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Spatial Distribution Coverage of Municipal Water Supply in the Jos-Metropolis, Plateau State, Nigeria

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Abstrast

Effective distribution of water supply in urban centres is a pivotal measure in attaining a more sustainable water supply amidst the expanding population of a metropolitan region. In order to improve the extent of water distribution, it is imperative to analyze the spatial distribution coverage of municipal water supply in the Jos metropolis of Plateau state this reseaerch propose tracing the water facilities, river catchment and buffering water distribution network in the region. it employed descriptive method of qualitative and quantitative data collection that was subjected to GIS procudeure of georeferencing,geodata base and creation of digized maps using ArcGIS10.4 for density analysis of the pipeline network system. The findings revealed that Plateau Water Service Corperation (PSWC) has six dams, four treatment plants and 8 reservoirs to supply water to 25115 households through pipeline netwerk of about 400km. The dams were sited in two rivers catchments of Laminga and shen, with dendritic features of first to four stream order the reflected diversity of the hydrological attribute of the basin. A concentrated centre of the metropolis have optimal and intermediate pipe transmission lines between 1-30 m and 31-100m safe buffer zone while large concentration far from the city centre lack pipe transmission lines.recommendation are made on maintenance, replacement of pipes and periodic extension of pipelines distribution for water supply in Jos-metropolis

Keywords:*Coverage, distribution, Jos-metropolis, municipal, pipelines, transmission lines, water supply*

Introduction

Urban areas are experiencing a growing water scarcity issue due to a disparity between the amount of water available and the amount required. The rapid acceleration of economic development and improvements in living standards due to globalisation has led to an increase in demand for urban water supply and related services. This is primarily driven by the interactive effects of demographic growth and migration to urban areas, which occur under the push and pull effect. The challenge of meeting the water demands of a burgeoning populace, particularly in developing

nations, is becoming increasingly pressing. Urban water supply systems frequently encounter challenges in meeting current demands and are not universally accessible ((UNWater Development Report, 2022). Certain consumers tend to consume disproportionate amounts of water, leading to inequitable distribution, with the poor being the most adversely affected. Developing urban areas face significant challenges, both financial and technical, in their efforts to expand and improve water supply infrastructure. One of the primary obstacles in this regard is the effective management and the distribution system. The scarcity of water has led to a predicament in several towns wherein the equitable allocation of the limited water supply among the populace has become a challenge. The water distribution system is a sophisticated hydraulic control parameter system that interconnects to transport water from its sources to the end-users. Additionally, it encompasses the physical condition of all water pipes within the network, as highlighted by Hunde and Itefa (2020) and Zhou (2018). Water distribution systems are of utmost importance in meeting the water needs of urban centres. These systems comprise a multitude of hydraulic components, including pipes, valves, reservoirs, pumps, pump stations, and various other valves (Pietrucha & Tchurzewska, 2018). The system in question is a dynamic infrastructure that has been specifically engineered to efficiently transport water from its source to the end-users' taps, while simultaneously ensuring that demand, pressure, and water flow are sustained at all times (Abebe, 2020; Kilinç et al., 2018; Wolde et al., 2020).

To evaluate the water distribution facilities are contingent upon the efficacy and proficiency of the water distribution infrastructure in delivering the requisite volume of water at an acceptable velocity and pressure, while navigating through diverse operational scenarios, both typical and atypical (Hamza et al. 2021; Milkecha and Itefa 2020). This is imperative in order to ensure the adequate provision of water to specific demand locations, while simultaneously avoiding significant alterations in the relevant parameters (Beyene 2020; Jilo 2020). As per the national standard, the distribution network's operational pressure should range from 15 to 60 m during normal conditions and 10 to 70 m during exceptional circumstances (Milkecha and Itefa (2020).
In order to understand the water distribution system is to map the distribution process in the urban settings ensuring area coverage of water facilities before ascertaining the water distribution coverage. This involves water facility Mapping which is the process of digitally identifying and mapping facilities infrastructure with the explicit goal to improve operational management and planning tasks such as dispatching, inventorying and maintenance according to National Research Council,(2006). One of the objectives of Water Facility Mapping is to display Water Distribution Facilities within a particular geographic area. Water distribution facilities carry drinking water from a centralized treatment plant or well and supplies to consumers' taps that consist of pipes, pumps, valves, storage tanks, reservoirs, meters, fittings and other hydraulic appurtenances (Walski et al., 2003).
Plateau state is not different with other developing state in Nigeria that is experience water related issue, especially water distribution coverage which the state saddled the water distribution process to Plateau Water Service Corporation (PWSC). The water distribution system existed even before the creation of Plataea as a state in Nigeria but was gazette in 2020 by the Plateau State Government as Plateau Water Service Corporation (PWSC) through Edit No. 4 and outlines functions of the Board. The Edict gives it the dual function of being a service provider and a

regulator with a primary duty to ensure that water is supplied to customers at reasonable charges and in potable quality and adequate quantity. To ensure PWSC achieves its primary objective neccessatted this research work. Thus, other studies were carried out on water in Plateau state (Jidauna, et al, 2013, 2014; Ryeshak, et al., 2015; Cotton, 2016 and Ziyok, 2018). However, this research work identifies water facilities and buffer the water distribution network of Jos-Metropolis.

Methodology of the Study

Jos lies between 9° 4515011 N and 9°591 l011 N latitudes and 8°5714011 E and 8°691 E longitudes. This study covers Jos South and Jos North, which are located around Bukuru and Jos of the Northern Senatorial Zone that borders Barkin-Ladi, Jos East, Riyom, and Bassa Local Government Areas of the state. it is 1,250 metres above sea level and 1002.19 square kilometers with Shere Hills having the highest peak at 1,777 metres. Jos Metropolis' high plains is between 1000-12000 m.a.m.s.l altitudes (Ali, 2018) with Older and Younger Granites are present as well as the Jenta and Delimi rivers that travel through the High Plains and into the Chad, Gongola, Benue, and Kaduna river basins while its lowland are between 100–300 m.a.m.s.l area's altitude. There are sedimentary inselbergs and remnant massifs from Barkin Angundi to Jos Museum, Gwong, Barakin Rafin Gora, Jos has a highland zone 1355 metres above sea level. Barkin Yan pita, Barakin Naraguta, Bauchi Road, Barkin Sabon, and Rafin are area of lowlands that lies at 1098 metres above mean sea level (see figure 2). The elevated Jos-Plateau is the source of most northern Nigerian rivers. Kaduna and Gongola rivers originate in Plateau. Due to precipitation patterns and other meteorological conditions, these rivers' flow rates vary greatly between rainy and dry seasons (Bingel, 1978; Musa and Fumen, 2013). The area has many rivers, streams, dams, hand-dug wells, ponds, and springs. The government dams Nupis, Shen, Gwash, Rafin-Sanyi, Agog, and Yelwa pond to give water to the metropolis. These rivers have dams such Toile Mache, Yakubu Gowon, Liberty (Laminga), Lamingo (Gwash), Kogin-giri, and Yelwa. Other sources include streams, ponds, mine pits, lakes, and small rivers (see figure 1). These sources can increase piped water system portability if dams are built (Daloeng, 2006).

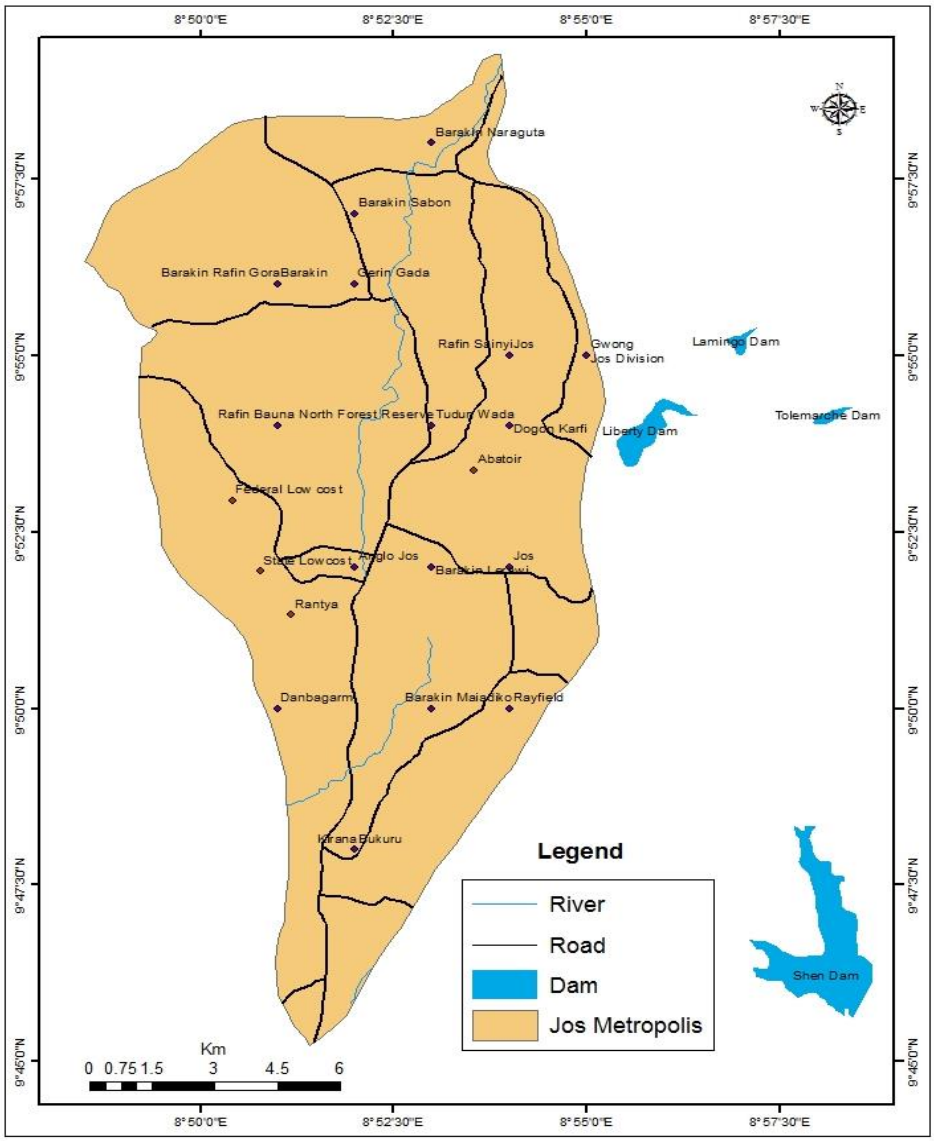


Figure 1: Jos- Metropolis (Study Area)

Jos-metropolis experiences AW climatic type and falls within the Koppens AW climatic sub-region. Generally, weather conditions are warmer during the rainy season (April – October and much colder during the hammattan period (December – February) (Ariyo , 2000). The mean annual temperature in the city ranges from 20°C to 26°C.These temperature ranges are as a result of the influences of rainfall, relief and cloud cover at different periods and seasons in the year. Relative humidity tends to be lower during the dry season between November to March and very high during the wet season with the peak values of between 81% and 84% in July and August (Omada, 2018). Precipitation on the Jos metropolis ranges from 70cm to 100cm at the peak period. The study area has wet and dry seasons. The wet season lasts about seven (7) months, between mid-

March and October, while the dry season takes about three (3) to four (4) months, from mid-November to mid-March (Omada, 2018).

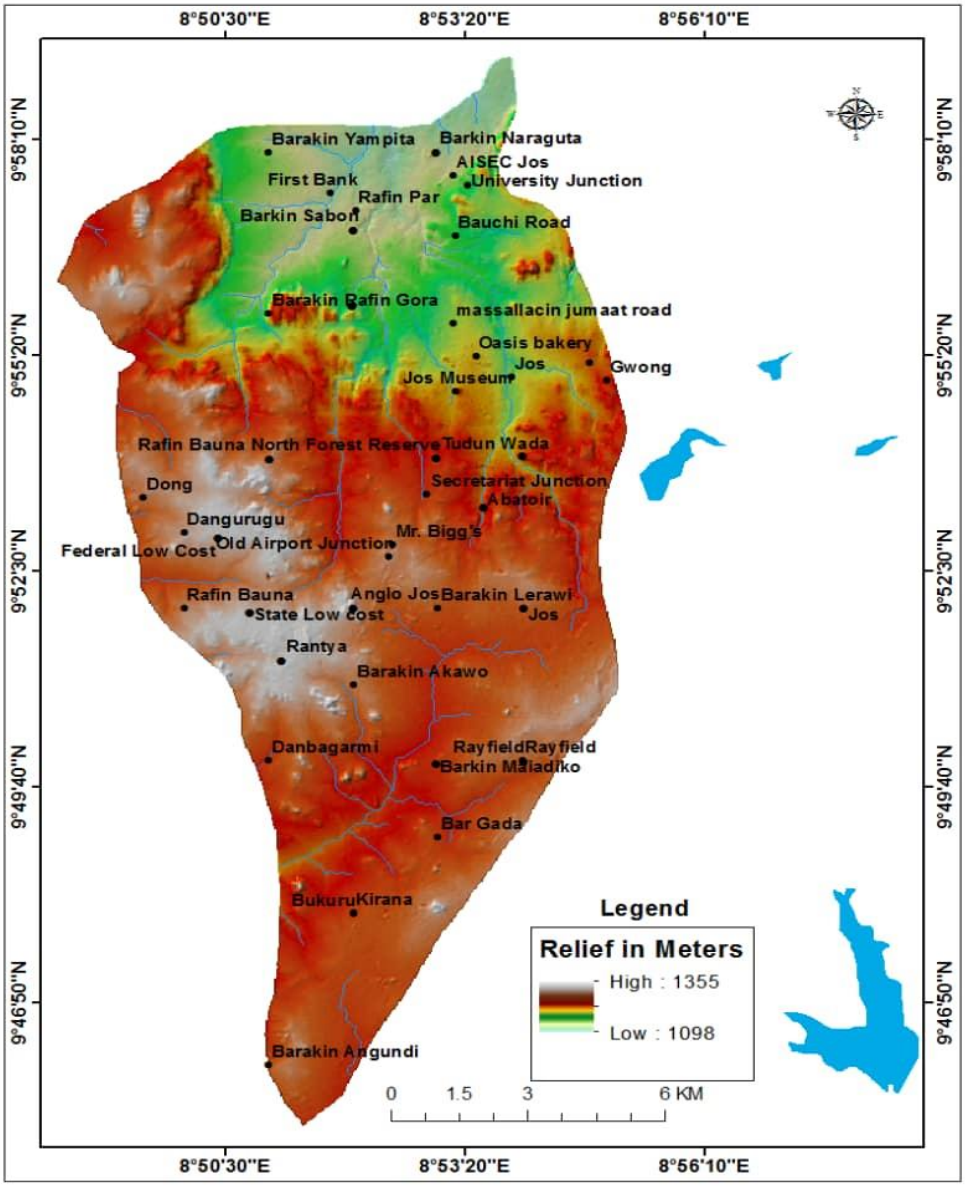


Figure2: Relief and Drainage of Jos-Metropolis

Jos-Metropolis has a heterogeneous population with Berom, Anaguta, Afizere, with few of Jere and Buji in Bassa and Jos North Local Government Areas. The other major ethnic groups of Plateau extraction residing in the city include Ron, Mushere, Ngas, Pan, Geomai, Mwagavhul, Tarok, Irigwe, Mupun, Amo, all numbering up to fifty(50) ethnic groups (tribes). The city is cosmopolitan in nature as it has nearly all Nigerian ethnic groups residing in it, some of which include Yoruba, Igbos, Hausa-Fulani, Kanuris, Tiv, Jukun, Ibibio, Idoma,Igala among other ones,

attracted partly from all over the world by mining activities and her status as the capital city. Population of people in Jos-Metropolis is 892, 914 according to National Population Commission (NPC) on projection (NPC, 2016). It has a density of about 391 persons per square kilometre and most densely populated and urbanized place in Plateau State. The social amenities provided by the government, individuals own businesses, private companies, educational institutions, health facilities, water infrastructure, electricity and road networks. Notable among is the government efforts to provide road construction activities which have opened up new areas and renew old ones, the construction of new water supply projects and maintenance of the existing ones, the linking of the new areas to the national electric grid and among other ones within the city. It is a city growing geometrically.

The research methodology employed in this study is descriptive in nature and involves the use of both qualitative and quantitative data collection techniques. The data is obtained from diverse sources such as pipelines, tanks, reservoirs, dams, and streams. Statistical analysis was utilised to evaluate the supply coverage of the entire town, and subsequently, a supply coverage map was generated using Arc GIS. The methodology utilised to attain the research study's objectives is illustrated in Figure 4, which presents a flow chart. The study's methodology began with an initial reconnaissance survey, which was then succeeded by the procurement of satellite imagery and GPS data. The aforementioned data were subsequently employed for cartography and the creation of a geographic database, which was subjected to analysis using Geographic Information Systems (GIS). The data pre-processing procedure encompasses a series of sequential actions, including but not limited to geo-referencing, study area delineation, geodata base and feature classes creation, and data digitization into map format. The aforementioned procedures hold significant importance in the execution of spatial analysis. The cartographic representations were precisely georeferenced through the utilisation of ArcGIS software, and subsequently underwent geocorrection in terms of their format. To enable the analysis of the research, a shape file was produced through the utilisation of ArCGIS software to delineate the study region and illustrate the necessary characteristics. The spatial coordinates of PSWC sources, pipelines, transmission lines, reservoirs, and water supply pipes were acquired via on-site data gathering. The technique of buffer analysis is commonly employed in spatial analysis, particularly in the domain of Geographical Information Systems (GIS). The matter of proximity is being tackled by means of depicting the correlation between a focal entity and other entities situated within a designated range. The Plateau State Water Corporation (PWSC) utilised buffer analysis to ascertain the distribution of pipelines within the Jos Metropolis. This was necessitated by the absence of adequate data on the scope of pipeline coverage and spatial extent of water distribution in metres. The aim was to establish the proximity relationship between pipelines and residential access to piped water. The buffer approach utilises proximity analysis techniques, which involve standard distance intervals of 1-30m, 31-100m, and 101-1000m for optimum, intermediate and no access to transmission lines, pipelines, and reservoirs.

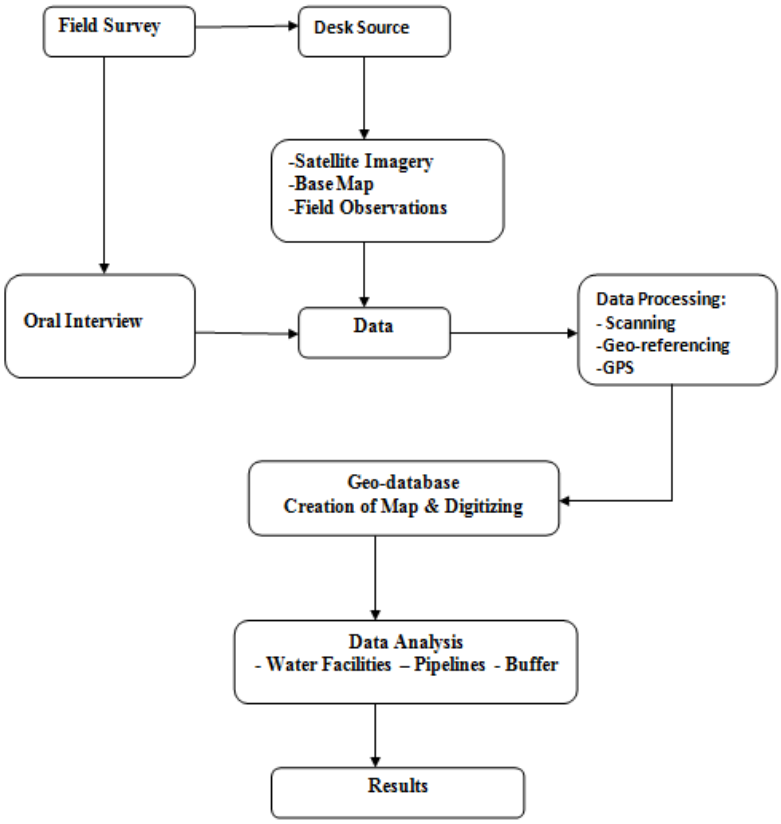


Figure 3: Method of Data Analysis Procedure

Results and Discussion

The result of the research revealed that the Plateau Water Service Corporation (PWSC) has six major dams that provide water for households, commercial activities and industries within Jos metropolis. These dams are Yakubu Gowon Dam, Tolle Mache Dam, Laminga (Liberty) Dam, Lamingo (Gwash) Dam, Yelwa pond and Kogin-giri Dam. Beside the dams are four (4) Treatment Plants; Yabuku Gowon, Laminga, Yelwa and Nabor Gwong with eight (8)water reservoirs, these includes; University of Jos, Nabor Gwomg Reservoir, Ministry of Water (MOW Reservoir), Tudun Wada Reservoir, Wild Life Park Reservoir, Yelwa Pond and Lion Hill (Doi) Reservoir). The water produced from these dams is transported through pipes of a length of 400km connections for onward distribution to about 25,115 households, establishment, private/industries and other consumers in the Jos metropolis of which only about 1.8% of these consumers have metres connection as seen in figure 5.

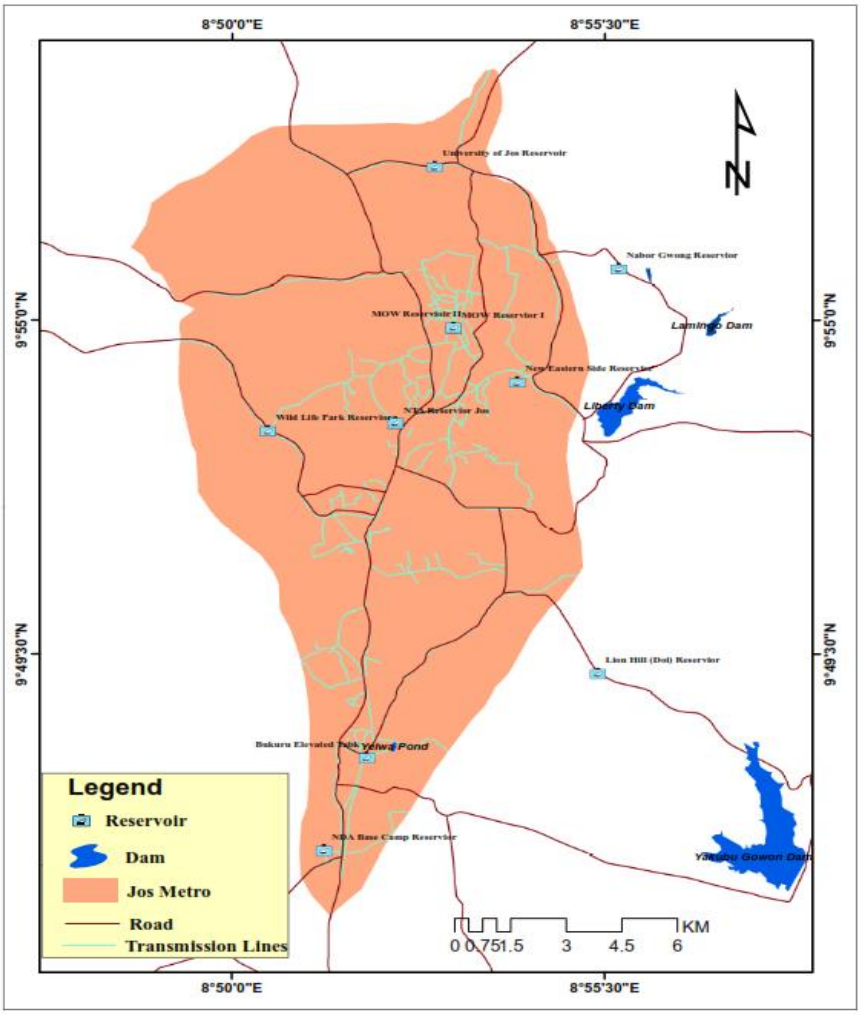
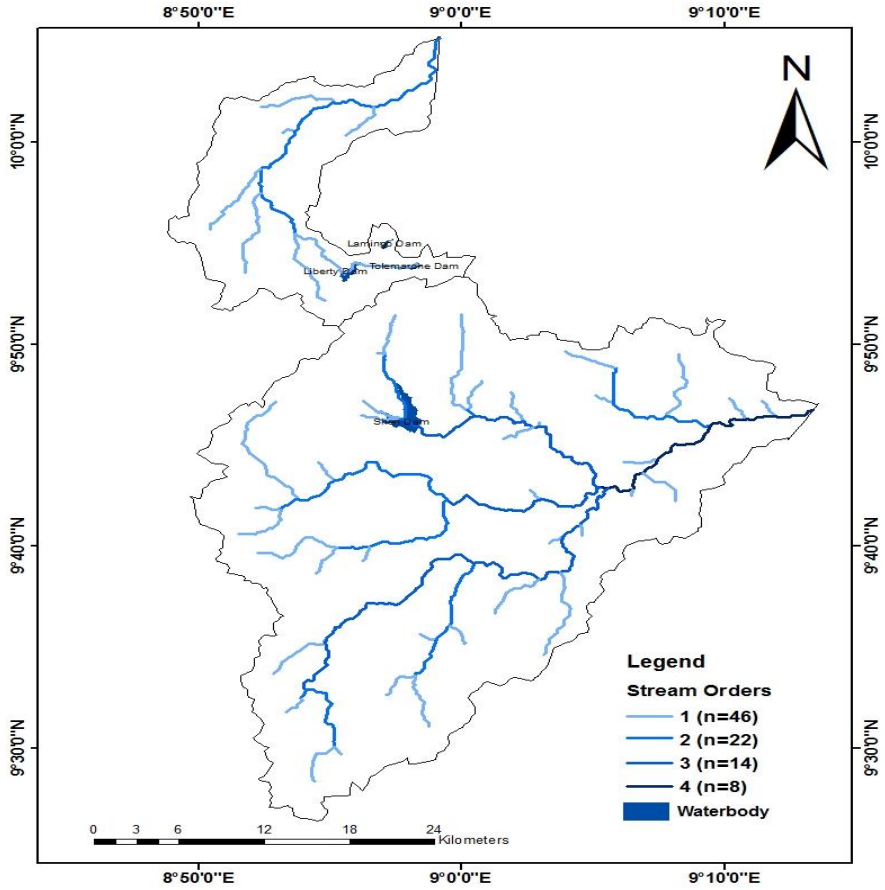


Figure 4: Dam, reserviors and transmision lines in Jos-metropolis

Dams, Drainages and Catchments

The research found out that the PWSC sources its water for distribution from six major dams namely Shen dam, Laminga Dam, Liberty Dam,Tollemache, Kogingiri and Yelwa pond all within Jos and environs. Attributes, catchment analysis, and drainage characteristics were studies to enhance the visual interpretation of the hydrological features. The study revealed that the six dams are covered by two catchment areas namely Laminga catchment and Shen Catchment with both having a dendrite characteristic (see figure.5). A total of 80 drainages were extracted ranging from 0.091km to 10.2km with total drainage length of 246km and 1604 Area sq. Stream length is one of the most significant hydrological features of the basin as it reveals surface runoff characteristics. The Laminga catchment has a fern shaped catchment while the Shen dam has a fan shaped catchment this means that the fan-shaped catchment (Shen catchment) has a higher runoff hence produces greater flood intensity since all the tributaries are nearly of the same length and hence

the time of concentration is nearly the same and is less, whereas in the fern-shaped catchments, the time of concentration is more and the discharge is distributed over a long period.

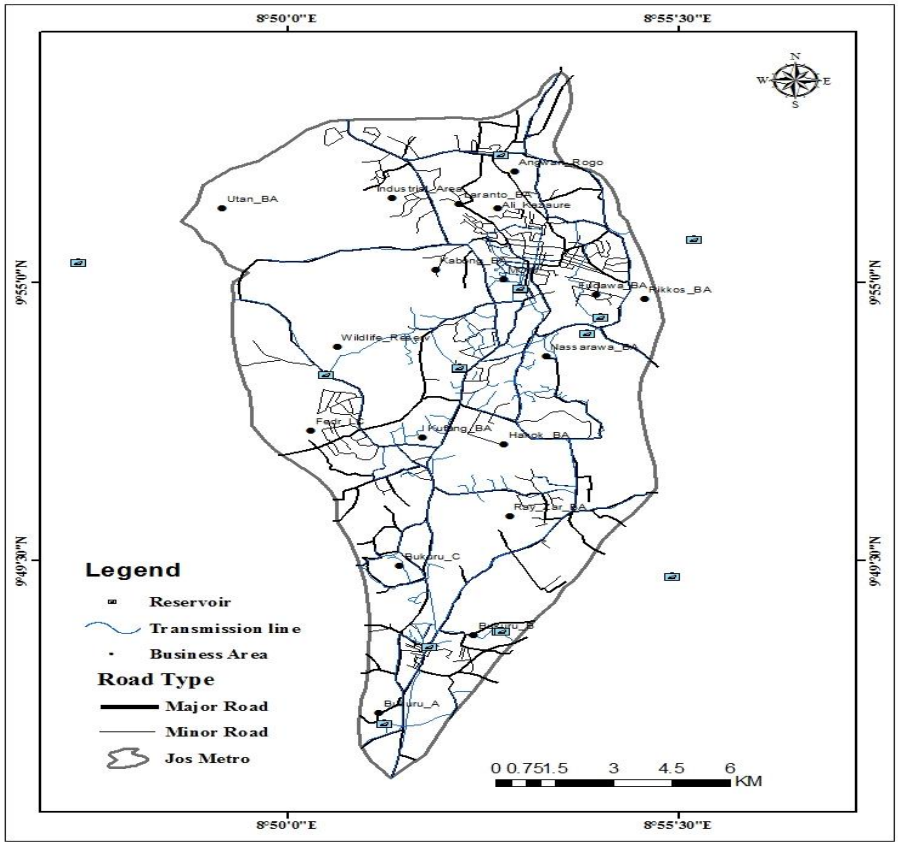


NCRS, 2023

Figure 5: Rivers Catchment Areas of Dams of Jos-Metropolis, Plateau State

The characteristics of these catchments; the size, the shape, the elevation, type of arrangement of stream channels, the vegetative cover, slope, geology, topography and orientation of these catchments are the various factors influencing surface run off within the catchments. The study also reveals that the stream order varies from first order to fourth order which indicates the extent of bifurcation of its tributaries and is a direct indication of the size and extent of the drainage network. There are four different system of ordering streams that are available. Strahler's system, (1952) which is a slightly modified of Hortons system, has been followed because of its simplicity, where the smallest, un-branched fingertip streams are designated as 1st order, the confluence of two 1st order channels give a channels segments of 2nd order, two 2nd order streams join to form a segment of 3rd order two channel of different order join then the higher order is maintained. This is catchment is a process to identify the availability of source of water for distribution. The Jos-Metropolis water distribution covergae is a critical part of assessing the efficiency of distribution of water supply in the region because it reveals the spatial area coverage of pipe borne water. The study of spatial coverage is connected with roads and transmission linenetwork, buffer of water

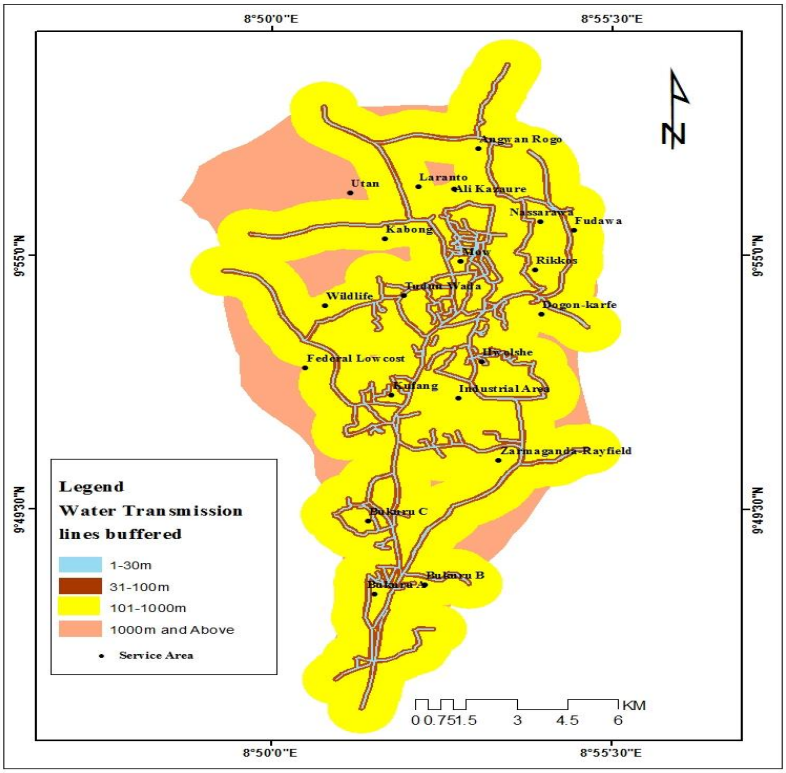
transmission line and transimision density as seen in figure 6,7 and 8 below. The PWSC transmission pipelines were considered also to obtained coverage distance of water distribution network of which density was applied through the use of GIS appropriate tools for water distribution source.



Source: NCRS, 2021

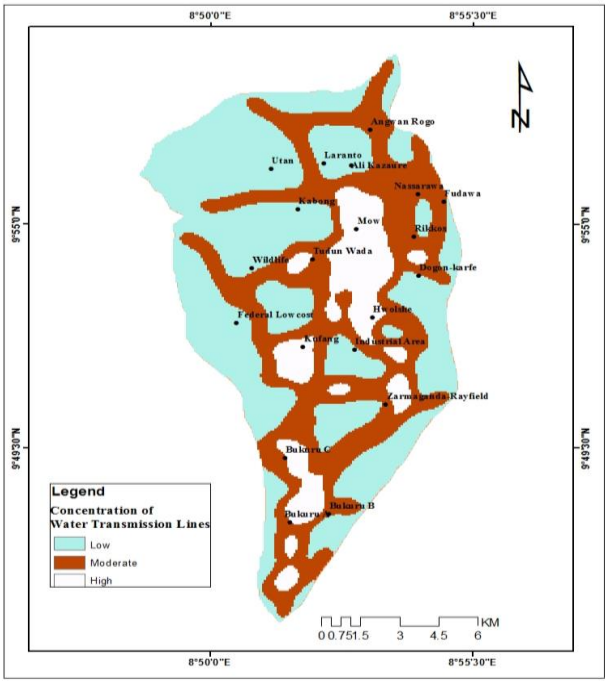
Figure 6: Jos Metropolis Raod and Pipeline Network

In general term, Tranmision line usuallyfollows main road network because road exerts certain influence on the constituents of the water distribution networks. The vast majority of water distribution system consists of pipes and couplings to link them to each other in different pattern, figure 6 revealed the transmision line and distribution line following the road network in the study region. Jos central, Tudun Wada axis, Fudawa, Nasarawa and Yelwa (Bukuru) have high concentration of transmission and distribution lines of pipes among the selected locations in the study while other locationslike Federal Lowcost, State Lowcost, Utan has less concentration with dead end pattern of water distribution coverage.These shows Jos central, Tudun Wada, Fudawa and Yelwa areas (wards) with highest concentration of distribution coverage in the study.



Source: NCRS,221

Figure 7:Buffer of Transmission and Distribution of Pipeline



Source: NCRS, 2022

Figure 8: Buffer of Transimision Pipeline coverage in diameters

Figure 7 shows buffering location between 1-30m, 31-100m in the study area are regarded to be areas with optimum access of water distribution pipe lines which includes Tudunwada, Nasarawa, Fudawa, Hwolshe, and Kufan, Bukuru A and Bukuru C. While area that falls within the range of 100m- 1000 is classified as having intermediate access to the water tranmission line and these are Fedreral Lowcost, Angwan Rogo, Dogon Karfe, Industrial Layout, Zaramangagda Rayfield, Bukuru B and Kabon. Whereas, areas that falls within 1000m above are classified as basic and no access, from the figure 8 Utan, some part of Laranto, some part of BukuruB, some part of Zaramaganda rayfield, some part of wildlife park and some part of Federal Lowcost. The study reveal from observations that places that falls within areas above 1000m always suffers water scarcity which according to the WHO, (2014) revolves around distance and time indices and the indicators show four (4) paramount levels of accessibility; no access for the worst scenario; basic access; Intermediate access and optimal access on the basis of time and distance, while Adeyemo et al (2016), indicated accessibility as the balance between the demand for and the supply of consumer services over a geographic space, from the multiple buffer ring proximity map. Figure 8 revealed that majority of the residents in Jos metropolis fall within the buffer zone (101-1000m) as such farther from transmision and distribution pipe lines of the PWSC.

Conclusion

The water distribution system is an advanced and efficient hydraulic control parameter system that effectively transports water from its sources to the end-users. It includes the opportunity to assess and improve the overall physical condition of all water pipes within the network. The system in question is a cutting-edge infrastructure that has been expertly designed to ensure the smooth and efficient delivery of water from its source to the end-users' taps. The Plateau Water Service

Corporation (PWSC) is saddle with the responsibility of supplying water to the Jos metropolis. PWSC has six key dams, four treatment plants, and eight reservoirs that provide water to 25,115 households through a 400 kilometre pipe network. This ensures that residences, businesses, and industries have access to clean water. Fortunately, there is still a lot of potential for more consumers to gain access to this resource. There are several dams located within the vicinity of Jos, including Shen Dam, Laminga Dam, Liberty Dam, Tollemache, Kogingiri, and Yelwa Pond. These dams are situated within two distinct catchment areas, namely the Laminga catchment and Shen catchment. This provides ample opportunities for water storage and management in the region. Both of these catchment areas have a unique dendritic characteristic. Knowing the length of a stream is a valuable hydrological attribute of a basin, as it offers valuable insights into the surface runoff behaviour. It's great to see that the stream order ranges from first to fourth order, which reflects the diversity and complexity of its tributaries. This serves as a direct indicator of the vast magnitude and scope of the drainage system. The spatial coverage is impressive, encompassing the road and transmission line infrastructure, a water transmission line buffer, and high transmission density. Water distribution infrastructure is well-established and consists of a variety of interconnected pipes and couplings that efficiently deliver water to where it's needed. The transmission and distribution lines are strategically placed on the road networks. Some areas have a concentrated network of transmission and distribution lines, while other locations are situated away from the bustling urban centres. This suggests that there is room for improvement in water distribution coverage in certain areas of the study. Areas with optimal access to water distribution pipelines have been identified and are buffered between 1-30m and 31-100m. This means that these areas have the most favourable access to water distribution. Even areas within the range of 100m-1000m are classified as having intermediate access to the water transmission line. large concentration of households are situated within a safe buffer zone of 101-1000m, which means they are at a safe distance from the transmission and distribution pipelines of the PWSC while new layout suffers water distribution coverage. We recommend that the PWSC implement town planning standard regulations in built-up areas to facilitate the installation of water supply pipelines and other public water supply infrastructure extensions, particularly in the recently developed built-up areas within the study region. Secondly, a course of action for the Plateau State Water Board is to undertake periodic pipeline extension services to ensure coverage of newly developed areas. Additionally, regular maintenance and replacement of damaged facilities should be carried out to improve the supply of water in the region.

References

Abebe, H. (2020). *Hydraulic performance of water supply distribution system in case of aiytyef subsystem, Dessie, Ethiopia* (Doctoral dissertation)

Adeyemo, I.A., Omosuyi, G.O., Olayanju, G.M. and Omoniyi, G.K. (2016) Hydrogeologic and Geoelectric Determination of Groundwater Flow Pattern in AlabaApatapiti Layouts, Akure, Nigeria. *The International Journal of Engineering and Science* (IJES), 3, 44-52.

Ali, A.Y (2018). *Cost Benefit Analysis of Water Supply Projects in Jos Metropolis, Nigeria*. A PhD Research Thesis submitted to Department of Geography and Planning, University of Jos, Nigeria

Ariyo, J. A. (2000).Plateau State in Mamman, A. B. et. Al (eds) Nigeria: *A people united, a future assured, survey of states.* Gabumo Publishing Company Ltd, Abuja, II.

Beyene TB (2020) hydraulic modeling of water supply and water losses in water supply distribution system of Adwa Town, Ethiopia

Bingel, A. D. (1978). Jos: Origins and growth of the town 1900 to 1972. University of Jos, *Department of Geography Publication* No 1, Nigeria 1978.

Cotton R. (2016). *Water Provision methods for Plateau State*. Module Code FC502.

Daloeng, H.M. (2006). *The sustainability of rural water supply projects in districts of Qua'an Pan L.G.A Plateau State*. An Unpublished M.Sc. Geography Thesis of University of Jos, Nigeria.

Hamza MA, Saqib M (2021) Evaluating hydraulic performance of water supply distribution network: A Case of Asella Town, Ethiopia

Hunde CM, Itefa H (2020) Hydraulic performance analysis and modeling of water supply distribution system of Addis Ababa Science and Technology University. Preprints, Ethiopia

Jidauna, G.G., Dabi, D. D., Saidu, B., Abaje,B. & Ndabula C. (2013). Assessment of well water quality in selected location in Jos, Plateau State, Nigeria. *International Journal of Marine, Atmospheric and Earth Sciences*,1(1):38-46. ISSN:2327-3356. www.ModernScientificpress.com/journal/Maes.asps.Accessed 15 December 2021.

Jidauna, G. G., Dabi, D. D., Saidu, B. J., Ndabula, C., & Abaje, I. B. (2014). Chemical water quality assessment in selected location in Jos, Plateau State, Nigeria. *Research Journal of Environmental and Earth Sciences*, *6*(5), 284-291

Jilo TF (2020) Analysis of hydrualic perfomance of Aleta Wondo Town water supply distribution system (Doctoral dissertation)

Musa, J.J. and Fumen, G.A. (2013) Assessment of Potable Water Supply Sources in Ilorin Metropolis, Kwara State. International Journal of Agricultural Research, Innovation and Technology, 3, 1-4. https://doi.org/10.3329/ijarit.v3i1.16042

Kilinç Y, Özdemir Ö, Orhan C, Firat M (2018) Evaluation of technical performance of pipes in water distribution systems by analytic hierarchy process. Sustain Cities Soc 42:13–21

Milkecha C, Itefa H (2020) Hydraulic performance analysis and modeling of water supply distribution system of Addis Ababa science and Technology University. Preprints, Ethiopia

National Population Commission [NPC], (2016). *Population projected data 2016. National population estimate*. https://nationalpopulation.gov.ng.Accessed 23 November 2021

Omada, R.M. (2018). Spatial Analysis of access to domestic water supply in Gyel district of Jos South Local government Area, Plateau, Nigeria. *Gombe Journal of Geography and Environmental Studies (GOJGES) . 1 (2)*

Pietrucha-Urbanik K, Tchórzewska-Cieslak B (2018) Approaches to failure risk analysis of the water distribution network with regard to the safety of consumers. Water 10(11):1679

Ryeshak, G.A, Amobi AK, Lekwot V.E., Yakubu.A.A. Kwesaba D.A & Sahabo A.A. (2015) Population increase and water supply in Nigeria cities: Case Study of Jos in Plateau state, Nigeria. *International Journal of multidisciplinary and Current Research.* ISSN:2321-3124. www. Ijmcr.com

Strahler ,A.N. (1952). Hypsometric analysis of erosional topography. *Bull Geol Soc Am* 63:111.

The United Nations World Water Development Report 2022: groundwater: making the invisible visible

(UNWater Development Report, 2022)

Walski, T. M., Chase, D. V., Savic, D. A., Grayman, W., Beckwith, & Koelle, E. (2003). *Advanced Water Distribution Modeling and Management.*

World Health Organization (WHO). (2014). *Guidelines for drinking water quality*. 3rd edition, WHO, Geneva, 1 Recommendations.

Wolde, AM., Jemal, K., Woldearegay, G.M., Tullu, K.D., (2020). Quality and safety of municipal drinking water in Addis Ababa City. Ethiop Environ Health Prev Med 25(1):1–6

Zhou, G., Huang, S., Wang, H., Zhang, R., Wang. Q., Sha, H., Liu, X., Liu, X., & Pan, Q. (2018). A buffer analysis bases on co-location algorithm. *The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, 43(3).*

Ziyok. I. M. (2018). *Evaluation of the performance of Plateau state water board in provision of potable water in Plateau State*. Unpublished PhD. Thesis at Department of Geography , University of Jos, Nigeria.