*Quest Journals*
*Journal of Research in Environmental and Earth Sciences*
*Volume 7 ~ Issue 1 (2021) pp: 76-85*
*ISSN(Online) :2348-2532*
www.questjournals.org

**Research Paper**

# Selection Of The Shortest Route Of Transporting Water From Yola Water Service Station To Yolde Pate, Adamawa State

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***ABSTRACT***
*Water is a basic resource which supports economic growth and maintains daily life but due to the high demand on the existing water facilities the water demand could not be met.The study aimed at selecting the shortest route of connecting water from Yola station to Yolde Pate station. The aim was achieved through mapping the existing water facilities in Yolde pate, determine the slope and determining the shortest route of connecting Yola to Yolde pate. The coordinates of the existing water facilities were collected and map out, The satellite Image of the study area was digitized, georeferenced and overlaid on the Google earth image of the study area to serve as a check. A Digital Elevation Model (DEM) was derived from SRTM, Contour map was produce from Inforterra Gmb Image (2019) of the study area with 0.6metres resolution. Pipeline network were overlaid on the updated road network map to show water distribution in the study area. Coordinates of the source and destination stations were obtained using GPS and the position located on the image. Data collected were analyzed using new route Network analysis tool of ArcGIS 10.4 to determine the shortest route. It was observed that the existing water pipeline network did not cover the study area and some areas within the study area are located on high ground above the location of the present water station in the area. This study determined the shortest route of transporting water to Yolde Pate using GIS techniques. The study concluded that, the use of GIS as a tool for determining route should be utilized by the water distribution authorities for proper planning and execution. Analysis to determine the domestic water consumption in the study area should be carried out for proper planning and location of reservoirs in the area.*
***KEYWORDS****: Pipeline, Route Selection, GPS , DEM and Spatial analyst*

*Received 15 Jan, 2021; Revised: 28 Jan, 2021; Accepted 31 Jan, 2021 © The author(s) 2021.*
*Published with open access at www.questjournals.org*

## I. INTRODUCTION

Water is one of the basic necessities of life, without which, life on planet Earth would not exist (Abrashinsky, 2014). Water is a basic resource which supports economic growth and maintains daily life. It is very important as it is the major constituent of both plants and animals (Chakhaiyar, 2010). As a resource to any nation, it should be well planned, developed, conserved, distributed and managed. Its infrastructure should be properly maintained to avoid decay 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 Ehiorobo, 2010).

Nigeria's fresh water resources cover only 3.4% of its total lands area 94,185,000 hectares to meet the demands 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 (2002) defined 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, 2007).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 reasons 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) Many cities and municipalities 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, Moran and Stam, 2007).

Over the years, digital representation of elevation has been the source of the information (Afshar, Akbari, Mariño, and Asce, 2006). Parameters like canal location of drainage splits, extent of canal and slope were traditionally acquired from maps or field investigations (Garbrecht and Martz, 1992). However, this study involves data collection and processing such as; water board location, street data, elevation data, existing water distribution network, existing map, and satellite imagery to determine the suitable route for transporting water.

**Statement of the Problem**

There is ample evidence to show that there is acute water shortage in Yolde pate. The population of inhabitants in this area has increased over time due to influx of people from rural to urban areas, being a settlement near a city, people that could not afford to rent or buy houses in the city result to settle in this area. Yolde pate is a community faced with the same water problem as any satellite town. The pumping station in the area is not fully

operational. There is only one storage tank serving the community, the water distribution network only covered few built up areas which was meant to serve a very few population some years ago when the population was small and the new areas of expansion due to increase in population were left out. Water requirement of the area could not be met even with the individual boreholes and wells in the area.

A walk around the area reveals a large number of children and women in search for water. Also numerous water hawkers popularly known as "Mai ruwa" are seen complementing water supply. Water is one of the basic amenities of life, used for domestic, commercial and agricultural purpose. Water demand and usage is the major factor contributing to shortage of urban water supply (Okeola, 2014). These factors also affect Yolde pate hence, this study tend to provide the means of linking the Yolde pate station with Yola distribution station to argument the only source of water in the area.

**Aim and Objectives**

The aim of the study is to develop the shortest route for transporting water from Yola town to Yolde pate water station through the following objectives:-

i. Mapping out existing public water facilities in the study area.
ii. Produce slope map of the study area.
iii. Select a shortest route for transporting water from source to destination.

**Justification of the Study**

Water they said is life, every human being need water to survive, and with the increasing population in Yolde pate the public borehole and the few ones drilled by individuals cannot sustained the water requirement of the population of this area. Water hawkers keep on increasing the price of water which is very difficult for the common man to even afford a truck of water.

As people pump groundwater for irrigation, drinking water, and industrial uses, the water doesn't just seep back into the ground -- it also evaporates into the atmosphere, or runs off into rivers and canals, eventually emptying into the world's oceans. This water adds up, and a new study calculates that by 2050, groundwater pumping will cause a global sea level rise of about 0.8 millimeters per year. (Yoshihide, Ludovicus, Frederiek, and Weiland, 2012) . In view of the consequences associated with the use of ground water, the use of boreholes for pumping water should be discourage, hence prompted the need to determine the optimal route that will connect the area to public water distribution system which generate water from free flows water (river).

**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 at altitude 162m above mean sea level and lies between latitude $09^0 12' 0''$ to $09^0 14' 0''$North of the equator and longitude $12^0 41' 0''$ to $12^0 45' 0''$ of the Greenwhich meridian. 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. Some prominent features in the area include new polo ground, prison quarters and new Nigerian prison under construction etc.

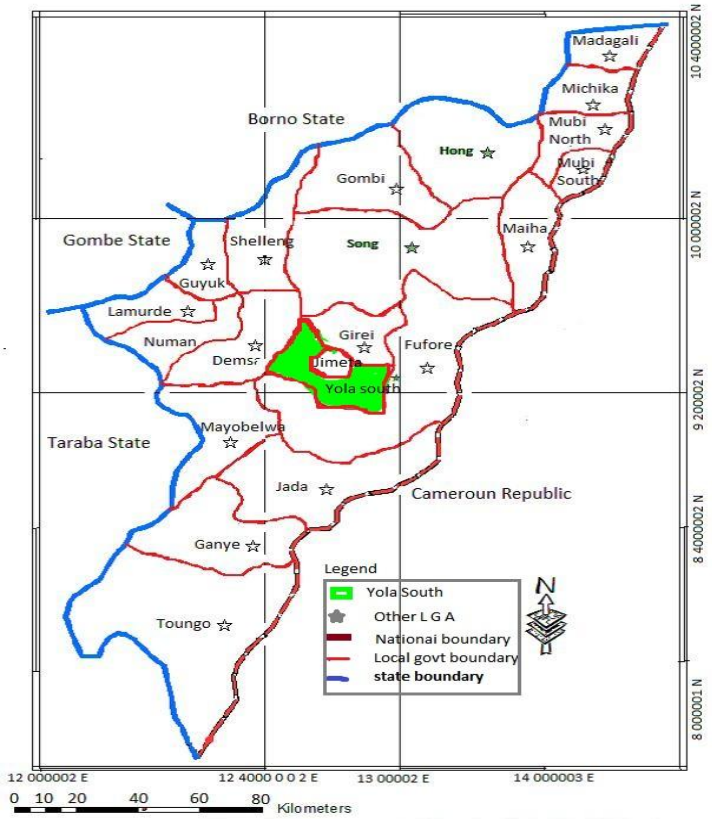


**Fig 1.**1 Map of Adamawa showing Yola South Local Government

**Application of GIS to Optimal Route Analysis**

A GIS assisted optimal urban route selection based on multi criteria approached by Ahmed and Asmael (2011) was aim at developing a GIS based model to determine suitable route. Four factors were considered-geotechnical, geometrical, social and economic factors for multi criteria evaluation to select the best route alternative, they applied GIS based analysis to demonstrate the multi criteria approach in determining the optimum route selection by considering different factors affecting decision- maker selections, in addition saves time and cost.

Manual pipeline route planning uses available maps, surveys and experience and is seriously constrained due to lack of updated data. This is inadequate for complex terrains and long routes. Remote sensing (RS) and GIS method on the contrary uses updated maps from latest RS data, integrates thematic cost (resistance/ impedance) layers in GIS environment and computes all possible routes with associated costs or impedances. Dubey( 2010)

Volkan, Yildrirm and Yomuralioglu (2011) carefully compares a GIS based approach of routing a pipeline to the conventional traditional route selection approach in turkey. Volkan *et al.* (2011) were able to prove that the cost of a GIS based pipeline route selection would decrease the cost of the project by 14 percent relative to the manual pipeline route approach. He further made emphasis on the friendly interface of the GIS software used.

During the last decade, a few attempts have been made to automate the route planning process using GIS technology and the methodology is still at an exploratory stage. Studies in this line include; a study done by Saha *et al.* (2005) concluded that computer-assisted methodology of route planning is fast in comparison with the conventional manual practice. Saha *et al.* (2005) A study done in the Caspian Sea, the least-cost path derived was 21% longer than the straight-line path between the source and destination, but it led to a reduction in construction costs by 14% Feldman *et al.* (1995).

Yola Water distribution station carried out water distribution to its environs without considering the shortest length or the distance to be covered in transporting water to the destination; pipes were laid using existing road network in the area without considering the financial implication of linking the water to the needed destination. This study consider the use of shortest route in transporting water from Yola town to Yolde Pate water station using the existing road, distance as impedance, source and destination points in selecting the route for effective water distribution and will also help the water board management into proper planning, monitoring and also save cost of executing the project.

## II. METHODOLOGY

### 2.1 General Framework

To achieve the objectives of this study, various methods adopted for the study is shown in figure 2.1 below

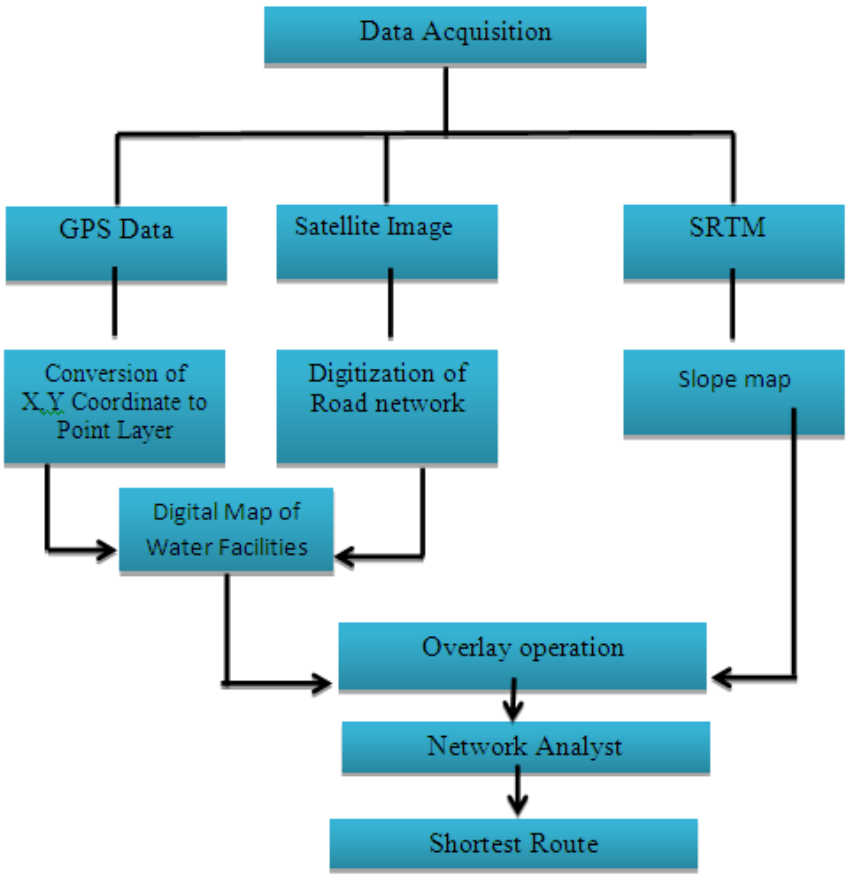


**Figure 2.1:** Methodology flow chart

### 2.2 Material

The hardware and software used includes the following:
GARMAN 76Sx hand held GPS, Laptop, Hp printer and ArcGIS version10.4

### 2.3 Data Source

***2.3.1 Primary data*** was acquired through field visitation and the use of hand held GPS to collect the coordinates of features in the study area which were integrated into the GIS environment.

***2.3.2 Secondary data*** were collected from the Adamawa state Water Board, Yola local government and by downloading the satellite imagery requires for the study. The secondary data used includes existing existing maps and satellite Imagery of the study area used to extract relevant geospatial data.

### 2.3.3. Data Acquisition

The positions of the water board facilities were acquired using hand held GPS by tracking the X,Y coordinates as shown in table 3.2, the attribute data for these facilities were acquired through oral interview from the Adamawa state water board, ministry of water resources Yola

The Geo eye satellite image was downloaded from goggle earth at 0.65m resolution for the purpose of updating image. Also. Infoterra Gmb image was downloaded fron SASplanet at 0.65m resolution which served as a reference data.

The SRTM data was downloaded from USGS which was 30m resolution and use to produce slope map and contour map of the area. The data collected were incorporated into the ArcGIS 10.4 software for processing. The existing distribution network was digitized on the street map to delineate areas covered by the existing network. Digital elevation model (DEM) was also classified on ArcMap and prepared for analysis.

**Table 2.1** The coordinate of existng water board stations used in the study.

| E(m) | N(m) | H(m) | Description |
|---|---|---|---|
| 218569 | 1019283177 | | Yolde pate water station |
| 223527 | 1018468203 | | Yola town distribution station. |

**Table 2.2** Attribute informatio of the components of Yolde- Pate Water Transmission and Distribution pipelines

| System Component | Pipe Material | Pipe Diameter | Deign Period (years) |
|---|---|---|---|
| Transmission pipes | uPVC | 100mm | 15 |
| Distribution Pipes | uPVC | 100mm | 15 |
| Distribution System | Endcap, Washout valves, Air relief valves. | | |

**Data Preparation**

**Geo-referencing**

The downloaded geo eye image was georeferenced using the geometric data of five Junctions of road within the scope of the study, the georeference geo –eye image was clipped to depict the area of interest and it was overlaid on Infoterra Gmb satellite image which serves as check or reference data as shown in figures 2.2

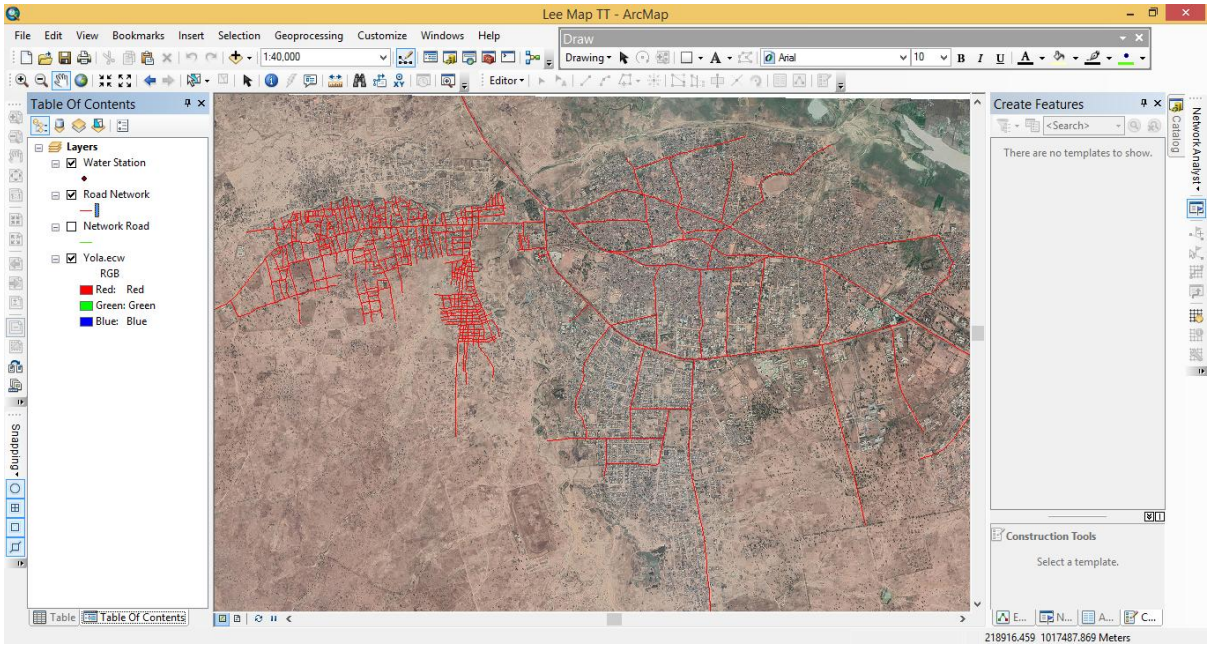


Figure 2.2: Overlay of the Geo-reference data of geo eye image on Infoterra Gmb satellite imagery

**Image Digitization**

Geo-eye satellite image of the study area was digitized in order to update the existing map of study area. The first processes involved was to create shape files of the entities in the study area in Arc-Catalogue. The shape files were added to the Arc Map environment for digitizing. The process of digitization involved the use of Editor Tool Bar to trace out all the features in the satellite imagery and other points of interest as shown in figure 2.4. In addition, the spatial data were captured and organized into different layers with on-screen digitization as described below. Finally, a dataset were created and filled for each of the layers and the entire attribute data gathered through Oral interviews and from records of water board, ministry of water resources Yola were used for the study.

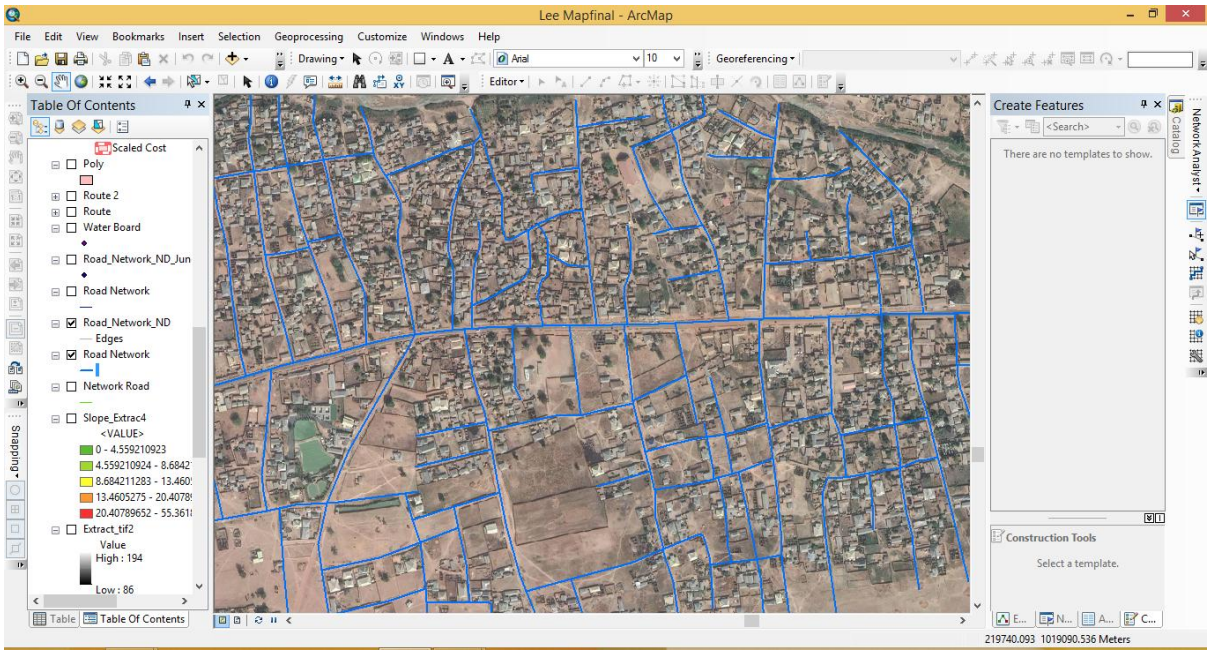


**Figure 2.3:** Digitization process of the satellite image of the study area..

**Route Selection Criteria**

The digitized distances were used for the selection, the analyst tool run through all the route calculate the distance and identified the shortest route. The shortest route selection was achieved by identifying the starting and the destination points. The shortest path trace tool was used to calculate the distance using a numeric network attribute of shape length to achieve a distance-based paths by avoiding the built up areas and satisfying engineering and construction requirement.

**Mapping of Existing Public Water Facilities**

The locational map of water board facilities was produced using the acquired coordinate of Yola distribution station and that for Yolde pate station. The existing water distribution network of Yolde pate were map out using the GPS to identified the position of water board station and the facilities on the ground

The location of water station, valves location and the destination of each service pipe were identified The acquired coordinates were imputed in Excel and added to ArcGIS 10.4 and in turn converted to shape file, the format that was acceptable by the software.

The collected coordinate were used to map out the water distribution network of the area, their location on the map were digitized on the street map to define the areas covered by the network. The plotted locational map of these facilities were overlaid on the digitized road network from the Goggle earth image shown in figure 2.1 to produce the map as shown in figure 2.2 and 2.3

**Slope Map and Contour Map of the Study Area**

The slope map of the study area was required to show the direction of water movement naturally to aid in water distribution. To produce the slope map the SRTM DEM was added to the ArcGIS 10.4 in which spatial analyst tool was used to produce the Slope map and contour map of the area as shown in figure 2.4 and 2.5.

**The Shortest Route**

Solving a route analysis can mean finding the quickest, shortest, or even the most scenic route, depending on the impedance used. The best route can be defined as the route that has the lowest impedance, or least cost, the impedance may be time, distance or speed. For the shortest route to be determine, the Network Analyst extension of ArcGIS 10.4 uses the actual street network, the data for water board facilities locations in Yola and Yolde pate and a network dataset of travel route to determine the shortest route

## III. PRESENTATION OF RESULTS

The result of the research was presented in form of maps and graphic display of the spatial analyses based to the objectives of this research done to explore the locational pattern of the water board facilities in the study area.

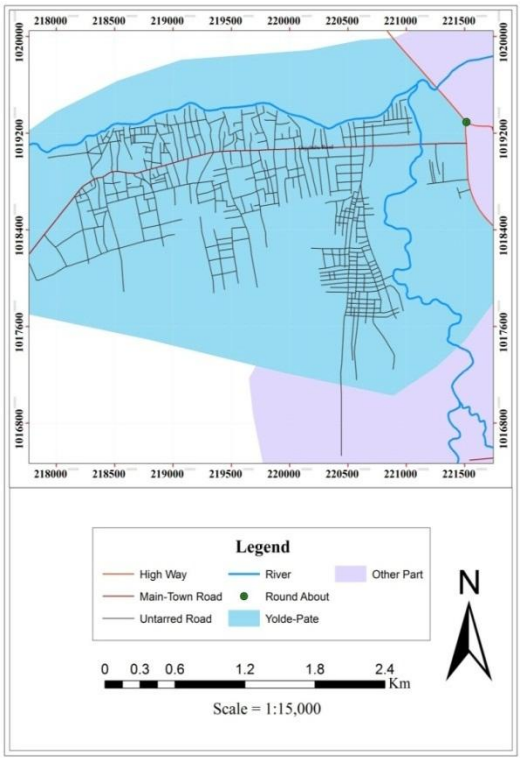


Figure 3.1: Updated road network board stations in the study area.

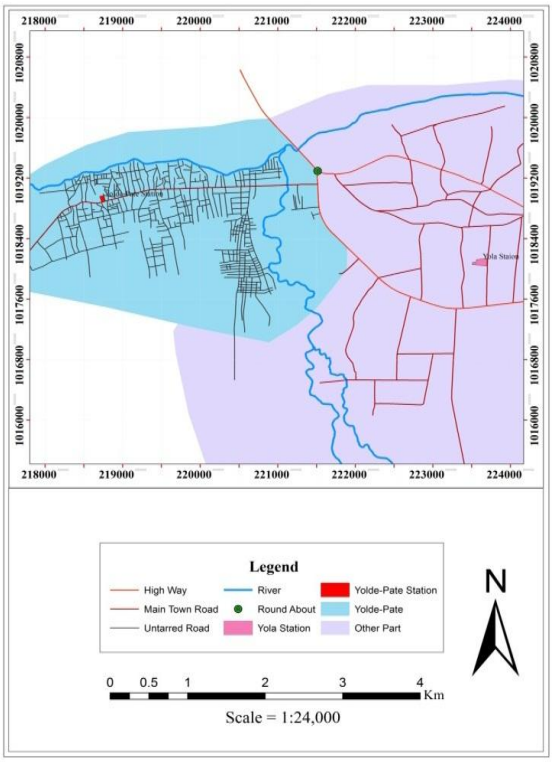


Figure 3.2: Map of existing water

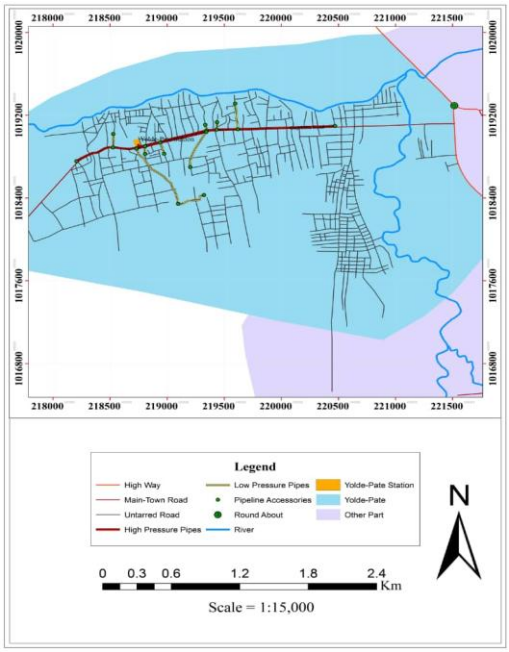


Figure 3.3: Pipeline network in Yolde pate.

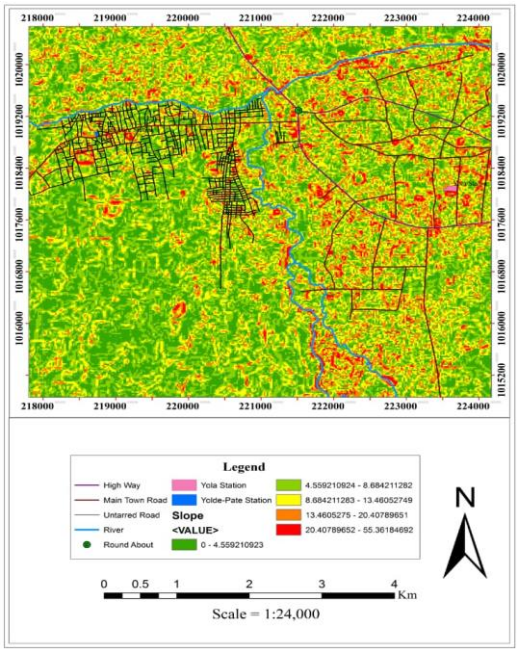


Figure 3.4: Slope map of the study area.

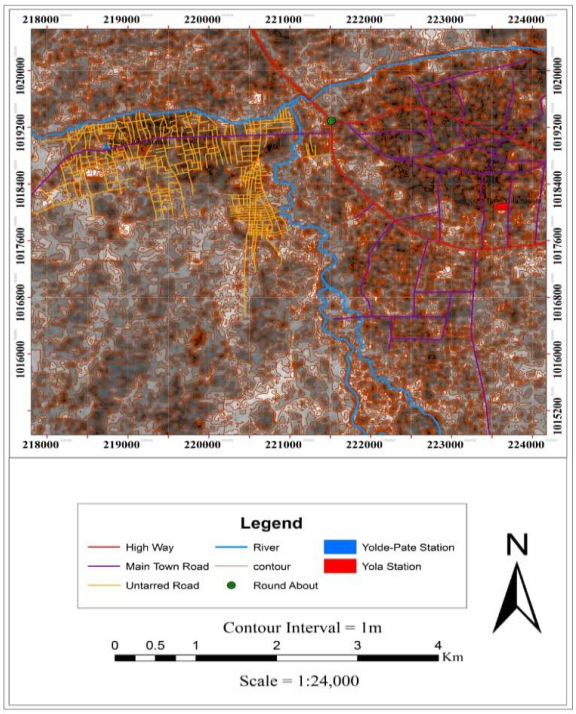


Figure 3.5: Contour map of the study area.

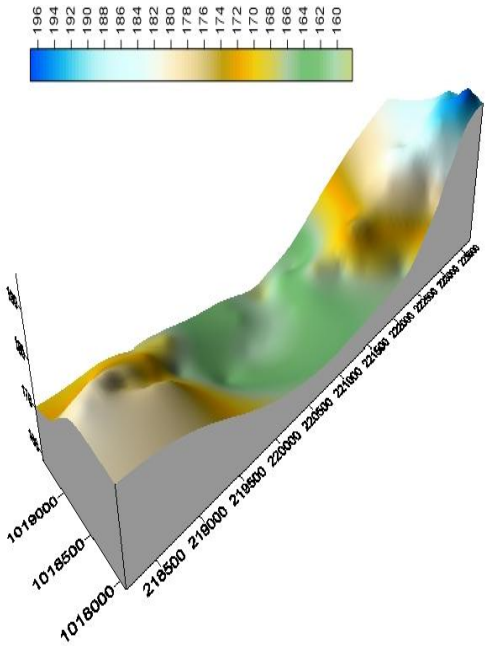


Figure 3.6: DEM of the Study area.

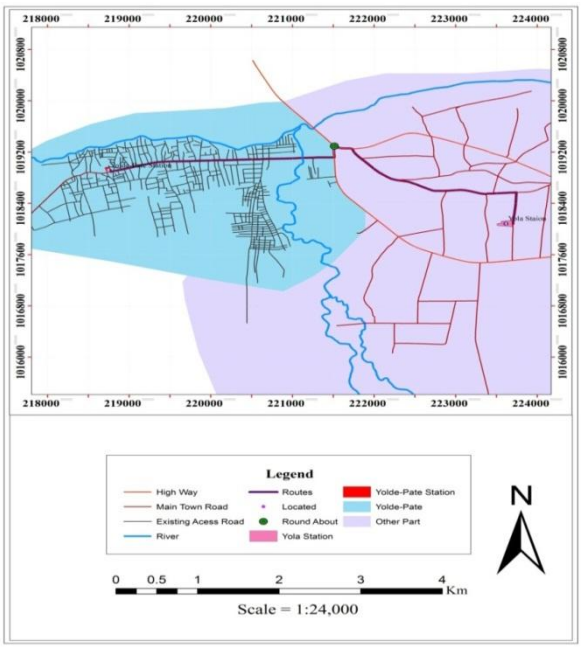


Figure 3.7 The shortest route from Yola station to Yolde pate water board station

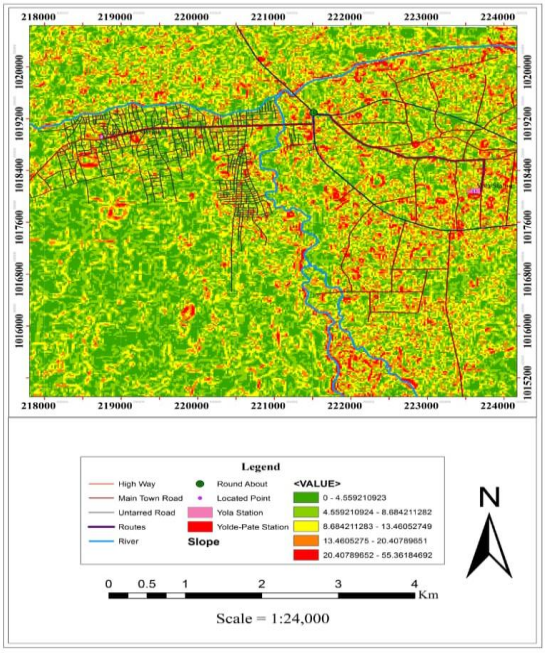


Figure 3.8: Overlay of shortest route on a slope map

**Discussion of Results**

The GPS coordinates, shown in table 2.1 played significant role in the location and geo-spatially positioning of the entire water distribution network of the study area, beside the various component of water distribution system were map out using the coordinate.

**Water Distribution Map**

Figure 3.1 shows the updated route network in the study area, the route were updated to map out the water network and to show the settlement in the area.

Figure 3.2 shows the location of the water facilities station located in the area of study, the right point is the location of Yola service station while the left point is the Yolde Pate station (Destination).

Figure 3.3 is the Digital map of the water distribution in the area. The map was produced to show pipeline coverage in the area as in (Pindiga,2012), the area served by the existing water facilities involved the region that encompasses all pipeline network.. This was achieved through the fusion of the base map with the water board stations positional data obtained using Hand held GPS device and a network dataset that included travel route, Hence the distribution network of the existing water facilities were identified.

**Slope Map of the Study Area**

The slope map of the study shows the direction of water movement naturally to aid in water distribution. The different colours shows degree (steepness) of slope for a terrain and degree of slope classes are mapped with saturation color so that the steeper slopes are brighter figure 3.4

**Digital Elevation Model (DEM)**

Figure 3.5 Digital elevations Model shows the topographical nature of the area with height representing different colours, the elevation is presented in form of raster and plays role in the distribution and flow of water in the natural landscape of the study area. Moreover, they contribute immensely in the determination of the actual location of reservoir in the area. The ground elevations are very useful when evaluating the hydraulic grades and operating elevations within the pressure systems.

**Shortest Route Selection**

The determination of the shortest route to supply water involved taking all the possible routes and presenting the one with the shortest path shown in figure 3.7 The satellite imagery acquired during this study has provided reliable, up-to-date information of the study area and aided in determining of the shortest route.

Various routes to access these water board facilities were as well noted and the shortest route identified. The first route starts from Yola station passes through Modibbo Adamawa way to Jippu Jam round about, Yolde pate Juntion and to Yolde Pate station with a covered distance of 5939m and the second route starts from Yola station travel along Yola Bye pass to Yolde pate Junction and to Yolde Pate station with a distance of 6232m.

Figure 3.8 shows the overlay of route on the slope map, the source is at right poimt with brighter colours of the slope and the destination point is at the left darker colours meaning lower elevation points in green. The slope shows that the elevation of the source is higher than the elevation of the destination point which allows free flow of water to the Water station in the study area.

## IV. SUMMARY

The water station in the study area is not connected to public water supply and has been in existence without a water distribution map which could be used for effective planning and extension of these facilities in the area. Therefore, the study tried to provide the shortest route of linking the study area with Yola station for the supply of water from the source. The coordinates of the two water stations were integrated into ArcGIS 10.4, Network analysis was carried out and the shortest route for transporting water from Yola station to Yolde pate water station determined as shown in figure 3.7. The coordinates of the water facilities in the area acquired using the GPS were used to locate their position on the satellite image of the area, their position digitized and overlaid on road network map to produce the water distribution map shown in figure 3.3. The study also shows that there is high demand on the present facility and water cannot be distributed at same time because some areas are located on high ground compare to the location of the present water station, lower valve has to be closed for water to reach other areas of demand.

The research also targeted public water distribution in Yolde pate based on reassessment of water distribution facilities across the study area and the result shows inadequate water supply in the area as most of the places lack pipeline network.

## V. CONCLUSION

The road were updated using Infoterra Gmb satellite imagery, the position of water board location identified, The longest distribution pipe length was used to determine the coverage in radius using service area analysis tool which is an extension of Network analysis. Therefore, based on the analysis the result shows that the facilities were seen to be unevenly distributed in the study area. The suitable route was identified starting from Yola station passes through Modibbo Adamawa way to Jippu Jam round about, Yolde pate Juntion and to Yolde pate station With a covered Distance of 5939m..This study concluded that suitability analysis using Network analyst extension provides suitable location for water station and a suitable pipeline route.

A digital map showing the water distribution network of Yolde pate and the shortest route was produced, these will help the management of water board in decision making, strategic planning and operation management,

## VI. RECOMMENDATIONS

Findings from the study show the shortest route, as the route that starts from Yola station passes through Modibbo Adamawa way via Jippu Jam roundabout and to Yolde pate as the shortest route for transporting water to the study area. The alternative route travels through technical school Junction through Yola Bye pass to Yolde pate. Hence the following recommendations suggested

i. The use of GIS as a tool for determining route should be utilized by the water authorities or agencies for proper planning and execution.
ii. The high ground area of the study area Gadawalowul can be better served if a reservoir is sited in the area.
iii. Digital map can also be of useful to the State water board in designing pipeline route, Constructions work and proper maintenance of the water facilities,

**Further studies**

Analysis to determine the domestic water consumption in the study area should be carried out for proper planning and location of reservoirs in the area.

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