people such as subsistence farmers make informed decisions such as crop planting and storage. However, there is a lack of detailed weather information for Africa. Within the continent there are 1152 weather stations at a density of approximately 1 per 26,000 km^2 which are distributed very unevenly [12]. By comparison, the UK has 4,400 weather stations for the variable of rainfall, a density of 1 per 7km^2 [13].

Hard Solutions - Infrastructure

In Africa, due to rainfall variability, and a long dry season in many regions, water storage is a key issue. For arid areas of the continent where rainfall variability is already high, and variability is likely to increase under climate change, storage becomes critical. Safeguarding water resources requires a range of small to large scale, surface and sub surface, water storage options. These include using, enhancing and managing natural storage such as groundwater, wetlands, and soil moisture, as well as engineered storage such as dams and reservoirs, small ponds and tanks (Figure 2).

Figure 2 A Typology of Water Storage[14]



All storage options will also be impacted by future climate change, which need to be investigated and anticipated. The most appropriate storage option will be most suited to local conditions. Combining, or diversifying, storage systems may increase resilience to climate change[15]. In the event of flooding, a technique is known as Managed Aquifer Recharge (MAR) can be used to artificially pump excess waters to groundwater. Similarly, in drought-prone areas, using MAR can ensure water resources are maximised and not lost to evaporation.

Further Pressures on Water Resources

A balanced approach should be taken to water resource management, placing climate change in context, alongside other environmental and human factors. At present, Africa uses substantially less water than elsewhere but pressure is rapidly increasing from competing sources such as:

- *Population growth* The population is expected to increase from 700 million in 2007 to 1.1. billion in 2030, and 1.5 billion in 2050[16].
- *Urbanisation* Africa is urbanising faster than any other continent, and it is estimated that by 2050 there will be more people living in African cities than the combined urban and rural populations of the Western hemisphere[17].
- *Agriculture* This is mostly rain-fed, with irrigation at 5.5% in Sub-Sahara Africa. Large scale irrigation as seen in Asia is not considered viable[18]. However there is much potential for small scale irrigation.
- *Industrialisation* This is uneven across the continent, but the more developed countries abstract more water, and they have a greater burden of water pollution to address.

International Policy

The "Cancún Agreements", an outcome of the UN Conference of the Parties (COP 16) held in December 2010, confirmed that developed countries will collectively commit to new and additional "fast-start" climate change funding of US $30 billion for 2010 to 2012, with allocation to be balanced between adaptation and mitigation activities. By 2020, the commitment is to raise jointly US$100 billion. The amount of fast-start funding promised by donors to date varies considerably, and there is no clear agreement on how funding should be split between adaptation and mitigation. While some suggest the balance should be roughly 50/50, only around 11-16% of total fast start funding has been allocated to adaptation so far. Overall, the UK has committed $2.375 billion from the aid budget, $319.8 million of which (13.5%) is for adaptation.

Adaptation financing is crucial to developing countries, but pledges currently fall very short of what is required. The "Cancún Adaptation Framework" and "Adaptation Committee" were established at COP 16, acknowledging the need to accelerate international co-operation, and action, on adaptation. Experts agree that plans, projects and programmes need to be urgently implemented to support regions that are most vulnerable to future climate change.

There is consensus amongst international experts that water should be recognised and funded as a foundation for adaptation to climate change. UN Water is an inter-agency mechanism co-ordinating the activities of 26 UN agencies in water resources. UN Water argues that "adaptation measures in water management are often underrepresented in national plans or in international investment portfolios. Therefore, significant investments and policy shifts are needed". The Global Water Partnership has stated that "investment in national water resources management capacity, institutions and infrastructure should be a priority for mainstreaming adaptation finance". Given that IWRM is an established framework for water governance, IWRM projects could be considered eligible for adaptation funds.

Endnotes

1 Goulden, M, *et al*, 2009, *Hydrological Sciences Journal* 54 (5), 805-828
2 Thornton, P, *et al*, 2006, *Mapping climate vulnerability and poverty in Africa*. ILRI
3 Hulme, M, *et al,* 1995, *The impacts of climate change in Africa*. CSERGE Working Paper GEC 95-04. UEA
4 World Bank, 2006, *Ethiopia: Managing water resources to maximise sustainable growth*
5 International Council for Science, 2007, *Hazards and disasters in Sub-Saharan Africa*
6 Mukheibir,P, 2007, *Access to water – the impact of climate change in small municipalities*. University of Cape Town
7 Intergovernmental Panel Climate Change, 2007,*Fourth Assessment Report AR4*
8 http://www.weforum.org/content/pages/world-economic-forum-water-initiative#node-98999
9 Royal Society of Chemistry, 2010, *Africa's water quality*
10 Adelana, S, *et al*, 2008, *Groundwater research issues in Africa*. BGS
11 1977 United Nations Water Conference
12 Conway, G, 2009, *The science of climate change in Africa; impacts and adaptation*. Grantham Institute for Climate Change
13http://www.metoffice.gov.uk/climatechange/science/downloads/Monthly_gridded_datasets_UK.pdf
14 http://africastorage-cc.iwmi.org/
15 McCartney, M. and Smakhtin, V, 2010, *Water storage in an era of climate change: addressing the challenge of increasing rainfall variability*. IWMI
16 UNFPA, 2009, *State of world population*
17 UNPD, 2009, *World urbanization prospects. The 2009 Revision*
18 Lankford, B, 2005, *Rural infrastructure to contribute to African agricultural development: the case of irrigation.* Report for The Commission for Africa, UEA

POST is an office of both Houses of Parliament, charged with providing independent and balanced analysis of policy issues that have a basis in science and technology. POST is grateful to Joanna Church for researching this briefing, to the National Endowment for Science, Technology and the Arts for funding her parliamentary fellowship, and to all contributors and reviewers. For further information on this subject, please contact the co-author, Dr Jonathan Wentworth.