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Routing and Scheduling of the Federal University of Technology Akure Campus Shuttle-A Geographical Information System Approach

Olugbenga Joseph OYEDEPO[1], Joshua ALADEJUYIGBE[2], Japheth Eromietse ETU[3], Rotimi EKUDEHINMI[4], Samuel Olumide AKANDE[5]

[1,2,3,4]*Department of Civil and Environmental Engineering, Federal University of Technology, Akure, Ondo State, Nigeria*
ojoyedepo@futa.edu.ng/jaaladejuyigbe@futa.edu.ng/jeetu@futa.edu.ng/rekudehinmi@futa.edu.ng

[5]*Centre for Space Research and Applications (CESRA), Federal University of Technology, Akure, Ondo State, Nigeria*
soakande@futa.edu.ng

Corresponding Author: jeetu@futa.edu.ng

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Abstract: *Geographical Information System (GIS) was applied to the routing of campus shuttle in the study area to determine the optimum route for safe, effective and efficient transport services. Google earth professional was utilized to extract both the Federal University of Technology, Akure (FUTA) road network imagery and the coordinates of some prominent places in the University. The road network map was geo-referenced, digitized with ArcGIS 10.2.1 and converted to a network analysis data set utilizing ArcCatalog. A maximum trekking distance of 200 metres from the existing bus stop to the service area was adopted to reduce students' travel time and maximize serviceability of the campus shuttle. The network analyst of the ArcGIS was used to analyse and determine the best routes for all service areas. The findings revealed that only 40.5% of all service areas in the school are currently being served by ten bus stops, while five new bus stops leading to an increase of 41.8% in the places that will be serviced over that of the existing bus stops was proposed. Hence, GIS is a veritable tool for vital decision making in transportation planning and for determining an optimal path.*

Keywords: *Geographical Information System, Road Network, Routing, Scheduling, Transportation Planning.*

1. INTRODUCTION

The Geographical Information System (GIS) is a collection of computer hardware, software, and geographic data for capturing, managing, analyzing, and displaying all forms of geographically referenced information [1]. In school bus transportation, the two most visible problems are routing and scheduling; in routing, students are assigned to a bus stop and those particular stops are summed up to form routes. In the morning, a bus follows these routes from one bus stop to another, picking up the students and carrying them to school. However, in the scheduling problem, particular buses are assigned to particular routes, for instance, in the morning bus A might begin at route 1, deliver the students from that route to their school, travel to the beginning of route 5, pick up the students along that route and take them to their school. In practice, it is possible and desirable to have one bus covering several routes [2].

The demand for road networks in Federal University of Technology, Akure (FUTA) is bound to increase due to the growing population and increase in infrastructural facilities. According to [3] there has been alteration in the original master plan of the University to accommodate the rapid rate of development. Hence, the need for proper routing and scheduling of campus shuttles using GIS to effectively and efficiently cater for the increasing population.

1.1 The Study Area

FUTA is in Akure the capital of Ondo State, South West Nigeria. Akure lies between latitude 7˚ 5′ 0″ and 7˚ 20′ 0″ north of the equator and between longitude 5˚ 5′ 0″ and 5˚ 20′ 0″ east of the meridian. The University has six schools namely: School of Environmental Technology (SET), School of Engineering and Engineering Technology (SEET), School of Agriculture and Agricultural Technology (SAAT), School of Earth and Mineral Sciences (SEMS), School of Sciences (SOS), School of Management Technology (SMAT), and School of Health Technology (SHET). It has administrative blocks, staff quarters, academic buildings, and student hostels, staff primary and secondary schools among others. Also, five commercial banks are located within the University campus. The University has a population of 15,000 students, i.e., 13,000 undergraduate and 2,000 postgraduate students [4]. The road network is fairly connected together, having 2.30 km major road network connecting the North to the Southern part of the campus. Thus, it becomes necessary to ensure that the network

of roads is properly scheduled and the transportation facilities are well distributed within the university campus. Figure 1 shows the FUTA road network map.

2. LITERATURE REVIEW

Transportation, the process by which humans, vehicles and other commodities moves from one geographic location to another. GIS is a complete computer system, which gives clear information about where things are located and gives detailed idea about what data it represents [5]. It is a mature technology that has been applied in many fields of endeavour, among which is transportation engineering and transportation planning. Many organizations and governments are using GIS because it helps them to make decisions very quickly and it saves a lot of time and money.

Selecting the best route through an area is one of the oldest spatial problems. But lately, this problem has been effectively solved with the help of GIS and Remote Sensing technologies. Several studies have been conducted using GIS techniques especially in highway, forest, roads and bike roads routing determination [6,7]. GIS has also been used in based route determination for railway [8], irrigation/drying channels [9], power line [10]. Results from these studies showed that the route which was designed applying GIS is more environmentally helpful and cheaper than traditional one, while [11] affirmed that GIS software enhances the abilities of school boards to deliver an efficient and effective student transportation system.

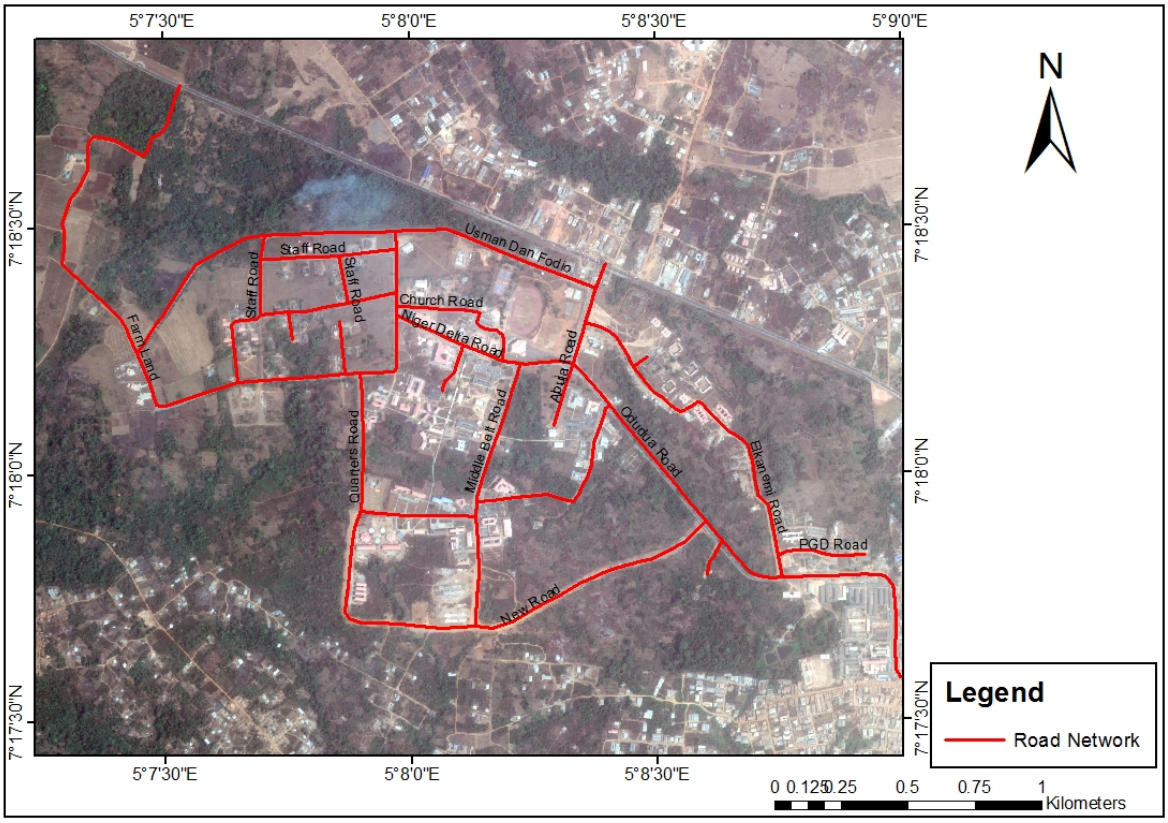

Figure 1: Digitized map of Existing FUTA road network
Source: Authors' Digitization, 2016

A systematic approach in determining the dynamically varying parameters and implementation attributes that were used for the development of a Web-based transportation routing application integrated with real-time GIS services was conducted by [12]. These features of the study help users and vehicle drivers in improving their service levels and productivity as the web application enables them to interactively find the optimal path and in identifying destinations effectively. GIS-Based road transport information management system was developed by [13] for Adamawa Central using ArcGIS software. The study also revealed dearth in road infrastructure facilities in the study area and therefore, recommended that government should establish GIS unit in the federal and state ministry of transport board and also encourage the local government areas to do the same for proper planning, development and management of road transport infrastructure. A research on Dynamic road segmentation of part of Bosso Local Government Area of Minna, Niger State, Nigeria using an IKONOS image of 1-m Pan-sharpened spatial resolution and other field survey acquired data was carried out by [14]. The result highlighted the present road pavement condition of the considered road segments, adjacent land use, traffic congestion rate, notable crime spots and accident hotspots. It also suggested that the building up of traffic congestion along the Kpakungun round about axis is due to the road width (8m), high traffic volume and the dilapidating state of the road's pavement and recommended that an alternate route be constructed to solve the reoccurring problem of traffic congestion in the Kpakungun axis. In another

study by [15], implementation of GIS concept in transportation planning was shown. He describes alternative strategies for planning support system of the traveling salesman problems so as to determine the shortest paths between points and set the path of multiple points in the optimum sequence with vehicle reschedule in Khonkhan Province, Thailand. The outcome of the study demonstrates that vehicle route planning has led to fuel consumption reduction by about 4.9% per month. There by making it a cost-effective tool for transportation planning.

Previous studies above have shown that using the GIS Software, buses can be routed to give the best service for the maximum number of students and routes can be planned to give the most economical operation of buses. Consequently, this study carried out routing and scheduling of the campus shuttle service in FUTA using GIS to make the shuttle service more effective.

3. RESEARCH METHODS

Google earth pro was used to extract FUTA road network imagery and to obtain coordinates of some prominent places for geo-referencing on ArcGIS interface so as to get their real positions placed on the map thereby determining the accurate location of the road networks for the analysis. Each road network, bus stops and service areas were traced out from the geo-referenced Google earth imagery so as to generate the road network shape file *by digitizing. Digitizing* in *GIS* is the process of "tracing", in a geographically correct way, information from images/maps. A buffer distance of 200m representing a maximum trekking distance from the bus stops to various service areas was created so as to determine area serviced by the bus stops. The road network shape file generated from digitizing was converted to the road network analysis dataset. The length of each road network was calculated using 'calculate geometry' tool in ArcGIS, while the speed limit within the school premises was added to the road network dataset through the attribute table to calculate the time in minutes from the length of road (distance) and speed limit (velocity) using the 'field calculator' tool. The network analyst component of the ArcGIS was later used to schedule the campus shuttles for every day of the week through optimum routes, number of bus stops and service areas based on distance, time or alternative routes. With these results relevant proposals were made.

4. RESULTS AND DISCUSSION

4.1 Existing Road Network, Shuttle Route, Bus Stops and Service Areas

Figure 2 shows that the Campus shuttle currently uses only 6 of 21 available routes to provide transportation service for the university campus. It can also be seen from Figure 2 that the network comprises 10 bus stops that are used to service the FUTA campus. The Campus shuttle bus stop is located at the south gate from where the buses originate to service 5 of these bus stops at the bank and academic area, 2 bus stops are used to service the students' hostel and the residential areas at the Northgate, while the remaining 2 bus stops are situated in the Obakekere Campus of the university and they service the Postgraduate hostel and Old library area.

Figure 5 shows the existing service area, created using the 200m buffer around the bus stops, it shows that only 32 (i.e. about 40.5%) out of a possible 79 service areas are being covered by the existing bus stops. This shows that the existing bus stops service area is one-sided.

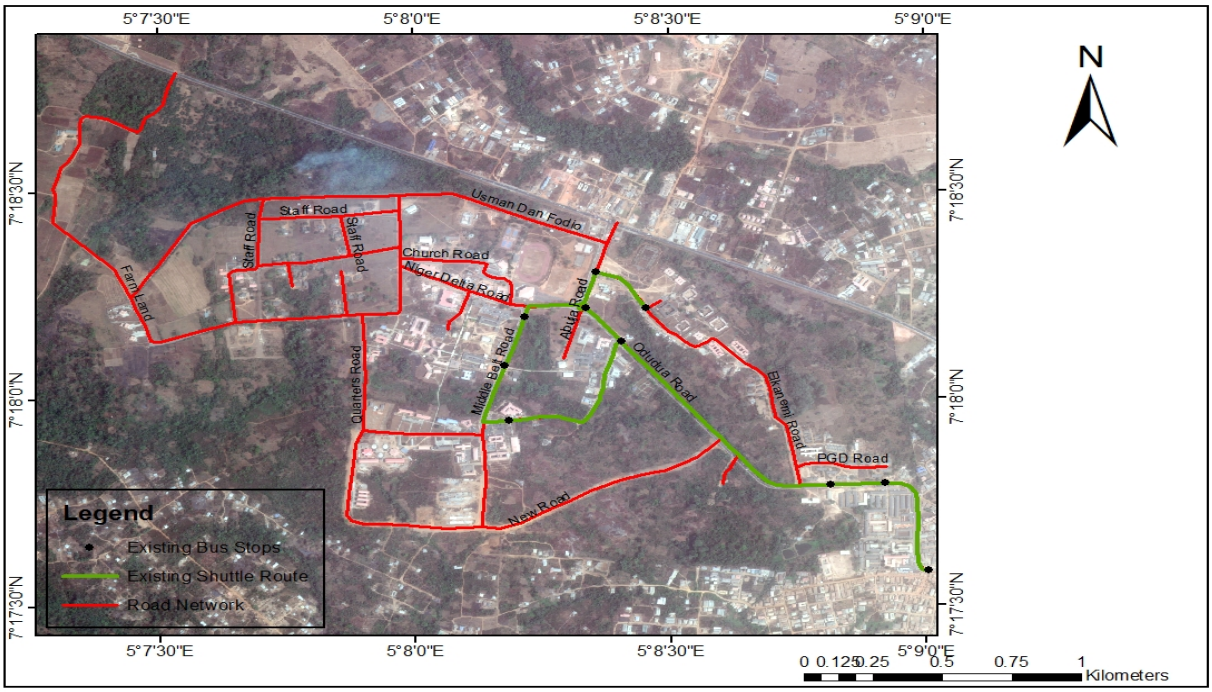

Figure 2: Digitized Map of Existing Campus Shuttle Route and Bus Stops
Source: Authors' Digitization, 2016

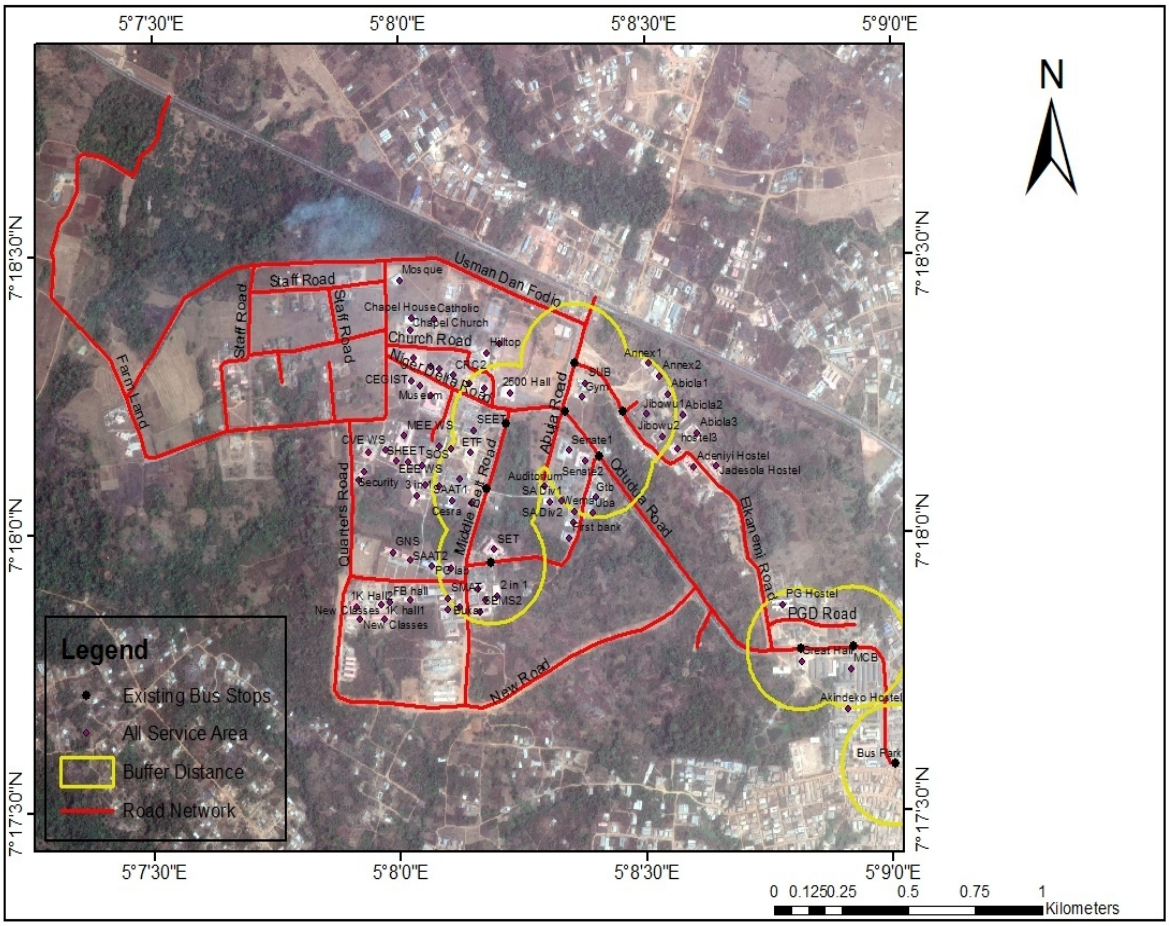

Figure 3: Digitized Map of areas serviced by existing bus stops
Source: Authors' Digitization, 2016

4.3 Scheduling of Best Route for Daily Trips

Best Service Route for Monday to Saturday Morning

Figure 5 shows the best route road network for campus shuttle bus for morning service on Monday to Friday. 8 bus stops including the bus park would be utilized. As seen in Figure 5 the best route will be for the campus shuttle bus to move from the bus park to Senate, SET/SEMS, SAAT, SEET, Library, CRC, Security and First bank hall bus stops consecutively and then return to the park through the newly created academic road. However, for Saturday morning as shown in Figure 6, when 200 level students go to the school farm, campus shuttles leave the bus park to Northgate and then to the farm bus stop. The bus would go back through the library road so as to pick students who are going to the south gate from the academic area.

Sunday Morning Best Service Route

Figure 7 shows the bus stops, service areas and best route that would be used to service these areas on Sunday morning. The major commuters will be Christian students going to their various churches for Sunday worship and 7 bus stops are going to be put into use in utilizing the best route. The order of transit from the map shows that the campus shuttle leaves the Bus park to the chapel bus stop to service those going to chapel and Catholic Church from where it moves to the SUB bus stop to service those going to fellowships at Northgate and to pick up those going to fellowships at south gate from north gate. The campus shuttle next stop would be at Jibowu, Adeniyi and PG hostel bus stops consecutively to pick those going to church and fellowships at south gate area.

Afternoon Best Service Route for All Days

As shown in Figure 8 the order of transit in the afternoon sees the campus shuttle begin its movement from the bus park at south gate from where it moves towards the academic area, first to service those going for afternoon lectures and in the process, pick up those going back home from the academic area. The special case of Friday afternoon as in Figure 9, which sees Muslims going to mosque, led to the creation of a new route which sees the shuttle go to the mosque bus stop from the SEET bus stop before heading to the SUB bus stop from where it would service the Jibowu hostel, Adeniyi hostel, PG hostel, MCB, and Akindeko bus stops consecutively before finally stopping at the south gate bus park.

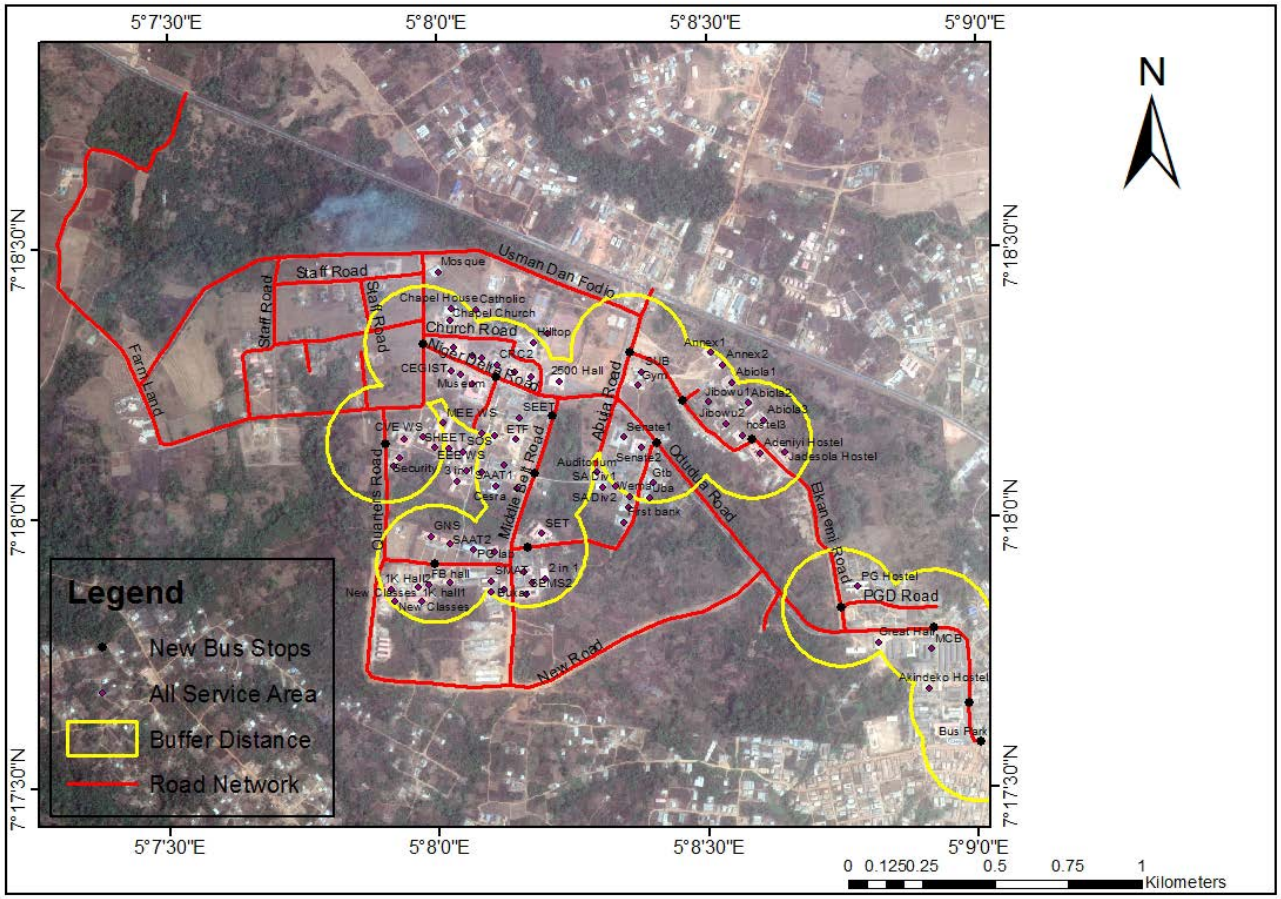

Figure 4: Map showing proposed bus stops and service areas.
Source: Authors' Digitization, 2016

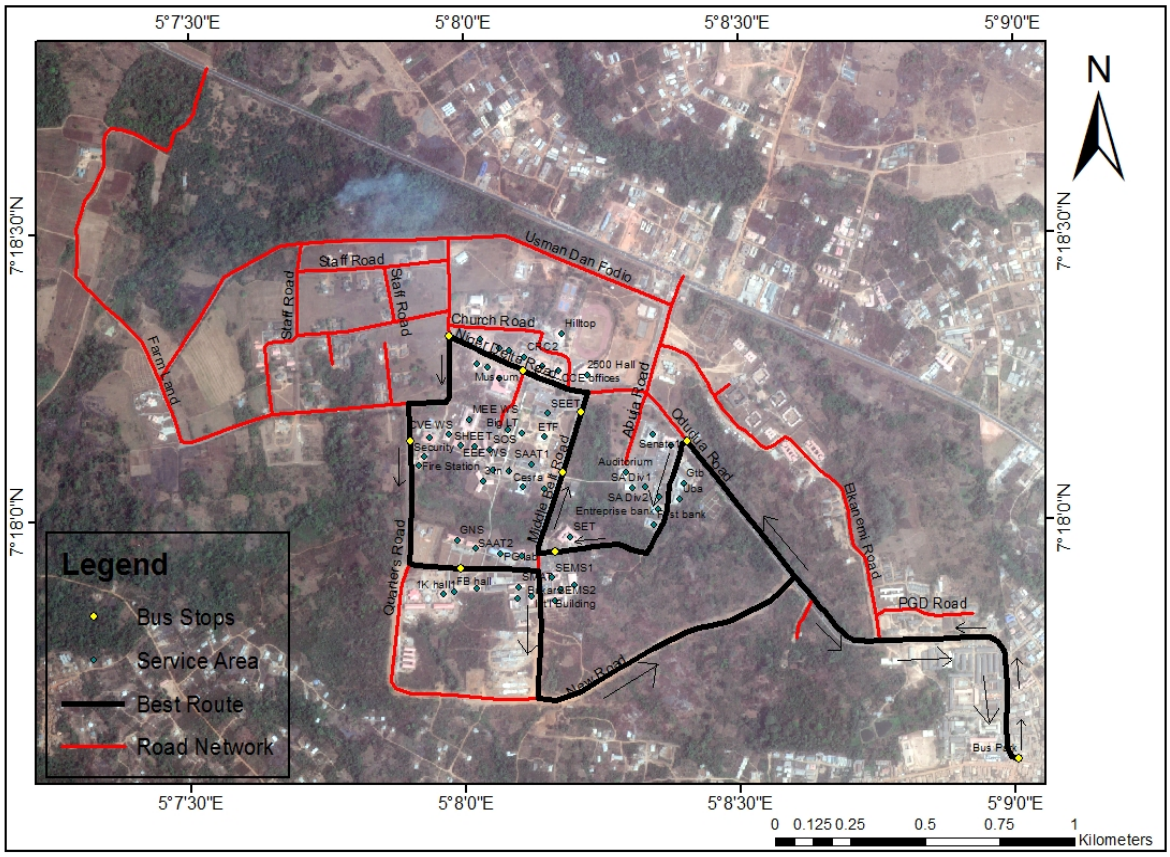

Figure 5: Map showing best route for Morning Service Area from Monday to Friday.
Source: Authors' Digitization, 2016

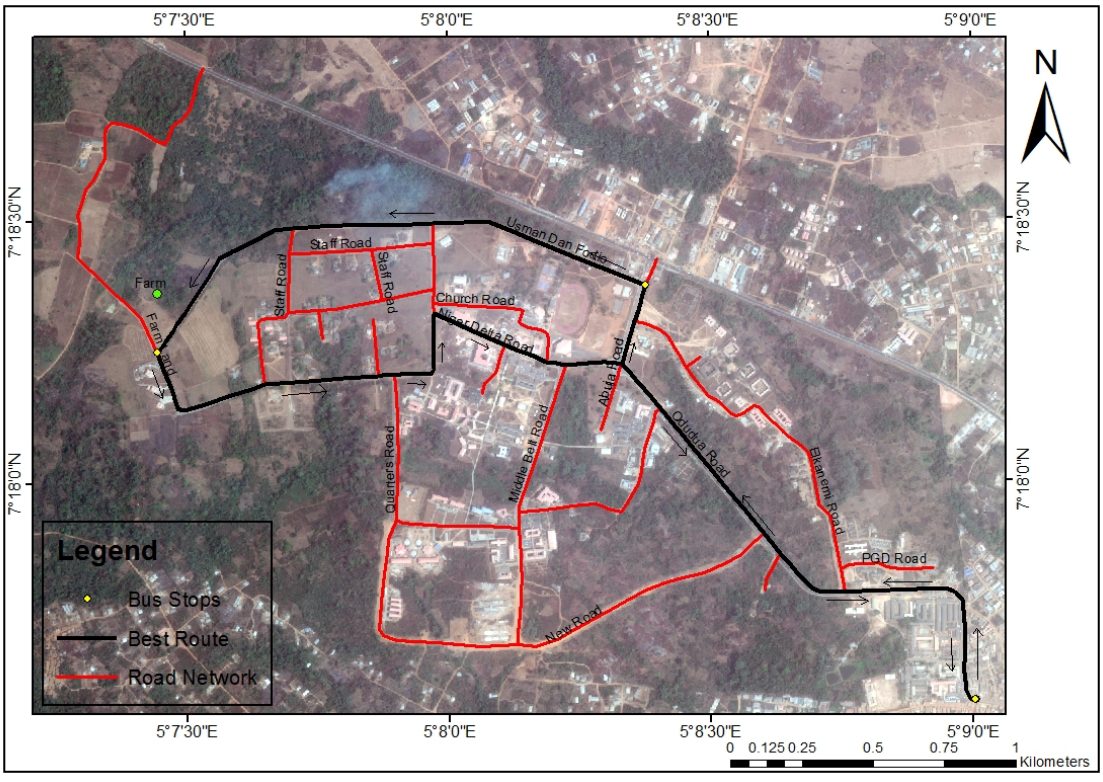

Figure 6: Map showing Saturday morning best route to service the farm area
Source: Authors' Digitization, 2016

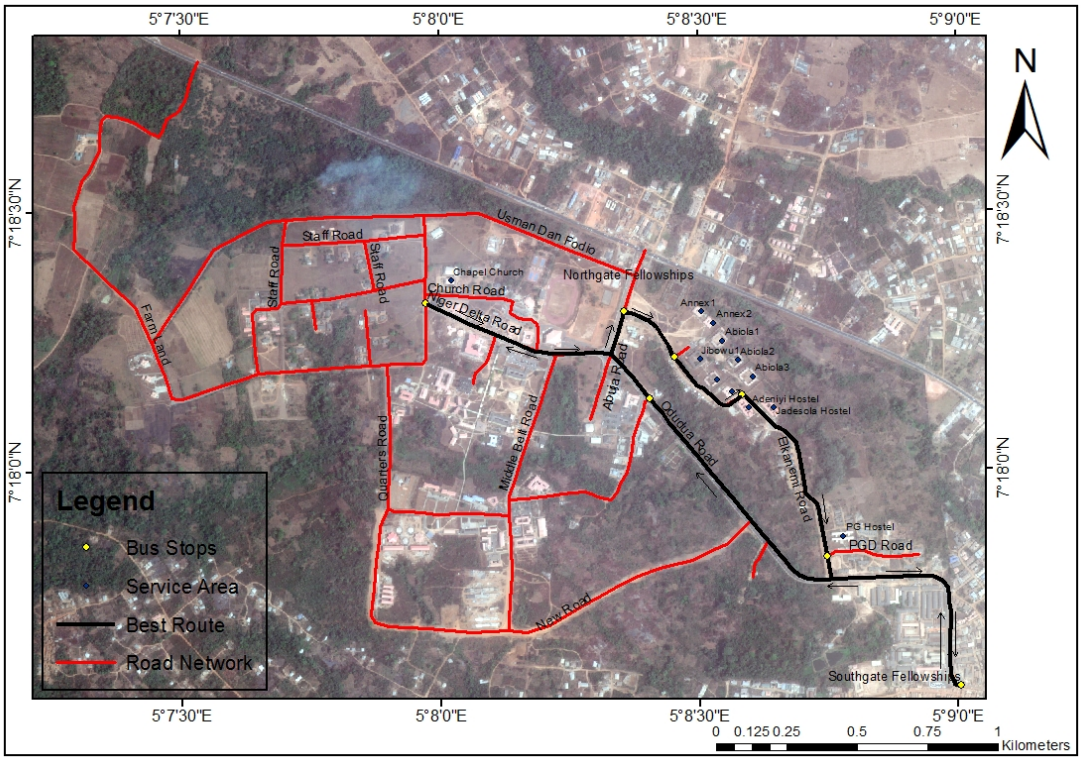

Figure 7: Map showing Sunday Morning service route
Source: Authors' Digitization, 2016

Best Service Route for Night Periods

During the night from Monday to Sunday, the usual pattern of movement sees students heading towards class areas, north gate, hostel area and south gate. The best route and number of bus stops to service these areas are shown in Figure 10. The best route derived from the ArcGIS utilizes 11 bus stops for its operations at this period of the night. The order of movement for this route sees the campus shuttles leave the bus park to the bank junction, from where it moves to the SET, SAAT and SEET bus stops consecutively. All these bus stops would be used to service those going to the academic areas to read at night. The next stop would be at SUB to service those going to SUB and north gate. The bus then moves to Jibowu, Adeniyi and PG hostel bus stops to service all those going to the hostels. The next stop would be at old library, the next stop would be at Akindeko and the last stop would be at the bus park.

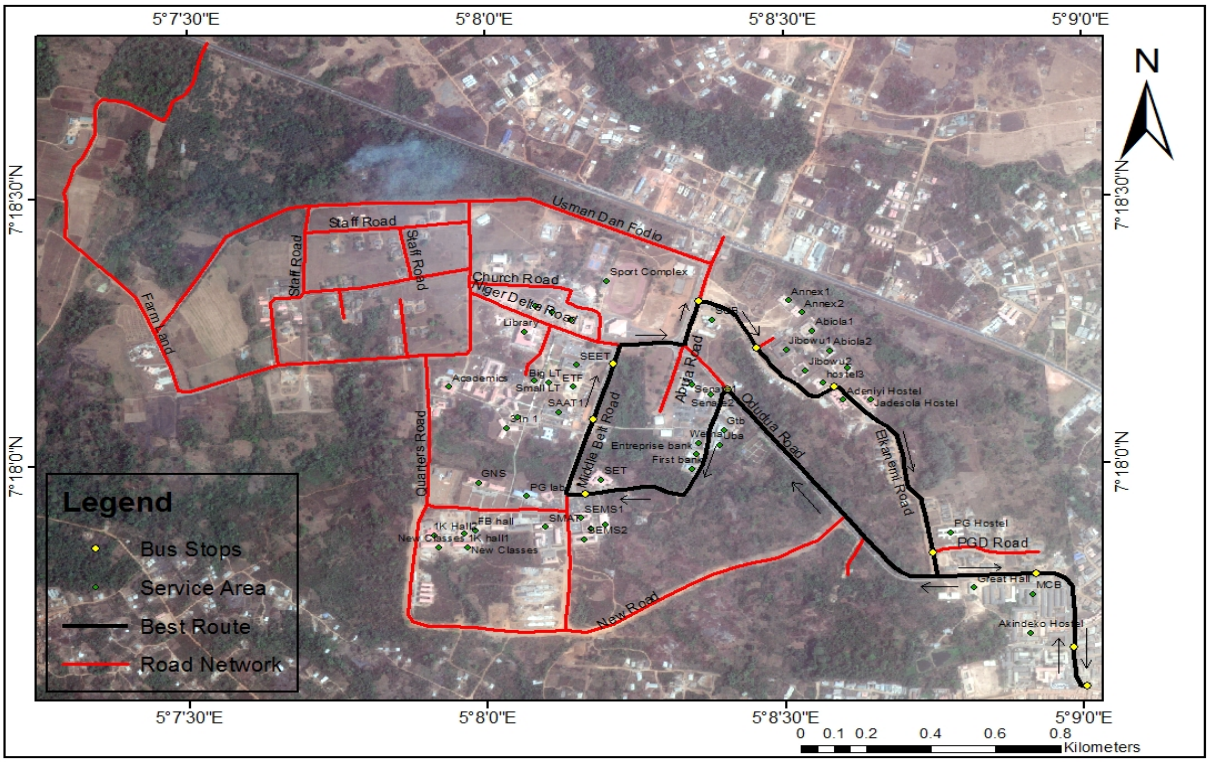

Figure 8: Map showing best route for afternoon service for Monday to Thursday, Saturday and Sunday
Source: Authors' field work, 2016

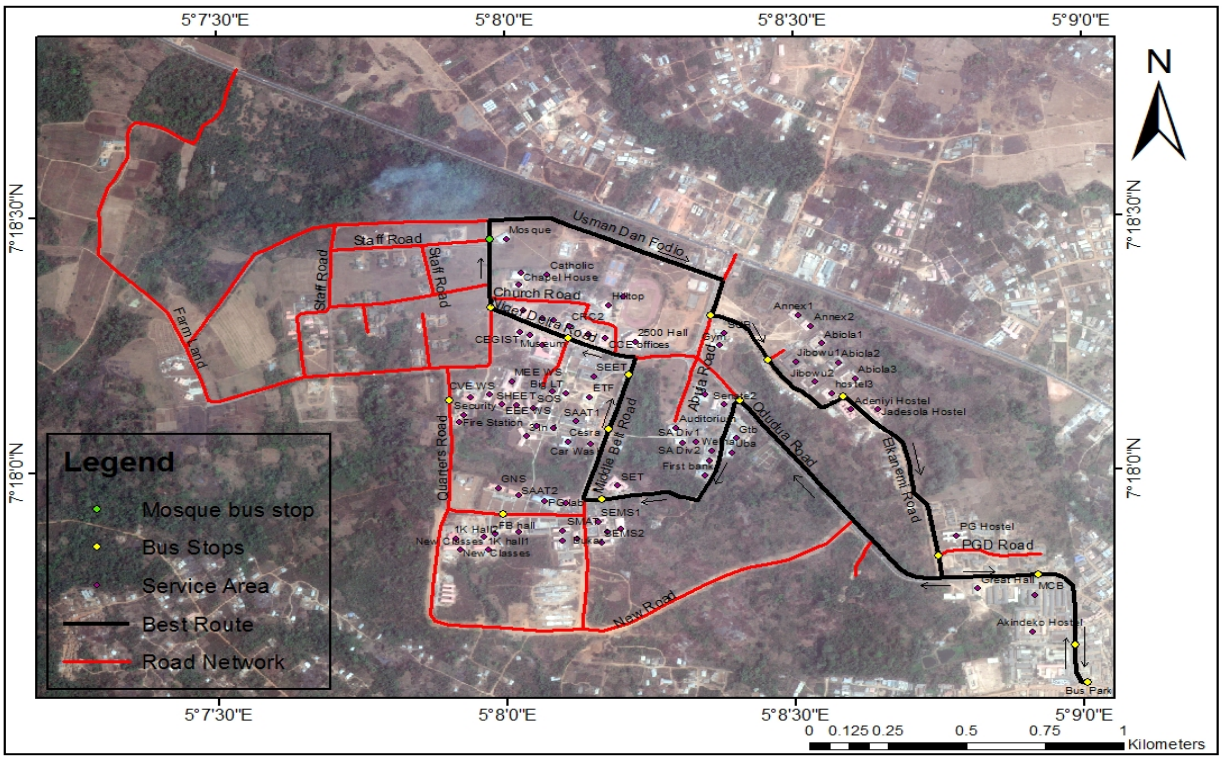

Figure 9: Map showing best route for afternoon service for Friday
Source: Authors' Digitization, 2016

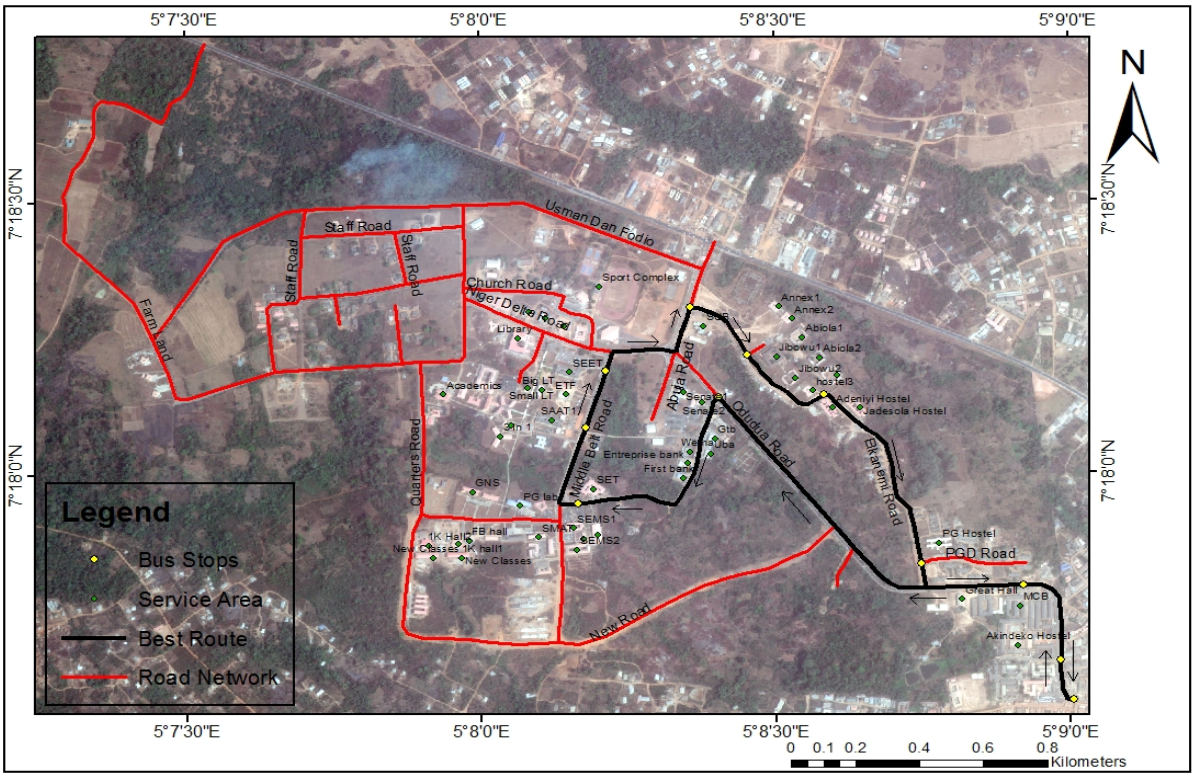

Figure 10: Map showing best route for night service for Monday to Sunday
Source: Authors' Digitization, 2016

5. CONCLUSION

It has been discovered that campus shuttle services on FUTA campus has been one sided, which has made it largely ineffective over time. Only some set of people benefit from the current route followed and service provided by campus shuttle in FUTA. Geographical Information System (GIS) was used to analyze this problem and to provide solutions using the network analysis tool in ArcGIS software so as to make the service more effective.

New bus stops were proposed to adequately service all areas of the campus usually visited by the students, since the students are the major passengers of the campus shuttle. This led to an increase in the number of bus stops from 10 to 15 and an increase of 41.8% in the number of service areas. The study also proposed construction of a new road linking the Postgraduate Hostel and the Undergraduate hostels so has to ensure proper functioning of the optimum route proposed. Routes and bus stops were also created for special cases and scenario like the Friday afternoon for those going to mosque, Saturday morning for those going to farm and Sunday morning for those going to church.

These increases in number of bus stops and service areas will increase the coverage of the shuttle buses and in turn give students better access to the shuttles' service on the campus of the Federal University of Technology, Akure, thereby making for a much more effective shuttle system. GIS has been proven in this study to be an efficient and reliable tool to solve transportation problems and should be expanded in future research to better utilize its applicability for the range of possible conditions in transport services throughout Akure.

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