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ANALYSIS OF DISTRIBUTION PATTERN OF DOMESTIC WATER SUPPLY SOURCES IN GYEL DISTRICT OF JOS SOUTH LOCAL GOVERNMET AREA, PLATEAU STATE, NIGERIA

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ABSTRACT

Domestic water supply has generally not kept pace with the population growth in most regions of the world. The existing problem has necessitated this study to examine the pattern of geographic distribution of potable water sources to domestic water subscribers in the area. The research involves the use of Satellite data, coordinates of various sources of domestic water and their attributes, population data coupled with a structured questionnaire and photographs from field in achieving the objectives. Spatial analytical method such as; Density and Proximity analysis were used to examine the objectives with the aid of ArC GIS 10.3 tool in Mapping and Geo-processing, while SPSS and Microsoft software were used for computing the Statistical analysis. Thus, the result obtained shows that Hand dug well has the highest frequency of coordinates among the public water sources, supported with the 60% of the respondents who used it as their primary source of domestic water supply. The pattern of the distribution of water supply facilities were found clustered around the city centre and well planned cadastral area, this exert serious pressure on access to the sources especially on those within the unplanned and newly developed area as only 32% of the respondents have access to the public domestic water source. Most of the built-up areas, which constituted the households falls within the basic access and No-access level were the standards for domestic water usage, are not met due to inconsistency of supply and effects of the seasons on the various water sources. The study recommends among other things that: Plateau State Water Board (PSWB) should extend services to unserved locations in Gyel District, private sector and individuals should embark on provision of potable water supply by engaging in massive house connections, drilling of wells and boreholes, The Jos metropolitan development board (JMDB) should ensure built-up area adopt town planning standard to enable PSWB ensure periodic extension service of water supply facilities in the area.

Keywords: Distribution Pattern, Domestic Sources, Gyel District, Water Supply

1. Introduction

Adequate and safe water supply is one of the basic services that influence economic progress of human settlements and the health of the dwellers. Although household

water demands constitute the least water use in the world, which is about 6% (Cunningham and Cunningham, 2004), it is however, a use that has no clearly defined substitute. It is thus a critical demand that is not negotiable. This is because domestic water use, including drinking, cooking, washing and general sanitation which entails a number of health implications. In many parts of Africa, domestic water supply is mainly the function of different traditional water supply sources; which often poses challenges to Households as supply is affected by such factors like income, household size and distance. The impact of inadequacy, manifest strongly on households in terms of time and distance taken to obtain water (Omada, 2018).

Water distribution system carry drinking water from a centralized treatment plants or well supplies to consumers' taps and these systems consists of pipes, pumps, valves, storage tanks, reservoirs, metres, fittings and other infrastructure. Water source distribution pattern on other hand, deals with the spatial distribution of different water supply projects such as wells, pipe borne water distribution network system, streams and boreholes across different areas (Omada, 2018). George, George and Jacob (2010) assessed accessibility of water services in Kisumu municipality, Kenya. Based on cross sectional survey and purposive sampling of 367 households, they examined the level of accessibility and distribution pattern to privatized water services in Kisumu Municipality. The study shows that the proportion of households with access to piped water supply within a distance of 200m is 77.1%, only 65.6% of the basic water requirements of the residents are met and that only 25% of the households access the minimum recommended 50l/c/d. The low-income households and low levels of investment in water infrastructure are related to reduced access to water services. This is the reason for agglomeration of water supply projects in some locations to the detriment and disadvantages of others. Atser and Udoh (2014) assessed dimensions in rural water coverage and access in Akwa-Ibom State, Nigeria. Four spatial factors of total length of road infrastructure in the Local Government Area, total area in square kilometers, poverty index, and rural population were used to investigate their influence on the number of safe water points among the Local Government Areas. All the four independent variables were surrogate to rural development.

However, the result showed that only the rural population factor was highly significant and correlated with the number of safe water points in the state ($r = 0.678$; $r^2 = 46\%$), implying that about 46% of variance in number of safe water points were explained by rural population. Odafivwotu and Abel (2014) investigated access to potable water supply in Yenagoa Metropolis, Nigeria. In achieving the aim, 15 borehole water samples were collected from 15 neighborhoods, which the metropolis was structured. The quality and quantity of water supply in Yenagoa were inadequate. The turbidity values (20.70-41.20 NTU) in all the sampled water were above the WHO 5 NTU threshold; while 7 (46.67%) samples had pH values below the WHO minimum value of 6.5, indicating acidity. Similarly, iron and lead also had 4 (26.67%) and 3 (20%) samples above the WHO thresholds of 0.3mg/l and 0.01mg/l respectively. It was also found that in spite of the proliferations of wells and boreholes, and the short distances to sources of major water supply, 29.28% of sampled respondents used below 20 litres of water per capita per day. This is mainly attributed to the high cost of water supply (average of N4, 500 per month) in relation to the monthly minimum national wage of N18, 000. This study is aimed to determine the distribution pattern of water supply sources

in Gyel District of Jos South Local Government Area of Plateau State, Nigeria.

2. Materials and Methods

The study area (Gyel District) is located between Latitude 9° 46'0" N and 9° 52'0"N of the Equator and Longitude 8°48'0"E and 8°52'0"E and is relatively bounded to the North by Tudun wada and Hwolshe in Jos North LGA, while in the South by Vom district, to the West by Bassa LGA and in the East by Dadin kowa,Whytt and Rahwol kanang respectively**,** in Jos South Local Government Area of Plateau State which covers the total land area of 81.9km/sq approximately. Omada (2018) asserted that the influence of the oscillation of the Inter Tropical Discontinuity (ITD) is completely modified by the high altitude of the Plateau. The area has more cold weather than most parts of Nigeria on the same Latitude**,** it is characterised with an average monthly temperatures range between 21–25 °C, and these cooler temperatures have made it a semi-temperate like area. It receives about 1,400 millimetres rainfall annually between April and October with the precipitation arising from both conventional and orographic sources, owing to the location of the area (Omada, 2018).

Gyel district is an area of Younger Granite intruded into the older basement complex rocks, which covers the entire locality and other neighbouring places. These younger granites are thought to be about 160 million years old. This creates unusual scenery of Jos. There are numerous hilly rocks with gentle slopes, characterized by a long period of weathering and erosion (Beka, 2020). According to Hassan (2010), two soil types can readily be identified at the superficial level. These are the sandy loam and grey loam soils. Most Soils are stony, fertile and hard to work on for the agriculturalist. This seems to result from the washing away of the top soil by denudation processes. The major soil is characterized by tropical ferruginous soils, which comprises of hills and rock outcrops containing younger granite rocks extensively intruded into the older basement complex rocks characterized by a long period of weathering and erosion.Ali (2018) asserted that the average elevation of the Jos Plateau is about 1150 meters above mean sea level and the highest peak on the Shere hills which is about 1777 meters above sea level.

However, the area is dominated by relief average altitude of 1,217m, with depressions, which pave way for drainages adjoining the plain area. Also according to Adams (2000), the drainage pattern of the area is in a radial pattern where the many rivers and streams diverge from the top of the plateau and flow away to different directions, some of the streams drain into river Ganawuri and Kaduna. The population of the area is 145,750 projected to 2019 from 2006 population census. The study area comprises 24 communities mostly dominated by the Berom, Hausa, Yoruba, Ibo and other minor tribes from within and outside Plateau State who are predominantly Christians with few Muslims and traditionalists. The area is known for vegetable farming, animal grazing; rock quarrying, tin mining activities and marketing, (Barbour, 1982 and Ali, 2018).

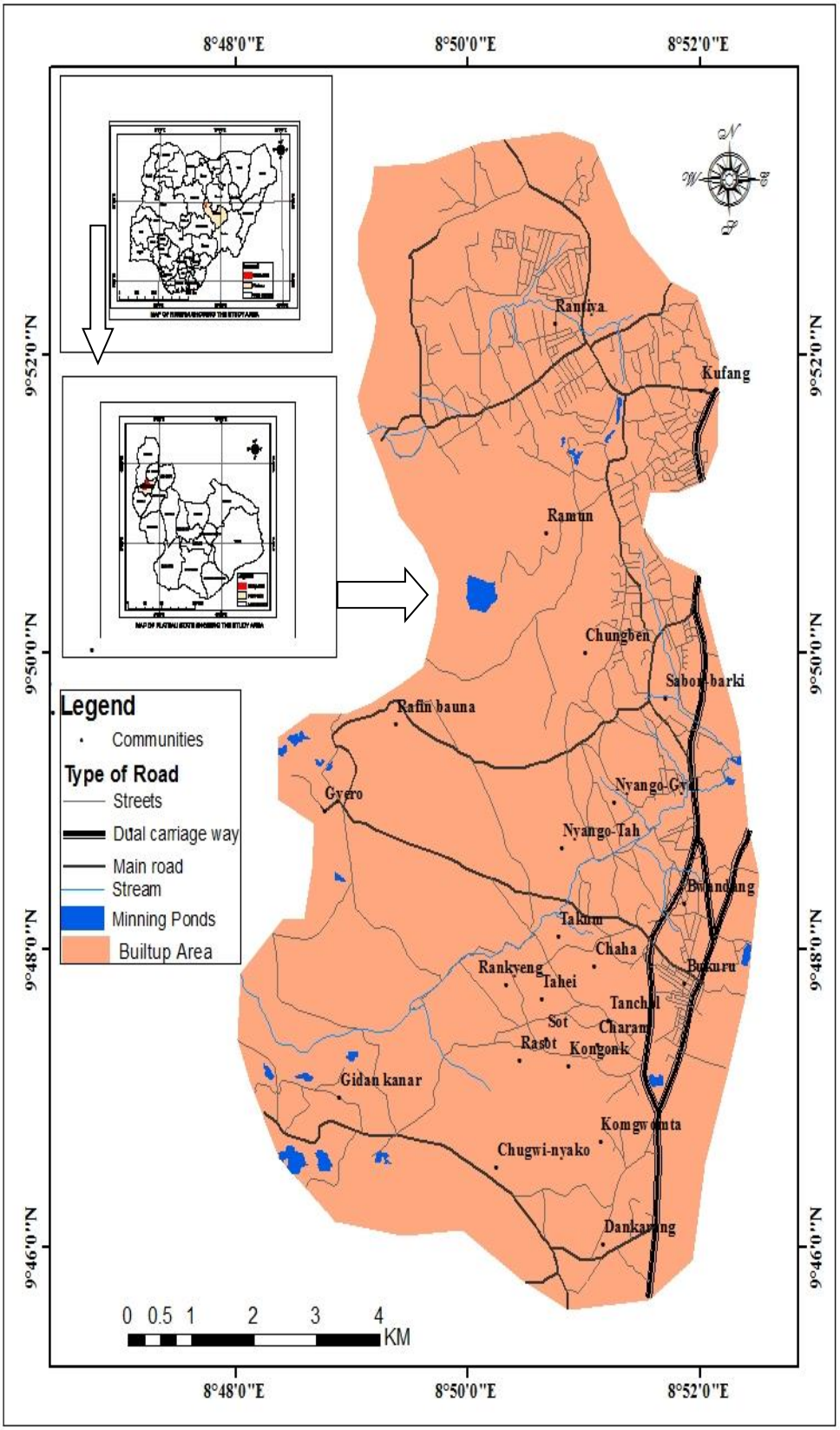


Figure 1: The Study Area
Source: National Centre for Remote Sensing, Jos, 2019

The Figure 2 show flow chart for methodology used in achieving the objectives of this research work.

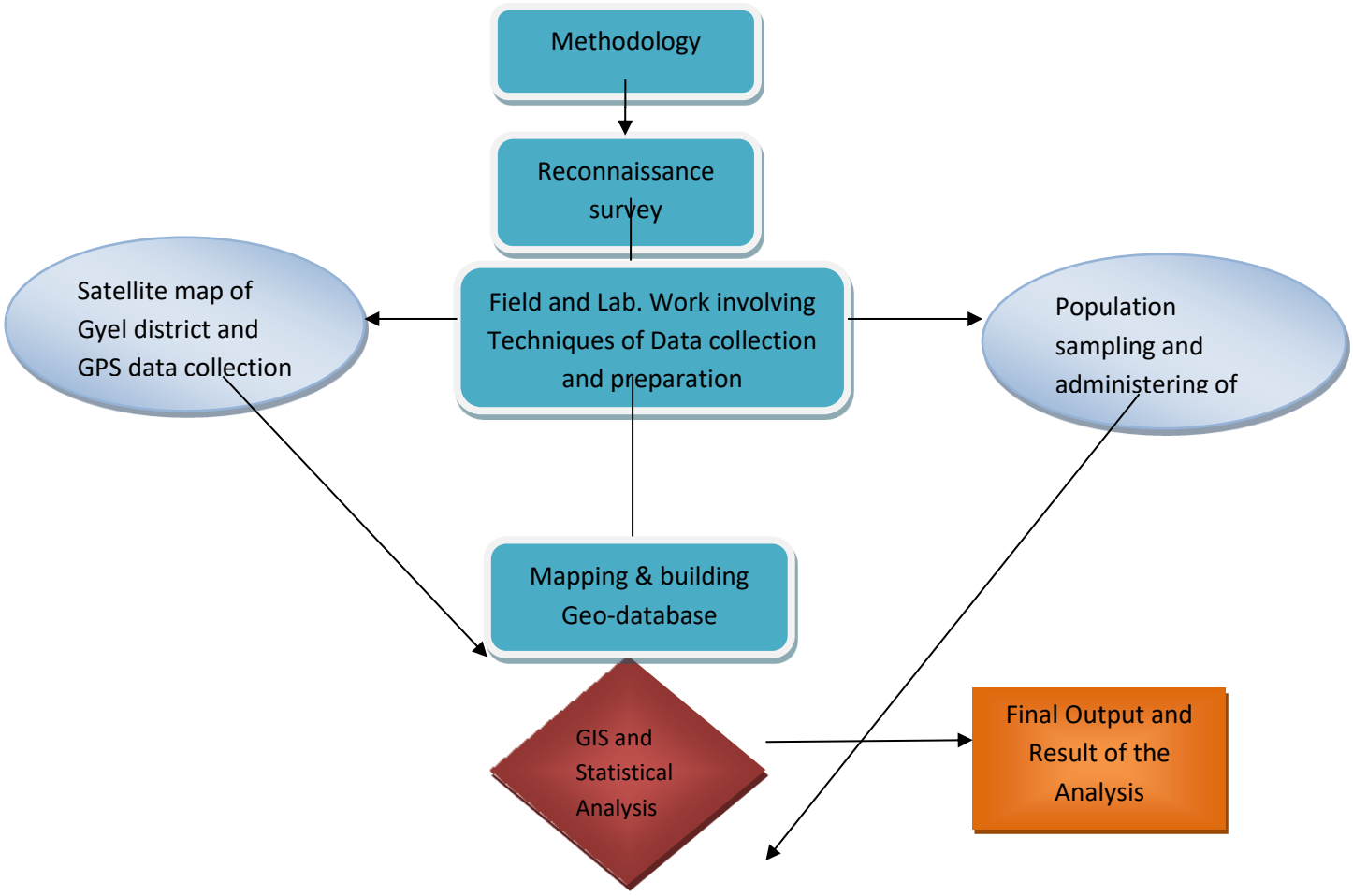


Figure 2: Flow Chart for the Methodology
Source: Compiled by the Authors, 2019

The procedure for undertaking the research started from reconnaissance survey, then, the use of satellite images, GPS data and population sampled through the use of structured questionnaire, followed by mapping and building of geo-database used for GIS analysis coupled with the statistical analysis to yield the result.

2.1 Data Used and Sources

Data used in the research work and their sources include;

Table 1: Data Used

Data Used	Data Sources
Coordinates of Public Reservoirs, hand dug wells, water supply pipe network, bore holes and water hydrants	Field work and Plateau State Water Board, Jos
Quick bird satellite image (0.6 m resolution) of 2015	National Centre for Remote Sensing, Jos
Population data.	National population commission, Jos
Photographs of the current situation of water supply sources	Field work
Statistical data	Fieldwork
Journals and other published documents on water supply	Library and Internet

Source: Field Survey, 2019

Data pre-processing include geo-referencing, delineating the study area using the data collected to create of geo-database and feature classes, which were digitized into map format used for the spatial analysis. All the maps acquired were properly geo-referenced in ArcGIS software and Geo-corrected to a common Projection System (UTM, Clarke 1880), and to a common Geo-TIFF data format. The maps were also geo-coded to a common resolution with the quick bird satellite image at a resolution of 0.6m to ensure both compatibility and data standard. A shape file was created in ArcGIS to delineate the boundary of the study area and to show the extent of features necessary for the research analysis. Stratified random sampling technique was adopted for the questionnaire administration to the respondents. A total of three hundred and eighty-four (384) questionnaires were distributed, in which the entire 24 communities within the study area covering both the urban and rural areas were randomly and proportionally represented with the total population of 145,750, using the formula by Krejcie and Morgan (1970);

$n^1/n \times N = N^1/N \times Q$ - - - - (1)

Where n^1: Sampled population for individual community

n :Sum total for the population of the whole sampled communities

N^1: Sampled proportion for individual community

N: Proportion of the sample size, which is 100% Q: Total Questionnaire Administered 384

Table 2: Sampled Communities in Gyel District and Number of Questionnaire Allocated

S/N	Sampled Communities	Population Size	Population Proportion (%)	Numbers of Questionnaires Allocated
1	Bukuru	95535	65.5	252
2	Rantya	6103	4.2	16
3	Rankyang	5166	3.5	14
4	SabonBarki	3548	2.4	9
5	Gyero	3283	2.3	9
6	Gidankanar	3037	2.1	8
7	Kufang	3216	2.2	9
8	Tanchol	3436	2.4	9
9	Sot	2447	1.7	7
10	Rasot	2080	1.4	5
11	Nyango-Gyel	2755	1.9	7
12	Ramun	2381	1.6	6
13	Dan karang	2276	1.6	6
14	RafinBauna	1316	0.9	4
15	Chugwi-Nyako	1476	1.0	4
16	Bwandang	1158	0.8	3
17	Chaha	802	0.6	2
18	Kongonk	992	0.7	3
19	Takum	939	0.6	2
20	Chunben	883	0.6	2
21	Kogwomta	875	0.6	2
22	Chararam	802	0.6	2
23	Tahei	434	0.3	1
24	Nyango-tah	620	0.4	2
Total	**24**	**145,750**	**100**	**384**

Source: NPC Office Jos, 2006 and Authors' Calculations, 2019

Data for this study were obtained from mainly primary and secondary sources. This involves the use of 384 questionnaire distributed to household heads and after four weeks, 263 retrieved. Oral interview was also conducted along with personal observations of the authors to gain more insight on domestic water supply in Gyel area, also the use of GPS receiver for establishing the coordinates of various water facilities and digital camera for photographs were ran concurrently. The coordinates of the various public water supply sources were collected from the field, which include; pipe-borne taps, hand dug wells, boreholes, reservoirs and water supply pipes which were inputted into an excel sheet and later imported to ArCGIS

10.3 environment for the creation of geo-database. ArcGIS 10.3 version was used to create a file geo-database for this research work. This consist of built-up areas, road network, water supply pipe network, public water reservoirs, taps, boreholes, hand dug wells, water hydrants, streams and ponds feature classes within Gyel district area and their necessary attributes such as location, diameter, condition, function and distance covered which were conceptually organized. Integrated approach was used to for the study, which includes both the GIS, and statistical analysis, thus; the GIS analytical techniques involved the use of ArcGIS 10.3 in carrying out the research and achieve its objectives. These techniques include; a handheld GPS receiver (Garmin CX 76) which was used to collect coordinate points of the domestic water supply sources such as pipe-borne taps, boreholes, hand dug wells, water hydrants, reservoirs and water supply pipes. Their attributes were transformed into ArcGIS environment using Microsoft excel which was used to create a file geo-database containing the feature classes which were digitized and compiled into a digital map provided by both government and individual households that the coordinate points were taken on the field to create geo-database for the spatial analysis.

3. Results and Discussion

3.1 Sources of Domestic Water Supply

Table 3 shows the various sources of domestic water supply in Gyel district area, which are the public water supply sources which form the basis for the analysis. Density analysis, which include; kernel density for the pattern of distribution of public hand dug wells, boreholes and line density for the distribution of water supply pipes were used respectively to describe the pattern of domestic water source distribution and concentration depicting the area of high, moderate and low concentration within the study area. Proximity analysis using multiple ring buffering of distance in metres to standard was adopted, this depicts four level of accessibility, which includes; optimum, intermediate, basic and no-access levels were used with the following distance interval, which were; 1-30m, 30-100m, 100-1000m and 1000m above to analyse the level of accessibility to domestic water sources within the area. The statistical analysis includes the use of results from a structured questionnaire administered on the field with the use of statistical packages for social science (SPSS) in computing simple percentage and statistical diagram for the following variables, which are the source, pattern and level of accessibility to domestic water supply source in Gyel area.

Table 3 Sources of domestic water

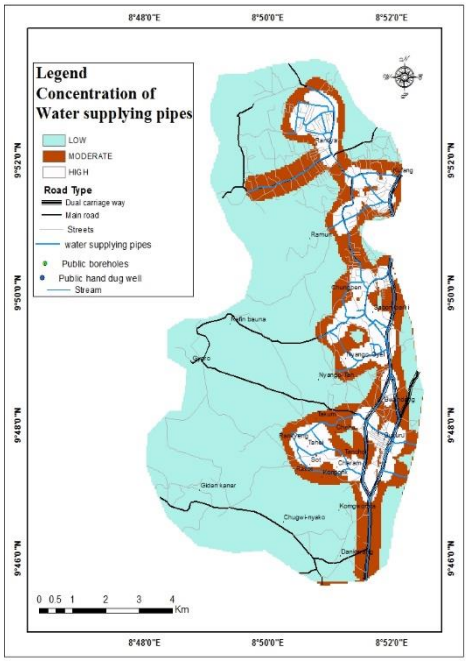
Sources of domestic water	Number of respondents	Percentage
Pipe borne	73	28
Hand dug Well	157	60
Borehole	11	4
Stream and ponds	22	8
Total	**263**	**100**

Source: Field survey (2016)

The sources of domestic water supply available to the residents in this area includes hand-dug wells, boreholes, and water supply pipes, streams and ponds complementing one another**.** From Table 3, hand dug well was the dominant domestic water source patronized by 60% of the respondents as their major source of water followed by pipe borne water which was just 28%, borehole 11% and stream 8%.

This indicates that hand dug wells are the primary source of domestic water supply in this area as almost every household has a well sunk within their vicinity.

3.2 Public Water Source Patterns Based on Density Analysis



Source: National Centre for Remote Sensing, Jos, 2019

Figure 3: Density map of public water supply pipes concentration

The density analysis for pipe-borne water supply source as seen in figure 3 shows that most of the pipe-borne water supply network are found clustered around the major roads in the centre of the town where the cadastre is well planned. The proof that areas are not planned and the newly extended area, which are at the outskirt of the town, has the problem of access to improved domestic water supply sources with very low density of water supply sources with areas with moderate population density and fewer road networks having moderate water supply sources density.

The density analysis used for public water facility indicates that most of the facilities are found along the major road and well planned cadastral layout area, which are the public service offices, commercial centres and low-cost areas. Oyebande (2005) which found that settlements that are provided with modern water supply networks are usually those situated along the major transportation networks and that pipe borne water from public water supplies are the most improved water supply sources in Nigeria asserted this. The public water sources used in the analysis include pipe-borne network, boreholes, hand dug wells and streams as depicted in figures 3,4,5,6 and Table 3.

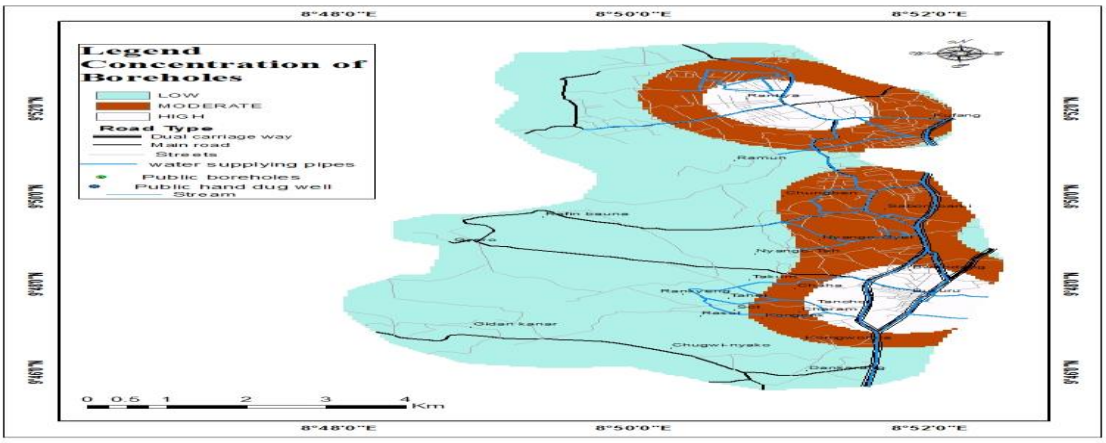
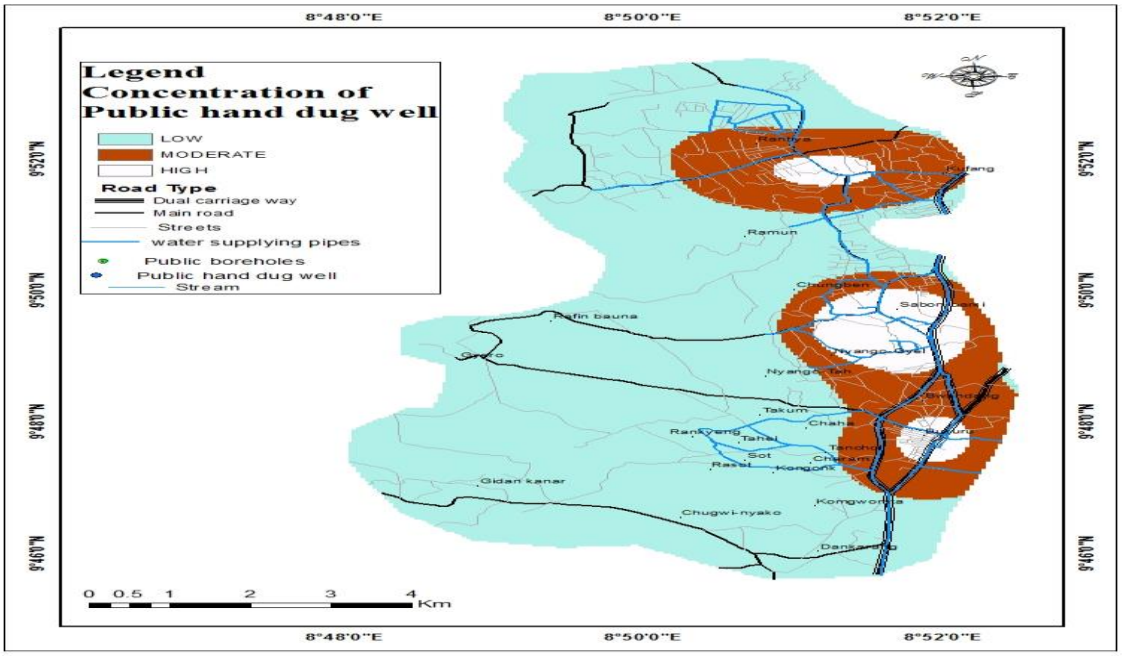


Figure 4: Density map of concentration of public borehole
Source: National Centre for Remote Sensing, Jos, 2019

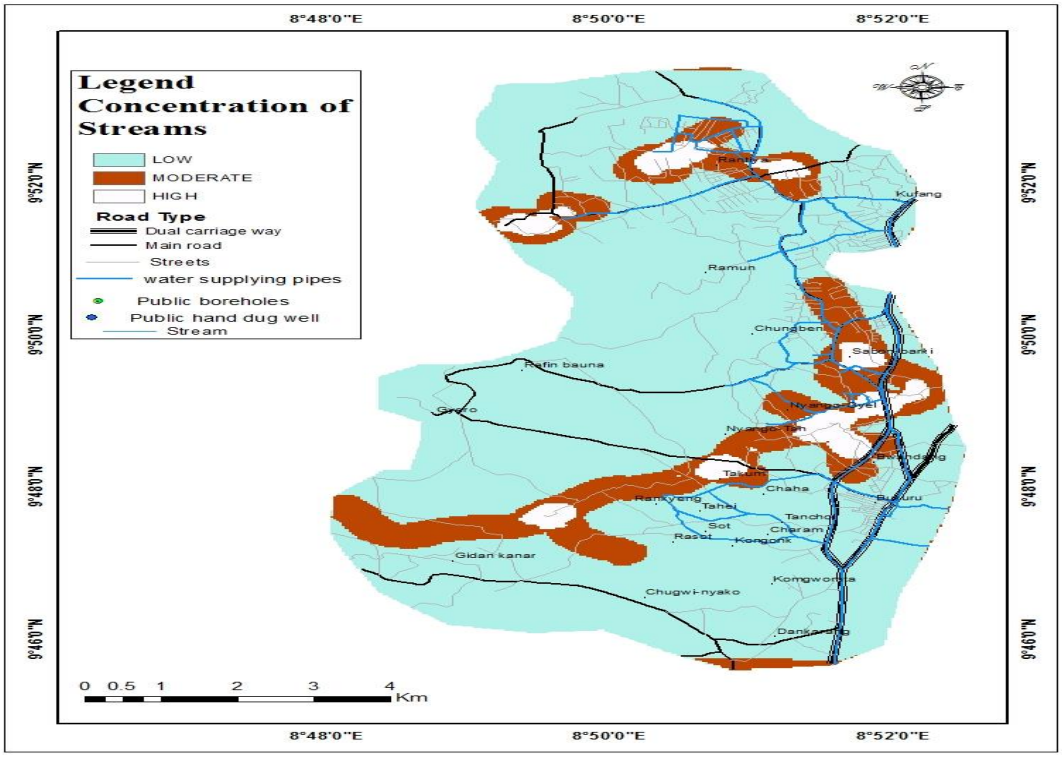
In addition, it was found that boreholes as sources of improved water supply in Gyel are seen to be clustered along the major roads and city centre with higher population concentration, which influenced the high concentration of many water sources and make easy access to water sources achievable. In figure 5, the core of the settlements has high concentration and agglomeration of water supply projects in Gyel district while the layer bounding the core has moderate water supply sources density and the peripheral areas have very low concentration of these water supply projects.



Source: National Centre for Remote Sensing, Jos, 2019
Figure 5: Density map of concentration of public hand dug well

Figure 5 shows the distribution of public hand dug wells with high concentration along the well planned area in the city centre and low concentration in the outskirt

which includes the newly extended area**.** The drainage pattern in the area is natural and mostly a reason for the evolution of most settlements in history as most people are attracted the natural drainage system. Water is central to life and all human activities as the origin and evolution of life became possible on earth because of its existence. It is one of the most indispensable resources and a basis for most civilizations in the world as considerations for settlements in space were done first around water as the primary reason (Ali, 2018). Other sources of manmade water sources were later created to cater for the growing population and the sustenance of human economic activities through the digging of wells, sinking of boreholes and piping of households. The sparsely populated parts of the study area have very low-density water supply sources due to very low demand. The Plateau State Water Board mostly extend their distribution networks to areas of high population density and avoid to a very great extent areas of low population densities to avoid phenomenal losses from low patronages.



Source: National Centre for Remote Sensing, Jos, 2019
Figure 6: Density map of concentration of streams

Figure 6 shows the distribution of the streams as very important source of raw domestic water supply in this area, because they are unevenly distributed and are seasonal. An interaction with most water users revealed that people use other sources to complement this source due to its seasonality and the inability of residents to use it for drinking purposes**.** They use this very important source mostly for washing, cooking, small-scale irrigation and construction purposes and most households boil water from this source and allow it to cool down before drinking.

4. Conclusion

The application of Spatial analytical tools such as density and proximity analysis, ArCGIS with the aid of Satellite, Global Positioning and Population data have proven important in Spatial analysis of distribution pattern of domestic water supply sources in Gyel area. This gives the Planners and decision makers from Plateau State Water Board, Private sectors and individual households the ideas on how to solve the complex problems of domestic water supply in the area.

5. Recommendations

Based on the forgoing, the study proffers the following recommendations:

i. The use of public private partnerships in the provision of more domestic water sources by the Plateau State Water Board, private sector corporates and individual households is encouraged as this will boost water supply.
ii. Also, creating awareness on the importance of various sources of domestic water supply as complementary and the use of policy instruments and planning laws in determining the pattern of water supply project execution is key to making available improved water sources to the citizenry. This would curb the distance and time residents wastes daily to get water from distant sources.
iii. The Jos Metropolitan Development Board should ensure that built-up areas adopt town planning standard rules to ease laying of water supply pipelines and other public water supply facility extensions, especially in the newly developing built-up areas of Gyel district.
iv. Plateau State Water Board should engage in periodic pipeline extension services to be able to cover the newly developed areas and engage in regular maintenance and replacement of damaged facilities to enhance the supply of water in the area.

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