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RESEARCH ARTICLE

WATER RESOURCE MANAGEMENT IN THE TOWN OF OUELLE IN CENTRAL-EAST OF CÔTE D'IVOIRE

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ABSTRACT

This article highlights the shortage of drinking water in the town of Ouéllé, located in central-eastern Côte d'Ivoire. The aim of this study is to obtain a better understanding of water resource management strategies and actions face to the difficulties in accessing to drinking water for the population of this city. This objective was achieved using a methodology based on documentary research, interviews with administrative and technical officials involved in water resource management, focus groups with the population and taking photographs. In addition, questionnaires were administered to 100 people living in Ouéllé's neighborhoods. The results showed that Ouéllé benefits from several sources of drinking water supply, dominated by boreholes. In addition, there are determinants that limit access to drinking water in the study area. Finally, people responded differently to the local water problem. 34% of respondents use 25l cans to retain CIWDCdrinking water, while 92% use borehole water. 7% turn to wells for their water supply.

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INTRODUCTION

Water is an inherent resource of nature and life. Rural and urban settlements have generally been built close to a body of water. Water resources enable life to develop, grow and survive on the earth's surface. The problems of access to drinking water are much more acute in towns and cities that are constantly growing and facing climate change and the obsolescence of drinking water supply facilities in urban centres. If we are to drive development through the growth of cities, and build sustainable, healthy cities with healthy populations, the availability and access to clean, quality water for all must be one of the major priorities of city management authorities. After independence, the State of Côte d'Ivoire set up actions and strategies to supply cities with drinking water. These actions have focused on three (03) main areas: Urban Hydraulics (UH), Village Hydraulics (VH) and Improved Village Hydraulics (IVH) (Abou D. et al., 2016, p 346).These policies apply to all towns in Côte d'Ivoire, including Ouellé. Located in the centre-east of Côte d'Ivoire in the Iffou region, the urban area of Ouéllé has benefited from a number of facilities and drinking water supply infrastructures. The town has a representative of the DrinkingWater Distribution Company (CIWDC) and a water tower. Despite the measures taken by the government and the strategies put in place by the local authorities, the town is facing a shortage of drinking water, as expressed critically by the local population.

The aim of this study is to gain a better understanding of people's coping strategies in the face of the inaccessibility of drinking water in the town. To achieve this objective, we identified the city's drinking water supply sources, then analysed the factors limiting access to drinking water and finally presented the various resilient responses of the population to the accessibility of drinking water in the city.

Location of the town of Ouéllé: Ouéllé is located in the center-east of Côte d'Ivoire in the Iffou region. It lies at the crossroads of the departments of Daoukro, Prikro and N'Bahiakro and covers an area of 1558 m² with an estimated population of 37641 inhabitants (INS, RGPH 2021) made up of 20011 men, i.e. 53.2% and 17630 women, i.e. 46.8%. The town is built on a relatively flat area with a relief of hills and marshes. The hydrographic network is characterised by small seasonal streams. The general rainfall pattern is divided into 4 seasons: A long rainy season from August to November, a long dry season from November to March, a short rainy season from March to April and a short dry season from May to July. This characteristic does not adequately reflect the reality on the ground.

Data collection and processing methodology

Data collection: The research methodology is based on documentary research and data collection in the field.

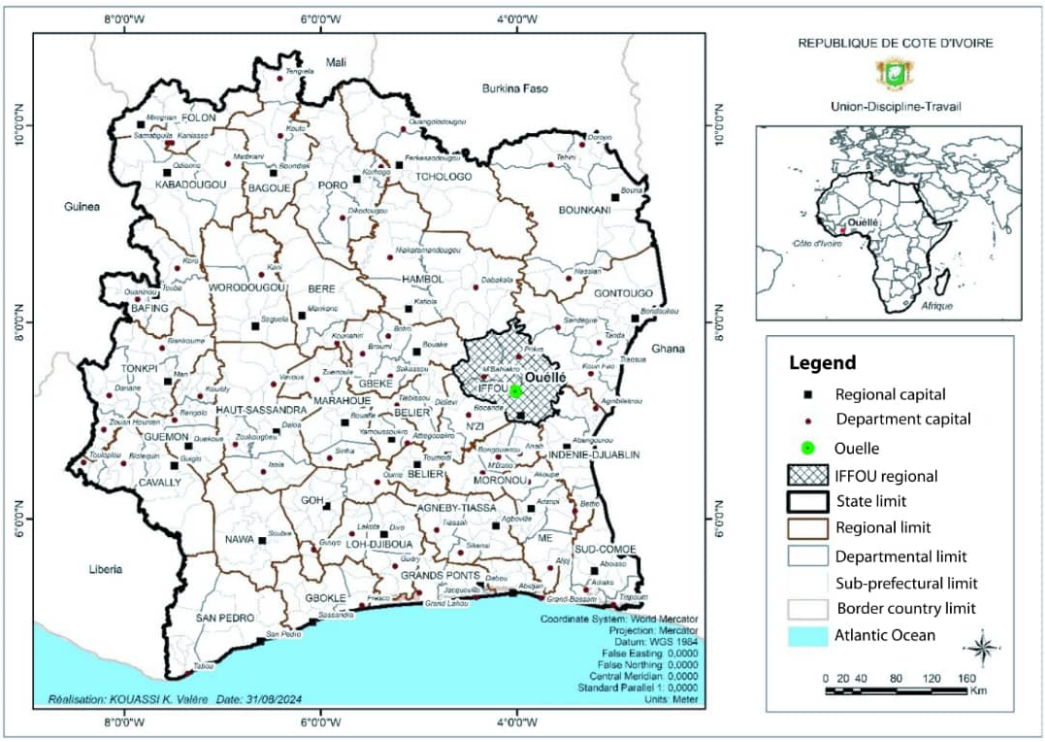


Figure 1. Location of the town of Ouéllé

Table 1. List of the city's neighbourhoods by location, age and source of water supply

ID	Name of district	Location within the city	Status	Source of water supply
1	Hospital North extension	East	New	Drilling, Rainwater
2	BayassouKôkô	North	Recent	Drilling, Rainwater, Wells
3	Bayassou Baoulé	North	Very old	CIWDC, Drilling ; Rainwater, Wells
4	Bayassou Dioula	North	Very old	CIWDC, Drilling, Rainwater
5	Hôpital	Centre-East	Former	CIWDC, Drilling
6	Hospital South extension	Periphery	New	CIWDC, Drilling
7	Trade	Center	Very old	CIWDC, Drilling
8	Tray	Center-South	old	CIWDC, Drilling ; Rainwater, Dam
9	Secondaryschool	West	old	CIWDC, Drilling ; Rainwater
10	Kodi	South	New	CIWDC, Drilling ; Rainwater
11	Campus	South-West	old	CIWDC, Rainwater
12	Bayassou Baoulé extension	North-Ouest	New	CIWDC, Drilling ; Rainwater
13	Administrative	Center	old	CIWDC, Drilling
14	Entente	East	old	CIWDC,Drilling

Source: Our field investigations, May 2024

The documentary research was based on theses, scientific articles and dissertations obtained online. The documents consulted were related to water shortages in urban centres, urban planning, climate variability, water management in urban centres, and water management policies and strategies in urban centres.

Table 2. The various boreholes operated by CIWDC

Drilling	Year of creation	Status	Flow rate (m3/h)
F1	1970	Operational	11
F2	-	Not Operational	-
F3	-	Not Operational	-
F4	2014	Operational	6
F5	2014	Not Operational	-
F6	2014	Not Operational	-
F7	2020	Operational	6
F8	2021	Operational	6

Source: CIWDC of the town of Ouéllé, May 2024

Field observation consisted of visits to spatial units faced with the problem of water accessibility and availability.

Photographs were taken using a smartphone (Redmi 9A), followed by the collection of geospatial data using the UTM Geo map mobile application for the Android operating system (mobile handheld GPS).The data collected concerned wells and boreholes. For the field surveys, interviews were held with heads of administration and experts in urban management and drinking water distribution, while questionnaires were administered to 100 people living in the Ouéllé urban area, selected on the basis of age (over 18), length of residence in the town (having spent at least 5 years in Ouéllé), access to drinking water and professional status. The data was collected using the snowball method, which consisted of sharing our questionnaire with people with the same characteristics, who in turn recommended other resource persons with a similar profile to respond to our document and distribute it to others, and so on. The purpose of these exchanges was to obtain information on the accessibility and availability of drinking water in the spatial entities of the study area, the ways in which water resources are managed and the people's coping strategies.

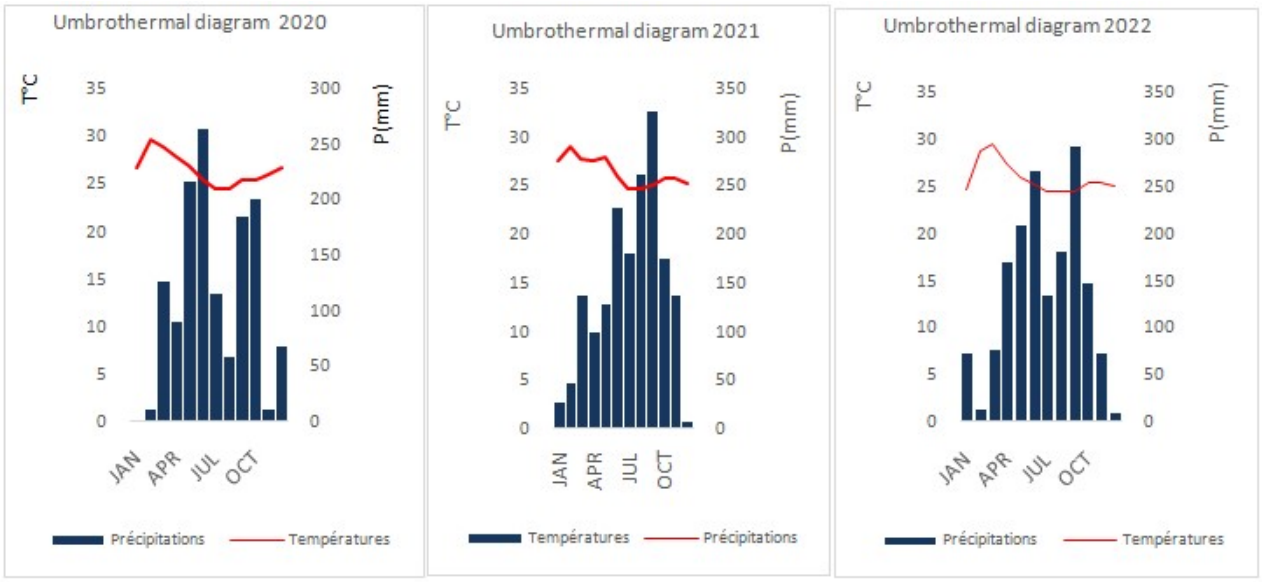
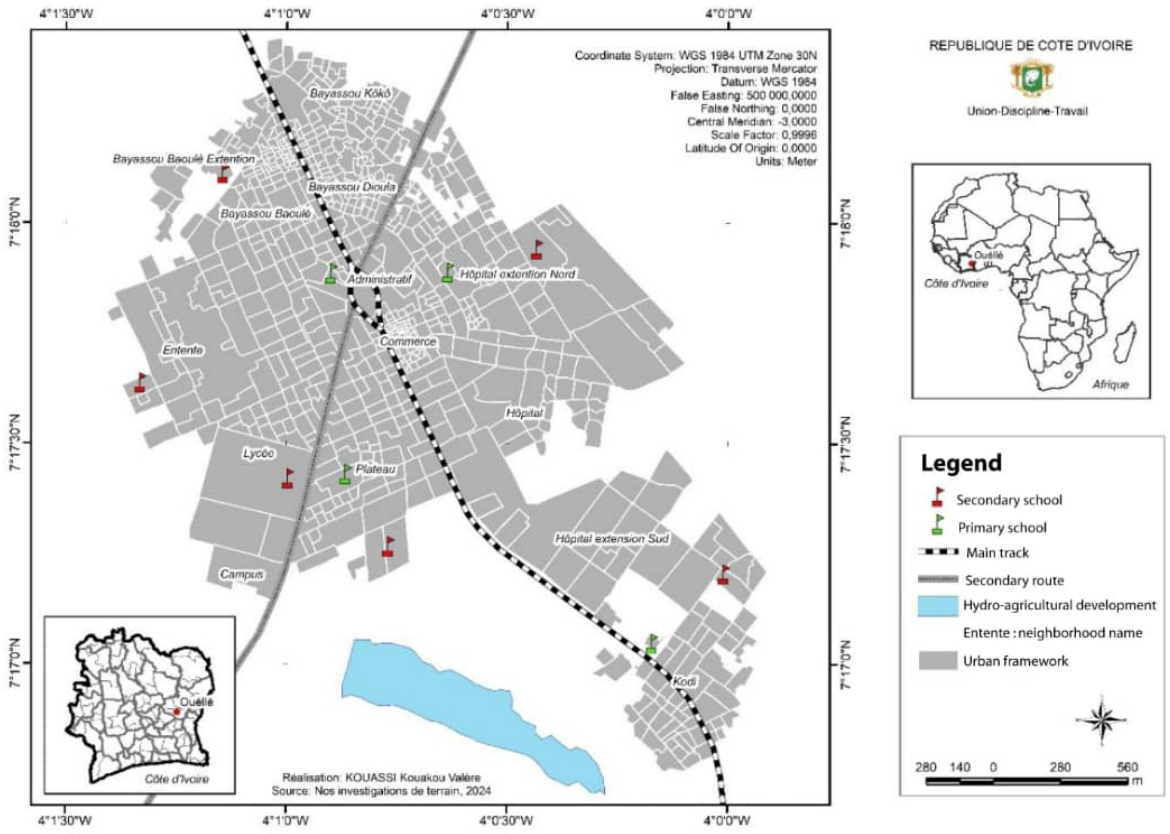


Figure 2. Umbrothermal diagrams of average monthly rainfall and temperatures in the town of Ouellé from 2020 to 2022



Source: Our fieldwork, 2024

Figure 3. Breakdown of the city's school facilities by neighbourhood

Data processing: The data collected was processed and analysed using statistical data analysis methods in a variety of software packages:

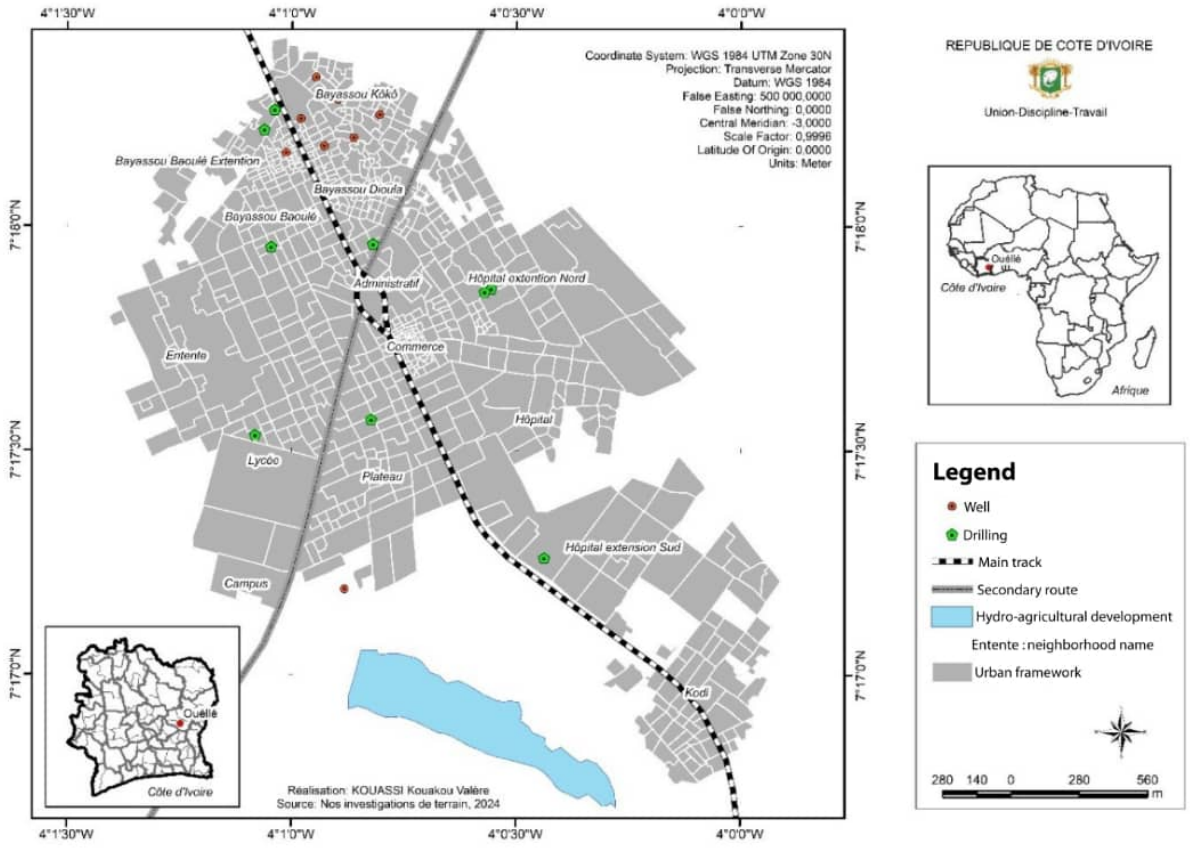
- Microsoft Excel (Microsoft Office 365) for organising, processing and producing diagrams and tables;
- Microsoft Word (Microsoft Office 365) for text entry;
- The integration of processed geospatial data into ArcGis 10.8 GIS (Geographic Information System) software for mapping purposes.

RESULTS

The different sources of drinking water supply in the town of Ouéllé: The town of Ouéllé has around ten districts. The Côte d'Ivoire Water Distribution Company (CIWDC), which guarantees access to drinking water in the town and should be the main source of water supply for the population, is having difficulty ensuring the availability of water in the study area; hence the use of other sources of supply (Table 1). The locality is therefore subject to irregular production of drinking water.

Source: Author, May, 2024

Photo 1. Can used by households to collect water in the event of a water shortage



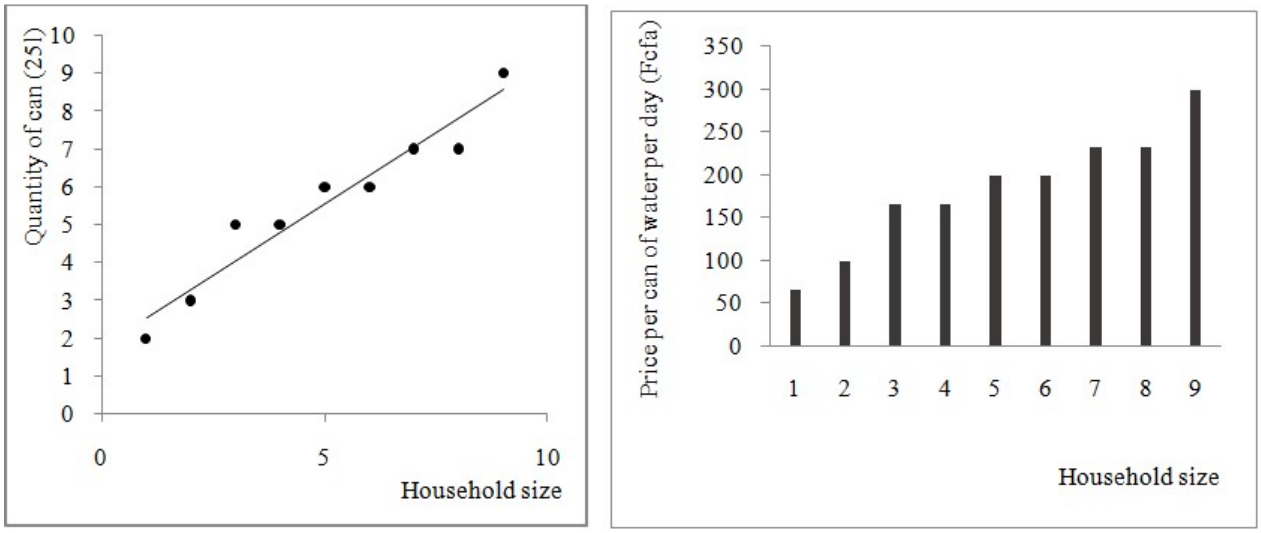
Source: Our fieldwork, 2024

Figure 4. Distribution of commercial boreholes and wells by neighbourhood

Table 3. Average daily, weekly and monthly expenditure by consumers during the water shortage

Household size (x)	Averagequantity moyenne/day	Averageprice FCFA/day	Price/week	Price /month
1	3	100 / 0,15 euro	750 / 1,14 euro	2000/ 3,05 euro
2	3	100 / 0,15 euro	750 / 1,14 euro	3000/ 4,57 euro
3	5	167 / 0,25 euro	1250/ 1,91 euro	5000/ 7,62 euro
4	5	167 / 0,25 euro	1250/ 1,91 euro	5000/ 7,62 euro
5	6	200 / 0,30 euro	1500/ 2,29 euro	6000/ 9,15 euro
6	6	200 / 0,30 euro	1500/ 2,29 euro	6000/ 9,15 euro
7	7	233 / 0,36 euro	1750/ 2,67 euro	7000/ 10,67 euro
8	7	233 / 0,36 euro	1750/ 2,67 euro	7000/ 10,67 euro
9	9	300 / 0,46 euro	2250/ 3,43	9000/ 13,72 euro

Source: Experimental observation of water collection activities at boreholes, May 2024



Source: RGPH 2021 and Experimental observation of water collection activities at boreholes, May 2024

Figure 5. Quantity and purchase price of water by household size

Source: Author, May 2024

Photo 2. Supplying a water wholesaler at the Bayassou Dioula borehole

Source: Author, May 2024

Photo 3 and 4. Water vendors using 1000-litre motorbike tankers at the secondary school district borehole, May 2024

Source: Author, May 2024

Photo 5. View of the HydroAgricultural Scheme

Figure 6. Rainfall-temperature umbrothermal diagram for Ouéllé in 2015 and 2019

This situation has persisted for some twenty years (2002) and continues to worsen with unprecedented population growth and urban sprawl. This statistical table shows the different sources of water supply for the people of Ouéllé. Boreholes are the main source of water supply for all neighbourhoods, ahead ofCIWDC, which serves only 12 of the town's 14 spatial units. Rainwater and well water are the last 2 sources of water in Ouéllé.

Factors limiting access to drinking water in the Ouéllé urban area

Not use of half of the CIWDC boreholes: CIWDC's primary objective is to ensure the availability of drinking water at all times and in all places.

In Ouéllé, only 04 of the 08 boreholes available are operational. In addition, it is important to note the low flow rate of these operational boreholes (Table 2).

This situation could be explained by the absence of permanent watercourses in the study area. The company therefore uses groundwater to supply the town with drinking water. This water is collected and treated before being redistributed to households. This involves a high investment cost for such a small locality. The statistical table shows the 04 operational boreholes (F1, F4, F7 and F8) in the town of Ouellé, which have a total flow rate of 29m3/h. However, it is important to point out that this flow rate is too low to supply the entire town and achieve the objective of providing households with full access to water. According to the CIWDC expert in the study area, a flow rate of at least 50m3/h is needed to supply the entire urban area. Moreover, CIWDC's network only covers 30 km of the entire city. The districts without a CIWDC drinking water supply network are: Hospital Extension North and BayassouKôkô. This situation could be justified by the fact that these spatial units are extension zones. They are therefore new districts located on the urban periphery.

With a society that invests as little as possible in the city, it should be understood that recent spatial entities are not the city's investment priorities. For a locality with insufficient drinking water supply, the lack of water considerably affects the quality of life of the population.Water is used in everyday life for domestic tasks such as cooking, bathing, hand washing, laundry, washing up and flushing toilets. For example, 76% of residents with flush toilets practise open defecation in order to save the water they buy. This state of affairs has a considerable impact on the urban environment and, in turn, on people's health through the proliferation of diseases such as typhoid fever, diarrhoea and malaria.

Variability of rainy seasons: The town of Ouéllé experiences variability in the distribution of rainfall. The number of months of heavy rainfall differs from one year to the next, as shown in the 03 figures below. Analysis of this figure shows that in the first diagram, the rainiest months are May and June, with 216mm and 263mm respectively. In contrast to the first diagram, the second shows August (261mm) and September (326mm) as the months with the most rainfall. In contrast to the first two diagrams, the last one shows that only June (266mm) and September (291mm) are the months with the highest rainfall. The comment that follows from this analysis of the graphs is that the town of Ouellé experiences a variability in rainfall.

The rainy season differs from year to year. Rainfall is therefore irregular and not confined to a given period. In addition to this, it is important to add that these diagrams show the 8 months with the least rainfall out of twelve (12), with less than 137mm per year, seven (07) months for the second and six (06) months for the third.As a result, the study area experiences dry periods when there is a real shortage of water. People are no longer able to collect rainwater regularly at this time of year. Drinking water supply in almost all cases, whether from CIWDC or the boreholes those are the town's main sources of drinking water, draws its sources from underground water. These sources are fed by rainfall. The water table is therefore insufficient, making it extremely difficult to supply neighbourhoods with drinking water, especially in the dry season. These variations in climatic data therefore have an impact on the availability of drinking water in the urban area. The worst water shortages are generally felt by the population during the dry season.

A large school population in a small town: The town of Ouéllé has a large number of school facilities (Figure 2). During the school year, demand for drinking water is high due to the presence of pupils in the locality. Water requirements are therefore high, which means that CIWDC's water supply is frequently interrupted.

The map above shows the 10 schools in the study area, including 04 primary schools and 06 secondary schools. Not all of this school population is permanently resident in the town. According to our surveys, 69% of them come from towns other than Ouellé. The town's population therefore increases during the school year, which explains the high demand for drinking water during this period. However, the situation improves during the school holidays, as these "temporary migrants" return to their localities of origin (sub-prefectures). According to a respondent by the name of Mr Yao: "If in a district, the water shortage lasts 7 days, during the holidays, the situation can be reduced to 3 days. It's a form of load shedding".

How have the people of Ouellé adapted to this situation?

Resilient population responses to water scarcity

Household use of 25-litre jerry cans and barrels: On average, each household has 07 jerry cans to hold water for use during water shortages (Photo 1). However, in neigh bourhoods served by CIWDC drinking water, only 34% of respondents use 25-litre jerry cans to hold drinking water, since the water is only available for half a day during the rainy season and school holidays.

Construction of boreholes by private individuals: There are a total of nine (09) functional boreholes and one (01) well spread proportionally throughout the town. This distribution facilitates the transfer of water from the borehole to the home by reducing the fatigue associated with transporting it on foot, in a wheelbarrow or on one's head, thereby reducing the cost of transport. As a result, 92% of people surveyed use water from boreholes, while 7% turn to wells for their free water supply. Water is sold at the boreholes by the managers: three (03) 25-litre cans at 100F CFA (€0.15) or people come and get their water from the nearest borehole. The map shows the other sources of water supply. These are 09 boreholes built by private companies and 07 wells belonging to local people. The population is developing other sources of access to water in order to obtain supplies, even if this means spending considerable amounts of money. The geographical documents presented above, in particular the statistical table and the 2 graphs, show household consumption of borehole water in relation to the cost of purchasing this resource. The average bill for an average household of 5 people supplied with drinking water by CIWDC is around 6,000 CFA francs (9.14 euros) every 3 months, i.e. 2,000 CFA francs (3.05 euros)/month. Buying water from boreholes is expensive for urban households, which use 06 jerry cans of water per day (Table 3 and Figure 4); this contributes to an average outlay of 6000 CFA francs (9.14 euros) per month, i.e. three times the water bill of a household normally supplied with drinking water from CIWDC. Water consumption depends on the size of the household and the financial resources disbursed. According to the RGPH (2021), the average household size in the town is 9 people, meaning that the average household spends CFAF 9,000 (€13.71) every month, or CFAF 27,000 (€41.14) every 3 months. The population is therefore faced with a real problem of access to drinking water.

The water is transported from the boreholes by resellers to the communities in small-capacity tankers or 25-litre cans, and then sold for 100 CFA francs (€0.15) per can. The drivers deduct the price of the fuel and the distance from the borehole to the delivery point (Photo 3 and 4). In addition, the National Drinking Water Office (NDWO) provides free drinking water in the town, particularly in the Bayassou district. Some households do not hesitate to obtain supplies from the hydro-agricultural site to the south-west of the town during periods of severe water shortage (Figure 4 and photo 5). However, the dam is at the mercy of climatic variability. The site was completely dry from 2015 to early 2016 and from 2018 to 2020 (Figure 6). In 2015, monthly rainfall did not exceed 150 mm, with the exception of October (305 mm), the rainy month, with temperatures reaching 28°C in February. For 2019, only September and October, to which we could add April, record heavy rainfall, with almost 300 mm, around 250 mm and more than 180 mm respectively.

These years mark an upheaval in the usual seasons. These changes, though continually perceptible over the years, accentuate the shortage of drinking water in the town, as well as the drying up of the site containing the water from the Hydro-Agricultural Development Scheme.

DISCUSSION

Sources of supply and factors linked to the inaccessibility of water: Water in urban center can come from several sources, including groundwater (aquifers) or surface water (Houssou D. J-C., 2017, p4). The lack of water in cities can be attributed to several factors. These include climate change and the disruption of rainfall calendars supplying groundwater and surface water (Peyrache-Gadeau V. and Pecqueur B., 2011, p8; Sandra A-B., 2004, p125). This is the case in Ouellé, our study area, where the water shortage can be attributed in part to the climate. It is also due to the malfunctioning of the town's drinking water supply systems. The water shortage may also be linked to a delay in the growth of infrastructure in relation to population growth. In the town of Sinfra in Côte d'Ivoire, drinking water shortages are attributed to the marginalisation of certain districts due to insufficient financial resources on the part of the town council and the rapid development of the urban fabric over the last three (03) decades (Anonymous, 2020, p8).

Management of water resources: Drinking water is normally managed by CIWDC in the town of Ouéllé. Because of the difficulties encountered by this company, private structures and families have built boreholes and wells respectively. As a result, people are spending considerable sums of money to obtain water supplies. According to Zoungrana (2003, p22), households spend an average of 5% of their income on water supply. This average should not exceed 6 to 8% for very poor households (Zoungrana, 2003, p22). In developed countries, the water bill represents on average 1 to 3% of the household budget, for an equivalent level of service for all. In developing countries, the financial burden of the water service is 5 to 6%, and can be as high as 20% for the poorest households, according to Zoungrana D. (2003, p22). Water management generally has three (03) independent objectives: social, economic and environmental (African Development Bank, 2000, p5). It is crucial to protect surface water and groundwater from the harmful effects of waste.

Strategies put in place to ensure access to drinking water: In Abidjan, a number of strategies have been put in place to deal with the water shortage. These include the project to supply drinking water to Abidjan and surrounding towns from the Bonoua water table, at a total cost of FCFA 59 billion, the construction of new water towers in the N'dotré district (FCFA 4, 637 billion CFA francs), Yopougon Niangon 2 (15 billion CFA francs), Angré Djibi (10 billion CFA francs), and Abatta (10.7 billion CFA francs) and social connections for the poorest social strata at a cost of 100,000 CFA francs (Diabagaté A., et al., 2016, p353- 353). In the urban district of Téra in Nigeria, in villages where there are no human-powered boreholes, wells are springing up in dry riverbeds to water animals, in order to avoid pressure on the boreholes (Ayé M., 2022, p15). In our study area, people are turning to commercial drilling, wells at least 3.5 metres deep in wet areas, rainwater harvesting and hydro-agricultural development, commonly known as dams.In Benin, according to Houssou D. J-C. (2017, p1), the national strategy for drinking water supply in rural areas for the period 2017-2030 is based on three (03) pillars, namely reasonable universal access to drinking water for the entire rural population by 2021, the professionalisation of drinking water infrastructure management and the strengthening of communal project management for the construction of infrastructure and the supply and distribution of drinking water. Their strategy provides for the use of new technologies, such as renewable energies for pumping, to avoid increasing operating costs that could penalise consumers. The strategies of the African Development Bank (2000, p13) are based on the integrated management of water resources. They call for good coordination of the activities of the water sub-sectors, which makes it possible to deal effectively with multi-sectoral and interdependent issues, in particular water-related environmental and health problems, as well as multi-purpose hydroelectric dam construction projects.To achieve these objectives, the integrated management policy will address the interdependent issues of water supply, sanitation and health; watershed protection and erosion control; biodiversity protection; environmentally sustainable construction of dams and reservoirs; involuntary resettlement of populations; protection of the marine and coastal environment; drought and desertification; and conservation of water as an ecological resource.

CONCLUSION

The water problem in the town of Ouellé goes back much further than that. It is now an integral part of the daily lives of the town's inhabitants. The problem has intensified with the growth of the town, which extends into the surrounding peripheral areas such as the village of Kodi. It is also exacerbated by the growth in the town's population, followed by variability according to school or holiday periods, and dry seasons accentuated by climatic disturbances. CIWDC, the main body responsible for ensuring the availability of drinking water, is struggling to perform its primary task of ensuring that drinking water is available to everyone, everywhere and at all times, due to various technical, structural and natural problems (lack of groundwater).The contribution of private operators is undeniable in ensuring the availability of water through the sales made (3 cans of 25 litres at 100 FCFA / 0.15 euro) by the creation of boreholes. However, the services provided by the National Drinking Water Office are not negligible, with water distributed free of charge in the city. The problem remains crucial, as it considerably affects the quality of life. A number of recommendations can be made, including

- Mobilising resources for investment in borehole construction by the municipality to support CIWDC;
- Making the non-functional boreholes built by CIWDC operational, while investing in the purchase of durable and efficient equipment through the implementation of a project;
- Facilitating access to land for water supply projects;
- Raising awareness of hygiene and water source management; training people to use a CIWDC water meter;
- encouraging rational water consumption and; finding funding to set up projects for the inclusion and integration of young people in the sustainable management of water in general and water supplies in particular, using local human, financial and natural resources.

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