

The Grand Challenge of Water Security in Africa

RECOMMENDATIONS TO POLICYMAKERS


by
NETWORK OF AFRICAN
SCIENCE ACADEMIES
(NASAC)



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The Network of African Science Academies (NASAC) was established on 13th December 2001 in Nairobi, Kenya, under the auspices of the African Academy of Sciences (AAS) and the Inter Academy Panel (IAP). NASAC is a consortium of merit-based science academies in Africa and aspires to make the “voice of science” heard by policy and decision makers within Africa and worldwide. NASAC is dedicated to enhancing the capacity of existing national science academies and champions the cause for creation of new academies where none exist.

This document is an output from the cooperation between NASAC and the German National Academy of Sciences Leopoldina. The Leopoldina is the world’s oldest continuously existing academy for medicine and the natural sciences. It was founded in 1652 and has been located in Halle since 1878. Its more than 1,400 elected members are outstanding scientists from all over the world. The Leopoldina was appointed Germany’s National Academy of Sciences in July 2008. In this function, one of the Leopoldina’s responsibilities is to provide science-based advice to policymakers and to the public. It represents German scientists in international academy circles and maintains links with scientific institutions in European and non-European countries.

The cooperation project between NASAC and the Leopoldina is funded by the German Federal Ministry of Education and Research (*Bundesministerium für Bildung und Forschung*, BMBF). Education and research are a Federal Government policy priority in Germany, based on the firm belief that they are the foundations on which we will build our future in a changing world, and that we will only be able to master the challenges of the 21st century through international cooperation in education, research and science. BMBF therefore cooperates with individual states and institutions on many interdisciplinary projects.

The Grand Challenge of Water Security in Africa Recommendations to Policymakers

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Contents

Foreword	vi
List of Acronyms	vii
1. Introduction – Why Water is Important in Africa	1
2. Key Messages	2
3. Water, Food and Energy Nexus.....	4
4. Education, Knowledge and Capacity Development.....	6
5. Access to Safe Water and Sanitation	8
6. Water Resources and Infrastructure for Economic Growth	10
7. Managing Transboundary Systems.....	12
8. Global Change and Risk Management	15
9. Water Governance and Management.....	17
10. Financing	19
11. Conclusions	21
12. Acknowledgements	22
13. References.....	23



Foreword

Water is a crucial resource with great implications for Africa's development. Climate change coupled with increasing population growth has led to an increase in water demand. In most African countries the demand outstrips the available water resources. As water availability constantly declines, partitioning of water for domestic consumption, agriculture and other forms of water use is becoming a subject of serious concern. Sound management of Africa's limited water resources is becoming increasingly important to help meet a fast rising population and increasing demand for food and energy, while ensuring the health of water ecosystems. It is with this background that during the IAP Water Programme meeting held in Pretoria on 30–31 March 2009, the representatives of 13 African academies of science resolved to establish a regional Water Programme for Africa under the auspices of the Network of African Science Academies (NASAC).

The principle objective of the programme is to assess and report on the status of water resources in Africa. Subsequently, on 28–31 March 2012, NASAC, in collaboration with the Royal Netherlands Academy of Arts and Sciences (KNAW), the Royal Dutch Ministry of Foreign Affairs and the German National Academy of Sciences Leopoldina, organised a conference on Water Management Issues in Africa. Two further meetings were held as part of the continuation of the cooperation between NASAC and Leopoldina. Following this conference, NASAC continued the collaboration with Leopoldina, to assess and report on the status of water resources in Africa, and this document is one major outcome.

This document focuses on why water is important to Africa, and elaborates, through key messages, on how water security, related development and human wellbeing, can be achieved and sustained through targeted policy actions that relate to: water, food and energy nexus; education, knowledge and capacity building; access to safe water and sanitation; water resources and infrastructure for economic growth; management of transboundary water systems; global change and risk management; water governance and management; and financing. Interventions to tackle such priority issues are the concern of all stakeholders (governments, policymakers, scientists, civil society, and, regional and international organisations). The implementation of the proposed actions will provide Africa's policymakers with a platform to work together to enhance water management capacity and thus improving access to safe drinking water to millions of people within the region.

Additionally, it is hoped that governments and the private sector will be stimulated to interact with science academies to enhance local water management capacities, and to contribute to national policy and decision making processes.



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List of Acronyms

AfDB	African Development Bank
AMCOW	African Ministers Council on Water
AUC	African Union Commission
AWF	African Water Facility
CAADP	Comprehensive Africa Agriculture Development Programme
CBC	Commonwealth Business Communications Limited
CICOS	International Commission for the Congo-Oubangui-Sangha Basin
COMEDAF	Conference of Ministers of Education of the African Union
EAC	East African Community
ECOWAS	Economic Community of West African States
ENSO	El Niño Southern Oscillation
FAO	Food and Agriculture Organization
FDI	Foreign Direct Investment
G&A	Governance and Accountability
GEF	Global Environment Facility
HLF	High Level Forum
IAASTD	International Assessment of Agricultural Knowledge, Science and Technology for Development
IAEA	International Atomic Energy Agency
IAP	Inter Academy Panel
IGAD	Inter-Governmental Authority on Development
IPCC	Intergovernmental Panel on Climate Change
IRIN	Integrated Regional Information Networks
IWRM	Integrated Water Resources Management
JMP	Joint Monitoring Programme
LVBC	Lake Victoria Basin Commission
MDGs	Millennium Development Goals
NSAS	Nubian Sandstone Aquifer System
NWSAS	North-West Sahara Aquifer System
OMVS	Organisation pour la Mise en Valeur du fleuve Sénégal
PAU	Pan African University
PAUWES	PAU Institute on Water and Energy including Climate Change
RMCs	Regional Member Countries
SADC	Southern African Development Community
SEI	Stockholm Environment Institute
TWAP	Transboundary Waters Assessment Programme
TWh	TerraWatt hours
TYS	Ten Year Strategy
UN	United Nations
UNDESA	United Nations Department of Economic and Social Affairs
UNDP	United Nations Development Programme
UNECA	United Nations Economic Commission for Africa
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
UNFPA	United Nations Population Fund
UNICEF	United Nations Children's Fund
WAS	Water and Sanitation for Africa
WASH	Water, Sanitation and Hygiene
WHO	World Health Organisation
WRC	World Radiocommunication Conference
WSAfrica	Water and sanitation for Africa
WWF	World Wide Fund for Nature

Introduction – Why Water is Important in Africa

1



Africa is a continent with unique but diverse characteristics in terms of societal structures, its economic development and natural resources. Its complexity demands regionally differentiated solutions for many developmental strategies and security issues. This is also true for water related issues which, despite their overarching nature, are governed by the heterogeneity of African landscapes and climate. Despite efforts made by countries and the international community to promote, for example, achievement of the MDGs, a number of countries in Africa fall short of their targets, particularly in relation to water supply and sanitation coverage.

Water is directly or indirectly used in almost every economic sector in Africa including agriculture, manufacturing, trade, mining, tourism, and transport. Water is both an ecosystem 'good', providing drinking water, irrigation and hydropower, and an ecosystem 'service', supplying people, whether they are aware of it or not, with functions such as nutrients cycling and supporting habitats for fish and other aquatic organisms, as well as 'cultural services' such as scenic vistas and recreational opportunities. The rural, urban, and peri-urban environments have unique differences with regard to availability, use and management of water resources, and these differences need to be appreciated and considered in the formulation of policies related to water development and management.

The Africa Water Vision 2025 – “An Africa where there is an equitable and sustainable use and management of water resources for poverty alleviation, socio-economic development, regional cooperation, and the environment” offers a context within which the resource may be sustainably managed. Rapid population increase, inappropriate water governance and institutional arrangements, depletion of water resources through pollution, environmental degradation, deforestation, and low and unsustainable financing of investments in water supply and sanitation are some of the main threats that pose challenges to the management of water resources on the continent. It is widely recognised that the threats cannot be successfully addressed by adherence to business as usual in water resources management at national and regional levels. Addressing the threats calls for adoption of good governance, societal consensus, innovative technologies and well developed frameworks for cooperative action, guided by the shared Africa Water Vision and Sustainable Development Goals. Therefore, there is a key role for government to play in all water development issues.



KEY MESSAGE 1: Why Water is Important in Africa

With a growing population, Africa needs more food and must secure the water and energy needed to ensure its production at the same time as good quality water resources are becoming scarcer.

KEY MESSAGE 2: Water-Food-Energy Nexus

There is opportunity to grow food with the current available resources. Water must not become the limiting factor for food and water security (Africa Water Vision 2025). African governments should build efficiency into food production and delivery, as well as resource use, through investment in education and innovation, green technologies, multiple uses of recycled products, and in the abundant renewable energy resources. This includes biogas production from organic waste, reuse of nutrients in agricultural production, and recycling of process water.

KEY MESSAGE 3: Education, Knowledge and Capacity Development

There is generally a shortage of human resources for water management in Africa. Education, knowledge and capacity development at all societal and institutional levels as well as good governance, are key for efficient and sustainable IWRM and resource development.

The African governments must strengthen capacity enhancement programmes at community, academic and institutional levels; support knowledge-based strategies for water management amongst policy and decision makers across the science/management divide.

KEY MESSAGE 4: Access to Safe Water and Sanitation

The African leaders have committed themselves to “ensure sustainable access to safe and adequate clean water supply and sanitation, especially for the poor” and “to plan and manage water resources to become a basis for national and regional cooperation and development”. [ref] Inadequate human, institutional and financial capacity constrains the sustainable management of water resources and seriously affects the proper planning and implementation of water and sanitation policies and programmes.

There is need for further development of the water resource to improve access to safe water and sanitation. However, where progress has been made serious efforts are necessary to maintain the infrastructure and services, and to implement wastewater treatment and recycling. The governments and private sector should develop nationally and locally appropriate and effective water quality treatment technologies, and low cost sanitation solutions.

KEY MESSAGE 5: Water Resources and Infrastructure for Economic Growth

Governments should focus on management of supply and demand by investing in water infrastructure operations and maintenance, and by promoting effective use of water. This should include enhancing water storage by water harvesting, adopting conjunctive water uses, promoting wastewater treatment and recycling, and reducing losses in the supply chain.



The African governments should promote an enabling environment, including appropriate legislation, public-private partnerships, community involvement, and economic incentives that will foster water infrastructure development for sustainable economic growth.

KEY MESSAGE 6: Managing Transboundary Systems

Africa has a number of international transboundary rivers, lakes and groundwater systems, as well as in-country basins that cut across different administrative jurisdictions. Lessons learnt from successful transboundary cooperation efforts and agreements among African states indicate that 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/lake basin and aquifer management.

To avoid any potential conflicting uses, the African Union should strengthen cooperation among regional economic communities and stakeholders to assure just and equitable distribution of water resources at regional and national levels. In addition, the African Union should provide a platform for the collection of data and dissemination of information to guide planning, monitoring and assessment of the water resources for joint management.

KEY MESSAGE 7: Global Change and Risk Management

The policy for reducing disaster risk is complex and multidisciplinary by essence; thus, it requires careful development planning, scientific knowledge, early warning systems that are people centered, and effective mechanisms for disaster responses including future risks related to climate variability and change.

African governments should put in place new or review existing strategies and policies to counteract the impact of global and climate change on water resources, and incorporate climate change adaptation strategies in their development plans and programmes.

KEY MESSAGE 8: Water Governance and Management

African countries need to streamline their efforts to promote good water governance, secure the promised financing for development, and invest in water infrastructure, human resources and institutions for proper management of the water resources.

African governments, in collaboration with water managers and communities of users, should develop and implement transparent, evidence-based policy, legal and institutional frameworks that adequately address water issues including governance, shared responsibilities, and water security.

KEY MESSAGE 9: Financing

There is a clear need in Africa to increase funding to build human and institutional capacities to effectively develop and utilise water resources. Investment in the water sector should come from both government and private sector, and initiatives like the CAADP should be encouraged and PPPs should be strengthened.

If water becomes a limiting factor in food production and energy supply, then the risk of a downturn in economy and societal well-being becomes extremely high. It is necessary for the governments to invest more in the water sector, and this should be done based on the real value of water. The real value analysis for water must include its environmental, social, operational and construction components. It is essential for water policymakers to ensure proper allocation and achieve economic efficiency and environmental sustainability.



Background

Globally, food and energy production is increasingly linked to limited water resources resulting in enhanced food insecurity and water scarcity for growing populations. Globally, agriculture accounts for 70% of water consumption (UNEP, 2008) but in Africa, as much as 86% of total annual freshwater withdrawal goes to agriculture. Thus, the demand for food is the most important driver of water use in Africa. With a growing population, Africa needs more food and must secure the water and energy needed to ensure its production at the same time as good quality water resources are becoming scarcer.

Reliance on rain-fed agriculture, low use of irrigation and water use efficient technologies for food production continues to compromise the wellbeing and economic productivity of Africa's people. This curtails their ability to generate revenue required for improving the availability and access to water for food. Africa has potential for developing energy from renewable resources such as water, wind, geothermal, solar and bio-energies. For example, the continent has enormous potential for hydroelectric power production, but only three per cent of its renewable water is used, against 52% in Asia. Access to electricity is uneven; only one in four people in Africa has access to electricity. More than 90% 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 electricity.

Energy production from biofuels impacts on agricultural lands and manpower. This practice also results in water pollution. Agriculture puts high demands on the water sector and can also contribute to pollution of water. There is thus a need to define policies that will integrate the energy, food and water nexus in order to move towards a green economy.

In general, food and energy production and water resources are closely linked so that a nexus between the three components does exist. As we all know, the demand for food is the most important driver of water use in Africa. With a growing population, Africa needs more food and must secure the water and energy needed to ensure its production at the same time as good quality water resources are becoming scarcer. The idea behind the nexus is for the Africa continent to find ways and means to manage the growing food, energy and water supply and demand with a holistic approach that takes into consideration the need to build environmentally sustainable economies and find synergies between these sectors. Because of Africa's large potential for developing energy from water and other forms of renewable resources such as wind, geothermal, solar and bio-energies, including bio-gases, optimisation of benefits arising from water, food and energy nexus will imply, for food and energy production, an ecosystems services approach in order to avoid degradation and irreversible damage to our ecosystems while ensuring food and energy security.

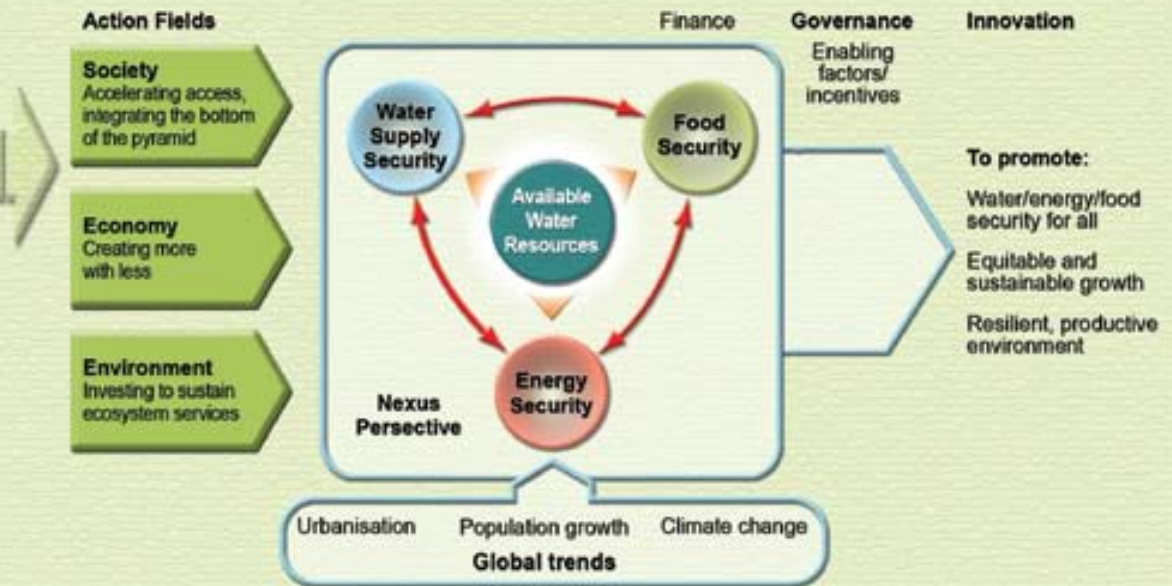


Figure 1. The water-food-energy nexus (from: SEI, 2011)

Hence, some of the following options for the future sustainable management of the water/food/energy nexus will require innovative approaches, strategies and technologies as well as changed knowledge and behavior (Figure 1). The options include: appropriate agricultural practices and organic fertilization; alternative sustainable farming practices include agroforestry and intercropping cereals with legumes to improve nitrogen deficient soils and reduce reliance on synthetic fertilizers and pesticides; natural pesticides and possible (re)introduction of native species and different crops; and sustainable hydropower linked to low flow enhancement and irrigation, including proper allocation of energy, water and food equitably and efficiently within the existing ecological constraints. In a nutshell, invest in simple and inexpensive irrigation technologies to get the best advantages for increasing irrigation for food production, while carefully managing to avoid environmental damage and simultaneously increase productivity and ecosystem resilience. This should take into account the fact that climate change, environmental pressures and growing economics and populations will exact more and more pressure on this nexus in the future.

Key Message

With a growing population, Africa needs more food and must secure the water and energy needed to ensure its production at the same time as good quality water resources are becoming scarcer. There is opportunity to grow food with the current available resources. Water must not become the limiting factor for food and water security (Africa Water Vision 2025).

African governments should build efficiency into food production and delivery, as well as resource use, through investment in education and innovation, green technologies, multiple uses of recycled products, and in the abundant renewable energy resources. This includes biogas production from organic waste, reuse of nutrients in agricultural production, and recycling of process water.



Background

One of the biggest challenges, that must be addressed if the targets of the Africa Water Vision 2025 and the MDGs are to be met, is the lack of adequate human (technical and managerial), financial and material resources water authorities face, in particular as this relates to planning and implementing water and sanitation policies and programmes (Pietersen *et al.*, 2006). The low rate of retention of qualified staff/expert and the lack of adequate training, the inadequate funding and the few research institutions, significantly affect the water sector. Besides inadequacy of manpower in water resources sector, there is the need for more qualified personnel in aspects of water laws and quantitative water resources economics.

There is need to develop societal capacity for WASH and resource use efficiency through education, information and strengthening of local knowledge and skills in communities and community-based organisations. Communities need to be made aware of the impact of poor sanitation on water quality and the associated human health hazards, and where practically possible, they should be involved in the design and development process.

There is generally a lack of know-how and institutional “strength”, particularly in the area of integrated water resource management (IWRM), and this has limited the success of water resource management initiatives (Pietersen *et al.*, 2006). Strengthening educational and training capacities at all levels and advance harmonisation and improvement of data collection and sharing is an asset to IWRM.

The countries of the region have many competencies and can benefit from the exchanges, between them, of successful experiences in various fields such as building dams, drinking water supply, and sanitation. In this sense, a platform for cooperation and sharing of experiences is essential, taking into account the similarities and dissimilarities with regard to water issues in the different countries and sub-regions of Africa. Such a platform could be established by NASAC. Strengthening educational and training capacities at all levels and advance harmonisation and improvement of data collection and sharing will go a long way in enhancing this cooperation and management of water resources across all scales.

ESTABLISHMENT OF THE PAN AFRICAN UNIVERSITY

Source: First extraordinary session of the conference of ministers of education of the African union (COMEDAF IV+), Nairobi, Kenya, 11–13 MAY, 2011

Capacity building is central to the development of Africa. The African Union through its Summits of Heads of State and Meetings of Ministers has recognised Education as a basic tool in developing Africa’s human potential in order to achieve Millennium Development Goals, and promote industrial production and innovation in Africa.

The dysfunctional nature of higher education and its dire conditions have been impediments for a meaningful contribution to the development of Africa. The structural deficiency of the systems coupled with inadequate funding levels, shortage of qualified university lecturers, explosion of enrolments, and obsolescence of infrastructures, equipment and instructional materials hinder higher education’s ability to fulfill its original mission in many African

countries. This is the reason why the Summit of Heads of State and Government of the African Union launched the Second Decade of Education for Africa EX/CL/224 (VIII) Rev.2 which identified tertiary level education as one of the seven priorities to be focused on for the time period 2006–2015.

In the Addis Ababa Declaration 2007, Assembly/AU/Decl.5 (VIII), the Conference of Heads of State and Government called for “the revitalization of African Universities” in their decision adopting the Consolidated Plan of Action for Science and Technology in Africa (2008–2013). This calls for enhanced collaboration amongst higher institutions of learning and research in order to create a global pool of knowledge and innovation; and better links with industry in order to enhance relevance and contribute to addressing local challenges. It is for these reasons that the African Union Commission (AUC) proposed, in 2008, the creation of the Pan African University (PAU). The PAU aims to promote network and develop programmes and research centres within selected existing high quality universities in the five geographic sub-regions (Figure 2). North Africa region, Algeria will host the PAU Institute on Water and Energy including Climate Change (PAUWES) which will be committed to select and to network high quality centers developing similar programs and to serve as a coordinating hub for those institutions.



Figure 2. Geographic distribution of the five regional thematic of the Pan African University Institutes

Key Message

There is generally a shortage of human resources for water management in Africa. Education, knowledge and capacity development at all societal and institutional levels as well as good governance, are key for efficient and sustainable IWRM and resource development.

The African governments must strengthen capacity enhancement programmes at community, academic and institutional levels; support knowledge-based strategies for water management amongst policy and decision makers across the science/management divide.



Background

The increasing freshwater demand resulting from high population growth rates particularly in urban centres, result in less water available per person, and impacts the quality of life and livelihoods of the sub-regions inhabitants. High costs for water supply infrastructure is a major reason for slow progress towards meeting the MDG goals in many sub-Saharan Africa countries (UNICEF, 2012). Political stability has heavily influenced progress in improving access to water supply and sanitation service with low-income stable countries outperforming low-income fragile and resource-rich countries, in addition to sector leadership, aid flows, and aid modalities which have also been critical factors in driving this progress (AMCOW, 2011). Large numbers of people are affected by water-related diseases like gastro-enteritis (diarrheal diseases due to microbial, parasitic, bacterial and viral pollution) malaria, guinea-worm, cholera, typhoid, bilharzia, etc. Chronic exposure to chemical pollution due to agricultural, industrial and mining practices also affect human health. This is related to many factors amongst which are low water supply and sanitation coverage.

There are some substantial regional differences. Provision of water supply and sanitation across the regions varies enormously, and the provision of adequate sanitation is lagging well behind the provision of water supply, with rural sanitation particularly poorly developed. Morocco, Algeria, Tunisia, and Egypt have almost closed the universal coverage of water supply in urban areas. However, in some countries, such as Zimbabwe and Zambia, urban water services coverage has in fact decreased. This is presumably due to urban migration and rapidly increasing urban populations, and the failure to meet the increasing demand adequately. Access to improved water sources for urban populations in most countries is greater than 50%, but in rural populations, access is much lower and is extremely dire in Somalia where it is less than 10%.

Key Message

The African leaders have committed themselves to “ensure sustainable access to safe and adequate clean water supply and sanitation, especially for the poor” and “to plan and manage water resources to become a basis for national and regional cooperation and development”. [ref] Inadequate human, institutional and financial capacity constrains the

WATER AND SANITATION IN AFRICA

In 2006, sanitation coverage in Africa was below 25% in sixteen of the fifty-four countries (WHO-UNICEF, 2008a,b) with a manifest slow progress against the MDGs for water and sanitation due to several factors including political unrest (Figure 3). WAS, standing for Water and Sanitation for Africa, as a Pan-African intergovernmental agency, is aiming at providing Water, Sanitation and Hygiene (WASH) services in the whole Africa through the development of strategies and support of government policies for the dissemination of sustainable and innovative solutions. Over twelve years since 2000, about 22 million people in Africa have taken advantage of the WAS achievements in the water and sanitation sector (WSAfrica, 2014).

WAS is intervening in several countries where political instability, conflict, and lack of will are among the main hurdles that have



impeded reaching sanitation coverage and access to safe drinking water. It is the case of the Democratic Republic of Congo, Nigeria, Mauritania, Sudan, and more recently Egypt, Libya, and the Central African Republic. The existing political conflicts and mismanagement have resulted in the displacement of rural populations, lack of maintenance of sanitary and water supply infrastructure in addition to frequent infringement of laws, when they exist, by industries and dwellers discharging liquid and solid wastes into the environment. This is resulting in serious pollution of the water resources and increasing prevalence of disease.

WAS developed several initiatives, covering 35 countries, among which the African Sanitation Think Tank and the High Level Forum (HLF). The latter is expected to come out with more commitment from governments to drive the private sector, communities, and civil societies and to investigate on ways to narrow the gap between policy and practice. This could contribute to reaching the Sustainable Development Goals on Water (WSAfrica, 2014).

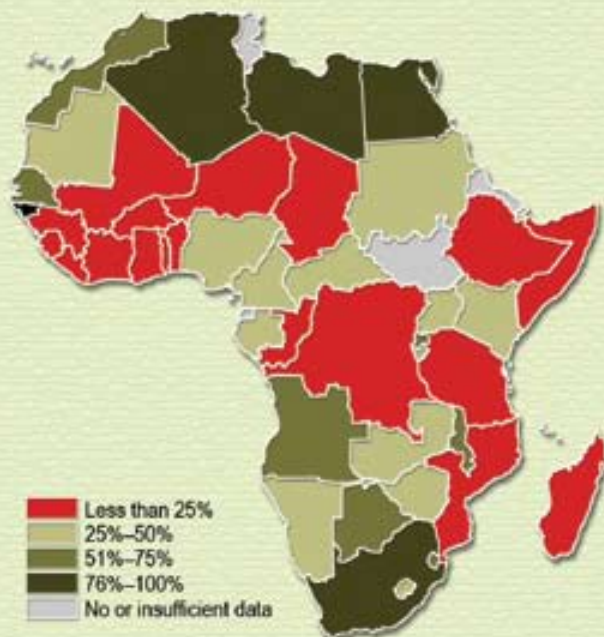


Figure 3. Sanitation coverage trends by population, Africa, 1990–2010 (AMCOW, 2012)

sustainable management of water resources and seriously affects the proper planning and implementation of water and sanitation policies and programmes.

There is need for further development of the water resource to improve access to safe water and sanitation. However, where progress has been made serious efforts are necessary to maintain the infrastructure and services, and to implement wastewater treatment and recycling. The governments and private sector should develop nationally and locally appropriate and effective water quality treatment technologies, and low cost sanitation solutions.



Background

In Africa, in general, storage capacity and development in water infrastructure has been low due to the fact that investment levels have been inadequate and have even been on a declining trend for many years in many of the countries. In comparison to South Africa and the rest of the world, there are relatively few large dams in Africa, but there are plans to build large multipurpose dams and other water infrastructures in the near future, particularly in the Congo and Nile sub-basins, and the West Africa region. Africa is dotted with many small to medium-sized dams which have been constructed for hydropower generation, irrigation, drinking water supply, aquaculture and livestock watering. The most obvious way of managing flood and drought is to develop physical infrastructure to increase water storage capacity in the region. However, due to the high level of investment required, the development of these structures has been grossly inadequate.

It has been recognised that economic growth efforts to reduce poverty and promote social development, relies on an increase in demand for water supply and related infrastructure for food and energy. The construction of irrigation systems, hydroelectric dams, waterways and water supply systems for residents, tourism and industry would significantly improve the lives of millions. In North Africa, the government is encouraging a shift from management of supply to management of demand as a large part of the exploitable water resource has already been mobilised. However, a number of countries in other regions still need to enhance their water storage and supply infrastructure and the potential to mobilise the resource is still great.

The proportion of water use for industry in North Africa ranges widely, from the highest value in Algeria (13%) to the lowest in Mauritania and Libya with about 3.6%. Anthropogenic impacts on fresh water resources in West Africa are mainly derived from population growth that outstrips economic growth, fast-growing urban areas and industrial, mining and waste disposal problem. The situation is similar in most other regions in Africa. Such negative trends may well be enhanced by the increasing and desired industrialisation unless rules and regulations are in place and enforced, demanding from industries repeated recycling in order to minimise environmental impact through wastewater discharge. The governments should ensure that an appropriate enabling environment is in place for sustainable industrial development, including for the fast growing mining industry.

BUILDING RESILIENCE IN AFRICA'S WATER INFRASTRUCTURE

Water plays a central role in society by providing the basic resource for irrigation, hydroelectric power, fisheries and aquaculture, and livestock production. Its availability is thus one of the most critical factors in the development of Africa. In Ethiopia, for example, so sensitive is economic growth to hydrological variability that even a single drought event within a 12-year period will diminish average growth rates across the entire 12-year period by 10% (World Bank, 2006). The failure to meet basic human needs for water; difficulties in meeting the financial requirements for maintaining, extending, and upgrading both new and ageing water systems; new regulatory requirements for water quality; increasing water scarcity; competition for limited capital,



and global climate change will continue to affect the development of the water sector (Palaniappan et al., 2006), and drives the cost of water management higher (Gartner et al., 2013). However, the potential for development, for example the hydropower potential, remains high (Figure 4). Investing in integrated water management strategies that combine engineered solutions with “natural infrastructure” can reduce costs, enhance services, provide a suite of co-benefits for communities and the environment (Gartner et al., 2013), enhance green economies, as well as build the resilience of water infrastructure to potential current and future regional and global natural and socio-economic shocks.

“The choices made today about infrastructure, energy and food production will shape humanity’s opportunities and options far into the future” (WWF-AfDB, 2012).

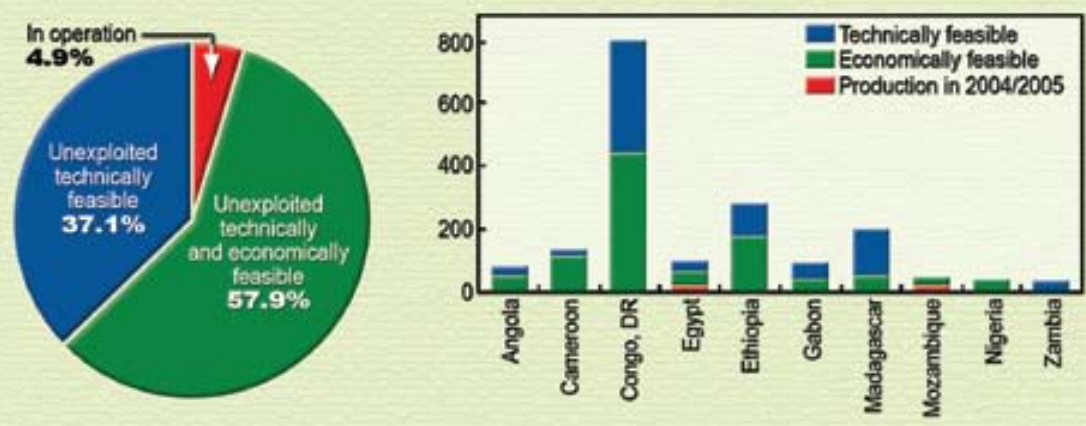


Figure 4. Africa's hydropower potential: Total African potential: 1.750 TWh; Data for top 10 countries in TerraWatt Hours (TWh) (from CBC, 2013)

Key Message

Governments should focus on management of supply and demand by investing in water infrastructure operations and maintenance, and by promoting effective use of water. This should include enhancing water storage by water harvesting, adopting conjunctive water uses, promoting wastewater treatment and recycling, and reducing losses in the supply chain.

The African governments should promote an enabling environment, including appropriate legislation, public-private partnerships, community involvement, and economic incentives that will foster water infrastructure development for sustainable economic growth.



Background

Africa has a number of international transboundary rivers, lakes and groundwater systems, as well as in-country basins that cut across different administrative jurisdictions.

There are some protocols or specific structures governing shared river basin and lakes (surface water) in certain sub-regions. In Southern Africa, the management of shared river basins is covered by the Revised SADC Protocol on Shared Watercourses, which has been ratified by all of the countries excluding Zimbabwe. In Eastern Africa, focus has been on the transboundary Lake Victoria (coordinated by the Lake Victoria Basin Commission (LVBC)), and by extension, the Nile River Basin that courses through Egypt in Northern Africa and terminates at the Mediterranean Sea. The Nile basin countries are still working on a transboundary agreement to manage the Nile basin water sources. In Central Africa, the International Commission for the Congo-Oubangui-Sangha Basin (CICOS) was created in 1999 by Cameroon, CAR, DRC and the Republic of Congo, to improve cooperation ties amongst the member states and to promote improved water management to enhance development and alleviate poverty (UNEP-WRC, 2008). The success of this institution has been mixed, with limited resources and relatively low levels of commitment to date. In Western Africa there are several institutions that govern many of the transboundary, mostly river basins, including the Niger, Senegal, Volta, Gambia and Komoé, as well as Lake Chad and transboundary aquifers. But so far, dialogue and cooperation has prevailed in the countries through bilateral or multilateral structures or organisations such as: Niger Basin Authority – NBA, Organization pour la Mise en Valeur du Fleuve Senegal – OMVS, Commission du Bassin du Lac Tchad – CBLT, Organization pour la Mise en Valeur du Fleuve Gambie – OMVG, Volta River Commission, among others). The major shared aquifers in Northern Africa are the Nubian Sandstone Aquifer System and the North-West Sahara Aquifer System. The Nubian Sandstone Aquifer System is one of the largest connected aquifers system in the world and is shared by Libya, Egypt, Chad and Sudan. The North-West Sahara Aquifer System (NWSAS) covers an approximately half the size of the Nubian Sandstone Aquifer System, and is shared by Algeria, Tunisia, and Libya. There are some agreements for the management and utilisation of the groundwater resources, establishing cooperation and disseminating information. However, these tasks have not been fully achieved since some agreements did not receive further development and practical actions implementation (Grath *et al.*, 2009).

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. International water cooperation presents an

INTERGOVERNMENTAL COOPERATION IS KEY TO MANAGEMENT OF TRANSBOUNDARY WATERS

Among the five basins worldwide shared between 9 and 11 riparian nations, four are located in Africa (the Congo, Niger, Nile and Zambezi), thus positioning Africa as the continent with arguably the most complex systems respect to management of international transboundary waters (Figure 5). International water management is playing a greater role in the framework of higher-level efforts aimed at regional integration. The fourteen member states of the Southern African Development Community (SADC) have committed themselves to an integrated and cooperative management of the

transboundary water bodies in the SADC region since signing the first Cooperation Protocol on Shared Watercourse Systems (1995), revised in 2000. Transboundary water management is also high on the agenda of other African regional organisations such as ECOWAS, EAC, and IGAD. All these have the political support of the Africa Ministers' Council on Water (AMCOW), and the financial assistance of the African Development Bank through its African Water Facility.

Several agreements dealing with benefit-sharing have been concluded on Africa's transboundary rivers, including: the cooperation project between South Africa and Lesotho in the so-called Lesotho Highlands Water Project; the cooperation-based infrastructure-development project between the four riparian countries of the Senegal River in the framework of OMVS, the joint South Africa-Swaziland river development project on the Komati River; the more recent agreements on water allocation for the Incomati-Maputo Basin, and; the shared-vision approach pursued in the Nile Basin.



Figure 5. Africa's transboundary rivers (Source: UNEP, 2010. Africa Water Atlas).

TRANSBOUNDARY GROUNDWATERS COOPERATION

Many of the 83 transboundary groundwater systems in Africa that have been identified by IGRAC have not yet been properly explored and characterised, and it is expected that on-going initiatives such as the GEF "Transboundary Assessment Project (TWAP)" and the IAEA project "Integrated and Sustainable Management of Shared Aquifer Systems and Basins of the Sahel Region" will improve the situation. The only transboundary groundwater cooperation projects so far are found in Northern Africa (the Nubian Sandstone Aquifer System, NSAS, shared by Egypt, Libya, Sudan, and Chad, and the North-West Sahara Aquifer System, NWSAS, shared by Algeria, Libya, and Tunisia) (Figure 6).

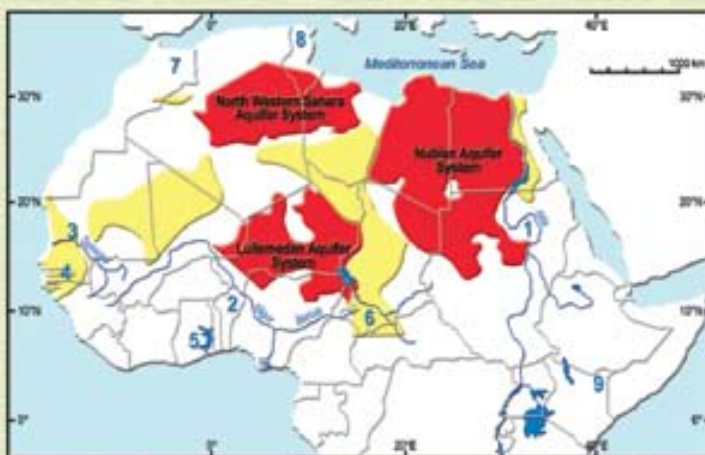



Figure 6. The large transboundary aquifers in Northern Africa (Nubian, North Western Sahara and lullemeden basins) (modified after Puri et al., 2001)



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/lake basin or aquifer 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

Key Message

Africa has a number of international transboundary rivers, lakes and groundwater systems, as well as in-country basins that cut across different administrative jurisdictions. Lessons learnt from successful transboundary cooperation efforts and agreements among African states indicate that 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/lake basin and aquifer management.

To avoid any potential conflicting uses, the African Union should strengthen cooperation among regional economic communities and stakeholders to assure just and equitable distribution of water resources at regional and national levels. In addition, the African Union should provide a platform for the collection of data and dissemination of information to guide planning, monitoring and assessment of the water resources for joint management.

Background

Global change and its impact on water resources is a common concern in Africa. The impacts include loss of habitat, alien plant invasions, and deteriorating water quality arising from industrial, agricultural and domestic pollution, particularly as a result of inadequate sanitation and poor waste removal systems. Soil erosion from poor land use practices is causing increased sedimentation in dams and rivers, while increased nitrates and phosphates from agriculture are causing eutrophication. Mining is also a significant cause of pollution in some areas. Wetlands have been lost as a result of being drained for agriculture or infrastructure development, reduced river flows, over-harvesting of reeds and other materials, and choking of the wetlands by invasive species. Climate change has the potential to impose additional pressures on water availability and accessibility, with key impacts related to extreme events – droughts and floods (IPCC 2001). Increased temperature will result in increased crop stress and crop water needs, with potential impacts on food security in the region (Lobell *et al.*, 2008).

In general, risks and disasters are difficult to avoid. However, there are solutions to reduce their impacts by strong preparedness, prevention and mitigation programmes. In Africa, the integration of disaster risk prevention into the National Development Strategy marks a political will to consider natural hazards as a major component of sustainable development. Thus, the fight against poverty is expressed in particular by strengthening the capacity of populations to cope with risks and to access to risk management instruments and systems of social protection. It results in the fact that not only must development be careful not to increase risks, but it should preferably participate in reducing risks and disasters as a whole. Disaster forecasting and risk modelling provides governments with tools to better able predict and prepare for catastrophic events (World Bank, 2014). An efficient policy for disaster risk reduction requires a comprehensive rather than a sectoral vision of the intervention, and should embed the principle of resilience-building.

AFRICA'S VULNERABILITY TO GLOBAL CHANGES

Africa's environment is closely linked with its climate. Indeed, the African continent is one of the most vulnerable regions to land degradation and climate change, and is subject to frequent droughts and famine. The livelihoods of most Africans are largely dependent on utilization of land-based resources, as well as on freshwater lacustrine and riverine systems as sources of potable water, fish, transport, etc. As a result of this dependency and widespread poverty, the African communities are particularly vulnerable to the multiple stresses, effects and impacts of global and climate change. The rise in global surface temperatures has been accompanied by an accelerated hydrological cycle, evidenced by, for example, increases in extreme precipitation, reductions in snow cover and mountain ice, and changes in the frequency and intensity of ENSO events. In eastern Africa, the last strong ENSO in 1997/1998 caused widespread destruction and losses in the agricultural sector, destroyed critical infrastructure such as roads, railways and power supply systems by extensive flooding and localised landslides, led to outbreak of climate and water related diseases, and caused significant loss of human and other life. The impact on the national economies and food security of the affected countries was extremely severe. More frequently recurring and intense droughts, as well as extensive land degradation are also major obstacles to agricultural production as 46% of the land is vulnerable to desertification. Over the last 40 years, the shallow Lake Chad, once the sixth largest lake in the world, has decreased by more than 90% in area

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(Figure 7): this has been attributed to persistent droughts and increasing irrigation withdrawals and it is noted that under current climate and water use, a full recovery of the lake is unlikely without an inter-basin water transfer (Gao et al., 2011).

The water, agriculture and energy sectors are sensitive to global changes, yet the adaptive capacity of the continent's inhabitants is generally low due to low levels of human and financial resources, as well as limited institutional and technological capability. This vulnerability is further accentuated by widespread poverty, wanting natural resources management, conflicts, inequitable land distribution, and dependence on rain-fed agriculture, amongst other factors. This combination of factors calls for sustainable, holistic, and inclusive integrated planning and management of water resources and their basins today and into the future.



Figure 7: The disappearance of Lake Chad in Africa
 (Source: <http://www.grida.no/images/series/vg-africa/graphics/14-lakechad.jpg>)

Key Message

The policy for reducing disaster risk is complex and multidisciplinary by essence; thus, it requires careful development planning, scientific knowledge, early warning systems that are people centered, and effective mechanisms for disaster responses including future risks related to climate variability and change.

African governments should put in place new or review existing strategies and policies to counteract the impact of global and climate change on water resources, and incorporate climate change adaptation strategies in their development plans and programmes.

Background

Water is at the core of sustainable development in Africa, but there are diverse and in some cases unique challenges experienced in each of the five sub-regions.

Many of the countries of Eastern Africa, Central Africa and Southern Africa sub-regions have undertaken and implemented legal and regulatory reforms in their water sectors since the year 2000; while these have in some cases covered satisfactorily the issues relating to surface waters, it is noted that, with the exception of a few countries such as Djibouti and South Africa, groundwater resources have been relatively neglected and the country water policies tend to be silent on this issue. While many sub-regions have developed legal and regulatory reform mechanisms, this requires active implementation, monitoring and controls that are often lacking. There is also a lack of knowledge, information and data that would allow the development of appropriate water policies and their implementation thereafter. In Western Africa, most water-related policies are coordinated at the ministerial level, and efforts are being made to expand public-private partnerships particularly in relation to water distribution and rural water supply. Several countries have incorporated IWRM principles in water management, but water policy coordination must be enhanced. Most countries in the Northern Africa sub-region have a long and rich legal tradition in codifying water resource management, and are modernising their water law frameworks. This includes the introduction of the private sector in the water sector and the reform of the pricing policy to provide full incentive for the consumer to use water efficiently and to invest in water-saving technologies.

WATER FOR ALL! A REALITY ONLY THROUGH GOOD GOVERNANCE AND ACCOUNTABILITY

Over the past decade, Africa has been undergoing economic and social transformation, with sustained economic growth, more peaceful transition of power through democratic elections; and an increase in the middle class who pay taxes and demand improved services. Revenues from natural resources and inflows from remittances and Foreign Direct Investment (FDI) vastly dwarf aid. Increasingly, Africa is getting to a position to use its own resources for development, but needs a strong governance framework to put them into effective use. This underscores the need for refocusing the strategic orientation of the Bank's governance work in Regional Member Countries (RMCs) to support a self-reliant continent, capable of mobilising and utilising resources for development, consistent with the demands and expectations of its people.

To respond to this accelerating transformation on the continent, the new African Development Bank Group Strategy for 2013–2022 (hereafter referred to as the Ten Year Strategy – TYS) was approved by the Board in April 2013 (Figure 8). The TYS puts the Bank at the center of Africa's transformation and is built around two core objectives: achieving inclusive growth and transition to green growth. The strategy has five core operational priorities, including Governance and Accountability (G&A), which is central to the achievement of its vision and objectives. Figure 1 presents the core elements of the TYS and the governance and accountability dimension.

In the water sector, collusion among government

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officials, unscrupulous water vendors and large farm owners results in diverted water supply lines, misappropriated funds, and failure to implement laws on protecting water sources from encroachment and pollution (IRIN, 2013). These are just some of the ways corruption is denying millions of poor people in Africa access to safe and clean drinking water, experts say. “The impact of corruption on the water sector is manifested by lack of sustainable delivery, inequitable investment and targeting of resources, and limited participation of affected communities in developmental processes,” Bethlehem Mengistu, regional advocacy manager at the NGO Water Aid, told IRIN. This report stressed on the fact that **governments and donors must ensure that rigorous checks and balances are in place to tackle corruption and minimise waste.**



Figure 8. The Bank’s Group Strategy for 2013–2022 and the Governance and Accountability Dimension (Source: AfDB, 2013)

Key Message

African countries need to streamline their efforts to promote good water governance, secure the promised financing for development, and invest in water infrastructure, human resources and institutions for proper management of the water resources.

African governments, in collaboration with water managers and communities of users, should develop and implement transparent, evidence-based policy, legal and institutional frameworks that adequately address water issues including governance, shared responsibilities, and water security.

Background

The investment from the private sector and the government is very low. Actually many countries have not achieved water security because they have engaged in small projects to address short term needs and have not invested sufficiently in water infrastructure and institutions. A vibrant private sector that could co-finance the development of the sector is required. High priority should be given to designing appropriate instruments to attract investment from bilateral international partners and private sector in order to meet urgent and critical needs in water resources development. This is a key to achieving water security. It is obvious that if African states want to manage natural risks, eradicate poverty and attain sustainable growth, they must invest adequately in water infrastructure.

Some countries have made commitments to mobilise and leverage funds for programmes such as the 2003 Comprehensive Africa Agriculture Development Programme (CAADP), but not all have been able to meet their commitments. However, there is potential to raise funds through increased public-private partnerships arrangements, which involves a sharing of risk and responsibility between the state and private firms. The private sector participation should focus on improving operation efficiency and service quality through an inclusive partnership with the public sector rather than just attracting private funding (UN, 2013).

Key Message

There is a clear need in Africa to increase funding to build human and institutional capacities to effectively develop and utilise water resources. Investment in the water sector should come from both government and private sector, and initiatives like the CAADP should be encouraged and PPPs should be strengthened.

INVESTING IN WATER INFRASTRUCTURE – A NECESSITY TOWARDS THE MDG GOAL, WATER FOR ALL

Water's crucial role in accomplishing the continent's development goals is widely recognised. Africa faces endemic poverty, food insecurity and pervasive underdevelopment, with almost all countries lacking the human, economic and institutional capacities to effectively develop and manage their water resources sustainably. Thus, a large number of countries on the continent still face huge challenges in attempting to achieve the United Nations water-related Millennium Development Goals (MDGs). Northern Africa and Sub-Saharan Africa even though in one continent, have made different levels of progress towards the Millennium Development Goal on water. North Africa has 92% coverage and is on track to meet its 94% target before 2015. However, sub-Saharan Africa experiences a contrasting case with 40% of the 783 million people without access to an improved source of drinking water from the region. Sub-Saharan Africa is off track from meeting the MDG on water with just 61% water coverage and with the current pace cannot reach the 75% target set for the region. In Africa, financing is insufficient and the institutional capacity to absorb what is available is limited. The danger of slippage to already made progress against the MDG on water and sanitation is real. Most countries within the continent are falling short to sustain Water Sanitation and Hygiene (WASH) commitments, with over 80% of countries reportedly falling significantly behind the trends required to meet their defined national

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access targets for sanitation and drinking-water. There is insufficient domestic financing for WASH overall with particularly serious shortfalls for sanitation. This is exacerbated by difficulties in spending the limited funds that are received (UNDESA, 2014).

The low rate of investments in the water sector has been a major obstacle to accelerate the development and improved management of water resources critically needed to help meet Africa's growing water demand. It is estimated that over US\$ 50 billion a year will be required for the next 20 years for the sector to keep up with exponential population growth and the increasing needs of water-dependent industries in sectors such as food and beverages, chemicals, energy, paper, tourism and wood (AWF, 2013). Poor access to sustainable funding has been one of the factors hindering appropriate infrastructure development in Africa. Investment in integrated water resources infrastructure for multiple uses is therefore the way to go (CBC, 2013).

If water becomes a limiting factor in food production and energy supply, then the risk of a downturn in economy and societal well-being becomes extremely high. It is necessary for the governments to invest more in the water sector, and this should be done based on the real value of water. The real value analysis for water must include its environmental, social, operational and construction components. It is essential for water policymakers to ensure proper allocation and achieve economic efficiency and environmental sustainability.



This analysis shows that the challenges in sustainable management and use of water resources can only be addressed in a holistic manner. Water could become a limiting factor for food and energy production, and could consequently have negative impacts on national economies and security as well as human development. On the other hand, there is clearly need to enhance public-private partnerships and community involvement and investments in water infrastructure development to meet national and globally agreed targets for water and sanitation. This should be supported by policy and decision makers through the implementation of appropriate and enforceable legislation. There is need to improve the human capacity to properly govern and manage the resource through investment in education and training.

Scientists and engineers in Africa should be encouraged to develop innovative technologies, based on local knowledge, that will contribute to higher water use efficiencies in various sectors, and that will help to reduce or eliminate loss, wastage and protect against pollution. Technologies for wastewater treatment and reuse at the agricultural, industrial and community levels will be necessary. These efforts can be supported through government incentives and funding from the public and private sectors, and regional organisations.

Good and transparent governance is essential for an efficient and sustainable development of the water sector in Africa, and the related policies should also mainstream gender and social equity, environment, and proofing against climate change and other risk reduction safeguards (AWF, 2012). These policies will be different across the various countries, and their effective implementation will require significant commitment and investment among government and relevant stakeholders (private sector, educational institutions, local communities, and civil societies) in the water sector.




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1. Cited References

- AfDB** (2013) E-Consultation on the Governance Strategic Framework and Action Plan (GAP II) – (2014–2018) – Promoting Good Governance and Accountability for Africa’s Transformation In: <http://www.afdb.org/consultations/afdb-group%E2%80%99s-governance-strategic-framework-and-action-plan-2014-2018/>.
- AMCOW** (2011) AMCOW Country Status Overviews – Regional Synthesis Report. Pathways to Progress: Transitioning to Country-led Service Delivery Pathways to Meet Africa’s Water Supply and Sanitation Targets. Washington, DC: The World Bank/Water and Sanitation Program. <http://www.wsp.org/wsp/content/pathways-progress-status-water-and-sanitation-africa>.
- AMCOW** (2012) A Snapshot of Drinking Water and Sanitation in Africa – 2012 Update. A regional perspective based on new data from the WHO/UNICEF Joint Monitoring Programme for Water Supply and Sanitation. Fourth Africa Water Week. Cairo, Egypt.
- AWF** (2012) Africa Water Facility Strategic Plan 2012–2016. <http://www.africanwaterfacility.org/en/publications-reports/>.
- AWF** (2013) ‘The African Water Facility: Boosting the Water Sector Through Sustained Collaboration). In: <http://www.afdb.org/news-and-events/article/the-african-water-facility-boosting-the-water-sector-through-sustained-collaboration-11633/>.
- CBC** (2013) The Africa Infrastructure Investment Report by Commonwealth Business Communications Limited. In: http://www.cbglobal.org/images/uploads/docs/Africa_Infrastructure_Promotional_brochure.pdf.
- Gao H., Bohn T.J., Podest E. and McDonald K.C.** (2011) On the causes of the shrinking of Lake Chad. *Environ. Res. Lett.* 6 (2011) 034021 (7pp), doi:10.1088/1748-9326/6/3/034021.
- Gartner T., Mulligan J., Schmidt R. and Gunn J.** (2013) Natural Infrastructure: Investing in Forested Landscapes for Source Water Protection in the United States. World Resources Institute. <http://www.wri.org/publication/natural-infrastructure>.
- Grath J., Ward R., Scheidleder A., Quevauviller P. and Phuong T.K.** (2009) Groundwater Monitoring. John Wiley & Sons Ltd., Chichester.
- IPCC** (2001) Climate Change 2001: Impacts, Adaptation and Vulnerability. Intergovernmental Panel on Climate Change, Working Group II Contribution to the Third Assessment Report of the IPCC. Geneva, Switzerland.
- IRIN** (2013) ‘In Africa corruption dirties the water’ Odiwuor, K., IRIN, Humanitarian News and Analysis. In: <http://www.irinnews.org/report/97642/in-africa-corruption-dirties-the-water>.
- Lobell D.B., Burke M.B., Tebaldi C., Mastrandrea M.D., Falcon W.P. and Naylor R.L.** (2013) Prioritizing Climate Change Adaptation Needs for Food Security in 2030. *Science*, 319 (5863): 607–610.
- Palaniappan M., Cooley H., Gleick P. and Wolff G.** (2006) Assessing the long-term outlook for current business models in the construction and provision of water infrastructure and services. OECD International Futures Project on Global Infrastructure Needs, Global Forum on Sustainable Development, Environment Directorate, Environment Policy Committee, OECD. Organisation for Economic Co-operation and Development, Paris.

- 
- Pietersen K., Beekman H., Abdelkader A., Ghany H., Opere A., Odada E., Ayenew T., Legesse D., Sigha-Nkamdjou L., Oyebande L., Abdelrehim A.** (2006) Regional Synthesis, Chapter 4, Freshwater. In: Africa Environment Outlook 2. United Nations Environment Programme (UNEP).
- Puri S., Appelgren B., Arnold G., Aureli A., Burchi S., Margat J. and Pallas P.** (2001) Internationally Shared Aquifer Resources Management. IHP-VI, Non serial documents in Hydrology. 71 p.
- SEI** (2011) Stockholm Environment Institute (SEI) Bonn 2011 Conference on “The Water, Energy and Food Security Nexus: Solutions for the Green Economy”. 16–18 November 2011, Bonn, Germany.
- UN** (2013) The Millennium Development Goals Report 2013. United Nations. <http://www.un.org/millenniumgoals/pdf/report-2013/mdg-report-2013-english.pdf>.
- UNDESA** (2014) ‘International Decade for Action – Water for Life, 2005–2015’, United Nations Department for Social Affairs.
- UNEP** (2008) Africa: Atlas of our Changing Environment. United Nations Environment Programme. Division of Early Warning, Nairobi.
- UNEP** (2010) Africa Water Atlas. Division of Early Warning and Assessment (DEWA). United Nations Environment Programme, Nairobi.
- UNEP-WRC** (2008) Freshwater Under Threat: Vulnerability Assessment of Freshwater Resources to Environmental Change – Africa. ISBN: 978-92-807-2951-1.
- UNICEF** (2012) UNICEF Water, Sanitation and Hygiene Annual Report 2012. UNICEF WASH Section, Programme Division, UNICEF New York.
- WHO-UNICEF** (2008a) Progress on Drinking Water and Sanitation: Special Focus on Sanitation. UNICEF, New York and WHO, Geneva. http://www.who.int/water_sanitation_health/monitoring/jmp2008/en/.
- WHO-UNICEF** (2008b) A Snapshot of Sanitation in Africa. A special tabulation for AfricaSan based on preliminary data from the WHO/UNICEF. Joint Monitoring Programme for Water Supply and Sanitation AfricaSan: Second African Conference on Sanitation and Hygiene, Durban, South Africa 18–20 February 2008.
- World Bank** (2006) “Managing Water Resources to Maximize Sustainable Growth: A World Bank Water Resources Assistance Strategy for Ethiopia”. A Country Water Resources Assistance Strategy, World Bank, Washington, DC.
- World Bank** (2014) Reducing the Impact of Natural Disasters in Malawi: Empowering Citizens and Taking Charge. <http://www.worldbank.org/en/news/feature/2014/01/29/reducing-the-impact-of-natural-disasters-in-malawi-empowering-citizens-and-taking-charge>.
- WSAfrica** (2014) Water and sanitation for Africa. Available on line at wsafrica.org/en. Visited 24/02/2014.
- WWF-AfDB** (2012) Africa Ecological Footprint Report: Green Infrastructure for Africa’s Ecological Security. World Wide Fund for Nature and African Development Bank. www.panda.org/lpr/africa2012; www.afdb.org.

2. Regional Reports


- Chaibi M.T. and Mahjoub O.** (2013) Status and Development of Water Resources in Northern Africa: Quantitative and Qualitative Evaluation. Network of African Science Academies (NASAC), Nairobi, Kenya.
- Gaye C.** (2013) Report on the State of the Water Sector in Western Africa. Network of African Science Academies (NASAC), Nairobi, Kenya.



- Kfir R.** (2013) Report on the State of the Water Sector in Mauritius, Mozambique, Namibia, South Africa, Zambia, and Zimbabwe. Network of African Science Academies (NASAC), Nairobi, Kenya.
- Olago D.O.** (2013) Report on the State of the Water Sector in Central Africa. Network of African Science Academies (NASAC), Nairobi, Kenya.
- Olago D.O.** (2013) Report on the State of the Water Sector in Eastern Africa. Network of African Science Academies (NASAC), Nairobi, Kenya.

3. Other References

- Banerjee S., Diallo A., Foster V., Wodon Q.** (2009) Trends in Household Coverage in Modern Infrastructure Services in Africa. World Bank Policy Research. World Bank. http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1372957###. (Last accessed on May 2, 2010).
- FAO** (1989a) Guidelines for designing and evaluating surface irrigation systems. Food and Agriculture Organization of the United Nations. FAO Irrigation and Drainage Paper 45. Rome.
- FAO** (1989b) Irrigation Water Management: Irrigation scheduling. Food and Agriculture Organization of the United Nations. FAO Training manual number 4. Rome.
- FAO** (2005) Special Event on Green Revolution in Africa. Background document. Committee on World Food Security 31st Session — 23–26 May 2005. Food and Agriculture Organization of the United Nations. http://www.fao.org/unfao/bodies/cfs/cfs31/cfs2005_events_en.htm. (Last accessed on April 25, 2010).
- FAO** (2009) AQUASTAT database. Food and Agriculture Organization of the United Nations. <http://www.fao.org/nr/aquastat>. (Last accessed on January 13, 2010).
- FAO** (2010) “Water and Food Security”. Food and Agriculture Organization of the United Nations. <http://www.fao.org/worldfoodsummit/english/fsheets/water.pdf> (Last accessed on September 15, 2010).
- IAASTD** (2009) “Summary for Decision Makers of the Sub-Saharan Africa (SSA) Report”. International Assessment of Agricultural Knowledge, Science and Technology for Development. Island Press.
- IPCC** (2007a) Summary for Policymakers: Contribution of Working Group II to the Fourth Assessment. Intergovernmental Panel on Climate Change.
- IPCC** (2007b) Africa. Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden and C.E. Hanson, Eds.), Cambridge University Press, Cambridge UK, 433–467.
- Kliot N., Shmueli D., Shamir U.** (2001) Institutions for management of transboundary water resources: their nature, characteristics and shortcomings. *Water Policy* 3: 229–255.
- MDG Africa Steering Group** (2008) Achieving the Millennium Development Goals in Africa. Recommendations of the MDG Africa Steering Group. June 2008. <http://www.mdgafrica.org/pdf/MDG%20Africa%20Steering%20Group%20Recommendations%20-%20English%20-%20HighRes.pdf>. (Last accessed May 9, 2010).
- Roy D., Barr J., and Venema H.** (2010) Ecosystem Approaches in Transboundary Integrated Water Resources Management (IWRM): A Review of Transboundary River Basins. (Unpublished report). IISD, Winnipeg, Canada and UNEP, Nairobi.
- Turton A.** (2003) The Hydropolitical dynamics of cooperation in Southern Africa: A strategic perspective on institutional development in international river basins. In *Hydropolitical dynamics of cooperation in Southern Africa*, pp. 83–103. http://www.anthonyturton.com/admin/my_documents/my_files/2BA_Chapter_4.pdf. (Last accessed on April 30).

- 
- Turton A.** (2008) The Southern African Hydropolitical Complex. In *Management of Transboundary Rivers and Lakes*, pp. 21–79.
- Turton A.** (2008b) A South African perspective on a possible benefit-sharing approach for transboundary waters in the SADC Region. *Water Alternatives* (1) 180:200.
- Turton A., Earle A., Malzbender D., Ashton P.** (2006) Hydropolitical Vulnerability and Resilience along Africa's International Waters. In *Hydropolitical Vulnerability and Resilience along International Waters: Africa*, pp. 19–67. United Nations Environmental Programme. <http://www.awiru.up.ac.za/pdf/CH%202%20UNEP%20Africa.pdf>. (Last accessed on April 30, 2010).
- UNDP** (2006a) "Human Development Report 2006 Presskit". United Nations Development Programme. http://hdr.undp.org/en/media/HDR_2006_Presskit_EN.pdf. (Last accessed on May 2, 2010).
- UNDP** (2006b) Human Development Report 2006. United Nations Development Programme. <http://hdr.undp.org/en/reports/global/hdr2006/> (Last accessed on May 2, 2010).
- UNECA** (2006a) "African Water Development Report. Economic Commission for Africa." United Nations http://www.uneca.org/awich/AWDR_2006.htm (Last accessed on 30 May 2010).
- UNECA** (2006b) African Water Development Report. United Nations Economic Commission for Africa. http://www.uneca.org/awich/AWDR_2006.htm (Last accessed on September 15, 2010).
- UNECA** (2009) Economic Report on Africa 2009: Developing African Agriculture Through Regional Value Chains. United Nations Economic Commission for Africa, Addis Ababa, Ethiopia. http://www.uneca.org/era2009/ERA2009_ENG_Full.pdf. (Last accessed on May 25, 2010).
- UNEP** (2002) Atlas of International Freshwater Agreements. United Nations Environment Programme.
- UNEP** (2006a) Africa Environment Outlook 2. United Nations Environment Programme, Nairobi.
- UNEP** (2006b) Hydropolitical Vulnerability and Resilience along International Waters: Africa. United Nations Environment Programme.
- UNEP** (2007) Chapter 3: Land. In: *Global Environment Outlook GEO4 Environment for Development*. United Nations Environment Programme, Nairobi.
- UNFCCC** (2006) Background Paper on Impacts, Vulnerability and Adaptation to Climate Change in Africa for the African Workshop on Adaptation Implementation of Decision 1/CP.10 of the UNFCCC Convention, Accra, Ghana, 21–23 September. United Nations Framework Convention on Climate Change.
- UNFPA** (2009) State of World Population 2009: Facing a changing world: women, population and climate. United Nations Population Fund. New York: UNFPA. Water footprint. (n.d.). "Water footprint and virtual water". <http://www.waterfootprint.org/?page=files/home>. (Last accessed on April 20, 2010).
- Van der Zaag P. and Carmo Vaz A.** (2003) Sharing the Incomati waters: cooperation and competition in the balance. *Water Policy* 5: 349–368.
- WHO/UNICEF** (2010) Progress on Sanitation and Drinking Water – 2010 Update. WHO/UNICEF Joint Monitoring Programme for Water Supply and Sanitation. http://whqlibdoc.who.int/publications/2010/9789241563956_eng_full_text.pdf. (Last accessed on May 20, 2010).
- World Bank** (2008) "New, high yield rice spells millions in savings for African countries". http://web.worldbank.org/WBSITE/EXTERNAL/COUNTRIES/AFRICAEX_T/0,contentMDK:21844287~menuPK:258657~pagePK:2865106~piPK:2865128~theSitePK:258644,00.html. (Last accessed on April 26, 2010).
- World Bank** (2010) Africa's Infrastructure, A Time for Transformation: Overview. http://siteresources.worldbank.org/INTAFRICA/Resources/aicd_overview_english_no-embargo.pdf. (Last accessed on April 29, 2010).

The Network of African Science Academies (NASAC) was established on 13th December 2001 in Nairobi, Kenya, under the auspices of the African Academy of Sciences (AAS) and the InterAcademy Panel (IAP).

NASAC is a consortium of merit-based science academies in Africa and aspires to make the “voice of science” heard by policy and decision makers within Africa and worldwide. NASAC is dedicated to enhancing the capacity of existing national science academies and champions the cause for creation of new academies where none exist.

As at June 2014, NASAC comprised of the following nineteen members:

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Ghana Academy of Arts and Sciences
Kenya National Academy of Sciences
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Uganda National Academy of Sciences
Academy of Science of South Africa
Tanzania Academy of Sciences
Zambia Academy of Science
Zimbabwe Academy of Science
Sudanese National Academy of Science
Mauritius Academy of Science and Technology
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