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A GEOSPATIAL ASSESSMENT OF URBAN TRANSPORTATION SYSTEMS IN IBADAN NORTH LOCAL GOVERNMENT AREA, OYO STATE

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ABSTRACT

Urban Transportation contributes immensely to the socio-economic growth of nations including Nigeria and also helps regions and countries to become more prosperous and productive. The study applied GIS in urban transportation planning in Ibadan North Local Government Area of Oyo State to solve problems like traffic congestions, illegal bus-stops and non-availability of digital road maps. GIS technology was used to look into transportation future in Ibadan by expanding the already existing roads and the affected structures were determined. GIS methodology was adopted by using both primary and secondary data sets to design and create spatial database. Handheld GPS was used to coordinate the locations of the bus-stops while the analogue map from Town Planning Office was scanned, georeferenced and the entities digitized using ArcGIS 10.8.1. The study adopted 1000m spacing for bus-stops to get 26 instead of existing 55. The study identified six major routes: Orogun-Mokola (7.31km), Orogun-Agodi-Beere (9.32km), Mokola-Agodi Gate (3.6km), Sango-Polytechnic (2.25km), Beere-Gate Bus Stop (2.80km) and Gate-Basorun (3.74km) with widths between 25.02m and 14.39m. The expansion of these routes will affect 1002 buildings for Bus Rapid Transit. Orogun-Mokola and Mokola-Agodi Gate routes were conceived for rail system. The road corridors if extended to 60m; 358 and 129 buildings will be affected along Orogun-Mokola and Mokola-Agodi Gate routes respectively. The study generated best and alternative routes to be 5.42km and 5.88km respectively between Amusement Park and UCH. The study concluded by recommending consideration for road junctions when citing bus stops and further study on congestion index along the major routes.

Keywords: GIS, Urban Transportation, traffic congestions, bus-stop, Bus Rapid Transit

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1.0 INTRODUCTION

Transportation in the study by [1] is the movement of people and or goods from one place to another through a means where the means may be walking on land, vehicle on road, train on the rail and plane in the air or ship on the sea. The study further stressed that transportation is a requirement for every nation regardless of its industrial capacity, political stability, population, size or technological development. [2] stated that urban mobility problems had been on the increase since independence which was due to rapid increase in population in urban areas which was not matched with growth in transport facilities such as road network, transport complimentary facilities, transport services and traffic management techniques. Transport was identified by [3] as one of the most pressing issues in Lagos State in 1999. Social and economic development of the country are dependent on good road network as road is the major means for transportation [4]. Optimization of public transportation network in terms of reducing travel time and providing access to areas currently without sufficient access to the service facility would certainly motivate private car owners to use public transport which will reduce vehicle numbers on the roads and undoubtedly lead to minimizing traffic congestion and reducing air pollution due to lesser exhaust emissions [5].

Transportation problem is fast becoming one of the social menace in Ibadan North Local Government Area and urban centres around the country due to the rural-urban drift. The movement puts immense pressure on the available facilities in the city centres including transportation systems. The problems include bad roads, congestion at the peak periods due to volume of traffic on the major routes, indiscriminate stops along the major routes, non-availability of up to date road network maps and absence of urban transportation planning. The consequences of these problems are waste of man-hour in traffic at peak periods; the sick or injured die on their way to the hospitals during emergencies; it is either there is a traffic jam or the vehicles are not available. Such deaths can ordinarily be prevented if there were adequate and efficient transportation planning in place. Also, the aged and the disabled are deprived of going to where they want because our conventional transportation systems cannot readily take care of their needs. Cities in developing countries like

Nigeria according to [6] face acute pressures due to increased motorization, urbanization and growing population

It was also revealed that accessibility of a bus stop is a critical element in deciding the bus transport ridership. The study by [7] concluded that a well-designed layout of bus stop can allow passengers to board and alight without the bus significantly impeding or delaying adjacent traffic. Bus stops play an important role as it serves as the transit service points of contact between the passenger and the bus [8]. [9] stated that bus stop accessibility is a vital component of a successful transportation system.

The analysis of Bus-stops locations in Ibadan North L.G.A Nigeria was carried out by [10] using Geographic Information System. The study focused on the determination of best location for bus stops to enhance public transport with the intention to evaluate the existing and adopt world best practices to create new ones where they are not present previously. Three (3) criteria were adopted: four hundred (400) meters bus stop interval on the major road, available setback from the road ideal for bus Stop shelter and slope. Seventy two (72) existing bus stops were identified, using the stated criteria for classifying the already existing bus stops. The study was able to identify best locations for the bus stops which will allow reduction of risk, accessibility to stops and by marginal walking distance were considered.

The study by [7] indicated that Bus stop spacing has a major impact on different type of buses and bus stop performance. Stop spacing also affects overall travel time, and therefore, demand for bus stop. The determination of bus stop spacing is frequently subdivided by development type, such as residential area, commercial, and/or a central business district (CBD).

To solve these challenges, transportation planning is required to eradicate the problems. In recent time, several activities and changes have been taking place in Ibadan that has necessitated the expansion of the existing routes, reorganize the bus stops and to also introduce Bus Rapid transit and possibly rail system in the nearest future. These will be the foundation for a functional urban transportation planning in Ibadan North Local Government Area of Oyo state as a model in Oyo State and other parts of the country at large.

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2.0 MATERIALS AND METHODS

2.1 The Study Area

The study area is Ibadan North Local Government Area and it is one of the eleven local government areas of Ibadan metropolis. It is part of the city of Ibadan and lies between Longitudes 3º 53' 20.922"E and 3º 56' 39.438" E; and between Latitudes 7º 23' 25.101" N and 7º 26' 07.185" N. The area was chosen because of the socio-economic activities in the area which attracts high population and traffic. It is bounded in the north by Akinyele Local Government Area, in the east by Lagelu Local Government Area, at the southern part by Ibadan North East and Ibadan North West Local Government Areas. The study area is as shown in Figure 1. The population of Ibadan North Local Government Area during the 2006 population census was estimated to be 308,119 made up of 152,608 males and 155,511 females [11] and projected with the growth rate of 3.2%. The 2024 population is given as 947,256 according to the estimated growth rate.

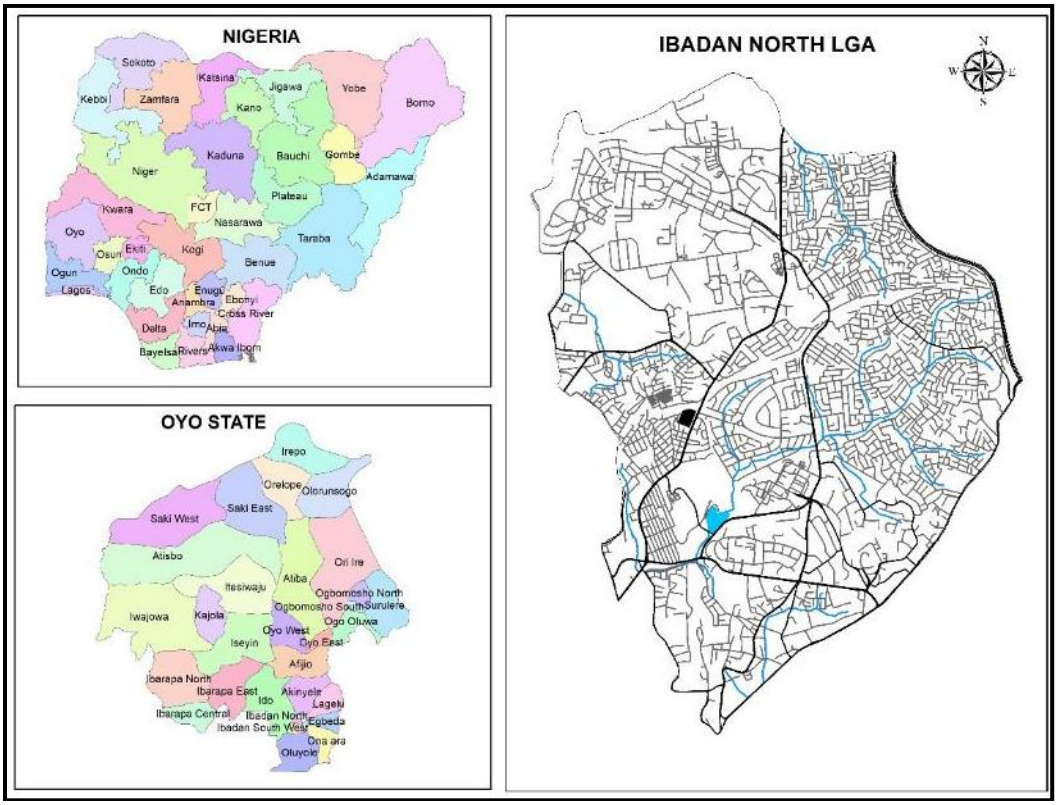

Figure 1. Location of the Study Area (Authors Laboratory analysis, 2024)

2.2 Methodology

Remote Sensing that is one of the tools for data acquisition for this study is a fast means of acquiring data about the environment without physical contact with the features has made significant advances over the past years in providing cost-effective data for mapping [12]. GIS and Remote Sensing in map production allow for the combination of data from different sources as well as the interpretation, manipulation, management, analysis and accurate presentation of map information. GIS is a robust technology that can manipulate, analyze and integrate non spatial (Information about the data captured) with the spatial data to solve the desired problem [13]. The use of GPS also has made data acquisition into a GIS easier, precise, effective and more efficient. [14] adopted Analytical Hierarchy Process (AHP) Approach to locate suitable locations for Bus Rapid Transit corridor.

Data for this study were from primary and secondary sources (Table 1). The primary data were acquired using a handheld GPS which are the locations of the bus stops and the main localities within the study area. The GPS was calibrated to Geographic Coordinate System (GCS) and World Geodetic System 84 (WGS 84) as the datum. The secondary data were from array of sources which were entered into the GIS environment with the use of the implementation software - ArcGIS 10.8.1.

The data for the study was processed by setting up the computer system with feature identification, coding and scrubbing which was to maintain data integrity [15]. The conversion of the analogue data into digital format was also carried out using a scanner. Data conversion according to [15] involves assembling, fitting together, transforming, and compiling diverse geographic spatial and attribute data to represent the specific features that will be entered into the GIS database. This includes locating the various features in their proper relative horizontal positions (planimetry) according to the GIS database's coordinate system, datum, and projection system, for use at the intended scales and the process of data conversion which involves digitizing, edge matching and layering. The analogue map of the study area was scanned, georeferenced and the entities were digitized. ArcCatalog was the tool for data layering and was also used to assign

the coordinate system for the entities. The study area falls within UTM Zone 31N. The digitized data layers were populated with the attribute data from the oral interviews and field observations.

Table 1. Data and Data Sources

S/N	Data	Source	Data Type	Date
1	Location of Bus Stops	Researchers' field work	Primary	2024
2	Localities	Researchers' field work	Secondary	2024
3	Map of the Study Area	Town Planning office, Ibadan	Secondary	2024
4	Imagery of the Study Area	Google Earth Pro Online	Secondary	2024

Source: Authors (2024)

3.0 ANALYSES AND RESULTS

The spatial analyses performed were based on the contents of the database created for the study. The database consisted of the spatial data and the attribute data collected from the field through various means. The map in Figure 2 shows the composite map of the study area. The map consist of the study area boundary that delineates the geographic extent of the area, the major road, the street, the rail line that runs from western part of the study area to the eastern part, rivers that run through the area, water body behind the University College Hospital (UCH), cemetery at Sango and the important locations in the area called locality for the purpose of the study.

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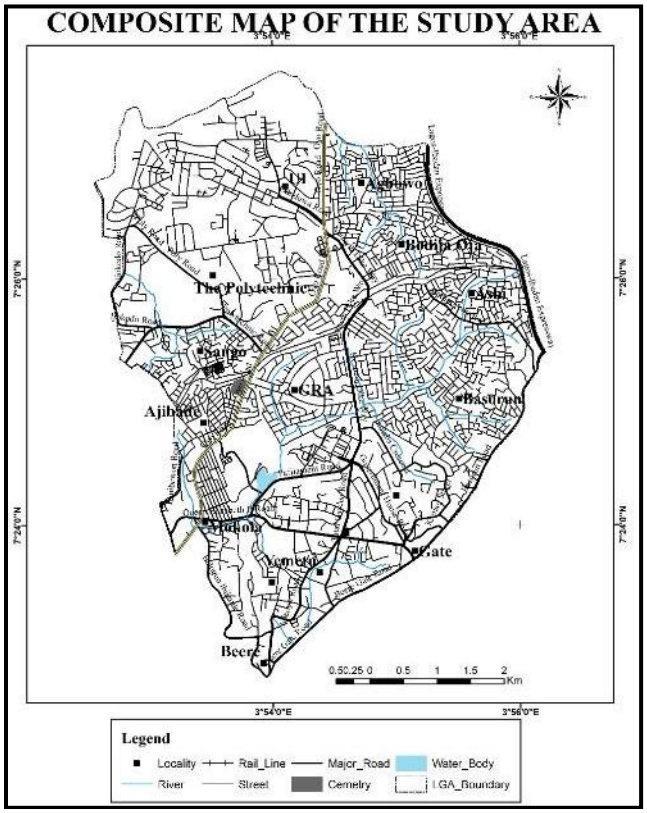

Figure 2. Composite Map of the Study Area (Authors, 2024)

3.1 Bus Stops for Mass Transit

The bus stop is the first point of contact between the passenger and the bus service and is recognized as a crucial element to improve the quality of bus services and is expected to provide required facilities for safe boarding and alighting of passengers [7]. The study at hand looks at the current spacing for Mass Transit Buses that will move over hundred passengers at a time and will not be stopping at the spacing of 400m as specified by [10].

This study considered the future of transportation by adopting 1Km as the least spacing for Bus Rapid Transit bus stop in the study area. The existing bus stops were 55 while the proposed bus stops are 26 as indicated in Table 2 covering a total of six routes and a distance of 29.08Km. The maps in Figures 3 and 4 show the existing bus stops and the proposed bus stops.

Table 2. Bus Stop Redistribution

S/N	Route	Length (Km)	Existing Bus Stops	New Bus Stops
1	Orogun to Mokola	7.31	13	7

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2	Orogun-Agodi-Beere	9.32	23	9
3	Mokola-Agodi Gate	3.36	6	3
4	Sango-Polytechnic	2.55	6	2
5	Beere and Gate Bus Stop	2.80	3	2
6	Gate Bus Stop to Basorun	3.74	4	3
	Total	**29.08**	**55**	**26**

Source: Authors Laboratory Analysis (2024)

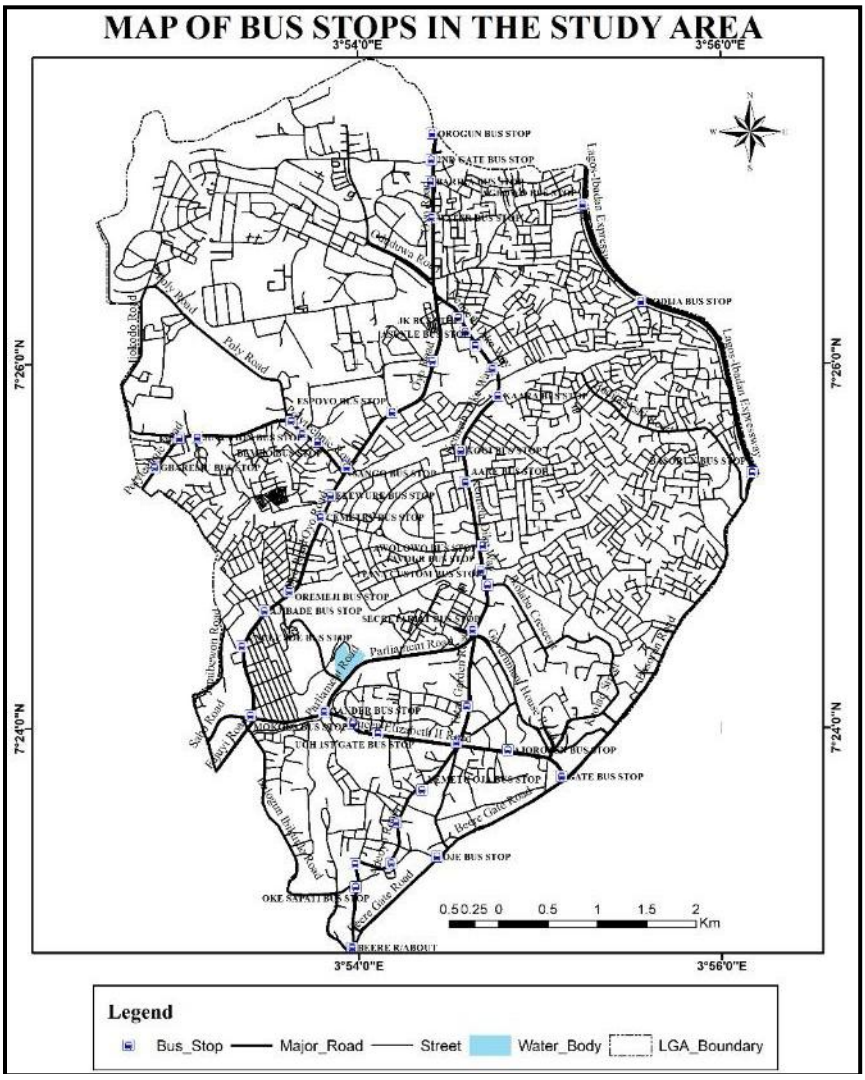

Figure 3. Map of the existing Bus Stops in the Study Area (Authors, 2024)

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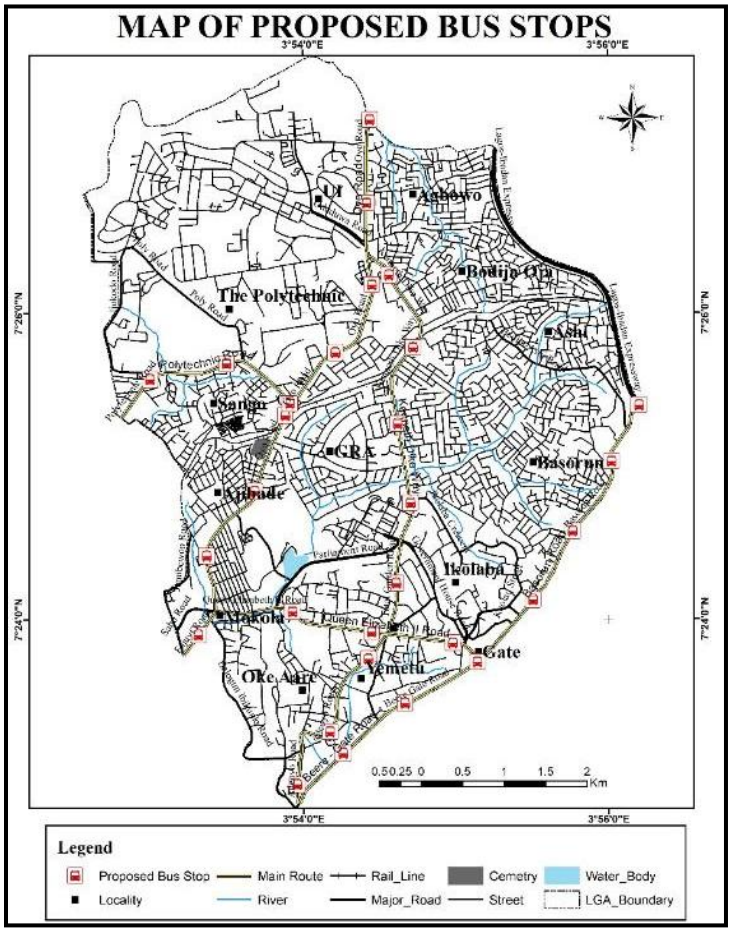

Figure 4. Map of proposed Bus Stops (Authors, 2024)

3.2 Bus Rapid Transportation Service Routes

"Africa's first Bus Rapid Transit (BRT) scheme began operations on March 17, 2008 in Lagos, Nigeria" [16]. The study classified the major roads into five different routes because of the movement of people and goods during or after the peak periods while deploying Mass Transit Buses that will move over a hundred passengers at a time. The routes as shown in Table 3 are Ojoo to Mokola axis (Route 1), Ojoo-Agodi-Beere (Route 2), Mokola-Agodi Gate (Route 3), Sango - Polytechnic (Route 4), Beere - Gate Bus Stop (Route 5) while Gate Bus Stop - Basorun along Lagos Ibadan Expressway was named Route 6. The routes are of different lengths and widths. The

routes are shown in Figure 5 with a formatted map indicating the different routes that were identified along the major roads within Ibadan North Local Government Area of Oyo State.

Table 3. Categories of the routes

S/N	Route	Route Number	Length (Km)	Width (m)
1	Ojoo to Mokola	Route 1	7.31	25.02
2	Ojoo-Agodi-Beere	Route 2	9.32	20.18
3	Mokola-Agodi Gate	Route 3	3.36	21.29
4	Sango-Polytechnic	Route 4	2.55	20.05
5	Beere and Gate Bus Stop	Route 5	2.80	14.39
6	Gate Bus Stop to Basorun	Route 6	3.74	20.63

Source: Authors Laboratory Analysis (2024)

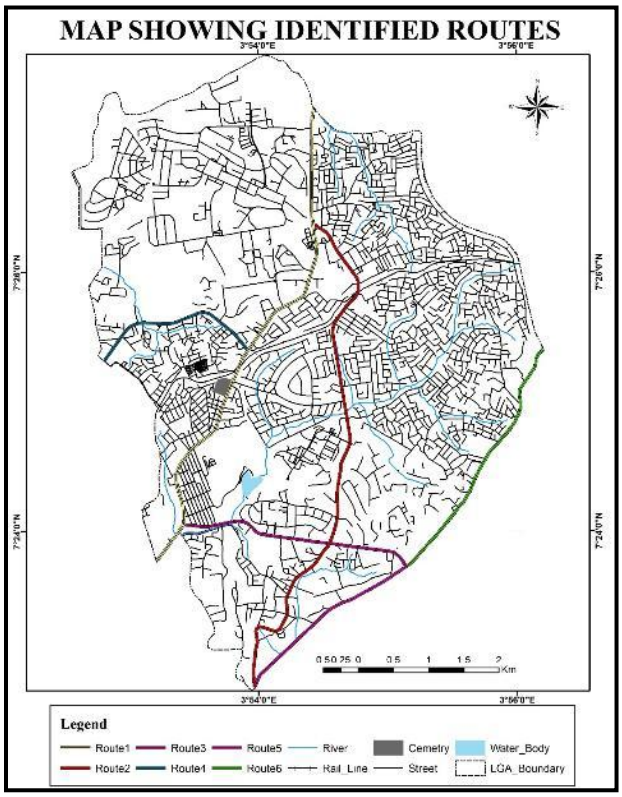

Figure 5. Map showing the classified routes (Authors, 2024)

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3.3 Buffering for the expansion of existing roads

Buffering was used in this study to look at the setback of these routes as it concerns the facilities along the roads. The intention of the study was to create additional lane along these routes that were identified as the major roads that carry a lot of traffic within the study area. Buffering is the area of influence around a feature [17] and described Buffer zone as an area of a specified width drawn around one or more map elements. The essence of the operation was to add a few metres to the existing road width for either Bus Rapid Transit that will serve as a mass transit to move passengers along the added lane which will be dedicated to that purpose alone or it can also serve as a way of making more space to accommodate more vehicles at a time which will reduce congestion along the routes.

The first operation was on the first route which is the Orogun-Mokola road. The boundary of the local government starts at the valley around Orogun Bus Stop at the northern part of the study area and terminates at Mokola Round about in the southern part of the study area. The route can continue and move into other local governments within Ibadan Metropolis. This is an advantage because most of the passengers move beyond Mokola which is where the route ends in the local government. Figure 6 shows the buffering of the route by 10m which is extending the road by 10m on either side of the existing road.

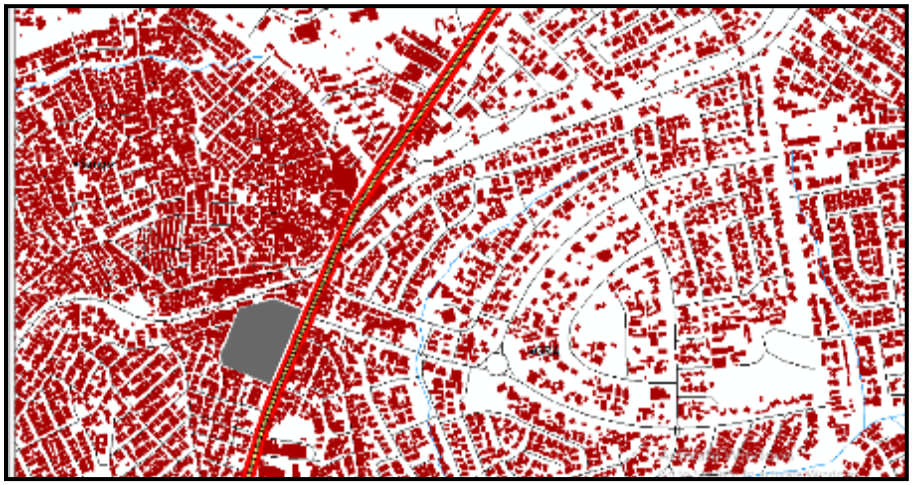

Figure 6. Buffering of Route 1 by 10m (Authors Laboratory analysis, 2024)

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3.4 Selection By Location

After buffering the road with the specified distance, the Selection By Location tool of the implementation software was used to select the buildings that fall within the setback. The output from the buffering operation served as the input into the Selection by Location operation. The number of buildings within the setback from the beginning of the route at Orogun Bus stop to the end of the route at Mokola under bridge was Two Hundred and Twenty Two (222) which serve various purposes in the study area and shown in a map (Figure 7). This process was repeated for the six routes and the result presented in Table 4.

Table 4. Buildings within Right of Way

S/N	Route	Length (Km)	Old Width (m)	New Width (m)	Buffer Type	Buildings Affected
1	Ojoo to Mokola	7.31	25.02	45	Both Sides	222
2	Ojoo-Agodi-Beere	9.32	20.18	35	Both Sides	279
3	Mokola-Agodi Gate	3.36	21.29	40	Both Sides	205
4	Sango-Polytechnic	2.55	20.05	40	Both Sides	226
5	Beere and Gate Bus Stop	2.80	14.39	30	Left Side	73
6	Gate Bus Stop to Basorun	3.74	20.63	30	Left Side	0
	Total	29.08				1005

Source: Authors Laboratory Analysis (2024)

The buffering of the routes were carried out on both sides of the roads except Beere/Gate and Gate/Basorun that falls on the boundary of the local government where the other side of those roads fall in another local government. One thousand and five (1005) buildings were affected by the expansion.

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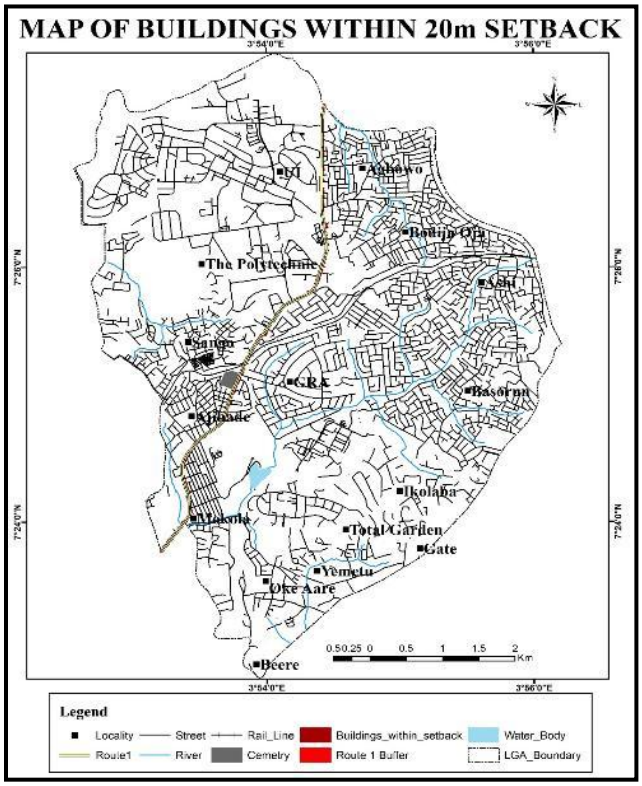

Figure 7. Map of buildings within the setback on Route 1 (Authors, 2024)

3.5 Rail line as a complementary Transportation System

The main road from the northern boundary of the study area from Ojoo axis to the Mokola area after the roundabout is a stretch of 7.37Km. This route is always busy at the peak period during the rush hours of the day in the morning and afternoon due to movement of workers and other road users to and from one part of the city to another at these periods. The rail system can be a complementary service to serve as mass transit for the road users at these periods which can decongest the roads thereby reducing the traffic on this major route and also elongate the life cycle of the roads. It will also reduce the stress people go through in the traffics and also reduce the emission of greenhouse gases which can cause urban heat around the study area.

Likewise, the Mokola to Gate Bus Stop route which is about 3.36Km can also be complimented with the services of light rail which can serve people from Mokola Roundabout to Gate Bus stop and can be extended beyond the boundary of the local government to the

neighbouring local governments like Ibadan North East and towards Egbeda local Government along Ife Road. The rail line altogether will be on a stretch of 10.73Km if it is implemented.

3.5.1 Buffering for the Rail system

The criteria for the location of a rail line is that it must not be less than 30m from utilities like buildings and other related structures because of noise and dangers inherent in the closeness to facilities [18]. It is with this condition that the main road was buffered by 30m so that the structures along the right of way can be known and the number determined for appropriate valuation and compensation when eventually the rail system is actualized. The rail line's right of way was added to the width of the existing route. The width of the first route (Orogun to Mokola) and the second route (Mokola to Gate) which were initially 25m and 21m were buffered to become 55m and 51m width respectively. The diagram in Figures 8(a & b) represent the buffering of the route between Orogun and Mokola by 30m from the centre line.



(a) (b)

Figure 8. Buffering of both sides by 30m (Authors Laboratory analysis, 2024)

Table 5. Number of Buildings within setback of the proposed rail line

S/N	Route	Route Width (m)	Buildings on the Right Side	Buildings on the Left Side	Total Number of Buildings
1	Orogun to Mokola	60	61	297	358
2	Mokola-Agodi Gate	60	61	68	129

Source: Authors Laboratory Analysis (2024)

The proposed rail systems will be suitable on the busy routes along Orogun to Mokola and Mokola-Agodi Gate. The affected buildings were put at 358 and 129 along Orogun to Mokola and Mokola-Agodi Gate respectively as shown in Table 5. This makes the total number of buildings to be affected by the rail system at 487.

4.0 CONCLUSION AND RECOMMENDATIONS

The use of GIS and allied technologies has shown that transportation planning in urban centres like Ibadan and also solving spatial problems is possible. This study showed that a lot can be done using GIS tools as seen in the case of predicting the future of the major routes in the study area and the use of the relevant tools as shown to predict the number of buildings that will be affected when there is expansion of the roads to ease congestion and the introduction of rail system cum Bus Rapid Transit system in the nearest future. The selection by location tool used to select buildings within the buffer zones of the roads can also be used to select features within areas of influence of phenomenon like flooding, forest zones and so on. The various analyses carried out to actualize the aim and objectives of the study were able to do so and the results were presented in a form that can be analyzed for decision making processes. After carrying out these analyses, it was concluded that the aim and objectives of this research were achieved.

The recommendations at the end of the study includes further study that will consider road junctions when considering bus stops, congestion index along the major routes should be determined, models for optimal and the alternative routes should be determined, findings from this

study should guide the future transportation planning in the study area while GIS should be encouraged in day-to-day running of the Town Planning Offices in the study area and in the country at large.

References

[1] Akomolafe, D.T; Adekayode, F.O; Gbadeyan, J. A. & Ibiyemi, T. S. (2009). Enhancing road monitoring and safety through the use of geospatial technology. International Journal of Physical Sciences. ***4***(5), 343-348

[2] Ogunbodede E. F. (2008). Urban Road Transportation in Nigeria from 1960 to 2006: Problems, Prospects and Challenges. *Ethiopian Journal of Environmental Studies and Management*. ***1***(1): 1-25

[3] Mobereola, D. (2009). Lagos bus rapid transit. SSATP Discussion Paper No. 9. Urban Transport Series. 4

[4] Udoh, I.B. & Igbokwe, J.I. (2014) Production of Revised Street Map of Uyo Urban Area, Nigeria Using Remote Sensing and GIS Approach. *International Journal of Engineering Research and Technology.* ***3***, 1792-1799

[5] Shatnawi, N., Al-Omari, A.A. & Al-Qudah, H. (2020). Optimization of Bus Stops Locations Using GIS Techniques and Artificial Intelligence. *Procedia Manufacturing*. ***44,*** 52–59. Available online at www.sciencedirect.com; accessed on 25th January, 2025

[6] Thondoo, M., Marquet, O., Márquez, S. & Nieuwenhuijsen, M. J. (2020). Small cities, big needs: Urban transport planning in cities of developing countries. *Journal of Transport & Health*, ***19***, 2020, 100944, ISSN 2214-1405. https://doi.org/10.1016/j.jth.2020.100944.

[7] Prathibaa, K. & Gunasekaran, K. (2016). Planning of Bus Stops for Safe and Efficient Passenger Boarding and Alighting. International Journal of Engineering Research & Technology (IJERT). ***5*** (6), 296-304. http://www.ijert.org ISSN: 2278-0181

[8] Fatunmibi, O. (2018). Assessment of Bus Stops and Its Effects on Major Roads in Ibadan Metropolis, Oyo State, Southwest Nigeria. *International Journal of Engineering Sciences & Research Technology.* ***7***(8), 1-12

[9] Daudu, P.I.U., Jibril, M.S. & Yashi, J. (2022). Spatial Analysis for Determining Accessibility to Bus Stops in Kaduna Metropolis. *Journal of Geographic Information System*. ***14***, 78-93. https://doi.org/10.4236/jgis.2022.141005

[10] Adebola, O & Enosko, O. (2012). Analysis of Bus-stops locations using Geographic Information System in Ibadan North L.G.A Nigeria. *Industrial Engineering Letters*. ***2*** (3), 20-37. ISSN 2224-6096 (print) ISSN 2225-0581 (online)

[11] National Population Commission (2006). National Population Census figure 2006

[12] Garba, H.A., Ojeh, V.N., Elijah, E. & Ayeni, B.E. (2018). The Use of GIS and Google Earth Images for Mapping of Taraba State University Campus. *Asian Journal of Geographical Research.* ***1***(1), 1-16; Article no. AJGR.40306

[13] Kolawole, I. S., Alaga, T. A., Ogunyemi, S. A., Popoola, O. S., & Oloko-Oba, M. O. (2016). Street mapping of Ife metropolis, Osun State, Nigeria. *Journal of Geographic Information System*. ***8***, 387-395. DOI: 10.4236/jgis.2016.83033

[14] Bhuiya, M.R., Rafiq, R., MdMorshed, K.N. & Rahman, M.I. (2023). Suitable Bus Stop Locations for a Proposed Bus Rapid Transit Corridor in a Developing Country City: An Analytical Hierarchy Process Approach. Transportation in Developing Economies. 9(10), 1-17. https://doi.org/10.1007/s40890-023-00179-6

[15] Lanter, D. (2008). Database Design in *Encyclopedia of geographic information science. Ed. Kemp, K.K.* Sage Publications Inc., 2455 Teller Road Thousand Oaks, California 91320. pp 66-69

[16] Dickson, O. (2015). Technical Inoovations in Bus Rapid Transit System in Lagos State: Operations and Infrastructure. Lambert Academic Publishing, Germany. ISBN 978-3-659-77178-1

[17] Aronoff, S. (1989). Geographic Information Systems: A Management Perspective. WDL Publications, Ottawa, Canada. ISBN 0-921804-91-1

[18] Nikitas, A. & Karlsson, M. (2015). A Worldwide State-of-the-Art Analysis for Bus Rapid Transit: Looking for the Success Formula. Journal of Public Transportation. ***18***(1), 1-33. doi.org/10.5038/2375-0901.18.1.3