Identifying Priorities for Achieving Water-secure African Cities: City Blueprint Approach

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Abstract

Africa's population growth rate more than doubles the global average. Most growth will occur in urban areas, posing water security challenges in sub-Saharan African Cities (sSAC). This study aims to identify capacity-development priorities for strengthening urban water security in sSAC by enhancing and empowering the abilities of young professionals to achieve measurable and sustainable results through integrated assessment and policy-dialogues. Based on the assessment of five sSAC conducted by local young water professionals. The results indicate that economic and social pressures such as GDP, high burden of disease and limited female participation in paid jobs, form less favourable conditions for water management performances. Water management improvement priorities have been observed with respect to access to potable drinking water and improved sanitation. Observations show that access to improved sanitation has to go together with wastewater treatment in order to prevent large-scale water pollution and related spread of vector-borne diseases. In addition, solid waste management as well as access to drinking water require upfront investments but also long-term operational financial planning that includes a reasonable salary and professional training of personnel. These water management priorities may provide important foci that enable a more sustainable transformation of sSAC. The assessment approach has demonstrated to support well-informed decision-making through independent, interactive, empirically based and city-specific assessments. Finally, by putting young water professionals in the driving seat, they become the water professionals of the future that have the necessary skills to think across organisational boundaries, political mandates and scientific disciplines.

Keywords: Urban Water Management, Sub-Saharan Africa, City Blueprint Framework, Water Security, Urban Transformation.

1. Introduction

The serious water security challenges today - especially in African cities, threaten lives and livelihoods, and negatively impact people's health and productivity to mention but a few. Action to improve water availability at a quality fit for purpose and protection of life, property and ecosystems are becoming extremely urgent and more important than ever. Africa is under threat of not actually achieving its Water Vision 2025 and the UN Sustainable Development

Goals (Naidoo and Fisher 2020). Africa's population growth is the highest among all continents and more than double the global average. Population projections indicate that the global urban population will more than double to 2.5 billion in 2050 and further growth to 4.3 billion in 2100 (UN 2019). Most of this growth will be directed in cities and urban areas, posing a huge challenge on water security, especially in urban areas. Climate change is intensifying these challenges by droughts that exacerbate water scarcity and changing precipitation patterns, often leading to water-related disasters. Urbanisation and climate change are largely irreversible and have become the "The new normal".

IWRM has been defined by the Technical Committee of the Global Water Partnership (GWP) as "a process which promotes the coordinated development and management of water, land and related resources, in order to maximize the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems." The proposed working definition of urban water security is based on the United Nations (UN) Sustainable Development Goals (SDG) on water and sanitation and the human rights on water and sanitation (SDG 6). It captures issues of urban-level technical, environmental and socio-economic indicators that emphasize credibility, legitimacy and salience.

Cities are experiencing the impacts of climate change through water-related issues while the sustainable management of water resources remains crucial for urban climate resilience. Accordingly, frameworks that integrate urban water management with climate change adaptation become increasingly relevant (Ozerol et al. 2020). Despite the lack of integrated tools and frameworks to assess urban resilience (Marana et al. 2019), several approaches that focus on water management and governance have been developed in recent years. These methods either focus on sustainability in a broader sense, at national or international level (SDGs 2018; ND-Gain 2020; Green City Index 2012) or are rather specifically focussed on drinking water and sanitation (IB-NET 2017). Little empirical work however addresses assessments of urban IWRM with the aim of strengthening the science-policy dialogue. The City Blueprint methodology provides an empirically-based holistic insight in water security in cities and is being tailored to the African context unlike most other methodologies.

At present, there is no internationally standardized indicator framework for urban IWRM. The 'City Blueprint' approach brings together three frameworks (Koop and van Leeuwen 2015a; Koop et al., 2017). It is a first attempt and aims to enhance the transformation towards water-wise cities by city-to-city learning (Koop and van Leeuwen 2015b). The City Blueprint Approach provides a platform in which cities can share their best practices and learn from each other (Koop and van Leeuwen 2017).

In order to strengthen the capacity of African cities in addressing climate change, urbanisation and becoming water secure, two factors can be identified as potential game changers. Firstly, it is important to obtain a transparent, comprehensive and policy-oriented understanding of the current status of urban water challenges such as too little, too much and too polluted water. Secondly, the role of independent young professionals can play as the main drivers in proving such a science-policy dialogue. In order to seize these opportunities, this study aims to identify capacity-development priorities for strengthening urban water security in Africa by enhancing and empowering the abilities of young professionals to achieve measurable and sustainable results through an indicator-based integrated assessment and further policy-dialogues. As such, the case studies have been led by a gender-balanced group of young professionals in five cities: Abuja (Nigeria, conducted by Mr. H. Ozoani), Bangui (Central African Republic, conducted by Mrs. V. Grekonzy), Harare (Zimbabwe, conducted by Mrs. G. Mukwirimba and T. Marekwa), Libreville (Gabon, conducted by Mrs. G. Ovenga) and Yaoundé (Cameroon, conducted by Mr. I. Abdoulahi).

2. Methodology and Materials

Realising sustainable urban water cycle services in municipalities and regions is a crucial step to achieving urban water security. The consequences of climate change and rapid urbanisation rate in sub-Saharan cities leave them with no option but to grasp which elements of the water cycle are sustainable and which need to be improved. For any strategic planning process, the baseline assessment is a crucial first step to take. It should be conducted before the actual interventions start to serve as a benchmark to determine priorities, set goals and monitor progress (Fig. 1).

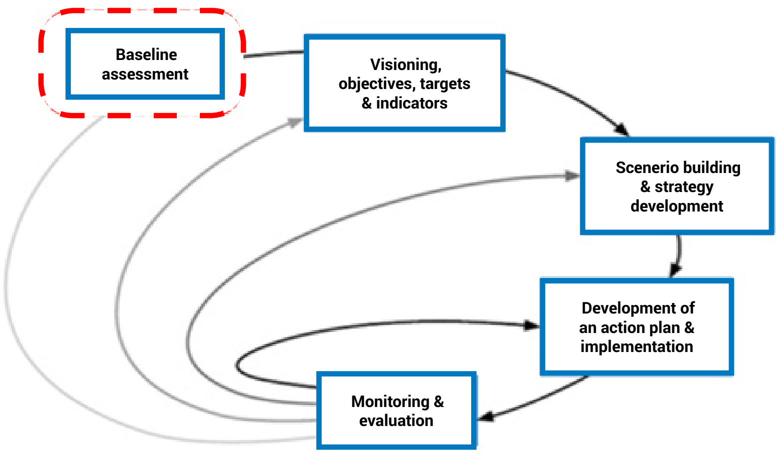


Figure 1. The City Blueprint Approach as the first step in the strategic planning process of municipalities and regions.

The assessment of the sustainability of IWRM was carried out, using the City Blueprint Approach in five African cities to give insights of their strengths, weaknesses and to give recommendations based on the analysis of the cities. The City Blueprint Approach is an ideal and practical communicative tool for any city that wants to transition to a water-wise city.

2.1 Assessment frameworks

The City Blueprint Approach is a diagnosis tool and consists of three complementary frameworks. The main challenges of cities are assessed with (1) Trends and Pressures Framework (TPF): https://library.kwrwater.nl/publication/61396712/. How cities are managing their water cycle is done with (2) the City Blueprint Framework (CBF): https://library.kwrwater.nl/publication/61397318/. Where cities can improve their water governance is done with (3) Governance Capacity Framework (GCF): https://library.kwrwater.nl/publication/61397218/.

2.1.1 Trends and Pressures Framework (TPF)

The TPF has a total of 24 indicators divided into four main categories which are: social, environmental, financial pressures and the fourth category, i.e., the World Bank governance indicators (Table 1).

Table 1. Overview of the TPF categories and indicators

<table>
<tr><th>Category</th><th colspan="2">Indicators</th></tr>
<tr><td rowspan="4">I. SOCIAL</td><td colspan="2">1 Urbanization rate</td></tr>
<tr><td colspan="2">2 Burden of disease</td></tr>
<tr><td colspan="2">3 Education rate</td></tr>
<tr><td colspan="2">4 Female participation</td></tr>
<tr><td rowspan="10">II ENVIRONMENTAL</td><td rowspan="4">Flood risk</td><td>5 Urban drainage flood</td></tr>
<tr><td>6 Sea level rise</td></tr>
<tr><td>7 River peak discharges</td></tr>
<tr><td>8 Land subsidence</td></tr>
<tr><td rowspan="3">Water scarcity</td><td>9 Freshwater scarcity</td></tr>
<tr><td>10 Groundwater scarcity</td></tr>
<tr><td>11 Sea water intrusion</td></tr>
<tr><td>Water quality</td><td>12 Biodiversity</td></tr>
<tr><td>Heat risk</td><td>13 Heat island</td></tr>
<tr><td>Air quality</td><td>14 PM2.5/10</td></tr>
<tr><td rowspan="4">III FINANCIAL</td><td colspan="2">15 Economic pressure</td></tr>
<tr><td colspan="2">16 Unemployment rate</td></tr>
<tr><td colspan="2">17 Poverty rate</td></tr>
<tr><td colspan="2">18 Investment freedom</td></tr>
<tr><td rowspan="6">IV GOVERNANCE</td><td colspan="2">19 Voice and accountability</td></tr>
<tr><td colspan="2">20 Political stability</td></tr>
<tr><td colspan="2">21 Government effectiveness</td></tr>
<tr><td colspan="2">22 Regulatory quality</td></tr>
<tr><td colspan="2">23 Rule of law</td></tr>
<tr><td colspan="2">24 Control of corruption</td></tr>
</table>

The 24 TPF indicators are standardized to a scale of 0-10 and divided in ordinal classes expressed as a 'degree of concern' as shown in Table 2.

Table 2. Scoring of the TPF indicators as degree of concern

TPF indicator score	Degree of concern
0 – 2	no concern
2 – 4	little concern
4 – 6	medium concern
6 – 8	Concern
8 – 10	great concern

2.1.2 City Blueprint Framework (CBF)

The CBF framework consists of 24 indicators divided over seven main categories: I basic water services, II water quality, III wastewater treatment, IV water infrastructure, V solid waste, VI climate robustness and VII plans and actions (Table 3). In the application of the CBF, 24 indicators are standardized according to a scale of 0-10 in which 10 points implies an excellent score and 0 points indicates a high improvement potential. This is done by comparing the values from an international range, using natural boundaries of 0 and 100% or by using ordinal classes. Often the min-max method is applied exemplified in equation 1:

$$\frac{value - minimum\ value}{maximum\ value - minimum\ value}\ X\ 10\ = \text{Indicator score} \quad (1)$$

For a detailed explanation of the indicators scores, one can consult the online questionnaire: https://library.kwrwater.nl/publication/61397318/.

Table 3. Indicators of the CBF

Category	Indicator
I. Basic water services	1 Access to drinking water
	2 Access to sanitation
	3 Drinking water quality
II. Water Quality	4 Secondary WWT
	5 Tertiary WWT
	6 Groundwater quality
III. Wastewater treatment	7 Nutrient recovery
	8 Energy recovery
	9 Sewage sludge recycling
	10 WWT energy efficiency
IV. Water infrastructure	11 Stormwater separation
	12 Average age sewer
	13 Water system leakages
	14 Operation cost recovery
V. Solid waste	15 MSW collected
	16 MSW recycled
	17 MSW energy recovered
VI. Climate adaptation	18 Green space
	19 Climate adaptation
	20 Climate-robust buildings
VII. Plans and actions	21 Management & action plans
	22 Water efficiency measures
	23 Drinking water consumption
	24 Attractiveness

2.2 Research method and case study description

Through a collaboration between KWR Water Research Institute and UNESCO Headquarters and five Field Offices, local young professionals with a background in water & environmental sciences have been supported to conduct this research in the city of Abuja (Nigeria), Bangui (Central African Republic), Harare (Zimbabwe), Libreville (Gabon) and Yaoundé (Gabon) (Fig. 2). The young professionals collected data on the key social, environmental and financial trends and pressures that can limit good water management – as well as the data needed for carrying out the City Blueprint assessments of water management performance. As a next step, a governance capacity analysis was conducted in Libreville and Yaoundé to identify the capacity-development priorities.

Figure 2. Map showing the 5 African cities on Africa's map

The assessments began in September 2019 and were completed in February 2020. To kick-off the assessments the young professionals were introduced to the CBA and had to read through the CBA reading materials on its rationale, methodology and applications. This was a good exercise as it provided good insight about their intended project. Simultaneously, the young professionals engaged in desktop research to complete the frameworks. The young professionals searched for the data through consulting public reports, websites, policy documents or scientific studies leading to preliminary scores of the indicators for which information was publicly available. The data for the assessments were gathered in two successive steps. First, an extensive literature study was carried out to determine the preliminary scores for all the indicators. Secondly, data collection interviews were carried out with municipalities and other relevant local stakeholders. An online webinar was organised by UNESCO headquarters and KWR Water Research Institute to present the methodology to be followed and instructions on conducting the assessment. The webinar provided an opportunity for questions the young professionals had, to be answered. Data collection interviews were carried out with municipalities and other relevant stakeholders. The young professionals were in regular contact with KWR and UNESCO headquarters for support in this process. In addition to the kick-of webinar, feedback sessions for each city were organised to go through every detail and discuss how to deal with methodological and practical barriers. Processing and analysis of the collected data following the CBA guidelines and development of reports was done.

An urban water security workshop was organised with the aim of jointly developing a roadmap for delivering water security in African cities based on the baseline assessment outcomes of the work implemented in the five cities. The workshop kicked off with keynote speeches, setting the scene for the discussion, by Dr. Callist Tindimugaya from the Ugandan Ministry of Water and Environment, and IWA Executive Director professor Kala Vairavamoorthy (KWR 2020). Presentations were prepared by the young professionals which they presented at the workshop together with their key recommendations to the local authorities. The workshop marked the beginning of a network of cities and the development of a city-to-city programme on water security. City workshops took place in each of the cities with local decision-makers, the results, recommendations and most viable solutions were presented. This was followed by discussions on how the cities can best improve their water management.

The study is now expanding with the assessment of Windhoek in Namibia as the goal is to include all African capitals to make sure no one is left behind. The young experts from Harare, already trained, are also supporting the Namibia initiative in a logic of training of trainers which ensures sustainability of the programme.

3. Results

The main findings of the five African Cities (Abuja, Bangui, Harare, Libreville and Yaoundé) are provided in this chapter.

Table 4. Case study brief description of each of the 5 African cities (population, population growth rate, climate & elevation, source of water, key stakeholders consulted)

City Name	Description	Key stakeholders consulted
Abuja (Nigeria)	Nigeria's Capital, Abuja City lies 477m above sea level and falls within latitude 745' and 739', and the climate is basically tropical. United Nations figures showed that Abuja grew by 139.7% between 2000 and 2010, making it the fastest growing city in the world. It currently has an estimated population of around 3.3 million people. Abuja receives part of its drinking water supply from the lower Usuma dam located in Bwari area council of the federal capital territory (https://www.watertechnology.net).	Federal Capital Territory water board Federal Capital Territory administration Abuja Environmental Protection Board ·Nigeria Integrated Water Resources Management Commission
Bangui (Central African Republic)	Bangui is the capital and largest city of the Central African Republic. As of 2012, the city had an estimated population of 734,350. Population growth is 2.14%/year, based on the 2019 population. According to Wikipedia Bangui has an elevation of 369 m. It has a tropical savanna climate (Köppen) with dry winters. The source of drinking water is the Oubangui River SODECA, boreholes.	Ministry of Energy and Water Resources Ministry of Urban Planning National Rural Water and Sanitation Agency Ministry of Public Health Water distribution company in Central Africa Department of the Public Service. Ministry of Planning and Economy National Water Agency
Harare (Zimbabwe)	Harare is the capital and most populous city of Zimbabwe. Population size of Harare increased from 1.87 million in 1997 to 2.24 million in 2014 growing at an average annual rate of 4.67%. Harare has an average population of 1.53 million people (excluding the satellite towns) in 2020 and estimated growth rate of 0.59% from 2019.It lies at an elevation of 1,483 metres and has a subtropical highland climate, temperate climate. Harare obtains raw water from four impoundments on the Manyame River. These are Harava and Seke dams which supply Prince Edward treatment works, and Chivero and Manyame dams which supply Morton Jaffray treatment works.	Harare city council Environmental Management Agency Zimbabwe National Water Authority Zimbabwe Statistics Agency Ministry of Lands, Agriculture, Water, Climate and Rural Resettlement UNICEF Zimbabwe
Libreville (Gabon)	Libreville is the capital and largest city of Gabon. As of the 2013 census, its population was 703,904. It has an equatorial, hot and humid climate, characterised by very high rainfall (2000 to 3800 mm) and a large number of rainy days ranging from 170 to 200.	National Anti-Pollution Centre National Climate Council General Directorate of Water General Directorate of the Environment and Nature Protection The Heritage Society The Institute of Hygiene and Public Health

City Name	Description	Key stakeholders consulted
Yaoundé (Cameroon)	Yaoundé is the capital of Cameroon, with a population of more than 2.8 million, the second-largest city in the country after the port city Douala. The population of the greater metropolitan area is around four million and the urban area grows at a rate of 6%, based on data of 2006. It lies in the Centre Region of the nation at an elevation of about 760 metres above sea level. The climate is of an equatorial type with an average temperature of 23.5°C.	7 municipalities that comprise the city of Yaoundé. Ministries in charge of water and energy, environment and sustainable development, scientific research, transport, housing and urban development private sector companies, managers of water treatment plants (INGEPRES and SOPREC) and ANT-Cmr

3.1. Results of the Trends and Pressures Framework (TPF)

The Trends and Pressures Analyse for the five African cities have been provided and scores have been calculated and reviewed and are provided in Table 5. The TPF results show that the social, environmental, financial and governance challenges are substantial which form less favouring conditions for water management performances. In particular, economic, and social pressures such as a high burden of disease and limited female participation in paid jobs stand out. The Trends and Pressures Index (TPI), the arithmetic mean of the 24 indicators of the TPF of five cities are: Abuja (5.5), Bangui (5.1), Harare (4.9), Libreville (5.1) and Yaoundé (5.2). This means that cities face considerable social, environmental, financial and governance pressures that can affect their local water management.

For Abuja, all the current values of indicator 21 (government effectiveness), indicator 22 (regulatory quality), indicator 23 (rule of law) and indicator 24 (control of corruption) are all of concern and great concern. Accordingly, Abuja's water management can be hindered by these governance issues. Therefore, there is a need for early intervention with the relevant authorities in the Nigerian water sector to correct this situation and gradually eliminate its detrimental impact on the overall water management of the Federal Capital Territory. For Bangui, the results show a multitude of high concerns related to the burden of disease, education, air quality, economic pressure, poverty, political stability, effective government, and rule of law. The Harare results show a high level of concern in terms of burden of disease, education, economic pressure and regulatory quality. Many other World Bank governance indicators (indicators 19-24) also attracted high concern. Libreville has two major concerns in the areas of education and unemployment. Many other governance indicators (indicators 19-24) of the World Bank are also of concern. For Yaoundé, nine indicators have "serious concern" in the areas of burden of disease, education rate, vulnerability to river floods, land subsidence, air quality, economic pressure and political instability. These pressures can hamper the efforts of water managers to provide good urban water services, as measured by CBF. Table 5 provides the assessment scores of the five sub-Saharan African cities that have been assessed in this study.

Table 5. Overview of the Trends and Pressures Framework (TPF) of Abuja (Ab), Bangui (Ba), Harare (Ha), Libreville (Li), Yaoundé (Ya). Great concerns are depicted in bold

Category	Indicators	Cities				
		Ab	Ba	Ha	Li	Ya
I Social	1 Urbanization rate	9.3	5.5	4.8	5.7	7.8
	2 Burden of disease	10.0	10.0	9.0	7.0	9.3
	3 Education rate	9.4	9.7	9.7	9.9	9.3
	4 Female participation	5.2	3.4	2.1	5.4	2.8
II Environmental	5 Urban drainage flood	6.9	5.3	7.5	10.0	10.0
	6 Sea level rise	0.0	0.0	0.0	10.0	10.0
	7 River peak discharges	0.0	0.0	0.0	0.0	0.0
	8 Land subsidence	0.0	0.0	0.0	10.0	10.0
	9 Freshwater scarcity	0.0	4.0	0.0	0.0	0.0
	10 Groundwater scarcity	0.0	2.5	0.0	0.0	0.0
	11 Sea water intrusion	0.0	0.0	7.5	0.0	0.0
	12 Biodiversity	3.0	3.2	2.9	5.8	5.8
	13 Heat island	4.8	5.0	5.0	0.0	0.0
	14 PM2.5/10	8.9	2.9	2.9	10.0	10.0
III Financial	15 Economic pressure	9.8	10.0	9.8	7.6	9.9
	16 Unemployment rate	4.0	1.4	2.1	10.0	1.2
	17 Poverty rate	8.9	10.0	5.7	0.6	4.0
	18 Investment freedom	5.5	5.5	7.5	4.0	7.0
IV Governance	19 Voice and accountability	5.8	7.4	7.3	6.9	7.2
	20 Political stability	9.4	9.6	6.4	5.5	9.6
	21 Government effectiveness	7.0	8.4	7.4	6.6	8.4
	22 Regulatory quality	6.8	7.7	8.2	6.8	6.6
	23 Rule of law	6.8	8.4	7.5	6.4	7.2
	24 Control of corruption	7.1	7.5	7.4	6.7	7.3

3.2 Results of City Blueprint Framework (CBF)

The City Blueprint Framework for Abuja, Bangui, Harare, Libreville and Yaoundé have been provided, scores have been calculated and reviewed and are provided in Table 6.

The Blue City Index (BCI) scores which are the overall performance levels of the five cities based on their CBF indicator scores: Abuja (2.3), Bangui (1.9), Harare (3.7), Libreville (2.5) and Yaoundé (2.4). Cities can be ranked according to the BCI scores assigned to each of them. Four cities with BCI scores between 2 and 4, are classified as wasteful cities, except for Bangui with a score of 1.9, are classified as cities with insufficient basic water services. All the cities scored high in terms of water consumption. High water consumption means that the residents of these cities do not consume a lot of water.

For Abuja, new measures should particularly address CBF indicators with a score from 0 to 4. These priorities are related to wastewater treatment, reduction of leakages and solid waste management. Increased government financial support for worker training and capacity building for these priority areas will be highly advantageous. Development of more creative and sustainable urban water management and record-keeping practices that are consistent with global best practices would help improve the current situation.

Bangui shows high scores in terms of drinking water quality, average age of sewers, leaks in the water system, solid waste collected, green spaces and consumption of drinking water. On the other hand, there are enormous challenges in drinking water supply, treatment of wastewater and collecting and treating solid waste.

Table 6. City Blueprint Framework's scores of Abuja (Ab), Bangui (Ba), Harare (Ha), Libreville (Li) and Yaoundé (Ya)

Category	Indicator	Cities				
		Ab	Ba	Ha	Li	Ya
I Basic water services	1 Access to drinking water	4.0	3.0	6.5	5.5	6.8
	2 Access to sanitation	9.7	2.8	7.0	4.8	9.3
	3 Drinking water quality	9.5	9.3	9.4	9.9	4.8
II Water quality	4 Secondary WWT	2.1	4.6	6.0	0.0	3.5
	5 Tertiary WWT	0.3	0.0	6.0	0.0	0.0
	6 Groundwater quality	2.9	2.0	5.3	9.0	4.9
III Wastewater treatment	7 Nutrient recovery	0.0	0.0	0.0	0.0	0.0
	8 Energy recovery	0.0	0.0	0.0	0.0	0.0
	9 Sewage sludge recycling	9.7	0.0	2.50	0.0	0.1
	10 WWT energy efficiency	0.0	2.0	2.0	0.0	0.0
IV Water infrastructure	11 Stormwater separation	10.0	0.0	10.0	0.0	0.0
	12 Average age sewer	6.0	9.6	0.0	5.0	4.2
	13 Water system leakages	0.3	8.0	4.30	0.1	8.8
	14 Operation cost recovery	2.7	6.0	3.9	9.3	5.4
V Solid waste	15 Solid waste collected	1.9	10.0	8.50	9.4	7.7
	16 Solid waste recycled	0.0	0.0	1.0	2.0	0.2
	17 Solid waste energy recovered	0.0	0.0	0.0	0.0	0.1
VI Climate adaptation	18 Green space	4.4	10.0	10.0	10.0	1.3
	19 Climate adaptation	4.0	5.0	6.0	9.0	7.0
	20 Climate-robust buildings	0.0	0.0	7.0	5.0	7.0
VII Plans and actions	21 Management and action plans	2.0	4.0	6.0	7.0	7.0
	22 Water efficiency measures	5.0	4.0	4.0	5.0	7.0
	23 Drinking water consumption	10.0	10.0	8.90	10.0	9.3
	24 Attractiveness	4.0	1.0	4.0	4.0	6.0

The Harare results show that drinking water quality, stormwater separation, green space, solid waste collected and drinking water consumption indicators achieve high results. On the other hand, there are great challenges in wastewater treatment, solid waste treatment and the average age of sewer.

Libreville scores well on drinking water quality, groundwater quality, operating cost recovery, solid waste collection, green space, climate adaptation and drinking water consumption. However, it is clear from table 6 that access to sewage facilities, wastewater treatment and solid waste management are the main challenges facing the city.

Yaoundé scores highly on issues such as access to sanitation, solid waste collection, climate adaptation, water system leakages and drinking water consumption. However, it is clear that stormwater separation, wastewater treatment and solid waste management are the main challenges facing the city shown in table 6.

The City Blueprint indicators that indicated the largest room for improvement in the five cities relate to wastewater treatment, solid waste collection and treatment as well as infrastructure planning. Recommendations were drafted and viable solutions for the cities were proposed based on the CBF results. One of the major recommendations is the need for capacity building and dialogues between the government, city's officials, municipalities and other relevant stakeholders to promote unity, in order to find solutions to current and future problems in their urban water cycle services.

4. Discussions

4.1 Sub-Saharan African cities in transformation

It is evident that sub-Saharan African cities will undergo an unprecedented transformation in the coming decades. Water management will be at the core of this intriguing transformation that will shape the lives of hundreds of millions of people. However, little systematic empirically-based studies have focussed on urban transformations. Based on a qualitative historical analysis of Australia's urban water management (Brown et al. 2009) identified six cumulative stages of urban transition: the water supply city, the sewered city, the drained city, the waterways city, the water cycle city, and the water sensitive city. A similar categorisation has been proposed by (Koop and Van Leeuwen 2015b) based on the CBF assessment of 45 cities across the globe (Table 7).

Table 7. Levels towards water wisdom based on 45 City Blueprint assessments (Koop and Van Leeuwen 2015b)

BCI	Categorization of IWRM in cities
0 – 2	Cities lacking basic water services Access to potable drinking water of sufficient quality and access to sanitation facilities are insufficient. Typically, water pollution is high due to a lack of WWT. Solid waste production is relatively low but is only partially collected and, if collected, almost exclusively put in landfills. Water consumption is low but water system leakages are high due to serious infrastructure investment deficits. Basic water services cannot be expanded or improved due to rapid urbanization
2 – 4	Wasteful cities Basic water services are largely met but flood risk can be high and WWT is poorly covered. Often, only primary and a small portion of secondary WWT is applied, leading to large scale pollution. Water consumption and infrastructure leakages are high due to the lack of environmental awareness and infrastructure maintenance. Solid waste production is high and waste is almost completely dumped in landfills
4 – 6	Water efficient cities Cities implementing centralized, well-known, technological solutions to increase water efficiency and to control pollution. Secondary WWT coverage is high and the share of tertiary WWT is rising. Water efficient technologies are partially applied, infrastructure leakages are substantially reduced but water consumption is still high. Energy recovery from WWT is relatively high while nutrient recovery is limited. Both solid waste recycling and energy recovery are partially applied. These cities are often vulnerable to climate change, e.g., urban heat islands and drainage flooding, due to poor adaptation strategies, limited stormwater separation and low green surface ratios.

BCI	Categorization of IWRM in cities
6 – 8	Resource efficient and adaptive cities WWT techniques to recover energy and nutrients are often applied. Solid waste recycling and energy recovery are largely covered whereas solid waste production has not yet been reduced. Water efficient techniques are widely applied and water consumption has been reduced. Climate adaptation in urban planning is applied e.g., incorporation of green infrastructures and stormwater separation. Integrative, centralized and decentralized as well as long-term planning, community involvement, and sustainability initiatives are established to cope with limited resources and climate change.
8 – 10	Water wise cities There is no BCI* score that is within this category so far. These cities apply full resource and energy recovery in their WWT and solid waste treatment, fully integrate water into urban planning, have multi-functional and adaptive infrastructures, and local communities promote sustainable integrated decision making and behaviour. Cities are largely water self-sufficient, attractive, innovative and circular by applying multiple (de)centralized solutions.

Most sub-Saharan African cities, including the five cities assessed in this paper, seem to be transforming from a city lacking basic water services towards wasteful cities. However, the identified levels towards water-wisdom are far from optimal and reveal a process of problem-shifting that has happened in many cities across the globe (Koop 2019). Problem-shifting refers to a process where a management solution results in the creation of new problems. Patterns of problem-shifting have been observed in the 45 City Blueprint assessments across the full range of water management performances. First, cities that improve the access to basic water services tend to shift their problems towards strong pollution since treatment of the resulting waste streams is often unaccounted for. Second, cities that invest in pollution control, tend to become highly invested into waste management and wastewater treatment that does not account for the emerging scarcity of raw materials. In many cases, Africa's traditional small-scale circular economy approaches are being replaced with large-scale efficient but also linear systems (Ddiba et al. 2020). Third, many cities achieve full access to basic water services and improve their pollution control, but have largely disregarded the key role that water has in the spatial adaptation to climate change related challenges of water scarcity, flood risk management and water quality.

Given the unprecedented growth of sub-Saharan African cities, it seems that sSAC can simply not afford to go through the same transformation process as many European, American and Australian cities have gone through in the past centuries. Hence, the challenge is to leapfrog this array of at least partly avoidable problems. This paper has provided an integrated empirically-based assessment of water management in Abuja, Bangui, Harare, Libreville and Yaoundé which includes key facets such as access to potable drinking water and sanitation, solid waste management, water infrastructure management, urban planning, and wastewater treatment. The results of this integrated assessment enable the identification of water management priorities that may help other sub-Saharan African Cities too in leapfrogging their city towards a higher level of water wisdom.

Improve access to sanitation and wastewater treatment simultaneously

Drinking water consumption is rather low (and thus, scores high) and the drinking water generally complies with local quality standards. Another positive observation is that the share of green area in these cities is moderately high. On the other hand, approximately 67% if the population in these cities has access to sanitation facilities (indicator 2) and has to improve substantially in order to prevent the transmission of diseases such as cholera, diarrhoea, dysentery, hepatitis A, typhoid and polio. Efforts to achieve better living conditions have led to substantially more people getting access to sanitation in the form of flush toilets and septic tanks with less people relying on open defecation (Dominguez Torres 2012). However, because of rapid urban growth, the percentage of urban dwellers lacking access to improved sanitation remained relatively unchanged meaning the absolute number of urban dwellers that lack access to sanitation still increases in sub-Saharan African Cities. The pressure is accumulating in these cities. Even more so, the CBF indicators also show that wastewater treatment has a rather low coverage or is non-operational (indicators 4 & 5).

In addition, the recovery of nutrients or energy from wastewater is particularly low (7-10). The unprecedented growth in the number of urban dwellers with access to improved sanitation poses a radical change in the pathway of nutrient emissions in sub-Saharan Africa. Historically, most nutrients have been reused in agriculture or biologically degraded on land. Nowadays, most nutrients directly enter surface waters in high point source concentrations that lead to oxygen depletion and biodiversity loss, threatening drinking water, fishery, aquaculture and tourism services on which many people rely for their daily income and food. Even more so, prolonged episodes of water scarcity and storm events – amplified by climate change – further increase the vulnerability and exposure of cities' inhabitants to polluted water. Africa's nutrient emissions are projected to double or triple over the next 40 years (Ligtvoet et al. 2014). Since access to safe drinking water and sanitation are – for obvious reasons – the top priorities under Sustainable Development Goal 6, most city planners however fail to notice this ongoing water pollution thread in and around their cities. Wastewater treatment can therefore be considered an absolute priority for urban planning.

Long-term investment strategies for drinking water supply

Access to drinking water was on average about 50% in the five cities (indicator 1). Although access to drinking water is projected to increase across sub-Saharan Africa, particularly through increased access to piped water and public taps, unregulated wells and boreholes remain a primary source of drinking water for about a fifth of the urban dwellers (Dominguez Torres 2012). Upfront investments and maintenance costs of public water supply infrastructure is challenging. Accordingly, drinking water leakages or non-revenue water is around 20 to 30% in the five cities assessed (indicator 13). Hence, upfront investments in drinking water infrastructure need to be intertwined with long-term operational financial planning that includes a reasonable salary and professional training of personnel (indicator 14).

Enhance solid waste collection & treatment

Finally solid waste poses significant challenges to the five cities. Overall, the amount of solid waste that is produced is moderate or even low compared to western standards (indicator 15). However, the issue is related to solid waste collection and treatment (indicator 16 & 17). Solid waste recycling or energy recovery from solid waste is limited and open dump landfilling is often the default. Such waste management practices lead to the exposure of waste collectors to toxic materials, large-scale pollution soil, surface and groundwater pollution, and urban flooding due to the clogging of drainage systems by solid waste (Rahmasary et al. 2019; Rahmasary 2020). Such floods in turn can cause or exacerbate vector-borne diseases such as Dengue fever or Malaria. Solid waste collection and treatment can be an opportunity for employment and decreases health costs and social deprivation.

4.2 Urban transformation: Young professionals can make a difference

How to exploit city-to-city learning opportunities?

As the urban population in sub-Saharan Africa is projected to roughly double in size in the next three decades, Africa's urbanisation challenge is at the core of seizing these opportunities. Of the total global infrastructure investment requirements between 2005-2030 (US$ 41 trillion), more than half (US$ 22.6 trillion) is required for water supply, sanitation and wastewater treatment which is more than the combined investment requirements of energy, roads, rail, air and seaports (UNEP 2013). Building Africa's cities of the future poses many opportunities provided that urban planning is supported by independent, interactive, empirical-based and, above all, city-specific assessments of the integrated challenges of water, waste and climate change.

Many cities facing rather similar challenges and the almost unlimited potential of sharing know-how between these cities is widely recognised in academia (e.g. Shefer 2019; Kern and Bulkeley 2009) and put into practice through Transnational Municipal Networks (TMNs) such as C40, 100ResilientCities, the climate alliance and Energy-Cities. TMNs are particularly helpful if there are common regional, national or transnational policies, guidelines and financial stimuli (Gierst and Howlett 2013; Hakelberg 2011; Den Exter et al. 2014; Hawkins et al. 2016). For sub-Saharan Africa, investment banks such as the African Investment Bank form such a stimuli that can connect cities in a common aim as formulated in the seven aspirations as Agenda 2063 which all underpin the essence of inclusive growth and sustainable development of cities (Agenda 2063).

However, the time and effort required to translate general expectations into a specific set of learning targets and activities that can bring about mutual learning between cities, is all too often underestimated. Each city is a network in itself and in order to learn from other city networks, it may be necessary to first identify capacity-development priorities together with local stakeholders. Only then, specific city alliances may be established where various professionals representing different organizations can mutually learn from one another. The City Blueprint methodology demonstrated in this paper might just be such a 'city-matching' methodologies.

The role of young professionals: A win-win-win

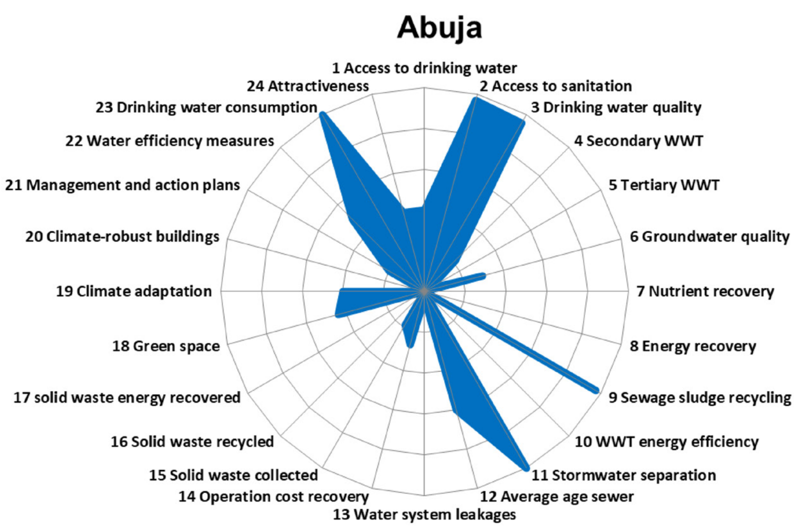
Through our study, it is demonstrated that the application of the City Blueprint Approach by local young professionals is both valuable and feasible because it taps into the almost unlimited potential of local young water professionals across sub-Saharan Africa. The collection of data has typically involved a lot of expert interviews and consultation of policy documents that have not been publicly accessible. The transparent collection and reporting of the data provides an independent, reliable and site-specific database that may attract investors. However, arguably more important, is that it also is a means of co-producing knowledge and overcoming management fragmentation within city-networks. With the support of local UNESCO offices, stakeholder meetings may enable the joint identification of water management priorities by these local stakeholders through the support of independent and integrated assessments. In addition, reassessments every three to five years may help to monitor and jointly evaluate progress. This approach can be repeated and improved across African cities. Based on the resulting data and network building, opportunities for city-to-city learning can be exploited. The reason why this is promising is that many sub-Saharan African cities face very similar challenges. Some of these cities may have developed rather successful programmes and policies. The experiences of these urban planners are invaluable for their professional peers in other cities. The more specific the formulation of improvement priorities and best practices are, the better cities can be matched. The subsequent (temporary) exchange of personnel, joint education and research initiatives or simply the power of a good example, can be a catalyst for improved urban water management and sustainable urban growth. Last but not least, the role that young professionals have in this progress is not to be underestimated. By doing these assessments they qualify themselves to be agents of change. They become professionals with the skills of thinking across organisational boundaries, political mandates and scientific disciplines.

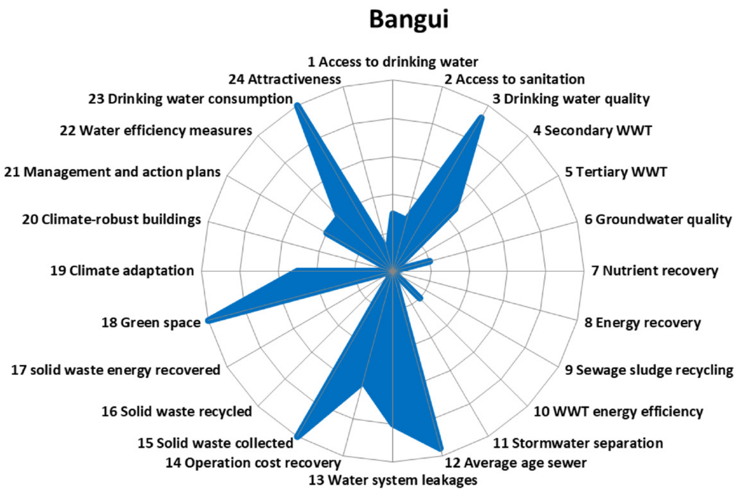
5. Conclusion

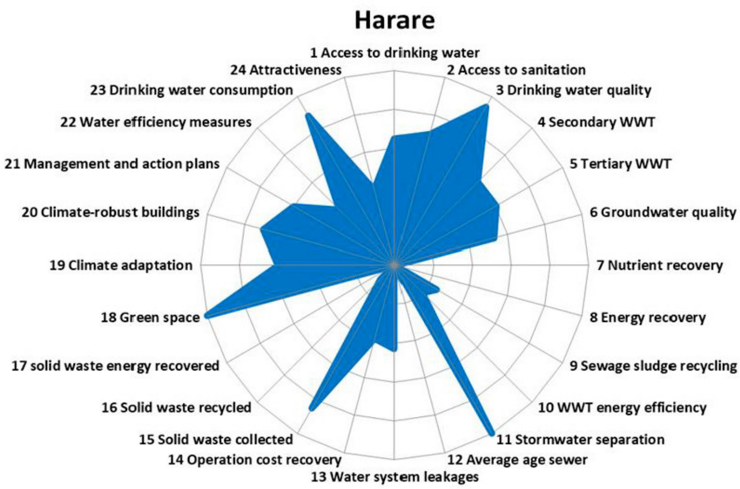
The young professionals were successful in meeting the aim of this study of applying the CBA in five cities and in providing science-policy dialogues. A larger fraction of Africa's population consists of young age groups and the youth should be largely and actively be involved in issues that concern their future. This study also clearly demonstrates the important role that young professionals can take in planning, decision-making and implementation phases of programmes to improve urban water management. They identified priorities for addressing integrated water challenges and went on to facilitate science-policy dialogues. The CBA provided good training on IWRM, water governance and stakeholder involvement by approaching stakeholders in the information phase (data gathering) and follow-up discussions (follow-up science-policy dialogues).

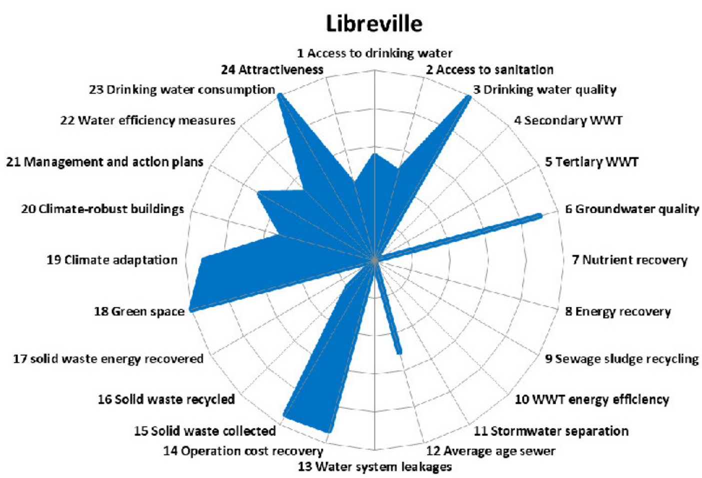
The radar charts of indicator scores for the CBF and the TPF are shown in Figs. 3 and 4 for the five African cities. The TPF (Fig. 4) shows that the social, environmental, financial and governance challenges are substantial which form less favouring conditions for water management performances. In particular, economic pressure and social pressures such as a high burden of disease and limited female participation in paid jobs stand out. The BCI scores which ranges from 0 to 10 gives the overall performance of the five cities based on their CBF indicator scores: Abuja (2.3), Bangui (1.9), Harare (3.7), Libreville (2.5) and Yaoundé (2.4). The improvement options are provided by the CBF indicators that showed the largest room for improvement in the five cities. These indicators relate to wastewater treatment, solid waste collection and treatment as well as infrastructure planning. River flooding, droughts and economic pressures have a great impact on the water sector of African cities. Wastewater treatment can be improved. Often only limited primary and secondary wastewater treatment takes place leading to large-scale pollution. In addition, solid waste collection and treatment are great challenges in African cities.

Recommendations were drafted and viable solutions for the cities were proposed based on the CBF results. These are to be presented in workshops with the cities' top-level decision-makers and other stakeholders, and discussions on options to improve water security are proposed to take place which is an approach to promote integration and unified work of stakeholders, simultaneously ensuring every group is involved in the issues that concern them.




Bangui
1 Access to drinking water
2 Access to sanitation
3 Drinking water quality
4 Secondary WWT
5 Tertiary WWT
6 Groundwater quality
7 Nutrient recovery
8 Energy recovery
9 Sewage sludge recycling
10 WWT energy efficiency
11 Stormwater separation
12 Average age sewer
13 Water system leakages
14 Operation cost recovery
15 Solid waste collected
16 Solid waste recycled
17 solid waste energy recovered
18 Green space
19 Climate adaptation
20 Climate-robust buildings
21 Management and action plans
22 Water efficiency measures
23 Drinking water consumption
24 Attractiveness


Harare
1 Access to drinking water
2 Access to sanitation
3 Drinking water quality
4 Secondary WWT
5 Tertiary WWT
6 Groundwater quality
7 Nutrient recovery
8 Energy recovery
9 Sewage sludge recycling
10 WWT energy efficiency
11 Stormwater separation
12 Average age sewer
13 Water system leakages
14 Operation cost recovery
15 Solid waste collected
16 Solid waste recycled
17 solid waste energy recovered
18 Green space
19 Climate adaptation
20 Climate-robust buildings
21 Management and action plans
22 Water efficiency measures
23 Drinking water consumption
24 Attractiveness


Libreville
1 Access to drinking water
2 Access to sanitation
3 Drinking water quality
4 Secondary WWT
5 Tertiary WWT
6 Groundwater quality
7 Nutrient recovery
8 Energy recovery
9 Sewage sludge recycling
10 WWT energy efficiency
11 Stormwater separation
12 Average age sewer
13 Water system leakages
14 Operation cost recovery
15 Solid waste collected
16 Solid waste recycled
17 solid waste energy recovered
18 Green space
19 Climate adaptation
20 Climate-robust buildings
21 Management and action plans
22 Water efficiency measures
23 Drinking water consumption
24 Attractiveness

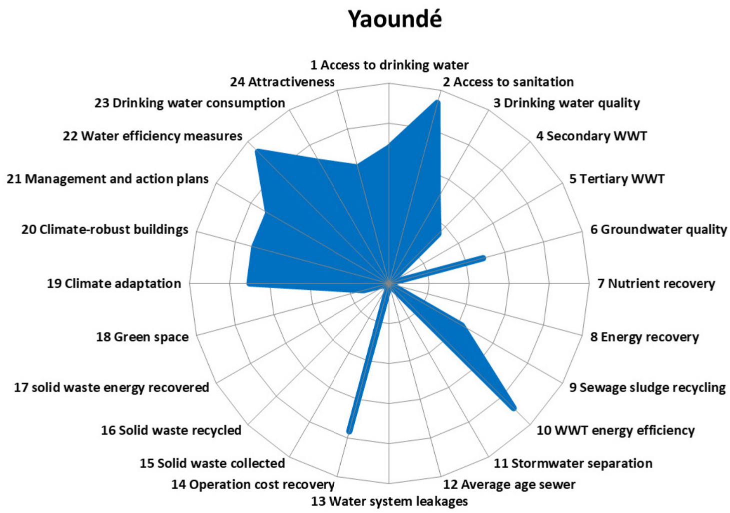
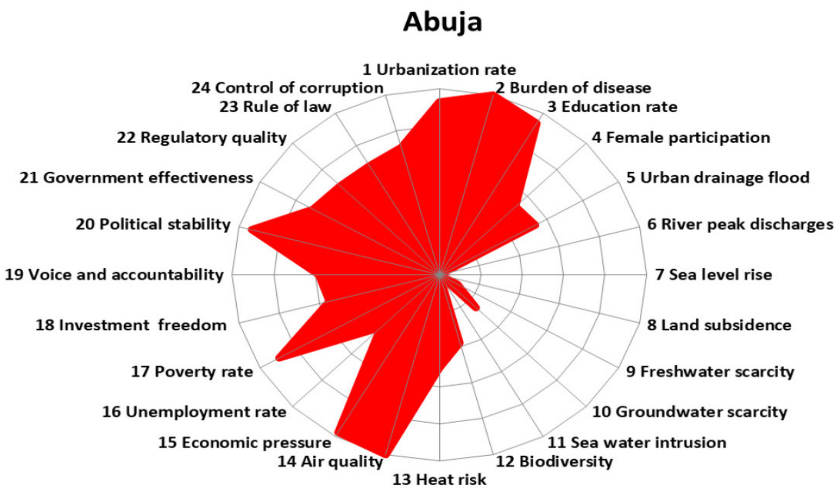
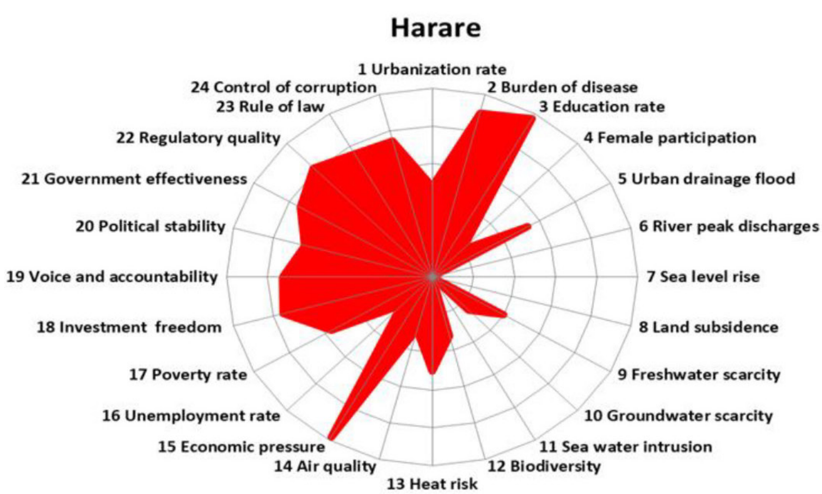
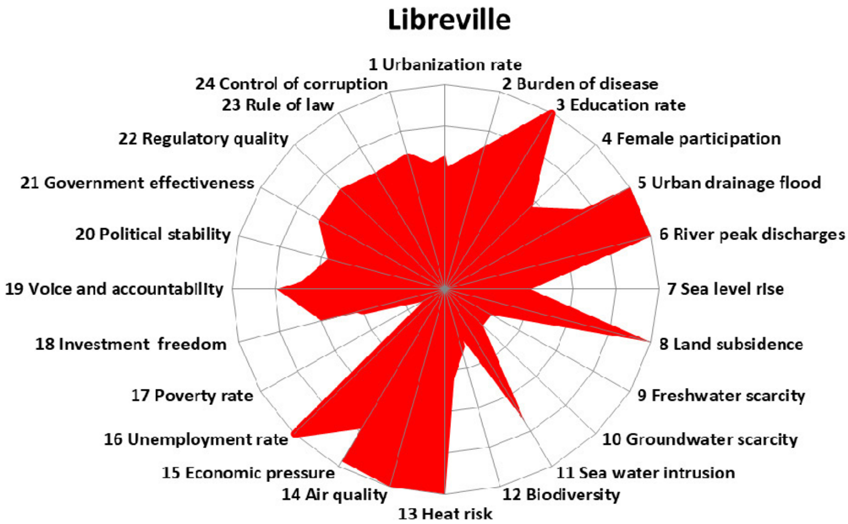


Figure 3. City Blueprints of Abuja (top), Bangui Harare, Libreville, and Yaoundé (bottom), based on 24 performance indicators. The geometric mean of the indicators, i.e., the BCI scores, are, 2.3, 1.9 3.7, 2.5 and 2.4 respectively







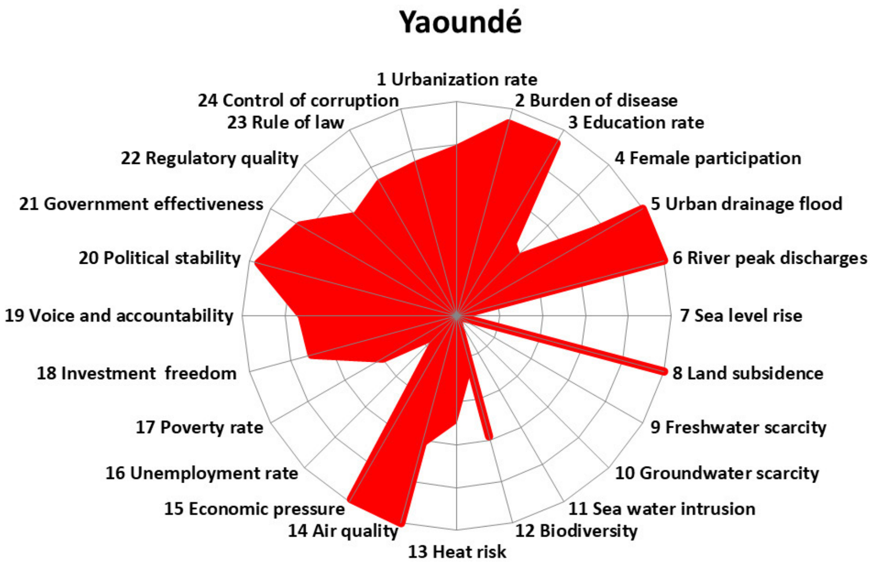


Figure 4. Trends and Pressures radar charts of Abuja (top), Bangui, Harare, Libreville, and Yaoundé (bottom), based on 24 performance indicators. The geometric mean of the indicators, i.e., the TPI scores, are, 5.5, 5.3, 4.9, 5.1 and 6.0 respectively

A workshop on water security in sub-Saharan African cities (Kampala, Uganda; February 2020) took place after the assessments to gather all the authors of the present article. This workshop has allowed to lay out a roadmap for enabling the uptake of the results of the assessments by practitioners and decision-makers in each city and the young professionals were involved in laying the road map that is the planning stage, not only as implementers or mere beneficiaries of the programme. One of the major recommendations was the need for capacity building and dialogues between the government, city's officials, municipalities and other relevant stakeholders to promote unity, in order to find solutions to problems in their urban water cycle services.

Accordingly, policy-dialogues with key stakeholders in each of the five cities have been organised by the young professionals to jointly identify viable solutions to enhance water security. This study in the 5 countries provided successful results showing that upscaling is a necessary next step. This can be organized in collaboration with UNESCO, the University of Bath and KWR. After diagnosis, finding the cure is necessary. This means that the results have to be presented at higher policy or political levels, to discuss the results, discuss the options and decide on investment decisions, if needed. Further steps are needed with relevant stakeholders to accelerate actions to make African cities water wise. In addition, based on the extensive experiences in these five cities, a methodological revision of the indicator assessment has been completed and a guideline for a city-to-city learning alliance has been initiated that has the ambition to include all capital cities in Africa, promoting the Pan-African approach. Africa's seven aspirations as formulated in the Agenda 2063 all underpin the essence of inclusive growth and sustainable development of its cities (Agenda 2063). As the urban population in sub-Saharan Africa is projected to roughly double in size in the next three decades, Africa's urbanisation challenge is at the core of seizing these opportunities. Of the total global infrastructure investment requirements between 2005-2030 (US$ 41 trillion), more than half (US$ 22.6 trillion) is required for water supply, sanitation and wastewater treatment which is more than the combined investment requirements of energy, roads, rail, air and seaports (UNEP 2013). Building Africa's cities of the future poses many opportunities provided that urban planning is supported by independent, interactive, empirical-based and, above all, city-specific assessments of the integrated challenges of water, waste and climate change. Our study demonstrated that such an approach is both valuable and feasible by tapping in the almost unlimited potential of local young water professionals across sub-Saharan Africa.

Disclosures

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