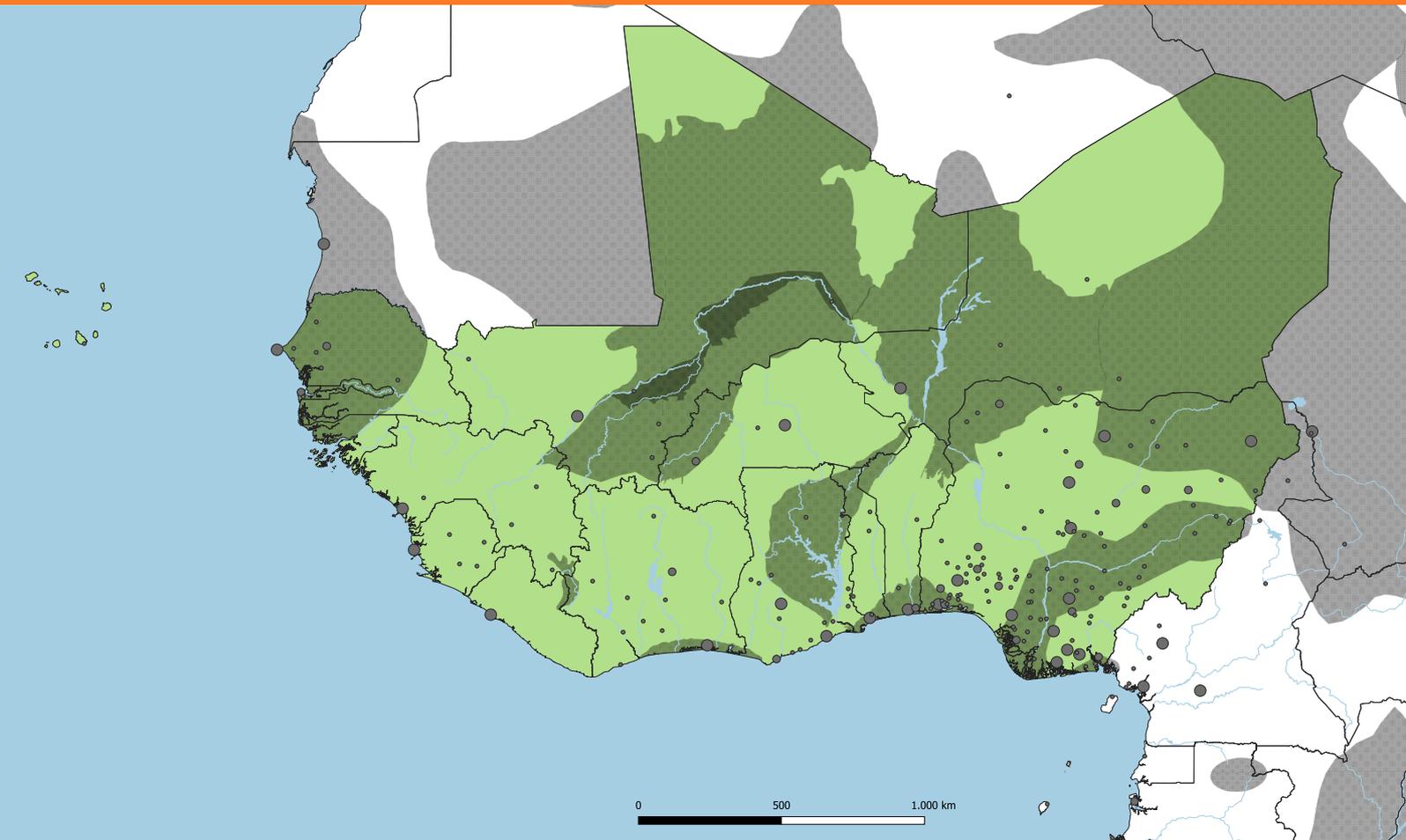


REPORT

Groundwater in fast growing cities in Western Africa



International Groundwater Resources Assessment Centre

Groundwater in fast-growing cities in Western Africa

1.0 Introduction

The population of Western Africa is growing rapidly, as a consequence of the demographic transition. The population of the region has grown from 316 million people in 2007 to 391 million in 2021, and is predicted to reach 796 million in 2050. This population increase is seen more in cities than rural areas, partly due to migration. The rapid growth of urban areas comes with planification and infrastructure challenges that include water supply and waste disposal. As many cities rely on groundwater for water supply, risks of groundwater over-exploitation and contamination need to be assessed and addressed.

As part of the World-wide Hydrogeological Mapping and Assessment Programme (WHYMAP), the status of groundwater use and management was assessed for the largest cities in the 15 member states of the Economic Community of West African States (ECOWAS). Information was collected on the use of groundwater in public water supply and alternative water supply (e.g. private sellers, private wells), groundwater availability issues, groundwater quality issues (natural and anthropogenic contamination), as well as groundwater management measures. Data and information supporting this assessment were collected during a comprehensive literature review. Because official data were scarce (e.g. water company reports), scientific papers, reports and news items were also consulted. The literature review was complemented with the inputs of national experts. The outcomes of this assessment is available in a poster, which can be downloaded at:

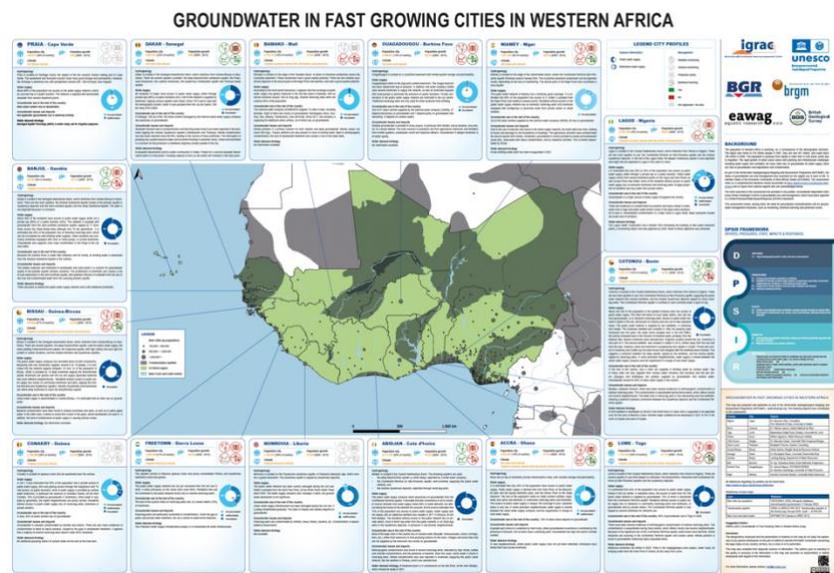
- English: <https://www.un-igrac.org/resource/groundwater-fast-growing-cities-western-africa/>;
- French: <https://www.un-igrac.org/fr/resource/les-eaux-souterraines-face-lexplosion-urbaine-en-afrique-de-louest>.

All material and references are also available online, at:

- <https://www.un-igrac.org/whymap-references>.

This map is intended to be used as an awareness-raising tool on groundwater challenges in fast growing cities in Western Africa and aims at advocating for groundwater management solutions and for the creation and the sharing of knowledge in the ECOWAS region.

This report describes some important choices in the methodology and summarizes the main findings of the assessment.



2.0 Selection of cities

Assessing the state of groundwater in West African cities is challenging and time-consuming because data are limited and their reliability uncertain. Therefore, this assessment covered only a selection of West African cities, i.e. the largest city in each ECOWAS member state (Table 1).

Table 1 Selection of West African cities.

City	Country
1. Cotonou	Benin
2. Ouagadougou	Burkina-Faso
3. Praia	Cape Verde
4. Abidjan	Côte d'Ivoire
5. Banjul	Gambia
6. Accra	Ghana
7. Conakry	Guinea
8. Bissau	Guinea-Bissau
9. Monrovia	Liberia
10. Bamako	Mali
11. Niamey	Niger
12. Lagos	Nigeria
13. Dakar	Senegal
14. Freetown	Sierra Leone
15. Lomé	Togo

In many cases, these large cities are also the capital cities of the member states. Within their countries, these cities amount to a significant part of the national population, up to 30%. It would have been meaningful to select the 15 largest cities in all ECOWAS, but most of these cities are in Nigeria and such a study would have lacked a geographic representativity. Instead, the study encompasses cities of different sizes, in different locations (e.g. coastal cities, river cities), different climate zones, different geological settings, different social, economic and political contexts, etc.

The situation in the largest cities cannot always inform what is happening in other cities within the same country. The management of water supply is greatly influenced by the local hydrogeological setting, the availability of surface water or the climate, which can vary throughout a country. It also depends on the urban growth. Since these largest cities often grow faster than the others, water supply challenges might be different. Because they are politically and economically strategic, these cities can also attract larger investments in water supply and sanitation infrastructure.

However, the groundwater management situation in the largest cities of a country can give an indication of how other cities may develop in the next few years as they too, experience rapid population growth. Large cities can be seen as full-scale experiments of urbanization and groundwater management, where good and bad practices can be identified. Lessons learnt can then be applied to other cities within the country.

3.0 Data availability

Few official statistics on (ground)water supply were found, such as activity reports from the water companies. These reports usually mention the number of connections (e.g. domestic taps, public fountains) or clients. Because one tap can be used by several people, usually one household, these statistics only provide an estimation of the number of people served by public water supply. Likewise, efficiency of the public network only gives an estimation of the illegal connections to the network (some of the water is actually lost through leakages). Moreover, water companies don't often report on the quality of the services they provide. If the service is hindered by shortages or low water quality, clients might turn to alternative water supply. In general, surveys have shown that urban dwellers often rely on various water supplies, which is not easily captured in official statistics.

Surveys provide a better understanding of water supply and the challenges thereof. Through questionnaires and interviews with urban dwellers, they allow for a quantitative and qualitative analysis of water supply strategies. However, the surveys that were found were carried out by academic researchers and were therefore limited to several hundred interviewees, often from one or a few neighborhoods. These surveys might not be representative of the entire city. Unfortunately, carrying out such surveys at the scale of the cities seems beyond the capacity of public authorities.

When official statistics or surveys were not available, figures of (ground) water supply were extracted from other sources of information, including scientific publications, reports, news items, etc.

The reliability of the data collected is questionable. In some cases, data provided by different sources of information were inconsistent. Alongside the difficulty in creating an accurate and comprehensive picture of (ground)water supply and management in West African cities, there is an additional challenge because the situation is evolving rapidly. Although preference was given to recent data (when available), it is possible that these data are already outdated.

Moreover, it might be that groundwater issues have gone undetected, where no data could be found. Absence of data on a given groundwater issue doesn't mean that the issue is not occurring.

Considering these challenges of data availability and reliability, particular care was given to back every piece of information in this study with one or several references. Moreover, data were screened and validated by national experts for 12 of the 15 cities¹. Nevertheless, the limitations of this assessment are acknowledged. First and foremost, this study calls for accurate and comprehensive surveys of (ground) water supply and management in West Africa.

¹ No expert could be contacted in Cape Verde, Guinea and Liberia.

4.0 Main findings

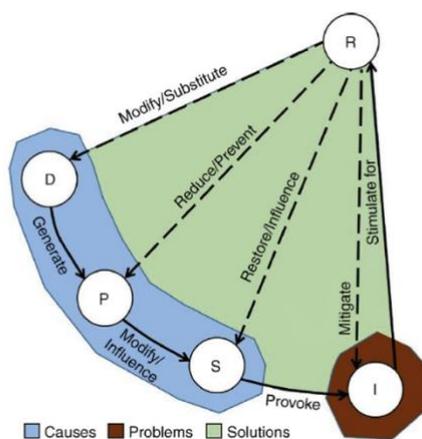
4.1 Dependency on groundwater

Seven cities rely primarily on groundwater, either through public water supply networks and/or hand-dug wells: Lagos, Cotonou, Lomé, Abidjan, Bissau, Banjul, Dakar. These cities rest on sedimentary basins containing high-yielding aquifers. These sedimentary basins are located along the Atlantic coast and are of the same geological age. They are also transboundary. Lagos, Cotonou, Lomé and Abidjan are part of the Coastal Sedimentary Basin, while Bissau, Banjul and Dakar are part of the Senegalo-Mauritanian Aquifer Basin. The Coastal Sedimentary Basin stretches until Cameroon (with the city of Douala, among others), while the Senegalo-Mauritanian Aquifer Basin stretches north until Mauritania, including the city of Nouakchott. Although these cities have different climates, they are all coastal cities and they share a similar hydrogeological setting.

The other cities are located on lower-yielding hydrogeological units, such as crystalline or volcanic rocks. Niamey is located in the Illumedén transboundary sedimentary basin but at its very fringe, where the thickness of sedimentary aquifers doesn't exceed 30 m. The same holds for Bamako within the Taoudeni basin. Niamey and Bamako are located on the Niger river, so their public water supply relies almost exclusively on surface water. Other cities need to pump the water from nearby rivers or reservoirs: Accra, Monrovia, Freetown, Conakry, Ouagadougou. Praia is an exception. Located on a desertic volcanic island with little groundwater and surface water, it relies mostly on seawater desalination.

4.2 Groundwater challenges

Groundwater availability or quality issues have been reported in all cities relying on groundwater resources. These issues relate to the rapid growth of the cities and the lack of investments in water supply and sanitation, as well as the lack of groundwater management measures. To understand how groundwater challenges relate to urban dynamics, the Driver-Pressure-State-Impact-Response (DPSIR) Framework was followed. The DPSIR framework allows capturing interactions between the environment (in this case groundwater) and social, economic or political factors (Figure 1). The Framework supposes a chain of causal links from Drivers to Pressures, from Pressures to States, from States to Impacts, and from Impacts to Responses. Responses in turn can act upon the Drivers, Pressures, States and Impacts, which reflects the ongoing evolution of relationships between the environment and the society. The DPSIR is particularly useful for translating complex situations into simple indicators, and it highlights the measures that can be implemented at different levels to improve the situation.



The DPSIR Framework was used, among others, for capturing the status of knowledge on groundwater in fourteen Asian cities, including groundwater dependency, problems related to groundwater over exploitation, implementation of various policy instruments and management practices². The DPSIR indicators of groundwater in West African cities is given in Figure 2.

Figure 1 Structure of the DPSIR Framework (Pandey & Shrestha, 2016)

² Shrestha, S., Pandey, V., Thatikonda, S., & Shivakoti, B. (2016). Groundwater environment in Asian cities, 1st edition. Elsevier. ISBN: 978-0-12-803166-7

DPSIR FRAMEWORK

DRIVERS, PRESSURES, STATE, IMPACTS & RESPONSES

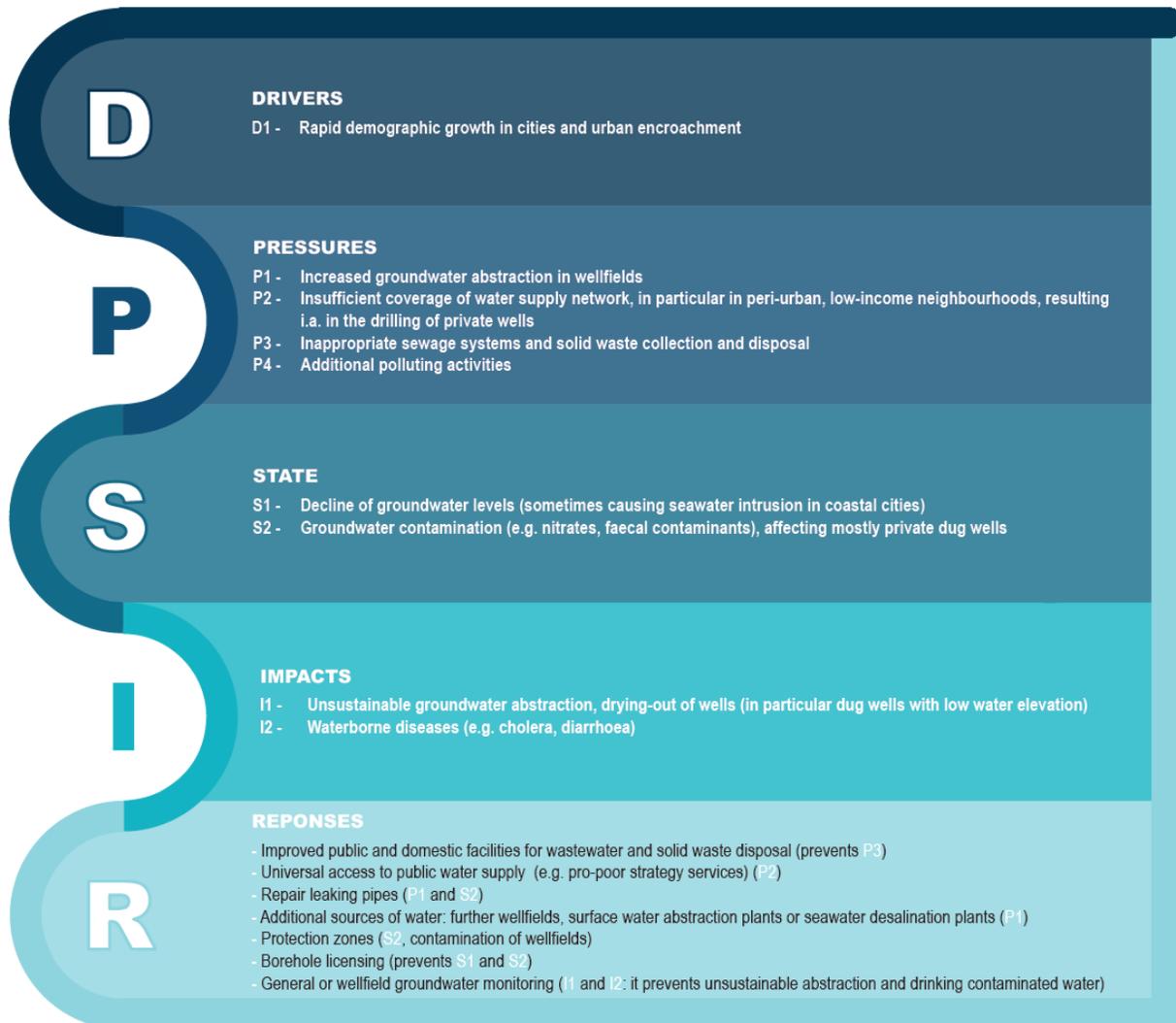


Figure 2 DPSIR indicators of groundwater in fast-growing West African cities

In addition to the DPSIR, groundwater challenges were depicted for one fictive West African city in Figure 3. These two sketches provide a visual representation of groundwater challenges geographically and at depth.

GROUNDWATER IN A FICTIVE WEST-AFRICAN CITY

CROSS-SECTIONAL VIEW (ABOVE) & AERIAL VIEW (BELOW)

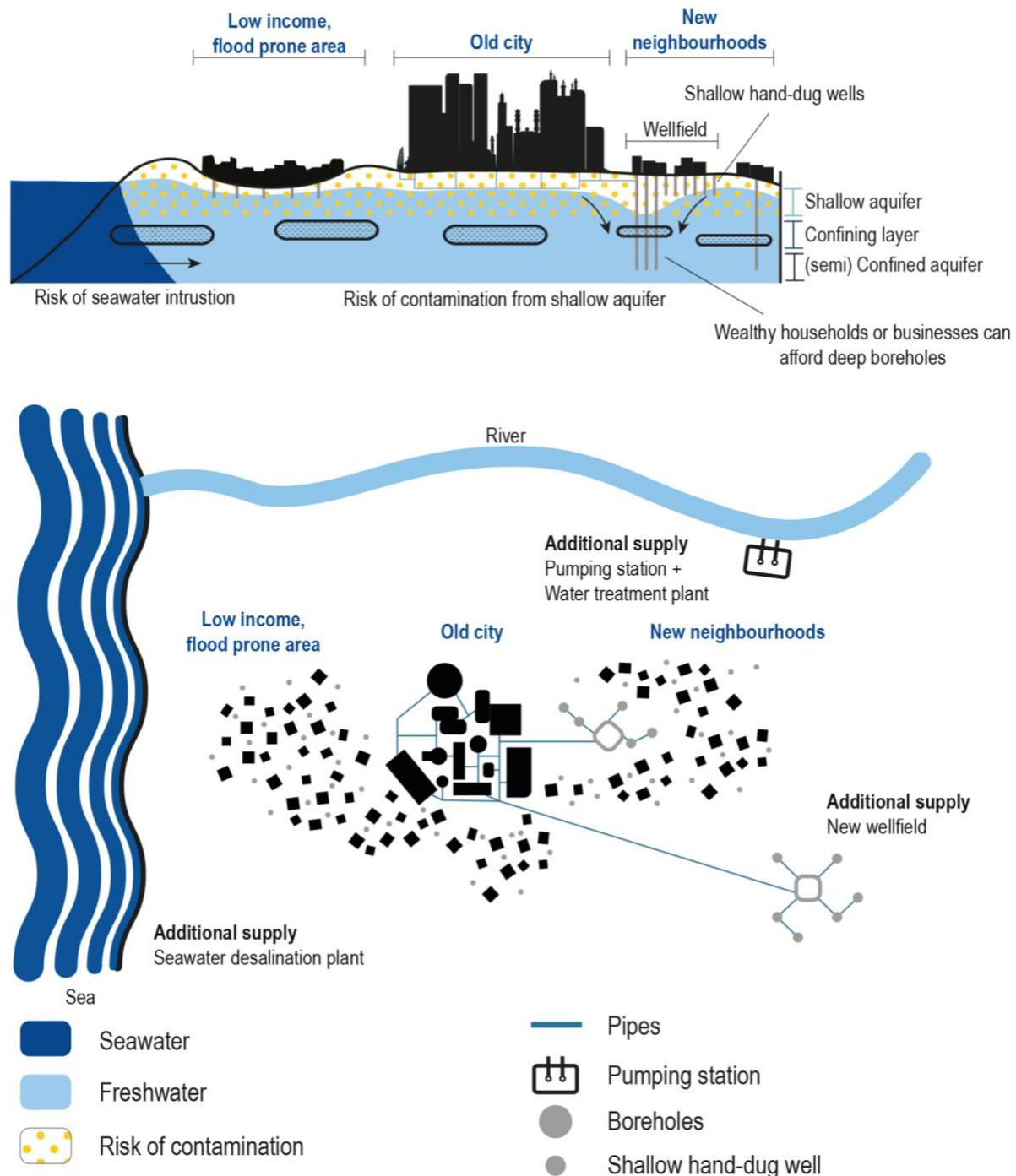


Figure 3 Cross-sectional view and aerial view of a fictive West African city showing the unequal access to groundwater supply and the challenges thereof.

4.2.1 Groundwater availability

Due to the rapid increase of water demand, cities relying on groundwater have experienced a decline of water levels in public boreholes and wellfields. In coastal cities, saltwater intrusion has sometimes been reported, like for instance in Cotonou and Dakar. Consequently, additional sources of water have been sought, such as additional wellfields further away from the city, surface water pumping and treatment plants, or (in coastal cities) seawater desalination plants. These alternative water sources come at a higher cost because of treatment (for surface water and – in particular – seawater) and transportation (from remote wellfields and surface water pumping plants or reservoirs). The search for alternative water supplies is best illustrated in Dakar. The city depended exclusively on groundwater until 1972, when surface water started to be abstracted 250 km away. To cope with the ongoing increase of water demand, transfers of surface water have increased significantly and, in addition, the city is building a seawater desalination plant.

In the majority of cities, public water supply is deficient and residents rely on alternative water supply. This is very often the case in modern neighborhoods where water supply infrastructure hasn't been developed yet. The older parts of the cities are in general better served, either through private taps or public fountains. Public water supply is the most developed in terms of coverage in Dakar, Ouagadougou, Bamako, Niamey and Praia. Among these cities, only Dakar relies significantly on groundwater (~ 60%), although the part of surface water there should increase significantly in the near future and surpass the part of groundwater. Alternative water supply can be domestic hand-dug wells or (for high-income households and organizations) boreholes, or retailers and street vendors. In the latter case, it is difficult to identify where the water comes from, as it could come from a private well or from a tap on the public water supply network. When public water supply relies on groundwater, it is possible to tell that water sold by private sellers is groundwater. In other cases, the origin of water is undifferentiated. In several cities, it is not even clear whether people rely on domestic wells or on private sellers. Surveys suggest that many residents rely on a combination of water sources, depending on purposes and availability. Uncertainty as of groundwater use in alternative water supply is particularly high in Accra, Monrovia, Freetown and Conakry.

A significant percentage of residents rely on domestic hand-dug wells in West African cities, in particular in Lagos, Cotonou, Lomé, Abidjan, Bissau and Banjul. In some other cities like Dakar, Bamako and Niamey, hand-dug wells were abundant but they have been progressively abandoned with the development of public water supply, or they are used for non-drinking purposes. In Niamey, the interruption of groundwater use and the leakages from the public water supply (supplied with surface water) have risen the groundwater table, which is a concern for public health and for infrastructure. A similar situation can be seen in Nouakchott. Because the water level is low in hand-dug wells, these wells are particularly sensitive to groundwater level decline. Cases have been reported where hand-dug wells dry out or need to be deepened. In Cotonou, it is suspected that hand-dug wells run dry due to the wellfields that have been installed nearby.

4.2.2 Groundwater quality

Public boreholes or wellfields are often drilled outside of cities, to prevent contamination from human activities. Due to urban encroachment, many wellfields that were drilled in the second half of the 20th century are now surrounded by the city. Protection areas have not been created or enforced, with a risk of contamination. There is also a risk of contamination of public water supply through broken pipes.

Next to potential polluting activities like industries or horticulture, the lack of waste disposal and wastewater treatment is a major threat for groundwater resources. When available, public sanitation infrastructure is limited to the old, inner parts of the city. Like wellfields, waste disposal sites were located outside of the cities, to prevent contamination. Because of urban encroachment, it is nowadays common to see these waste disposal sites surrounded by the city. Hand-dug wells are particularly vulnerable to these sources of contamination because they

tap shallow aquifers which are very close to the surface. It is common to find fecal bacteria, nitrates or other anthropogenic contaminants in shallow hand-dug wells. Flooding events have been reported to aggravate the dispersion of contaminants in the subsurface and the subsequent contamination of wells. Flooded areas are usually occupied by low-income neighborhoods. Deeper aquifers that are confined or semi-confined are less at risk. These aquifers are tapped by public wellfields or by households and organizations that can afford drilling a borehole.

On the other hand, boreholes tapping deep aquifers constitute a pathway for contaminants to travel from the surface to aquifers that would be otherwise confined and protected. This is a potential thread for deep, confined groundwater resources. Although these are less vulnerable to contamination than shallow groundwater resources, they are less resilient in case of contamination (they will need more time to recover, unless costly remediation plans are made).

4.2.3 Social issues

Four main groups of groundwater users can be identified:

- Clients of the public water supply company (if public water supply relies on groundwater). These clients often reside in the older, central part of the city. The groundwater they are supplied with is from deep, confined or semi-confined aquifers tapped by public wellfields or boreholes.
- Hand-dug well owners. These residents are usually not served by the public water supply (unless they use their hand-dug well for irrigation or other non-drinking purposes). They often live in recent, peripheral neighborhoods. They tap shallow groundwater, with a high risk of contamination.
- Borehole owners. These residents have higher income and can afford drilling boreholes that are often higher yielding. Boreholes give them access to deeper groundwater that is generally of better quality and less vulnerable to water level fluctuations than hand-dug wells. These borehole owners can be households but also organizations or industries. They can be located in peripheral neighborhoods but also sometimes where tap water is available, in which latter case it is assumed that the public water supply is unreliable.
- Clients of private sellers (if they rely on groundwater). These clients often live in recent, peripheral neighborhoods.

In many cities, access to water is still a challenge for many residents, in particular the poor. Those who are served by public water supply can endure water shortages or water quality issues. Those who rely on hand-dug wells are vulnerable to contamination and groundwater level decline. In several cities, complicated access to water is a source of social unrest. Although it is not possible to determine the exact cause of diseases like cholera and diarrhea, the low quality of shallow groundwater is a serious concern for the health of urban dwellers who depend on it.

4.2.4 Groundwater management strategies

Investments in water supply and sanitation are necessary in virtually all cities, either in terms of public infrastructure (e.g. renewing/extending public water supply networks, sewage systems) or domestic equipment (e.g. improved dug wells, improved sanitation facilities). For cities depending on groundwater resources, there is also a need for groundwater management measures. Groundwater monitoring is crucial because it informs on the trends in groundwater availability and groundwater quality, on which basis timely interventions can be made. It tells whether groundwater is suitable for consumption or not. Groundwater monitoring need to be implemented around the wellfields, because they are of strategic importance. It is also important to monitor groundwater elsewhere to have a good overall picture of trends in groundwater resources. Groundwater monitoring is often insufficient even where groundwater is the principal resource, sometimes it is even inexistant, like in Lagos and Bissau.

Next to groundwater monitoring, it is good to regulate the drilling of boreholes with the application of registration or licensing. In many cities, there is no such regulation or the regulation is not enforced. The unregulated drilling of boreholes can result in over-abstraction or contamination of deep, strategic groundwater resources. There is little chance that such regulation could prevent new boreholes to be drilled as long as public water supply doesn't meet the demand, but it can at least provide information on groundwater abstraction. It can also be an opportunity to gather significant groundwater data collected during the drillings, such as stratigraphic logs or pumping test data. Finally, protection zones must be drawn around the wellfields and they must be enforced. The common absence of such protection zones is serious threat to public water supply.

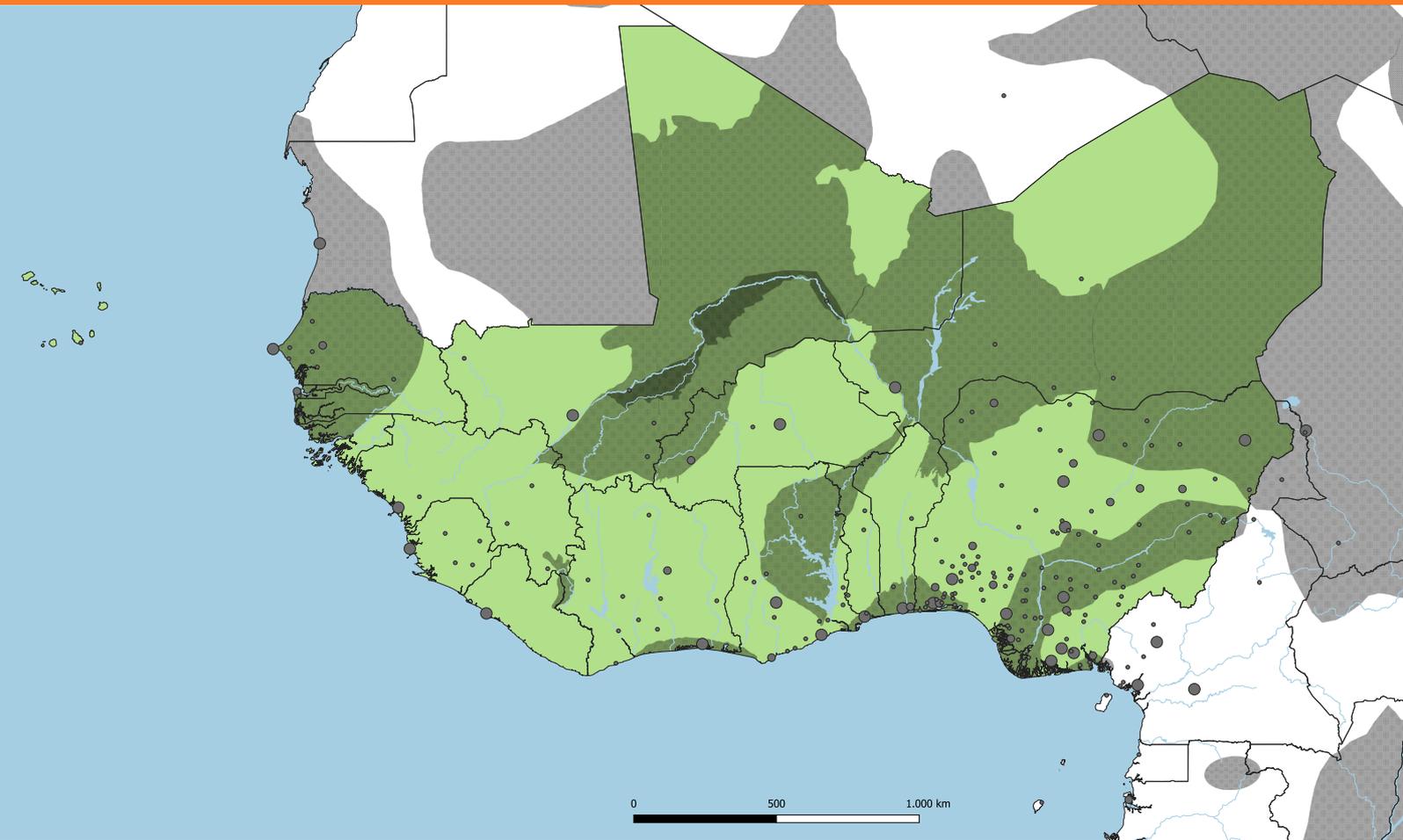
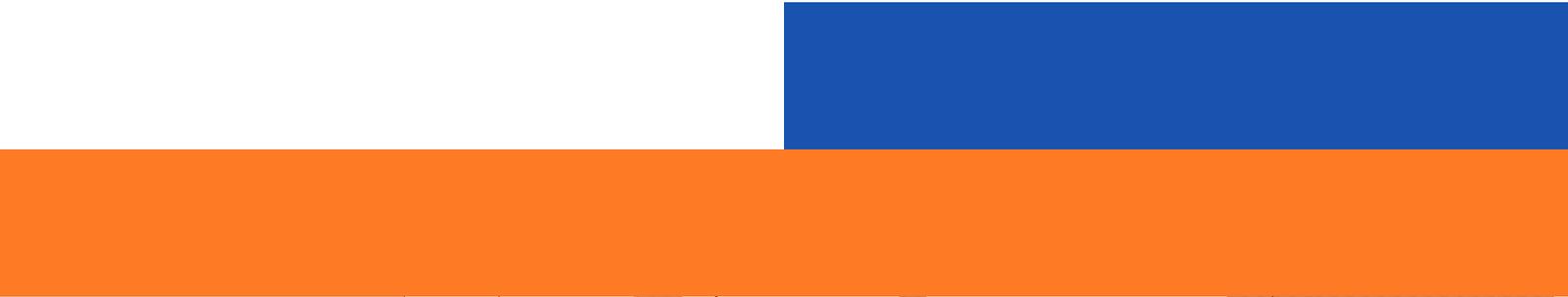
5.0 Key messages and future work

Groundwater is a major water resource for several large West African cities. It supports public water supply networks and is also exploited by households or organizations through private hand-dug wells or private boreholes. It can also be distributed by private sellers. All groundwater users are under threat of groundwater over-abstraction and contamination, although at different levels. This study shows that groundwater issues stem from the rapid growth of cities, whereby urban encroachment outpaces the development of water supply and sanitation infrastructure. The relationships of urban dwellers to groundwater resources reflects such urban dynamics.

Besides investments in water supply and sanitation, this study advocates for adopting and implementing groundwater management measures, like groundwater monitoring, borehole registration or licensing and protection zones. These measures are instrumental to improve the efficiency and the sustainability of groundwater use. Wellfield monitoring and borehole registration would provide statistics on groundwater abstraction, which are mostly lacking.

Because several cities share the same hydrogeological settings and face the same groundwater challenges, there is much potential for synergies and the sharing of experiences and good practices in the region, in particular among the cities located on coastal sedimentary basins. Measures like groundwater monitoring or improved dug wells could be advanced at the regional level, with collaboration between cities and countries.

This study has clearly shown a need for further research in this field. In particular, it would be valuable to extend this assessment to the other cities, to draw out regional statistics on urban groundwater use in West Africa. There is also a need to investigate how far groundwater resources can support the increase of water demand over the next decades.



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