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EDITORIAL

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Hydrolink Editor

Africa's many water-related challenges

Many parts of Africa face several water-related challenges including the lack of access to safe drinking water and sanitation, the availability of water for food production, protection from catastrophic floods, the sustainable management of its water resources, and the protection of aquatic and terrestrial ecosystems. Despite the significant geographic and cultural differences between countries and especially between the two major regions of the continent, North Africa and Sub-Saharan Africa, there are several common factors that exacerbate the severity of these problems, such as population growth, climate change, urbanization, governance and transparency issues, political and military conflicts in parts of the continent, and national or international disputes over the allocation of limited water resources.

Different agencies of the United Nations use specially developed indicators to monitor progress towards the specific targets in each of the Sustainable Development Goals (SDGs) of Agenda 2030. Especially relevant for addressing water problems is SDG 6 which includes specific targets for drinking water and sanitation, wastewater treatment, water quality, water-use efficiency and integrated water management among others. Even though progress towards these targets has been made, a report published by the UN Water program in 2021 concluded that "the world is not on track to achieve SDG 6" by 2030. This is especially true for Africa. For example, according to the same report the proportion of population using safely managed drinking water services in Sub-Saharan Africa has increased from 17 percent in the year 2000 to 30 percent in 2020, still way too short of the ambitious goal to reach 100 percent by the year 2030. The percentage of people with access to safely managed drinking water is even smaller, only 13 percent, among the rural population of the region which in 2020 was about 667 million people. Similarly, slow progress has been made in sanitation, where the number of people using safely managed sanitation services in Sub-Saharan Africa has increased from 14 percent of the total population of the region in 2000 to only 17 percent in 2020. Based on data for 2017-2020 the proportion of domestic wastewater flow safely treated was 28 percent. It should be noted that there is a close link between the lack of access to safe drinking water in combination with poor sanitation conditions and the transmission of several waterborne diseases such as cholera, diarrhea, dysentery, hepatitis A, typhoid, amoebiasis, gastroenteritis and cryptosporidium. Hundreds of thousands of people die every year from waterborne diseases in Africa.

North Africa seems to be relatively closer to meeting the targets of SDG 6, especially the target of providing safely managed drinking water services to all. It should be noted though that there are gaps in all these assessments, as some countries have not reported data on progress towards the SDGs.

Africa is undergoing rapid urbanization, with its urban population projected to soon surpass its rural population and double by 2050. This creates the need for increased water supply and sanitation services, as well as stormwater drainage and flood protection to the growing cities. This can be especially challenging as the expansion of many cities is unplanned and includes informal urban settlements, an alternative term to "slums", which is perceived by some as defamatory. According to UN Habitat in 2018, 56 percent of the urban population in Sub-Saharan Africa lived in informal settlements, where drinking water supply and sanitation conditions are very poor. In addition, many such settlements are in low-lying floodplains where often urban debris is dumped in streams. This in combination with increased runoff due to urbanization increases the risk of severe flooding and loss of life.

Water infrastructure counts amongst the most significant challenges for Africa. The African Development Bank estimates that the continent's water potential remains largely underutilized, with only 5% being exploited, less than 5% of cultivated land being irrigated and only 10% of hydroelectricity potential being realized. The development of the available hydropower potential in parts of Africa could bring electricity to millions of people who now live without it. The challenge though is that such development should avoid any of the potential adverse social and environmental impacts of dam construction and reservoir creation. A similar challenge is faced by water projects supporting irrigated agriculture, where it is critical to ensure that water is used efficiently and wisely.

How IAHR can help

Addressing Africa's water problems successfully requires the coordinated work of different parts of government in collaboration with the private sector and civil society. UN Water has identified five broad areas of work that can accelerate progress towards SDG 6. They are improved data and information, capacity development, innovation, optimized financing, and governance. The first three of these are areas where international scientific and engineering associations and societies can contribute not only towards SDG 6, but also in addressing other water related problems of the continent. The new "Policy on Water" of the African Development Bank as well as the African Union's Agenda 2063 blueprint for development, have clearly put water at the heart of achieving sustainable and resilient economies and communities.

Recognizing this, IAHR has included in its current strategic plan the goal of expanding its engagement in Africa. This includes an effort through its Africa Division to not only connect practicing engineers and scientists, academics and researchers working on water issues in order to facilitate the sharing of knowledge and experience within the continent, but also with others in other parts of the world whose expertise may be relevant to the water problems in different parts of Africa. In addition, IAHR's publications, conferences and congresses can serve as platforms for raising awareness about yet unsolved problems and for inviting those interested to work to find solutions.

This issue of Hydrolink includes six articles primarily by authors from Africa that cover a range of topics that we hope will stimulate discussions and create opportunities for new collaborations.

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Cover picture: *The African continent in the spotlight for a sustainable planet* | DREAMSTIME

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IAHR in Africa: the impact and vision of the IAHR African ambassador's initiative

By Moez Louati and David Ferras

The traditional view of Africa from outside the continent needs to be rethought. Currently, the word "Africa" solely represents a collective of 54 countries within the boundaries of a large, unprosperous continent. In reality, Africa is inherently heterogeneous in all aspects of state functions, social expressions and geographic features including culture, living standards, education, economy, life expectancy and water resources. It is thus not surprising that water security and policies differ radically among countries. To make matters worse, these different attributes are interconnected and can only be addressed by applying a holistic approach.

Figures 1-4 show worldwide data of five distinct metrics, namely the improved water supply, freshwater resources, poverty rate, secondary school enrolment and life satisfaction/happiness, respectively. It is clear and glaring from these figures that all metrics vary within the Africa continent. Many issues must be studied and accounted for to explain how African countries with lower water resources, especially in North Africa, have actually larger education enrolment, higher access to improved water supply, greater life satisfaction and lower poverty index, even though water resources are supposed to be crucial for the economic and social development of a country. Definitely, the influence of other factors from within the continent and from overseas have played crucial roles on the development of the African countries.

In this diverse landscape, it is unrealistic to apply solutions based solely on past experience gained from other regions of the world. First and foremost, it is quintessential to identify the issues that plague the different parts of the continent of Africa. In fact, in the past, it has been challenging or even futile to engage African scholars, and professionals in IAHR. One of the reasons is that Africa's challenges and requirements for development and water security are diverse and vary from one country to another, and the means to address them are usually interlinked with each country's unique characteristics and culture. Understanding these challenges and positioning IAHR in Africa's dynamic landscape is not straightforward.

In 2020, "IAHR-Africa ambassadors" was initiated as a task force team to strengthen the connection between IAHR and Africa. Soon after the task force team was formed, it made great strides in placing Africa in the spotlight of the IAHR community. For instance, the task force published an article in Hydrolink, Special Issue on IAHR 85th Anniversary, on the Hydro-environmental Education in Africa[1] and openly discussed the potential role that IAHR members can play to contribute to this initiative. It also organised a special session on Water Challenges and Professional Development in Africa, held at the 1st IAHR Online Forum 2021. An overview of the water resources distribution in Africa was presented in this session, as well as the state of hydraulic infrastructure in the continent and its management. Additionally, the challenges and opportunities for water research in the continent were pointed out, together with the need to empower the African youth through education, especially in terms of water security. Finally, the role of IAHR in Africa was discussed among the panellists with the general agreement that IAHR, as an international research association, is key to connect the new generation of African scholars with the international community working in hydro-environment issues.

More recently, the IAHR-Africa ambassadors submitted a proposal to the IAHR council to obtain funds for providing free one-year memberships to African scholars and young professionals and for establishing an Africa online summer school dedicated to teaching and introducing the fundamentals of hydro-environmental engineering. The proposal was accepted in 2021 and we are now in the process of expanding our team members and organising a series of capacity building events with the focus on Africa. The first in the agenda is the Africa Online Summer School (https://africasummerschool.iahr.org/), which will be held in October 2022 with the aim to introduce the main principles of hydro-environmental engineering and their importance and practical applications in Africa

The extended IAHR-Africa ambassadors team is now forming the new leadership team of the Africa Regional Division. Our main objective and vision for the Africa Division is to bolster IAHR's impact on the continent by exploring and identifying the main water challenges, and expand the IAHR network, by attracting and engaging African institutes, universities, and professionals. As part of this vision, we will connect African scholars, professionals and institutions with worldwide organisations, and promote collaborations to advance towards climate change adaptation, water security, environmental awareness and to help meet net-zero and sustainability targets. In fact, IAHR is fully committed to support the UN Water 2030 strategy and has established two dedicated Working Groups on the Global Water Security and on the Sustainable Development Goals. Both working groups collaborate with other IAHR committees with the purpose to help UN Member States to sustainably manage water and sanitation and achieve the water related SDGs. There is a need to articulate the pathways to make this possible in Africa.

The Leading Team of the IAHR African Division is exploring the best ways to reach out and embrace hydro-environmental professionals in Africa. An upcoming initiative is to organise an international forum to identify the main problems and challenges not only related to the scientific and engineering aspects but also covering the cultural, economic, social or political dimensions related to water, and to discuss potential actions that could be considered to mitigate, move forward and overcome them.

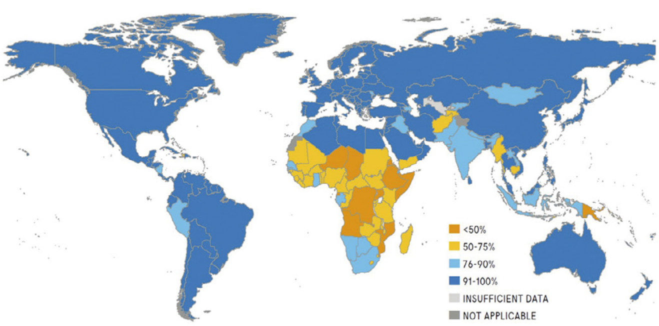

Figure 1 | Worldwide access to improved water supply in 2015[2]

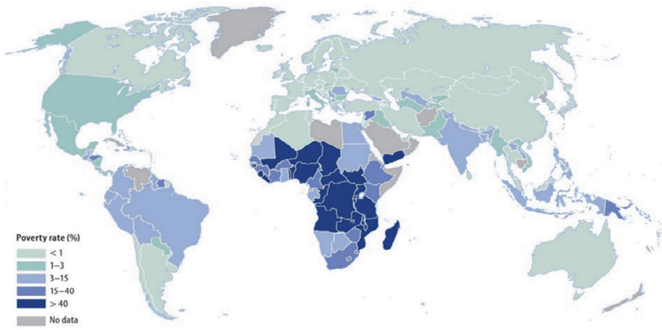

Figure 2 | Powerty Rate at the US $1.90-a-Day Poverty Line, by Economy[4]

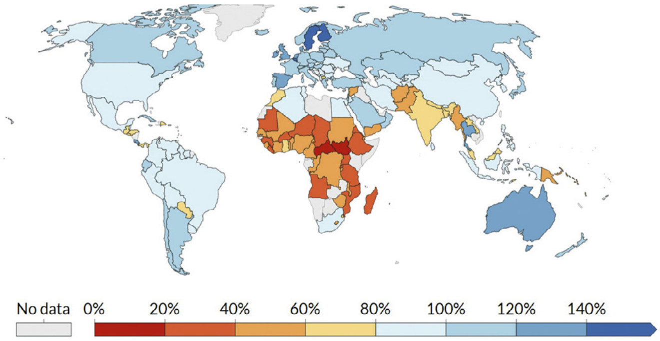

Figure 3 | Gross enrollment radio in secondary education (2016)[5].

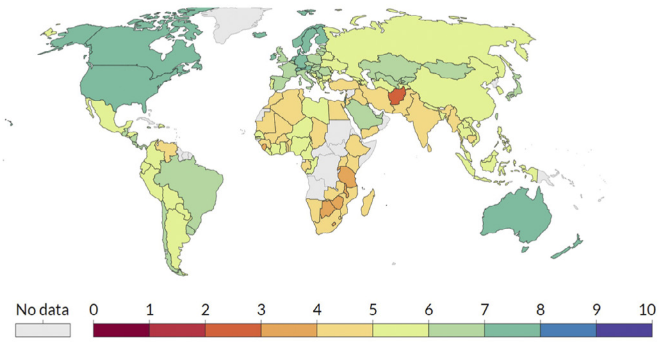

Figure 4 | Self reported life satisfaction (2015)[6].

The forum will include representatives from different African and International organisations which are fully or partially dedicated towards the development of Africa, as well as IAHR members with experience in African projects. Moreover, we will launch an online workshop where African scholars residing in Africa or overseas present and discuss their research work and connect with other African scholars for possible collaborations.

The IAHR-led African Ambassadors initiative is the first foray into gaining clarity, understanding, and building knowledge on the water-related needs in Africa. If embraced, supported and nurtured by an expanding, enthusiastic, and committed African member base, the Africa Division has the prospect of establishing a reforming force in the region by uniting and connecting the hydraulic community locally and across country borders, and defining the role of IAHR in the continent for the years to come.

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3 | Source: Renewable internal freshwater resources per capita. The World Bank, 2014. Link: https://www.mapsofworld.com/world-freshwater-resources.htm

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https://openknowledge.worldbank.org/handle/10986/34496
PovcalNet (online analysis tool), World bank, Washington, DC.

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6 | Source: World Happiness Report (2021) https://ourworldindata.org/happiness-and-life-satisfaction

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The imperative for establishing a Water Institute of the Greater Horn of Africa

By Yonas Kinfu and Nebiyu Daniel Tiruneh

The Greater Horn of Africa Region (GHAR) which includes Burundi, Djibouti, Eritrea, Ethiopia, Kenya, Somalia, South Sudan, Sudan, Uganda, Rwanda, and Tanzania has a combined population of about 375 million people. Apart from Burundi, Rwanda and Tanzaia, the rest are member states of the Intergovernmental Authority on Development (IGAD).

The population of the GHAR suffers from food, energy, and water insecurity despite the potential it has in terms of resources. Water has been identified as an entry point to alleviate poverty, improve the quality of human life, and ensure sustainable economic development. This article contends that the GHAR has a tremendous opportunity to benefit from the water resources it is bestowed with by pulling resources together and establishing a regional water institute.

Background

Historical records indicate that over the past several centuries numerous water conflicts have occurred across the globe. The global water conflict database maintained by the Pacific Institute[1] has a record of more than 900 conflicts dating back to 3000 BC. The 20th century has witnessed 177 conflicts ranging from small scale tribal conflicts to weaponization of water to attack the enemy and to full-fledged attacks using artillery. Wars were fought over water and the lack of access to water has also resulted in human suffering from hunger, thirst, and spread of water related diseases. The combined stress of global increase in population, which has changed from about 1 billion in 1800 to about 7.7 billion today, and the adverse impacts of climate change has also played a significant role in changing the spatial and temporal availability of water resources. The impacts of climate change and increasing population are becoming causes of concern to the continent of Africa. It is therefore necessary for Africa and Africans to focus on managing their water resources using appropriate technology, sustainable methods, and collaborative efforts.

The success of water resources planning, management, development and operation (including policies and decision-making processes) relies among other factors on the availability of reliable data of sufficient spatial and temporal coverage. Reliable data with appropriate quality control and quality assurance (QC-QA) mechanisms is important in order to have a meaningful data interpretation, data analysis, and modeling. The other key component of a sound water resources management strategy is implementation of appropriate technologies to effectively and sustainably utilize the water resources. Sustainable use and management of water resources is a cornerstone for sustainable development which Africa and Africans need desperately. Institutional capacity plays a critical role in ensuring the success of regional integrated water resources management policies and strategies. In the case of Africa and GHAR in particular, regional and international organizations such as IGAD, the African Ministers' Council on Water (AMCOW), the International Association for Hydro-Environment Engineering and Research (IAHR), UN-Water, and the Stockholm International Water Institute (SIWI) can play critical roles in narrowing skill gaps that exist between institutions, government entities, practitioners, academicians, experts and other professionals of the GHAR member countries involved in the various sectors of water resources, energy, food security, and sustainable development.

Water resources development provides an impetus for economic growth, and overall improvement in the quality of lives. Over the last few decades the nexus between food, energy, and water systems (FEWS) has been demonstrated with substantial data and analysis. Scientific understanding of the FEWS nexus is of growing importance, even more so as humanity is facing emerging challenges from global environmental change. Experience has shown that several important decisions that influence the FEWS nexus are made by national as well as regional decision makers. Since the FEWS nexus is not necessarily bound by geographical boundaries, regional planning and implementation of FEWS management is shaped by national and global dynamics that include changes in the socioeconomic and technological sectors as well as the dynamics in the regional and international trade and business activities. In the context of global issues such as climate change, economic growth, and the sustainable development goals (SDGs), it is clear that the ability of nations to achieve these broader societal goals is strongly influenced by regional decisions.

In addition to the food and energy systems, the water sector is also interconnected with various other sectors such as health (water supply, sanitation, hygiene, and epidemiology), environmental protection, watershed management, and ecological (bio-diversity) preservation.

As a result, this article proposes the establishment of a water institute that focuses on serving the GHAR by building upon existing institutional capacities. **Figure 1** shows the various sectors that are interconnected with the water sector and how the proposed water institute can become a core component of the system.

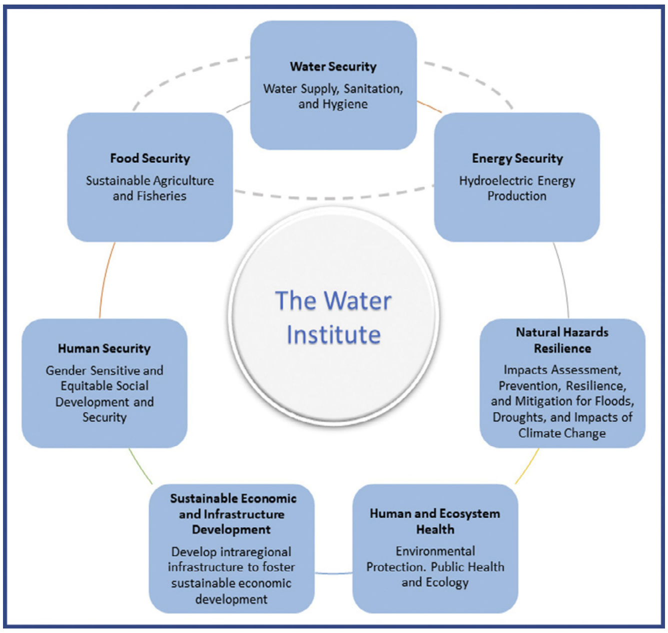

Figure 1 | Thematic interconnectivity of the Water Institute with other sectors.

Figure 2 | The Greater Horn of Africa Region.

Assessment of Existing Water Resources Related Institutions

A map with the GHAR is shown in Figure 2. Table 1 provides population and water-related data for the region. In addition, Figure 3 shows water falls on River Nile (called Abay in the local language), which is one of the major rivers in GHAR.

Variable Name	GHAR Country					
	Burundi	Djibouti	Eritrea	Ethiopia	Kenya	Rwanda
Total population (1000 inhab)	10827.02	944.099	3412.893	106399.9	50227.14	11980.90
GDP per capita (current US$/inhab)	296.1105	2891.235	1169.566	731.5802	1584.66	748.350
Human Development Index (HDI) [highest = 1]	0.421	0.492	0.431	0.467	0.574	0.529
Surface water produced internally (10^9 m³/yr)	10.06	0.3	2.7	120	20.2	9.5
Groundwater produced internally (10^9 m³/yr)	7.47	0.015	0.5	20	3.5	7
Total renewable surface water (10^9 m³/yr)	12.536	0.3	7.215	120	30.2	13.3
Total renewable groundwater (10^9 m³/yr)	7.47	0.015	0.5	20	3.5	7
Fresh surface water withdrawal (10^9 m³/yr)	—	0.001	—	—	3.507	—
Fresh groundwater withdrawal (10^9 m³/yr)	—	0.018	—	—	0.525	—
Total population with access to safe drinking-water (%)	75.9	90	57,8	57.3	63.2	76-1
Variable Name	Somalia	S. Sudan	Sudan	Tanzania	Uganda	
Total population (1000 inhab)	14589.18	10910.76	40813.4	54660.34	41166.59	
GDP per capita (current US$/inhab)	101.5634	606.0064	3059.744	954.8774	634.7691	
Human Development Index (HDI) [highest = 1]	—	0.414	0.507	0.522	0.522	
Surface water produced internally (10^9 m³/yr)	5.7	26	2	80	39	
Groundwater produced internally (10^9 m³/yr)	3.3	4	3	30	29	
Total renewable surface water (10^9 m³/yr)	14.4	49.5	35.8	92.27	60.1	
Total renewable groundwater (10^9 m³/yr)	3.3	4	3	30	29	
Fresh surface water withdrawal (10^9 m³/yr)	3.167	—	—	—	—	
Fresh groundwater withdrawal (10^9 m³/yr)	0.131	—	—	—	—	
Total population with access to safe drinking-water (%)	31.7	58.7	55.5	55.6	79	

Table 1 | Population and water-related data of the GHAR for 2017[2]

Figure 3 | Blue Nile (Abay) Waterfall [Tis Esat] about 30 km from Lake Tana.

A general and simplified assessment of the water resources related institutions within the IGAD countries was performed to identify possible gaps that exist and therefore inform the establishment of the proposed water institute. The countries included are Ethiopia, Kenya, Sudan and Uganda. Regarding the other IGAD countries of Djibouti, Eritrea, Somalia and South Sudan, no substantial water resources institutions were identified.

In Ethiopia, the two major water resources related institutions are: 1 | Ethiopian Institute of Water Resources (EIWR) and 2 | Water & Land Resource Centre (WLRC) established in 2011, and associated with Addis Ababa University.

EIWR is a higher education institution mainly engaged in training water professionals and community outreach in the management of water resources. WLRC's main engagement is in water resources as is relates to land management with primary focus on addressing sedimentation within catchments.

In Kenya, the following four water resources related institutions were identified:

- Kenya Water Institute (KEWI) (established in 2001 by act of government);
- Water Resource and Research Center (WRREC) (hosted by Jomo Kenyatta,University of Agriculture and Technology and supported by Ministry of Water and Irrigation since 2011)
- Institute of Environment and Water Management (IEW) (established in 2005)
- Kenya Climate Innovation Center (KCIC) (established in 2012)

The mandate of KEWI is to offer training, administer examinations, and involve in research and consultancy services in the water sector. Training and consultancy services seem to be the focus of KEWI because it has to generate income to support itself. WARREC is setup to encourage and facilitate research (the use of science, technology, and innovation) and to build the capacity of water related stakeholders and has a slight academic slant. The focus of IEW in water resources seems to be related to women's participation; capacity building through training and forums; and dissemination of information; and excludes hardcore science and engineering aspects of water resources development. KCIC's focus to provide solutions to climate change impacts in relation to energy, water and agribusiness.

In the Sudan, the major water resources institution is the Water Research Centre (WRC) that was established by the University of Khartoum in 2009. The main focuses of the Center are research and development, training, providing advice to policy makers and stakeholders and technology transfer in relation to water and the environment. Because the Center is structured under a faculty of engineering, it appears to have an academic slant and focus on training activities. In fact, it receives students from the region for training in water resources.

In Uganda the major and leading water resources related institution is The Appropriate Technology Centre for Water and Sanitation (ATC), which was established by Ministry of Water and Environment. ATC's main focus is research and the implementation of appropriate technology in relation to water supply and sanitation, with some engagement in irrigation works.

Based on the country-by-country assessment it was found that the various water resources related institutes and centers within the IGAD countries have different emphasis, scope and context. None of them have an all-encompassing program on water resources related themes. The proposed water institute is expected to encompass a wide range of water related activities as outlined in this article.

Motivation

The need for the proposed water institute became apparent while attempting to find hydro-meteorological data in the region. Neither raw nor processed data were readily available to be used for analyses. This experience resulted in informing the following three main motivations that form the basis for the formation of the proposed water institute are described as below:

1 | Preliminary assessment of technical capabilities in the GHAR indicate that there is a shortage of systematically organized, quality controlled, and readily accessible water resources data for use in formulating policies, planning, and design of water infrastructures. As a result, there is an emerging need to address the shortage of valuable water resources data necessary to implement a sustainable water resources management plan. In addition, data deficiencies and uncertainties are inextricably linked to improper designs resulting to incorrect capacity, shorter design life span, inflated project cost and unduly longer design and construction schedules of civil infrastructures.

2 | There is an urgent need to effectively mobilize and utilize resources with backing by the political establishment of member states in order implement sustainable development of water resources with a shared vision and common goal.

Africa needs to reverse the current trends of endemic poverty, extreme underdevelopment and migration of its younger population in search of a better life. The role of water in helping achieve the desperately needed socio-economic development goals is well understood. Notwithstanding the issue of spatial and temporal distribution, Africa has the benefit of substantial rainfall and water resources. However, Africans still face a myriad of severe and intricate natural and man-made problems that have put significant constraints on the sustainable development of water resources in many parts of the continent.

In an attempt to map a chart aimed at utilizing water as a driver to the challenges Africa is facing, the UN-Water/Africa produced a report in 2004 (in collaboration with other African-related organizations) titled "The Africa Water Vision for 2025: Equitable and Sustainable Use of Water for Socioeconomic Development"[3].

The report outlines human threats to the sustainability of water resources which include inappropriate governance, depletion of water resources, failure to invest in resource management, unsustainable financing.

In addition, the report states the key water resources related challenges Africa faces. Those that are relevant to the proposed water institute, such as reforming water resources institutions to establish good governance, securing and retaining talent, developing research and development capability, outlining strategies to tackle water security threats and mobilization of political will.

The 2012 Status Report on the Application of Integrated Approaches to Water Resources Management in Africa prepared with information contributed by the member states of AMCOW[4] provides key messages and recommendations based on the survey it conducted. Those among them that are relevant to the proposed water institute are lack of financing of water resources management, lack of progress in the development and implementation of transboundary agreements and institutional capacity constraints.

3 | A careful examination of individual country experiences demonstrates that there is a clear and demonstrable gap in the areas of shared knowledge and technical resources necessary to manage water resources sustainably. It is apparent that organizations such as IGAD, AMCOW, IAHR, UN-Water and SIWI can play a crucial role in bridging this gap. Through consultation and a shared vision, such organizations can create a paradigm shift by establishing a shared platform for regional integrated water resources planning and management through regional cooperation and by building the technical know-how and enhancing infrastructural, and technical resources mobilization in the Greater Horn of Africa Region.

Establishing a water institute as a Technical Center of Excellence will help coordinate efforts, provide technical support, assess performance, map future paths, and make the task of accomplishing the ideals identified above achievable. **Figure 3** illustrates the thematic connectivity of the proposed water institute with other sectors of human welfare and development.

Vision and Objectives

The vision of the proposed water institute is to establish a center of excellence to help sustainably manage the water resources of the countries of the GHAR by creating a mechanism that facilitates integrated planning, management and development of water resources and other critical water infrastructures by considering the impacts of climate change and other stressors. The institute would be a technology driven powerhouse and repository, that systematically and seamlessly integrates data and methods for management of water resources and timely exchange of data and information. The institute will adapt, innovate and create appropriate technologies and enhance efforts to bridge gaps through knowledge transfer, capacity building, and cooperation among GHAR countries. The institute would also provide leadership, training, research, as well as best practices and knowledge transfer services to member states of GHAR. The objectives of the proposed water institute would be:

1 | Facilitate the establishment of data collection systems; perform data processing and analysis, and dissemination of water-related data and information.

2 | Conduct applied research and development activities to address and amicably resolve water resources related issues identified in the region.

3 | Create a platform for knowledge transfer and adaptation of appropriate technology.

4 | Perform water resources systems modeling and simulations that include both physical and numerical modeling of processes, natural features, and engineered structures.

5 | Facilitate and support the coordination of planning, management and development of transboundary water resources including river basins, lakes and aquifers.

The rationale for establishing a Water Institute

There are two underpinning rationales that demonstrate the benefits of the proposed for the GHAR region:

1 | The proposed water institute would create an enabling environment that fosters cooperation and the institutional setup to help improve the livelihood of people in the region and strengthen regional peace and security.

2 | The proposed water institute would help bridge existing gaps in technical and scientific capacities in the area of water resources management by pulling together resources from the region. The Institute would also provide a platform for sharing experiences, lessons-learned and coordination on climate change related issues.

The need to establish the proposed regional water institute rests on the following two main reasons:

1 | The need to develop an integrated water resources planning, management and development within the GHAR countries, given that the water sector is a critical component of any economic development.

2 | The contribution the institute would make in the economic cooperation/integration of the Greater Horn of Africa Region.

Most of the major river basins and aquifers within the GHAR countries are transboundary in nature because political boundaries rarely follow basin or aquifer divides. The transboundary basins in the GHAR include White Nile/Lake Victoria, Omo River/Lake Turkana, Wabi Shebelle River, and Tekeze River. In addition, some of the trans-boundary aquifers are Rift, Dawa, Gedaref, Sudd basin and Awash Valley. The development of a river basin by an upstream country influences water availability in the downstream countries. In addition, the same is also true for flooding and water quality. Any water quality degradation and improper watershed management by an upstream country has an adverse effect on the downstream countries. Because of the highly interconnected nature of basins and aquifers between countries, the need to develop a framework for an integrated water resources planning, management and development amicably within GHAR countries is critical. Transboundary basins and aquifers have to be managed proactively so that any differences do not lead to conflict threatening peace and stability in the region.

The establishment of the proposed water institute is expected to contribute to the economic cooperation/integration, development, and stability of GHAR. Recent economic trends indicate that Africa's economy, and more specifically the GHAR, is experiencing growth in economic and infrastructural development. (Africa's and East Africa's (GHAR countries and the Comoros and Seychelles) GDP growth rates are projected to reach about 4.6% and 5.6% in 2022, respectively[5]. Infrastructure investment in Africa is expected to reach about $149 bn in 2022[6].) In addition, there seems to be a desire for a broader economic cooperation/integration within the GHAR. Economic cooperation/integration entails building institutional capacities and legal frameworks that would facilitate the collaboration and coordination of various economic and technical activities among member countries. The proposed water institute would facilitate the economic cooperation/integration by providing a suitable platform for the development

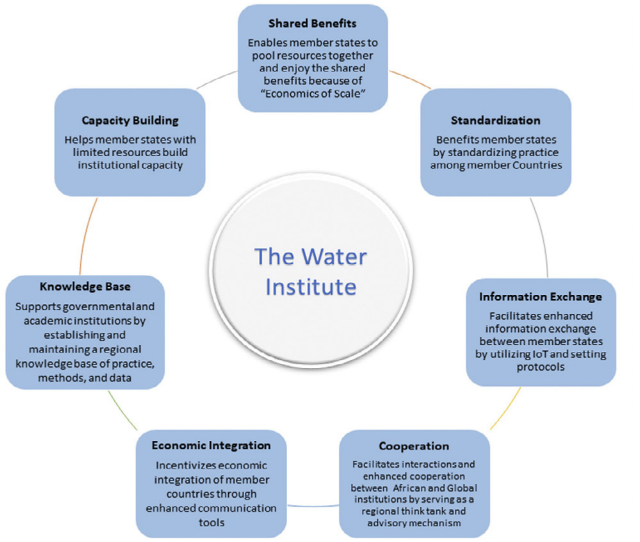

Figure 4 | Potential benefits of the Proposed Water Institute.

of the water sector that is a critical component of an overall economic development. Economic cooperation/integration in turn is expected to lead to peace and stability, which in turn is a prerequisite for an economic growth.

Summary and Conclusions

This proposal calls for the establishment of a regional water institute for the Greater Horn of Africa Region, either under the auspices of IGAD or any other regional organization, with support of international organizations such as UN Water and scientific and engineering associations such as IAHR. The water institute would serve as a technical center of excellence for the region in regards to the water sector. The institute would serve as a "clearing house" for water resources related data, foster collaboration with the states in the region, provide technical capabilities, and serve as a think tank on water related polices.

The establishment of the water institute is expected to contribute to the economic cooperation/integration and stability of the region. Wider economic cooperation/integration within the region is possible, notwithstanding some political hiccups.

A regional approach is considered to be more suitable than developing a pan-African organization. Africa is a big continent with unique and diverse regional features. As a result, organizing the water sector at regional level is advisable. Since the water sector is interconnected with various other sectors and social organizations, the proposed water institute is expected to interface both internally within governmental entities and externally with NGOs, international and regional organizations.

Some challenges are expected in reaching a consensus and establishing the proposed water institute. The expected challenges may include financing naming of the water institute, choosing a location (or locations) for the institute and staffing arrangement, including leadership positions. However, to overcome these challenges trust must be developed among the different countries within the GHAR to garner goodwill. For the proposed plan, the coordinating body that would facilitate the establishment of the water institute should be seen as impartial and acceptable to all.

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Land dynamics and sustainable management of the Fincha River Basin, Ethiopia

By Motuma Shiferaw Regasa, Dereje Adeba, Jiregna Nugusa and Michael Nones

During the last decades, Ethiopian society started to develop at an ever-increasing pace, transforming the country from a place mainly occupied by forest and uncultivated areas to a region mostly covered by commercial farms and settlements. Such changes caused higher soil erosion, affecting the quality of the inland waters and increasing the rate of siltation in hydropower reservoirs. Focusing on the Fincha River, we are studying past land use and land cover changes, to predict future trends and to evaluate how they alter the river sediment yield. The final goal is to develop guidelines for the sustainable management of the entire sub-basin.

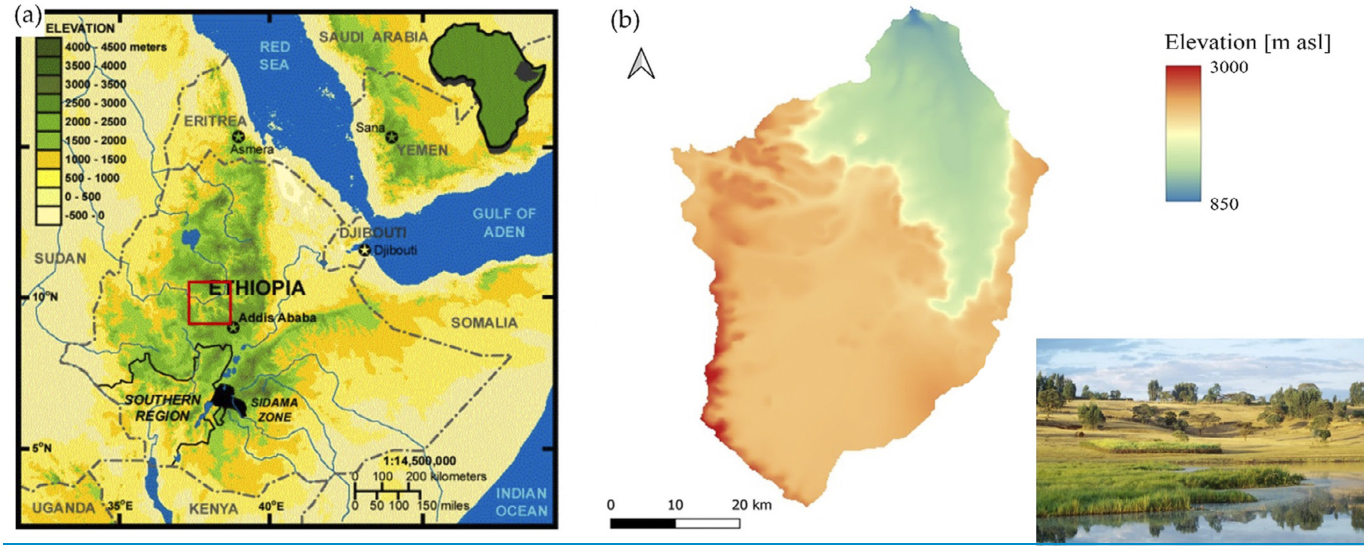


Figure 1 | A | Map of Ethiopia and location of the Fincha sub-basin, B | Digital Elevation Model of the study area, and photo of the Fincha Lake (courtesy of M. Regasa).

Background

In Africa, land use and land cover (LULC) changes across different scales are among the main drivers of physical alterations of the environment, with consequent socio-economic impacts. At the larger scale, for example, the increase in the use of land for agricultural purposes is linked to deforestation and forest degradation, as well as to increased carbon emissions. At the regional and local scales, LULC change can lead to increases in soil erosion and sediment yield, which, in turn, can reduce the lifetime of reservoirs and the potential for power production. Such changes can have a significant impact on the development of African countries, the habits and livelihoods of local populations, and the economic structure of African societies.

International organizations and programmes, such as the United Nations (UN) Land Degradation Neutrality initiative or the UN's Programme on Reducing Emissions from Deforestation and Forest Degradation (REDD), are now in place to counterbalance the loss or degradation of ecosystem services from soils and forests with the recovery of degraded areas, putting in place measures to conserve, sustainably manage, and restore the land. These initiatives often involve multi-stakeholder engagement and planning across different scales and sectors.

Soil erosion is a relevant problem that has threatened the water resources development in the Blue Nile River basin for centuries, particularly in countries like Ethiopia, Sudan and Egypt[1]. This issue is now even more relevant, as the present socio-economic condition can eventually worsen the situation, increasing the erosion due to a reduction in vegetation coverage. Indeed, many studies pointed out that, across most of the Ethiopian basins, agricultural land, waterbody, commercial farm, built-up/settlement, and bare/rock outcrop increased during the last decades in a dramatic manner, while the area covered by forest, grazing land, and shrubland decreased. Such changes are mostly connected with increasing human pressure on the Ethiopian environment, driven by the need to improve the living conditions of the local population[2].

The Fincha River case study and project goals

The Fincha River is one of the tributaries of the Blue Nile River originating from the high plateau of Ethiopia. The Fincha Dam was constructed in 1965 at a location around 300 km northwest of Finfinnee in the Abbay Choman district, Horroo Guduruu Wollega province, Oromia Regional State, Ethiopia (Figure 1). In the study site, bare land expansion, increased surface runoff and soil erosion are major environmental consequences partly attributed to LULC changes. These degradation processes have adverse impacts on local agricultural productivity, water resource availability and food security of local communities. In addition, heavy rains cause severe erosion and sediment transport, which ultimately leads to degradation of soil and contributes to negative off-site impacts on downstream flooding, pollution and siltation of water bodies and reservoirs[5]. Given the interaction between multiple natural (e.g., more extreme events due to climate change) and anthropogenic (e.g., change of land use, preferring settlements and agriculture instead of forest) forcings that accelerate soil erosion, a proper estimate of future reservoir capacity is a difficult task for water managers dealing with the design, maintenance and operation of a reservoir, and adequate monitoring and modelling tools should be applied.

A 4-year project started in October 2020 and financed by the NCN National Science Centre of Poland, is aiming at analysing LULC changes in the Fincha River sub-basin, and addressing the following research questions:

- What is the sediment yield of the selected river catchment under the present conditions (land cover/use)?
- How does sediment yield correlate with topography, flow discharge, channel geometry, land cover and drainage characteristics, and what are the causal mechanisms beneath these correlations?
- What is the impact of LULC changes on the sediment yield of the catchment and do these effects vary seasonally?
- What are possible management strategies and mitigation measures that can be applied to reduce the sediment volume coming from the sub-basin hillslopes, and the consequent siltation in the Fincha Dam reservoir?

To do that, a combination of modelling and monitoring techniques will be used, together with field evidence (**Figure 2**). Due to its versatility and applicability to complex watersheds, researchers have identified the Soil and Water Assessment Tool (SWAT) as one of the most consistent and computationally efficient models, able to analyse the interaction of several hydrological parameters and the impact of land management practices in both large and small watersheds[4]. Calibration and validation of the SWAT model will be performed by comparing the modelling results with observed information and data on water and sediment flow, considering the periods 2010-2014 (calibration) and 2015-2019 (validation).

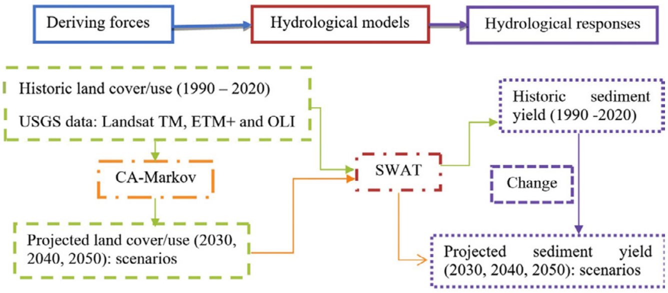


Figure 2 | Project Workflow.

The model will then be applied to the period 1990-2020 and will be used to simulate future scenarios forced by different LULC changes. To produce future scenarios, an integrated Markov Chain and Cellular Automata (CA-Markow) system dynamic model will be applied, as usually done in such kinds of studies. In Markov Chain models, LULC is thought of as a stochastic process: the state at a given time t is dependent exclusively on the state at previous time step t-1 and not on the states before that (i.e., at times t-*2*, *t*-*3*, etc.). However, Markov modelling alone is not sufficient for analysing LULC change simply because it does not consider the spatial distribution of each class, even if it can correctly predict the magnitude of change. Thus, a cellular automata model is implemented to account for the spatial nature, as, in this case, the state changes not only depend on its previous state but also on the state of the cells immediately neighbouring the study cell[3]. Based on the produced scenarios and via a continuous involvement of local stakeholders, water authorities and citizens, appropriate management strategies and mitigation measures for the Fincha River watershed will be developed and discused with decision and policy-makers.

During the first year of the project, remotely-sensed data from three reference years (1989, 2004 and 2019) were analysed to derive past LULC changes (**Figure 3**). Preliminary results showed that, in 2019, the areas covered by forest and shrubs decreased, respectively, by around 40% and 12%, with respect to the 1989 reference. On the contrary, there was a significant increase in areas devoted to agriculture (18%), waterbodies (33%) and built-up settlements (290%). In fact, to sustain new cultivations and human settlements, additional dams were built during the last decade. These preliminary results will be validated during the next few months, via field surveys, discussions with focus groups and interviews with local citizens, stakeholders and water managers.

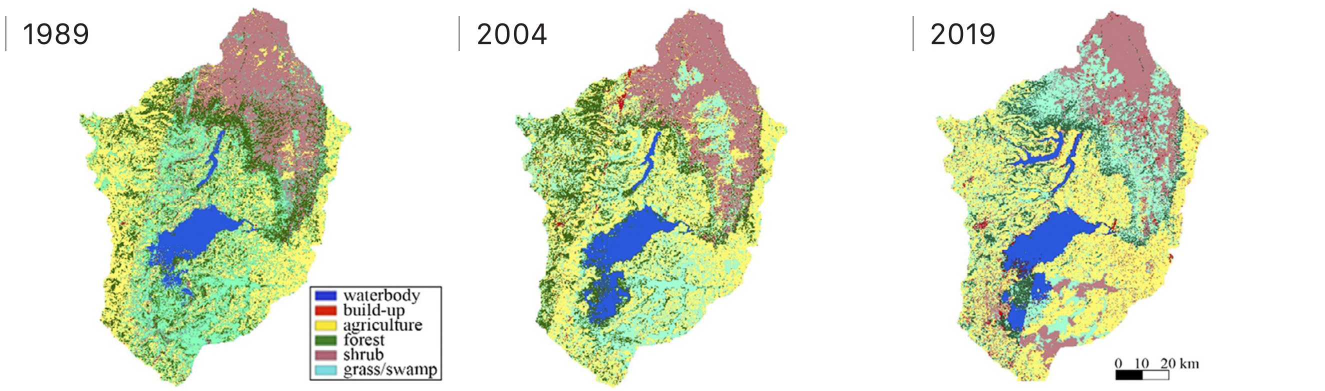


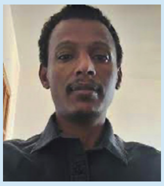
Figure 3 | Maps of Land Use Land Cover in 1989, 2004 and 2019.

Challenges and Expected projects outcomes

The proposed approach relies on the availability of reliable field data, which could be not the case in undeveloped countries. Besides that, the actual uncertain political situation in the study area could affect the data availability, and the opportunity to validate the remotely-sensed information with field evidence. The use of CA-Markov analysis will also provide uncertainty to the study. Indeed, this approach has many limitations, such as the non-capability to account for human influences and government policies while modelling a situation, or the assumption that the factors that drove LULC change in the past remain the same during the future. As suggested by the review of Ghosh *et al.*[3], there are many workarounds to overcome the limitations intrinsically connected with the CA-Markov approach, such as varying the weighting coefficients, and they will be tested to improve the reliability of the study.

Despite all the drawbacks due to the lack of data and the modelling approach, studies like this one will help provide water managers and policy-makers with hints on the future management of both the sub-basin and the hydraulic infrastructure therein.

The case of the Fincha River is exemplary: over the last thirty years, the natural forest was mostly converted to agricultural and grass/swamp areas. An increase in areas covered by water-bodies and built-up was also observable, mainly connected with increasing human pressure and the construction of new hydropower reservoirs. For the future, a similar trend is more than probable. Indeed, if management strategies will not be changed towards a more sustainable approach, also via proper reforms at the national level, an even more significant decrease of the forest coverage should be expected, in favour of new settlement areas and cropland. This change could help locals in sustaining their livelihood in the short term, but, in the medium/long term, the reduction of areas covered by forest will contribute to decreasing biodiversity and ecosystems services, as well as in fostering soil erosion, with detrimental consequences such as reservoir siltation.



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Spotlighting the disparity of funding, personal and policy in Africa's water research

By Modupe Olufunmilayo Jimoh

In terms of research in Africa, there are two schools of thought. The first is "Water research and researchers in Africa receive adequate funding", and the second is "Water research and researchers in Africa are not well funded". Interestingly, none of these two statements is entirely true because the experiences of researchers across the continent are poles apart. Water research in Africa, therefore, cannot be judged under the same measure.

Water Research Focus by Country and Region

According to AfDB[1], African countries have failed to match the growing water demand with adequate investments as countries invest only 0.5% of their gross domestic product in the water sector – leaving an annual investment gap of USD 43-56 billion. This means that just a little finance trickles down from the public sector towards water research. Each country's government in Africa has been the principal financier of research or policy design and implementation. However, few countries have successfully received research support from international organisations such as the Nordic Development Fund; the Ministry of Foreign Affairs, Denmark; the Swedish International Development Cooperation; the Austrian Development Agency and the Islamic Development Bank; which has considerably boosted their research profile[1].

Most of the water research in Africa is carried out at Higher Education Institutes or by other water research institutions. Thriving research culture relies heavily on available finance and policy (**Figure 1** and **2**). These two components would enhance the availability of different features such as human capacity, laboratories, consumables, channels to implement, scale and disseminate research. The challenge, nonetheless, is that the story across the continent varies.

UNESCO[9] reported on education and research funding, publications, and personnel for countries within each region of the African continent. It reported that in West Africa, Burkina Faso and Senegal spent 0.61% and 0.58 % respectively of their Gross Domestic Product (GDP) on funding research and development. In the same region, lower funding was reported for Cote d'Ivoire and The Gambia at 0.10% and 0.07% respectively. In the Central and East Africa regions, in 2016, Rwanda and Burundi spent 0.61% and 0.21% of their GDP on research and development, while Uganda spent about 0.17%. For the Southern Africa region, South Africa sits in a class of its own, with 0.83% of its GDP going towards research and development. Next to it is The Democratic Republic of Congo at 0.41% (half of South Africa), and Madagascar has one of the lowest at 0.01%. For North Africa, Egypt and Tunisia spend 0.72 and 0.60 % of their GDP respectively on research and development. In contrast, for the same region, Mauritania has one of the lowest at 0.01%. These data highlight a significant disparity within the same regions and across the continent. It is certain that the differences will be reflected in the quantity and quality of outputs from each country in terms of research and development.

The Joint Research Centre[4] presented data on the most recurrent water related keywords from each country's research on water resources use and management. The data was a subset of over 162 thousand records of documented episodes of violence related to water resources use and management from the Armed Conflict Location & Event Data Project collection. The subset data shows that water research in Algeria, Burkina Faso, Egypt, Ethiopia, Kenya, Somalia, South Africa, South Sudan, Sudan, Tunisia, Uganda and Zimbabwe covers several keywords. The keywords include water demand, drought and shortage, flood, agriculture, irrigation, farming, food, and sanitation. Meanwhile research in other countries such as Togo, Swaziland, Mali, Malawi, Guinea, Cameroon had only one or two main water-related keywords. In addition, according to UNESCO[9], most research publications across the continent are in the health sciences. Water related research sits within the environmental science publications and the percentage varies across each region of the continent. West, Central, Eastern and Northern Africa had about 10% of all publications in environmental sciences, whereas the Southern Africa region had about 23%. The data from these reports show the variation in water research focus across the continent.

Although there is no clear data on the number of female researchers in water related disciplines, an interesting highlight from UNESCO[9] is the disparity in the number of female researchers across the countries in Africa. In the West African region, Cape Verde has the highest percentage of women researchers at 28.4%, approximately three times as much as Togo. In Central and Eastern Africa, Uganda has the highest percentage of women researchers at 29.8%, while Chad has one of the least at 3.4%. Like the tale of two cities, a significant difference was evident in the Southern Africa region with the percentage of women higher than in previously considered area. Several countries across the region had over 40% women researchers. Likewise, the percentage of women researchers in the North African region is also very high. Tunisia has about 56.1%, and Mauritania has the least at 24.5%, higher than what is obtained in most West African countries.

Figure 1 | Drinking Water Quality Laboratory funded by USAID in Ghana. ©USAID.

Figure 2 | Laboratory at Ifakara Health Institute in Tanzania. ©gatesfoundation.org.

Income of Professors

Figure 3 compares the annual income of the most experienced professors in selected countries across Africa. There might be a few countries where salaries are lower than what is obtained in Nigeria, but Nigeria is undoubtedly among the countries where professors are paid the least. At the other end of the scale, the highest paid professors are in South Africa. To provide a fair economic comparison between the countries, the purchasing power parities across Africa for these countries are shown in Figure 4.

The data in Figure 4 implies that for each South African Rand paid for an item in South Africa, it costs 14 times more to buy the same item in Nigeria[1]. This shows that a professor in Nigeria for example is multiple times less empowered to carry out any academic or professional activity that requires financing. Interestingly, the remuneration for Nigerian Professors has been the same since 2009 to date (2022).

It is expected that professors in the water sector (like other disciplines) carry out research, have research groups, have or run laboratories, and publish their work. In addition, they are expected to be members of professional bodies (locally and internationally, where they pay membership fees), pay to attend conferences and sometimes support student research activities. Higher paying countries such as South Africa provide additional research grants and financial support to cater to the listed activities. They also give incentives and reward academics when they have research achievements that contribute to lifting the international research profile of their university.

Sadly, in the lowest paying countries, the professors are expected to do all these from their salary because there is little or no research funds to draw from. For example, in Nigeria, there is only one major organisation, the Tertiary Education Trust Fund (TETFUND) that provides research funds to academics. TETFUND[6] reported that Institutional Based Research (IBR) received N909,955,600 while the National Research Fund (NRF) received N526,160,418. This makes a total of N1,436,116,019 ($3.5 million) that over 73,443 academic staff[5] compete for their research for the whole year. In reality, only one research group per faculty gets funding of approximately N2,000,000 ($5,000) to conduct research each academic year. The question is: based on their salary, how much can they afford to spend towards international recognition and top-tier publication of their outputs?

These disparities imply that poorly paid professors would be less motivated, struggle to carry out their desired research, and never reach their full potential. Capacity building and research output countrywide would also be poor. The opposite happens in the higher-paying countries. Therefore, it is not possible to have the same expectations from all researchers across Africa.

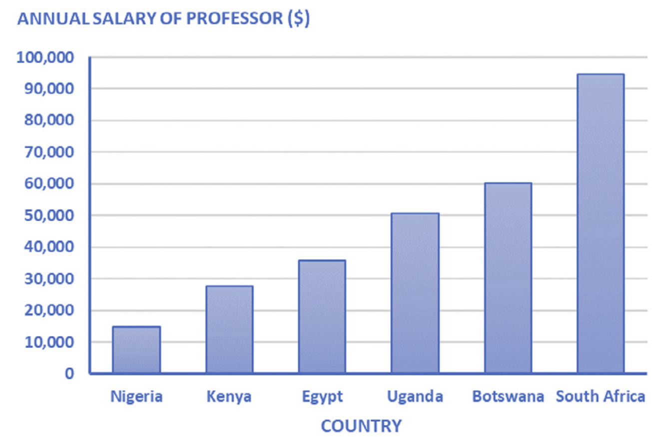

Figure 3 | Average Annual Income of Professors Across Africa.

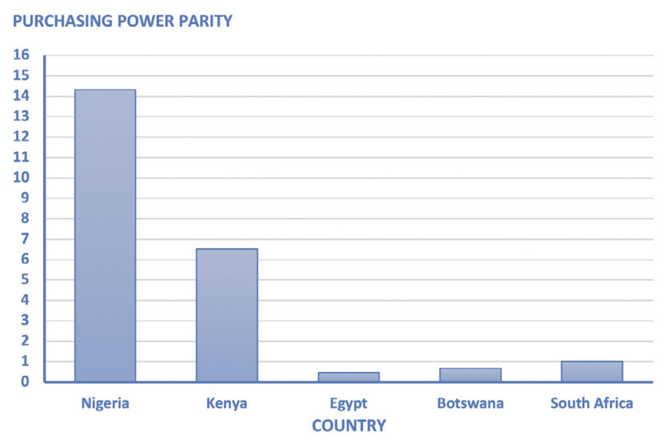

Figure 4 | Purchasing Power Parity (Source: AfDB[1]).

Water Policy in Africa

A country or continent-wide success in research is driven by evidence-informed good policy and its strategic implementation[7]. For example, research in Europe is backed by policy and it has recorded a lot of success stories and great output[3]. There are several policy documents across Africa that relates to education, research, science and technology or water resources. They include reports addressing issues at the national, continental, or international level. While some African countries have national policies on Science, Technology and Innovation, most countries do not have any such policies. On both sides of the divide, there are countries with water resources specific policies.

The Economic Commission for Africa, the African Union, and the African Development Bank produced and presented "The Africa Water Vision for 2025: Equitable and Sustainable Use of Water for Socioeconomic Development" at the World Water Forum, The Hague, The Netherlands, in March 2000. The Vision was for "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"[8]. It recognised challenges relating to research and education and proposed specific actions and milestones. Unfortunately, 21 years later the continent has not yet achieved the set milestones.

In January 2016, the African Union Development Agency adopted a Continental Education Strategy for Africa, 2016–2025, to meet the goals of Agenda 2063. The strategy endorses the principle of quality education, training, and research to support innovation, creativity, and entrepreneurship. Progress within Africa in implementing the provisions of this strategy has attracted a mixed reaction. Overall, the commitment of national governments to R&D and human capacity building is wanting, with support coming primarily from external sources[2].

Most recently, in May 2021, The African Development Bank approved a new Policy on Water (AfDB, 2021). The policy aims at enhancing Africa's water security and transformimg its water assets to foster sustainable, green, inclusive socio-economic growth and development. The policy identifies measures for strengthening the knowledge base on water risks and addressing the technical, financing and governance challenges to achieving water security. It highlighted seven key operational dimensions of the policy, with the 6th being Knowledge management, innovation, technology, and research. It went further to highlight the actions the bank would commit to for success in this dimension. We hope for a successful implementation of the new policy.

Way forward

There is a significant disparity across the continent and within each region regarding water research, personnel and funding. However, there is room for change and growth. The way forward would be for African countries to increase their commitment to education, research and development funding and increase the remuneration of researchers to be at par with their colleagues across the continent. There is a need to realise that the key to the growth desired across Africa lies in research and education that is indigenous to the continent. In countries with poor economies, strategies should be designed to attract funds solely for research purposes from willing donors and organisations (local and international) by building sustainable partnerships with them. Governments should strengthen national research programmes and policies and facilitate research partnerships between African countries. Overall, Africa must take responsibility for Africa.

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Dr Modupe Olufunmilayo Jimoh is a Civil Engineer with a specialisation in Water and Environmental Engineering. She obtained her PhD from the University of Warwick as a commonwealth scholar. Currently, she works as a Assistant Professor (Civil and Humanitarian Engineering) at the University of Warwick, United Kingdom. Before that, she was a Senior Lecturer of Water and Environmental Engineering at the University of Ilorin, Ilorin, Nigeria. In her roles, she has built expertise in training, research, leadership, and policy formulation. Her themes of interest are water, sanitation, environmental management, and gender advocacy.

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The effects of flooding and drought on clean water accesibility in Ethiopia

By Tassew Mekuria

In Ethiopia, the daytime temperature is constant throughout the year. The dry season has bright, sunny days with moderate to cool temperatures. From September to February is the long dry season known as Bega. The long rainy season is in June, July, and August known as Kiremt. Excessive heavy rains in Ethiopia start in April, peak in May, and continue up to August. Overall, Ethiopia has a tropical monsoon climate. The interior plateaux, usually above 2,400 meters in elevation, experience warmer days and cold nights. The hot zone consists of areas of low elevation which are very hot year-round and humid in the tropical valleys and the East of the country. The main economic source of the country is agriculture, for which activities such as plowing land for cash crops and fostering grass food for livestock are carried out after the soil is moistened from the rainwater during and after the rainy season. Recently, climate change is affecting the timing of the dry and rainy seasons. The unusual and unexpected flooding and droughts negatively affect cash crops, grasses, fruits, and vegetables, significantly reducing their production. This article aims at sharing information on some of the recent flooding and drought events in Ethiopia and their impacts on human life, health, well-being, and development.

Background

Ethiopia is in the horn of Africa within the tropical latitudes and with similar North-South and East-West dimensions[1]. Most of the country's land is the mountainous plateau. The Ethiopian Highlands is a rugged mass of mountains in northeast Africa[2]. The Ethiopian highlands cover large regions and form the largest continuous mountainous area in the horn of Africa. This type of topography is susceptible to rain runoff and creates flooding in downstream areas. According to the world health organization and UN reports, between 80-90% of all documented disasters from natural hazards during the past 10 years have resulted from floods, droughts, tropical cyclones, heatwaves, and severe storms. The frequency and intensity of extreme precipitation, and related flood events, are expected to continue to increase due to climate change[3].

Global climate change and environmental degradation increase the flood risk. Flooding causes displacement and loss of lives, damage to infrastructures in different parts of the country. According to national authorities, flooding has so far affected more than 470,000 people in the Somali region in the past 2 years, including more than 300,000 people who have been displaced. The Somali region was severely hit, with nearly 80% of the flood-affected and displaced people located in this region. Floods often cause major damage to basic civil infrastructures such as water supplies, sanitation, waste disposal systems, and other essential services[2], causing serious challenges to public health such as the spread of diseases, pathogens, and pollutants into water supplies from the flooded sewer system and open defecation. The Office for the Coordination of Humanitarian Affairs (OCHA) is part of the United Nations Secretariat responsible for bringing together humanitarian actors to ensure a coherent response to emergencies. OCHA Ethiopia indicated that floods could pollute water sources, damage shallow wells, boreholes, and water pipes. As a result of flooding, people are unable to access safe drinking water. These effects have even more severe consequences in community-managed rural water supply systems[2]. Global warming increases precipitation variability, meaning there will be more periods of both extreme precipitation and drought. This creates the need for expanded water storage during drought years and increased risk of flooding, and drought.

Recent flooding events In Ethiopia

Massive flooding occurs frequently in five regions of Ethiopia, Afar, the Oromia, Gambella, Southern Nations Nationalities People's Region (SNNPR), and Amhara. According to the flood list Africa, https://floodlist.com/africa, floods are repeated in Ethiopia and cause deaths and significant property damages[3]. The OCHA Ethiopia flood reports stress that the country is getting life-threatening and infrastructure destructive flooding events frequently. Some of the major flooding destruction that occurred in Ethiopia between 2014 and 2022 are the following:

A | Addis Ababa: The flood list report indicated that at least 7 people died in flash floods that struck the city of Addis Ababa, capital of Ethiopia in August 2021. Several neighborhoods of the city were inundated after heavy rain. Roads were submerged, cars were stranded, and buildings were damaged (see **Fig. 1**). Such a kind of city flood creates significant contamination to nearby municipal water wells from washed-out solid wastes due to the city's poor waste management practices.

B | Afar Region: In August 2021 the Awash River broke its banks in northern Ethiopia, flooding areas of the Afar Region. The overflowing Awash River caused flooding in Asayta. Over 50 hectares of farmland were damaged, and the flooding affected thousands of people in the region from late April to early May 2021. Around 27,400 people were displaced. UN warned that several people may have been exposed to waterborne diseases in the region due to this flood event.

C | SNNPR and Somali regions: From April to May 2021, flooding affected thousands of people across the SNNPR and Somali regions of Ethiopia. In the SNNPR, hailstorms damaged crops in Chama Hembecho and Afama Mino Kebeles of Boloso Sore Woreda in Wolayta Zone, and some 250 hectares of land were

Figure 1 | Buildings and cars submerged during a flood event in Addis Ababa city. Source: Flood list Africa.

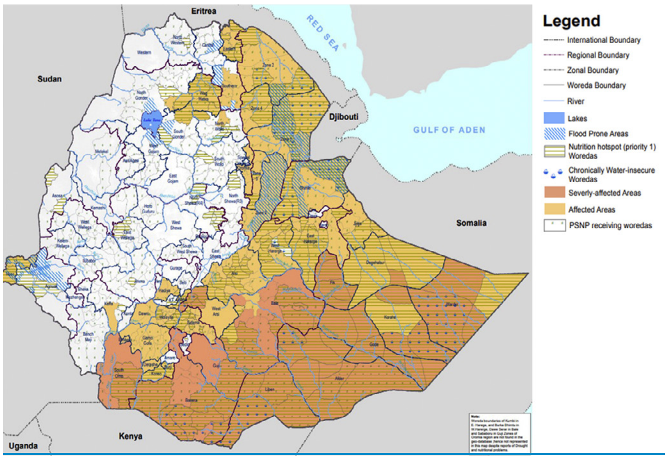

Figure 2 | Ethiopian zonal, regional, and national map contemplating flood-prone areas, rivers, lakes, and arid areas. Source: OCHA Ethiopia.

flooded in Abela Abaya Woreda. Seven people died and around 11,200 households were displaced. The flood list report indicated that these areas were not in the flood-prone zone but received heavy rains in May 2021. The Shabelle, Jarar, Dolo, Afder, Fafan, and Korahe Zones of the Somali Region were all flooded, and numerous people were displaced.

D | Dire Dawa: This region is flood-prone and nine people died when a wall collapsed in a residential area following hours of heavy rain in Dire Dawa city in May 2021. The flood list report indicated that the accident took place at Kebele 03, known as Shementeria, after 4 hours of heavy rain. At least four people died in the city under similar circumstances in late April last year. Recent heavy rainfall also caused buildings to collapse in neighboring Somalia. In this region, access to clean and safe drinking water is considerably challenging[1].

E | Awash River in Amhara and Afar region: In September 2021, heavy summer season rains caused flooding in many parts of Ethiopia. Over 500,000 people were affected, 300,000 people were displaced by flooding around the Awash River areas in Amibara and Awash Fentale woredas (districts) of the Afar region, and at least five people died according to the OCHA Ethiopia report. The Koka and Kesem dams on the Awash River commonly known as the lowland dams represent a flood risk for the downstream communities due to overflow. This caused the displacement of more than 144,000 people in 2020. Heavy rainfall was reported in the northern Amhara Region, Bahir Dar, and Gondar[3]. The Somali, Tigray, and Afar regions are leading in the number of people affected or displaced by flooding in 2020 and 2021 (**Table 1**).

F | Gamo zone in south Ethiopia: The flood list Africa noted that at least 10 people died in a landslide caused by heavy rainfall in southern Ethiopia in May 2020. The landslide buried a two-story house, and several other homes were also damaged or destroyed in the area. Flooding has blighted wide areas of the country since late April. Seasonal flooding affected over 470,000 people in southern Ethiopia (**Figure 2**).

Flooding in Eastern Africa affected over 2.8 million people in 2019. In Ethiopia, about 570,000 people were affected, including more than 200,000 displaced, and rains have negatively affected the harvest season. (The OCHA Ethiopia August 2020 report).

Region	# of people affected	# of people displaced
Somali	336,810	179,140
SNNPR	398,491	98,306
Amhara	586,342	12,329
Oromia	539,761	52,429
Afar	63,410	40,490
Tigray	14,550	3,500
Gambela	44,340	30,635
Benishangul Gumz	55,979	3,915
Dire Dawa	15,000	10,000
Harari	2,000	500
Addis Ababa	10,000	3,000
TOTAL	**2,066,683**	**434,154**

Table 1 | The number of people per region displaced or affected by flood in Ethiopia in 2020. Source: Disaster Risk management and Food security sector.

It is estimated that more than 2 million people were affected by river and flash floods in the 2020 kiremt season in the flood-prone regions (**Figure 2**). Moreover, about 435,000 people, or 21% of the population across the country are likely to have been displaced (**Table 1**).

The above flooding events significantly reduced the accessibility to clean and safe drinking water supplies[3]. Floods are the main sources of contamination in poorly regulated water supply systems in several towns and cities of the country. Research indicated that more than 2,000 children die every year in Ethiopia due to contaminated drinking water-related diseases. Researchers estimate that 25% to 35% of the unknown causes of children's deaths in Ethiopia may be associated with contaminated water-related illnesses[2].

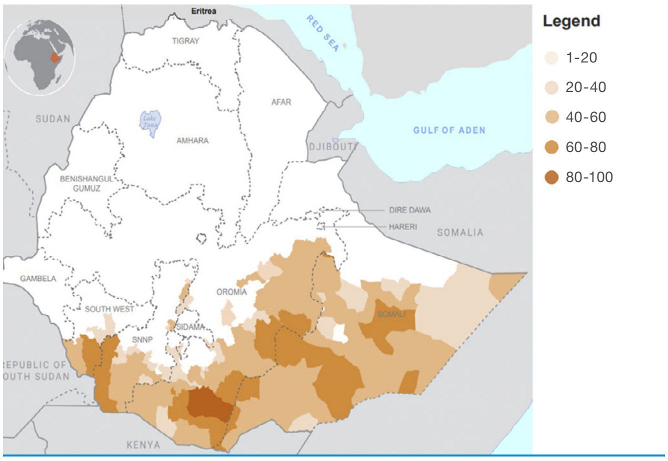

Figure 3 | Drought intensity comparison map. Several areas in southern and southeastern Ethiopia have been affected by the drought. Source: OCHA Ethiopia.

Figure 4 | Photos showing the impacts of drought on children's life. Kids traveling several kilometers barefoot to fetch water. Source: African News and OCHA Ethiopia.

The impacts of Droughts on water accessibility in Ethiopia

According to UNICEF, about 6.8 million people will need urgent humanitarian assistance by mid-March 2022 due to water scarcity. In Oromia and Somali around 225,000 malnourished children and over 100,000 pregnant and breastfeeding women need urgent nutrition support[4]. The lack of clean water is further worsening the situation for children and women[5].

Children are forced to drink contaminated water, risking contracting various diseases including diarrhea, which is a major cause of death among children under five. Children are also missing out on an education due to the drought[6]. The African news indicated that several students are out of school to help their parents in searching for safe drinking water (**Figure 4**). Over 155,000 children in the lowlands of Somali and Oromia regions have dropped out of school because of water scarcity. Frequently women and children travel more than 10 kilometers to fetch water[1]. African News reported that in Ethiopia and Somalia children are unable to attend their school due to water scarcity as they are busy searching for water all day long.

The report also highlighted, that three consecutive failed rainy seasons have brought on a severe drought in Ethiopia's lowland regions of Afar, Oromia, SNNPR and the Somali regions drying up water wells, killing livestock, and destroying crops.

The Africa renewal report indicated that Ethiopia is in the grip of its worst drought in recent history. More than ten million people need assistance. Humanitarian needs in Ethiopia have tripled since early 2015 as severe drought in some regions, intensified by the strongest *El Niño* in decades, caused successive harvest failures and widespread livestock deaths[4]. Acute malnutrition has risen dramatically, and one-quarter of Ethiopia's districts are now officially classified as facing a nutrition crisis[5]. The accessibility to clean and safe drinking water has been reduced significantly from 2015 to the present[1]. Village streams are drying, the water volume of rivers has decreased by more than 60%, groundwater is unavailable, and surface water is very little and contaminated[4]. The impacts of flooding, drought, and environmental contamination together worsen clean water accessibility, as well as the washed-out animal and human feces, solid wastes left on open ground, and plastics easily transported by flooding and mixed in the waters of rivers, streams, ponds, and wells[4]. Similar kinds of contaminants might be blown by dry wind bringing them into different water sources[6]. That is how both flooding and droughts play important roles in affecting the availability of clean and safe drinking water in Ethiopia. Climate change is directly impacting activities of human life in countries like Ethiopia[2].

According to OCHA, Ethiopia is highly vulnerable to severe seasonal droughts, having experienced them every decade since 1953. The 1983-1985 drought caused up to an estimated million famine-related deaths. The droughts of 2002, 2011, and 2015-2016 left also millions of Ethiopians without enough food[4]. Droughts not only cause food and nutrition insecurity, but they also limit access to water for people and animals, increase the burden of waterborne diseases, and can lead to displacement, disruptions in school attendance, and other negative effects[1]. After November 2020, four regions of Ethiopia, Afar, Oromia, Somali, and SNNP did not provide enough food, with about 12.9 million people being affected.

The intensity of drought increased significantly from 2020 to 2021. Ethiopia is experiencing a prolonged drought after three consecutive failed rainy seasons since late 2020 affecting 6.8 million people living in the Oromia, SNNPR, Southwest, and Somali regions. Several areas in southern and southeastern Ethiopia have been affected by the drought. **Figure 3** shows how frequently there was a dry ten-day period between October and December 2021, the last rainy season. Dry is defined as 80 percent or less than the zonal median normalized difference vegetation index.

The drought is compromising fragile livelihoods heavily reliant on livestock and causing worsening food security and nutrition. The affected people are in urgent need of food, water, healthcare, shelter, and livestock assistance.

Large-scale humanitarian assistance will be needed throughout much of the country in 2022, coupled with unhindered humanitarian access in northern Ethiopia, to avert the loss of lives and livelihoods[5].

Conclusions

The effect of climate change in terms of floods and droughts has become paramount in the global setting since it involves hydrological extremes affecting the natural, economic, and societal environment. The lack of access to safe and clean drinking water is aggravated by frequent flooding and drought events in Ethiopia. Climate affects the spatial and temporal availability of water across several regions of Ethiopia. However, several regions of the country including big cities such as Addis Ababa are experiencing unexpected and unseasonal rain, causing floods that destroy infrastructures and contaminate drinking water tanks, and wells. In other regions such as Somalia and Afar, people spent several hours and travel more than 10 kilometers to fetch a bucket of water. As a result, agricultural, educational, trading, mining, nomadic, and other activities are negatively impacted, affecting the overall economy of the country.

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Tassew Mekuria

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The role of water in developing social capital in Sub-Saharan Africa

By Musonda Joseph Mwansa and Jörg Imberger

Water is a core component of life for every living thing on this earth. Whether it's humans, animals, or plants, water plays a pivotal role in the maintenance of the ecosystem and its components. For humans, the need for water encompasses domestic and industrial uses to ensure the continuity of diverse life processes. The lack of access to clean drinking water shifts community focus away from employment and education opportunities and stigmatises affected families, rendering them hopeless and destitute. This is a delicate issue that demands urgent attention.

For six years in Australia, the first author recalls that he never once worried about accessing clean water or what life would be like without having a tap with clean water to use. Clean and safe drinking water was readily available within the house. When dining out, like most people in Australia, he had the freedom to choose between still and sparkling water.

After returning to his birth village of Kawambwa in Zambia, in search of his identity, he remembered vividly the mornings before school when he and his siblings rose early to collect water from a well, which would then be boiled to ensure it was safe for consumption. Seventeen years later, while on a visit back home to Kawambwa, he once again drank from the very well his father dug when he was eight years old. Unfortunately, the same kind of lifestyle in his village continues to this day.

Thousands of rural communities across Zambia and Sub-Saharan Africa collect their water from unprotected, self-dug wells and, in worst cases, from unprotected surface water (rivers, dams, lakes, ponds, streams, canals, and irrigation channels) sources which are all prone to faecal matter contamination. For example, a study investigation in a township in Eastern Zambia in the Petauke District, where most of the houses use borehole water, showed 75% of the 50 boreholes tested were microbiologically contaminated rendering the water unsafe for drinking[1].

Drinking untreated water exposes people in rural communities to water-borne diseases such as typhoid fever, cholera, and dysentery. Diarrhoeal diseases are the world's second leading cause of death with an estimated annual loss of 525,000 children under five years of age, mostly in developing countries[2]. Research on water, sanitation, and hygiene (WASH) in healthcare facilities in Sub-Saharan Africa identified a lack of basic WASH services available to patients and healthcare workers. This poses the threat wherein patients may get sicker when they enter these facilities, rather than find relief from illness and similarly puts healthcare workers at risk[3]. The need for clean and safe drinking water has become increasingly more important in the past two years, particularly due to COVID-19. Access to clean water is particularly important as handwashing is one of the most effective actions to reduce the spread of pathogens and prevent infections, including the COVID-19 virus.

There is often talk about building a united and sustained Africa, but the loss of nearly half a million future leaders yearly greatly jeopardises this dream. Safe and clean water reduces poverty as it sets the foundation for change to happen. The social and economic effects of lack of clean and safe drinking water plays a significant role in the ability of rural communities to develop and contribute economically to their country.

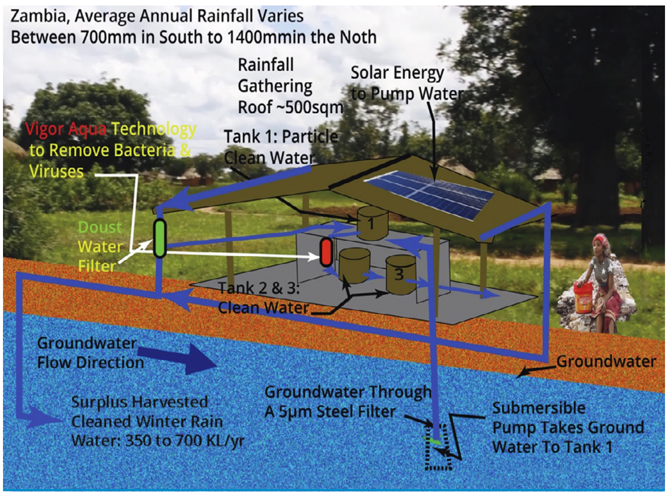

Figure 1 | Schematic of a Water Does Matter Smart Water Station.

Figure 2 | Global Empowers introduces water quality awareness during COVID-19 at Mwibeth academy in Zambia, 2021.

In Sub-Saharan Africa, people spend 40 billion hours a year fetching water, equivalent to a year's worth of labour by the entire workforce of France[4]. This translates into an economic loss of approximately USD260 billion, which is approximately 10% of Sub-Saharan Africa's GDP. In Zambia alone, the deaths caused by water-borne diseases account for economic losses equivalent to about 1.3% of its GDP or approximately USD 0.3 billion. The benefit-cost ratio of interventions to attain universal access to improved drinking-water sources and sanitation in Sub-Saharan Africa has been estimated to be 2.7, with a global economic return of US$4.3 per US dollar invested on water expenditures. For every dollar invested in water and sanitation, there is an economic return of between USD 3 and USD 34, which provides a great opportunity for local entrepreneurs, communities, and Sub-Saharan countries[4].

The development of rural drinking-water projects in Sub-Saharan Africa is largely dependent on financial aid from NGOs, which includes both monetary and non-monetary investments[4]. Approximately USD133.9 billion was allocated to safe drinking-water supply in developing countries between 1990 and 1994[5]. Zambia is one of the main benefactors of external aid for clean water projects. However, over time a reliance on financial aid results in most rural water projects lacking materials as well as technical resources for continuing maintenance of these projects when such aid is withdrawn. In 2015, Zambia's external debt reached USD 14.5 billion with more than 58% of Zambians earning less than the international poverty line of USD 1.90 per day[5]. This implies that the problem of access to safe drinking water is widespread in many Sub-Saharan African countries. In general, although donor investment has increased in developing countries, most rural communities still do not have access to safe drinking-water either because the people in these areas live far from water pump points or the existing water pumps break down and are not successfully repaired. This points to the need for an increase in donor investment which must also be accompanied by an increase in community involvement–from project planning to project completion to ensure project longevity and sustainability.

A donation to a charity is an excellent way to show solidarity with impoverished people, but this solidarity is often compromised because most charities see people only for how they are now, but not for what they are capable of becoming if they are given the right opportunities. All actions towards eliminating poverty and providing access to clean and safe drinking water should be taken while also maintaining the beneficiaries' dignity. Failure to do so contributes to further undermining Africa's self-image and reputation. The affected population requires programs that foster independence and provide economic freedom, together with opportunities to develop and use their abilities. There is also a need to create an awareness of personal control and develop confidence in having the capacity to influence individual outcomes. Academically driven associations such as IAHR could play an important role towards capacity-building and professional development. In fact, the General Assembly of the United Nations, through Resolution A/RES/64/292 (since 28 July 2010), recognised "the right to safe and clean drinking water and sanitation as a human right that is essential for the full enjoyment of life and all human rights." Through this Resolution, the General Assembly urged "states and international organisations to provide financial resources, capacity-building, and technology transfer through international assistance and cooperation, particularly to developing countries, to scale up efforts to provide safe, clean, accessible, and affordable drinking water and sanitation for all."

Inspired by the history of his childhood experiences and his longing for change in himself and in African societies, the first author started Global Empowers; a purpose-driven social enterprise focused on uplifting and freeing people to empower each other. Global Empowers helps impoverished people to become more self-aware of their strengths, enhancing their capacity to impact their communities. This personal experience is being shared here as a model of mindset and initiative that could be replicated in different parts of the continent.

Global Empowers has embarked on the Water Does Matter (WDM) project, partly funded by the Perth Rotary club and private donors. The purpose of the WDM is to change mindsets through water. The project aims to contribute towards improving the quality of life by reducing mortality and poverty rates caused by the consumption of contaminated water. Access to pathogen-free drinking water throughout rural Zambia alone will save the lives of approximately 9,000 Zambians every year. This includes 7,000 children under five-years who die from diarrhoea per year and presents an opportunity to gain the 1.3% in GDP lost due to lack of safe and clean drinking water[1].

Traditional centralised water supply schemes in remote or isolated communities are usually not economically viable due to the high capital, maintenance, and servicing costs for the required infrastructure. The objective of the WDM project is to empower remote districts starting in Kawambwa, Sinazongwe, and Mpulungu in Zambia to have the capacity to clean their water and create the conditions for a healthier life without the fear of contracting water-borne diseases like cholera, dysentery, and diarrhoea. This will be accomplished by the provision of sixty water stations which provide treated, clean, and enriched water that meet the drinking water standards of the Zambia Bureau of Standards and the World Health Organisation. These water stations are to be installed in or near local school and health centre campuses in the ten worst-affected communities, accounting for approximately 29% of suspected water-borne diseases in Zambia like typhoid and cholera. The station will be fitted with a digital community notice board providing information on water quality in a form easily understood by the community. Following the results of Global Empowers' recent water samples analysis from Water Corporation's water research and innovation precinct in Perth, Western Australia, the first station will be assembled in Zambia by June 2022. Water Corporation is the principal supplier of water, wastewater, and drainage services throughout the state of Western Australia. This project will yield two main outcomes. The first deliverable will be job opportunities for the local people. The pilot project will impact approximately 350 households per station.

Each station will have the capacity to provide a household of six with 10 litres of water per person, per day for drinking, cooking, and basic hygiene[4]. This provides a potential income of USD0.36 per household per day. The pilot project is the start of a larger, two-stage project that will target first, another 137,500 households in full-scale operation across rural Zambia and later, 5,000,000 households across Sub-Saharan Africa.

The second deliverable will be an educational program. Specifically, the WDM Ambassadors Programme which will focus on providing rural communities and school children with important water, sanitation, and hygiene information. The program will also teach participants how to use and maintain the water stations. The objective of this effort is to make each water station a hub for the educational program. A local water committee (comprising of teachers and parents) will be formed to include health workers, station sanitisers, and caretakers who will take over the daily operation and maintenance of the stations. Such communities will develop a sense of ownership. The pride associated with owning and caring for such a station will breed many enthusiastic water ambassadors. The project will also provide the WDM Ambassadors a training facility where individuals can learn essential water, sanitation, and hygiene education skills. The objective is to open this training programme to all, with initial enrolments aimed towards teachers in rural schools. The WDM Ambassadors club will facilitate the start of a movement throughout Sub-Saharan Africa motivated by the hope that water-borne diseases can become a thing of the past. Once students graduate from high school, the Water Ambassadors will be encouraged to spread their knowledge across Sub-Saharan Africa and play a key role in community behaviour changes regarding clean water practices, boosting therefore the project outreach and impact.

The mindsets of Sub-Saharan populations in rural and isolated areas require a paradigm shift. Every action aimed at their prosperity and improvements to their quality of life should first target their capacity building to empower their mindset with confidence, motivation, and unlimited possibilities. Maintaining human dignity is a central point for changing mindsets, and access to clean water is the least that any human should afford. Having access to clean drinking water and sanitation will facilitate Sub-Saharan African countries to progress towards the United Nations Sustainable Development Goal for safe and affordable drinking water for all by 2030 (SDG6) and sets a foundation for achieving other SDGs, which in return will lessen the financial health and economic burden and improve the mental wellbeing of individuals.

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Jörg Imberger
Jörg Imberger was the director and founder of the Centre for Water Research (1981-2015) at the University of Western Australia. Jörg Imberger in 1996 received the Stockholm Water Prize, also known as the Water Nobel Prize. He has been passionate in his love of Africa: from 1971, when he made a four-month journey with his wife, by public buses, along the East Coast of Africa from Cape Town to Addis Ababa in Ethiopia right up to recent times when he worked on a World Bank-funded project quantifying the horizontal mass transport in Lake Victoria.

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Metropolization and stormwater management in Casablanca city, Morocco

By Dalila Loudy and Saâd Azzaoui

Casablanca city is the economic capital of Morocco. With its 4.36 million inhabitants, the city has known significant pressure in terms of housing and related necessary infrastructure and utility services. To take control over a looming informal urban sprawl, a Master Plan for Urban Development, which is referred to by the acronym SDAU from its French name Schéma Directeur d'Aménagement Urbain, has been released in 2009.
The Plan launched the metropolization phase of Casablanca and its neighborhood in order to frame an unprecedented urbanization dynamic. The SDAU planned to open 20,000 ha to urbanization by 2030, including the creation of seven new towns in the city vicinity.

Casablanca metropolization and stormwater management problems

The increasing demographic development and related housing demand led to an update of the SDAU in 2014 that opened an additional 5000 ha to urbanization. Since 2009, the development rate of serviced lands has ranged between 300 ha/year and 800 ha/year, which considerably increased the impervious surfaces to be drained towards outlets mainly located on the Atlantic shores. Moreover, a number of urban centers were developed around the city implementing real estate projects in a geographic scattered way leaving thus many wide undeveloped land gaps between new real estate projects and already urbanized areas (Figure 1).

This horizontal development was also combined with vertical development as several villa zones were turned into high building zones. Therefore, impervious surfaces have increased and the existing stormwater networks in these zones have become undersized. The risk of urban flooding in such areas has then become higher urging the water utility to reinforce the stormwater system in order to evacuate the increased stormwater flows towards natural outlets.

Additionally, land constraints weigh heavily on stormwater drainage in peripheral areas. Indeed, 63% of the retention basins solutions recommended by the Stormwater Master Plan, require the use of various land, located in areas planned for urbanization. Land use controls and cost in these areas hinder the feasibility of the proposed solutions.

Despite the efforts made to support urban development and reduce areas prone to overflow problems, both at operation and investment levels, several projects could not be carried out due to the lack of funding.

In order to overcome these constraints and adapt to changing factors, a dual approach was adopted to support the city development: it consists of carrying out new infrastructure projects identified within the framework of the Stormwater Master plan, along with a rain event management approach for optimizing the operation of existing networks and structures, particularly in areas with deficiencies.

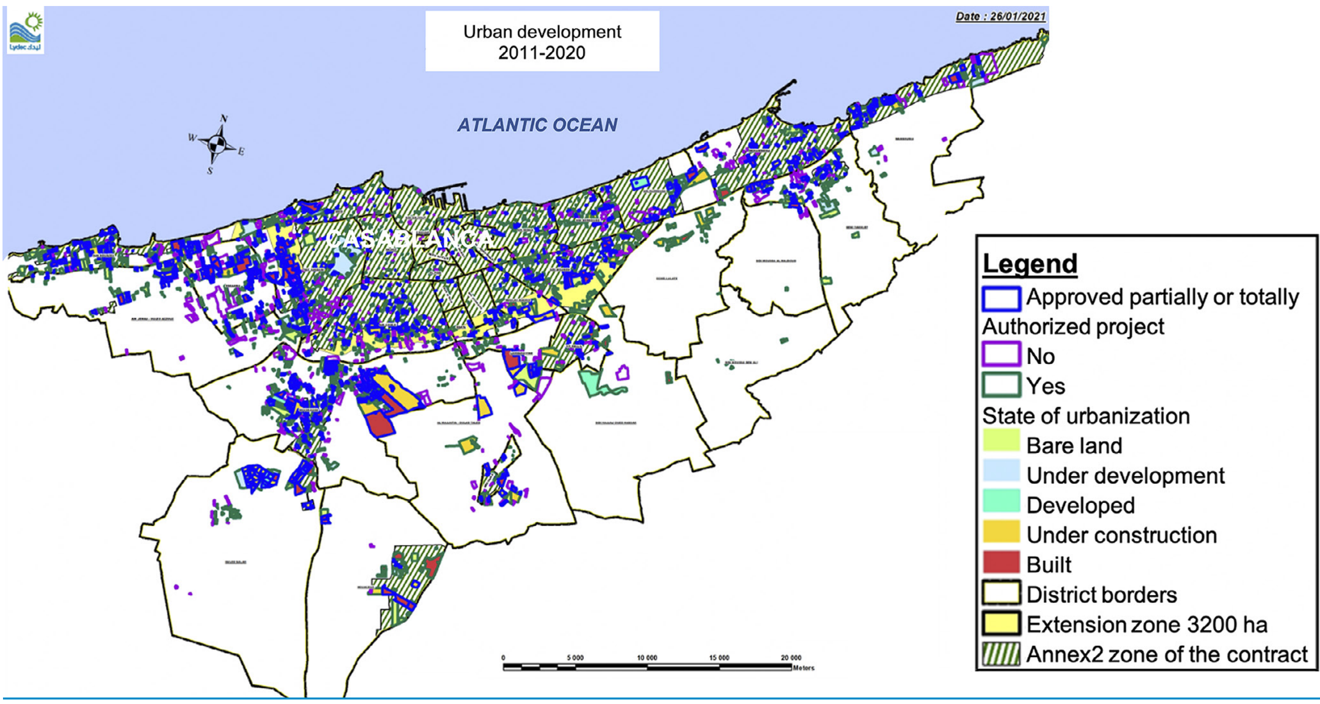


Figure 1 | Layout of real estate projects having submitted a sewer network connection request to Casablanca water utility LYDEC (2011-2020).

Urban Stormwater Master Plan measures to support the city metropolization

As part of the urban vision of Greater Casablanca drawn by the SDAU, the city water, sanitation and energy utility LYDEC, (a branch of SUEZ) produced an Urban Stormwater Master Plan (USMP) for extension zones in 2006, that was updated in 2011 in order to take into account new urban planning provisions. The main directives of the plan are new stormwater system development and runoff zoning.

1 | Stormwater system new development

Urban development of the city and its neighboring districts caused a population density increase and larger areas to be connected to sewer networks. Meeting this service demand requires both network extension and reinforcement.

A | Network extensions

• For the coastal extension zones located to the North of the axis formed by the urban highway, the Rabat-Casablanca highway to the East, and the National Road RN1 to the West where the discharge of rainwater towards the sea or few coastal wadis is possible without restricting the flow rate, a stormwater system based solely on the creation of collectors has been planned (**Figure 2**);

• For the extension zones located to the south of the Highway axis - RN1, the creation of storage basins will be necessary given the distance from the ocean and the inability of existing networks and wadis to accommodate the full flows generated by future zones open to urbanization. These basins will be emptied downstream into wadis or existing networks, infiltrating to the subsurface at a low rate (generally 1 l / s / ha), and sometimes by pumping when the topography requires it. The surface of the areas planned for urbanization within the scope of the SDAU can be estimated at nearly 25,000 hectares. The investments required for stormwater management of these extension areas have been summarily estimated at around 10.5 billion MAD excluding taxes.

B | Existing stormwater networks reinforcement

The USMP recommended the implementation of three large drainage culverts mainly because of their very low needs in terms of land mobilization and a better capacity to cope with odd rainfall events. These tunnels are (**Figure 3**):

• The SRO (System of Reinforcement of Western Casablanca): over a length of nearly 10 km, the SRO is designed to convey a ten-year peak flow of approximately 90 m³/s from the western basin of Casablanca to the Atlantic shores at the El Hank wastewater preliminary treatment station;

• The SRE (Reinforcement System of Eastern Casablanca): over a length of about 18 km, discharging into the sea at the point of Oukacha. This infrastructure is designed to evacuate a ten-year peak flow estimated at around 125 m³/s from the eastern basin of Casablanca;

• The SRM (Reinforcement System of Mohammedia city) allowing to evacuate a ten-year peak flow of around 25 m³/s.

These three reinforcement tunnel systems are supplemented by several local reinforcement storm sewer pipes operating as independent "local" reinforcement solutions.

The investments required for the implementation of the SRE, SRO, SRM reinforcement systems, including local reinforcement solutions has been summarily estimated at around 3.6 billion MAD excluding taxes.

Figure 4 shows part of the SRO stormwater drainage tunnel under El Jadida road in the south western part of Casablanca. The tunnel has a 3 m diameter and a length of 3.3 km.

Figure 5 shows the construction of the drainage well of the Hay Sadri neighborhood stormwater tunnel, part of the SRE system. The tunnel is at 40 m depth, and has 4 m diameter and 1.4 km length. The two infrastructures have been operational since December 2021.

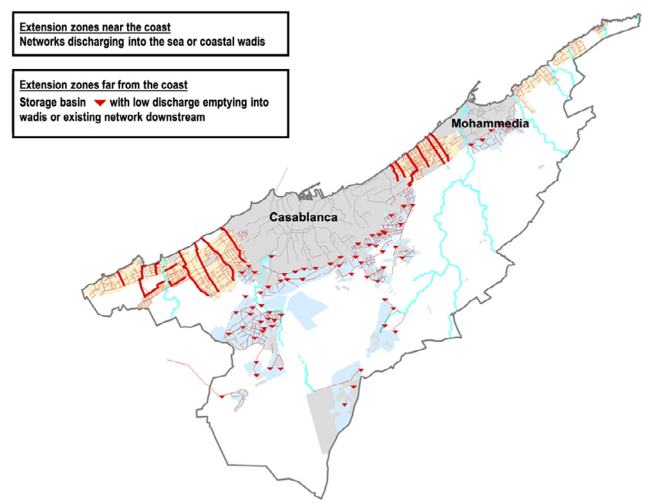


Figure 2 | Stormwater management provisions in extension zones.

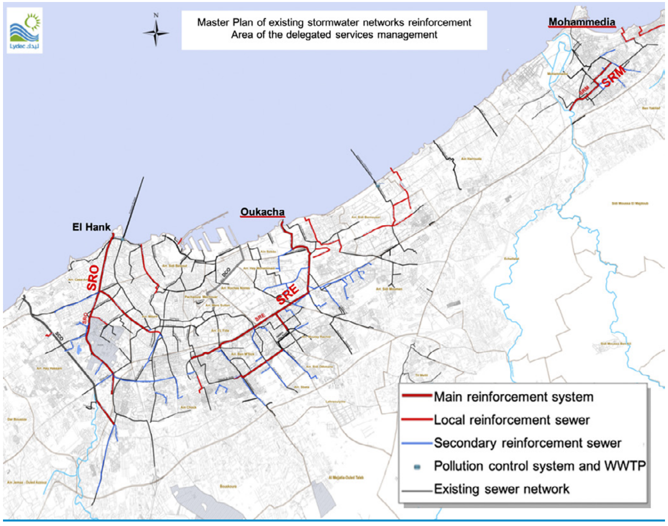


Figure 3 | Master Plan for reinforcing existing stormwater system in Casablanca and its neighboring municipalities.

Figure 4 | SRO stormwater drainage tunnel under *El Jadida* road in western Casablanca.

Figure 5 | A 4 m -diameter drainage well of the *Hay Sadri* neighborhood stormwater tunnel, part of the SRE system in eastern Casablanca.

2 | Runoff zoning

In order to update the USMP, an independent expert assessment was carried out for the implemented solutions for stormwater drainage, that aimed also at recommending optimal new measures within the boundaries of delegated management of the new extension zones. This study adopted a participatory and concerted approach between the various stormwater management stakeholders including the Ministry of the Interior, delegating Authority, municipalities, prefectures and provinces, the Urban Agency of Casablanca, the regional council of Casablanca –Settat, the River Basin Agency of Bouregreg and Chaouia, the water utility LYDEC and the National Meteorology Directorate.

Analysis of the various technical, urban and environmental constraints, the latest implemented developments, the projects in progress and the difficulties encountered during the completion of a number of solutions provided in the USMP, reconfirmed the need to use alternative infiltration and retention techniques upstream, establishing sectorial, integrated and multifunctional retention basins within the peripheral extension zones. These solutions should consider optimizing the drainage flow rates of the stormwater basins taking into account the capacity of the wadis and existing downstream networks. A runoff zoning study will then be carried out in order to:

- Differentiate between stormwater management systems and techniques according to each sector of Casablanca and its neighboring municipalities
- Adapt management methods according to the vulnerability of neighborhoods and the challenges of sustainable development
- Stormwater management rules adapted to each sub-basin
- Identify low-lying areas unsuitable for urbanization
- Integrate the water cycle in urban development decision making process.

Stormwater systems and infrastructures operational measures

The management of rainfall extreme events by the water utility in Casablanca and its neighboring districts, namely LYDEC, is carried out mainly through three type of actions that are preventive operations, mitigation/crisis management measures and Return on Experience (REX) or lesson learned/ postmortem documentation.

1 | Preventive measures

Flood preventive measures are based on the knowledge of flood risk-prone areas that are identified through a review of operational actions carried out by LYDEC. These measures concern the preventive cleaning of networks and checking the availability of operation equipment such as rain gauges, sensors, screens, pumps, etc., prior to each rainfall period. Furthermore, meetings with external services are organized and campaigns are deployed among the population for raising awareness with regard to the risk of clogging of different structures and its impact on the performance of stormwater systems in protecting against urban flooding.

2 | Flood mitigation and crisis management

The management of a major rain event requires a significant emergency response that depends on the "reaction time", which is the main element of management success. This requires precise knowledge of the flooding extent, related damages and the resources that can be mobilized by zone. Coordination plans are established at the district level to direct response teams to the most affected areas.

3 | Return on Experience (REX): flood events - networks modeling and improvement of hydraulic model calibration

As a final step in the management of flood events, the Return on Experience (REX) seeks to draw conclusions on the consequences of the flooding, to measure related human and economic impacts, and mostly to analyze the relevance of the means deployed during the crisis management phase. The REX step makes it possible to build and improve policies for flood risk control by achieving two main tasks:

– Summary of REX from field teams: Series of meetings are organized to collect and analyze observation data on overflows at the level of each district's zone. Overflow points maps are updated. The causes and impacts of each black point are analyzed and sketches of solutions are thus drawn up in collaboration with the operation teams. The main collected parameters are rain events characteristics (duration, intensities, return period, etc.);

flood zones and extents (flooded area, cause of the overflow, duration of the flood, etc.); solutions development (temporary solution, final solution, etc.) and required sectorial analyses for updating the stormwater master plan and the urban development master plan if necessary.

– Sewer networks modeling: Based on data of flow measurements, recorded rainfall and field observations, simulations of the events that have occurred are carried out to diagnose the networks and identify the causes of overflows (e.g., hydraulic deficiencies, operating problems, runoff, etc.). Comparison of on-site observations with the simulation models for several rainy events makes it possible on the one hand to refine the nature of observed dysfunctions, but also to improve the quality of the models taking into account urban development in the city and its neighboring areas.

4 | Towards dynamic management of Casablanca stormwater system: Interactions between the three components of the "Prevention-Mitigation/Management, and REX" process result in a cycle of continuous improvement of strategies, policies and means to prevent, manage and draw important lessons for future extreme rainfall events. In order to have greater capacity for analyzing network data in real time at the scale of the utility delegated management area, LYDEC uses the AQUADVANCED software, developed by SUEZ Environment. It is a modular software that provides a global view of real time network performance, while facilitating rapid and cross-analysis of any type of technical, asset or customer data. The AQUADVANCED tool is used to achieve the following tasks:

- Statistical analyses of rainy events
- Monitoring of main pipes: transit flows and filling rates
- Wastewater treatment plant: volumes of water treated, discharged, stored, etc.
- Stormwater weirs: Volumes discharged during rain event and in dry weather
- Storm basin: Max volume, filling rate
- Pumping stations: number of pumps in operation, maximum water levels reached.

By combining the results of hydraulic simulations, field findings and measurement data, the various forms of stormwater system deficiencies are analyzed to define areas for improving measures to control and manage flood risks. Such measures include adaptation of means and approaches to manage overflow areas; monitoring equipment to be added for completing data collection on AQUADVANCED models and updates of the final solutions provided by the stormwater master plan taking into account future urban development.

Recommendations

A more sustainable vision for the implementation and management of urban stormwater systems is becoming possible through an integrated approach involving all stakeholders. The objective is to find the right balance between urban development and the mobilization of investments while ensuring the safety of people and goods. Achieving such objective strongly relies on:

- Establishing appropriate financing modalities that enable building infrastructure while paying the related financial costs;
- Optimizing urban planning through provision of land and necessary easements for implementing infrastructures;
- Adopting alternative integrated resource management techniques to support urban development while limiting the impacts on existing networks downstream.

Low-lying areas are highly vulnerable to flooding. Therefore, it is recommended to reduce population density and limit compact urbanization in these areas, along with providing flood resilient infrastructure such as gardens, sports fields and playgrounds. Such infrastructures would operate as temporary retention areas during extreme rain events that exceed the capacity of stormwater networks, avoiding any negative impacts on local people. A large percentage of Africa's urban population lives in coastal cities and are facing climate change impacts particularly extreme rainfall events. Casablanca's stormwater management could serve as an example of good flood control practices for many coastal cities in Africa with similar climate and urbanization conditions (e.g., Abidjan, Dakar, Freetown, Lagos, Accra).

Dalila Loudy

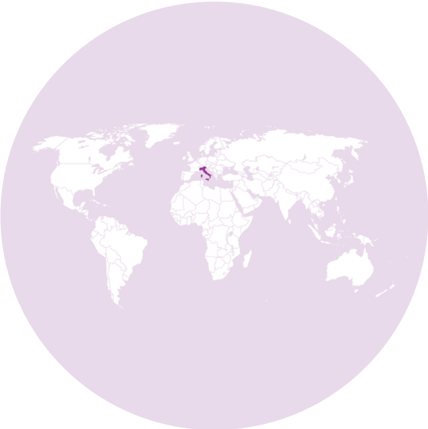
Dalila Loudy is a Professor at the department of Water and Environmental Engineering at the Faculty of Science and Technology of Hassan II University of Casablanca since 1996. In 1995, she graduated from Mohammedia School of engineers, in Rabat, Morocco and got her PhD in environmental water management at Cardiff school of engineering in the United Kingdom in 2005. Prof. Loudyi was selected by the Moroccan ministry of higher education as a National Contact Point in environment, in 2010, to promote the use of the Seventh European Framework Program (FP7) for research and development at a national level. She was the IAHR council member for MENA/India Subcontinent region during 2019-2021 period and currently a council member of LYDEC (SUEZ-Casablanca) Foundation.

Saâd Azzaoui

Mr Saâd Azzaoui is the Director of operations and works supervision at LYDEC (SUEZ branch in Casablanca, Morocco), Chairman of the SUEZ Asset Management Technical Committee and 'The City of Tomorrow' company's project manager. Graduated in Environmental Engineering and Regional Planning from Agro Paris Tech, he also holds a Master's degree in Development Projects Management from Agropolis Montpellier, France. Mr Azzaoui participated in the technical negotiations for the revision of LYDEC's delegated management contract from 2005 to 2009, as well as in technical exchanges for the preparation of the new Master Plan for Greater Casablanca with the Urban Agency of Casablanca and the Institute of Urban Planning of the Ile de France Region in 2008 and 2009.

FAMOUS WOMEN IN HYDRAULICS

The IAHR task force on Strengthening Gender Equity intends to raise the profile and visibility of women who made major contributions to hydraulics.



Gabriella Giuseppetti
1945 – 2003, Italy

Gabriella Giuseppetti graduated as a civil engineer from the University of Bologna in 1968. From 1971 she was at the Centre for Hydraulic and Structural Research CRIS of the national energy company ENEL in Milano, where she was in the research and development group for advancing the finite element method. She was appointed technical director of CRIS, a position she held until the *Italian Centre for Experimental Electrotechnics* CESI took over the former organization. Difficult years from 1995 to 2002 engaged Giuseppetti not only as director of CRIS and as ENEL's official representative abroad, but also in the defense of the autonomy of 'her' Centre. She was engaged in confrontations leading to a drastic downsizing of the research activities, and eventually to the merging of CRIS into CESI.

Giuseppetti's qualities led her not only to be chosen as a representative of CRIS in official missions but also to assume a more prominent role in her working environment. She was finally the head of the theoretical analysis section from 1988. Her nomination as director of CRIS in 2002 was warmly welcomed by the personnel, a group of some 150 collaborators, because she was sensitive to the personal vicissitudes and human troubles of her employees, which she took to heart with personal interest. Technically, she was mainly interested in numerical models relative to Italian dams and to safety aspects of dam schemes. International recognition of these qualities was not waiting, because she was conferred the chairmanship of an ICOLD committee. The International Congress of Large Dams ICOLD awarded her Honorary Membership in 2002. In 2003 she was conferred the title *Ufficiale dell'Ordine al Merito* by the Italian president.

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Biography extracted from the IAHR book *Hydraulicians in Europe 1800-2000 (Vol. 2) A biographical dictionary of leaders in hydraulic engineering and fluid mechanics* by Willy Hager. ISBN 9789078046066 p. 1272, 2003.
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IAHR Events Calendar

IAHR World and Regional Congresses
IAHR Technical Committees Events

04 2022 April

Online Youth Water Congress: "Emerging water challenges since COVID-19"
6–8 April 2022 | Online

IAHR-SPAIN WATER Workshop on the effects of climate change on the snow phenomenon and the evolution of glaciers in Spain
21 April 2022 | Online

05 2022 May

2nd IAHR Young Professionals Hydro-Environment Challenge
7–21 May 2022 | Online

Webinar on Methods for Ecohydraulics: Remote Sensing
17–20 May 2022 | Online

14th International Conference on Hydroscience and Engineering
26–27 May 2022 | Cesme, Turkey

14th annual meeting (InterPore2022)
30 May–2 June 2022 | Dubai, United Arab Emirates

06 2022 June

Flood Modelling and Forecasting Challenges in Industry Workshop
14–16 June 2022 | Sheffield, United Kingdom

26th IAHR International Symposium on Ice
19–23 June 2022 | Montreal, Canada

39th IAHR World Congress "From Snow to Sea"
19–24 June 2022 | Granada, Spain

31st IAHR Symposium on Hydraulic Machinery and Systems 2022
26 June–1 July 2022 | Trondheim, Norway

07 2022 July

4th International Conference on research and action in the service of rivers and large rivers [Co-sponsored]
4–7 July 2022 | Lyon, France

14th International Conference on Hydroinformatics (HIC2022)
4–8 July 2022 | Bucharest, Romania

6th W.A.T.E.R. Workshop on Advanced Measurement Techniques and Experimental Research
18–22 July 2022 | Lisbon, Portugal

08 2022 August

10th International Conference on Sewer Processes and Networks
24–26 August 2022 | Graz, Austria

9th International Symposium on Stratified Flows
29 August–1 September 2022 | Cambridge, United Kingdom

09 2022 September

7th IAHR Europe Congress: Innovative Water Management in a Changing Climate
7–9 September 2022 | Athens, Greece

4th International Symposium on Outfall Systems (ISOS 2021)
12 September 2022 | Buenos Aires, Argentina

10 2022 October

Africa Online Summer School
2–12 October 2022 | Online

14th International Symposium on Ecohydraulics (ISE 2022)
10–14 October 2022 | Nanjing, China

French National days for Coastal&Civil Engineering
11–13 October 2022 | Paris, French

1st IACRR International Conference on Coastal Reservoirs and Sustainable Water Management
17–20 October 2022 | Nanjing, China

9th International Symposium on Hydraulic Structures 2022 (ISHS 2022)
24–27 October 2022 | Roorkee, India

14th International Conference on Coasts, Ports and Marian Structures
31 October–2 November 2022 | Tehran, Iran

11 2022 November

30th IAHR Latin American Division Hydraulics Congress
7–11 November 2022 | Iguassu Falls, Brazil

River Flow 2022: the 11th International Conference on Fluvial Hydraulics
8–10 November 2022 | Online

14th International Conference on Preasure Surges
23–26 November 2022 | Czechia

12 2022 December

23rd Congress of the Asian Pacific Division of IAHR
14–17 December 2022 | Chennai, India

06 2023 June

9th Gerhard Jirka Summer School on Environmental Fluid Mechanics
6–10 June 2023 | Bari, Italy

08 2023 August

40th IAHR World Congress "Rivers-Lifelines connecting Mountains and Coasts"
21–23 August 2023 | Vienna, Austria

09 2023 September

18th International Symposium on River Sedimentation (ISRS)
5–8 September 2023 | Florence, Italy

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