



Contribution of Local Knowledge to Adapting to Drinking Water Shortages in Rural Areas: A Case Study in Gboguhé Sub-Prefecture, Central-West Côte d'Ivoire

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Accepted: 25 July 2025

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Abstract

We examined how local knowledge helps communities adapt to water shortages in the rural areas of Gboguhé's sub-prefecture. Using a bioanthropological perspective, we employed a qualitative approach that included methods such as direct observation, in-depth semi-structured interviews with five village chiefs, and focus groups with ten social groups representing the surveyed villages. The results demonstrate that traditional water practices help communities manage shortages while effectively meeting their water needs. Additionally, our research underscores the significance of traditional knowledge in addressing water shortages. It underscores the need for collaboration between local and scientific knowledge to develop solutions suited to the specific context, thereby promoting sustainable community resilience.

Keywords Drinking water shortage · Rural communities - traditional knowledge · Resilience · Gboguhé, Central-West côte d'Ivoire

Introduction

Access to safe drinking water is vital for improving living conditions, as it meets fundamental human needs and reduces health risks (Diouf et al., 2024; Azadi et al., 2024; Hanif et al., 2024). In rural areas, it plays a crucial role in easing the burden on women and children, which enhances

educational opportunities and frees time for economic activities, ultimately empowering women (Choudhuri & Desai, 2021; Fonjong & Zama, 2023; UNICEF, 2021). Recognizing its importance, access to safe drinking water is considered a fundamental human right and a global priority within the Sustainable Development Goals (SDGs), particularly Goal 6 of the 2030 Agenda (Biswas et al., 2024; Tufail et al., 2024; UN-Water, 2023).

Despite these initiatives, the global water shortage persists. The world population living in water-scarce areas increased from 2,04 to 2,36 billion people between 2010 and 2020, and this number is expected to reach 2.70 billion people by 2030. (Berg, 2024; Karimi et al., 2024; World Health Organization, 2022). This situation highlights the pressing need for adaptable and resilient solutions to address water shortages. Trends highlight that water shortage is likely to affect indigenous and marginalised populations increasingly. Supporting the sovereignty of indigenous and rural populations to create a water-secure future through local knowledge, local management, and community adaptation measures can help address this crisis (Basel et al., 2021).

Local knowledge, passed down through generations and deeply rooted in community realities, offers

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promising alternatives to enhance water resilience in rural areas (Zaouaq, 2021; Acharibasam et al., 2024; Chanza et al., 2022). This body of knowledge includes traditional water management practices, which, although often overlooked, represent invaluable resources for addressing climate uncertainties and water-related challenges.

In the Sub-Prefecture of Gboguhé, located in central-west Côte d'Ivoire, local populations face chronic shortages of safe drinking water. The manually operated pumps, which are the primary sources of drinking water, often break down or cannot meet the community's needs (Seri & Amani, 2022). An assessment conducted by the National Water Distribution Company of Côte d'Ivoire revealed a pump failure rate of 65%, with only 26 out of 46 pumps in the sub-prefecture still operational. Faced with this situation, rural communities have relied on traditional knowledge to manage this vital resource, highlighting the importance of local practices in reducing water-related risks.

Although several researchers have gradually acknowledged the relevance of local knowledge in terms of adaptation to environmental risks, most of this knowledge remains tied to the context of climate change (Maldonado et al., 2016; McPherson et al., 2016). The few studies tackling the issue of adaptation to water scarcity very often focus on technological or institutional solutions to improve access to drinking water (Sukanya & Joseph, 2024; Jabbar et al., 2024; Inkani et al., 2021), neglecting traditional practices. Very little research provides specific empirical examples of how local knowledge is mobilized to address a shortage of drinking water in contexts where modern infrastructure is failing. In response to this issue, our bio-anthropological study adopts an innovative approach by focusing on local knowledge as a lever for water resilience in the specific rural context of the Gboguhé Sub-Prefecture. Unlike existing studies that predominantly emphasize technological solutions or modern infrastructure, our research analyzes the contribution of local knowledge, often marginalized, in the communities' adaptation to water shortages in Gboguhé's Sub-Prefecture.

Using a qualitative approach that combines semi-structured interviews, focus group discussions, and direct observations, our study highlights the resurgence and effectiveness of community strategies rooted in centuries of environmental interactions. We offer a new perspective by incorporating indigenous solutions into scientific and policy discussions while emphasizing their complementarity with modern interventions. This method underscores the importance of local knowledge in shaping sustainable and inclusive water management policies, thereby opening up new avenues to address gaps in prior research, which has primarily focused on purely technical approaches.

Conceptual Framework

The interaction between traditional knowledge and adaptation to water scarcity is a crucial area of research for understanding how rural communities manage environmental risks. We focus on the experiences of rural communities in the sub-prefecture of Gboguhé, which face significant challenges related to the limited availability of clean water. It is essential to establish a robust analytical framework that captures the complex dynamics between traditional knowledge, coping strategies, and rural communities. To achieve this, we rely on the theory of cultural ecology developed by Julian Steward. This theory examines the interactions between human cultural practices and their natural environment (Steward, 1955). From this perspective, local practices are not simply perceived as isolated traditions but as dynamic adaptive responses to ecological constraints and opportunities offered by the environment (Buskell, 2024). This approach is particularly relevant for analyzing the role of local knowledge in water resilience in rural areas, where the interactions between social and ecological systems are often crucial for ensuring access to essential resources, such as water.

In terms of water resource management, the hydro-social paradigm shift towards adaptive planning based on local knowledge has proven beneficial in terms of socio-environmental development and cost efficiency compared to new physical infrastructure solutions. In the face of increasing water shortages, many global communities are adopting ancestral practices to adapt to new water conditions (Folke, 2006). Such knowledge influences daily water management practices, including collection, storage, and distribution within rural communities, enabling them to cope with resource scarcity (Thornton & Bhagwat, 2021) (Belay and Bewket, 2013).

Examining these traditional water-related methods provides greater insight into how communities thrive in resource-limited regions despite seasonal droughts and floods. These works form the conceptual foundation of our study, aiming to understand how ancestral knowledge and local practices are mobilised to address water scarcity and support community resilience under challenging environmental conditions (Fig. 1).

To address the challenge of accessing drinking water, local communities depend on knowledge passed down through generations. This knowledge includes techniques for managing and restoring natural water sources, as well as traditional methods for storing and using water efficiently. These strategies enhance the community's ability to adapt by protecting against water scarcity and helping conserve available resources. Such practices demonstrate the ability of rural populations to adjust their behaviors and social systems to environmental challenges, in line with the core principles of cultural ecology.

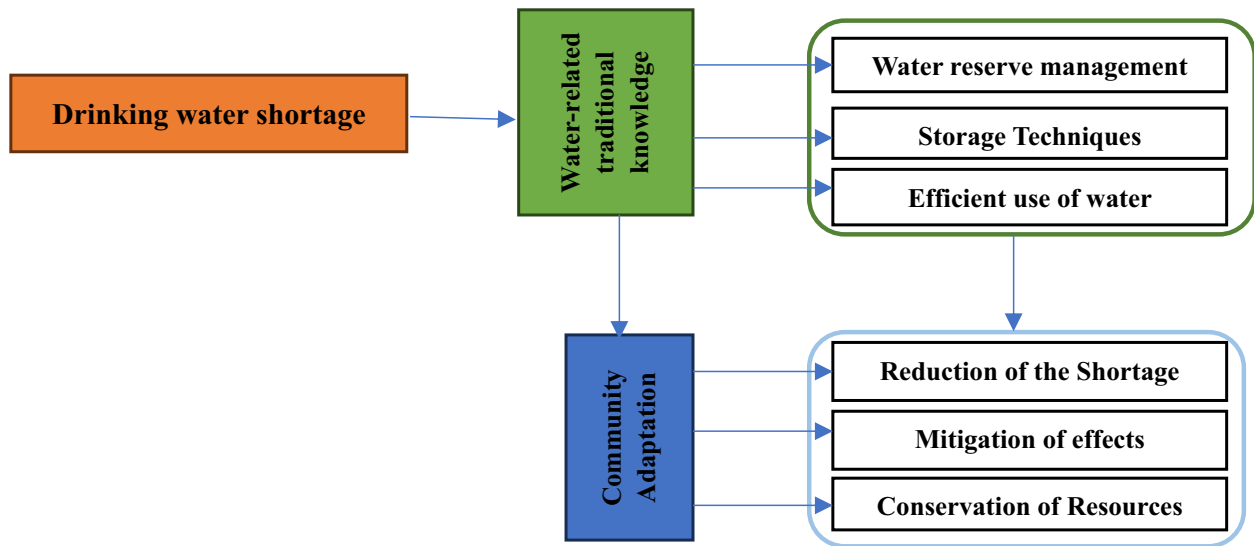


Fig. 1 Analytical model

Methodology

Study Area

We conducted this study in five villages within the Gboguhé Sub-Prefecture: Gboguhé, Gbiéguhé, Zobéa, Koréa 2, and Kékégoza. These villages are part of the 36 villages in the Gboguhé Sub-Prefecture, located in the Central-Western region of Côte d'Ivoire, specifically in the Haut-Sassandra area, within the Daloa department (Fig. 2).

According to the latest General Population and Housing Census (GPHC) published by the National Statistics Agency of Côte d'Ivoire (ANSAT), this rural area has approximately 69,020 inhabitants, including the indigenous Bété people, other allochthonous groups (such as Gouro, Yacouba, Baoulé, and Sénoufo), and immigrant communities (from Mali, Burkina Faso, Guinea, and Togo), (ANSAT, 2021). The Gboguhé Sub-Prefecture faces persistent challenges in accessing clean water due to the malfunctioning of Pumps with an estimated failure rate of 65%, meaning 26 out of the 40 existing pumps in this area are out of order¹(SODECI, 2019). Therefore, for representativeness, we selected the following criteria to determine the geographical sample for investigation:

- **Geographical affiliation:** The selected localities are within the same area of interest, specifically the Sub-Prefecture of Gboguhé.
- **Cultural belonging:** The chosen localities are part of the same Bété ethnocultural group. This provides a

logical basis for the study by establishing a connection with the core culture.

- **Types and numbers of water facilities:** The focus was solely on localities with at least one operational human-powered pump.
- **Population size:** The selected localities have at least 1,000 residents to assess the extent of the phenomenon.

Sampling Method and Composition of Participants

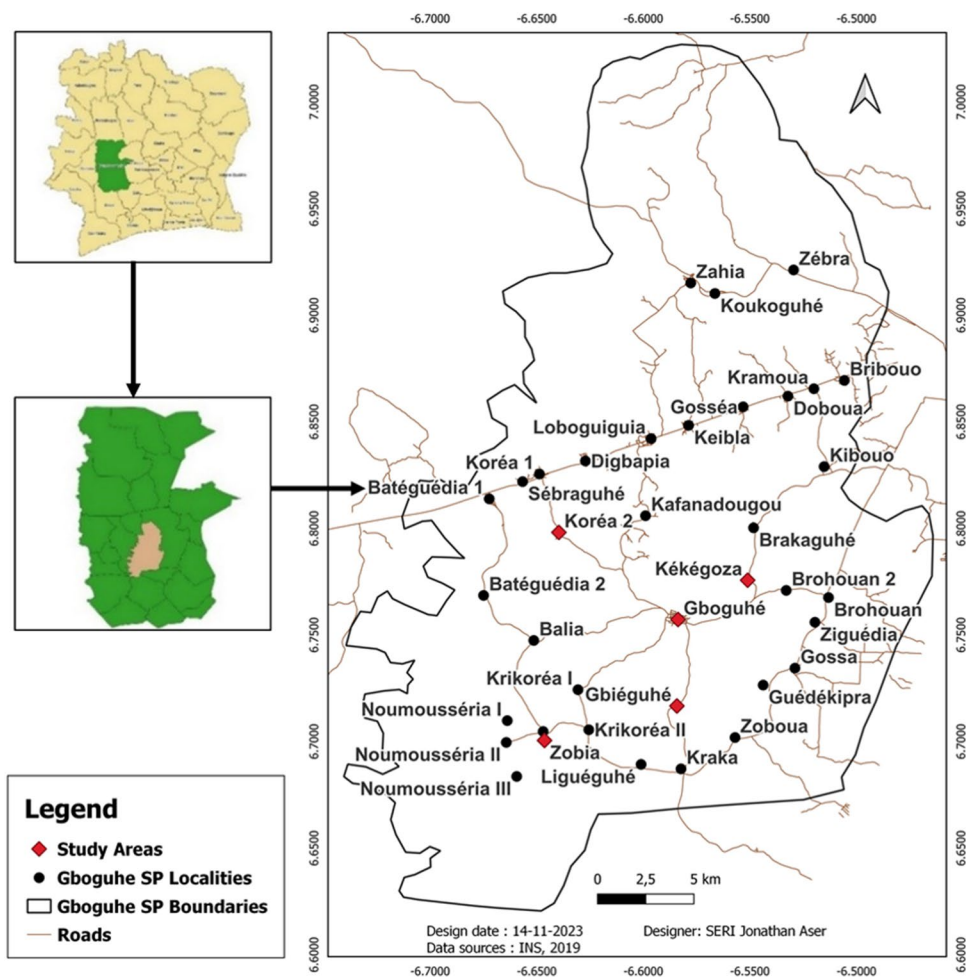
We conducted this study with a sample of informants carefully selected using the sampling method, aimed at ensuring the relevance, contextual diversity, and comprehensiveness of the data required for our research (N'Da, 2015). This method involves identifying and including participants or cases that representatively reflect the characteristics, dynamics, and contextual realities of the phenomenon under study, namely resilience to water scarcity in the Sub-Prefecture of Gboguhé. For this study, typical case sampling was prioritized due to its ability to provide rich and contextual data, which is indispensable for exploring local knowledge. By focusing on “representative” actors, this method enabled us to capture practices and perceptions widely shared within the community, while offering a solid basis for analyzing the social and cultural dynamics related to adaptation to water shortage.

To ensure a thorough and detailed understanding of local knowledge used in response to water scarcity, four main groups of actors were identified for data collection.

- **Village chiefs:** Within the Bété community, these individuals serve as custodians of ancestral knowledge and oversee customary practices related to the management

¹ Consultation of the database for the diagnosis of hydraulic facilities carried out by SODECI in 2019.

Fig. 2 Map of Gboguhé Sub-Prefecture



of natural resources. The village chief, in particular, acts as the administrative leader and guardian of traditions, responsible for upholding cultural norms and maintaining peace within the community.

- **Women:** Recognized locally as household managers, women possess practical knowledge about daily water management due to their key role in securing and utilizing this resource within households.
- **Youth:** Their inclusion enables an in-depth understanding of how traditional knowledge is transmitted to emerging generations and helps assess the socially differentiated impacts of potable water scarcity from their perspective.
- **Local government officials:** These institutional actors participate in water resource management and local resilience efforts. Their involvement is essential for understanding the social, economic, and political factors shaping water management in the sub-prefecture of Gboguhé, helping to contextualize water scarcity and develop suitable recommendations.

The informants were selected based on well-defined criteria, including:

- Recognized local expertise, demonstrated through proven knowledge of water management in the area or personal experience in applying adaptive strategies;
- Availability and willingness to share relevant and detailed information;
- Representativeness of the study context, by belonging to groups or communities directly affected by water scarcity in the sub-prefecture of Gboguhé;
- Geographic diversity encompasses different villages or localities, accounting for territorial specificities.

A total of 20 semi-structured interviews were conducted, evenly distributed across the four identified categories. Sampling continued until theoretical saturation was reached, after which additional sampling did not yield any new relevant information.

Approach

We adopted a qualitative approach to assess the impact of local knowledge on community resilience in the face of water scarcity. To achieve this, we conducted a comprehensive literature review encompassing topics such as the challenges to accessing clean water in rural areas, traditional water management practices, and the resilience strategies employed by rural communities to cope with water scarcity. Focus groups were explicitly organized in each village, resulting in ten focus groups studied across the five villages.

The use of focus groups as a qualitative data collection technique proves appropriate for examining natural resource governance, as recent research has demonstrated (Azad & Pritchard, 2023). This approach is gaining popularity among social science researchers and qualitative researchers, particularly to investigate the resilience process of communities while analyzing their experiences (Saha, 2015; Alam & Collins, 2010). It is well-established that qualitative research techniques are conducive to producing dense and nuanced data (Aldrich, 2011; Chamlee-Wright & Storr, 2011). In this regard, the focus group emerges as a preferred qualitative technique, characterized by its practicality, relatively low cost, high face validity, and ability to generate meaningful results quickly (Caretta & Vacchelli, 2015; Krueger, 1994). This technique is particularly relevant in our study focused on resilience to water scarcity, as it provides valuable insights into the context and lived experiences of local communities in their adaptation (Ahmed et al., 2019; Zamasiya et al., 2017). On average, the duration of focus group sessions ranged from 1 h to 1.5 h, providing a suitable framework for in-depth exploration of the topics discussed.

In addition to these methods, semi-structured individual interviews with youth and direct observations were conducted to collect firsthand data on how rural communities apply ancestral knowledge to address this issue. Additionally, a review of hydraulic structures in the villages helped develop an understanding of the issue of clean water scarcity. These different techniques were supported by specific tools, including a reading grid, an interview guide, and an observation grid, to ensure the collection of accurate and detailed data.

The audio recordings from the interviews were carefully transcribed word for word to maintain the authenticity of the participants' stories. After transcription, the data were analyzed using a systematic thematic content analysis, a thorough method designed to identify, organize, and understand the important patterns in the informants' speech. This process was repeated in several stages to ensure both depth and accuracy in the analysis.

Initially, the transcripts were carefully read and re-read to gain a deep understanding of the data and to identify initial

themes and ideas. This was followed by open coding, where segments of text were assigned codes that represented key concepts or patterns. The coding process was driven by the data, allowing code to naturally emerge from the participants' stories, which kept the analysis grounded in their actual experiences.

Next, the codes were organized into broader categories based on thematic similarity, creating overarching themes that captured the essence of the participants' perspectives. During this phase, constant comparison was used, where data within each category were examined to ensure consistency, and differences were noted to refine the themes further.

The analysis took a holistic approach, highlighting the connections between themes to develop a thorough understanding of how local knowledge enhances resilience to water scarcity in the Gboguhé Sub-Prefecture. This process involved not only identifying explicit information but also examining implicit meanings and the underlying cultural, social, and environmental factors that influence participants' perspectives.

To enhance the reliability and validity of the findings, the thematic framework was repeatedly reviewed and cross-verified against field notes and additional contextual information collected during the study. This triangulation process ensured that the data interpretation was strong and reflected the complexities of the local context.

The final step involved synthesizing the themes into a cohesive narrative that aligned with the research goals. This narrative not only reflected the diversity of the participants' experiences but also highlighted shared practices, adaptive strategies, and cultural values that support local resilience to water scarcity, thereby making a meaningful contribution to both the theoretical and practical understanding of the phenomenon under study.

Research Ethics Considerations

Throughout this study, the consideration of ethical principles has been a fundamental part of the research methodology. In this regard, great care was taken to obtain informed consent from each participant, emphasizing respect for their autonomy and their right to make informed decisions about their participation in the study. Furthermore, special attention was given to maintaining the anonymity of participants, ensuring the confidentiality of their identities, and safeguarding their right to privacy. To respect the sensitivity of the collected data, the presentation of results used initials for participants' names, eliminating any risk of unauthorized disclosure of their identity. This approach was implemented to protect the integrity and dignity of the participants, in line with the strictest ethical standards of scientific research.

Results

Dynamics of Drinking Water Shortage in the Sub-prefecture of Gboguhé

Factors of Drinking Water Shortage in the Sub-prefecture of Gboguhé

Several factors contribute to the water shortage in the Gboguhé Sub-Prefecture. They are of both structural and socioeconomic nature.

- a) Structural factors related to the shortage of drinking water

Structural factors play a significant role in the water shortage in the Sub-Prefecture of Gboguhé. These refer to the essential elements of the water supply system that directly impact the availability and accessibility of drinking water. In the context of Ivorian hydraulic infrastructure, the Ministry of Hydraulics has set specific standards for drinking water supply, as shown in Table 1.

Within the surveyed villages, a thorough comparison of the available modern water supply points against the criteria set by water distribution standards at the village level reveals a significant gap in these communities (Fig. 3).

The demographic data for the various localities was obtained from the official database of the general population

Table 1 Drinking water supply standards in Côte d’Ivoire

Sectors	Sub-sectors	Standards
Urban Hydraulics	SODECI	- Population over 4000 inhabitants
		- Financial participation (pay the subscription fee)
Rural Hydraulics	HVA	- Subdivided, electrified locality with at least 60% solid construction
		- Estimated water requirement between 21 and 30 L per inhabitant
	HV	- Population between 2000 and 4000 inhabitants
- Financial participation varies between 10 and 20% of the investment cost, depending on the donor		
		- Subdivided and electrified village
		- Existence of 3 m ³ /hour borehole
		- Establishment of a management committee
		- Population less than 2000 inhabitants
		- 1 borehole equipped with a pump for a range of 100 to 600 inhabitants
		- 1 additional borehole for every additional 400 inhabitants
		- Establishment of a management committee

Source: Daloa regional Directorate of Hydraulics (2022)

and housing census of Côte d’Ivoire (ANSAT, 2021). Data on existing pumps in the localities and their operating condition were gathered through field observations and compared with the SODECI diagnostic database. The number of pumps needed in each locality was calculated by dividing the population by 500, where 500 represents the maximum number of inhabitants that can be served by one pump. The results have been rounded up.

The analysis of this diagram reveals that the population exceeds (2000) residents in most of the studied areas (i.e., four localities), which necessitates at least four hand pumps or their equivalent, based on current water supply standards. However, there is an apparent inadequacy in the hydraulic infrastructure compared to the needs expressed by community members. This creates a significant gap between the actual number of facilities (3, 1, 1, 1, and 2 pumps, respectively) and the required number of pumps for drinking water (8, 3, 5, 5, and 6 pumps needed, respectively), highlighting a mismatch between national guidelines and local hydraulic service realities. This situation impacts these facilities’ ability to meet the water needs of residents, as indicated in this statement:

“Today, it is difficult to get water from the pump because of the crowd over there. Previously, our parents had around 100 to 200 inhabitants in the village, and they managed this pump. However, today there are more than 2,000 inhabitants. Immigrants, people from the sub-region, came to the village, resulting in overcrowding, yet we still have a single pump. It is no longer sufficient for this population, so, normally, there is always a water shortage.” – Interview with the Chief of Zobéa, survey 2022.

These words highlight a tangible reality in which the insufficiency of existing hydraulic resources exacerbates water shortages in these communities. The significant increase in population, driven by the influx of immigrants and residents from the sub-region, has revealed the limitations of the single hydraulic infrastructure built for a much smaller population. As a result, this one pump’s capacity to meet the rising water demand is severely limited, directly affecting the water availability and accessibility for residents. Moreover, the current hydraulic infrastructure, besides being inadequate, also suffers from operational failures, which further contribute to worsening the water scarcity in these areas (Table 2).

These failures result from various factors, including inadequate maintenance, mechanical issues, and improper facility management. Consequently, the challenges faced by the population in accessing reliable and regular drinking water are exacerbated.

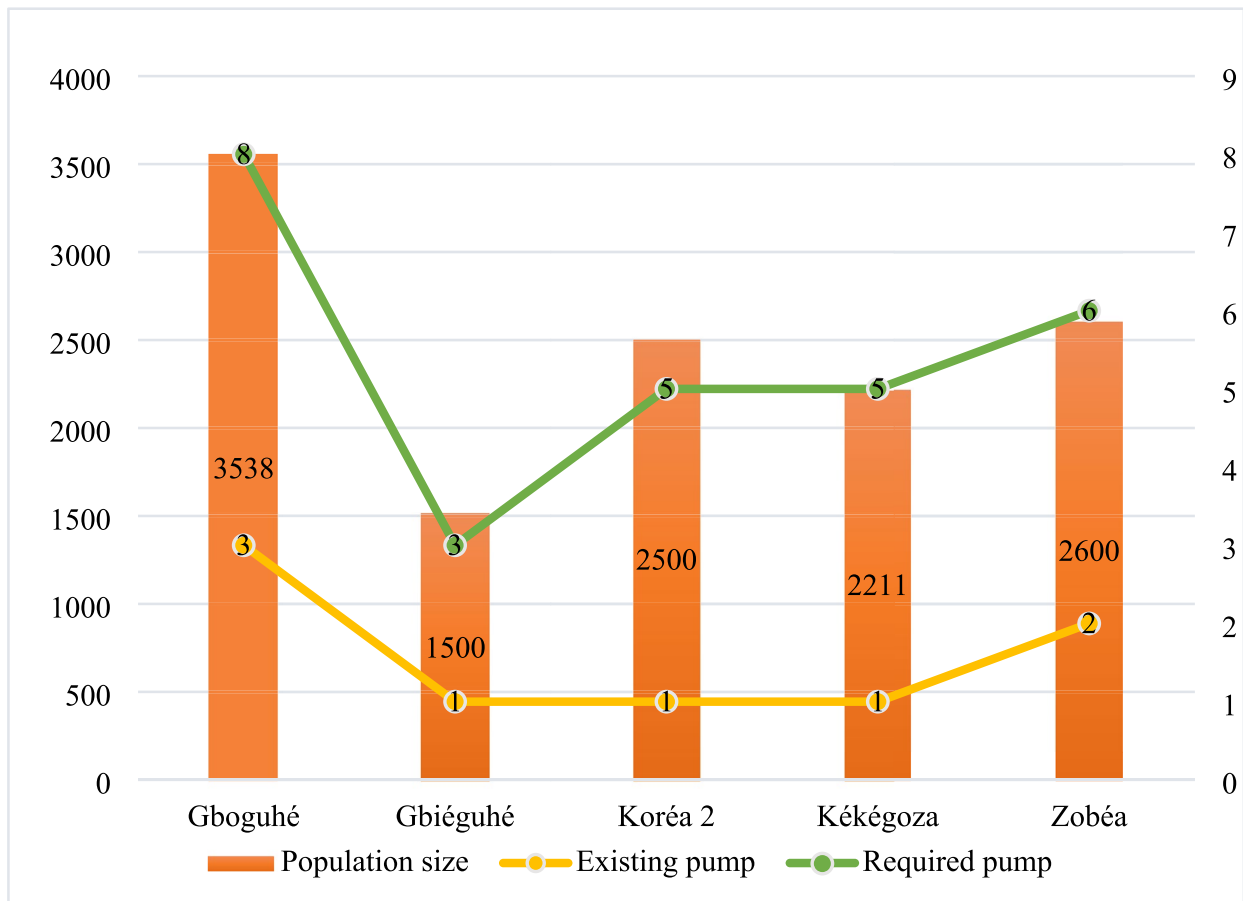


Fig. 3 Comparison between existing and necessary pumps in the study area. (Source: Field survey, 2022)

Table 2 Inventory of water facilities in the villages surveyed

Villages	Population size	Existing PMH	Operational status		
			Good	Bad	Failure
Gboguhé	3538	3	2	0	1
Gbiéguhé	1500	1	1	0	0
Korea 2	2500	1	1	0	0
Kékégoza	2211	1	0	1	0
Zobéa	2600	2	1	1	0

Source: Field Survey, 2022

b) Socio-economic factors related to drinking water scarcity

An in-depth analysis of the situation outlined above reveals important implications for managing hydraulic resources in the Gboguhé Sub-Prefecture. The large gap between the number of existing pumps and the actual demand underscores significant shortcomings in planning and executing hydraulic projects at the local level. These disparities reveal a disconnect between the national standards, established based on strict guidelines for water supply, and the local communities' capacity to meet the population's urgent need

for access to a safe and reliable water source, as shown in Table 3.

The examination of Table 3 reveals significant population growth in the surveyed areas. However, the steady number of hydraulic facilities across the three main periods of the General Population and Housing Census in Côte d'Ivoire highlights the challenges faced by local authorities (Regional Council of Haut-Sassandra and Gboguhé Municipality) in adjusting their investments in drinking water to keep up with rapid population growth. The challenges reveal critical technical and financial gaps that limit their ability as project owners of hydraulic infrastructure. Technically, the lack of regular updates to databases on local hydraulic infrastructure hampers effective planning, which is influenced by community demands and the political priorities of elected officials. The shortage of qualified personnel in the hydraulic sector presents another obstacle. On the financial side, Gboguhé Municipality and the Regional Council of Haut-Sassandra rely heavily on state subsidies, with budget restrictions and deductions that hinder effective implementation of development projects despite often insufficient funding, as shown in Table 4.

Table 3 Evolution of population and water infrastructure in 1998, 2014 and 2021

	Year 1998		Year 2014		Year 2021	
	Population	Number of Pump	Population	Number of Pump	Population	Number of Pump
Gboguhé	1149	3	3289	3	3538	3
Gbiéguhé	451	1	808	1	1500	1
Zobéa	657	2	1831	2	2600	2
Kékégoza	479	1	1452	1	2211	1
Koréa 2	620	1	1496	1	2500	1

Source: ANSAT 1998, 2014, and 2021; Field Survey, 2022

Table 4 Local government budget report

Modality	Gboguhé Town Hall		Haut-Sassandra Regional Council	
	2019	2020	2019	2020
Notified subsidy (FCFA)	83.151.000	93.106.000	1.081.785.000	1.131.785.000
Subsidy Recovered (FCFA)	62.363.838	56.218.933	887.941.988	819.853.690

Source: Financial report 2019 and 2020 of Gboguhé Town Hall and Haut-Sassandra Regional Council

The inability of local authorities to recover the entirety of their budget over the period constitutes a significant obstacle to the effective integration of the water needs of affiliated village populations, as well as the establishment of adequate mechanisms for monitoring and maintaining hydraulic infrastructure, considering the average costs mentioned in Table 5.

However, the Regional Council is involved in some hydraulic projects, mainly focused on the rehabilitation of pumps, as the Technical Director, Haut-Sassandra Regional Council, 2022, indicated:

Regarding access to drinking water in the region, we face serious problems. The existing pumps are all in poor condition. In the villages, residents ask us to build new wells, but our current budget does not permit this. Therefore, we are only able to rehabilitate the damaged pumps. Today, constructing a water point costs approximately \$12,000 to \$13,000. Instead of spending that amount on a new water point, we prefer to rehabilitate the existing ones. As a result, technicians visit, assess the current situation, and repair the facilities.

Table 5 Average price of hydraulic facilities

Type of Hydraulic facilities	Component	Price (FCFA)
HVA	Borehole+Tank+Equipment+Pipeline	80.000.000
PMH	Borehole+Pump	8.000.000

Source: ONEP, 2022

This statement raises concerns about the long-term sustainability of water supply initiatives and infrastructure management in the region. The limited capacity of local authorities to mobilize sufficient resources undermines the sustainability of projects and their ability to provide water in a timely and adequate manner to meet the changing needs of local populations. All these factors contribute to situations of drinking water shortages, thereby affecting the daily lives of local communities.

Impacts of Drinking Water Shortage on People's Daily Lives

Clean water is vital in the communities of Gboguhé, Gbiéguhé, Kékégoza, Koréa 2, and Zobéa, significantly influencing local social and ecological systems and helping maintain social and cultural stability. When this essential resource is scarce, it causes a range of impacts that affect various aspects of community life, including social, economic, and health-related areas.

a) Social impacts.

The ongoing shortage of clean water fosters a sense of inferiority among communities, highlighting social inequalities and reinforcing social hierarchies. Water is vital for development and is viewed as a driving force that influences social life and interactions within communities. This dependence strengthens local identity, making water a significant cultural symbol. The classification of affected villages as “camps” by wealthier communities highlights social and symbolic barriers, influencing intercommunity relations and perpetuating perceived inequalities in access to clean water.

Often, when we go to play soccer, the youth from other villages say that we still live in a ‘camp.’ Moreover, even at the Gokra market, women use this expression to mock other women because there is a water tower there. It is often embarrassing, but we cannot speak proudly about our village in these conditions. - KNF, youth from Gboguhé, 2022.

The stigma associated with water scarcity has a significant impact on marriage within the community. Young people

and adult men see marriage as a key marker of maturity and responsibility in the local traditional culture. It is regarded as a significant symbol of respect and regard among the Bété people. For young people, especially, marriage is a significant step in assuming responsibility in the community and participating in decisions about local development. Since the Bété are an exogamous society, people from Gboguhé, Gbiéguhé, Kékégoza, Koréa 2, and Zobéa marry outside their clan. Because villages often consist of several lineages that share a common ancestor or patriarch, young people must find spouses in villages without any familial ties to avoid incest, a socially condemned act. Today, most villages in the Sub-Prefecture have modern water systems that ease domestic chores, especially for women, making it harder to find marital partners outside the village. For women, leaving their hometown to marry in a village with poor water conditions in search of better water sources can cause distress and suffering. This quote confirms this analysis, illustrating the complex social and cultural tensions caused by water scarcity and the stigma it creates.

I had to get my wife from Gokra. I did not understand it myself; she says she will not come to live in my village because the water access situation is challenging here. For that reason, she cannot come to get married here, especially since other women have their partners married in other villages where there is water. When you talk to them about this village, they now refuse to come and get married. Young man from Koréa 2, focus group 2022.

The scarcity of drinking water heightens tensions among community women, leading to verbal confrontations that stem from accumulated frustrations over accessing this vital resource. When the pumps are finally available during peak demand, individual or family needs often clash, sparking fierce disputes over water. This competition can worsen existing tensions, intensifying conflicts and rivalries among women. Verbal arguments can quickly escalate into physical fights, highlighting the profound impact of the pressure

to access water in their daily lives. Though often temporary and spontaneous, these disputes underscore the significant impact of water scarcity on social relationships within the community and highlight ongoing challenges in managing water resources fairly and sustainably.

b) Economic impacts

The scarcity of drinking water is a significant obstacle to women's economic productivity, limiting their ability to participate in other income-generating activities. Due to the extra effort required to find and supply water for basic domestic needs, women often spend a significant amount of their time and energy on this essential task, thereby sacrificing the opportunity to pursue additional income sources. This limitation hinders women's income diversification, depriving them of key economic opportunities and restricting their capacity to contribute to local economic growth. The reduction in time and resources available for productive activities worsens women's economic vulnerability, reinforces existing socio-economic inequalities, and blocks the potential for inclusive economic development in the community.

c) Health impacts.

The scarcity of drinking water leads to health problems. This situation endangers the health and well-being of residents, increasing their risk of contracting waterborne diseases and other health issues resulting from poor water quality and inadequate hygiene practices. Relying on questionable or contaminated water sources (Fig. 4) puts community members at risk of diseases such as diarrhea, dysentery, typhoid, and other waterborne infections, particularly among vulnerable groups like children and the elderly.

Meanwhile, the shortage of drinkable water hampers residents' ability to keep proper hygiene, increasing health risks. To address this issue, local communities in the Sub-Prefecture of Gboguhé depend on their traditional knowledge to adapt.

Fig. 4 Backwater polluted by dead leaves in Kékégoza and Koréa 2. (Source: Field survey, 2022)



Evolution and Adaptation of Traditional Water-Related Practices

Cultural and Historical Context of Water-Related Traditional Knowledge among the Bété

Water is a vital resource, a cornerstone of human sustenance, and access to it is a critical issue for rural communities in Africa, especially among the Bété communities. In this area, water management is deeply embedded in a complex cultural and social fabric. Ancestral practices developed over time due to close interaction with the environment, traditional beliefs, and wisdom passed down through generations. Understanding the significance of these practices involves grasping the symbolism of water in these communities, their traditional methods of using this resource, and the sources and techniques used for water supply.

a) Symbolism of water among Bété people

In the Bété culture, water or *Gnou* has a deep and complex symbolism. It is an essential part of daily life, spirituality, and traditional rituals.

- **Water, the source of life**

Water is seen as a symbol of life. It is essential for sustenance, fertility, and growth. According to the communities, water is a requirement for the existence of plants, humans, and animals. That is why the seasonal distribution of rainfall is critical, as it sets the rhythm of activities within these communities, based on past and current experiences related to this vital resource. From their perspective, the two main seasons help to illustrate the crucial role of water. The first is the dry season, called *yourou ba gui do*. This period features plenty of sunshine, *yourou*, and little to no rain, typically occurring from January through March. During this time, rivers and backwaters dry up, and vegetation withers. Conversely, the second season, known as *Goudé* or the rainy season, brings life back to plants, as water bodies flow again. These sources provide water for irrigation, drinking, cooking, and religious rituals. Just as water restores balance among the elements of nature, it also brings harmony to human life. According to the local chieftaincy, human existence is closely tied to water. That is why, in traditional healing practices, water plays an important role. In this community, water is also widely used for infants, because it is believed to give children more strength and vitality, helping them fight off diseases related to their environment. Nearly all human activities here revolve around this precious resource.

- **Water, mediator between the material and immaterial worlds**

In Bété culture, water is also viewed as a mediator between the material world and the spiritual realm. This belief stems from the idea that water, as a vital natural element for life, possesses intrinsic power, some vital energy that transcends the boundaries of our tangible reality. Certain water bodies are used as a sacred means of communication with spiritual forces (Table 6).

These water sources act as a bridge, enabling people to connect with ancestors or deities. Libation rituals, such as pouring water as an offering, reinforce this spiritual bond. Water symbolizes purification, helping people establish a genuine connection with the sacred. The chief of Kékégoza demonstrates this practice through an example.

In our tradition, water is used as a symbol of blessings. When a father or mother wants to speak words of blessing over their child, or when a stranger is leaving our home to return to their own, we take water. We put the water in our mouths and spit it on the ground. After spitting on the water, we say ‘pissiah’ and speak words of blessing to the child or the stranger. (Interview with a lineage chief in Kékégoza, 2022).

- **Water as an Instrument of Socialization.**

Among the Bété people, water is regarded as a tool for socialization, playing a vital role in building and reinforcing social bonds within the community. More than just its physical use, it symbolizes sharing, cooperation, and social unity. Water points, such as rivers, wells, or fountains, serve as natural gathering spots where women come together to fetch water, chat, and exchange news.

Table 6 Synthesis of the sacred water sources of our study area

Villages	Name	Description
Gboguhé	<i>Gabada</i>	<i>Gabada</i> means the river of the antelopes. It owes its sacredness to a rock on its shores that the natives worshiped.
Kékégoza Koréa 2	<i>Srodou</i>	The name <i>Srodou</i> is the name of the protective spirit of the village, who is said to reside in this river.
Gbiéguhé	<i>Gnono</i>	The River Gnono is a water source named after the protective genius of the village of Gbiéguhé.
Zobéa	<i>Zougrougni</i>	The name <i>Zougrougni</i> means “the water of catfish” in the Bété language. This river is home to sacred catfish worshipped by the natives of Zobeia.

Source: Field survey, 2022

Fetching water from the backwater is an enjoyable experience. It is not dull. That is where all the women go. In the village, each woman is in her own home. Except on meeting days, we often do not have time to chat with each other because we have to prepare, do the dishes, take care of the children, and manage our household. It is often challenging. Most of the time, we meet at the backwater when we go to fetch water. There, while fetching water, we can talk and share news. (Excerpt from a focus group with the women of Gbiéguhé, 2022)

From these words, we see that interactions strengthen social bonds by creating opportunities for casual conversations and sharing experiences. Additionally, water is used in social and cultural rituals, such as weddings or baptism ceremonies, marking important moments in society and reinforcing a sense of belonging and unity.

b) Traditional water supply sources for the Bété people

Among the Bété, the backwater or *Gnibeu* (Fig. 5) has always been a traditional source of household water supply. These are surface water bodies located near communities, usually in low-lying areas. These sources are typically shallow and shaped like a circular water catchment basin. Water from underground layers, also replenished by rain, is naturally stored in these areas.

The social history of the surveyed communities reveals that selecting a village's location is a crucial decision influenced by geographic, environmental, and cultural factors. Having a water source or a backwater is traditionally considered one of the most important criteria for selecting a settlement site due to its functional benefits.

In the past, when our ancestors established a village, the first thing they sought was water. When they



Fig. 5 A backwater in Zobéa. Source: Field survey, 2021

found water in a specific spot, that is where they set up their small camp. Water encouraged the growth of cities because, without it, nothing could be built. That is why, in Bété country, a village always needs to be near a marsh. You cannot place a village out in the desert. In Bété country, nearly all the villages are located along the edges of backwaters. The first village site our ancestors chose was not here; it was located right next to the backwater, providing access to water. (Chief of Koréa 2, survey 2022).

Among the Bété people, backwaters are not just water sources, but they are the central pillars of daily life, providing essential resources for a variety of needs. In addition to drinking, residents use backwater water for cooking and cleaning, which is vital for the health and well-being of the community.

Although access to backwaters is generally open, strict hygiene rules have been established to prevent any contamination of this precious resource, as shown in this statement:

Anyone can fetch water from the backwater. It is open to everyone, and admission is free. However, it is important to follow the rules to prevent contaminating the water, as it is meant for drinking. Therefore, you are not allowed to enter with shoes, and if you have a wound, you will not be permitted in. Using a dirty container to fetch water is also prohibited. (Excerpt from a focus group with the women of Zobéa, 2022)

This quote demonstrates that community management rules for the backwaters include:

- Prohibition of entering the backwater with shoes on.
- Prohibition of entering the backwater with a foot injury.
- Prohibition of entering the backwater during the menstrual period.
- Prohibition of using unhygienic containers in the backwater.

The established rules that reflect the importance placed on maintaining water quality in local communities mirror hygiene standards and cultural customs that govern interactions with this vital resource. In addition to the backwaters, some rivers near villages are used for irrigating crops. These fertile areas along the banks support staple crops, such as rice and vegetables, which contribute to the community's food security. These rivers also provide fishing opportunities, supplying essential protein for local consumption.

Besides backwaters, rainwater harvesting, known as *Gnizako gnou*, is a traditional method of water supply among the Bété. This process involves collecting and

storing rainwater during the rainy season for future use. House roofs are specially designed to help gather rainwater, which is then directed into locally made clay storage jars called *Kounaka Laki*, demonstrating the Bété's ingenuity in water management. This practice provides an additional water source during the dry season when other sources, like backwater, are scarce.

Adapted Traditional Practices

For a long time, modern water sources, such as hand pumps, have replaced traditional water supply methods. Although seen as practical and efficient, these sources did not always meet the cultural and environmental needs of rural communities. However, because modern systems are fragile, communities are reconsidering their ancestral water management practices. The adoption of various resilience strategies often accompanies this shift toward traditional methods.

a) Adaptation and reuse of traditional sources: the backwater

At the core of this adaptation is the backwater. These natural water sources have been the preferred water supply for Bété communities for centuries. Backwater plays a vital role in residents' daily lives. They provide water for drinking, cooking, washing, and crop irrigation, and also serve as places for social gatherings and cultural exchange. Today, local communities are rediscovering the importance of backwaters and beginning to rehabilitate them, adapting them to modern hygiene standards. Preservation and cleaning efforts are ongoing to restore these valuable water sources. Additionally, old preservation practices, such as restricting access to backwater with shoes or in cases of foot injuries, are being reintroduced to protect the purity of these natural sources. Some protective structures have been built around the sources to shield them from animals and plants that could contaminate the water (Fig. 6).

These ancestral practices originate from the wisdom and traditions of the communities' ancestors. The elders had

deep knowledge of the local environment, seasonal patterns, and natural water sources, which strengthened their trust in these sources. They passed down this valuable cultural heritage from one generation to the next, providing a helpful guide for sustainable water management. The reuse of backwater among local communities helps them adapt to drinking water shortages. These water sources provide clear economic benefits to users. Unlike hand pump mechanisms, which require high maintenance costs, backwater sources require minimal human intervention to remain functional. Plus, access to backwater is free, reducing the financial burden on households. Additionally, these sources are credible due to their geographical features. They are replenished by the region's ample rainfall and the numerous water sources that provide environmental benefits for rural communities (Fig. 7).

Backwater serves as a natural water reservoir for local communities. This water reserve is valuable, especially when pumps are unavailable. In this way, backwater helps to ensure a reliable and consistent water supply, which is essential for the survival and well-being of local communities.

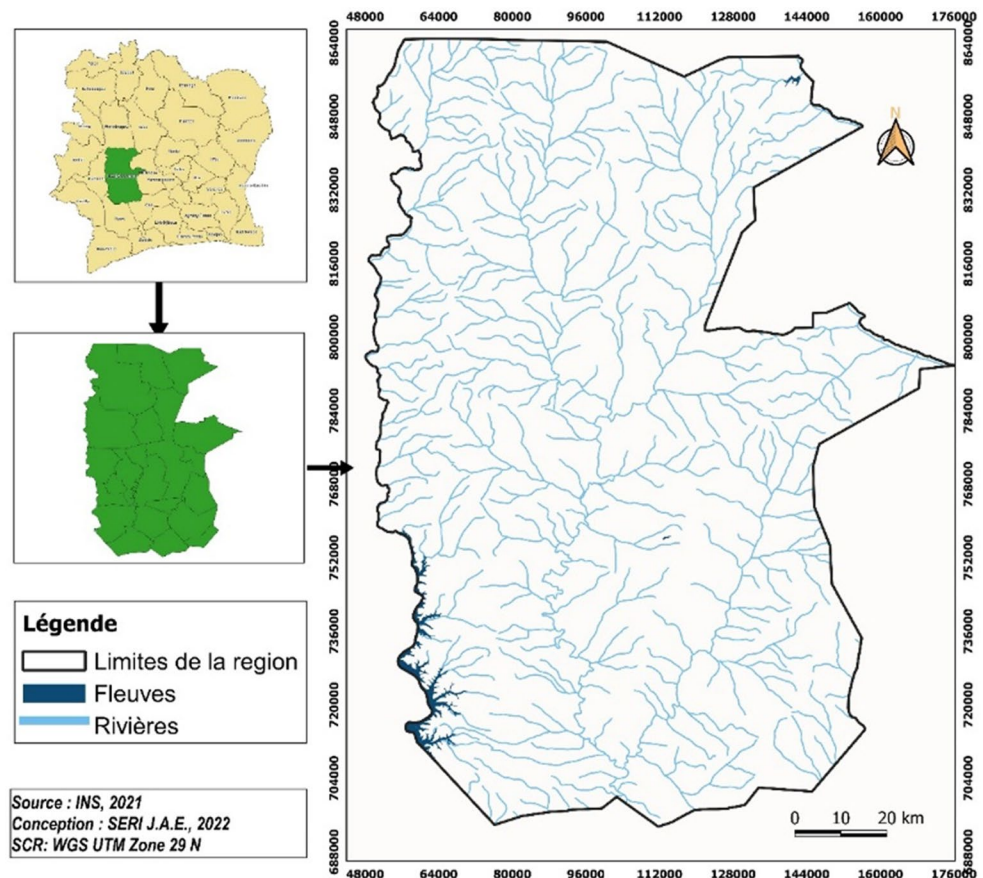
a) Rationalization of water use

Rationalizing water use among rural households is a crucial coping strategy for addressing water shortages. This approach relies on careful and economical water management, along with the implementation of social and cultural rules to regulate usage. A key aspect of water rationalization in rural households is reactivating local knowledge to confront water scarcity. Aware of the importance of this resource, households draw from their cultural heritage to develop practices that prevent unnecessary waste. This use of local knowledge aligns well with the communities' lifestyles, strengthening their resilience against water-related challenges. One notable practice is adjusting bathing habits. Traditionally, baths are mainly taken in the late afternoon before nightfall. However, the Bété have adapted this practice by further restricting baths, except in specific cases. For example, women during menstruation and children

Fig. 6 Example of backwater improvement in Gbiéguhé and Gboguhé (Source: Field survey, 2022)



Fig. 7 Map of the river system of the Haut-Sassandra region



preparing for school are allowed to bathe in the morning and evening, while others are permitted to bathe only in the evening. This method significantly reduces water consumption related to bathing while still maintaining essential hygiene.

Furthermore, local communities have also changed their dishwashing habits. Traditionally, dishes were washed whenever needed throughout the day. However, to tackle water scarcity, households now only wash dishes in the morning, especially since household members are in the fields during the day, which reduces dishwashing during daylight hours. This strategic choice reduces water usage for this task while maintaining the cleanliness of kitchen utensils.

Another key strategy used by these communities is assigning specific uses to water depending on its source. For instance, water transported within the home is strictly for human consumption, meal preparation, and personal hygiene. This clear division helps ensure water is used efficiently to meet the basic needs of household members. Additionally, activities that require a significant amount of water, such as washing clothes, are carried out directly at the water source (Fig. 8).

This effective practice helps conserve valuable water that would otherwise be used for these household tasks. Communities have, therefore, succeeded in combining their local

knowledge to develop suitable water management strategies, thus reducing losses and waste.

This change in habits shows how the Bété communities can reactivate their traditional knowledge to adapt to the shortage of drinking water. These practices fit with the lifestyle and cultural values of the people, strengthening their resilience against challenges related to limited water access. In short, managing water use wisely is vital for the resilience of rural households in the Gboguhé Sub-Prefecture. This approach enables communities to efficiently utilize their limited water resources to meet their basic needs while also preserving the future availability of this valuable resource. It promotes sustainable water supply, environmental preservation, and community resilience amid increasing water challenges.

b) Water storage

Rural communities, in their struggle to cope with the shortage of drinking water, have relied on local knowledge to develop vital coping strategies. One of these key strategies is water storage, which has become widespread among local households. This approach is crucial for dealing with the unpredictable availability of water at the pump and even in the backwaters. Households gather and store water in

Fig. 8 Women and children doing laundry at the backwater in Koréa 2 and Kékégoza. (Source: Field survey, 2022)



containers for planned use over a specific period. This storage duration can range from two to three days, depending on the household size. These days represent the time needed to replenish their water supply. In the Gboguhé Sub-Prefecture, water storage and supply are two interconnected activities. They aim to secure household water access, both in terms of quantity and to address concerns related to water scarcity. This strategy not only fulfills daily household needs but also conserves as much water as possible.

However, water storage is not a modern practice. It has always been one of the most effective strategies in the daily lives of local populations. In the past, women used traditional water collection and storage containers made of clay, called *Bâ Laki*. According to them, these containers were suitable for transporting water without wasting it. They were carefully designed to be lightweight and easy to handle, allowing women to carry them on their heads or shoulders with ease. They also helped keep the water cool, making it pleasant to drink. Today, these traditional containers have been replaced by various modern devices. The methods of collecting, storing, and using water vary significantly from one village to another within the rural communities of the Gboguhé Sub-Prefecture, and these practices are often adapted to suit the specific use of the water. Women, in particular, play a central role in managing water within households.

Generally, water is stored in basins, which are usually kept in the kitchen of homes. These basins have a capacity of 20 to 25 L, and buckets are also used for water storage. Basins or buckets containing water for drinking typically have lids, which help reduce the risk of water contamination and ensure its quality for drinking and food-related uses. On the other hand, basins used for washing dishes, cooking, and bathing are usually left uncovered (Fig. 9).

In some areas, households can be distinguished by the type of water storage equipment they have and could be described as “better equipped.” These households possess large-capacity water storage containers. For example, in Gboguhé, households have relied on a 25-liter yellow or green jerry



Fig. 9 Storage device for water stored in a household in Kékégoza. (Source: Field survey, 2022)

can for water storage. This trend has spread throughout the community and has become somewhat of a fashion. These jerry cans, which initially contained palm oil, became popular after being emptied and are now highly sought after in the local market. The use of 25-liter jerry cans is not accidental; their shape makes them especially suitable for transporting water over long distances and for the sustainable storage of water collected from backwaters. For large-capacity containers, such as jars that can hold up to 350 or even 400 L of water, as well as 200-liter barrels (Fig. 10), these are used to store water collected from the backwaters.

This practice demonstrates both the awareness of rural households about the importance of strategically storing water and their ability to adapt their equipment to meet their water needs. It also illustrates how members of rural communities develop specific skills in water management to tackle the challenges of water scarcity, while appreciating the local resources available to them. These storage practices, created in harmony with their environment and specific needs, serve as a powerful example of how resilience can be strengthened by utilizing local wisdom.

Fig. 10 Example of containers with a large water storage capacity (Source: Field survey, 2022)



Discussion

The water shortage in West Africa, particularly in rural areas, remains a significant concern both socially and environmentally. This shortage results from a complex mix of factors, including the effects of climate change on water resources. Climate change, including reduced rainfall and increased evaporation, reduces freshwater availability and exacerbates existing problems (Bates et al., 2008; Cooper et al., 2022). Additionally, there are serious gaps in hydraulic infrastructure in these regions. A lack of investment in building and maintaining this infrastructure significantly limits access to clean water in rural areas. Poor management of these systems further worsens the water crisis in these regions (Rahman & Islam, 2018).

Our study reveals that local communities face water shortages that have a profound impact on their daily lives (Seri, 2023). In response, they have adapted by utilizing their traditional knowledge, emphasizing the importance of local knowledge in mitigating risks associated with environmental changes. This local understanding has helped rural communities better comprehend and interpret their natural surroundings. Ancestral knowledge has provided vital information about seasonal cycles and the behavior of local water sources, such as streams. This detailed understanding has enhanced their ability to manage water shortages and cope with the lack of hand-powered pumps. These findings suggest that when a community is informed and prepared through local knowledge, it is better equipped to address challenges resulting from environmental disruptions.

The failure of hand-powered pumps posed a serious threat to the water supply in rural communities. However, by reviving their traditional knowledge, these communities could take reactive steps to tackle these challenges. For example, they relied on traditional sources, such as streams, and established more efficient water management systems based on community rules and standards to conserve this

vital resource. These findings underscore the crucial importance of preserving this knowledge, as its loss could have a profoundly detrimental impact on water management and the resilience of local communities (Johnson et al., 1997). Keeping this knowledge alive is essential for passing sustainable water management practices down through generations. That is why Berkes (2009) stresses the importance of intergenerational transmission.

Similar to these findings, the reactivation of traditional sources is viewed as a key resilience strategy in rural areas where modern water sources are unavailable or fail. Rural populations rely on diversifying and using surface water sources seasonally. For example, in Farko Tondo and Zindigori, the lack or poor condition of boreholes, their malfunction, and their distance from the villages they serve lead to a return to abundant surface waters in the area (Mei, 2003). In the Senegalese Ferlo, it has been shown that before the dry season, people tend to use traditional water points more because they are more accessible (proximity to the village, free access, and difficulties in repairing boreholes due to the number of users) (Sy, 2009). Elsewhere, this choice is also a strategy for managing distance, as demonstrated by Moussa (2011, 2018). The work of Alcamo et al., (2003) also highlights the effectiveness of traditional water management systems in other dry regions of the world, such as the Sahel in Africa. Outside Africa, the research of Chen et al., (2023) in rural parts of China confirms the importance of ancestral knowledge in conserving water resources amid increasing challenges from climate change.

However, our results differ somewhat from those of Gupta et al., (2020), whose study highlighted the limitations of traditional practices in water conservation in similar regions, emphasizing issues related to inadequate resource management and the overexploitation of water sources. These comparisons underscore the complexity of how traditional knowledge impacts the resilience of rural communities facing water scarcity, while also emphasizing

the importance of considering contextual nuances and local dynamics when implementing sustainable water resource management policies.

Ultimately, reactivating and adapting local knowledge in the Gboguhé Sub-Prefecture has helped communities reduce their vulnerability and maintain a more stable and reliable water supply, supporting their adaptation to water shortages. Therefore, similar to Adger (2010) and Walker and Salt (2006), the identification, promotion, and valorization of local knowledge can not only improve local understanding of water resources but also boost the capacity of rural communities facing similar challenges to develop and implement adaptation strategies that fit their local realities and culture.

Conclusion

Our study uniquely emphasizes the vital role of local knowledge in helping rural communities adapt to drinking water shortages, using the Gboguhé Sub-Prefecture as a case study. Unlike standard approaches that focus on technological or institutional solutions, our research demonstrates that ancestral practices, deeply ingrained in the cultural and environmental fabric of local communities, offer a robust and practical alternative for managing water crises.

Our research shows that revitalizing traditional practices, such as utilizing backwater, rationalizing water use, and adapting water storage techniques, has helped communities overcome the limitations of failing modern infrastructure. It has also improved their ability to adapt to increasing environmental challenges. These strategies, rooted in specific community norms and collective management, emphasize the importance of local knowledge as a tool for adaptation. This study makes a significant contribution to the development of bioanthropological perspectives on adaptation and resource management, demonstrating that these knowledge systems, far from being outdated, are essential for context-specific responses to modern problems.

Scientifically, our study enhances understanding of the interactions between traditional knowledge and water resilience, providing an analytical framework applicable to other rural contexts facing similar challenges. It promotes greater recognition of local knowledge as an intangible heritage, capable of complementing and sometimes exceeding modern technological solutions, especially in settings where such solutions fail or remain inaccessible. Additionally, the integrative approach presented in this study offers practical avenues for developing hybrid public policies that combine traditional knowledge with modern innovations to promote sustainable water resource management.

However, this research has limitations. The focus on the Gboguhé Sub-Prefecture limits the broad applicability of the results. Additionally, while the qualitative approach allowed for an in-depth examination of sociocultural dynamics, incorporating quantitative data could further strengthen and support the findings. Furthermore, the long-term effects of the strategies, especially on resource sustainability and social equity, still need to be evaluated in the context of resilience.

These limitations open up several avenues for future research. One approach could involve comparative studies across different regions or countries to assess how the effectiveness of local knowledge varies in response to water shortages. At the same time, longitudinal studies could examine the sustainability of revitalized traditional practices and their capacity to adapt to future challenges, such as climate change or demographic shifts. Lastly, interdisciplinary collaboration among anthropologists, hydraulic engineers, and public policymakers would help turn the insights from this study into practical recommendations for water resource management policies.

In conclusion, our study extends beyond simply analyzing local knowledge to provide a comprehensive and innovative perspective on water resilience. It advocates for greater institutional and academic recognition of these knowledge systems, not as remnants of the past, but as living, adaptable solutions to modern environmental challenges. By highlighting that combining tradition with innovation can create a promising path for inclusive and sustainable water policies, this research paves the way for renewed reflection on water governance. It provides practical tools to address the urgent needs of rural populations worldwide.

Acknowledgements The authors express their gratitude to the Regional Directorate of Hydraulics of Haut-Sassandra, who provided us with information on the standards for drinking water supply in Côte d'Ivoire. We also extend our thanks to SODECI for granting us access to the database of hand-pump diagnostics in the Haut-Sassandra region. Lastly, we sincerely appreciate the cooperation and availability of village chiefs, women's association leaders and women who actively participated in this study.

Author Contributions JAES, DAZZ, and CYA contributed to framing the research question. JAES collected field data with the support of DS. JSK and YVK aided in data processing. JAES analyzed the data and drafted the article under the supervision of DAZZ and CYA.

Funding The authors wish to sincerely thank the Executive Secretary of the Strategic Support Program for Scientific Research (PASRES) for funding the doctoral research project that this article is based on. Their generous support has played a key role in the successful completion of this study.

Data Availability No datasets were generated or analysed during the current study.

Declarations

Competing interests The authors declare no competing interests.

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