Analysis of Bus-stops locations using Geographic Information System in Ibadan North L.G.A Nigeria

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Abstract

This study focuses on the determination of best location for bus stops to enhance public transport in Ibadan north, Oyo State.The significance of having suitable locations for Bus stop is recognised as a crucial element in the drive to improve the quality of bus services and public transport in general.This study employs the tools of Geographic Information System (GIS) in the determination of the suitability of the bus stops location, stop spacing and the evaluation of characteristics of the existing stops in the study area.

The major roads and bus stops in Ibadan North Local Government were identified and the roads were digitized as line features. Garmin 12 Global Positioning System Receiver (GPS) was used to get the locations of the bus stop. The GPS was calibrated to Geographic Coordinate System (GCS) and World Geodetic System 84 (wgs84) as the datum. For this study, determination of best locations for the bus stop is based on three (3) criteria; these are four hundred (400) meters bus stop interval on the major road, available setback from the road ideal for bus Stop shelter and slope. Thereafter, poorly located bus stops were identified by adding the existing bus stop layer on the suitability map derived from determination of best locations for the bus stops. In all, seventy two (72) existing bus stops were identified, using the stated criteria for classifying the already existing bus stops. The analysis showed that there are four (4) very good bus stops, thirty five (35) good bus stops and thirty three (33) bad bus stops.

The paper recommends that guidelines for locating stops should be followed to reduce the risk, accessibility to stops should be considered by standard spacing and by considering marginal walking distance. The conclusion was that giving bus stops location a thorough consideration would help in a long way in enhancing public transport system by boosting the principle of good access which is Safety, Affordability, Accessibility and Reliability.

Keywords: Public Transport, GIS, Bus-stops Locations

1. Introduction

The quality of life of the citizens is heavily dependent on the efficiency and effectiveness of its transportation system. Urban transportation is essential to the fabric of urban life. The true goal of transportation is access (ICT, 1974; O"Sullivan et al., 2000). Public transport service is an essential system which helps in curbing the menace of transportation. Public transport is diversified, and each of its components must be well articulated in order to have a vibrant and sustainable transport system. Among the components or factors that needed to be considered for proper implementation of public transport system are bus stops and bus stations.

Bus stop design and location is recognised as a crucial element in the drive to improve the quality of bus services and public transport in general. The concept of 'Total Journey Quality' recognises that bus passengers are also pedestrians at each end of the bus trip and requires that all aspects of the journey are considered. The convenience and comfort of bus stops must not be overlooked (Bus priority team, 2006).

Improvements in urban mobility require better optimal location of bus stops and an articulated bus services; this will motivate private car owners to use public transport. This can bring about reduction in private cars plying the road which in turn reduces congestion and delay. In enhancing existing service, the use of spatial optimization can be used to support strategic planning. By selecting new service stops that provide access

to areas currently without sufficient access to a service facility given specific limitations on the number of stops to belocated (Matisziw et al. 2006). It is very important to enhance the existing stops if possible thanthe outright relocation due to opposition that is likely to be faced from some users that see the location as a plus to their services.

Therefore, for public transport enhancement, determining the optimal location of bus stops is an important strategic and operational consideration; bus stops in transportation networks should be located in a manner that ensures an adequate coverage and quick accessibility to allcategories of users. Covering models measure effectiveness through assessment of whether demand can receive service from located facilities. The key concept in these models is the acceptable proximity or coverage (Church and ReVelle 1974, Brimberg and Love 1995).The design must give consideration to the physically challenged and the oldpeople. In bus services, elements of uncertainty appear with respect to the time the bus will arrive the stop and the speed of the required bus services cannot be accurately predicted with congestion frequently arising as a result of stochastic nature of travel demand and general mobility on the road. The characteristics of bus stops; both in location, design and usage should be able to accommodate all categories of users. This in turn will enhance public transport and mobility in general (Metro, 2009, KRW, Inc 1996).

Equally, bus stop spacing has a major impact on transit performance. Stop spacing affects both access time and line-haul time, and therefore affects the demand for transit service. In general,there is a trade-off between: (a) closely spaced, frequent stops and shorter walking distance, but more time on the vehicle and (b) stops spaced further apart and longer walking distance, but less time on the vehicle (Church, 1984,).

Pulugurtha and Vanapalli (2008) developed a Geographic Information System (GIS)-based methodology to assist decision makers in identifying and ranking bus stops in high auto-pedestrian collision areas. The GIS-based methodology is illustrated by using 2000-2002 auto-pedestrian 21 collision data, traffic volumes, bus stop coverage, transit ridership data, and street centre line coverage for the Las Vegas metropolitan area. Vogel and Pettinari (2002) focus on the design of transit environments as they consider the personal safety of transit users and address the nature of the larger environment in which the transit stop or station is located. Issues of access also are addressed because the characteristics of the pathways leading to and from transit stops are integral parts of the transit environment. Studies such as the one by Moudon and Hess (2003) show a strong relationship between direction of auto-traffic and pedestrians. Providing appropriate pedestrian facilities along bus transit corridors makes access to transit systems more effective.

This study will employ the tools of Geographic Information System (GIS) in the determination of the suitability of the bus stops location, stop spacing and the evaluation of characteristics of the existing stops in the study area.

2. Overview of the Study Area

Ibadan is the capital of the largest city in Oyo state. It is located in South-Western Nigeria, 78 miles inland from Lagos. It lies between latitudes 7° 9 ' North and 7° 29' North and longitude 3° 47' East and 3° 59' East. Its human population is 2,555,593 according to 2006 Census of which Ibadan North is 306,795 (The Nigerian Government, 2007) and is reputed to be the largest indigenous city in Africa, south of the Sahara. It is the centre of administration of the old Western region; the principal inhabitants of the city are the Yoruba.

Ibadan has a domestic airport which was formally served by the Ibadan railway station on the main railway line from Lagos to Kano before it was relocated to another location. Road network in the city suffer a level of neglect in terms of adequate maintenance and are always chaotic in the rainy season reflecting poor drainage system within the city. The term interstate highways in United State are known as expressways in Ibadan, Nigeria. The Local Government Areas in Ibadan are responsible for the naming of the bus stops in the city. There are not many kilometers of dual carriage ways with little road furniture in Ibadan. The primary routes go from Ibadan to Benin-city, Lagos and Ilorin. Modes of transportation are taxis, mini-buses commonly called "danfos" and the private cars.

3. An Exposition on Bus Stops

There are various types of bus stops that are dependent on location, ridership, and adjacent land uses. Pasco County Public Transportation (PCPT) identifies three types of bus stops used and these are standard local stops, major local stops, and super stops. These designs range from a single signpost to a full bus bay with other special facilities. Bus bays are typically constructed on high volume or high-speed roadways; and this typical in Florida (KRW, Inc 1996).

United Kingdom experience reveals that access to bus stops has in practical terms witnessed slight work. However, the bus stop and its interface with the bus are beginning to be tackled. A number of modern schemes and improvements are in progress around the U.K. which seeks to improve the stops and its environment and ease boarding and alighting from low-floor buses, often as part of Quality Bus Partnerships between local authorities and bus operators. The aims of these schemes entail provision of guaranteed step-fee access to the bus by means of accurate docking at raised kerbs; to ensure the ability of the bus to pull in to and align itself properly with the stop; information provision in a user-friendly plan; designing of stops for absolute comfort, security with stress free accessibility; and to enhance entire bus route network to provide an accessible, dependable, prompt and attractive services (Patchett et al 2005, GMPTE, 2007). In London, The task of carrying out the measurement of locations of bus-stops first appears inconsequential since GPS does not now have selective availability (SA) degradation. However, there are limitations in GPS devices, most especially in urban environments. This has been proved by previous research in London. In addition the location of bus-stops often changes, there are in the region of 500 new or relocated bus-stops in London each year (Patchett et al 2005).

In Washington, with almost 12,000 bus stops, Metro possesses a broad on-street bus stop information system for effective Public Transport service. Nevertheless, the present system is facing a number of challenges which include the problems of readability, obsolete technology, and an absence of location and regional design coordination. Bus Stops are recognised as the gateways to bus systems by Metro projects (Metro, 2009). To emerge the "Best Ride in the Nation" there is identification and implementation of safety features, Improvement of function and accessibility to stops, implementation of proficient measures to sustain program elements, the customer experience enhancement and stop placement evaluation impact on performance Metro bus system. The output of spacing analysis and impact on performance are reconsideration of stop spacing optimization and consolidation studies, other transit systems discovered that an average of 4-5 stops per mile provides best balance of customer accessibility cum operational efficiency, bus stops reduction could minimise travel times and operational costs and a project will be initiated to review stop spacing and safety to optimize locations, spacing and travel times (Metro, 2009).An ideal spacing for bus stops is approximately 400m, although a closer spacing in town centres and residential areas may be necessary to meet passenger requirements, and at space are provided for more than one bus to access and serve the stop at the same time (Bus Priority Team, 2006).

The recent introduction of the Bus Rapid Transit System (BRTS) has sought to improve transportation in the Lagos state. Lagos city, Nigeria's commercial capital, is one the most population dense cities in Africa. Consequently, introduction of standard bus stops along the BRTs corridors, easing the traffic congestion of the commercial city. The lack of a functioning public transport system with well designed stops spurred on the development of the informal transportation industry. Prior to the BRTS, the availability of safe transport for Lagos commuters was tenuous at best. These therefore bring a level of standard in the location of bus stops and some form of uniformity in characteristics of bus stops in terms of shelter (Oseni, 2009).

It is therefore, important to view the bus stop as an interchange, rather than simply a location along a bus corridors where buses stop. Its contribution in the enhancement of public transport system of any society cannot be over-emphasized.

4. Research Methodology

This involves visits to Ibadan North Local Government area to establish my Area of Interest (AOI), identify the bus stops on the major roads and also to groundtruth the roads digitized from satellite image. The accuracy of Elevation values generated from Shuttle Radar topography Mission (SRTM) was also verified through ground truthing. Some relevant information about Ibadan North was also obtained through Primary Source such as width of roads.Satellite Imagery was gotten from Google Earth so as to extract relevant data/information for the research work.

4.1 Data Pre-Processing

This is primarily a deskwork that involves digitizing and feature extraction.

4.1.1 Digitizing

The relevant geographical spatial features on maps/images were digitized using on-screen (called "head-up") digitizing, by tracing a raster data onthe computer screen.

4.1.2 Feature Extraction

The spatial features on maps were captured and developed into digital database in ArcGIS 9.3. Table 1 shows the features used for the mapping.

4.2 Identification of the Present Locations of Bus Stops

The major roads and bus stops in Ibadan North Local Government were identified and Garmin 12Global Positioning System Receiver (GPS) was used to get the locations of the bus stop. The GPS was calibrated to Geographic Coordinate System (GCS) and World Geodetic System 84 (wgs84) as the datum. The GPS was synchronised with a computer and point features represented asEastings (X) and Northings (Y) was extracted from the GPS in notepad format. The notepad format was edited and converted to comma delimited (.csv) so as to import the point features intoArcGIS 9.3.

4.3 Determination of Best Locations for the Bus Stops

For this study, determination of best locations for the bus stop is based on three (3) criteria i.e.

1. Four Hundred (400) Meters Bus Stop Interval on the Major Road

2. Available Setback from the Road Ideal for Bus Stop Shelter

3. Slope

4.3.1 Four Hundred (400) Meters Bus Stop Interval on the Major Road

The 400meters interval was arrived at by digitizing the major road as line feature in such a way where all vertices will be in 400meters. The line features were then converted to point features and the point features were automatically spaced in 400 meters interval.

4.3.2 Available Setback from the Road Ideal for Bus Stop Shelter

The Area of Interest was extracted from the Satellite imagery. The available setback from the road ideal for bus stop shelter is a polygon feature which was achieved by overlaying the digitized building by the road side with the setback created 8 meters away from the center of the road.

4.3.3 Slope

Slope is derived from the Digital Elevation Model (DEM) which was derived from elevation values. Elevation values were extracted from Shuttle Radar Topography Mission (SRTM) which is a Digital Elevation Model (DEM) using ArcGIS script. The elevation values were extracted at 50meters interval so as to reduce interpolation. DEM and slope were generated in raster format, the slope was reclassed into three (3) classes i.e. low, medium, high and the raster slope was converted to vector. Overlay analysis of these three layers (i.e. 400 meters bus stop interval, available setback from the road ideal for bus stop shelter and the slope map) gives us a suitability map for Bus Stop location in Ibadan North Local Government Area.

5. Data Analysis and Discussion of finding

The data manipulation and Spatial Analysis capabilities of Geographic Information Systems distinguishes it from other comparable systems. This section discusses the Results of the Data Analysis.

5.1 Bus Stop location in Ibadan North Local Government Area

The identification of existing bus stops was acquired through Primary source and represented as point features. In all, seventy two (72) bus stops were identified (see table 2). The point features are connected to a back end database which is known as attribute table. The attribute table consist of eleven (11) fields namely the FID, Shape, ID, Road name, Bus Stop Name, Longitude, Latitude, Intersection, Shelter, Status

and Nature of Road. The FID is the feature identification, shape is the feature type i.e. the geometry, the ID is the unique identification number, the road name is the name of the road that the bus stop is located, the bus stop name is what the bus stop is popularly known as, the longitude is the Eastings coordinate of the bus stop, Latitude is the Northings coordinate of the bus stop, intersection is to know if the bus stop is located at or close to a junction, shelter means if the bus stop has a space for canopy, bus setback gives information if there is an offset from the road, status provide information about the road condition i.e. good or bad, Road represents if the hierarchy of the road which is single or dual road. From figure 1, it was observed and found that the bus stops do not follow any form of pattern, that is to say the bus stop is not located at any regular interval. Figure 1 shows the bus stops along the major Roads.

5.2 Determination of Best Locations for the Bus Stops

Bus stops should be at safe locations. To determine the best location, the Slope Map, Shelter map and the Bus-Stop Spacing Map were generated.

1. Four Hundred (400) Meters bus stop interval on the major road
2. Available Setback from the road ideal for shelter
3. Slope Map

5.2.1 Four Hundred (400) Meters Bus Stop Interval on the Major Road

Bus stops should be located at convenient locations, at the same time, standards and criteria must be set especially in terms of distance between one another. Four hundred (400) Meters bus stop interval on the major roads was established so as to avoid cluster and at the same time serve commuters. The Four hundred (400) Meters interval is represented as point features, the origin of the 400 meters bus stop interval was established from Northern axis major road, specifically Ojoo– Sango road at the boundary of the study area (Orogun) denoted with a distinct symbology. Major areas are also represented with distinct symbology for which the 400 meters fall. Figure 2 shows the arrangement of the bus stops located at 400 meters interval.

5.2.2 Available Setback from the road ideal for shelter

In planning, it is stipulated that a reasonable space be left between the road shoulder and any form of development. The space between the road shoulder and any development is known as buffer zone or setback. It is important so that when the road is to be expanded or when government wants to provide certain services such as bus stops, the government would not need to pay compensation for legal owners of the land. Ibadan North like many other places in urban Nigeria is faced with that problem where there is little or no setback from the road shoulder. This has restricted where bus stops can be located because a road should have setback so as to avoidcongestion which will enhance the flow of traffic. For this research, buildings along the road side were digitized as polygon feature and the road map was buffered at 8 meters from the centre of the road to make room for space where any further development beside the road can be located to enhance the flow of traffic. An overlay analysis of the polygon features was carried out using the merge option and classification was used to distinguish different features. The polygon features are the buildings along the road side and the 8 metres buffer of road network. Places where the digitised residential polygon falls inside the 8 meters road buffer denotes that there is no space in that particular location where bus stop can be located without the bus stop serving as hindrance tothe flow of traffic. Figure 3 shows the overlay analysis (merge option) between the buffered road network and the buildings along the road side.

5.2.3 Slope Map

The total numbers of elevation values generated at 50 meters interval are represented as point feature and the number of Elevation Value points is 23,520. The lowest elevation point value is 171m above sea level (asl) while the highest elevation point value is 278m asl. The location of each elevation point is represented by its X and Y i.e. Easting and Northing Coordinate respectively. Table 2 shows part of the Elevation Values which was used to generate digital elevation model (DEM), figure 4 shows the DEM. Inverse Weighted Distance interpolation method was used to convert to raster. From the DEM, Slope was derived; the output measurement was set to percentage. Figure 5 shows the slope map. The slope was reclassified into three (3) classes i.e. low, medium and high as shown in figure 6 for a proper analysis. Bus Stops should

not be located on sloped surfaces to ensure safety.

The slope was then vectorized as shown in figure 7 so as to carry out overlay analysis. Union option of overlay analysis was used with the vectorized slope and other polygon feature data so as to produce a seamless layer. (See figure 8).Figures 9 shows the adding of 400 meters interval point layer to the union polygon feature layer. This gives us a suitability map of bus stops locations in Ibadan North Local Government area.

5.3 Identification of poorly located Bus Stops

The suitability map was used to determine which of the existing bus stop meets the standard of slope, shelter and Four Hundred (400) metres interval. This was done by adding the existing bus stop layer over the suitability map.

To determine risky bus stops due to characteristics, the bus stops are categorized in three levels of "very good," "good," and "bad." These three levels were defined based on three bus stop characteristics: slope, 400 metres interval between bus stops, and shelters.

The criteria are as follows:

(1) If the bus stop has all three characteristics, it is described as "very good."

(2) If the bus stop has two characteristics, it is described as "good."

(3) If the bus stop has none of the characteristics, it is described as "bad." A "bad" bus stop is considered a risky bus stop.

Using the above criteria for classifying the already existing bus stops, the analysis shows there are four (4) very good bus stops which is about 5.56%, thirty five (35) good bus stops amounting to 48.61% and thirty three (33) bad bus stops which stand at 45.83%. Figure 10 shows the bus stops added to the suitability map.

6. Recommendation and Conclusion

The existing public transport system of any given area has a high impact on the entire traffic, ease of traffic and transport system of that particular area. The bus stops are locations and their characteristics must be such that would make the interchange most appealing to the users. So when such interchanges are problematic and poorly situated, it becomes an impediment to Public transport systems. It is therefore essential to give priority to this essential public transport infrastructure in terms of its location, characteristics and spacing.

6.1 Recommendation

Safety first in anything, the guidelines for locating stops should be followed to reduce the risk at the interchange. A relatively uniform stops spacing should be followed except in few points where there are acceptable conditions in consideration but it must not be less than 300metres interval in any case. Accessibility to stops should be considered by standard spacing and routing, considering marginal walking distance. There should be proper naming and statistics of the stops to give identity to each for orderliness and references. In areas with bus stops of risk due to slope, there should be sign post to inform and remind the users of the need to be careful. Equally the road surface of such stops should be made from materials that will improve friction so as to avoid easy slides. Periodic assessment of the stops should be carried out to assess their functionality in respect to changes i.e. expansion of roads and agglomeration of economic activities in the area. It is important to map out the routes and the stops to create easy ride for the emergence of more vibrant urban public transport system. Also, government should encourage data acquisitions in digital format and transport database through adequate funding.

6.2 Conclusion

This research work is a GIS-based methodology to identify poorly located bus stops with various degree of risk in the selected study area. Bus stops were identified based on three attributes; these are location, characteristics, and surface (located on a sloped surface). The result of standard uniform spacing was

shown and if this is implemented it will give a level of attractiveness and orderliness to bus services in the study area.   Geographical Information Systems cuts across many professions. The study has demonstrated the spatial analysis capability of GIS technology in identifying poorly located stops, determination of best location and pointers to an articulated decision making in public transport route management.

Therefore applying Geographic Information Systems to location of stops will help in modelling spatial problems for decision makers and will also proffer solutions to different forms of spatial issues affecting man and his environment.

Finally, adopting this methodology, would accomplish the principles of good access which are Safety, Affordability, Accessibility and Reliability in public transport in the study area.

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Table 1. Geographic Layers used for Analysis

S/N	GEOGRAPHIC FEATURES/LAYERS	FEATURE CLASS
1	Junctions	Point
2	Road	Line
3	Bus Stop	Point
4	400 Metres Bus Stop Location	Point
5	Area of Interest (AOI)	Polygon
6	Spot height/Elevation Values	Point
7	Slope	Polygon
8	Slope_ Buildings Merge	Polygon
9	Road Setback	Polygon
10	Building	Polygon

Table 2. Bus stops Identified along the Major Roads in Ibadan North Local Government Area

ID	ROAD NAME	BUS STOP NAME	LONGITUDE	LATTTITUDE	SHELTER	BUS STOP SETBACK	STATUS	ROAD
1	Eleyele-Sango	Eleyele	3.859090	7.419580	No	No	Good	Dual
2	Eleyele-Sango	Oluseyi	3.869720	7.418790	No	No	Good	Dual
3	Eleyele-Sango	Mosafejo	3.873090	7.419410	No	No	Good	Dual
4	Eleyele-Sango	Barrack	3.880270	7.422150	No	Yes	Good	Dual
5	Eleyele-Sango	Barrack	3.881130	7.423380	No	Yes	Good	Dual
6	Eleyele-Sango	Apete (B)	3.884130	7.426650	No	No	Good	Dual
7	Eleyele-Sango	Alaro (B)	3.888230	7.426700	No	No	Good	Dual
8	Eleyele-Sango	Adebayo	3.891950	7.427920	No	No	Good	Dual
9	Eleyele-Sango	Sango (B)	3.898510	7.423376	No	No	Good	Dual
10	Sango-Mokola	Elewure	3.897132	7.420463	No	No	Good	Dual
11	Sango-Mokola	Leventis	3.895250	7.415692	No	No	Good	Dual
12	Mokola Roundabout	Mokola Roundabout	3.890960	7.410107	No	No	Good	Single
13	Total Garden	Medical	3.890285	7.402500	No	No	Good	Single
14	Total Garden	UCH	3.890777	7.400977	No	No	Good	Single
15	Total Garden	Total Garden	3.891670	7.400800	No	No	Good	Single
16	NTA Govt House	Mokola-Total Garden	3.901160	7.399403	Yes	Yes	Good	Single
17	Mokola-Total Garden		3.908590	7.598410	Yes	Yes	Good	Single
18	Mokola-Total Garden	Gate	3.917450	7.391745	No	No	Good	Single
19	Secreteriat Road	Secretarial Bus Stop	3.912990	7.397850	No	No	Good	Single
20	Secreteriat Road	Zoo/Total Garden	3.918510	7.396350	No	No	Good	Single
21	Secreteriat Total Gard	Wema	3.909988	7.408023	Yes	Yes	Good	Single
22	Secreteriat Total Gard	Shift Other Side	3.900771	7.406160	No	Yes	Good	Single
23	SecreteriatTotal Gard	Shift Other Side	3.910499	7.407879	Yes	Yes	Good	Dual
24	Yetetu Road-Adeoyo	Mokola	3.910147	7.406179	Yes	Yes	Good	Dual
25	Yetetu Road-Adeoyo	Yemetu Oja	3.910045	7.401844	Yes	Yes	Good	Dual

| 26	Mokola-Yemetu road	Yemetu Alaidorin	3.908650	7.397920	Yes	Yes	Good	Dual
27	Mokola-Yemetu road	Agbada Gbudu	3.904920	7.390492	No	No	Good	Dual
28	Adeoyo Mokola	Adeoyo	3.903622	7.391624	No	No	Good	Dual
29	Adeoyo Mokola	Yemetu Oja [B]	3.899856	7.387602	No	No	Good	Dual
30	Adeoyo Mokola	Yemetu Oja [B]	3.902490	7.387280	Yes	Yes	Good	Dual
31	Gate-Iwo Road	Gate	3.903881	7.391956	No	No	Good	Dual
32	Gate-Iwo Road	Yidi	3.905142	7.394279	No	Yes	Good	Dual
33	Gate-Iwo Road	Garage	3.919558	7.395890	No	No	Good	Dual
34	Gate-Iwo Road	Idi Ape	3.922200	7.398820	No	No	Good	Dual
35	Idi Ape Basorun	Basorun	3.922600	7.399240	No	No	Good	Dual
36	Idi Ape Basorun	Abe Brigde	3.926689	7.404167	No	No	Good	Dual
37	Orogun- UI Express	Akobo Junction	3.933847	7.416600	No	No	Good	Single
38	Orogun- UI Express	Power House	3.936550	7.422970	No	Yes	Good	Dual
39	Orogun- UI Express	Ajao	3.937820	7.425530	Yes	No	Good	Dual
40	Orogun- UI Express	Agbowo	3.932640	7.436330	No	No	Good	Dual
41	Orogun- UI Express	Orogun	3.921537	7.445240	No	No	Good	Dual
42	Orogun- UI Express	Orogun Junction	3.921033	7.447890	Yes	Yes	Good	Dual
43	Orogun- UI Express	UI Second Gate	3.918600	7.458500	No	No	Good	Dual
44	Orogun- UI Express	Agbowo UI	3.907535	7.454782	No	No	Good	Dual
45	U.I to Sec	Preboyes	3.906942	7.451749	No	No	Good	Dual
46	U.I to Sec	Aasunle	3.907159	7.440451	No	Yes	Good	Dual
47	U.I to Sec	Bodija Mkt Shift Ot	3.907990	7.438920	No	No	Good	Dual
48	U.I to Sec	Bodija	3.910505	7.435522	No	No	Good	Dual
49	U.I to Sec	Ojurin	3.911700	7.434077	No	No	Good	Dual
50	U.I to Sec	Aare	3.912140	7.433190	Yes	No	Good	Dual
51	U.I to Sec	Oshuntokun	3.912350	7.430170	No	No	Good	Dual
52	U.I to Sec	Favors	3.909997	7.422630	No	No	Good	Dual
53	U.I to Sec	Awolowo	3.909977	7.423955	No	No	Good	Dual
54	U.I to Sec	Customs Sec	3.910821	7.418829	Yes	Yes	Good	Dual
55	U.I to Sec	Ojirin Inside	3.911027	7.416510	No	No	Good	Single
56	Sango - U.I	U.I Sango	3.911590	7.412793	Yes	No	Good	Dual
57	Sango-U.I	Samonda	3.913027	7.430457	No	No	Good	Dual
58	Sango - U.I	Airport	3.906929	7.441460	No	No	Good	Dual
59	Sango-U.I	Garage	3.907087	7.434094	No	No	Good	Dual
60	Sango-U.I	Sango	3.906250	7.431341	No	No	Good	Dual
61	Eleyele- Sango	Poly	3.900636	7.426087	No	No	Good	Dual
62	Eleyele- Sango	Alaro	3.899014	7.423775	No	No	Good	Dual
63	Eleyele- Sango	Alaro	3.893170	7.428270	No	No	Good	Dual
64	Eleyele- Sango	Akintoye	3.887900	7.426820	No	No	Good	Dual
65	Eleyele- Sango	Barracks	3.883580	7.426590	No	No	Good	Dual
66	Eleyele- Sango	S.T Rita	3.888127	7.426725	Yes	Yes	Good	Dual
67	Eleyele- Sango	Oluseyi	3.880602	7.422695	No	Yes	Good	Dual
68	Eleyele- Sango	Eleyele	3.877860	7.420490	Yes	Yes	Good	Dual
69	Akobo	Ashi Junction	3.869220	7.418890	No	No	Good	Single
70	Govt's House	Gate	3.889240	7.419940	Yes	Yes	Good	Dual
71	Sango-Mokola	Uncle Joe	3.935480	7.420900	No	No	Good	Single
72	Sango-Mokola	Veternary	3.917349	7.397370	No	No	Good	Single
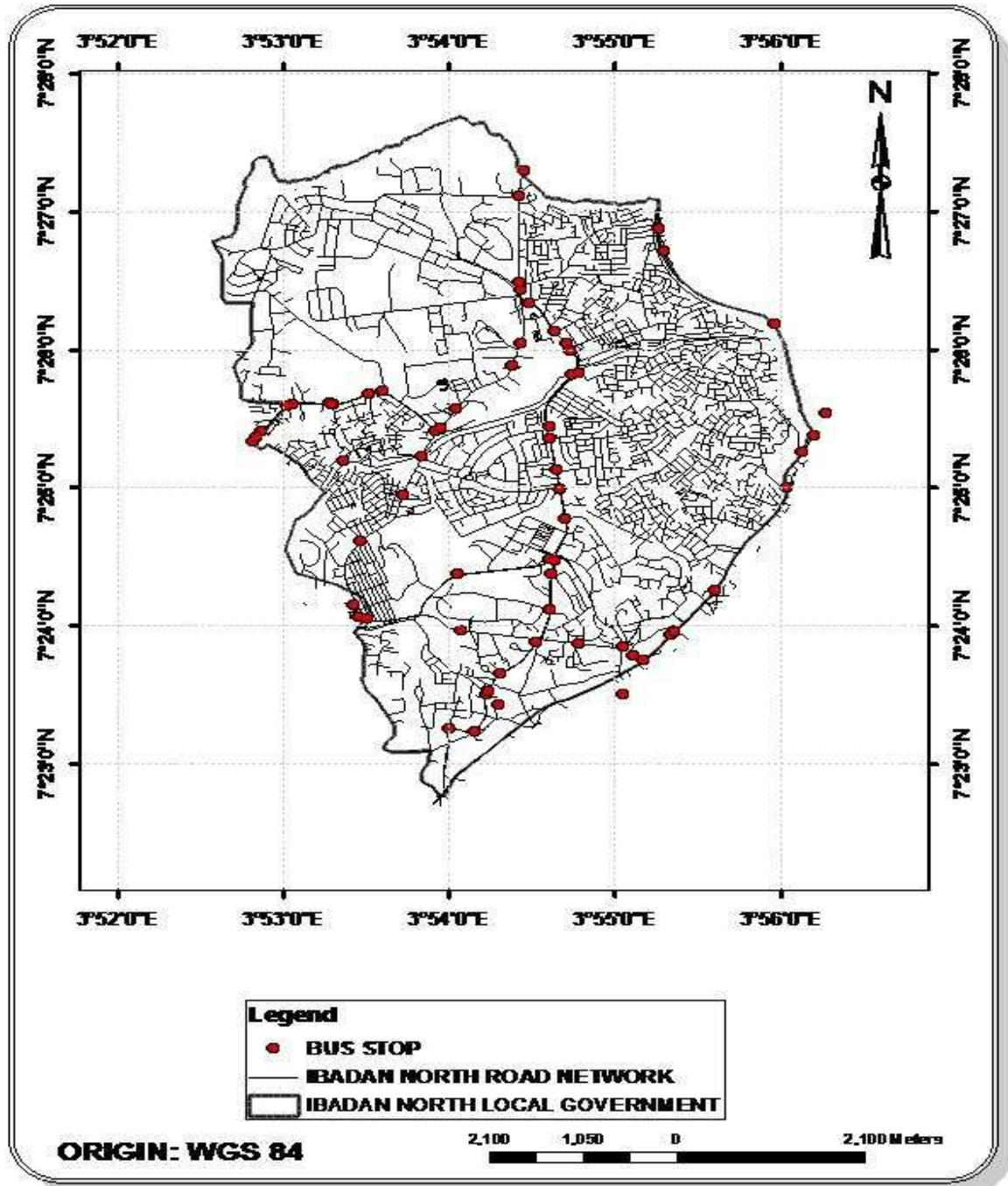
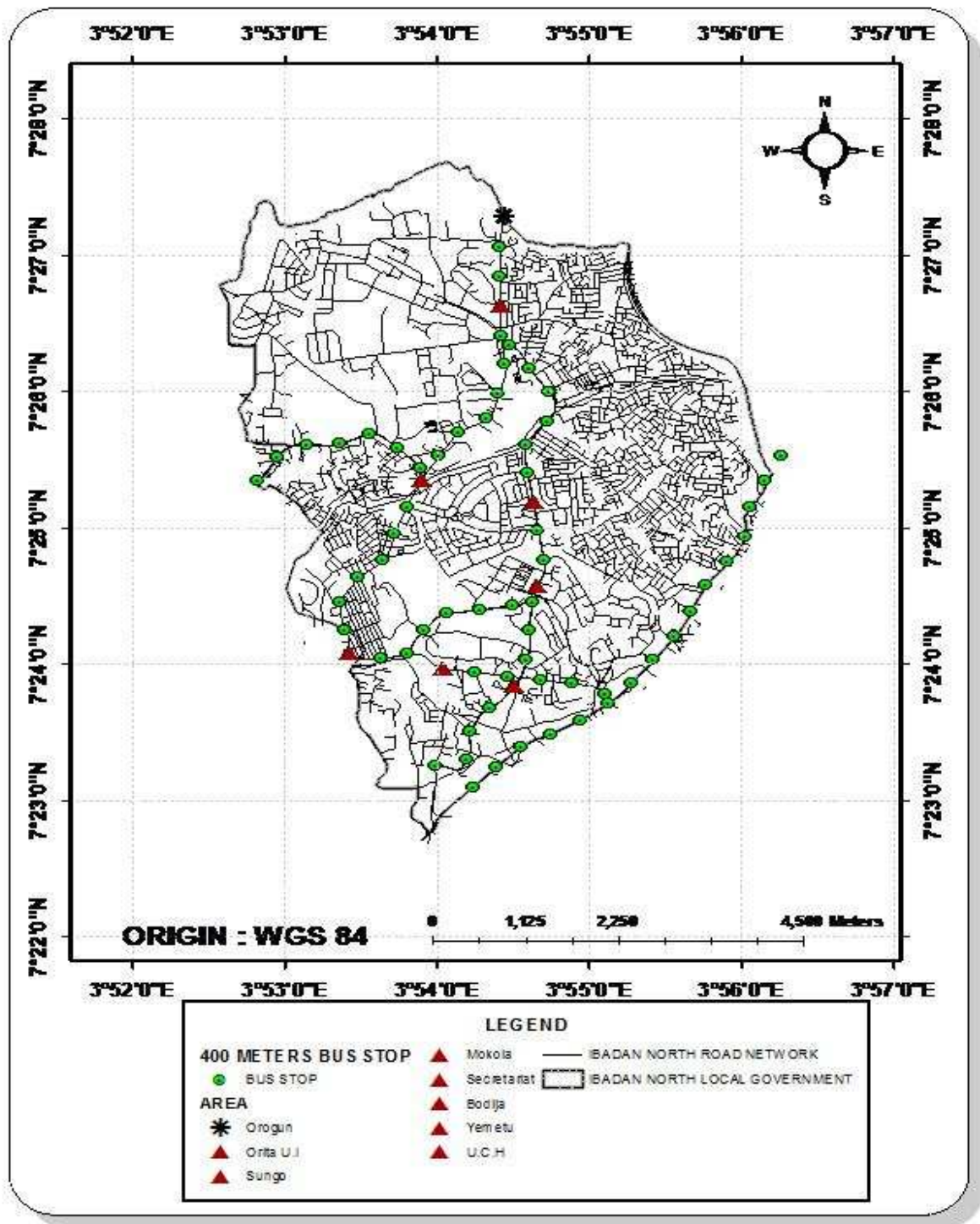Figure 1. The bus stops on Major roads in Ibadan North Local Government Area.

Figure2. Four Hundred (400) meters interval Bus Stops on Major Roads in Ibadan North.
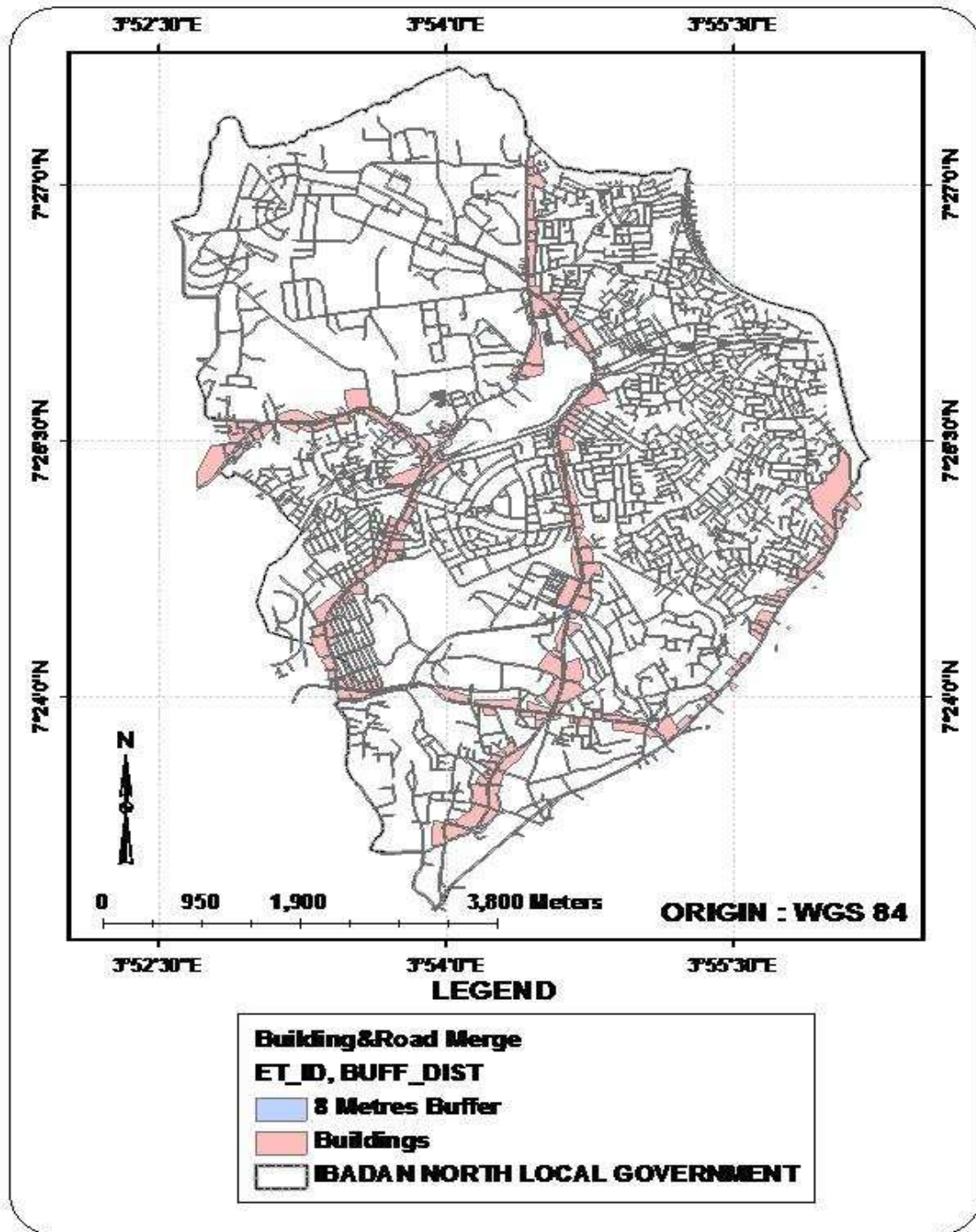
Figure 3. Buildings along the Major Roads in Ibadan North Local Government area.
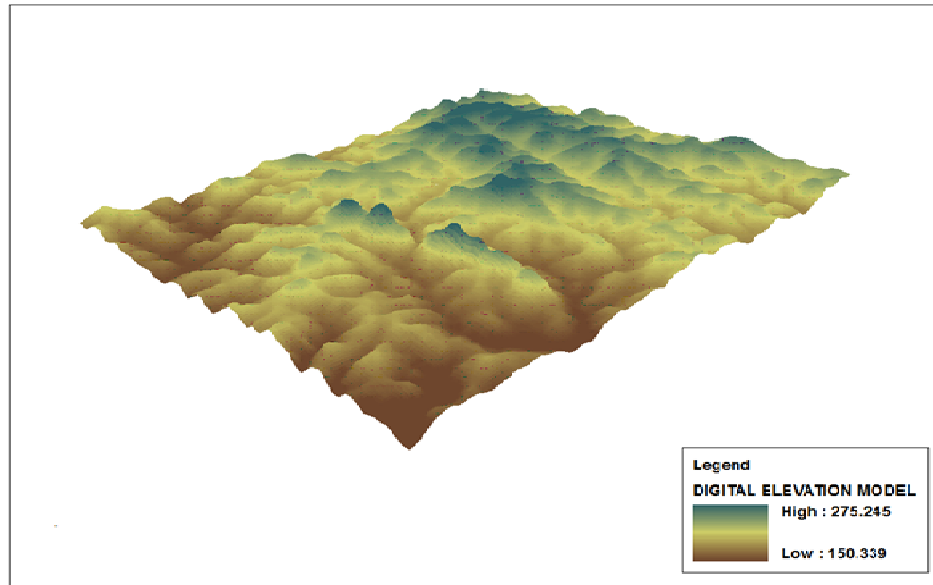
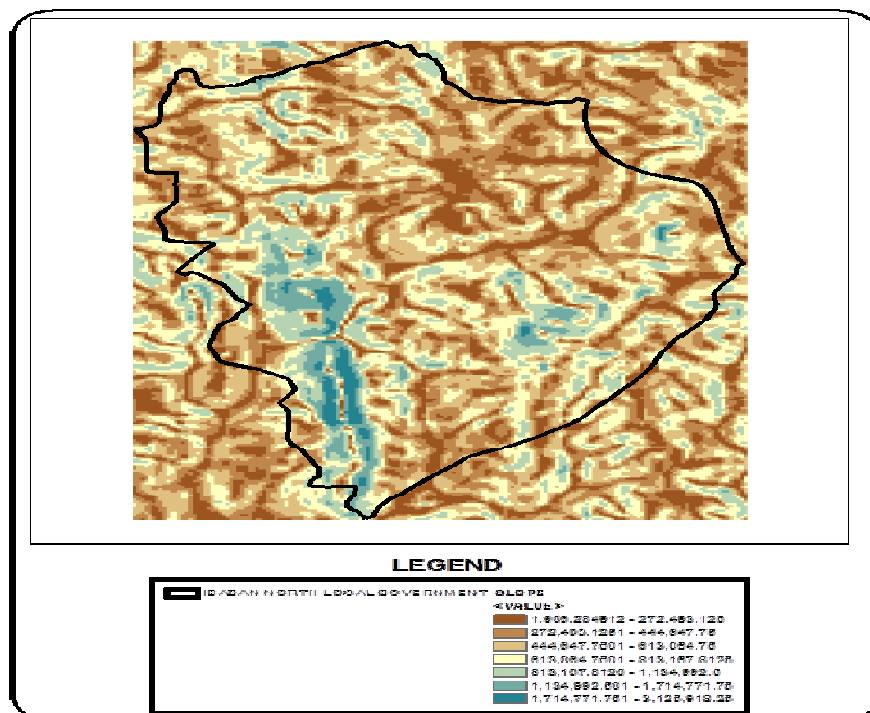Figure 4. Digital Elevation Model of Ibadan North Local Government Area using Arcscene.

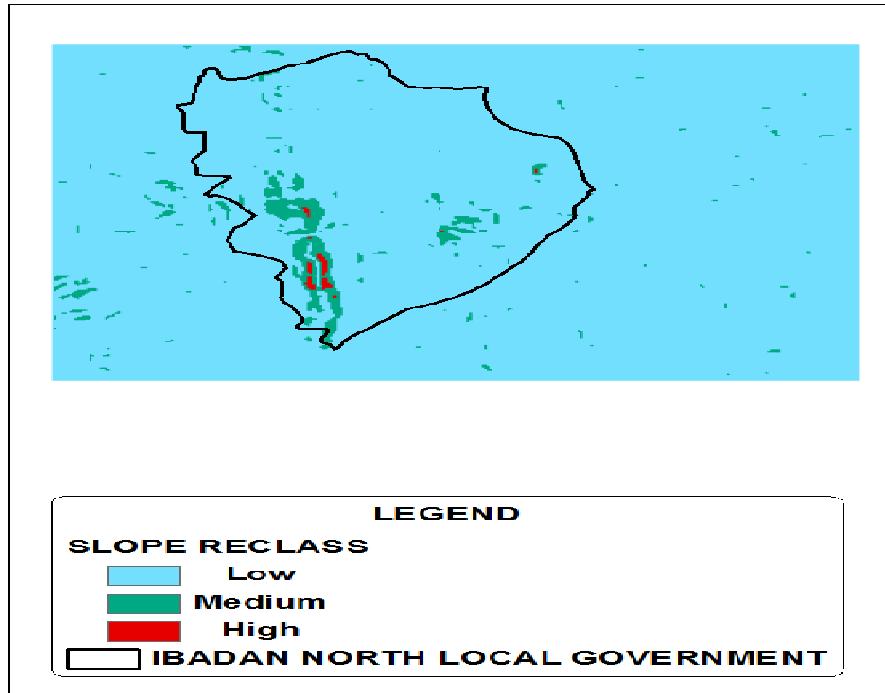Figure 5. The Slope Map of Ibadan North Local Government Area.
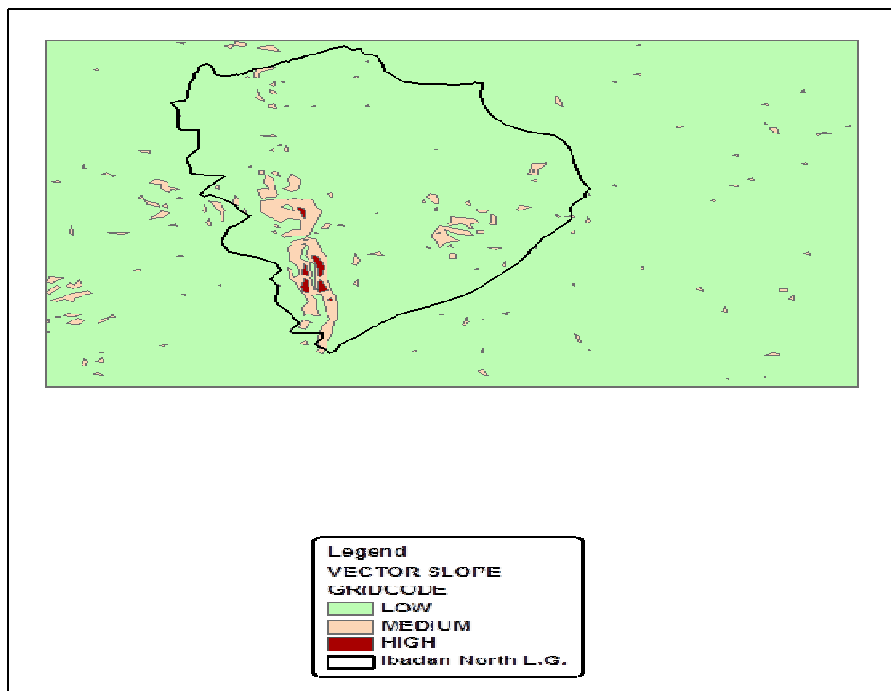
Figure 6.   Reclass Slope.
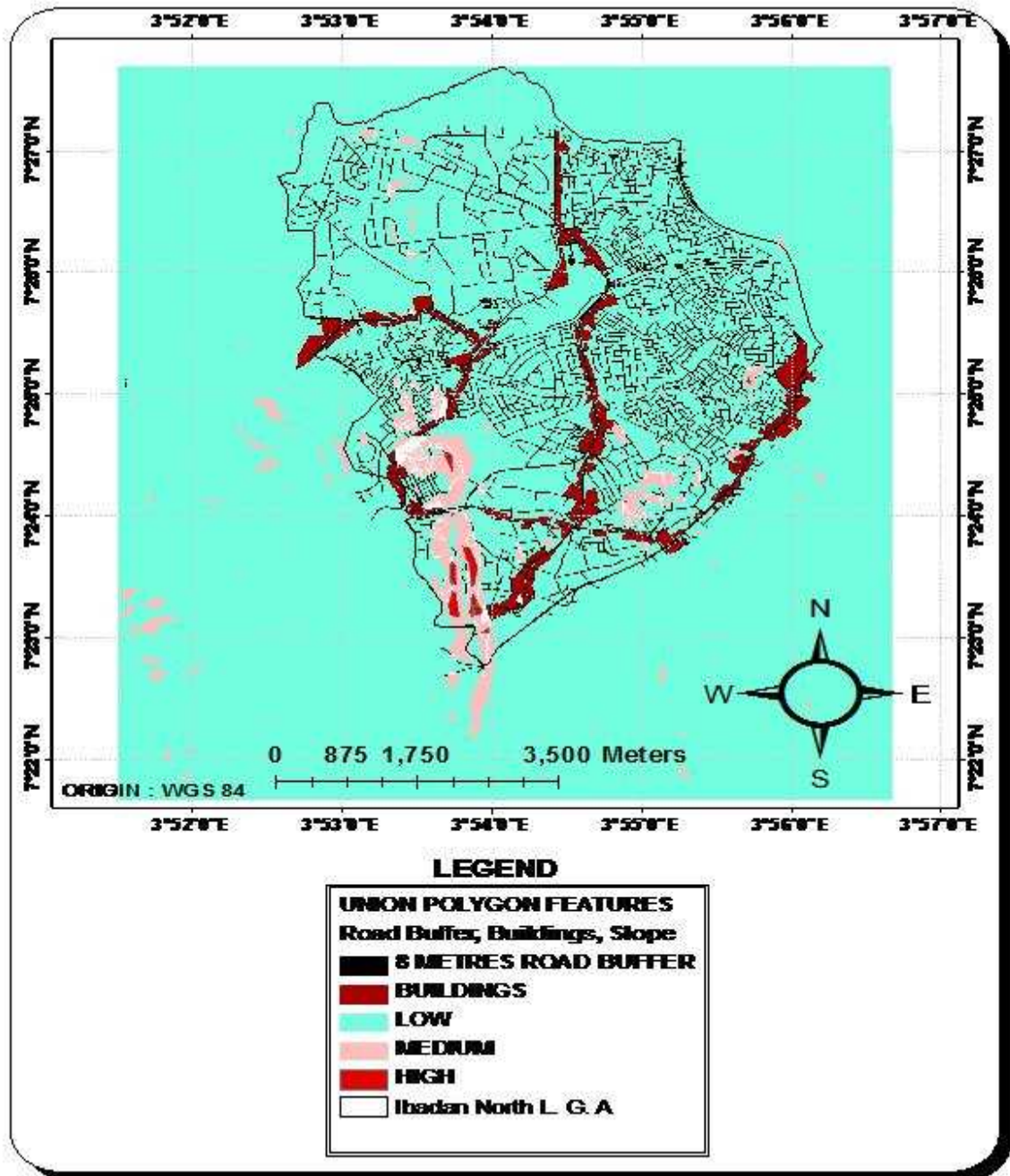

Figure 7. Vectorized Slope in three (3) distinct classes.

Figure 8. The union polygon features.
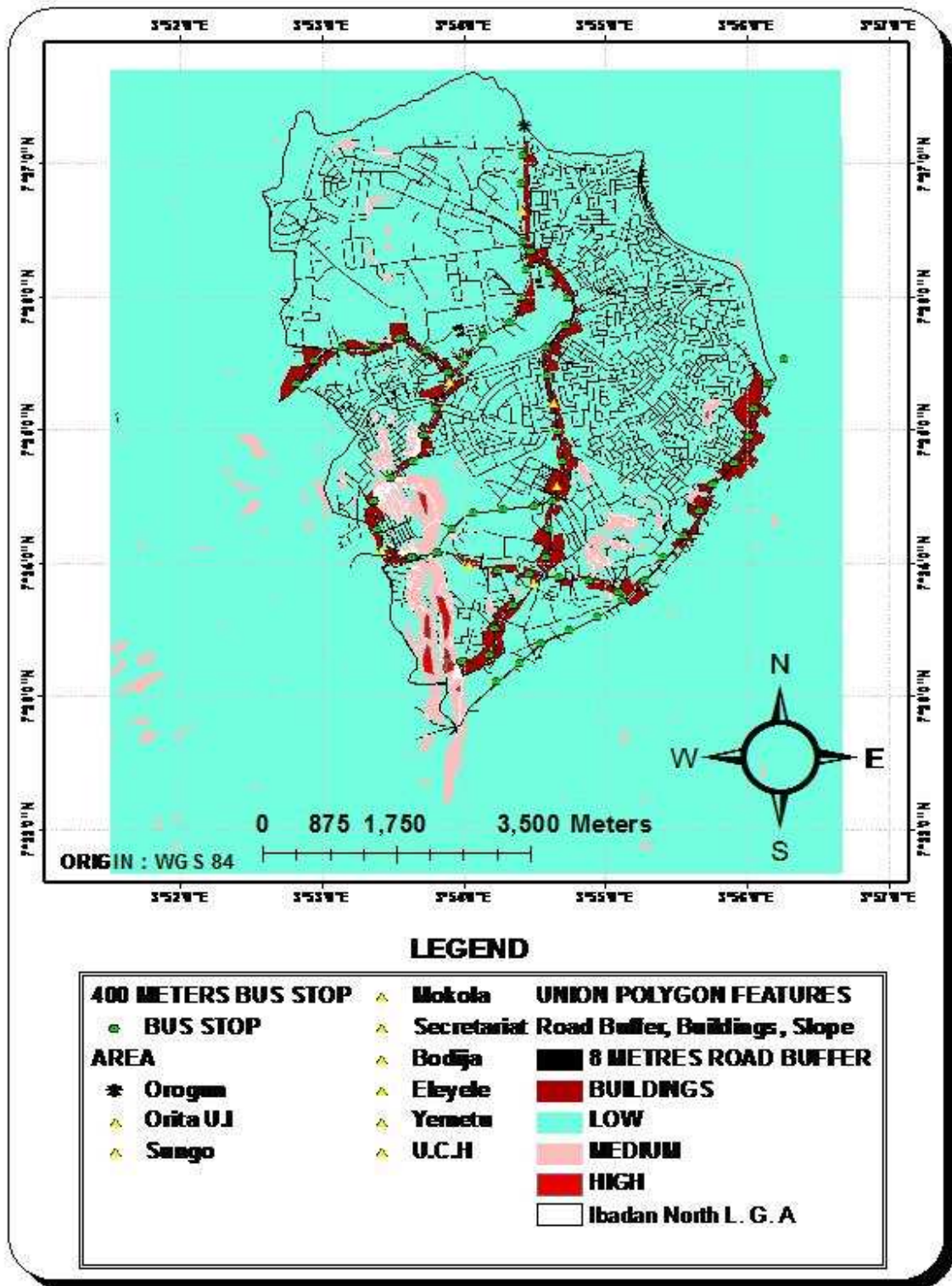
Figure 9. The Suitability Map of Bus Stop Location in Ibadan North Local Government

Area.
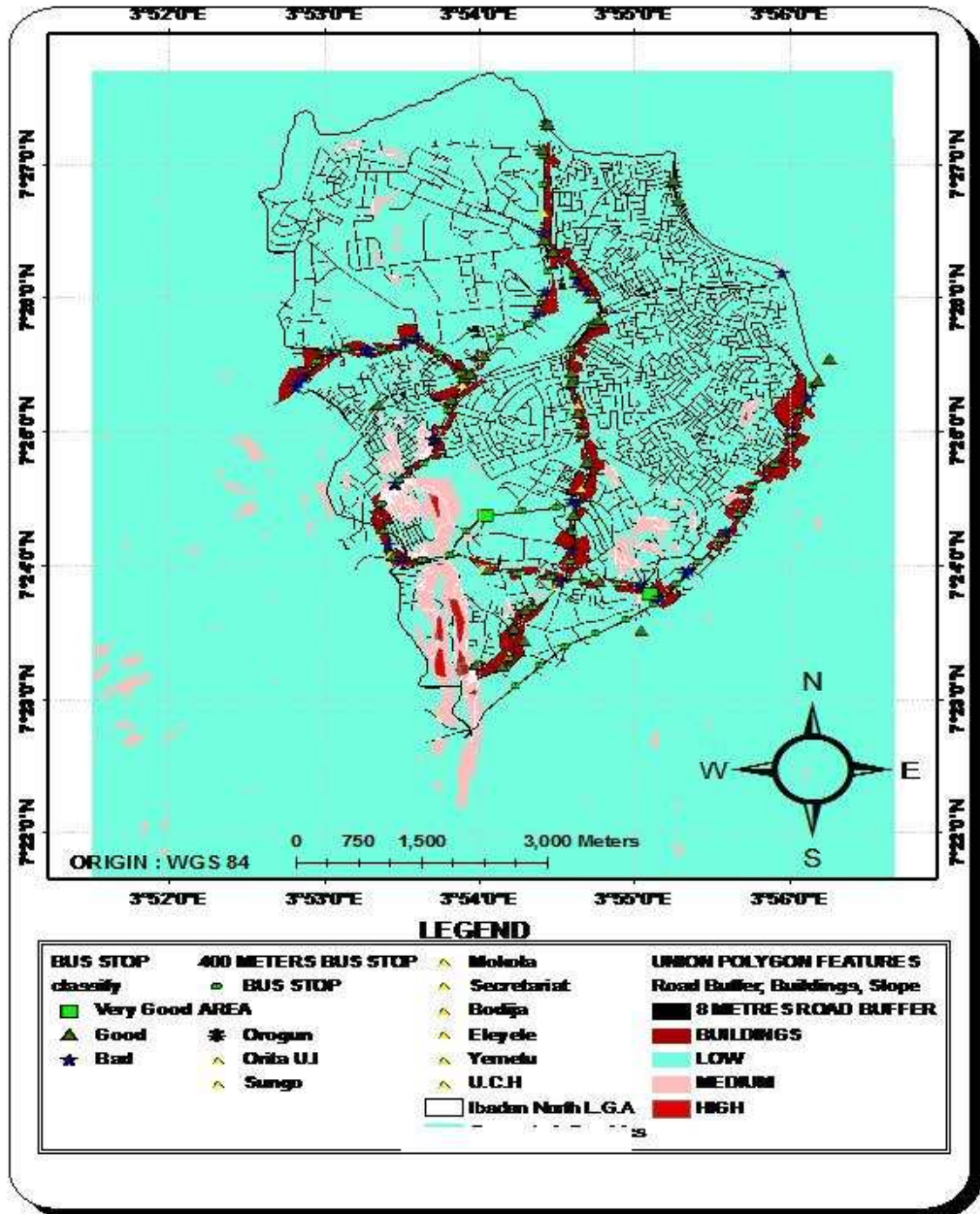
Figure 10. The classified Bus Stops Added on the Suitability Map.