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Coverage Estimation of Mobile Communication Network in Osogbo Using Remote Sensing and GIS, Osun State, Nigeria.

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ABSTRACT

Mobile phone or cellular telecommunication technology is a breakthrough in the economy of Nigeria since its introduction in the early 1980s but not without shortcomings to the end-users. The low level of signal transmission in some regions still characterized the operations of this sector. Sequel to this challenge the study investigated the extent of the network service available to the customers in an ancient city of Osogbo. The coordinates of cell towers of seven different GSM/CDMA companies were ascertained and their location was analyzed on a digital elevation pattern map generated from the contour lines of a high-resolution satellite data SPOT-5 HRVIR with a spatial resolution of 10 meters. Buffer analysis was performed on the net cell towers of individual network companies to estimate the network coverage and identify the network shadow zones. It was observed that MTN mobile network with twenty-three towers covered the study area more than the rest mobile networks. Odua Networks has the least coverage with two mobile towers. Overall findings into coverage estimation show that all the mobile networks have left out network shadow zones in the north, west, and southeast of the study area due to the construction of mobile towers without much consideration of the elevation factor. The mobile network provider should plan to construct cell towers in the shadow zones to get a better network for a better facility.

KEYWORDS: GIS, Cellular Telecommunication, Digital Elevation Pattern, Coverage

1. Introduction

Global System for Mobile Communication (GSM) revolution began in August 2001 and changed the face of Information and Communications Technology in Nigeria (Adeoye, 2010). Following the launch of GSM networks in Nigeria by MTN and Econet (now Airtel) in August 2001, the active combined GSM subscribers now have increased to 199.3 million in May 2020 (NCC, 2021). Going by this huge population patronizing this sector, mobile coverage, and quality of service call for constant measurement for uttermost satisfaction of the subscribers. Improvement on the poor quality of services and inadequate coverage especially in some rural communities in Nigeria can be achieved by combining spatial data from base maps and non-spatial data such as cell station databases through Geographic information system (GIS) technology (Chen *et al.*, 2012). Remote communications require efficient network planning of cellular mobile communication. The essential operations in the telecommunication network industry include network site identification and planning, signal strength measurements with coverage estimation to expand

the system (Naveenchandra *et al.,* 2011; Basavaraja Simpi *et al.,* 2011). The first rate of the cell carrier is predicated on the signal strength at the consumer's area. The signal originates from a community of antennas sited at strategic locations across the landscape. Working out the pleasant community of antennas over a big location is hard and dependent on various factors, which consist of land cover, terrain undulations, building heights, composition, and morphology (Naveenchandra *et al.,* 2011). There is a combination of models made by electrical experts within the past decades to analyze wave proliferation in cellular systems, but none of them can be called the last arrangement since each one of them has a few specific restrictions in its application. Most confinements have connections with the geographic highlights of the locale to which they are being connected. Geographic data frameworks (GIS) can arrange such location-based data proficiently and precisely(Bekele & Demissie, 2017). The study is aimed to know the locations of all towers of distinctive GSM/CDMA companies such as MTN, Globacom, Airtel, Etisalat (now 9 – mobile network), Visafone, Multilinks, and Odua Network (now Odua Tel) with digital elevation pattern of the city and to estimate the availability of network coverage by their buffer zone, to distinguish the network shadow zones and to make a recommendation for improvement.

2. Study Area

Osogbo is the capital of Osun State, Southwestern Nigeria. It is some 88 kilometers by road Northeast of Ibadan. It is also 100 kilometers by road South of Ilorin and 115 kilometers Northwest of Akure. It is situated at Latitude 9.7°N and on Longitude 4.5°E. Osogbo city seats the Headquarters of both Osogbo Local Government Area (Osogbo South) and Olorunda Local Government Area (Osogbo North) see Figure 1. Based on the 1991 Census (provisional result) Osogbo has a population of about 280,000 people. Osogbo is situated on a raised land which is well over 500 meters (800 feet) above the sea level and is drained by the Osun River and its tributaries. The town with an annual rainfall of about 0.6 meters lies mainly in the deciduous forest area which spreads towards the grassland belt of Ikirun, north of Osogbo. Osogbo is an important Railway Station. The establishment of the Railway Station is perhaps the most important single factor in the tremendous developments of Osogbo. Apart from the railway, there are postal services and telecommunication services. There are facilities for quality potable water.

3. Materials and Methods

The work used high-resolution satellite data (SPOT-5 HRVIR acquired in November 2005 with a spatial resolution of 10 meters), Google maps, and other maps. The satellite data was further engaged in the ArcGIS 9 environment in the extraction of road and rail networks. Google maps were used for updating the road network and the settlement extent of the study area and also used for further analysis. For GIS data generation, the Global Positioning System (GPS) was used to take the coordinates of towers of the GSM and CDMA operators (MTN, Globacom, Airtel, Etisalat (9 mobile), Visafone, Multilink, and Odua Network) at the dense urban of Osogbo and the environs.

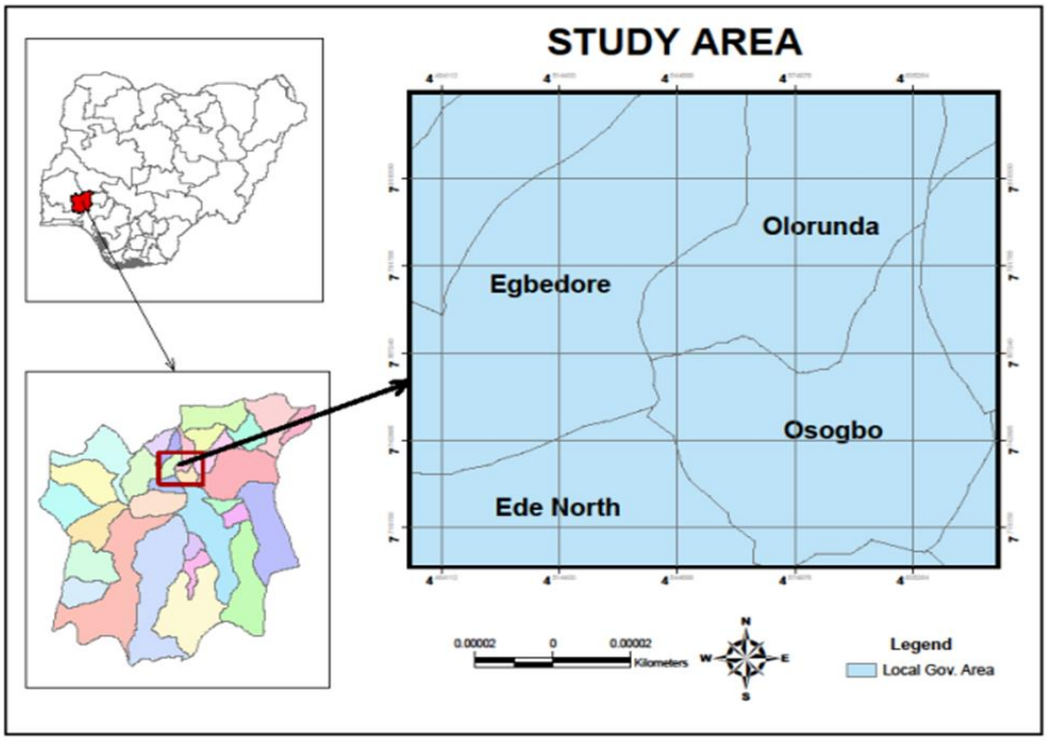

Figure 1: Location map of the study area showing Osogbo and the environs.

4. Results and Discussions

4.1 Results

The locations of towers of each GSM/CDMA operator have been presented on a georeferenced image of the study area (Figure 2). The image also shows the congested part (in terms of buildings and road networks) of the city which is mainly at the center spreading towards the west, northeast, and southwest of the city. There are 65 fixed-mobile towers in Osogbo and its environs at the time of this study. The distributions of the mobile towers among the individual company are as shown in Table 1.

GSM/CDMA Operators	Tower	Colour
Airtel	10	Red
Etisalat	6	Purple
Globacom	12	Green
MTN	23	Yellow
Multilink	4	Blue
Odua Network	2	Deep Pulple
Visafone	8	Orange

Table 1: Distributions of Mobile Towers

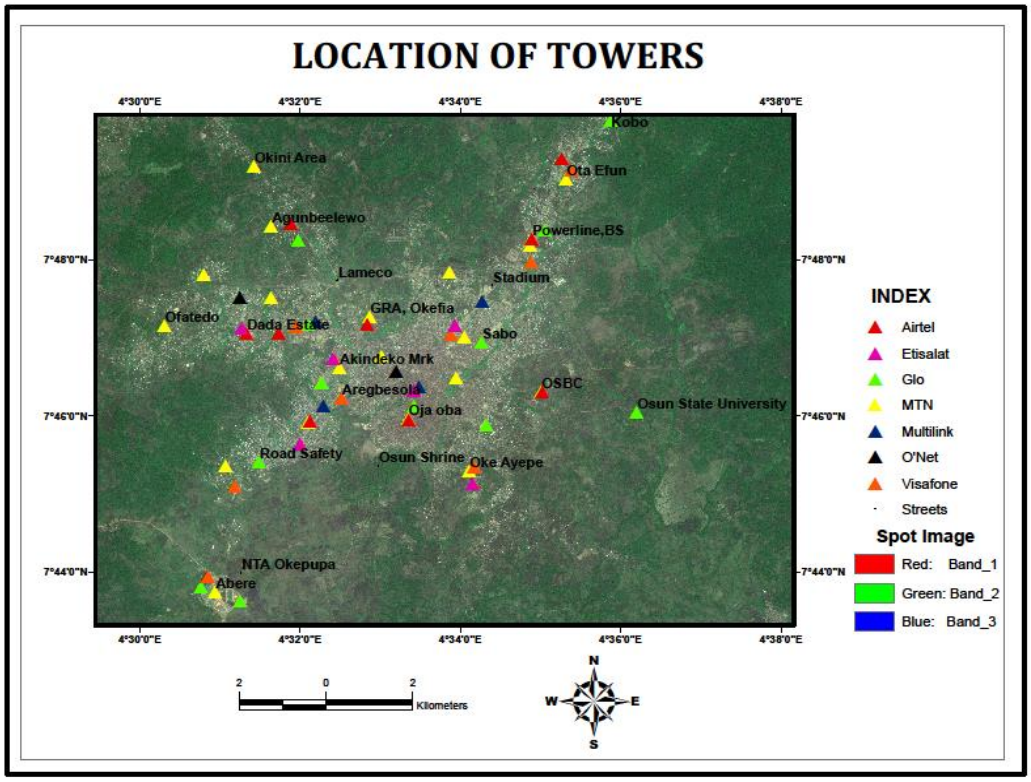

Figure 2: Location of Towers on the Spot-5 Image of thestudy area.

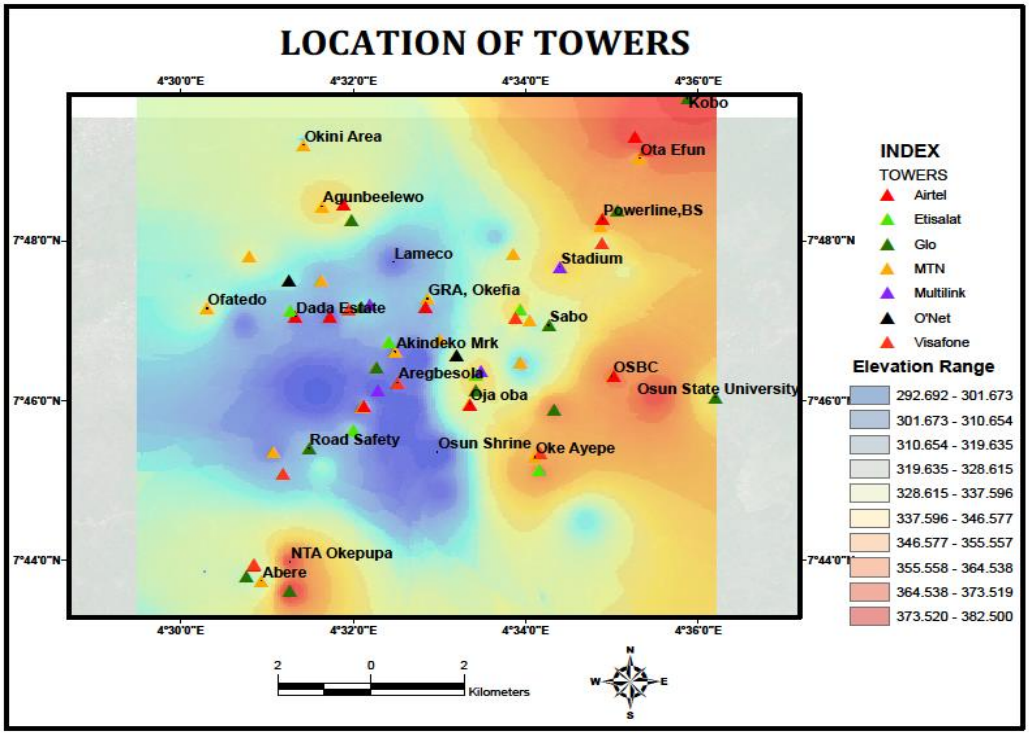

Figure 3: Location of Mobile Towers with Elevation Pattern.

4.1.1 Location of Towers with Elevation Pattern

From the elevation pattern map derived from the contour lines of the study area (Figure 3), it was observed that towers had been largely located among the people without much consideration of elevation factors especially areas like Osun shrine, Aregbesola, Akindeko market, GRA located at Okefia, Dada Estate and Sabo. These areas are characterized by low terrain and also the major route of Osun River and its tributaries (see the blue portion of Figure 3). Therefore, to establish good coverage and effective network service in these areas, putting into consideration the bulk of the load on each antenna, individual wireless companies tend to locate more mobile towers on the terrain.

4.1.2 Coverage Estimation and Shadow Zones

The buffer analyses produced for each of the wireless companies, the coverage extent, and their shadow zones had been presented and discussed in Fig 4-10. To spot the areas of the city receiving little or no mobile network taking into consideration the net coverage of all the wireless companies, their buffer zones have been further buffered and presented in Figure 11.

Airtel Tower

Ten mobile towers had been located in the study area by Airtel Nigeria having an individual tower's coverage area of 1.7-1.8 km with a height of 70-90 ft. The majority of the towers are located at the northeast, central, and one at the southwest of the city (Figure 4). The southeast and west parts are not getting proper network connection and would be characterized with weak signals. It is suggested to have towers in the western and southeastern parts of the city.

Etisalat Tower (9-mobile)

Six mobile towers had been located in the study area by Etisalat Nigeria having an individual tower's coverage area of 1.7-1.8 km with a height of 80-100 ft. All the six towers had been located mainly at the center spreading towards the southeastern part of the city (Figure 5). The north, east, west, and southwest had been largely left out and would be characterized with weak or no signals. It is better to locate more mobile towers in the portions concerned especially in the north part of the city.

Globacom Tower

Twelve mobile towers had been located in the study area by Globacom Nigeria having an individual tower's coverage area of 1.7-1.8 km with a height of 70-90 ft. The twelve towers have almost covered the city leaving out the west, southeast, and a gap in the northern part of the city (Figure 6). It is suggested to have towers in these zones for proper network connection.

MTN Tower

Twenty-three mobile towers had been located in the study area by MTN Nigeria having an individual tower's coverage area of 1.7-1.8 km with a height of 70-90 ft. The twenty-three towers have covered the entire city except for a few parts of the southeast (Figure 7). The entire city will have a good network connection except for part of the southeast and towers should be constructed in this zone.

Multilink Tower

Four mobile towers had been located in the study area by Multilink Nigeria having an individual tower's coverage area of 1.8-1.9 km with a height of 80-100 ft. The four towers are located at the center portion of the study area leaving out the north, south, southeast, and western part of the city (Figure 8). The left-out area would be characterized by weak or no signals. For proper network connection, it is better to construct more mobile towers at the zones concerned especially at the north, west, and southeast of the city.

Odua Network Tower

Two mobile towers had been located in the study area by Odua Network Nigeria having an individual tower's coverage area of 1.8-2.0 km with a height of 100-120 ft. One of the two towers is at the center and the other one is at the northwest portion of the city (Figure 9). There is no network coverage in the northeast, southeast, and southwest of the city and would be characterized with weak or no signals. So it's suggested to construct towers in the northeast, southeast, and southwest of the city.

Visafone Tower

Eight mobile towers had been located in the study area by Visafone Nigeria having an individual tower's coverage area of 1.7-1.8 km with a height of 70-90 ft. The towers are located mainly at the center, northeast, and southwest portion of the city (Figure 10). The network is not available in the northwest, west, and southeast portion of the city and would be characterized by weak signals. There is a need to construct towers in the northwest, west, and southeast portion of the city for proper network connection.

From Figure 11, it was observed that all the mobile networks have left out network shadow zones in the north, west, and southeast of the study area. This is due to the construction of mobile towers without much consideration of the elevation factor and therefore having network coverage one above the other of the same company.

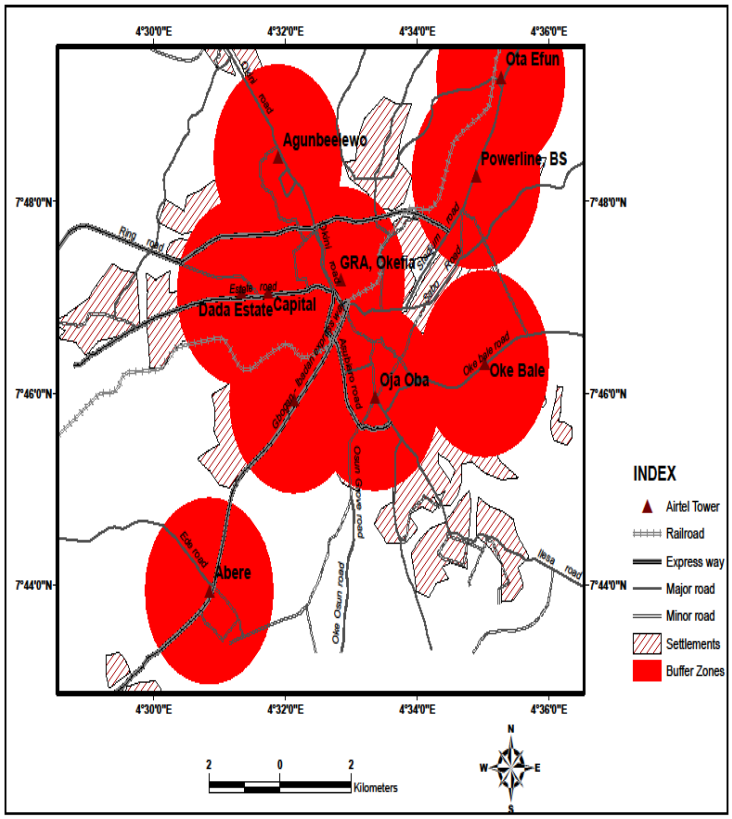

Figure 4: Buffer Zone of Airtel

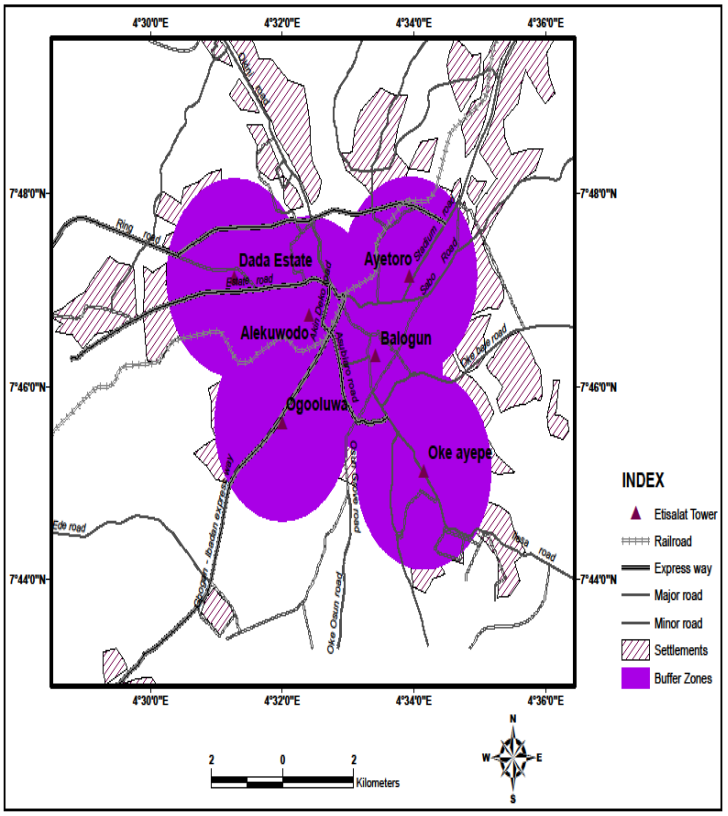

Figure 5: Buffer Zone of Etisalat

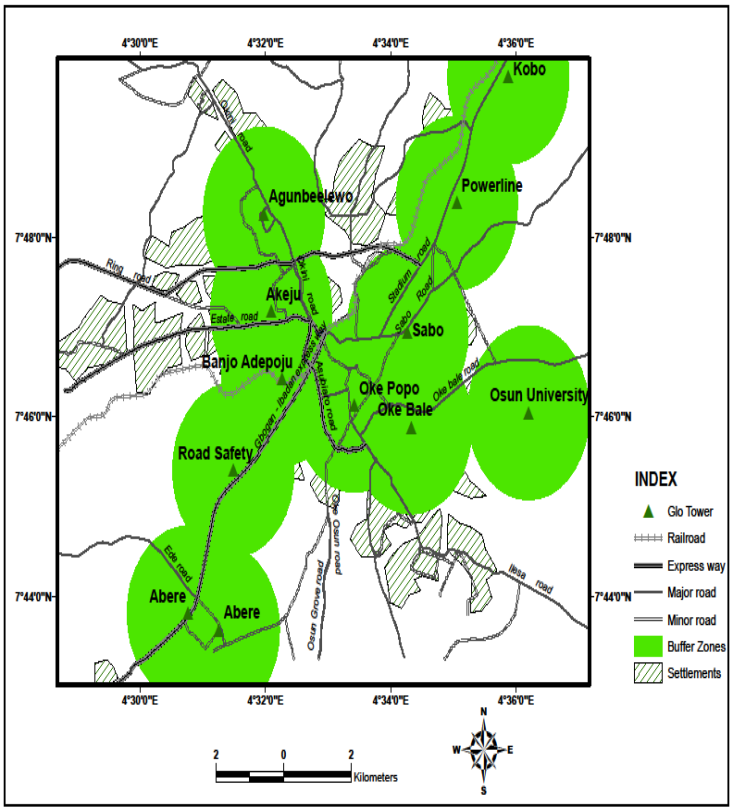

Figure 6: Buffer Zone of Globacom

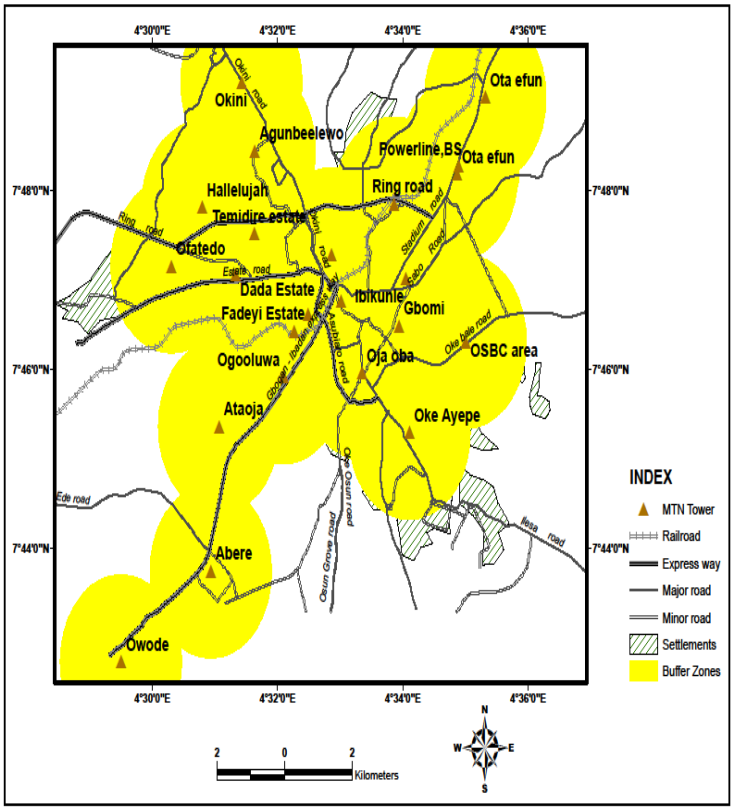

Figure 7: Buffer Zone of MTN

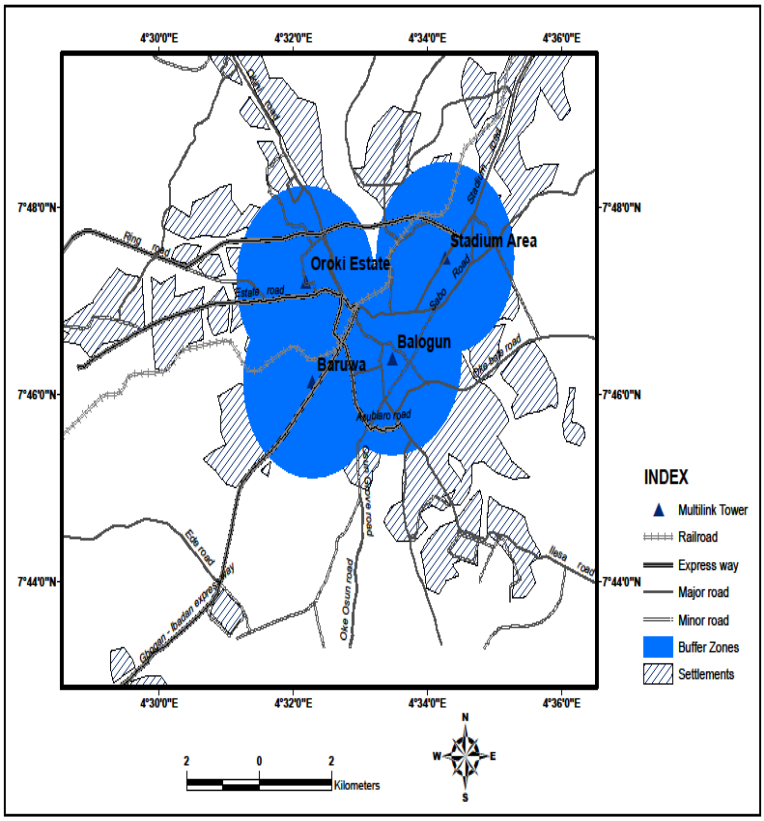

Figure 8: Buffer Zone of Multilink

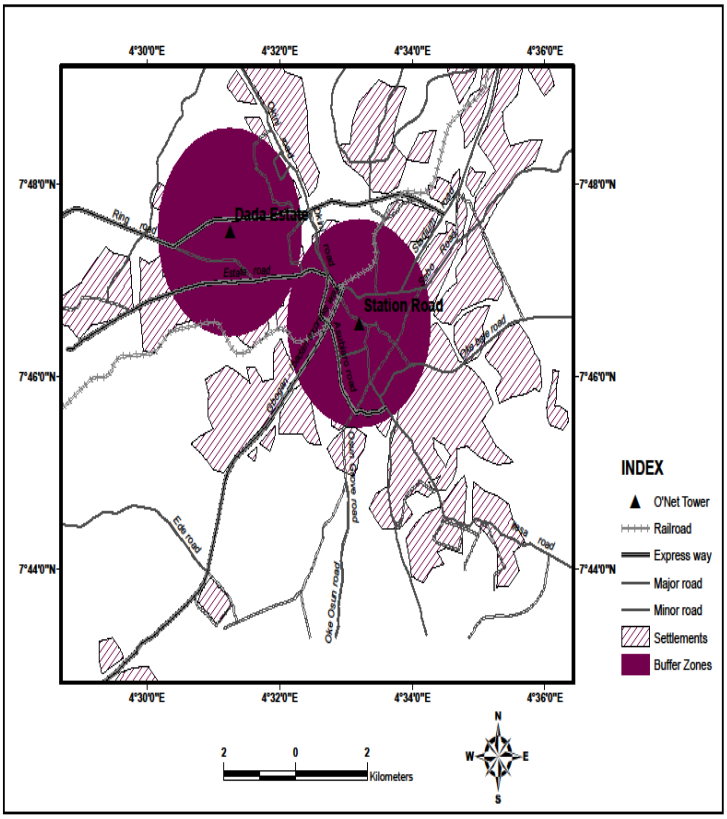

Figure 9: Buffer Zone of Odua

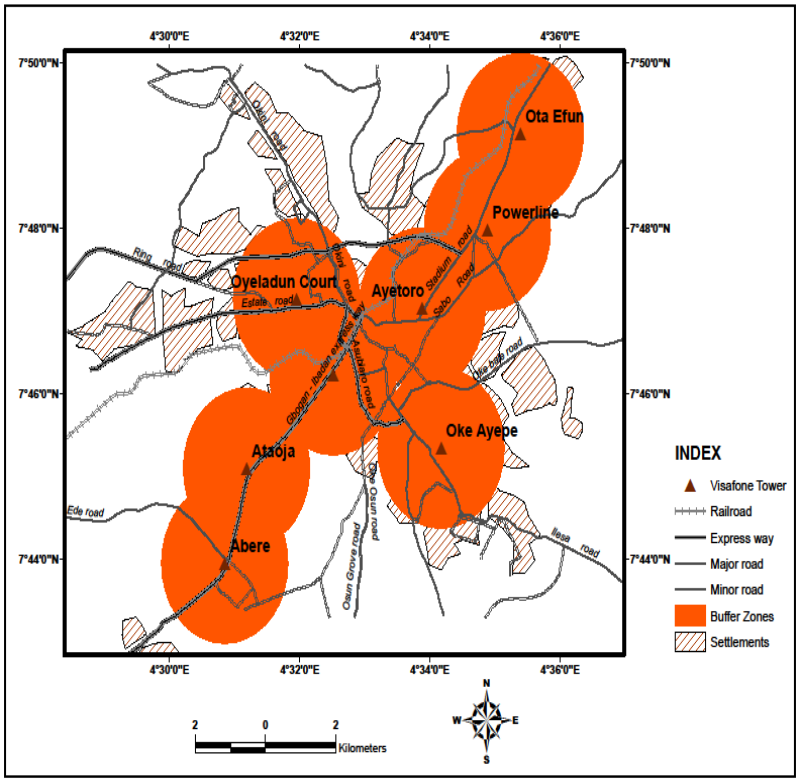

Figure 10: Buffer Zone of Visafone

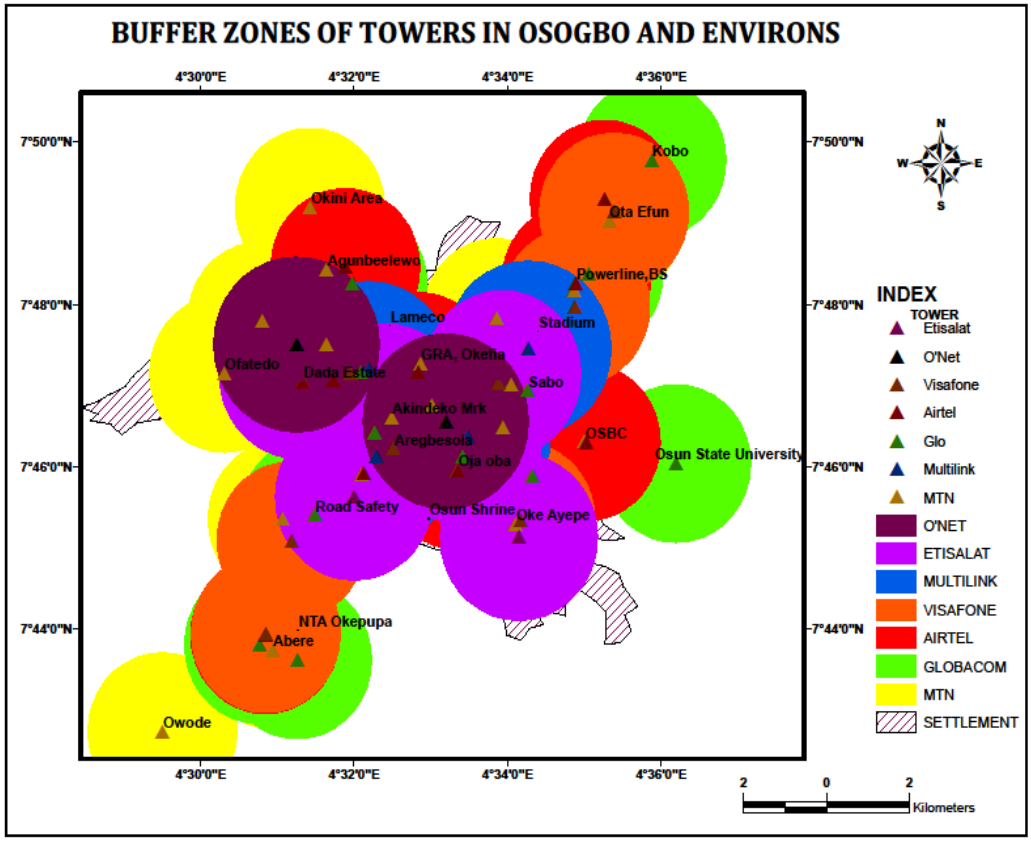

Figure 11: Buffered zones of all the towers in Osogbo and environs

4.2 Conclusions

The study has indicated the importance and significance of remote sensing and GIS integration for facility management in the field of telecommunication. Seven mobile networks (GSM/CDMA) had been mapped out for coverage extent and pattern in Osogbo and its environs by exploring the technology of RS/GIS. It was observed that MTN mobile network with twenty-three towers covered the study area more than the rest mobile networks. Odua Networks has the least coverage with two mobile towers. Overall findings into coverage estimation in this study show that all the mobile networks have left out network shadow zones in the north, west, and southeast of the study area due to the construction of mobile towers without much consideration of the elevation factor. The study suggested constructing towers in the shadow zones to get a better network for a better facility.

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