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Analysis to determine the domestic water usage in Yolde - Pate Area of Yola South Local Government Area of Adamawa State Nigeria

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Abstract

This research study presents findings of the analysis of determining the domestic water usage in Yolde-Pate area of Yola South LGA of Adamawa State Nigeria. During the recce survey and final survey; the sources of domestic water were identified and mapped out in the study area which include: 127 Industrial borehole, 16 hand-pumps, 6 well water and 1 public tap. Domestic water usage moves in hand with its source and accessibility this is where Nearest Neighbor Analysis NNA was used and its summary depicts the following; z-score of 0.205792265731; which means the pattern does not appear to be significantly different than random; which is fairly recommendable. Mean Distance is 51.1643 Meters, Neighbor Ratio is 1.024, and p-value: 0.836953. This was achieved due to the highly precision DGPS used in determining the spatial positions of each of the 150 XYZ points of each water source location and digitally mapping out the whole study area. Then 600 well-structured questionnaires that were randomly distributed within the study area with the respondent's responses largely related to the analysis of determining domestic water usage were retrieved and analyzed with the End User Analysis (EUA)Technique. The results show that the total volume of water used daily per house ranges from 52,247 to 78,856 liters for each house hold with a range of 54.53liters to 67.69 liters of water consumption per individual in a day; which fall short of WHO standard of 120 liters. However the EUA based on the population density of the study area reveals: first for the high density areas, which has 3 wards Gadawalowol Yolde Patte ward, Jalingo Yolde Patte ward and Chaka Midari ward with a mean population of 1187, mean household size of 4.67 individuals, 71500 liters as the mean total of consume water daily, 60.35 as the mean per capita water consumption per day individually while standard still remains 120 liters and the mean total of daily demand is 142,440 liters; which shows deficit of what is needed. For the medium density areas with an average population of 1093 which are made up of 2 wards depicts 61100 liters as the mean total of water consumed daily by each household, 55.86 liters was consumed by an individual with a daily mean demand of 131,160 liters. While the low-density areas which mainly is occupied by the Sabonpegi Yolde Patte ward residence has a population of 876, total water consumption per household of 52,247liters, Per Capita Water Consumption (liters per day) is 59,64liters while its water daily demand is 105 120 liters; similarly, a shortage of what is demanded and WHO standard exist also in the medium and low-density areas. Recommendations were then spelt out to improve water consumption and usage with well design accessibility structure to improve well-being of the people in this study area.

Keywords: Domestic water; Usage; Nearest-Neighbor-Analysis; End-User-Analysis

1. Introduction

Water is one of the basic requirements of life, without which, life on universe Earth would not exist (Abrashinsky, 2014). Water is a rudimentary resource which supports economic growth and maintains daily life. It is very significant as it is the major component of both plants and animals (Chakhaiyar, 2012). As a resource to any nation, it should be well planned, developed, conserved, distributed and managed effectively. Its infrastructure should be properly maintained

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to avoid deterioration in the system. The total water requirement is on the increase and the per capita water consumption is also on the increase due to the increase in population and civilization (Audu and Ekeke, 2013)

The cumulative rate of population and water demand has compounded the issue of water sources depletion in many parts of the world. Towns and cities in developing countries are currently facing serious challenges of efficiently managing the scarce water resources, urbanization, and infrastructural decay, as well as the issue of sustainability of conventional water management (Zeraebruk et al, 2014).

Nigeria's fresh water resources cover only 3.4% of its total lands area 94,185,000 hectares to meet the demands of over 170 million people. Therefore, Nigeria needs to be able to use water in a sustainable way and this present the country with a big challenge (Food and Agricultural Organization, 2006). Water is used for different purposes this include residential, commercials, industrial and Agricultural water uses.

World Health Organization (2012) refers domestic water as water uses for all usual domestic purposes including consumption, bathing, and food preparation. Household water use is usually the most important part of municipal water use because it accounts for more than half of the total municipal water use in many developing countries (Lu, 2017).The increase in demand for water as a result of increase in population and changes in life style and economic activities has put pressure on water supply systems which is considered as the leading cause of shortages in Nigeria's Urban Centre's.

Other explanations have been adduced to this problem ranging from inability of water boards to abstract water from sources, leakages in the distribution system, outright breakdown of machineries, unreliable estimates of urban water demand, the pattern of water use and determinants of water use (Victor, 2012)

Numerous cities and metropolises are facing steady population increase and community growth which, as a result, exerts greater strain on these cities' resources. Inevitably, urban infrastructure has had to compensate for this growth and accommodate for the needs of the community (Cross et al, 2017).

1.1. Statement of the Problem

Human beings or humanity generally needs water for drinking, cooking, bathing, sewage disposal, irrigation, industrial uses and for recreational purposes amongst many other uses. Washing hands after defecation and before preparing food is of particular importance in reducing disease transmission, but without abundant water in or near homes, hygiene becomes problematic or impossible. (Aderibigbe et al, 2018). In some cases, the various wards/sections of the cities in developing countries are provided with water on rotational basis because the supply of the whole city is below requirement.

One of the problems facing Yolde- pate metropolis therefore is the provision of adequate amount of water for the smooth operation of its various sectors. Reliable figure for water actually used are hard to come by. Where they exist, they tend to reveal more about hardship involve in obtaining drinking water than they do about statistics of water use.

The WHO (2020) revealed that 3.4 million people die every year as a result of water borne disease globally. Also, UNICEF (2020) revealed that more than 100,000 children under five years of age die annually due to water-borne diseases in Nigeria. These water diseases include; Thyphoid, Cholera, Giardia, Dysentery, Escheria Coli and Hepatitis A. It is against this backdrop that this research analyzed household water consumption in Yola metropolis with a view to making recommendations that can help improve the current water situation in Adamawa State and Nigeria at large.

This study focused mainly on "traditional" determinants of water use and socio-cultural characteristics with implication for water use. It is against this background that this study, intends to analyze the domestic usage of water in Yolde- pate and its environs in Yola South Local Government Area of Adamawa State.

1.2. Research Questions

- What is the pattern of water use in high medium and low residential areas of Yolde- pate
- What is the determinants of water use in high medium and low residential areas in Yolde- pate
- What is the estimated quantity of water use in high, medium and low residential areas in Yolde- pate

Aim and Objectives

This study analyzed the domestic usage of water in residential areas of Yolde- pate and its environs, through the following objectives: -

- Mapping out existing public and private water facilities in the study area.
- Analyse determinants and compare pattern of water use in high, medium and low residential areas of Yolde-pate.
- To estimate the quantity of water use in residential areas of Yolde- pate and its environs.

Scope

This study covers water usage determinants in Yolde- pate constituting high, medium and low residential areas.

2. Literature Review

According, the World Health Organization WHO (2000), lack of funds, poverty, level of education, poor government policy, gender inequality, poor implementation strategies and natural disaster contributes to the problem hindering the provision of portable (safe) water supply and sanitation in both rural and urban areas in developing countries including Nigeria.

The United Nations Children's Fund (UNICEF) in 2020 ranked Nigeria 3rd behind China and India as countries with the largest population without adequate water supply and sanitation. The water system in Yola North Local Government Area is public sector oriented; controlled and managed by Adamawa State water board. To this end, out dated equipment is still in use for water supply. Furthermore, the existing infrastructural facilities used for water supply are not maintained regularly and there is erratic power supply to run the machinery for better supply.

Sule et al (2016) said that producing a reliable estimate of water demand and use in most cities in the developing countries is a difficult task as urban water uses are predominantly for residential and commercial. Also, most uses are not metered and tariff is based on fixed rate.

Schnleich and Hillenbrand (2017) studied the determinants of residential water demand in Germany and found that differences in price and income alone explain the largest part of the gap in residential water use. But household size had a negative impact on water demand while higher age appears to be associated with higher water use.

Ali and Terfa (2012) studied the state of water supply in urban areas at household level in Neke town Ethiopia found that household size income levels, education and availability of tap water as the major determinants of water use.

Ayanshola et al (2013) studied water demand at household level in Ilorin Nigeria and found that income education level and sex as the major determinants of water use.

Sani (2018) identified household size income and housing type at the factors affecting water use in Gombe town.

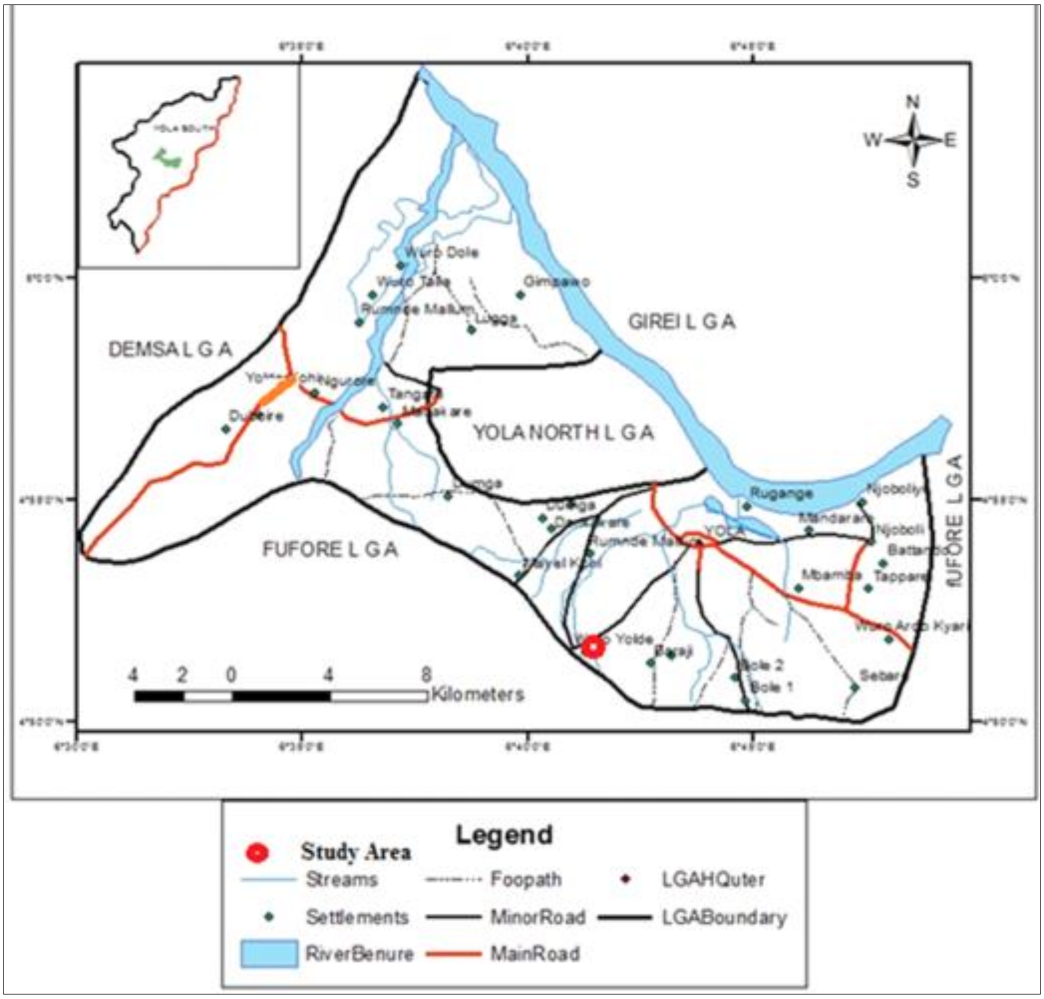
Abranshinky (2014) in his study of domestic use of water in Clare USA identified the pattern of use as bathing, laundry, brushing, washing and girding.

Ibeziako (2015) found that factors influencing residential water demand in Enugu Urban Residential Area are dwelling type, frequency of water supply, the educational level of the head of household the density of public taps, household size and distance from water source. this research tends to examine the consumption rate in the study area that have not been previous taken into consideration by either the policy makers or the inhabitants themselves to curtail the shortage in domestic water usage.

3. Materials and Methods

3.1. Study Area

In terms of its spatial extent, the Yolde pate is a community in Yola south local government. Yolde pate is situated about 1.5km west of Yola town and lies between latitude 09012' 0" to 090 14' 0"North of the equator and longitude 120 41' 0" to 120 45' 0" of the Greenwich meridian. The map of the study area is shown in Figure 1 below. The name Yolde pate, originated from word Yolde meaning Knoll. It is bounded with Yola to east, karewa and Nyibango to the north, Rumde Mallum to the south and Gireji in the west. Yolde pate has a population over 6,000 inhabitants. The inhabitants are mostly farmers, retirees and civil servant. There are many ethnic groups in the area namely: Fulani, Hausa, Vere, Batta, Lakka, Higgi etc, the widely spoken languages in the area are Hausa and Fulfulde. Christianity and Islam are the two major religious practices in the area,



Source: Survey Dept, Yola South Local Govt Council.

Figure 1 Map of Yola South showing the Study Area

3.2. Method of Data Collection

Data was collected through Primary and Secondary sources. Primary data involve a preliminary reconnaissance survey and GPS positioning (XYZ) determination surveying was carried out mapping out the study area, identifying and numbering the precise spatial distribution of residential household's water sources in the study area and the administration of structured questionnaires. While the secondary data source gathering involves reviewing of official record books, journals, conference papers and online materials which provides information on tools and techniques that were adapted in collection, presentation and analysis of data.

3.3. Sampling

For this research study, sampling technique was determined in three perspectives, which were; sampling frame, sampling size and sampling techniques.

- Sampling frame: this denotes the body of the unit from which the target respondents are selected. In this case the study area was divided into sections referred to as high, medium and low residential areas as the sample frame. From each unit a proportionate number of households are selected for the purpose of administering questionnaire. These divisions form the sampling frame or population of the study.
- Sample size: Ball and Gall (1971) Suggested that for a social survey like this for a target population 1000 unit a sample size of 20% should be adopted, 10% for a sample size of 5000 population and 5% for a population of 50,000, the sample size for this research study was determined based on the target population. Since there are

6,441 households in the study area 10% of 6, 441 households were taken and served as the sample size which is 644.1. Hence 640 Structured questionnaires were distributed and 600 were retrieved and analyzed in context with determining domestic water usage or consumption in the study area.

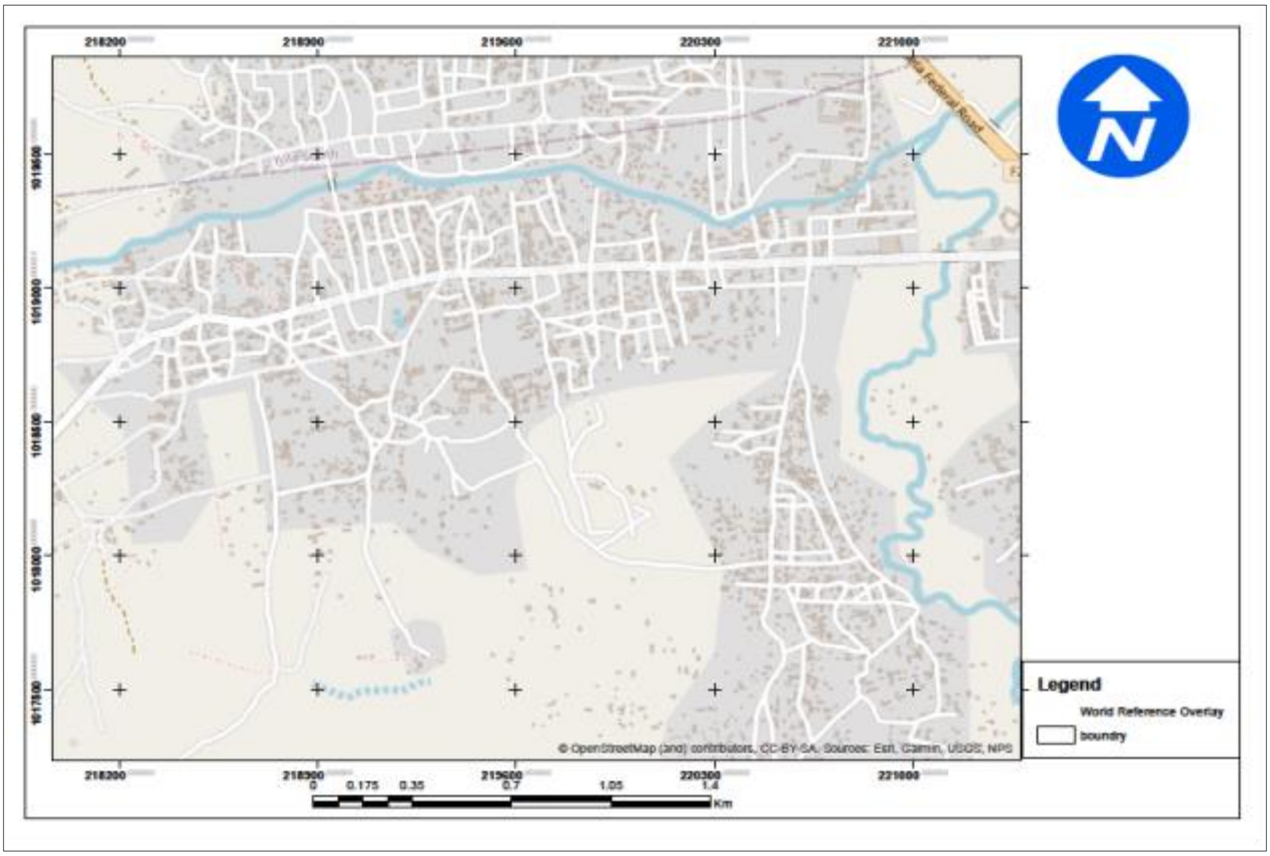
- Sampling technique. There are various sampling techniques and each has some assumed pre conditions suitable for its application. For a heterogeneous environment like Yolde- pate where population density, income level and probably occupation which to a great extend determine water demand and use, a stratified systematic random technique was adopted. The selection of these samples techniques was the most suitable because they are scientific and easy to apply as acknowledged by (Gaveller and Wallman 2014).

3.4. Data Presentation and Analysis

Data collected was presented using statistical graphs, charts, tables and digital maps; for the mapping and the spatial distribution of existing water sources within the study area in terms of high, medium and low-density areas; the coordinates (Eastings Northings and Heights XYZ was gathered using the Differential GPS Surveying Instrument was plotted and analyzed using the ArcMap 10.5 software. While for the analysis on determining how far and close positioning of the water sources within the study area in terms of high, medium and low-density areas; this was accomplished with aid of nearest neighborhood analysis (NNA) application software within the ArcMap 10.5 software. Furthermore, the data retrieved through the structured questionnaire was analyzed by using the End Use Analysis Method (EUA) and its Principles; which established the structural relationship between the variables and household water demand and further revealed the determinants of the variation of water use and consumption, also in terms of high, medium and low areas within the study area with further multivariate statistical analysis was also performed.

3.4.1. Base Map of the Study Area

A base map of the study area was extracted from the World Reference Overlay, which is an Environmental Systems Research Institute (ESRI) topographic base map that serves as the basis depicting all the desired mapping elements in their geospatial context; this was done in ArcMap 10.5 environment. The base-map is shown in the figure 2.0 below:



Source: Environmental Systems Research Institute (ESRI)

Figure 2 Digital Base Map of the Study Area

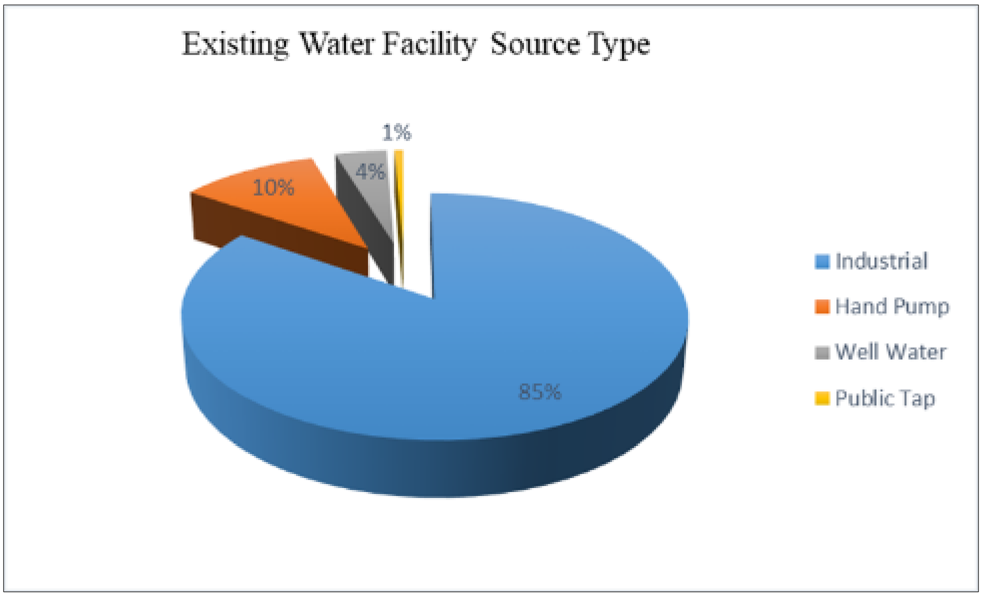
3.4.2. Existing Water Facilities in the Study Area

The table below depicts the existing water facilities in the study area, whose XYZ Coordinates were obtained using a Differential Global Positioning System (DGPS). The DGPS technology ensures high accuracy in determining the XYZ coordinates of the water facilities. This information is crucial for analyzing and managing the water resources in the study area effectively.

Table 1 Existing Water Facilities

S/N	Source Type	Number of Points	Percentage (%)
1	Industrial	127	85%
2	Hand Pump	16	11%
3	Well Water	6	4%
4	Public Tap	1	1%
Total		**150**	**100%**

Source: The Researcher Field work



Source: Researcher's Field work

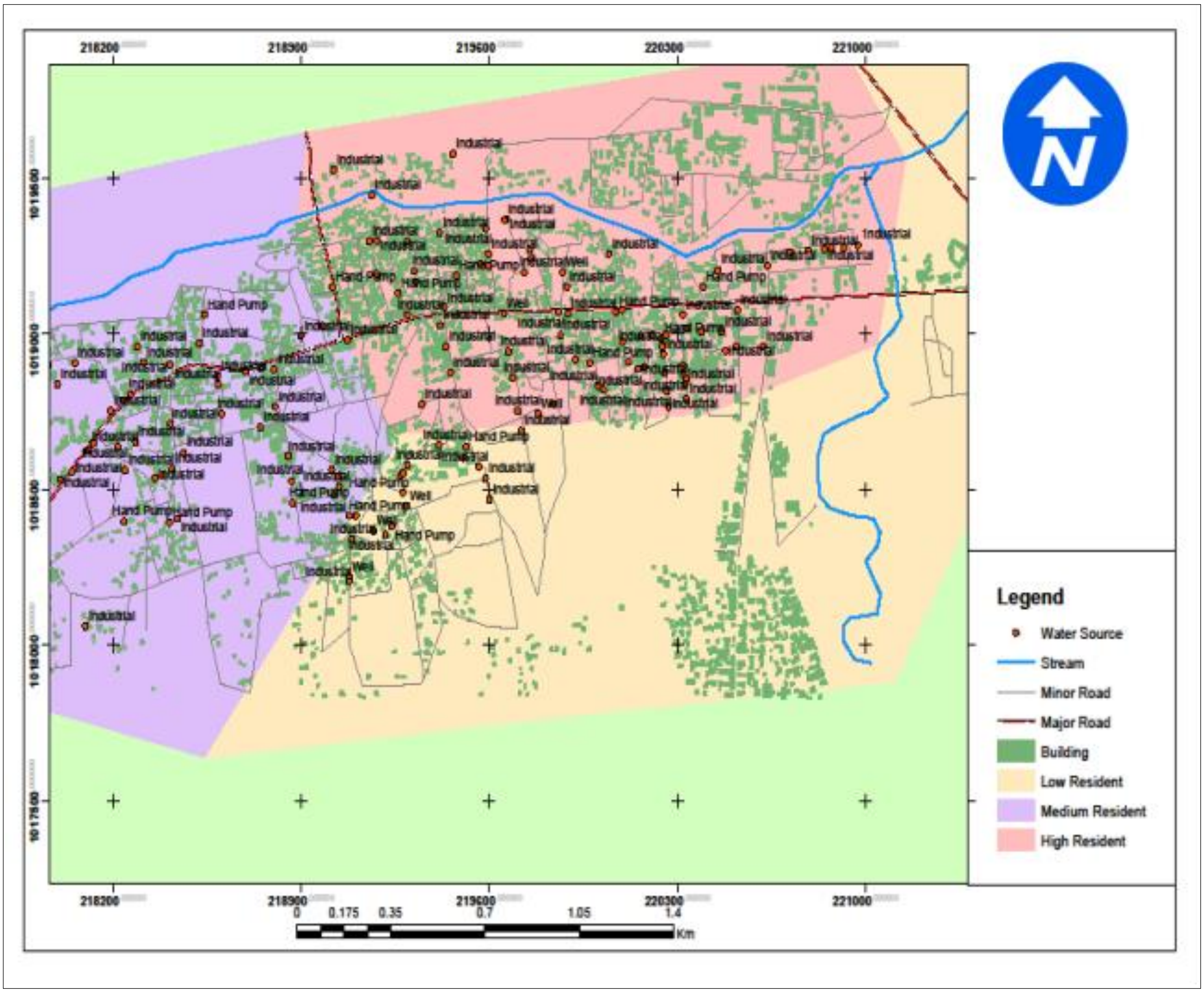
Figure 3 Distribution of existing water facilities based on source type

3.4.3. Digital Map Existing Water Facilities

The digital map showing all the existing water facilities in the study area was designed in ArcMap 10.5. This digital map was created using various data sources, including satellite imagery and geographic information system (GIS) data. It provides a comprehensive view of the types of water infrastructure sources, such as industrial wells, hand pumps, and public taps, allowing for effective planning and management of water resources in the study area.

The digital map was created by downloading Google Earth imagery of the study area at a maximum resolution of 0.5 meters per pixel. This high-resolution imagery was then georeferenced and digitized in ArcMap. The XYZ coordinates of existing water facilities were saved as a comma-separated value (CSV) in Excel format, which was then imported into ArcMap for spatial analysis and mapping, ensuring accurate placement of the water infrastructure sources on the map.

The digital map is shown in the figure below:



Source: Research field work

Figure 4 Distribution of Existing Water Facilities Based on Resident Type

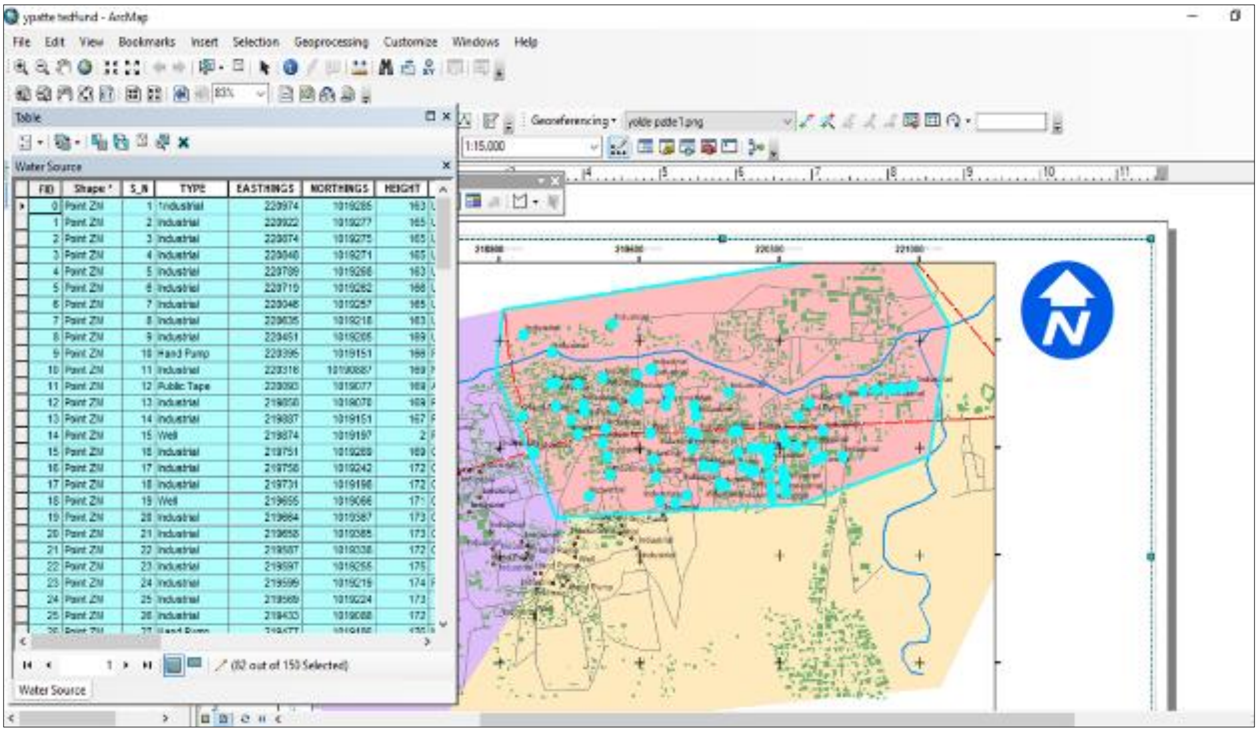


Figure 5 Geographic User Interface (GUI) of Existing Water Facilities in High Residential Area Source: Research Field work

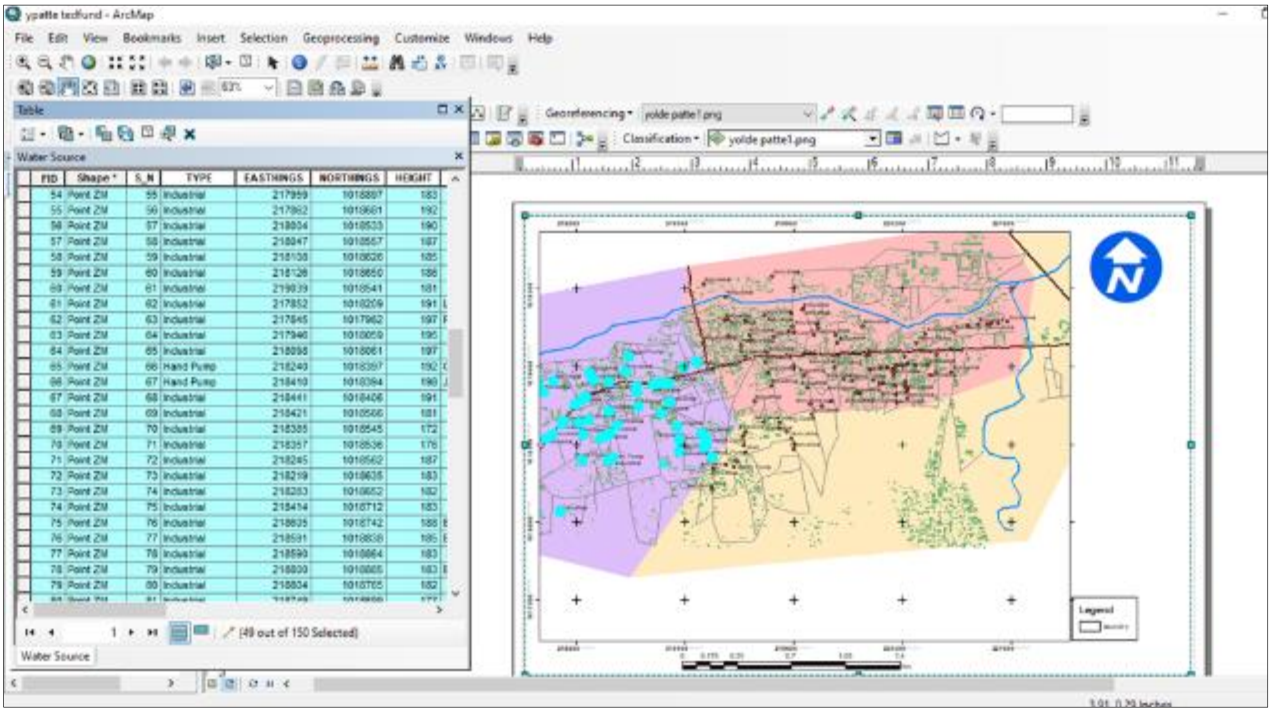
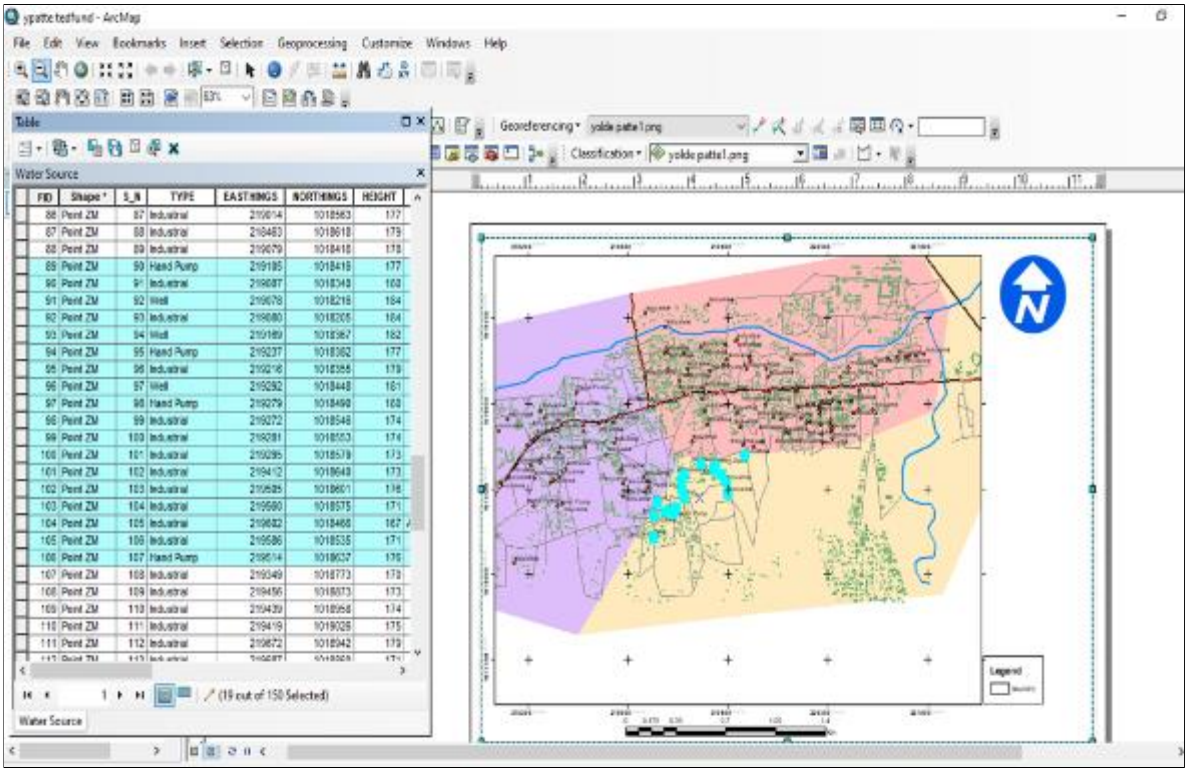


Figure 6 Geographic User Interface (GUI) of Existing Water Facilities in Medium Residential Area. Source: Research Field work



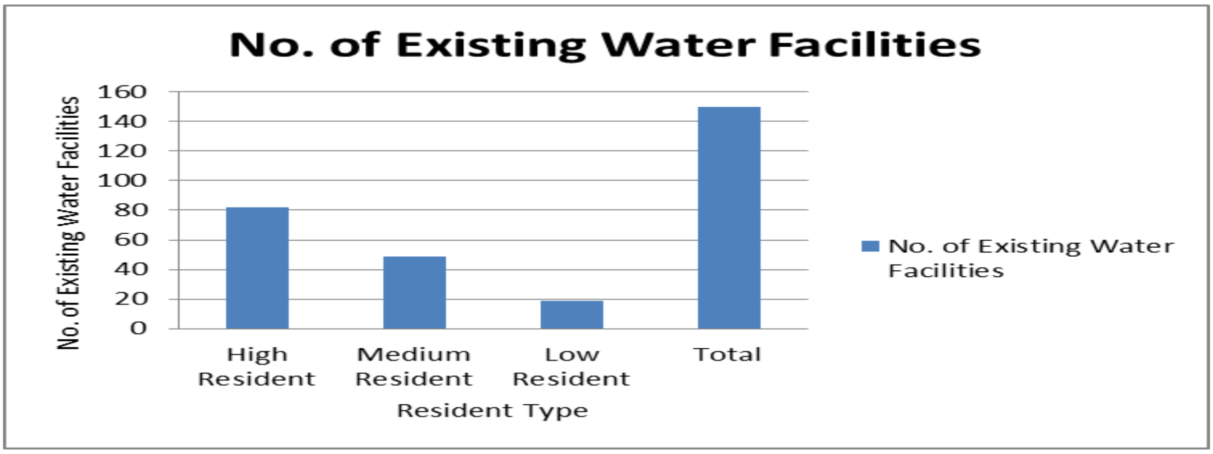
Source: Research Field work

Figure 7 Geographic User Interface (GUI) of Existing Water Source in Low Residential Area

Table 2 Summary of Existing Water Facility Based on Residential Type

Resident Type	No. of Existing Water Facilities	Percentage
High Resident	82	55%
Medium Resident	49	33%
Low Resident	19	13%
Total	150	100%

Source: Research Field work



Source: Research Field work

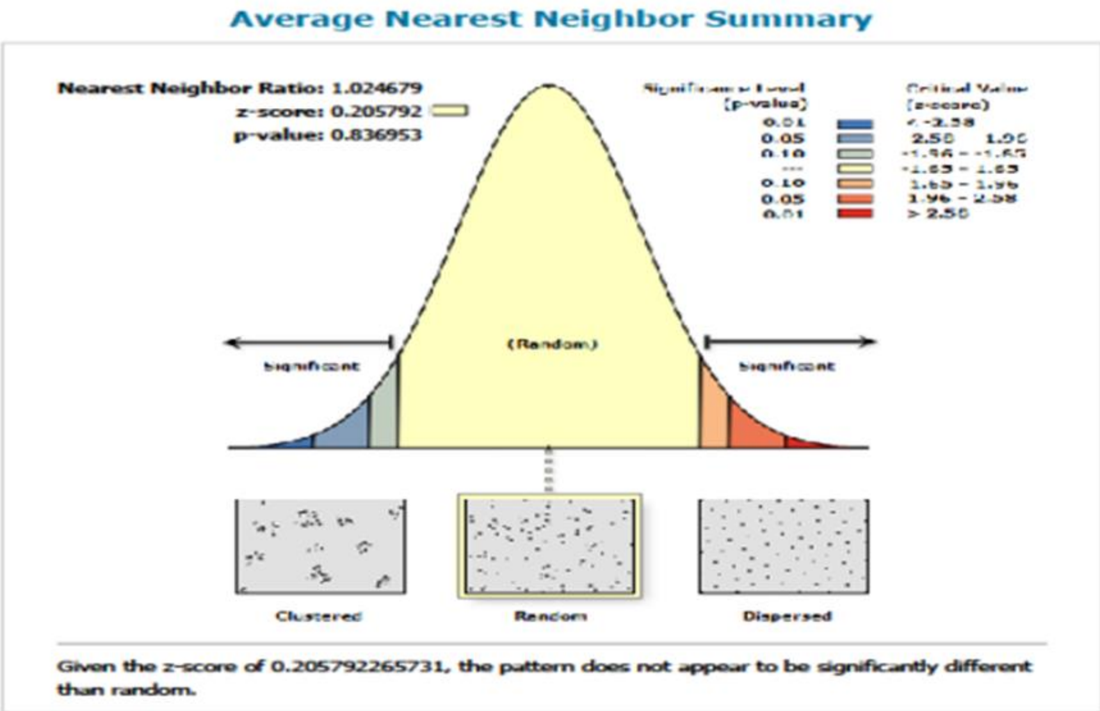
Figure 8 Clustered Column Chart Showing Existing Water Facilities based on Resident Type

3.5. Spatial Distribution of Existing Water Facilities in the Study Area

The nearest neighborhood analysis (NNA) of existing water sources was conducted in ArcMap 10.5 to determine the proximity of each water source to its nearest neighbors. This analysis helps identify potential areas where water sources may be too close together or too far apart, allowing for better planning and management of water resources. Additionally, the NNA provides insights into the spatial distribution and clustering patterns of water sources, aiding in understanding the overall connectivity and accessibility of these resources.

The result shows that existing water sources are randomly distributed across the Yolde Patte, with no significant clustering or pattern observed. This information can be valuable for decision-makers to prioritize areas for the establishment of new water sources, ensuring a more equitable distribution and improved accessibility for all communities.

The result is shown in the figure below:



Average Nearest Neighbor Summary

Observed Mean Distance:	51.1643 Meters
Expected Mean Distance:	49.9320 Meters
Nearest Neighbor Ratio:	1.024679
z-score:	0.205792
p-value:	0.836953

Dataset Information

Input Feature Class:	Water Source
Distance Method:	EUCLIDEAN
Study Area:	189483.600000
Selection Set:	True

Source: Research Field work

Figure 9 NNA Analysis

3.6. End Use Analysis Method (EUA) and its Principles

End Use Analysis (EUA) is the initial step to understand the components of household water use. It has been used for water demand management in other parts of the globe. End Use Analysis (EUA) is one of a number of techniques that can assist water utilities service providers to understand the demand for water, to enable projection of water demand

and to design effective demand management programs (White and Milne, 2014). "EUA involves the disaggregation of water demand by customer sector and ultimately by end use within each sector. It focuses on the factors and technologies that affect water use, including emerging trends (Turner and Comphell, 2013).

3.6.1. End-uses Selection

"End Use" varies within different literature sources depending on the scale of investigation. Due to limited time and information, in this study end use analysis considered only the residential sector because more than half of municipal water is used in households (LU, 2012)

Household water use largely referred to that water used within a house and surrounding area within the residential property boundary. Normally residential water end use is divided into two components, indoor use and outdoor use. Different regions will have different end uses. For instance, in Australia, swimming pools and outdoor conditioners could be significant outdoor end use. Because of water supply in Yolde- pate is not metered and for a social survey of this nature the questionnaire method was used for the data collection.

3.6.2. End User Analysis

The result of the responses obtained for each ward was categorized into indoor and outdoor End User category.

Table 3 Summary of Water Consumption Estimates by End User Category and Ward

End User Category	Ummare-Yolde Patte	Sabonpegi Yolde Patte	Jalingo Yolde Patte	Doyolde-Yolde Patte	Gadawalowol Yolde Patte	Chaka Midari
Indoor Water Use						
Bathing	49.3 L/person/day * 1123	48.1 L/person/day * 876	51.4 L/person/day * 1165	45.6 L/person/day * 1063	50.1 L/person/day * 1231	49.7 L/person/day * 1165
Toilet Flushing	7.3 L/person/day * 1123	10.6 L/person/day * 876	15.7 L/person/day * 1165	8.3 L/person/day * 1063	6.1 L/person/day * 1231	6.4 L/person/day * 1165
Dishwashing	25.3 L/load * 5	28.1 L/load * 8	19.5 L/load * 6	18.4 L/load * 5	25.1 L/load * 4	25.8 L/load * 4
Laundry	55.7 L/load * 5	53.3 L/load * 8	56.7 L/load * 6	59.1 L/load * 5	84.2 L/load * 4	64.7 L/load * 4
Outdoor Water Use						
Gardening	65.1 L/sqm/week * 0.4 ha * 5	19.6 L/sqm/week * 0.4 ha * 8	29.6 L/sqm/week * 0.4 ha * 6	64.2 L/sqm/week * 0.4 ha * 5	76.1 L/sqm/week * 0.4 ha * 4	30.7 L/sqm/week * 0.4 ha * 4
Car Washing	132.4 L/wash * 1	112.1 L/wash * 1	156.6 L/wash * 1	158.6 L/wash * 1	166.3 L/wash * 1	149.8 L/wash * 1

Source: Research Field work

The table 3.0 above presents an overview of water consumption estimates for different end user categories across various wards. It includes both indoor and outdoor water use activities such as bathing, toilet flushing, dishwashing, laundry, gardening, and car washing. The values are provided in litters per person per day or per load, depending on the activity, and are multiplied by the relevant parameters such as population, average household size, or area.

Table 4 Final Water Consumption Estimates by End User Category and Ward

End User Category	Ummare-Yolde Patte	Sabonpegi Yolde Patte	Jalingo Yolde Patte	Doyolde-Yolde Patte	Gadawalowol Yolde Patte	Chaka Midari
Indoor Water Use						
Bathing	55363.9	42135.6	59881	48472.8	61673.1	57900.5
Toilet Flushing	8197.9	9285.6	18290.5	8822.9	7509.1	7456
Dishwashing	126.5	224.8	117	92	100.4	103.2
Laundry	278.5	426.4	340.2	295.5	336.8	258.8
Outdoor Water Use						
Gardening	130.2	62.72	71.04	128.4	121.76	49.12
Car Washing	132.4	112.1	156.6	158.6	166.3	149.8
	64229.4	52247.22	78856.34	57970.2	69907.46	65917.42
Total	64492	52422.04	79083.98	58257.2	70195.52	66116.34

Source: Research Field work

The table 4.0 above presents the final water consumption estimates categorized by end user category and ward. The values represent the total water consumption in liters for each specific activity within each ward. From the results, the sum of water consumption across all end user categories for each ward was presented. These estimates are crucial for water resource management and planning initiatives within the respective areas.

3.6.3. Water Demand Estimation

$$Per\ Capita\ Water\ Consumption\ = \frac{\text{Total Water Consumption}}{Population\ of\ the\ Ward}\ \text{In lpcd (litters per person per day)}$$

$$Total\ Water\ Demand = Per\ Capita\ National\ Standard\ Water\ Demand\ \times Population$$

Table 5 Water Demand Estimation

	Population	Average Household Size	Total Water Consumption	Per Capita Water Consumption (litres/person/day)	Per Capita National Standard Water Demand (litres/person/day)	Total Water Demand (litres/day)
	1,123	5	64,229	57.1944791	120	134,760.00
	876	8	52,247	59.6429452	120	105,120.00
	1,165	6	78,856	67.6878455	120	139,800.00
	1,063	5	57,970	54.5345249	120	127,560.00
	1,231	4	69,907	56.7891633	120	147,720.00
	1,165	4	65,917	56.5814764	120	139,800.00
Total	6,632	32	389,126	352.43	720	794,760.00
Mean	1,104	5.33	64,854	58.74	120	132,460.00

Source: Research Field work with EUA

Table 6 High Density Area, Depicting Total Water Demand and Consumption per day

Wards	Population	Average Household Size	Total Water Consumption	Per Capita Water Consumption (litres per day)	Per Capita National Standard Water demand litres/per//day	Total Water Demand per day
Gadawalowol Yolde Patte	1231	4	69907	5 6.7891633	120	1 47720
Jalingo Yolde Patte	1165	6	78856	6 7.6878455	120	1 39800
Chaka Midari	1165	4	65917	56.5814764	120	1 39800
Total	3561	14	214680	181. 0584852	360	427, 320
Mean	1187	4.666667	71560	60.3528284	120	142,440

Source: Research Field work with EUA

Table 7 Medium Density Areas, Depicting Total Water Demand and Consumption per day

Wards	Population	Average Household Size	Total Water Consumption	Per Capita Water Consumption (litres per day)	Per Capita National Standard Water demand litres/per//day	Total Water Demand per day
Ummare-Yolde Patte	1123	5	64229	57.1944791	120	134760
Doyolde-Yolde Patte	1063	5	57970	54.5345249	120	127, 560
Total	2186	10	122199	111.729004	240	262,320
Mean	1093	5	61100	55.864502	120	131,160

Source: Research Field work with EUA

Table 8 Low Density Areas; Depicting Total Water Demand and Consumption per day

Wards	Population	Average Household Size	Total Water Consumption	Per Capita Water Consumption (litres per day)	Per Capita National Standard Water demand litres/per//day	Total Water Demand per day
Sabonpegi Yolde Patte	876	5	52,247	59,6429452	120	105 120

Source: Research Field work with EUA

3.6.4. Percentage of Water Demand Met

$$\text{Percentage of Water Demand Met (\%)} = \left(\frac{\text{Total Water Consumption of Each Ward}}{\text{Total Water Demand of Each Ward}}\right) \times 100$$

Table 9 Percentage of water Demand Met

Ward	Total Water Consumption	Total Water Demand (litres/day)	Water Deficit (litres/day)	Percentage of Water Demand Met (%)
Ummare-Yolde Patte	64,229	134,760.00	70,531.00	47.68
Sabonpegi Yolde Patte	52,247	105,120.00	52,873.00	49.68
Jalingo Yolde Patte	78,856	139,800.00	60,944.00	56.47
Doyolde-Yolde Patte	57,970	127,560.00	69,590.00	45.42
Gadawalowol Yolde Patte	69,907	147,720.00	77,813.00	47.34
Chaka Midari	65,917	139,800.00	73,883.00	47.18
Total/Sum	389,126	794,760.00	405,634	293.77
Mean	64,854.33	132,460.00	67,605.67	48.96

Source: Research Field work EUA

Table 10 High Density Areas; showing total consumption, demand, deficit and % of H2Odemand.

Ward	Total Water Consumption	Total Water Demand (Liter/Day	Water Deficit (Litres/Day)	Percentage of Water Demand Met
Gadawalowol Yolde Patte	69907	139800	60944	56.47
Jalingo Yolde Patte	78856	147720	77813	47.34
Chaka Midari	65917	139800	73883	47.18
Total	214680	427320	212640	150.99
Mean	71560	142440	70880	50.33

Source: Research Field work with EUA

Table 11 Medium Density Areas; showing total consumption, demand, deficit and % of H2Odemand

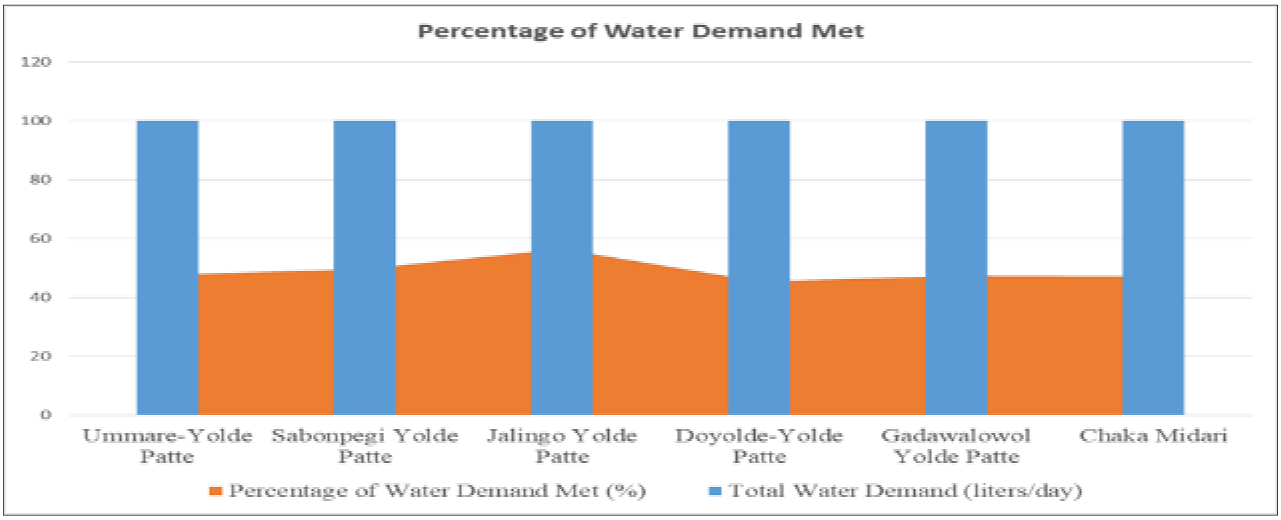
Ward	Total Water Consumption	Total Water Demand (Liter/Day	Water Deficit (Litres/Day)	Percentage of Water Demand Met
Ummare-Yolde Patte	64229	134760	70531	47.68
Doyolde-Yolde Patte	57970	127560	69590	45.42
Total	122199	262320	140121	93.10
Mean	40733	87440	46707	31.03

Source: Research Field work with EUA

Table 12 Low Density Areas; showing total consumption, demand, deficit and % of H2Odemand

Ward	Total Water Consumption	Total Water Demand (Liter/Day	Water Deficit (Liters/Day)	Percentage of Water Demand Met
Sabonpegi Yolde Patte	52247	105120	52873	49.68

Source: Research Field work with EUA



Source: Research Field work

Figure 10 Clustered Column and Stack Area Chart depicting Total water demand and percentage of water demand met

Table 13 Domestic Water Accessibility

Ward	Average Distance to Nearest Water Source (m)	Proximity Category	Access
Ummare-Yolde Patte	101.76	100-1000m	Basic
Sabonpegi Yolde Patte	117.96	100-1000m	Basic
Jalingo Yolde Patte	47.36842105	30-100m	Intermediate
Doyolde-Yolde Patte	45.625	30-100m	Intermediate
Gadawalowol Yolde Patte	95.56	30-100m	Intermediate
Chaka Midari	101.56	100-1000m	Basic

Source: Research Field work with NNA

Determinant of water usage or consumption refers to factors which decisively affects the nature or its outcome, and which from the questionnaire respondents a number of water determinants usage were enumerated which were common include: Socio-demographic determinants which include: family size, age, gender, income education level and others. House: ownership, age, value, appliance efficiency, and others. Yard: Lot size, garden size, garden composition, irrigation system, rain-water tank, pool and others. Enjoy gardening, value gardening, awareness of value of water, awareness on how to save water. Perception on behavioral control, conservation of water. Habits such trusting others, tolerance of antisocial behavior Average temperature, average rainfall, water price (A. Cominola et, al.,2023)

4. Discussion

The study area comprises various water facilities categorized into powered boreholes, hand pumps, well water, and public taps. The XYZ coordinates of these facilities were obtained using Differential Global Positioning System (DGPS) technology, ensuring high accuracy. The distribution of water facilities by type is as follows: powered boreholes (85%), hand pumps (11%), well water (4%), and public taps (1%). This information was essential for analyzing and managing water resources effectively.

Water facilities are distributed across different resident types within the study area. High, medium, and low resident areas exhibit varying densities of water facilities. A summary of existing water facilities based on resident type shows that high resident areas have the highest concentration of water facilities (55%), followed by medium resident areas (33%) and low resident areas (13%). This distribution pattern ensures equitable access to water resources across different residential zones.

The spatial distribution of existing water sources was analyzed using nearest neighborhood analysis (NNA) within the ArcMap 10.5 GIS Software. The results indicate a random distribution of water sources across the Yolde Patte, with no significant clustering or pattern observed. This information is valuable for decision-makers to prioritize areas for the establishment of new water sources, ensuring equitable distribution and improved accessibility for all wards.

Water consumption estimates for each ward were categorized into indoor and outdoor end user categories. Activities such as bathing, toilet flushing, dishwashing, laundry, gardening, and car washing were considered. From the responses obtained, the accumulated indoor and outdoor domestic water consumption obtained were as follows: Ummare-Yolde Patte (64492 lpcd), Sabonpegi Yolde Patte (52422.04 lpcd), Jalingo Yolde Patte (79083.98 lpcd), Doyolde-Yolde Patte (58257.2 lpcd), Gadawalowol Yolde Patte (70195.52 lpcd), and Chaka Midari (66116.34 lpcd). The results provide insights into the total water consumption for each specific activity within each ward, aiding in water resource management and planning initiatives.

Water demand estimation was conducted considering population, average household size, and per capita water consumption. The results show the total water demand for each ward, which was then compared with the total water consumption. The percentage of water demand met was calculated, highlighting areas where water deficits exist. From the result obtained, domestic water deficit exists in all wards in Yolde Patte. Additionally, domestic water accessibility was assessed based on the average distance to the nearest water source and categorized into proximity categories. The study identified a total of 150 existing water supply locations within the study area and its level of accessibility by the residents, shows that Ummare-Yolde Patte, Sabonpegi Yolde Patte and Chaka Midari (100-1000m, Basic access), while Jalingo Yolde Patte, Doyolde-Yolde Patte, and Gadawalowol Yolde Patte (30-100m, Intermediate Access). This shows that majority of the population in Yolde Patte have to go as far as 100 meters to access water. This is similar to the findings by George and Jacob (2010) in accessibility of water services in Kisumu and Meshach Omada (2018) in spatial analysis of access to domestic water supply in Gyel district, Jos South Local Government Area, Plateau State, Nigeria.

4.1. Findings

- EUA based on the population density of the study area reveals: first for the high density areas, which has 3 wards with a mean household size of 4.67 individuals, 71500 liters as the mean total of consumed water daily, 60.35 as the mean per capita water consumption per day individually while standard still remains 120 liters, which is far short from what WHO Standard stipulates as the mean total of daily demand is 142,440 liters. For the medium density areas with an average population of 1093 which are made up of 2 wards depicts 61100 liters as the mean total of water consumed daily by each household, 55.86 liters was consumed by an individual with a daily mean demand of 131,160 liters; also, not matching the demanded figure. While the low-density areas which mainly is occupied by the Sabonpegi Yolde Patte ward residence has a population of about 876, total water consumption per household of 52,247liters, Per Capita Water Consumption (liters per day) is 59,64liters while its water daily demand is 105 120 liters; also, what is demanded was not sufficient.
- The study area exhibits a diverse distribution of water facilities, with powered boreholes being the predominant water source and high resident areas have the highest concentration of water facilities, ensuring adequate access to water resources for densely populated zones.
- Existing water sources are randomly distributed across the Yolde Patte, indicating the need for strategic planning to address potential gaps in accessibility plus the Indoor and outdoor water consumption patterns vary across wards, reflecting differences in lifestyle and water usage behavior.

- Water demand exceeds consumption in all the wards, indicating inefficiencies or deficits in water management and distribution with the domestic water accessibility varies across wards, with some areas classified as having basic access and others as intermediate access.

4.2 Recommendations

The Government should invest in the development and maintenance of water infrastructure, particularly in areas with inadequate access to water facilities. In addition, priority should be the equitable distribution of water facilities across different residential zones.

Promotion of water conservation practices among residents through education and awareness campaigns. Also encouraging the provision of more domestic water source by the Adamawa State Water Board, Private Sectors and Individual household as this will boost water supply.

The Adamawa State Urban Planning Development Authority should ensure that built-up area adopt town planning standard rules to ease laying of water supplying pipes and other public water supply facility extensions, especially in the newly developing built-up area. And to conclude, further research that should cover ground water analysis in the study area should be performed in future to augment this research.

5. Conclusion

Basically, this study reveals that, the mean per capita water consumption per day per individual and per household across all three various density levels of the entire study area are far from what the WHO standards stipulates; that is the water in demand daily does not match what is obtainable. It also depicts that sources of water supplies are indeed randomly distributed and not strategically planned making some significant number residents to cover long distance so as to gain access to water every day. Hence with the mean per capita water consumption per day per individual and per household required and the short fall, all estimated and water sources positions accurately determined; it could be applied by the government to plan and solve the issues of water accessibility within this study area most especially in areas that are worst hit; by constructing more industrial boreholes. However, such research can be replicated in other regions in addition with studying the old existing water tapes of the Government water Board and also the very common and close house to house construction of private borehole implications underground and the quality of the water.

Compliance with ethical standards

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Disclosure of conflict of interest

No conflict of interest to be disclosed.

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