World Journal of Engineering Research and Technology
WJERT
www.wjert.org
SJIF Impact Factor: 5.924

MAPPING AND ANALYSIS OF TRANSPORTATION NETWORK OF ONITSHA METROPOLIS USING REMOTE SENSING AND GIS TECHNIQUES

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Article Received on 11/05/2020 **Article Revised on 31/05/2020** **Article Accepted on 21/06/2020**

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ABSTRACT

In recent times, Transportation System has been in a very bad state due to the deteriorating state of our intra and inter-city roads around the country including Onitsha. The problem of not getting to destinations on time by the roads users on time and a lot of artificial difficulties are encountered on roads on daily basis. This is also important in these days of COVID-19 pandemic where evacuation of victims is of utmost priorities. The aim of the study is to map and analyze the road transportation network of Onitsha using Remote Sensing and GIS techniques. The objectives include designing a geodatabase for the entities of interest in the study area; acquisition of 1.0m resolution Ikonos image of the study area from where the features of interest were extracted through head-on digitizing; creation of a suitable geodatabase and spatial analyses like queries, network analysis to generate best and alternative routes. The methodology involved database design and implementation. It was shown at the end of the study that total road segments were in good condition, 20.61% represents roads in fair condition and 65.36% of the total road segments are in bad condition. The difference in travel distances from the Head Bridge to the Central Police Station (CPS) using the Best and Alternative routes is 50.20m. This is an indication that the best routes are always shorter than the alternative routes all things being equal. The recommendations at the end of the study include paving of bad roads with asphalt and providing functional drainage

systems.

KEYWORDS: COVID-19, Transportation, Network, GIS and Remote Sensing.

1.0 INTRODUCTION

Onitsha plays a major role in the economic life of the eastern part of the country and other parts of Nigeria including other West African countries like Benin Republic, Togo, Ghana and others. The ease of movement of the influx of all these merchants and other road users in Onitsha metropolis depends on the conditions of the road network. Many developmental projects seriously depend on transport network because transportation is the factor determining the speed of growth and development of a place which can occur through roads, rails, airways, waterways, pipelines etc. (Obafemi, 2011). Ritesh (2013) conducted a research on Road Network Analysis by employing Geoinformatics techniques for Akola City, Maharashtra State, India. The study was targeted at finding solutions to routing problems related to traversibility, rate of flow, and network connectivity in the study area which would help in identifying optimum locations for services to be provided. The similar problem was observed in Onitsha, Nigeria where human and vehicular movements are almost impossible on daily basis. Onuigbo (2015) also conducted a research on solving the problem of generation of road network database for Minna and environs using Surveying and Geoinformatics' techniques. The objectives of the study were to use GIS, Remote Sensing and Surveying techniques to gather data and create the road network database of the study area. Satellite images and existing road map of the study area were used to carry out field survey. Road names were identified from the field survey and subsequently the creation of road network database for the study area were done.

Onitsha is growing in population and development on daily basis because of the booming socio- economic activities in the city. The influx of the merchants from across the country and other sets of people who throng into the city for daily economic activities from surrounding cities like Asaba from the western side across the Niger River, Awka- the state capital and from Owerri axis has a significant impact on the road network usage in the city. This is observed in the work of Masser (2001) when he observed that the magnitude and potential scale of the anticipated tremendous impacts in the form of population explosion and mounting pressures on the carrying capacity of the environment. Due to the projected growth pattern, over Five billion people will be residing in urban area by 2025 with 80 percent of that number in developing countries. He further noted that such a trend poses a difficult task for

urban planner and natural resource managers in containing the problem. The influx of people from other parts of the country into Onitsha in these period of COVID-19 pandemic has called for proper analyses of transportation network especially when referring patients to available isolation centre.

The study is targeted at mapping and analyzing the road network of Onitsha metropolis with a view of solving the traffic grid locks experienced on daily basis around the study area using Remote Sensing and Geographic Information Systems' techniques. Vector data model was adopted for the study. The objectives include the design and creation of geospatial database for the entities of interest in the study area. Primary and secondary data were also acquired from statutory organisations saddled with the responsibilities of keeping such data. Onitsha is a city on the eastern side of the lower Niger basin about 1km south of the confluence with the Anambra River in Anambra state. It is approximately between latitude 6°10' 38'' N and longitude 6° 15'47''E and measures about 150 miles north of River Niger (Izueke & Madu, 2013) as shown in Figure 1. The city and its environs belong to the equatorial rain forest belt of West Africa and receives more than 80 inch of rainfall annually, mostly during six months of the raining season.

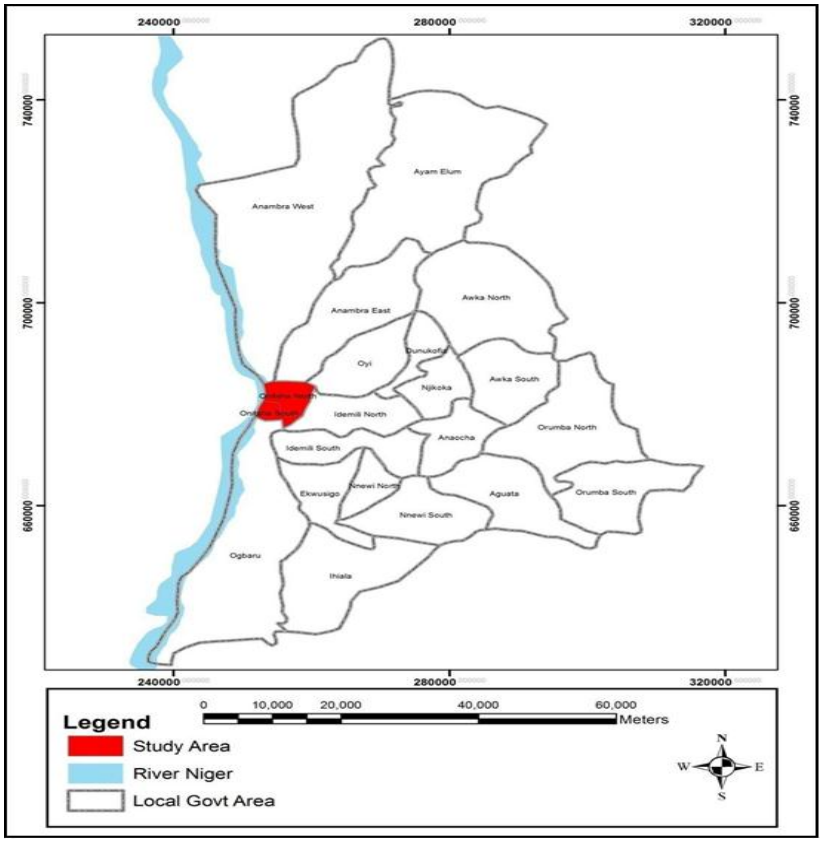

Figure 1: Map of Anambra State showing Onitsha South and North.

2.0 METHODOLOGY

This section discusses the methods used to implement the mapping and analysis of the transportation network of Onitsha metropolis using Remote Sensing and GIS approach. The methodology flow chart is shown in Figure 2. The Topographic Map Sheet (Onitsha Sheet 300) and high resolution satellite imagery (Ikonos) formed the base data for the whole process and they serve as secondary data sources for the work. The topographic map sheet was scanned and imported to ArcGIS 10.2.2 environment and overlaid on the satellite image. Ground truthing and verification of data were done so that errors were minimized as much as possible. This was followed by Georeferencing. The coordinates of the known points on the ground which serve as the primary data source were collected using handheld GPS with an accuracy of about 3.0m.

This was followed immediately by digitizing the entities of interest in the study area using on- screen method. This is also referred to as extraction or creation of layers. The vector data model was adopted for the study which classified the layers into Point layer representing the Facilities, Line layer representing the Roads and the Polygon layers representing Water body and study area boundary. Database was designed and created for each of the participating entities in the study area. The secondary data representing the descriptions of the entities were attached as the attributes which were collected by visiting the study area to ascertain the names of the entities like the facilities and the roads. ArcGIS 10.2.2 was used as the implementation software for the various analyses carried out. The summary of the processes involved in carrying out the research work is shown in Figure 2 as methodology flow chart.

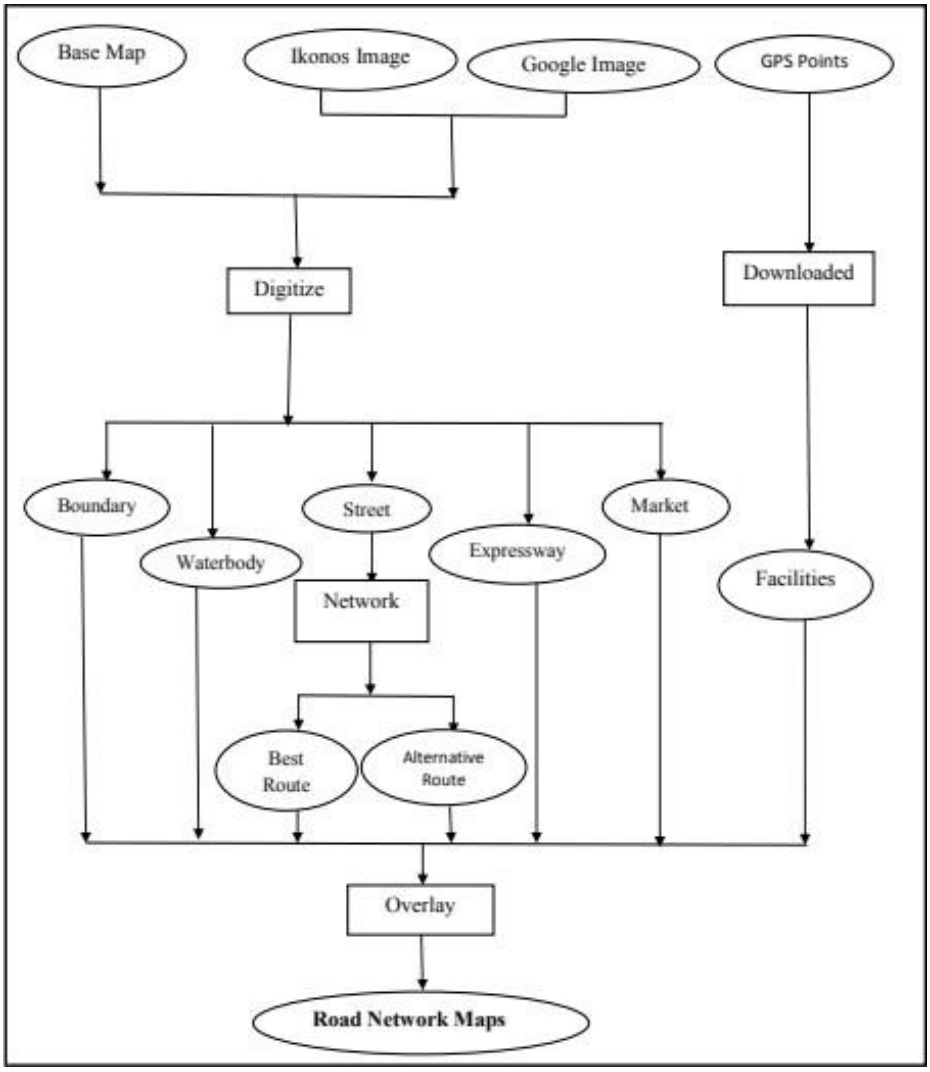

Figure 2: Methodology Flow Chart.

3.0 Analyses and Discussion of Results

The section presents the results generated from the various analyses performed. It gives the details of the results and the applicability of the results with regards to the mapping and analysis of Road Transport Network of Onitsha Metropolis in Anambra State of Nigeria. The database designed and created was tested by querying for certain conditions of the roads and performing network analyses on the roads by using the Best and the Alternative Routes methods on the network of roads digitized from the various data sources.

3.1 Spatial and Attribute Queries

Spatial and attribute queries were carried out to test the database created. The queries were used to look into the roads' conditions in the study area. Queries are also useful for testing the database created under Single criterion query and Multiple criteria query. Single criterion queries use only one field or the column in the table created for the entities. They are also

called single condition query. The query will use only one field of the tables created for the entities. Queries were carried out under this single criterion query to extract from the database the three categories of road conditions in the study area which include good, fair and bad. The result is presented in Table 1. The number of road segments sampled in the study area are 574 from the overall total of 1247 digitized for the study irrespective of the length of each segment.

Table 1: Table showing the conditions of the roads.

S/N	Road Condition	Number of Segments	Percentage of Total
1	Good	175	30.49
2	Fair	257	44.77
3	Bad	142	24.74
Total	**Selected Roads**	**574**	**100**

DISCUSION OF RESULTS

Table 1 shows various percentages of the road segments that fall into the different categories used for the classification of the conditions of the roads in the study area. The selected roads' segments were carefully taken from the total because they fall in the areas where commercial activites abound. The criteria for the categorization of the roads into good, fair and bad include whether the roads are passable or contain manageable potholes and whether the roads can be used during the raining season for most of the asphalts have been eroded.

3.2 Network Analysis

GIS solves such problems like identifying best route to facilities, closest facilities, vehicle routing problems (shortest path) and closest service area using Network Analysis. The study only focused on the use of the Best Route and the Alternative route in the study area in carrying out economic activities within the area of study.

3.2.1 Best Route

Environmental Systems Research Institute (ESRI) in 2014 defined the best route as the route that has the lowest impedance, or least cost, where the impedance is chosen by the user. Also, any cost attribute can be used as the impedance when determining the best route. Solving a route analysis can mean finding shortest route which is the focus here because the users want to save time and cost to get to their various destinations. Figure 3 shows the diagram defining Points 1 and 2 representing Head Bridge Junction and Central Police Station at the northern part respectively and Figure 4 shows the best route from Head Bridge Junction to CPS.

Figure 5 shows the direction window of the Best Route from Head Bridge Junction to CPS and Figure 6 shows the formatted map of Best Route from Head Bridge Junction to CPS.

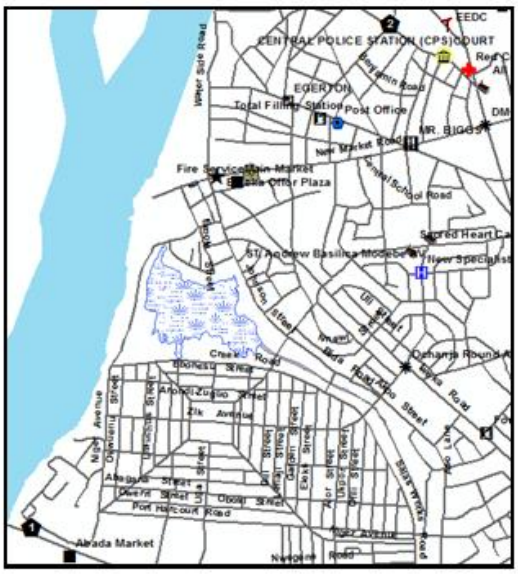

Figure 3: Defining locations Head Bridge Junction (1) and CPS (2)

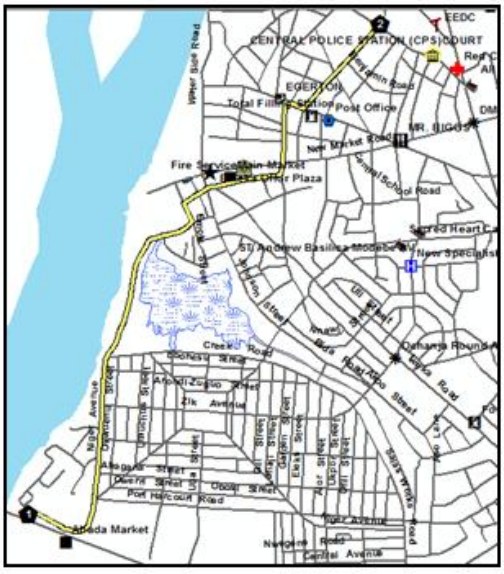

Figure 4. Best Route from Head Bridge Junction to CPS

Directions (Route)

[−]	**Route: Head Bridge Junction - CPS**	4210.9 m
1:	Start at Head Bridge Junction	
2:	Go east	249.3 m
3:	Turn left on Niger Avenue	2126.1 m
4:	Turn left	120.2 m
5:	Turn right	152.9 m
6:	Turn left on Johnson Street and immediately turn right	442.2 m
7:	Turn left on Venn Road	70 m
8:	Turn right on New Market Road	88.1 m
9:	Turn left	310.3 m
10:	Bear right on Oranyaru Road	644 m
11:	Turn left to stay on Oranyaru Road	7.7 m
12:	Finish at CPS, on the right	
	Driving distance: 4210.9 m	

Figure 5: Direction window of the Best Route from Head Bridge Junction to CPS.

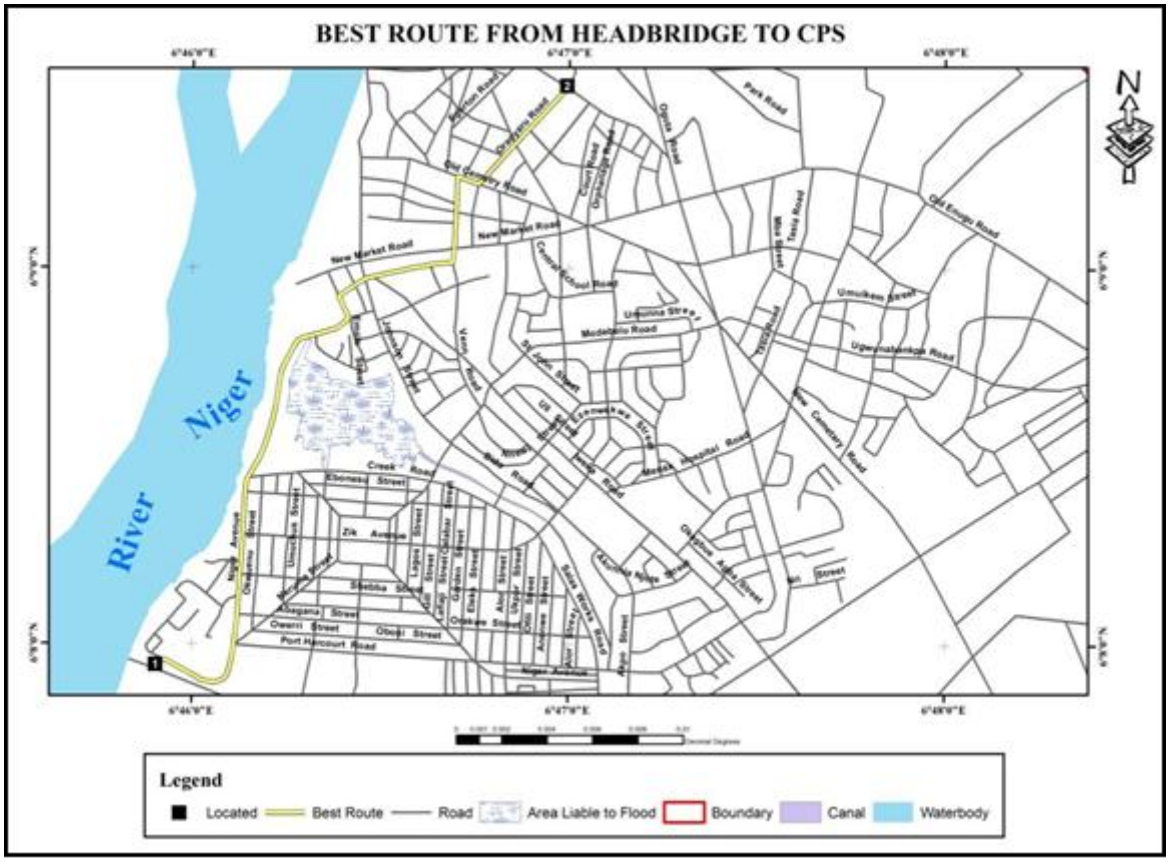

Figure 6: Map of Best Route from Head Bridge Junction to CPS

DISCUSSION OF RESULTS

The result showed that a total distance of 4.21Km is covered between the Head Bridge and the Central Police Station (CPS). This is relevant when combatting crime around the Head Bridge that needed the rapid response of the men of the Police Force from CRS. The other application can be for new officers posted to the station to have a guide to the CRS from the Head Bridge and can also be useful for civilians living around the area.

3.2.2 Alternative Route

The alternate route is necessary when there is a barrier on the best route. In the contrary, the system finds another route that can be followed in case of restriction or barrier on the best route. The barrier may be traffic hold up, terrible pothole on the roads, road blockage during celebrations and vehicular breakdown on these roads. In order to avoid all these, alternative routes are created with a barrier along the Best Route as shown in Figure 7 and eventual Alternative Route shown in Figure 8 in the bid to save time and eventual loss of life in case of emergencies.

Figure 7: Locating Head Bridge Junction, the Barrier and the CPS

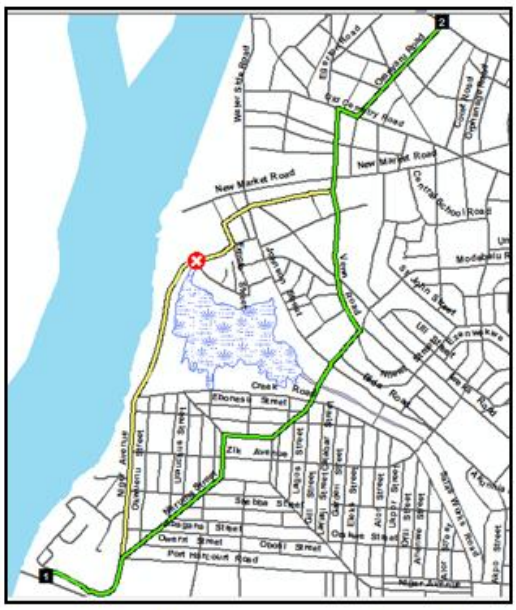

Figure 8. Alternative Route from Head Bridge Junction to CPS

Directions (Route)

[−]	**Route: Head Bridge Junction - CPS**	4261.1 m
1:	Start at Head Bridge Junction	
2:	Go east	249.3 m
3:	Turn left on Niger Avenue	302.7 m
4:	Turn right on Nkruma Street	656.1 m
5:	Turn left on Obasi Street	216.9 m
6:	Turn right on Arondi-Zuguo Street	245.9 m
7:	Bear left on Modebe Avenue	487 m
8:	Turn left on Johnson Street and immediately turn right	237 m
9:	Turn left on Venn Road	816.1 m
10:	Turn right on New Market Road	88.1 m
11:	Turn left	310.3 m
12:	Bear right on Oranyaru Road	644 m
13:	Turn left to stay on Oranyaru Road	7.7 m
14:	Finish at CPS, on the right	
	Driving distance: 4261.1 m	

Figure 9: Direction window of the Alternative Route from Head Bridge Junction to CPS.

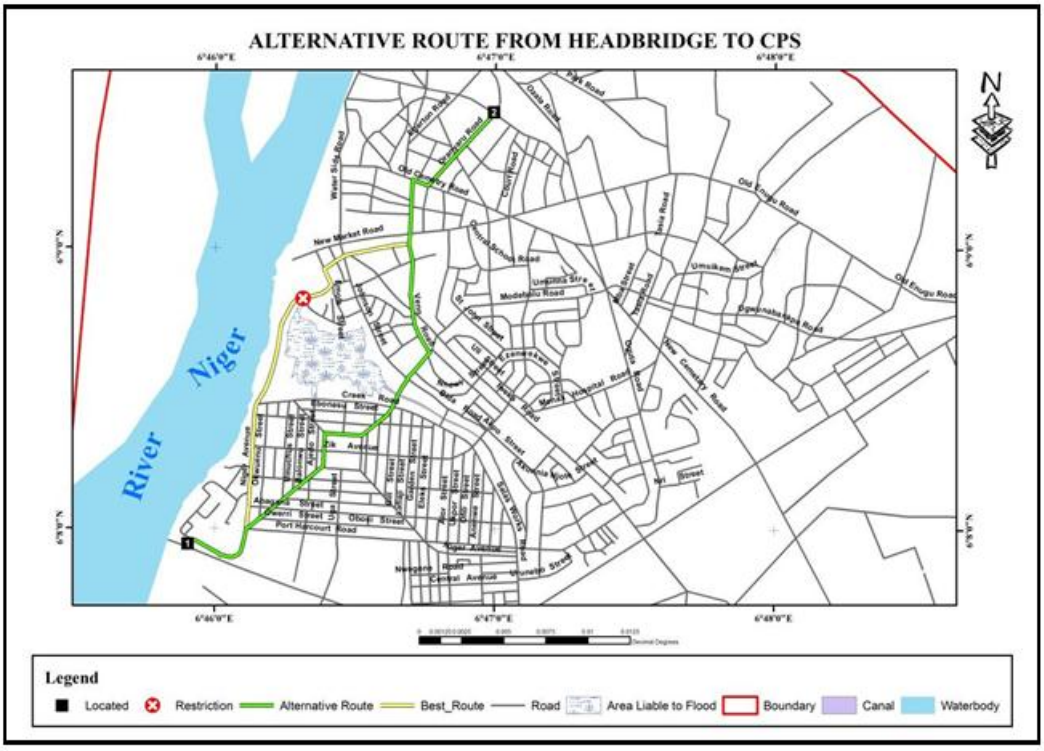

Figure 10: Map of the Alternative Route from Head Bridge Junction to CPS.

Discussion of Results: The map in Figure 10 shows the direction to be travelled on the Alternative Route. This is with a difference of 50.2m. The result generated from travelling on the Best Route and the Alternative Route indicated that the Best Route remains the shortest and the Best to take when travelling to and fro between Head Bridge junction and the CPS.

4.0 CONCLUSION AND RECOMMENDATIONS

4.1 Conclusion

The capabilities of the methods adopted for the study clearly showed that a lot of the geospatial problems confronting the developing nations including transportation problems can be solved by applying the Remote Sensing and Geographic Information Systems techniques. The Remote sensing equipment can have access to very remote areas that cannot be accessed by human and the data collected analyzed and processed using proper GIS software and hardware. It is therefore concluded that the aim of this study to create a model for solving transportation network problems in Onitsha metropolis was achieved using Remote Sensing and GIS techniques.

4.2 Recommendations

The recommendations at the end of the study include but not limited to the following.

1. A lot of drainage systems have gone bad where they are available and non-existence of drainage systems in some parts of the study area expose the roads to be washed away during raining season which makes the roads nearly impassable every time rain falls. It is suggested that the roads be rehabilitated and drainages provided to allow free flow of running water during raining seasons to allow free flow of traffic at any time.
2. Most of the bad roads were untarred which exposed them to surface erosion thereby allowing erosions to create deep gullies that almost divide the roads in some parts of the study area. Such roads should be repaired or given complete rehabilitation as soon as possible.
3. Where there are obstructions due to break down of trucks in the areas allocated as markets, the traffic agents should always be on patrol to evacuate such to ease the traffic congestion at peak periods.

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