IMPACT OF POPULATION GROWTH ON CURRENT CONDITION OF WATER SUPPLY IN ENUGU METROPOLIS, ENUGU STATE, NIGERIA.

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Abstract

Water is the essence of life, indispensable to human health, agricultural productivity, and industrial development. It is a vital resource that shapes the socioeconomic fabric of societies, with its availability determining the extent to which regions can thrive and evolve. From ancient civilizations to this modern time, water management has been central to urban growth and sustainability. As cities continue to expand and populations surge, the challenge of ensuring a sustainable and reliable water supply has placed regions in perpetual agony of highly limited access to steady water supply, Enugu metropolis inclusive. This study aimed at examining the impact of population growth on the current condition of water supply in Enugu metropolis, highlighting how rapid urbanization and infrastructure inadequacies have contributed to water scarcity and unequal access. The specific objectives were to assess the rate of population growth in Enugu metropolis and its relationship with the increasing demand for water and propose recommendations for improving water supply systems and resource management considering ongoing population growth. The study employed the mixed-methods approach, combining surveys and interviews to obtain information from the field using structured questionnaires which was distributed to 400 persons with 376 retrieved, and direct interviews with key stakeholders in water management in the study area. Tables, charts, frequencies and simple per centages were used to bring the work to clear view, while Chi-square test was used to test the hypothesis. The results indicate that population growth has significantly strained water infrastructure, with 43.1% of respondents reporting occasional access to water and 56.9% expressing dissatisfaction with the current water supply. The population projections show an increase from 722,664 in 2006 to 1,155,631 in 2023, growing at an annual rate of 2.8%. In terms of infrastructure impact, 84% of respondents agreed that population growth had a considerable effect on water availability. The study concludes that the water supply in Enugu metropolis is inadequate to meet the demands of its growing population. Recommendations include prioritizing investments in modernizing water infrastructure, implementing public awareness campaigns on water conservation, and developing structures that encourage sustainable water management practices like rainwater harvesting and water use and recycling.

Keywords: Population growth, water supply, infrastructure, Enugu metropolis, urbanization, water management

Introduction

Population growth remains one of the most significant challenges affecting water supply systems globally. As the world's population increases, so does the demand for freshwater, a resource already under considerable strain. The Global population has been estimated to rise to 9.7 billion by 2050, creating unprecedented stress on water resources, particularly in urban areas where population densities are highest (United Nations, 2020).

In many regions, particularly developing countries, urban centers are rapidly expanding without a commensurate increase in water supply infrastructure. African continent is already home to 319 million people without access to safe drinking water figure that continues to rise as cities grow and rural-urban migration intensifies (WaterAid, 2021).

Nigeria, the most populous country in Africa, presents a critical case study in understanding the relationship between population growth and water supply challenges. With an estimated population of over 213 million, Nigeria's water infrastructure has struggled to meet the increasing demand, particularly in its urban centers (National Population Commission, 2021).

This rapid population growth has placed considerable strain on the city's existing water infrastructure, originally designed to meet the needs of a much smaller population. For example, water supply systems that were installed in the 1980s and 1990s are now grossly inadequate for the current demand. As the population has surged, access to clean and reliable water has become increasingly erratic, especially in the densely populated urban zones where the demand far exceeds supply capacity. This imbalance between water demand and available resources continues to widen as population growth accelerates without corresponding investment in water infrastructure development and management (Okeke, Uzuegbunam, Nnaemeka-Okeke & Ezema, 2021). This analysis on population trends over the past decades shows the exponential increase which has greatly impacted the sustainability of the water supply, necessitating urgent reforms to prevent further depletion and inefficiencies (National Population Commission, 2021).

Enugu metropolis, located in southeastern Nigeria, is the capital and largest urban center of Enugu State. It spans three local government areas: Enugu North, Enugu South, and Enugu East, covering a total area of approximately 72.8 square kilometers. The city is geographically positioned between latitudes $7^{o}23'$N and $7^{o}30'$N and longitude $7^{o}23'$E and $7^{o}30'$E of the Greenwich meridian. (Fig 1). Enugu sits on the Udi Plateau at an elevation of about 223 meters above sea level, contributing to its unique topography of rolling hills and valleys. The state is an illustrative example of how rapid population growth can outstrip water supply capacity. With an annual population growth rate exceeding 3.5% (National Population Commission, 2021), Enugu metropolis has experienced significant demographic changes over the years, from 722,664 by 2006 following Nigeria's national census (National Bureau of Statistics, 2006) to a projection of over 1 million residents, reflecting an increase driven by rural-urban migration, natural growth, and economic expansion in the area (UN-Habitat, 2020).

Enugu's urban expansion has far exceeded the capacity of its water infrastructure. Despite the presence of key water sources such as the Ajalli and Oji River Waterworks, the city has been unable to meet the increasing demand for water, leaving many residents dependent on alternative sources like private boreholes, wells, and water vendors. This growing reliance on unregulated water sources raises concerns about equitable access to water, as those without the financial resources to invest in private solutions are often left without sufficient water for daily use.

In addition to the sheer inadequacy of the infrastructure, population growth in Enugu has exposed and exacerbated inefficiencies in water resource management. The city's water systems are plagued by frequent pipe bursts, illegal connections, and distribution losses, all of which are aggravated by the increasing pressure on aging infrastructure (Ikechukwu, 2022). The rapid population increase in Enugu has led to water supply infrastructure being stretched beyond its intended capacity. For example, water treatment plants designed for a much smaller population are now forced to serve a far larger number of residents, leading to frequent breakdowns, longer maintenance periods, and reduced water pressure in certain parts of the metropolis. Overloaded water mains and pipes are more prone to leaks and bursts, further limiting access to water. This infrastructural strain is directly correlated with the city's demographic expansion, making it harder for existing facilities to meet rising demand.

Furthermore, the lack of an integrated urban water management system in Enugu has hindered efforts to optimize the use of available water resources. Poor coordination between municipal authorities, regulatory bodies, and water utility providers has resulted in fragmented and inefficient water delivery, leaving large segments of the population underserved. Enugu metropolis, as population growth continues to outpace the capacity of water supply systems, the need for sustainable and integrated water management in Enugu has become more urgent than ever (Inmpey, 2019). This paper seeks to bridge the gaps in existing research by providing a detailed analysis of how population growth has impacted the water supply in Enugu metropolis, with particular emphasis on the challenges posed by infrastructure deficits, pollution, and climate variability. By situating Enugu's water crisis within the broader context of national and global water supply challenges, this paper offers insights into potential solutions that can help mitigate the effects of population growth on water systems (Ikechukwu, 2022).

Objectives of the study

This study aimed to examine the impact of population growth on the current condition of water supply in the Enugu metropolis. Specifically, the study seeks to.

- Assess the efficiency of the current water supply in Enugu Metropolis to meet the growing population.

Research hypothesis

The study hypothesis was.

- The current water supply in Enugu Metropolis inefficient in meeting the growing population.

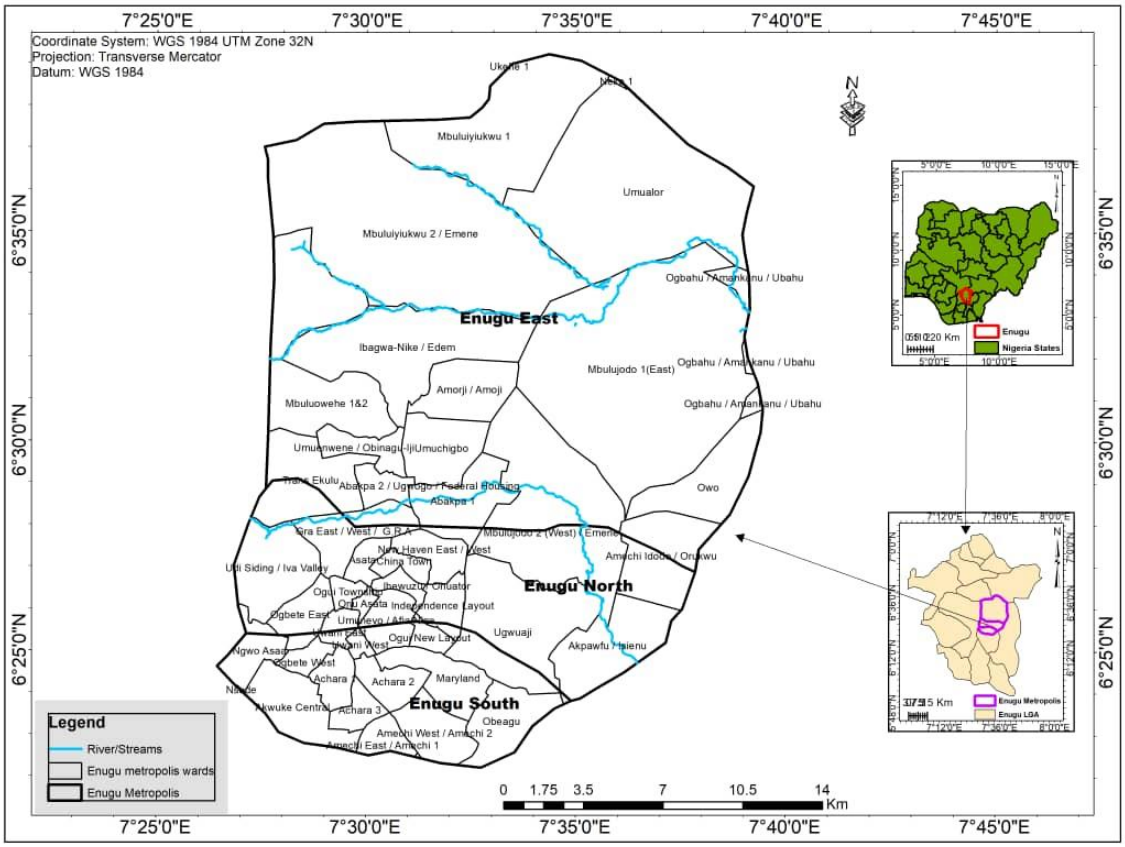

Figure 1. Map of Enugu Metropolis

Source: Ministry of Lands, Survey and Town Planning, Enugu State.

Literature Review

Human population is a vital component of development. Its growth and demand on available resources generate tangible concern to the global community (Uttah, 2018). As the global population approaches 9 billion, the demand for water for domestic, agricultural, and industrial purposes has surged. According to the United Nations World Water Development Report (2023), water demand has grown at approximately 1% per year due to population growth and economic development. This increase in demand places significant stress on existing water resources, particularly in urban areas.

For instance, a study by Gleick, Cooley, & Wolff, (2020) highlighted that urban centers in developing countries face acute water shortages as populations expand beyond the capacity of infrastructure. In Dhaka, Bangladesh, population growth has led to the over-extraction of groundwater, causing a drop in the water table by over 3 meters annually. Population growth has exacerbated water scarcity in many regions. A study by Mekonnen and Hoekstra (2016) revealed that 4 billion people experience severe water scarcity for at least one month per year. This issue is most pronounced in arid and semi-arid regions, where population growth outpaces the replenishment rate of water resources.

Modern water supply systems are designed to deliver adequate, safe, and reliable water to populations. However, with rapid population growth, many systems struggle to maintain efficiency. According to the International Water Association (2022), non-revenue water lost through leaks, theft, or meter inaccuracies accounts for an average of 35% of the total water supply in developing countries, significantly reducing efficiency.

Al-Omari, Abdallah, & Al-Zu'bi, (2020), the water distribution network in Amman, Jordan, was analyzed for efficiency under growing population pressure. The results showed that aging infrastructure and inefficient water management practices led to water losses of over 40%, highlighting the urgent need for modernization. Urban centers face unique challenges in maintaining efficient water supply systems. A study by McDonald, Weber, Padowski, Boucher, & Shemie, (2018) reported that by 2050, over 1 billion urban residents will live in water-scarce cities. The study emphasized that current inefficiencies, such as poor pipeline maintenance and inadequate water reuse strategies, hinder cities' ability to meet growing demands. Singapore's water management system, however, provides a model of efficiency. By integrating advanced technologies such as smart metering and water recycling, Singapore has reduced water loss to less than 5% (Lee & Lee, 2020). This demonstrates that technological innovations can significantly enhance efficiency, even in densely populated regions.

Rural water supply systems often lag in efficiency due to limited funding and inadequate infrastructure. Kjellén and McGranahan (2021) revealed that rural communities in Sub-Saharan Africa frequently rely on manual wells and surface water, which are less efficient and vulnerable to contamination. Agriculture, which consumes about 70% of global freshwater resources, remains a significant factor affecting water supply efficiency. A report by FAO (2022) highlighted that inefficient irrigation practices result in water losses of up to 60% in many developing regions. Transitioning to drip irrigation and other water-saving techniques could improve efficiency and ensure better water allocation for growing populations.

The adoption of integrated water resource management (IWRM) frameworks has been shown to enhance efficiency in several countries. For instance, a study by Wang et al. (2021) demonstrated that implementing IWRM in China's Yellow River Basin improved water use efficiency by 25% over five years. Smart water grids, incorporating real-time monitoring and predictive analytics, have also proven effective. In California, USA, the deployment of smart water management systems reduced water loss by 20% within three years (Brown, Mahat, & Ramirez, 2019).

Africa faces some of the most severe challenges in terms of water supply due to rapid population growth, urbanization, and underdeveloped water infrastructure. The United Nations Economic Commission for Africa (UNECA, 2021) estimates that Africa's population will double

by 2050, reaching over 2.5 billion people. Most of this growth is occurring in urban areas, where water infrastructure is often inadequate to meet rising demands. The African Development Bank (AfDB, 2020) warns that the water crisis in Africa is primarily driven by poor planning, lack of investment in water systems, and inefficient water resource management, compounded by population growth.

Research has shown that many African cities, including Lagos, Nairobi, and Johannesburg, face serious challenges in ensuring equitable water distribution to their rapidly growing populations (Eze & Onyebuchi, 2020). In sub-Saharan Africa, where rural-to-urban migration is a significant driver of population growth, urban centers are expanding rapidly without corresponding investment in water infrastructure. This imbalance between population growth and infrastructure capacity has left millions of Africans without access to reliable water sources. The literature suggests that one of the most critical gaps in African water systems is the failure to integrate population growth projections into urban planning and water resource management strategies (AfDB, 2020). In Sub-Saharan Africa, rapid population increases have strained water supply systems, reducing access to clean water. For example, Nyenje, Foppen, & Kulabako, (2021) documented that over 60% of urban residents in Kampala, Uganda, rely on unsafe water sources due to insufficient public water infrastructure.

Several studies have examined the relationship between population growth and water supply. Ibe (2019) points out that Nigeria's water infrastructure, much of which was constructed during the colonial era, has not been significantly upgraded to meet the needs of a rapidly growing population. This failure to modernize has led to frequent water shortages in many of the country's urban centers. According to Adewumi and Uche (2020), many Nigerian cities operate with water supply systems that serve only a fraction of their populations. In addition to infrastructural inadequacies, mismanagement of water resources and fragmented governance structures are also major contributors to Nigeria's water supply crisis. The water management challenges in Enugu are compounded by poor governance and lack of investment in water infrastructure. Moreover, the absence of an integrated water management strategy has hindered efforts to coordinate water distribution, leading to high levels of water wastage through pipe leakages and illegal connections (Uche, 2020). As a result, much of the city's population remains underserved, particularly in peri-urban areas where water infrastructure is virtually nonexistent. The reliance on private boreholes, wells, and water vendors has grown considerably as the city's population has expanded, leading to disparities in water access. Wealthier residents, who can afford private solutions, enjoy better access to water, while poorer communities face significant water insecurity.

The increase in world population is quickly becoming urbanized as people migrate to the cities (Uttah, Akeh, Awan and Obiefuna 2022). Enugu metropolis, one of the major urban centers in southeastern Nigeria, has experienced substantial population growth over the past few decades, driven by rural-urban migration, natural population increase, and economic opportunities. According to the National Population Commission (NPC, 2006), Enugu's population was approximately 722,664 in the 2006 census, with an estimated annual growth rate of 2.8%. This growth rate has pushed the city's population above one million by 2024, causing significant urban expansion and heightened pressure on the city's infrastructure (Eze & Nwankwo, 2020). The rapid urbanization, spurred by Enugu's role as a political and educational hub, has further contributed to this demographic surge, resulting in a growing demand for essential services, including water supply (Adewumi & Uche, 2020).

The increasing population has outpaced the city's water supply infrastructure, which has not been significantly upgraded since the colonial era. This has led to frequent water shortages and a heavy reliance on alternative water sources such as private boreholes, wells, and water vendors (Uche, 2020). As discussed by Gleick et al. (2019) and Eze and Onyebuchi (2020), Enugu's growing population has exacerbated the city's water crisis, with governance issues and

a lack of investment in infrastructure further straining the water distribution system. Researchers like Eze and Onyebuchi argue that existing studies have underestimated the combined effects of population growth and poor infrastructure on water supply systems in African cities. They highlight the need for more targeted interventions that account for regional disparities in water access and consumption patterns (Eze and Onyebuchi, 2020).

This literature review has identified key gaps in the research, particularly in the area of population dynamics and their direct impact on water infrastructure in Enugu. While studies as Eze and Nwankwo (2020) have documented how the city's growing population has increased demand for water, there is a need for more detailed analyses that examine how population growth is stretching the city's water supply systems beyond their capacity. This paper further assesses how the surge in population has directly strained the existing water infrastructure and exacerbated system inefficiencies.

Methodology

The study made use of survey research design. This method was adopted because it aids to really present the nature of the challenges at hand. Data collected was obtained using both primary and secondary data source. Primary data was collected through the administration of questionnaires while secondary data was gathered from government reports and academic literature. The target population of the study was population of Enugu Metropolis with a total population of 722,664 by 2006 following Nigeria's national census (National Bureau of Statistics, 2006) to a projection of over 1 million residents. Thus, the sample size for the study was determined using the Taro Yamane formula with a sample size sample size to 400. For easy field work, the study made use of purposive and simple random sampling techniques. Thus, key stakeholders who are responsible for water management and distribution in the city selected using the purposive sampling technique due to their experience or knowledge on the subject matter. The simple random sampling technique was employed to administer the questionnaire to the respondents. This method was adopted due to large population of the area. Data collected were analysis using both descriptive and inferential statistics. Descriptively, the study tables, charts, frequencies and simple per centages to bring the work to clear view, while Chi-square test was used to test the hypothesis.

Results

Population of the study area were projected using the National Population Census figure of 2006 as base population and the growth rate of 2.8 per cent. The formular used is as follows:

$P_n = P_o (1 + r/100)^n$

Where P_n = projected population

P_o = population at base year

r = growth rate

n = number of years

Table 1: Population trend of selected years in Enugu metropolis

Year	Population	% Annual increase
2006	722,664	2.8
2014	901,325	2.8
2018	1,006,593	2.8
2023	1,155,631	2.8

NPC, 2006 & Researcher's Linear projection, 2024

Table 1 presents data on the population growth in Enugu metropolis in 2006 and calculated projected population of 2014, 2018 and 2023. The figures show a 2.8 per cent growth rate confirming increase in population. Despite minor improvements in water infrastructure, population growth has consistently outstripped the capacity of the water supply system, leading to significant challenges in providing adequate and reliable water to residents.

Table 2: Access to water supply in Enugu metropolis

Variables (%)	Frequency	Per centage (%)
100- 95	20	5.3
94-55	112	29.8
54- 25	162	43.1
24- 0	76	20.2
0	6	1.6
Total	376	100

Researcher Fieldwork, (2024).

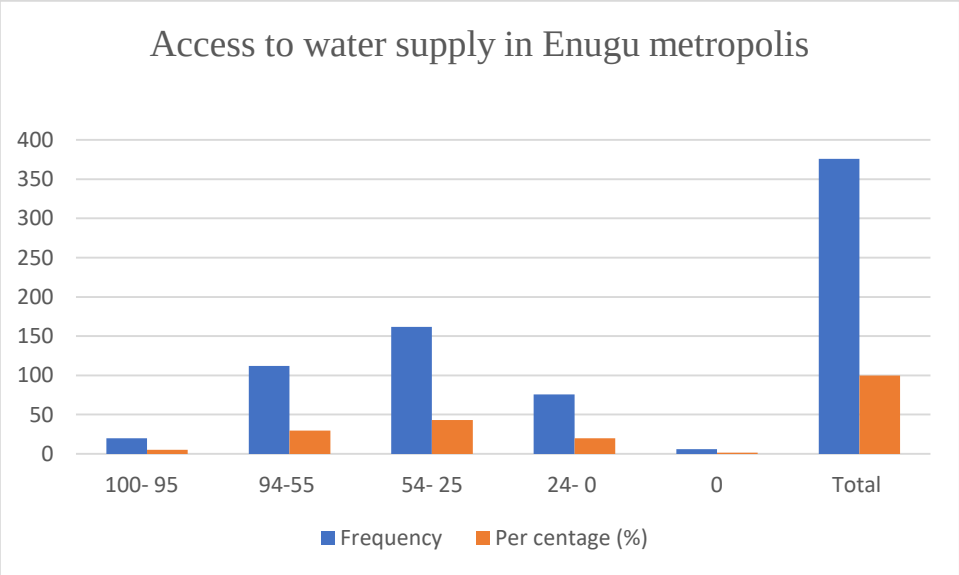

Figure 2. Access to water supply in Enugu metropolis
Researcher Fieldwork, (2024).

The study has shown that 5.3 per cent of the respondents noted that they always have access to water, 29.8 per cent of the respondents stated that they frequently have access to water supply, 43.1 per cent of the respondents opined that they have access to water supply occasionally, 20.2 per cent of the respondents pointed out that they rarely have access to water supply and 1.6 per cent of the respondents indicated that they never have access to water supply (Table 2, Fig 2). Hence, from the study it was observed that residents in Enugu Metropolis occasionally have access to water which hinder sustainable water distribution among households.

Table 3: Level of satisfaction with the quantity of water provided by the current infrastructure

Variables (%)	Frequency	Per centage (%)
100 – 70	35	9.3
69 – 30	127	33.8

29 - 0	214	56.9
Total	376	100

Researcher Fieldwork, (2024).

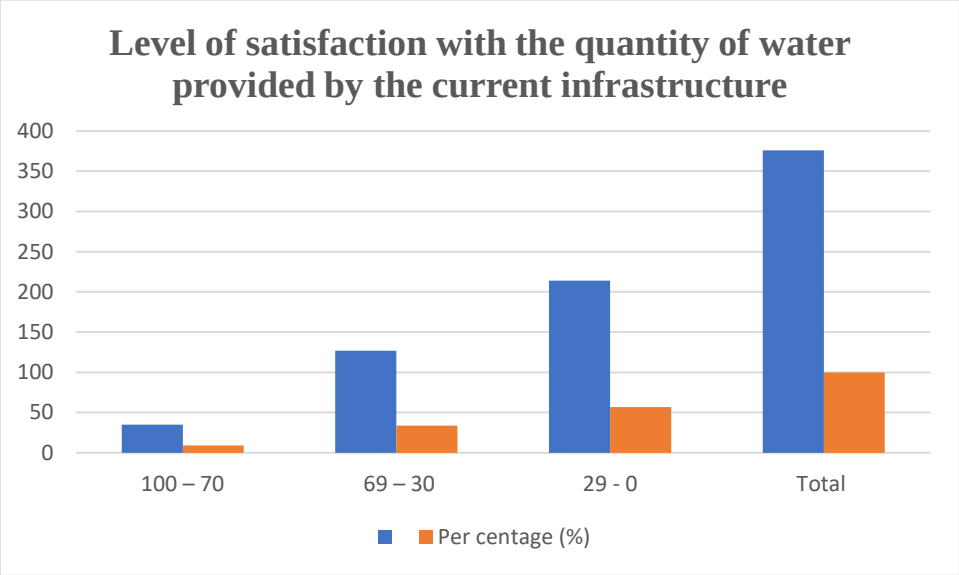

Figure 3: Level of satisfaction with the quantity of water provided by the current infrastructure.
Researcher Fieldwork, (2024).

From the study it was observed that 9.3 percent of the respondents noted that they are very satisfied with the level of the quantity of water provided by the current infrastructure, 33.8 percent stated they are satisfied, and 56.9 percent of the respondents opined that they are not satisfied with the quantity of water provided by the current infrastructure (Table 3, Fig 3). Thus, from the result, it was observed that majority of the respondents expressed their level of dissatisfaction with the quantity of water provided by the current infrastructure in Enugu Metropolis.

Table 4: Population strain on water supply infrastructure

Options	Frequency	Per centage (%)
Yes	316	84
No	60	16
Total	376	100

Researcher Fieldwork, (2024).

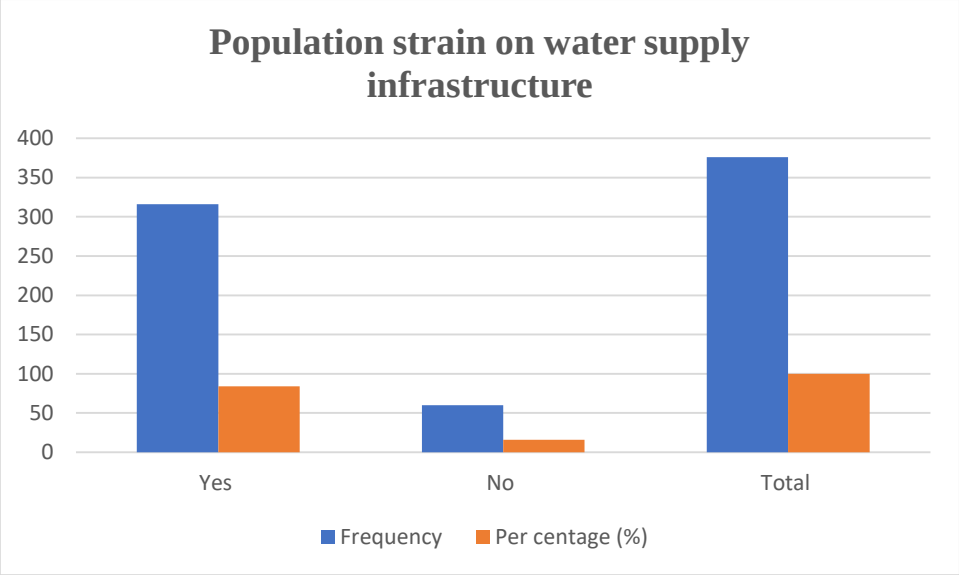

Figure 4. Population strain on water supply infrastructure
Researcher Fieldwork, (2024).

From the study it was observed that 84 percent of the respondents agreed that population growth strain has significant impact on water supply infrastructure and 16 percent of the respondents disagreed that population growth strain has impact on water supply infrastructure (Table 4, Fig 4). Thus, majority of the respondents agreed that population growth strain has significant impact on water supply infrastructure due to increase in population which puts pressure on the available water supply infrastructure.

Hypothesis testing

The study hypothesis which looked at whether the current water supply in Enugu Metropolis inefficient in meeting the growing population. The Chi Square (X^2) was employed. The Degree of Freedom (DF) was determined as (R-1) (C-1). Therefore, (DF) was = 2. The critical table value 2 at 0.05 = 5.991. Since, calculated X^2 = 4.22 is less than the tabulated X^2 = 5.991 the null hypothesis was accepted while the alternate hypothesis was rejected. From the analysis it was concluded that current water supply in Enugu Metropolis inefficient in meeting the growing population.

Table 5: Summary of Chi Square (X^2) Analysis

Fo	Fe	Fo-Fe	$(Fo-Fe)^2$	$\frac{(Fo-Fe)^2}{Fe}$
17	13	4	16	1.23
18	22	-4	16	0.73
52	47.3	4.7	22.09	0.47
75	79.7	-4.7	22.09	0.28
71	79.7	-8.7	75.69	0.95
143	134.3	8.7	75.69	0.56
				X^2 = 4.22

Discussion of findings

From the analysis, the study revealed that the current water supply is significantly impacted by the population in Enugu Metropolis. This implies that the quantity of available water is inadequate to meet the growing population. This supported the study of Galadima, & Garba,

(2019) who noted that the current condition of water supply is influenced by a complex interplay of factors, including sustainable management practices, climate change, population growth, and aging infrastructure. Thus, rapid urbanization and sustainable management practices contribute to increased water demand, leading to water scarcity, especially during periods of high demand or in areas with limited access to water sources. Enugu Metropolis, with its diverse and growing population, relies on a complex water supply infrastructure to meet the demands of its residents. This follows Garcia (2022) who explained that the poor state of existing infrastructure, including water sources, treatment plants, distribution networks, and storage facilities is the cause of inadequate water supply to the growing demand of the growing population. The increasing population has outpaced the city's water supply infrastructure, which has not been significantly upgraded since the colonial era. This has led to frequent water shortages and a heavy reliance on alternative water sources such as private boreholes, wells, and water vendors. As discussed by Gleick et al. (2019) and Eze and Onyebuchi (2020), Enugu's growing population has exacerbated the city's water crisis, with governance issues and a lack of investment in infrastructure further straining the water distribution system.

Conclusion and Recommendations.

The inadequate water infrastructure, population growth, and inefficient resource allocation have led to widespread disparities in water access and quantity, exacerbating the vulnerability of communities, particularly in developing regions. Based on the findings of the study, the current water supply infrastructure has significant impact on the growing water demands population in Enugu Metropolis. This entails the quantity of available water needed by the growing population is inadequate to meet the growing population, thereby negatively impacting the socio-economic wellbeing of the residents.

Based on the findings of this study the following recommendations are proposed by the researcher. These include:

- The state government should prioritize investments in upgrading and modernizing the existing as well as providing new water supply infrastructure to make water affordable and accessible to the growing population in the study area.
- Enugu state water corporation agency should launch public awareness campaigns and structures to educate residents on the importance of water conservation and sustainable practices like rainwater harvesting and management.

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