A Pragmatic Study on Water Reticulation in Lautech Ogbomoso, Southwestern Nigeria

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ORIGINAL RESEARCH

Abstract— Water obviously play an importance role in our day to day life. Water distribution system is faced with myriads of challenges such as increasing water demand, limited resources, aging supply pipes that often result in water leakages. The supply of water could no longer fulfil the required demand of water supply with increase in the population of Ladoke Akintola University of Technology (LAUTECH). This study therefore examined water distribution in LAUTECH Ogbomoso campus. Primary and secondary data were used for this research. The primary data were sourced from registry, physical planning and work units of LAUTECH Ogbomoso, (8.13333º N, 4.26667º E), while the secondary data were from Global Positioning System (GPS) and google satellite imagery of LAUTECH campus. Field survey was conducted, from which the GPS point of each water source (Borehole) was obtained on the field. The study area has 14 boreholes and 3 wells, the distribution mains PVC pipes of diameter ranging from 50mm to 300mm. Spatial distribution of building with access to water and unmet water demand were determined. The secondary data were digitized using ArcGIS to produced variability map. The map showed that the water demand of each building per person was averagely estimated as 54.67 litres per day. The lowest water demand falls within 0-18 litre/day, while the highest falls within 391-2350 litre/day. The study revealed that the existing water distribution and infrastructure of LAUTECH is no longer sustainable.

Keywords— ArcGIS, Reticulation, LAUTECH.

1 Introduction

Water reticulation system in Ladoke Akintola University of Technology (LAUTECH) campus can be generally described as the process of achieving a sustainable water distribution network, as the water being pumped from the borehole to the overhead tank. Water is commonly distributed through a network of pipes. Water distribution network perform an excellent function in modern societies being its proper operation directly related to the population wellbeing (Muranho *et al.*, 2013). Quality of water use by man will continue to be an issue of concern since water itself is life to man. Globalization, and cross-border health issues, from the point of effects of contaminated water sources is being initiated (Oginni and Ojoawo, 2014).

Water distribution system can be either looped or branched. Looped system are generally preferable to branching system because pipe breaks can be isolated and repaired with minimal impact on users outside the immediate area of the looped system. While in a branched system, all users at the receiving end of the supply pipe will have their water supply cut off until repairs are completed. (Shambel et al., 2021).

The management of the distribution system requires a more holistic and integrated approach to both the day to day operations and its maintenance planning. With linked systems, a failure with a key component in one system can impact on other systems. The need for system planning of operators and for a solid understanding of the dynamics of the overall linked system by managers is high. This understanding can be achieved with the aid of computer analysis using hydraulic modelling (Cardno, 2006 cited in Bellgalmano, 2012).

According to the data from the feasibility study, the majority of LAUTECH population is partially supplied by borehole located behind the 250 capacity lecture theatre, the supply of water could not fulfil the required demand of water supply. This occurs due to rapidly growing population, expansion and development of infrastructure of the study area LAUTECH.

Water is one of the essential needs of humans and all living things. Worldwide, clean water suitable for domestic use accounts for no more than 2% of the planet's natural water resources. (WHO, 2009). Accordingly, the research interest focuses on water distribution network planning using EPANET to find the optimal combination of decision variables (e.g., rate and pressure drop) from multiple solutions. (Temesgen *et al.*, 2016)

The aim of this study is to examine a sustainable water distribution system for Ladoke Akintola University of Technology (LAUTECH). The objectives of the study are to appraise the existing water distribution network in Ladoke Akintola University of Technology (LAUTECH) campus and to design an appropriate water supply model and system for LAUTECH.

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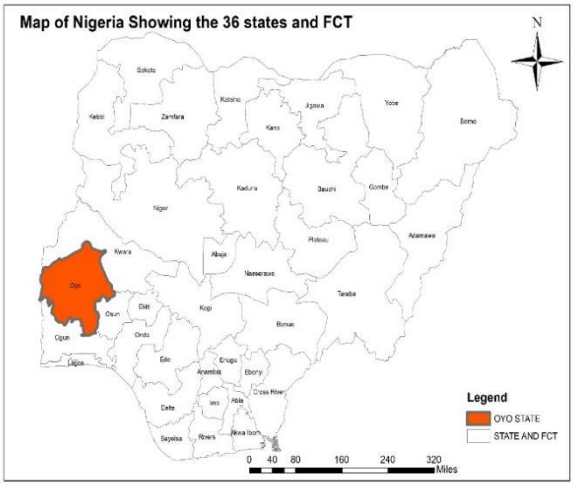
2 Methodology

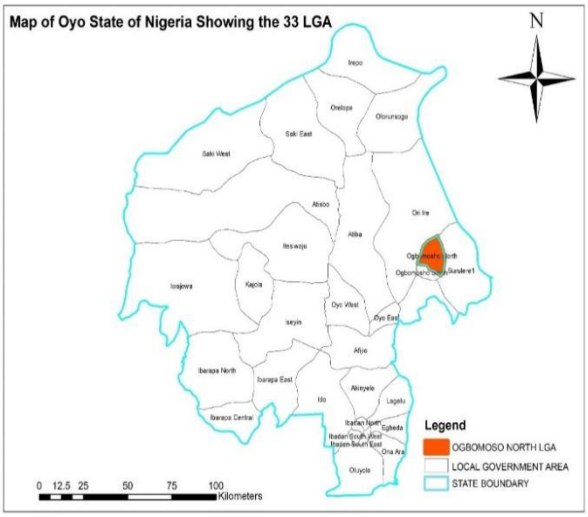
2.1 Study Area

Ladoke Akintola University of Technology formerly Oyo State University of Technology is a tertiary institution with main campus located at Ogbomoso town in Ogbomoso North Local Government, Oyo state. The study area is located in a serene environment in the city of Ogbomoso with a coordinate of $8^{0}8'0''$North, $4^{0}16'0''$East.

2.2 Materials and Data required:

The material and data required for this research is a combination of both primary and secondary data source that was generated. The data was sourced from the physical planning and work units of LAUTECH requesting the existing data on water supply sanitation of the campus. While the other data was source from the following: ArcGIS version 10.4, Global Positioning System (GPS), Shuttle Radar Topographical Mission (SRTM map), and Google Satellite Image.





Evaluate the current water distribution system in LAUTECH: By gathering data from the works and physical planning department. This data will be used to determine the per capita water demand and identify areas where there is a shortage of water supply to certain buildings, taking into account the existing infrastructure in the study area.

Procedure:

i. High resolution satellite image of the study area was obtained; the satellite image was extracted from Google Earth (with spatial resolution of approximately 15 cm)
ii. Import into the ArcGIS 10.4 geo-processing software.
iii. Existing roads and buildings were extracted onto their respective layers using the available tools.
iv. Field survey was conducted to derive the location of water sources (borehole), number of existing borehole and their yield was estimated.
v. The location of the water source and node of existing distribution network were imported into ArcGIS 10.4.
vi. The map displayed the spatial arrangement of buildings based on their water access, indicating the percentage of buildings with and without access to water. By utilizing attributes such as the number of offices, toilets, and laboratories in each building, the water consumption levels were estimated and depicted on the map according to their spatial distribution.

Based on the outcome, we successfully determined the value of the current water source and the network for distributing water within LAUTECH campus.

3. *Results* and Discussion

Appraisal of the existing water distribution network

A high-resolution satellite image of LAUTECH with a spatial resolution of approximately 30cm/pixel was obtained by extraction from google earth; the high-resolution satellite image was imported into the ArcGIS 10.4 geo-processing software as shown in figure 3.0. Every road, building and other features digitized.

A field survey was conducted, from which the GPS point of each water source was obtained on the field. The spatial distribution of buildings with access to water and unmet water demand is shown in Figure 5. Having identified the need to model the pipe-borne water network of the LAUTECH campus, the existing piping network of LAUTECH was analyzed using ArcGIS. The required water demand, associated drivers, water withdrawal and consumption, monthly variation, as well as loss and reuse, existing management policies, and pipeline capacity were acquired using a structured questionnaire during the reconnaissance survey.

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The study area has fourteen (14) borehole systems and three (3) wells powered by a pumping machine of different capacities. The water is distributed to different buildings and facilities on the campus through a network of distribution mains, starting from the distribution reservoir. These distribution mains consist of PVC pipes with diameters ranging from 50 mm to 300 mm, spanning a distance of approximately 50 kilometer, these pipes are laid underground. To ensure sufficient water supply, the distribution mains are linked to various strategically positioned service reservoirs throughout the campus.

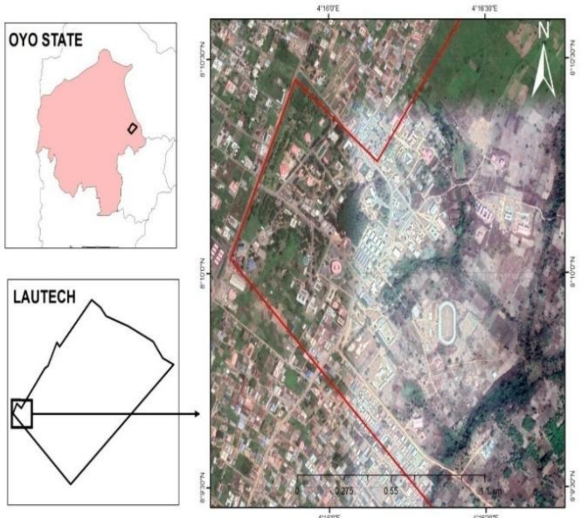

Figure 3: Satellite Imagery of the study area overlay with LAUTECH land Boundary

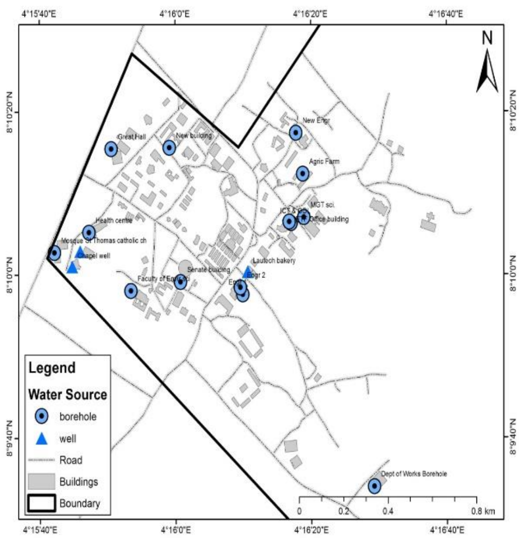

Figure 4: Identified Water Sources in the Study Area

3.1 Monthly Water Demands

Monthly average water demands are the water requirements by different sectors each month. Theoretically, the monthly water requirements differ considerably from month to month, depending on various factors such as the number of days in a month, the number of days the school is active in a month (days of public holidays, inter-semester break and session break) in a month, seasonal climatic conditions, etc. the demands vary not only due to the number of days in a month but also the availability of rain during that specific month.

3.2 Unmet Water Demand, Coverage and Demand Coverage

The monthly water demand, unmet water demand and demand coverage for some demand nodes at Ladoke Akintola University Ogbomoso, Oyo State, which includes department of Civil Engineering shown in figure 6, Sport Arena, and Bakery Zone etc. The choice is based on random selection, it was observed that the maximum average monthly unmet water demand occur in January, march, may, July, august, October and December at about 75, 164, 81.5m^3 respectively while the minimum average monthly unmet water demand occur in February at about 68, 149, 74, m^3 respectively. The amount of unmet water demand is greater than the estimated water supplied from supply nodes represented in table 1 which show the water supply nodes of the selected buildings in the study area.

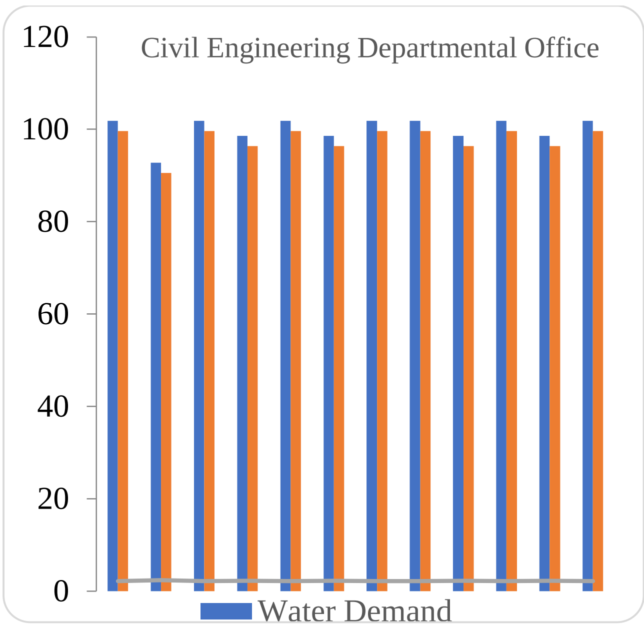

Figure 6: Average monthly water demand, unmet demand and demand site coverage for Civil Engineering Departmental Office

3.3 Water Demand Estimates

Water demand is the amount of water a community, industry, or agriculture requires to meet their needs. The water demand of LAUTECH in litre/day is represented in Figure 7 below. These individual water demands were grouped to produce a variability map. The map showed that the water demand of each building on the school campus. The map was divided into five (5) different

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categories from the highest to the lowest. The lowest water demand falls within 0-18 litre/day, while the highest falls within 1720-2980 litre/day. The calculation for the average daily water demand is 54.67 litres/capita/day. It was noticed that the water demands are directly proportional to the population of each building. Consequently, administrative buildings with numerous offices have higher daily water demands compared to lecture halls with limited or no office spaces. Likewise, the daily water demand is influenced by the number of toilets in each facility. The Senate building, which has the highest number of toilets (150) from the ground floor to the 5th floor, exhibits the largest water demand, estimated at 2350 litres/day in each floor of the building.

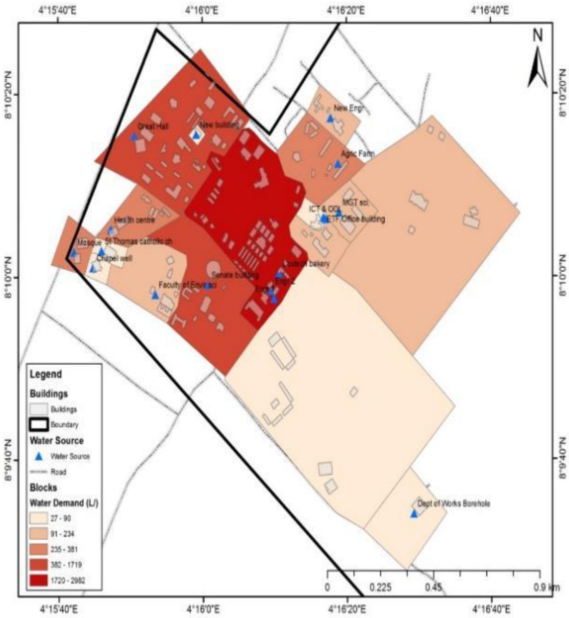

Figure 7: Building level water demand/Variability map.

4. Conclusions

The study sought to observed the water reticulation in LAUTECH and design a sustainable water distribution system for Ladoke Akintola University of Technology, while also assessing the current water distribution system at the university campus. Figure 5 showcases the water usage of every building within the campus, categorized into five distinct groups ranging from the highest to the lowest demand. The lowest water consumption falls within the range of 0-18 liters per day, while the highest falls within the range of 1720-2980 liters per day as shown in figure 7. A positive correlation between water demand and the population of each building was observed. Consequently, administrative buildings with numerous offices had higher daily water demands compared to lecture halls, which have fewer or no dedicated office spaces. This corroborates Atiquzzaman (2004) claim that water distribution network that is well planned is very essential in the development of urban area. The network must be built to satisfy various consumer demands while meeting minimum pressure requirements at certain nodes.

Since the unmet water demand in LAUTECH is still high, alternative water supply sources such as springs and boreholes should be further explored. Proposed water reservoirs in LAUTECH should be constructed to meet current and future domestic water demands.

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Table 1: Water demand and supply nodes at selected building in LAUTECH.

S_N	Demand Node	De_X	De_Y	Populat-ion	Supply BH	Su_X	Su_Y	Status
1	University Gate	4.26	8.17	5	Great Hall BH	4.26	8.17	Connected
2	Security Office	4.27	8.17	24	Maths Dept BH	4.27	8.17	Connected
3	ICT (Old)	4.27	8.17	10	SBH2	4.26	8.17	Connected
4	FPAS LT	4.27	8.17	300	mathsOld			Unconnected
5	The Hall + FPAS 1000LT	4.26	8.17	200	Great Hall BH			Connected
6	Great Hall + Amphi Theatre	4.26	8.17	150	Great Hall BH			Connected
7	Passa Secretariat	4.27	8.17	10	Earth Science BH			Unconnected
8	FMGS (Old)	4.27	8.17	19	Library BH	4.27	8.17	Connected2
9	Olusegun Oke Library	4.27	8.17	150	Library BH	4.27	8.17	Connected
10	Zenith Bank	4.27	8.17	30	BOVAS BH			Unconnected
11	FAG LT	4.27	8.17	150	BOVAS BH			Unconnected
12	FET 1200 LT	4.27	8.17	1200	Metal Wksp BH			Connected

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S_N	Demand Node	De_X	De_Y	Populat-ion	Supply BH	Su_X	Su_Y	Status
13	Bakery + OwodunniGbadamasi Building + Chemical Engineering Laboratory (Old)	4.27	8.17	50	Metal Wksp BH	4.27	8.17	Connected
14	Faculty of Computer Sciences	4.28	8.17	50	Central Lab BH	4.28	8.17	Connected
15	PG School	4.27	8.17	30	Great Hall BH			Connected
16	FPAS (New)	4.27	8.17	30	SBH2			Unconnected
17	Earth Sciences Dept	4.27	8.17	30	Earth Science BH	8.17	4.27	Connected
S_N	**Demand Node**	**De_X**	**De_Y**	**Populat-ion**	**Supply BH**	**Su_X**	**Su_Y**	**Status**
18	FET Departmental Offices	4.27	8.17	60	SBH2			Connected
19	High Rise Building + FSE + Chemical labs	4.27	8.17	200	SBH2			Connected
20	Food & Consumer Faculty	4.27	8.17	50	SBH2			Connected

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21	Central Engineering Workshop + Micron Electrical Laboratory + Metal Workshop	4.27	8.17	100	MetalWorkshop BH			Connected
22	ICT (New)	4.27	8.17	70	ICT BH	4.27	8.17	Connected
23	Health Centre	4.26	8.17	85	Health Centre BH	4.26	8.17	Connected
24	University Chapel	4.26	8.17	100	Chapel Well	4.26	8.17	Connected
25	University Mosque	4.26	8.17	100	Mosque Well	4.26	8.17	Connected
26	Statistics Department	4.26	8.17	25	Health Centre BH			Connected
27	General Studies Department	4.27	8.17	40	Health Centre BH			Connected
28	Fine Arts Department	4.27	8.17	20	WksOld	8.17	4.27	Connected
29	Architecture Department	4.27	8.17	40	Archy BH	8.17	4.26	Connected

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