Global Scientific and Academic Research Journal of Multidisciplinary Studies
ISSN: 2583-4088 (Online)
Frequency: Monthly
Published By GSAR Publishers
Journal Homepage Link- https://gsarpublishers.com/journals-gsarjms-home/

` Space and Time Dimensions in Pipe-borne Water Delivery in Erelu Waterworks Zone, Oyo state, Nigeria

By

Oyelami A A, Omotoso B.M[1], & Olayiwola[2]

[1,2]Department of Geography and Environmental Education Emmanuel Alayande University of Education, Oyo

Article History

Received: 15/07/2026
Accepted: 28/07/2026
Published: 31/07/2026

Vol – 5 Issue –7

PP: - 54-66

Abstract

Clean piped water is essential for health, productivity, and sustainability. Unfortunately, the delivery of this vital service becomes increasingly difficult in urban areas of Nigeria owing to various infrastructural and demographic challenges. Descriptive statistics and percentages were used to analyze expert interviews and customer records.The analysis of household subscriptions in the Erelu water zone shows an enormous systematic drop over four decades. In the 1970s, subscriptions reached 76.94%, divided equally between traditional (31.62%) and first-generation modern districts (31.94%). In the 1980s, there was an addition of 9.69%, but there was only a 4.20% addition in the 1990s—this brought the percentage of subscriptions to 90.83%, which showed a gap between demand and supply. The implementation of a rotation plan of supply in the 1990s did not succeed due to electrical breakdowns and inefficiency of high-lift pumps to reach the Sooro Hill booster station. In the 2000s, there was an enormous drop in active subscriptions to 9.17%, of which 8.81% were found to be restricted to Atiba Local Government Area alone, where the water works were located. More importantly, 90.83% of previous subscribers in historical areas, including some whole districts in Afijio and Oyo East, were disconnected. Delivery of water became economically discriminatory, where institutions like the Federal Government Girls' College received water, whereas traditional areas like Balogun and Saakin did not receive water. Pipe-borne water sustainability can be guaranteed by ensuring that IWRM is adopted, infrastructure development is done as a matter of urgency, corruption is tackled vigorously, and tariffs are increased through law.

1.0 Introduction

Potable water refers to water that can be safely consumed by humans without posing any health risks (Khalmirzaeva, 2022). According to the WHO/UNICEF Joint Monitoring Programme (JMP 2025), potable water is water that is available on-site, accessible whenever needed, and free from contamination. It is water that meets established quality standards, aligns with human rights principles, adheres to sustainable development goals, and is safe for human consumption. Beyond aesthetic qualities such as taste and appearance, potable water is characterized by proper treatment, continuous monitoring, and protection from harmful agents, ensuring it can be consumed without adverse health effects. The concept of potable water constitutes a fundamental element in environmental health, policy formulation, and sustainable development frameworks.

In contemporary discourse, potable water encompasses scientific, technical, and legal dimensions. Scientifically, potable water must comply with microbial safety criteria and chemical contaminant thresholds as stipulated in regulatory frameworks such as the European Union Drinking Water Directive and national drinking water standards across various countries. From a technical perspective, potable water must address issues of accessibility and reliability, as formalized by global monitoring mechanisms (EU Directive, 2020; Cherkashyna, Sokolova & Brears, 2025).

Globally, the most widely recognized form of potable water is pipe-borne water. It is a water supply system in which water undergoes treatment and filtration before being distributed via underground pipes. The designation "pipe-borne" serves to distinguish this supply method from alternatives such as boreholes, hand-dug wells, and surface water sources where water is collected directly (Jo, 2017;Dhoba, 2020). The whole concept of pipe-borne water delivery includes the temporal reliability and contamination-free pipe and on-site availability (Edith et al., 2020). Delivery is an operational service, which means that water is available in regular quantities, known flows, and chemical safety within the legal borders of the city (Desta et al., 2022). If it proves effective, it can be a good basis for public resources, and the water it generates is more cost-effective than commercial water alternatives, which are provided by the private sector per litre (Chunwate et al., 2021).

There are five forms of pipe-borne water delivery channels in Nigerian cities. The first is the in-house direct water connection from the waterworks to homes and industries (Ogunkolu, 2025; Olanrewaju et al., 2023). The second is the neighborhood public single standpipe where households will have to fetch water from the neighborhood waterpoint to their respective courtyard (Olanrewaju et al., 2023). The third category is the direct connection to government-owned institutions, parastatals, and agencies like secondary Schools, Colleges, Courts, government secretariats,Police stations, Health centers, among others.Tanker trucks constitute the fourth; they load treated water directly from the water works to remote urban areas, particularly outside the city's underground piping system (Maheshwari et al., 2024). The fifth takes the form of water vendors (Mairuwas) who fetch water from public stand-pipes and sell it through plastic jerry cans in metal pushcarts, particularly along the informal urban peripheries with no municipal water pipes (Omokhudu et al., 2016; Chukwuemeka et al., 2023).

Piped water is significant when considering improved living standards as it reduces the cost of living for the poor, reduces urban-rural gaps, and helps to achieve equity in national growth (Abramovsky et al., 2020). Access to safe drinking water is a prerequisite for progress in combating poverty, hunger, child mortality, and gender inequality (Ifabiyi and Ashaolu, 2013). Access to safe water supplies allows meeting international human rights standards for water and sanitation (Frounfelker& String, 2025) as it is one of the yardsticks by which development is measured.

Piped connections save hours of household water collection that women can use for formal employment or to run micro-businesses, and should improve children's school attendance (Winter et al., 2021). This is a key factor in human capital formation, increasing household income, and the national labor force (Winter et al., 2021).When considering establishments, high, steady, clean water supplies are necessary for high-tech manufacturing facilities, food processing plants, and service businesses. Nations with policies in favor of piped utilities provide platforms for private investments and create local industries (Picazo &Tekinerdogan, 2024).

With regard to the environment, piped water drastically reduces the local supply of bottled or containerized water alternatives. This decrease in plastic waste helps alleviate stresses on the municipal waste management system, avoiding blockages in drainage channels and second pollution of the environment (Casas et al., 2026). Piped water is vital to maintaining public parks, green belts, and urban landscaping. To keep plants healthy, cool the local environment, and combat the hard surfaces of urban development, urban green spaces need regular watering (Adegun et al., 2021; Raap et al., 2022).

In regions with reliable pipe-borne water infrastructure, residents can access clean, treated water directly from household taps for drinking, cooking, bathing, and other domestic activities (Babu, 2018; Tully et al., 2019). Pipe-borne water has a transformative impact in strengthening the institutional hygiene of schools, workplaces, and public spaces (Jordanova et al., 2015). It eliminates a lot of challenges associated with psychological stress, physical restrictions, water scarcity, and prolonged extraction time (Okon & Njoku, 2017)

Piped-borne water helps to reduce health risks as it allows for the continued use of sanitary latrines, thus preventing the presence of faecal pathogens in soil and local storm drains (Okesanya et al., 2024). Piped water is on-site and leads to easy body cleansing and bathing routine (Arowosegbe et al., 2021); it promotes mental health and personal worth (Adeoti et al., 2023). Piped water provides a wide public health intervention with long-term health benefits to lower the burden on health systems and improve life expectancy (Renwick & Rotert, 2019). It greatly reduces the incidence of acute diarrhoea in infants and preserves their nutrient absorption and physical development (Manetu et al., 2022), and lowers the infant mortality rate. There is less exposure to toxins and heavy pathogens in water in early childhood years (Fan & He, 2023). A piped water supply ensures adequate water flows to prevent skin infections and chronic skin diseases spreading through secondary vectors like clothes (Abney et al., 2021). Access to pipe-borne water plays a critical role in preventing the transmission ofwaterborne diseases, thereby reducing morbidity and mortality rates. Piped water is essential for human well-being and contributes significantly to enhancing the overall quality of life within communities.

1.2 The Study Area

Generally, the entire Oyo geo-political region is found within latitudes 07° 48'00"N to 08° 22' 00"N and longitudes 03° 47 00"E to 04° 05!00"E.The region covers 1,130 square kilometers of landmass, having 57.9 square kilometers of urban area (05.12%), 667.5 square kilometers of rural areas (59.07%), and 404.617 square kilometers of forest reserve (35.81%) in 2022 (Figure I).Erelu waterworks zone is found along latitudes 7^{o}40’ to 7^{o}56’ north of the Equator and longitudes 3^{o}51’ to 3^{o}59’ east of the Prime Meridian. The zone marks the only urban conglomerate in the entire region. (See Figure II).

Erelu waterworks was constructed along the course of Aawon River. The drainage basin of the Aawon River is geographically situated between latitudes 7°45'1" and 8°12'1" North and longitudes 3°04'51" and 4°00'51" East. The basin encompasses a land area of approximately 2,644.018 square kilometers (2, 644,018,000 square meters) and contains a total stream length of 916.5 kilometers (Oyelami, 2012c). However, the channels that drain into Erelu Dam have a combined length of 563.431 kilometers, representing 61.48% of the basin’s hydrological potential. The remaining 353.07 kilometers (38.52%) of channel length are located downstream (Oyelami, 2012a). The topography of Aawon Basin gradually ascends from an elevation of 650 meters along Ogun River to approximately 1,350 meters at its source, around Arojosu village, south of Ikoyi (Oyelami, 2012b).

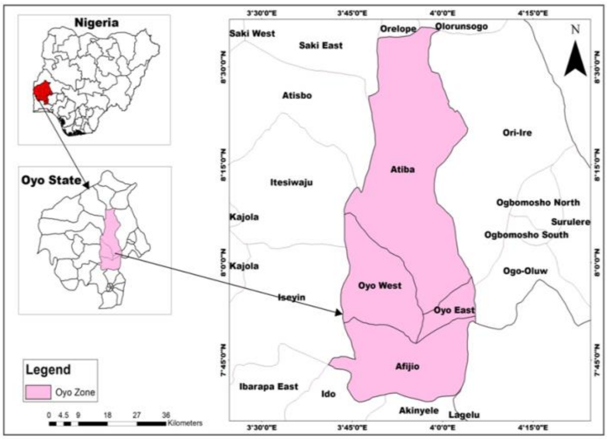

Figure 1.1: The Map of Oyo Region.

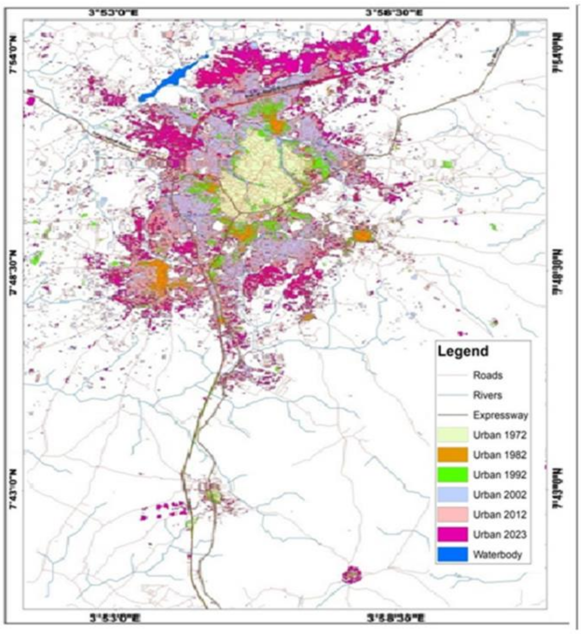

Figure II: The Map of Erelu Waterworks Zone. Source: Oyelami et al 2026

Aawon stream is of the subsequent category, being a tributary to the Ogun, a consequent river. Dendritic pattern persists throughout the basin area, and the streams display youthful, mature, and old age characteristics (Topographical maps of Oyo NW, NE, SW, and SE). The basin valleys vary considerably in shape. Common types are the V- shape, saucer shape, U-shape, and broad floor valleys. Broad floor valleys are known for periodic waterlogging. Streams swell up to the fullest between May and October, and dry up almost completely between January and March. Awon and its consequent tributaries carry a lot of materials in suspension and in solution on a yearly basis. Streams that originated within the township possess water along their courses all year round due to household liquid wastes that normally find their way into them (Oyelami 2013).

The impoundment (catchment) area of Erelu Dam covers approximately 161.07 hectares; its volume is approximately 2,975,635.29 cubic meters (2,975,635,290 liters); the surface area of the dam is 120.94 hectares, and the maximum height is 13.106 meters. The water level of Erelu Dam has remained stable at a predetermined standard level, even during dry seasons, up to the present time (Olasunkanmi et al. 2021, Ufoegbune et al. 2011). Erelu Dam is situated where the Precambrian Basement complex of migmatite formations crosses the Aawon River. Quartzite formations in the zone are generally massive and occur as elongated ridges trending northwest-southeast, which crosscut the migmatites. Schistose quartzites are also present and are characterized by alternate layers of mica, quartz, and feldspar.

Based on the analysis of Oyo (NW, NE, SW, SE) topographical maps, the Erelu waterworks zone is located on the wide upland plains to the south of western plateaus of Nigeria. Rocky outcrops and lateritic beaches occur along the major break of slope as one approach the valley. The land rises slowly from the northwestern riverside towards the southeastern end. The ridges gradually attain a height of 1,100metres along Akinmorin road from 850 meters at Oroki. Areas that can be taken as important heights are Soro, Mogi, Yidi, Low Cost Height, Kosobo Height, Miracle Center, Oke Border Awe, Mogi, Olivet, among others. These quartzite ridges serve as watersheds for the urban streams like, if they are to be named by their origin, are: Awe (Ajegunle), Awe (Sogidi), Awe (Odo Ogunmola), Kosobo (Akunlemu), Ilaka, Jabata, Araromi, Sawmill, and many others. These streams originated in the East and flow westward to join the Aawon and Ogun rivers in the west.

Erelu Waterworks is a public utility under the Oyo State Ministry of Water Resources. It is responsible for the provision of potable water to the urban areas of Oyo Zone in Oyo State, Nigeria. Erelu waterworks was commissioned on the 30th of November, 1962, by the then Commissioner for Works and Transport in Western Nigeria, Mr Adeniyi Williams (Oyo State Government 2025) The Water Corporation of Oyo State evolved out of the then Western Nigeria Water Corporation through the Enabling Water Corporation of Oyo State Edict No 24 of 1977 and as reviewed by the Water Corporation of Oyo State Amendment Law of 2006. The waterworkswere constructed where the Aawon River flows very close to Oyo main town as at 1961. It was built to treat 7.5 million liters of potable water per day (Ufoegbune et al 2011, Kareem et al 2018, Amusat 2020). In this study, water delivery would be determined in terms of household subscription patterns and how such subscriptions pattern could be used to understand the challenges facing the corporation overtime, and to determine the extent of such challenges, considering the present state of potable water demand in the zone

1.3 Method of Data Analysis

Expert sampling technique was used to conduct interviews with stakeholders at the Ministry of Water Resources, Ibadan, and Erelu Waterworks, Oyo. Records on household past and present subscription patterns to Erelu waterworks services were retrieved from stakeholders. The documents were first sorted based on area names used in preparing them overtime. Later, the area names were arranged on the basis of the periods when each urban district was colonized and became urban. This was guided by a recent study which clearly showcased the phases of urban expansion in Erelu Waterworks Zone between 1972 and 2022. On the whole, descriptive statistics involving percentage values and illustrative charts were employed in carrying out the analysis of data.

2.0 The Result

2.1 Urban Expansion and Pipe-borne Water Delivery along the Early Urban Districts.

Urban district as used here represents a segment of urban space singularly identified based on age, dominant land use, or class considerations. Based on age and housing characteristics, two classes were made here, and these are the traditional and the modern housing districts. A study of the list containing the households that were officially connected to Erelupipe-borne water indicates that the majority were in the traditional housing districts and the first-generation modern housing districts that constitute the urban space as at 1972. The two accounted for 83.56% of the total Erelu commercial customers. This cohort comprises 31.62% from traditional areas and 31.94% from first-generation modern housing districts. Notably, each traditional housing district accounted for approximately 20 subscribers, whereas early modern housing districts averaged 67.33 subscribers each.

According to the stakeholders at Erelu waterworks, urban districts were adequately served with Erelu pipe-borne water in the 1960s and 1970s. Field observation indicated that household subscription patterns in the early periods were a reflection of: (i) the materials used for the construction of houses, (ii) availability of neighborhood public tap, (iii) location of neighborhood (central or peripheral), and (iv) the size of each neighborhood.

The mud houses along the core traditional neighborhoods were not compatible with direct household connection to pipe-borne water, unlike concrete structures. Few spaces were with modern concrete structures, and as a result, household connection rates were generally low; the value ranges from .1% to .9% in the zone. It is important to also note that public taps were provided free of charge along these traditional neighborhoods (see Table I).

Table I: Household Connections to Erelu Pipe-borne Wateralong the Early Urban Space (%)

Afijo LGA			Atiba LGA			Oyo East LGA			Oyo West LGA			Total	
Urban Districts		%	Urban Districts		%	Urban Districts		%	Urban Districts		%	No	%
Iware		.12	Adikuta		.16	Bara		.40	Sanga		.28		
Idiigba		1.52	Samu		.16	Ilaka		.40	lemomu		.48		
Ilora		2.00	Lagbondoko		.28	Molete		.36	Agbala		.08		
Akinmorin		1.72	Amejiogbe		.20	Okeloogun		.24	Ahumaro		.12		
Fiditi		1.56	Iyalamu		.12	Alebiosu		.16	Baba Ib.		.24		
Awe		3.40	Bago		.40	Asogo		.12	igboowa		.12		
			St Andrews		.20	Oluajo		.12	Mogba		.12		
			Oke olola		.48	Opapa		.12	Ogese		.12		
			Ogbomosho Rd.		.48	Arowona		.32	Ojongbo.		.64		
			Adesina		.68	Ago-isona		.32	Idode		.60		
			11. Sakutu		.84	Tengba		.20	Ogbegbe		.68		
			Koso		.84	Alalubosa		.76	Ladigbol.		.72		
			Esinle		1.3	Idiape		.72	Akeetan		1.44		
			Basorun		.80	Agboye		.68	Iyaji		1.16		
			Isale Oyo		2.72	Ajagba		.56	Oke afin		1.00		
			Agunpopo		3.36	Kanga		.68	Iseke		.80		
						Balogun		.96	Ladindin		.84		
						Apaara		1.12	Alagbon		.80		
						Odo aro		.96	Pakoyi		2.00		
						Oke apo		1.16			2.28		

						Apinni Hosp. rd GRA Akeetan Jabata Kosobo Araromi Owode		1.0 1.40 1.2 2.0 1.92 3.48 5.84 9.89	Isokunne wAket		1.92		
Sub-total		10.34			13.05			37.11			16.45		76.94

Source: Compiled from Archival Records at Erelu Water Office, Oyo. 2026.

Next were the traditional neighborhoods with spaces for physical development. They are in two categories: we have clan reservations within the city as obtains at Awe, Ilora, Fiditi and some neighborhoods in Oyo. The scattered pattern of traditional housing development in these districts allows for appreciable infill of modern structures that were connected to Erelu pipe-borne water.These were 3.40% of total subscription in Awe and 2.00% in Ilora. Thirdly, we have traditional districts located along peripheral locations of the city in the 1960s and 1970s.Such neighborhoods attracted an appreciable number of concrete structures after independence, with a sizable number of them connected to pipe-borne water. Examples are: Agunpopo (3.36%) and Akeetan (1.44%).

Closest to the traditional neighborhood were the first set of modern houses that develops majorly since independence. Their emergence coincides with when the Erelu waterworks was established. And because public taps were not provided for such districts, household connections were widely felt. These were Owode (9.89%), Araromi 5.84% and Kosobo (3.5%). It is important to add that property developments with pipe-borne water connection continue in these urban districts for decades. They constitute the area considered "urban" in 1961 that actually warranted the establishment of municipal water infrastructure (see Table I).

During the 1980s, property developments were more of infilling along the early housing districts, and as a consequence, new urban districts were very few, just as households that got connected to Erelupipe-borne water were not appreciable (9.69%). Areas with significant household connections were Sabo (4.64%) and Federal Low Cost (1.32%). The new urban districts were, however, most prominent in Atiba LGA (6.48%), followed by Oyo East (1.68%), Afijio LGA (1.20%), and the least was Oyo West LGA (.32%). Generally, households that got connected to pipe-borne water in Erelu water zone increased from 76.94% in the 1970s to 86.63% in the 1980s (See Table II).

Table II: Household Subscription to Erelu Pipe-borne Water in the Urban Space of the 1980s (%)

Afijio LGA			**Atiba LGA**			**Oyo East LGA**			**Oyo West LGA**			**Total**	
District		**%**	**District**		**%**	**District**		**%**	**District**		**%**		**%**
Aguo		.12	Yidi		.20	Saw mill		.40	Alliance		.24		
Elekara		.32	Alaafin		.08	Tech. Coll.		.40	Cele		.04		
Abojupa		.52	Akunlemu		.24	Olivet		.68	Farade		.04		
Jobele		.24	Fed low C.		1.32	Bernard		.20					
			Sabo		4.64								
Sub total		1.20			6.485			1.68			.32		9.69

Source: Compiled from Archival Records at Erelu Water Office, Oyo. 2026.

In the 1990S, the early urban districts were still receiving considerable attention. The emerging urban districts assumed a concentric form around the traditional districts, particularly in Oyo, but were more outward extensions along the early modern urban districts and infilling in Afijio. The newly established urban districts developed outside the coverage limits of Erelu waterworks infrastructure. Just as in the 1980s, the majority of the new developments and, by implication, households that are connected to Erelu pipe-borne water were along the present Atiba LGA (2.52%); others include Oyo East LGA (.42%) and Oyo West LGA (.76%). No new urban district in Afijio LGA was connected to Erelu pipe-borne water. Urban districts with an appreciable number of pipe-borne water connections were Sooro (1.28%), Ojegbolu (.72%), Oranyan (.52%), and Tobacco (.48%). Urban districts of the 1990s were able to make an additional 4.20% increase in pipe-borne water connection, raising the zonal subscription total to 90.83% (see Table III).

Table III: **Household Subscription to Erelu Pipe-borne Water in the Urban Space of the 1990s**

Afijio LGA			Atiba LGA			Oyo East LGA			Oyo West LGA			Total	
District		**%**	**District**		**%**	**District**		**%**	**District**		**%**		**%**
			Sooro Sabo(Ojegb) Oranyan		1.28 .72 .52	Okooba Folatyre Akinmorinrd Agodongbo Durbar		.08 .20 .08 .28 .28	Idigedu Alaka Es Tobacco		.16 .12 .48		
Sub total				63	2.52		23	.92		19	.76	105	4.20

Source: Compiled from Archival Records at Erelu Water Office, Oyo. 2026.

2.2 Urban Expansion and Water Delivery Management in Erelu Waterworks Zone

It is imperative to note that the expansion of urban areas and the concomitant rise in urban population have increasingly diminished the significance of EreluWaterworks within the region. Stakeholders' accounts at Erelu Water Office indicated that the impact of urbanisation, particularly in the vicinity of Oyo, began to affect water delivery patterns since the 1980s. Around 1989, a substantial surge in demand prevented treated water from reaching distant (Awe, Akinmorin, Ilora,Fiditi, and Iware) and upland (Okeebo, Kosobo, Araromi, Olivet) locations, except by deliberate intervention.

The continued expansion of the urban area and the inability of Erelu waterworks to meet the daily demand for potable water necessitated the adoption of a rotational water delivery scheme in 1990 (refer to Table IV). Examination of the water supply rosters revealed some basic facts: (I) Each of the districts served in the 1960s and 1970s had increased in size considerably and would need many folds of the quantity earlier supplied by 1990 (ii) Some neighborhoods like Adesina, Martins, Kosobo road, Pakoyi, and Agunpopo were favored overtime, possibly for factors such as social influence, ability to pay, or the ease of water diversion. (III) By 1994, some traditional neighborhoods, including Balogun and Sakin, were excluded from the water supply network, whereas emerging working-class urban districts such as Low Cost, Araromi, and AkinmorinRoad were incorporated. This suggests that economic considerations were given better consideration in potable water delivery. Emphasis on economic relevance became more pronounced in 1998 when the Federal Government Girls' College (FGGC) received preferential treatment. This trend continued with the inclusion of Survey School in 1999 and Baptist Conference Center in 2000. In 2000, additional traditional neighborhoods were reintroduced into the supply roster, possibly in response to the COVID-19 pandemic; however, these newly added areas were removed from the roster after one year (see Table II).

Table II: Weekly Rotation of Potable Water Delivery in Erelu Waterworks Zone. Oyo

1993	1994	1998	1999	2000	2002	2003
Awe Rd.	-	01	01	-	01	01
KosoboRd.	01	01	01	01	-	01
Isokun	01	01	01	01	01	01
Pakoyi	01	01	-	01	01	01
Balogun	01	-	-	-	-	-
Saakin	01	-	-	-	-	-
Martins	01	02	02	03	-	02
Agunpopo	01	01	01	01	01	01
Adesina	01	01	02	02	01	02
Fiditird	-	01	01	-	-	01
Oluajo	01	01	01	01	-	01
Low Cost	01	-	01	01	-	01
Araro/Owode	01	01	01	01	01	01
AkinmorinRd.	01	01	01	01	-	01

*Corresponding Author: **Oyelami A A, Omotoso B.M**

Ilora Rd.	-	01	01	01	02	01
F.G.G.C	-	01	02	02	-	01
Survey	-	-	01	01	-	01
Bapt.Conf.	-	-	-	01	-	-
SPED	-	-	-	01	-	-
Jobele	-	-	-	01	-	-
Oke Olola	-	-	-	-	01	-
Isale Oja	-	-	-	-	01	-
Gedu	-	-	-	-	01	-
	-	-	-	-		-
Oke Apo	-	-	-	-	01	-
Lemomu	-	-	-	-	01	-
Koso	-	-	-	-	01	-
Aatan	-	-	-	-	01	-
Sakutu	-	-	-	-	01	-
Amejiogbe	-	-	-	-	01	-
Lagbondo	-	-	-	-	01	-
Akesan	-	-	-	-	01	-
Obananko	-	-	-	-	01	-
Akunlemu	-	-	-	-	01	-
Ajegunle	-	-	-	-	01	-

Source: Compiled from Archival Records at Erelu Water Office, Oyo. 2026.

The water diversion agenda was not yielding the expected results due to some technical failures. It is important to note that the potable water diversion program was based on regular supply of electricity and the usage of high-lift pumps for 24 hours daily, conditions that were increasingly becoming difficult to meet.

2.3 Recent Urban Development and Water Delivery in Erelu Waterworks Zone

Starting from the year 2000, some newly established urban districts were fortunate to be along the passage of the arterial main that conveyed treated water from Erelu waterworks to Sooro Reservoir. These are Koso Express, Oroki Express, Alayande, Olooro, and Waterworks areas. Direct connections to the arterial main (12 inches pipe) had been going on marginally around Sabo since the 1990s, and by the 2000s, it was extended to the entire six-kilometer length of the arterial main. Much of a setback here was the inability of water pumped from Erelu waterworks to reach the distribution booster station (reservoir) on top of Sooro hill. Once water was not getting to Sooro Reservoir, the primary population that Erelu Waterworks was established to serve, representing 90.83% of its registered household subscribers, had been completely cut off. Erelu Potable water is now available for 9.17% of recently registered households. 8.81% of the said subscribers are in Atiba LGA while the remaining .36% is in Oyo West LGA (See Table IV).

Table IV: Household Subscription Pattern to Erelu Pipe-borne Water in the Urban Space of 2000s (%)

Afijio LGA			Atiba LGA			Oyo East LGA			Oyo West LGA			Total	
Districts		**%**	**Districts**	**No**	**%**	**Districts**	**No**	**%**	**Districts**	**No**	**%**	**No**	**%**
			Irapada		.48				Ayetoro		.36		
			Opabode		.32								
			Olooro		.92								
			Off Alay.		.44								
			Owini		.68								
			Adesina		.28								
			Ayedire		.36								
			Idi-Odan		.52								

*Corresponding Author: **Oyelami A A, Omotoso B.M**

			Surulere Isomalu Elikanka 2nd. Gate Erelu rd.Okemogi Okeoroki		.32 .32 .80 .68 .64 .32 1.72								
Sub total				220	8.807					09	.36	229	9.17
L.G.A Total	288	11.53		771	30.87		992	39.71		447	17.89	2498	100

Source: Available Erelu Customer Records.

Going through the entire household subscription pattern in Erelu waterworks zone, one can say that (1) the major beneficiaries were the early modern districts, particularly in Oyo East. This might be due to the non-availability of public tap alternatives in the districts. Early housing districts equally enjoyed the services of Erelu waterworks for nearly four decades; pipe-borne water availability would likely be a factor attracting developments to such locations over a long period of time (see table V).

Table V: Summation of Household Subscription to Erelu Pipe-borne Water (%).

	Afijio	Atiba	Oyo East	Oyo west	Total
1970s	10.33	13.05	37.11	16.45	76.94
1980s	01.20	06.49	01.68	00.32	09.69
1990s	-	02.52	00.92	00.76	04.20
2000s	-	08.81	-	00.36	09.17
	11.53	30.87	39.71	17.89	100

Source: Available Erelu Customer Records.

The decreasing trend in household subscription in the 1980s (4.98%) compared to what obtained in the 1970s clearly signaled: (i) the increases in potable water demand along the traditional and early modern urban districts, and (ii) the inability of the waterworks to meet up with the increase in potable water demand.

Subscriptions to Erelu pipe-borne water got reduced further in the 1990s (4.19%). (iii) Since the 1990s, most property developments occur far away from where pipe-borne water can be profitably accessed, and in most cases, no attempt was made to extend water pipelines to such new urban districts in the zone (see figure III).

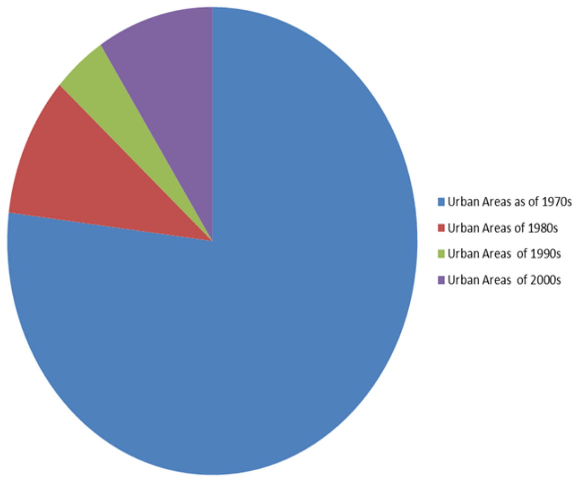

Figure III: Household Subscription Pattern by Periods of Urban Development

Subscription to pipe-borne water supply increases better only in the Atiba LGA from 1980s, an indication of the inability of the waterworks to cope with urban demand. Erelu waterworks and its main water distribution reservoir are in Atiba Local

Government Area. Today, neighbourhoods recently established in the 2000s (7.03%) along an active water pipeline in Atiba Local Government Area are the only group still benefiting from pipe-borne water in Erelu waterworks zone. And it can be argued that the decline in Erelu service delivery might not be solely attributed to increases in urban size but also a question of deficiencies in potable water production.

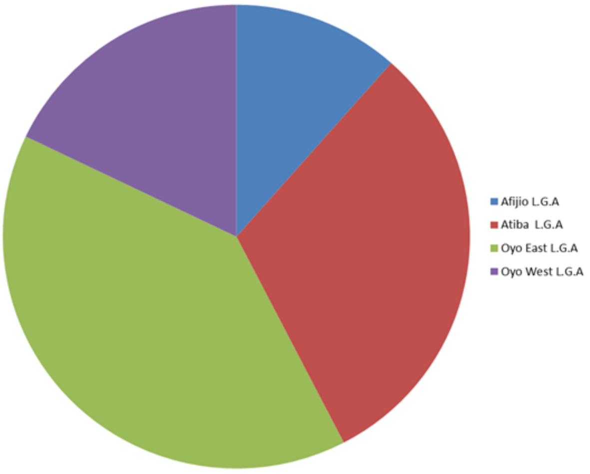

Figure IV: Household Subscription Pattern by Local Government

3.0 Overview of Pipe- borne Water Delivery in Nigerian Cities

Over the past decades, Nigeria has experienced a gradual reduction in pipe-borne water available in the urban centers (Fashae et al., 2024). Before independence and since then, progressive deterioration of the municipal distribution network has been a common phenomenon. The number of people using urban public water systems has decreased considerably (Edith et al., 2020). Some state capitals have a considerable number of neighbourhoods without pipe-borne water access, and many have had water shortages for several months (Thomson et al., 2024). The results of the National Health Survey and Infrastructure Assessment confirm the decreasing contribution of pipe-borne water systems in Nigeria; more than 86% of the population does not have access to a safely managed drinking water source (Edefo, 2025).

The physical size of existing municipal pipeline systems has not been able to follow the pace of urban population growth. During the Urban Water Resource Survey, only 15.4% of surveyed households reported using pipe water as their main source of water (Akoteyon, 2019). On the other hand, 53.8% of households have to use private boreholes for water supply, while 30.8% of households rely on commercial water vendors, illustrating the shift from public water supply to private sources (Oyerinde& Jacobs, 2022). As new sub-urban areas and informal settlements spring up around cities, public water mains are rarely extended to them (Gilbert & Shi, 2023). This creates a gap between the new urban districts and pipe-borne water sources. New urban districts have become totally detached from the water supply of the municipality (Aliyu & Amadu, 2017).

Piped tap water is now a luxury in the city, and millions of urban residents are now dependent on the unpredictable availability, quality, and cost of private water (Balogun & Redina, 2019). Residents are most times forced to ration water supplies, and many neighborhoods are without water for long periods of time (Ibrahim, 2025).The amount of water that the average urban person receives daily tells the degree of the infrastructure deficit. According to national assessments, the Per Capita Water Availability for each person has reduced to nine litres per day (Ogunkolu et al., 2023). The total water amount is below the WHO minimum of 50 to 100 liters per person per day necessary for basic health, hygiene, and metabolic needs, which shows a great domestic deficit (Ezugwu et al., 2021).This non-reliability often leads to negative feedback as consumers are made to pay for untouched utilities (Erickson et al., 2020). Rapid population growth and urbanization imposed heavy strain on water infrastructure. The populations of major cities, such as Lagos, Kano, and Abuja, have doubled within the last few decades, making older water treatment plants insufficient to handle the increased demand for water (Aliyu & Amadu, 2017).

The reduction in pipe-borne water supply in the cities of Nigeria is a result of a mixture of governance failures, institutional disintegration, and accountability lapses. The foundational economic model for municipal water provision in the country relies heavily on apublic welfare approach, where water is treated as a social good rather than an economic commodity (Obeta, 2018). Consequently, the tariffs mandated by state governments are kept artificially low, completely decoupled from the actual operational expenditures (OPEX) incurred during water collection, chemical treatment, and distribution. SWAs are forced to rely on irregular, highly politicized financial subventions from state governments to bridge their budget shortfalls (Iyi, 2020). When state budgets experience macroeconomic shocks, or when government prioritizes alternatives between infrastructure and debt servicing, subventions to water are downscaled, leaving water treatment facilities without the necessary liquidity to purchase water treatment chemicals and specialized equipment (Ali, 2026). This dynamic directly explains why water treatment plants regularly suspend operations at certain periods (Netshitanini et al., 2023).

Unauthorized taps, clandestine service line bypasses, and the unmetered siphoning of primary water mains are widespread in dense urban zones (Nasara et al., 2021). The rate of these illegal line modifications is exceptionally high because the structural expansion of public water grids has historically lagged behind demographic growth (Casas et al., 2026). Lack of visibility ensures that the operational density of illegal network taps continues to grow unchecked across major metropolitan networks (Laolang, 2024). In the absence of consistent utility audits, businesses and domestic households install subterranean bypass loops that draw directly from the grid prior to the metering point (Laolang, 2024). The lack of digitalized utility mapping and geographic information systems (GIS) across most SWAs makes identifying unauthorized connections a major logistical challenge (Abdullah et al., 2025).The systemic prevalence of these illegal linkages means that public utilities routinely lose more than half of their treated water volume before it reaches legitimate end-users (Gift & Skylar, 2026).

Empirical assessments of the financial metrics governing water treatment in Nigeria reveal a profound and widening gap between operational investments and actual revenue collection (Ali, 2026). The production of potable pipe-borne water requires substantial capital expenditures for specialized coagulants, disinfectants, and continuous electricity to run heavy treatment facilities (Netshitanini et al., 2023). Data from national utility reviews indicate that the average cost of producing a cubic meter of clean water has escalated dramatically, while realized tariff revenues have remained completely stagnant (Fitriani et al., 2023). This indicates that the minimal tariffs officially levied against consumers are rarely recovered by the utility's billing departments (Iyi, 2020). The financial data is further skewed by the extreme proportions of Non-Revenue Water (NRW) that plague state networks, often exceeding half of the total produced volume due to physical leaks and commercial theft (Al-Khalid et al., 2013). Many of the largest institutional consumers of municipal water, including government ministries, military barracks, and public universities, are historically the largest non-paying debtors (Laolang, 2024). This means that for every 1,000 liters of water chemically treated and pumped from a central station, less than half is formally tracked on a customer invoice (Malek et al., 2021).

The operational capacity of Nigerian state agencies to monitor, detect, and suppress illegal water connections is severely limited by institutional, technical, and regulatory deficits (Ajibade et al., 2015). Efforts to enforce utility regulations are deeply undermined by widespread corruption and systemic collusion between utility personnel and informal water syndicates (Laolang, 2024).

The apparentwithdrawal of political interest in maintaining central pipe-borne networks stems from the immense fiscal burden of grid rehabilitation (Ali, 2026). Revitalizing subterranean pipe networks requires massive capital investments that remain invisible to the public, prompting administrations to favor superficial, highly visible infrastructure projects instead (Pointet, 2022). Additionally, the rapid proliferation of decentralized self-supply alternatives such as private motorized boreholes and sachet water industries has relieved immediate public pressure on the state (Shuaibu et al., 2025). Multilateral development banks and international non-governmental organizations (INGOs) have stepped in to fund major water rehabilitation projects whenever a state network faces total collapse (Waziri & El-Sadiq, 2023). This dynamic creates a severe moral hazard, where state governments deliberately underfund their own water maintenance budgets, knowing that external international aid will eventually step in to prevent a total humanitarian crisis (Harman, 2026).

4.0 Conclusion and Recommendations.

The Government is to encourage the use of the Integrated Water Resources Management (IWRM) framework, which seeks to manage water and land resources together for the regional river basin. The policy framework aims at harmonization of extraction policies, preventing raw water reservoirs from being contaminated by industries, and ensuring a continuous supply of raw water to the state water treatment plant.

The state-level infrastructure development is geared towards upgrading old waterworks and expanding the water distribution network in major cities. Government is investing in high-capacity electric pumping machines, and in the reconstruction of primary treatment plants. Some urban areas have refurbished distribution lines; however, there is often limited funding for projects.

State government is looking for ways to expand the utilities through Public-Private Partnerships (PPPs) in the face of budget constraints. The scheme seeks private companies to fund, construct, and manage local water supply networks and automated commercial kiosks. The scheme aims to increase cost recovery, optimize revenue collection, and increase uniformity in the delivery of potable water.

Legislation to restructure State Water Boards from a bureaucratic to a business-like organization is required. The legal changes will allow for independent tariff regulations, define clear service delivery standards, and institute measures to guard against illegal connections, defaults, and corruption. There is a need for a clear policy on annual budgetary allocation that must be used for the development of water infrastructure, rehabilitation of old schemes, and the expansion of services to the new urban districts.

Reference

1. Abney, S. E., Ijaz, M. K., McKinney, J., & Gerba, C. P. (2021). Laundry Hygiene and odor Control: state of the science. Applied and Environmental Microbiology, 87(14), e0300220. https://doi.org/10.1128/aem.03002-20.
2. Abramovsky, L., Andres, L., Joseph, G., Rud, J. P., Sember, G., & Thibert, M. (2020). Study of the distributional performance of piped water consumption subsidies in 10 developing countries. In World Bank, Washington, DC eBooks. https://doi.org/10.1596/1813-9450-9245.
3. Adegun, O. B., Ikudayisi, A. E., Morakinyo, T. E., &Olusoga, O. O. (2021). Urban green infrastructure in Nigeria: A review. Scientific African, 14, e01044. https://doi.org/10.1016/j.sciaf.2021.e01044.
4. Adeoti, O. S. (2023). Water infrastructure sustainability in Nigeria: A systematic review of challenges and sustainable solutions. Water Policy, 25(11), 1094–1111. https://doi.org/10.2166/wp.2023.094.
5. Ajibade, F. O., Adewumi, J. R., Ojo, O. M., & Oguntuase, A. (2015). Issues, challenges and Management of water supply and sanitation in

Nigeria: An Overview. ResearchGate. https://www.researchgate.net/publication/291697932_Issues_Challenges_and_Management_of_Water_Supply_and_Sanitation_in_Nigeria_An_Overview.

6. Akoteyon, I. S. (2019). Factors affecting household access to water supply in residential areas in parts of Lagos metropolis, Nigeria. Bulletin of Geography Socio-economic Series, 43(43), 7–24. https://doi.org/10.2478/bog-2019-0001.
7. Ali, K. H. (2026). Critical success factors for sustainable water supply projects in Nigeria: A systematic literature review and meta-analysis. International Journal of Built Environment and Sustainability, 13(2), 11-24.
8. Aliyu, A., & Amadu, L. (2017). Urbanization, cities, and health: The challenges to Nigeria – A review. Annals of African Medicine, 16(4), 149. https://doi.org/10.4103/aam.aam_1_17.
9. Al-Khalid, A., Al-Senafy, M., &Azrag, E. (2013). Estimation of leakage from the freshwater network in Kuwait. WIT Transactions on Ecology and The Environment, 1, 129-138. https://doi.org/10.2495/wrm130121.
10. Amusat, M. O. (2020). Water insecurity and socio-economic implications in Nigeria: A review. African Journal of Sustainable Development, 10(2), 25–36.
11. Arowosegbe, A. O., Ojo, D. A., Shittu, O. B., Iwaloye, O., & Ekpo, U. F. (2021). Water, sanitation, and hygiene (WASH) facilities and infection control/prevention practices in traditional birth homes in Southwest Nigeria. BMC Health Services Research, 21(1), 912. https://doi.org/10.1186/s12913-021-06911-5.
12. Babu, A. (2018, January 5). Pipe Dreams: Waterborne Diseases and Barriers to Access to Safe Drinking Water and Sanitation in Rural India. Journal of Integrated Community Health, 06(04), 11--20.
13. Balogun, O. R., & Redina, M. M. (2019). Water supply regulation in Nigeria: problems, challenges, solutions and benefits. RUDN Journal of Ecology and Life Safety, 27(1), 65–81. https://doi.org/10.22363/2313-2310-2019-27-1-65-81.
14. Casas, A., Hutchings, P., Bell, A. R., Kupiec-Teahan, B., Lewis, A. R., Sanchez, J. M., Willcock, S., Anciano, F., Barrington, D. J., Dube, M., Karani, C., Llaxacondor, A., López, H., Mdee, A. L., Ofori, A. D., Riungu, J. N., Russel, K. C., Kristensen, B. R., & Parker, A. (2026). Beyond the grid: Navigating water supply and sanitation service ecosystems in informal settlements. PLoS ONE, 21(3), e0342657. https://doi.org/10.1371/journal.pone.0342657.
15. Cherkashyna, M., Sokolova, A., & Brears, R. C. (2025). The Right to Safe Drinking Water as a Condition for Ensuring Human Health and Life: Legal Regulation and Judicial Protection in Ukraine and Other Countries. Access to Just. E. Eur., 193.
16. Chukwuemeka, N., Onyekwelu, A. C., Ayogu, C., & Ossai, O. G. (2023). Spatial distribution and quality of water vending in Nsukka Urban, Enugu State, Nigeria. Nigerian Journal of Environmental Sciences and Technology, 7:325-336.
17. Chunwate, B. T., Madaki, R. B., & Kabiru, M. D. (2021). Access to Pipe-Born water evaluation in Akwanga Local Government Area of Nasarawa State, Nigeria. Journal of Geography Environment and Earth Science International, 1–9. https://doi.org/10.9734/jgeesi/2021/v25i830299.
18. Desta, W. M., Feyessa, F. F., & Debela, S. K. (2022). Modeling and optimization of pressure and water age for evaluation of urban water distribution systems performance. Heliyon, 8(11), e11257. https://doi.org/10.1016/j.heliyon.2022.e11257.
19. Dhoba, L. (2020). Going to scale with rural water supply: a reflection on experiences from sustaining community-managed piped water schemes in rural Zimbabwe. Journal of Water, Sanitation and Hygiene for Development, 10(3), 527–538. https://doi.org/10.2166/washdev.2020.081.
20. Edefo, J. W. (2025). Water and sanitation access in Nigeria. Water Conservation Science and Engineering, 10(2). https://doi.org/10.1007/s41101-025-00402-y.
21. Edith, M., Samuel, A. T., & Odunayo, O. (2020). Comparative assessment of Pipe-Borne water and groundwater quality and their health implication in Gwagwalada Town, Nigeria. International Journal of Innovative Research and Development, 9(4). https://doi.org/10.24940/ijird/2020/v9/i4/apr20007.
22. Erickson, J. J., Quintero, Y. C., & Nelson, K. L. (2020). Characterizing supply variability and operational challenges in an intermittent water distribution network. Water, 12(8), 2143. https://doi.org/10.3390/w12082143.
23. European Union. (2020). European Parliament & Council of the European Union. Directive (EU) 2020/2184 of the European Parliament and of the Council of 16 December 2020 on the quality of water intended for human consumption (recast). Official Journal of the European Union, L 435, 1–62.
24. Ezugwu, C., Onyelowe, K., Ezugwu, C., Onyekweredike, K., Odumade, A., Omunakwe, O., Nigeria, R. S. M. O. W. P. H., Hussaini, M., Oloyede, A., & Innocent, W. (2021). Community Water Demand and Sustainable Water Supply Planning in Nigeria: a review. JurnalKejuruteraan, 33(3), 517–530. https://doi.org/10.17576/jkukm-2021-33(3)-13.
25. Fan, L., & He, G. (2023). The global burden of childhood diarrheal diseases attributable to suboptimal breastfeeding from 1990 to 2021: an exploratory analysis of estimates from the global

burden of disease study. International Breastfeeding Journal, 20(1), 19. https://doi.org/10.1186/s13006-025-00713-9.

26. Fashae, O. A., Àkànle, Ọ., Olusola, A. O., & Ola-Lawson, O. D. (2024). Household water access and challenges of public water supply in Ibadan metropolis, Nigeria. African Journal for the Psychological Study of Social Issues. 27(9),154 – 167
27. Fitriani, H., Kurniawan, M. A., &Hadinata, F. (2023). Analysis of tariff adjustment for clean water usage. Scientific Review Engineering and Environmental Sciences (SREES), 32(2), 155–174. https://doi.org/10.22630/srees.4790.
28. Frounfelker, R. L., & String, G. M. (2025). Water, sanitation, and hygiene insecurity and psychological distress in South Sudan. Social Psychiatry and Psychiatric Epidemiology, 61(1), 169–179. https://doi.org/10.1007/s00127-025-02934-z.
29. Gift, A., & Skylar, B. (2026). Economic impact of water leakage in urban supply systems. ResearchGate. https://www.researchgate.net/publication/402945370_Economic_Impact_of_Water_Leakage_in_Urban_Supply_Systems
30. Gilbert, K. M., & Shi, Y. (2023). Slum Evolution and Sustainable Urban Growth: A comparative study of Makoko and Badia-East areas in Lagos City. Sustainability, 15(19), 14353. https://doi.org/10.3390/su151914353.
31. Harman, E. (2026). Managerial Performance of a Water User Association under Governance Reform and Drought: Evidence from the İnönü Open-Channel Irrigation Scheme (2012–2024). Black Sea Journal of Agriculture, 9(2), 233–243. https://doi.org/10.47115/bsagriculture.1847686.
32. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv%3AOJ.L_.2020.435.01.0001.01.ENG.
33. Ibrahim, U. (2025). Urbanization and its Impact on Population Health in Nigeria. ResearchGate. https://www.researchgate.net/publication/399427367_Urbanization_and_its_Impact_on_Population_Health_in_Nigeria.
34. Ifabiyi, I.P., &Ashaolu, E.D. (2013). Analysis of the impacts of rainfall variability on public water supply in Ilorin, Nigeria. J. Meteorol. Clim. Sci. 18–26.
35. Iyi, I. (2020). Ekiti State Water Supply, Sanitation, and Hygiene (WASH) Policy, 2020. Ministry of Infrastructure and Public Utilities.
36. JO, O. (2017). Antibiotic Resistance Pattern of Bacteria Isolated from Pipe-Borne Chlorinated (Treated) Water and Untreated Water in Ilorin. MOJ Bioequivalence & Bioavailability, 4(1). https://doi.org/10.15406/mojbb.2017.04.00057.
37. Jordanova, T., Cronk, R., Obando, W., Medina, O., Kinoshita, R., & Bartram, J. (2015). Water, sanitation, and hygiene in schools in low Socio-Economic regions in Nicaragua: a Cross-Sectional survey. International Journal of Environmental Research and Public Health, 12(6), 6197–6217. https://doi.org/10.3390/ijerph120606197.
38. Kareem, O. K., Ajani, E. K., Omitoyin, B. O., Olarewaju, A. N., Orisasona, O., & Osho, E. E. (2018). Spatial and Temporal Limnological Status of Erelu Reservoir, South Western Nigeria. Journal of Science, V. 2013.13, Pp 509-518.
39. Khalmirzaeva, S. S. (2022). The Importance Of Personal Hygiene In Maintaining Human Health. Экономика и социум, (9 (100)), 93-96.
40. Laolang, G. (2024). Exploring perceived factors contributing to poor performance of water infrastructure systems in Gauteng Province, South Africa. University of Johannesburg Research Repository, 45-58.
41. Maheshwari, A., Misra, S., Gudi, R., & Subbiah, S. (2024). A Short-Term Planning Framework for the operation of Tanker-Based water distribution systems in urban areas. arXiv (Cornell University). https://doi.org/10.48550/arxiv.2408.01184.
42. Malek, H. A., Zakaria, M. H., Zulkifli, M. L., & Roslan, N. F. (2021). DETERMINANTS OF NON-REVENUE WATER. MALAYSIAN JOURNAL OF COMPUTING, 6(1), 642. https://doi.org/10.24191/mjoc.v6i1.10435.
43. Manetu, W., M'masi, S., & Recha, C. (2021). Diarrhea Disease among Children under 5 Years of Age: A Global Systematic Review. Open Journal of Epidemiology, 11, 207-221. doi: 10.4236/ojepi.2021.113018.
44. Nasara, M. A., Zubairu, I., Jagaba, A. H., & Yerima, B. (2021). Assessment of Non-Revenue Water Management Practices in Nigeria (A Case Study of Bauchi State Water and. . . ResearchGate. https://www.researchgate.net/publication/352291911_Assessment_of_Non-Revenue_Water_Management_Practices_in_Nigeria_A_Case_Study_of_Bauchi_State_Water_and_Sewerage_Cooperation.
45. Netshitanini, M., Adeeyo, A. O., &Edokpayi, J. N. (2023). Determinants and evaluation of onsite water loss due to leakages in a selected institution in South Africa. Water, 15(2), Article 217. https://doi.org/10.3390/w15020217.
46. Obeta, M. C. (2018). Rural water supply in Nigeria: policy gaps and future directions. Water Policy, 20(3), 597–616. https://doi.org/10.2166/wp.2018.129.
47. Ogunkolu, A. B. (2025). Exploring public perception on Pipe-Borne water in Kaduna metropolis of Kaduna State, Nigeria. ResearchGate. https://doi.org/10.4314/dujopas.v11i2b.12.
48. Ogunkolu, A. B. (2025). Exploring public perception on Pipe-Borne water in Kaduna metropolis of Kaduna State, Nigeria. ResearchGate. https://doi.org/10.4314/dujopas.v11i2b.12.

*Corresponding Author: **Oyelami A A, Omotoso B.M**

49. Okesanya, O. J., Eshun, G., Ukoaka, B. M., Manirambona, E., Olabode, O. N., Adesola, R. O., Okon, I. I., Jamil, S., Singh, A., Lucero-Prisno, D. E., Ali, H. M., & Chowdhury, A. B. M. A. (2024). Water, sanitation, and hygiene (WASH) practices in Africa: exploring the effects on public health and sustainable development plans. Tropical Medicine and Health, 52(1), 68. https://doi.org/10.1186/s41182-024-00614-3.
50. Okon, I., & Njoku, C. G. (2017). Evaluation of Domestic Access to Pipe-Borne Water in Calabar Metropolis, Southern Nigeria. Open Access Library Journal, 4; e3924. https://doi.org?10.4236?oalib.1103924..
51. Olanrewaju, S., Abazu, C., & Babajide, R. (2023). Distribution and access to public Pipe-Borne water in urban areas of West Africa: a case of Ilorin-West Local Government Area, Nigeria. Ghana Journal of Geography, 15(2), 162–183. https://doi.org/10.4314/gjg.v15i2.8.
52. Olasunkanmi, N., Ayobami, S. L., Owolabi, D., &Oyelami, A. (2021). Investigation of Dam Integrity from Electrical Resistivity Methods: A Case Study of Erelu Dam, South Western Nigeria. Indonesian Journal on Geoscience, Vol 8, No 2, pp. 265-274.
53. Omokhudu, G., Ahijo, T., Adeleye, A. O., &Aperverga, P. (2016). Influence of Socio-Economic Attributes of Water Vendors on Methods Adopted in Cleaning the Jerry Cans used for Water Delivery to Residents of Dutse, Jigawa State, Nigeria. Journal of Environment and Earth Science. 6(6), 159 – 165.
54. Oyelami, A. A. (2012a). Channel Morphometry of Aawon Drainage Basin. Journal of Professional Teacher Trainers (JOPTET) VOL.9 PG11-20.
55. Oyelami, A. A. (2012b). Slope Morphometry of Aawon Drainage Basin, Oyo, Nigeria. Atiba Journal of Arts and Social Science Education 4 (1) pp 207-219.
56. Oyelami, A. A. (2012c). Areal Morphometry of Aawon Drainage Basin, Oyo, Nigeria. International Journal of Environmental Issues vol. 9, No. 1, pp 95-107.
57. Oyelami, A. A. (2013). The Structure of Oyo Urban Space in NBN Taninowo (Ed) Oyo Region, Lagos Sibis Ventures, pp. 123- 147.
58. Oyerinde, A. O., & Jacobs, H. E. (2022). The complex nature of household water supply: an evidence-based assessment of urban water access in Southwest Nigeria. Journal of Water Sanitation and Hygiene for Development, 12(3), 237–247. https://doi.org/10.2166/washdev.2022.176.
59. Oyo State Government. (2025). About Oyo State. https://oyostategov.ng.
60. Picazo, M. Á. P., &Tekinerdogan, B. (2024). Urban water distribution networks: Challenges and solution directions. In Elsevier eBooks (pp. 245–264). https://doi.org/10.1016/b978-0-323-99330-2.00005-2.
61. Pointet, T. (2022). The United Nations World Water Development Report 2022 on groundwater, a synthesis. LHB: Hydroscience& Journal of Fluids Engineering, 108(1), Article 2090867. https://doi.org/10.1080/27678490.2022.2090867.
62. Raap, S., Knibbe, M., & Horstman, K. (2022). Clean Spaces, Community Building, and Urban Stage: the Coproduction of Health and Parks in Low-Income Neighborhoods. Journal of Urban Health, 99(4), 680–687. https://doi.org/10.1007/s11524-022-00644-4.
63. Renwick, D. V., & Rotert, K. (2019). Deteriorating water distribution systems affect public health. Opflow, 45(9), 12–15. https://doi.org/10.1002/opfl.1246.
64. Shuaibu, A., Hassan, A., & Abubakar, I. J. (2025). Towards integrating self-supply to enhance urban water governance in Yola North, Nigeria. Journal of Umm Al-Qura University for Engineering and Architecture, 16(4), 1184–1193. https://doi.org/10.1007/s43995-025-00151-y.
65. Thomson, P., Pearson, A. L., Kumpel, E., Guzmán, D. B., Workman, C. L., Fuente, D., Wutich, A., Stoler, J., & Network, H. W. I. E. R. C. (2024). Water Supply Interruptions Are Associated with More Frequent Stressful Behaviors and Emotions but Mitigated by Predictability: A Multisite Study. Environmental Science & Technology, 58(16), 7010–7019. https://doi.org/10.1021/acs.est.3c08443.
66. Tully, J., DeSantis, M. K., & Schock, M. R. (2019). Water quality--pipe deposit relationships in Midwestern lead pipes. AWWA Water Science, 1(2). https://doi.org/10.1002/aws2.1127.
67. Ufoegbune, G. C., &Eruola, A. O. (2011). Municipal Water Supply planning in Oyo Metropolis, Oyo State, South Western Nigeria. Journal of Geography and Regional Planning, vol.4 (7), pp 392-400.
68. Waziri, M., & El-Sadiq, M. B. (2023). Contribution of private boreholes in water supply system of Maiduguri, Borno State, Nigeria. ResearchGate. https://www.researchgate.net/publication/369645955_Contribution_of_Private_Boreholes_in_Water_Supply_System_of_Maiduguri_Borno_State_Nigeria.
69. WHO /UNICEF (2025). 1 in 4 People Globally Still Lack Access to Drinking Water
70. Winter, J. C., Darmstadt, G. L., & Davis, J. (2021). The role of piped water supplies in advancing health, economic development, and gender equality in rural communities. Social Science & Medicine, 270, 113599. https://doi.org/10.1016/j.socscimed.2020.113599.

*Corresponding Author: **Oyelami A A, Omotoso B.M**