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Strategic Plan to Site Iron and Steel Fabrication Plant in Ibadan, Oyo State, Nigeria

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Abstract —The aim of this research is to optimally select the best site for iron and steel fabrication plant in Ibadan, Oyo State of Nigeria. The evaluation criteria were determined, and they were exactly seven parameters considered in this project. They were railway, slope, road, river, settlement, power substation and power line. The datasets were sourced from SRTM and world population for the remote sensing and the Ibadan Master Plan for the GIS data. The GIS data were processed using Euclidean distance and were reclassified into three classes with various levels of suitability. Weights were assigned on the pairwise comparison table and the AHP scale values were considered according to the influence. The multi-criteria analysis was done before the weighted overlay was finally carried out to obtain the map for the optimum location for iron and steel fabrication plant in Ibadan. This study reveals that Ido and Akinyele have the optimal locations **A, B and C** that are closest to both the railway lines in Ibadan and at the same time farthest from the city centre with almost no settlement in the area among other factors considered. The total land area covered by the optimum locations was approximately 2% of the entire land area of Ibadan equivalent to about 6545 hectares.

Key words: AHP, Iron & Steel Industry, GIS, SDGs, GDP, Ibadan, Nigeria.

1 INTRODUCTION

THE population of Ibadan is the third largest city in Nigeria and based on 2016 population estimate of 6.018 million, with 3.32% growth rate yearly and in two decades, it is projected that the population will hit almost 11.6 million (Dar, 2017). The lack of success recorded from Nigeria's inability to become industrialized can be attributed to the moribund Ajaokuta Integrated Iron and Steel Complex. Despite huge investments made by the Nigerian government to the steel company since 1979, there has been limited progress towards iron and steel production in Nigeria (Agbu, 2002). The industrialization following the development of steel company will stimulate economic activities in Nigeria and even help to absorb most of the Nigerian working population that will work in the steel plant, thereby curbing crimes and criminality. This is in line the United Nations Sustainable Development Goals numbers 9 and 12 that focused on innovative ways of reproducing old materials and recycling of metals respectively. Most developed and industrialized nations around the globe such as India and China in Asia, United States and Mexico in North America and so on, all make use the method of iron and steel recycling techniques which in turn generate employments, foreign exchange earnings and boosting of the gross domestic product of their countries. That iron and steel are needed for successful economic growth of Nigeria cannot be over emphasized as steel has been the driving force of Japan's industrialization and modernization since 19th century (Agbu, 2004). There is the deficit of steel in Nigeria as the country has failed to actualize her dream of iron and steel extraction from iron ore in the past. Iron and steel industry were not included or considered when developing the Ibadan Master Plan in 2017. Two inland dry ports are planned to be established along the two major rail lines in Ibadan, one by the Catamaran group and the other by Chinese investors (Punch, 2019a). These inland ports when fully operational will support the growth of iron and steel fabrication plants in Ibadan. The employment benefit and economic growth that such industries will bring should not be an oversight for any development plan for a big city like Ibadan. In Ibadan today, they pick up the steel and iron scraps from near and within the city without having a steel plant to recycle them. Taken into consideration the geographical location of Ibadan, being central and accessible to most parts of South Western Nigeria and being connected by efficient rail network, siting an electric arc furnace for recycling of iron and steel scraps will be very beneficial not only to Nigeria alone but to the whole of West Africa. By 2030, there is therefore the need to import or manufacture new vehicles locally which means that there will be many iron scraps (vehicles) to be recycled in Nigeria. In this study, satellite remote sensing and GIS was used for optimum site selection for the iron and steel fabrication plant in Ibadan, Oyo State, Nigeria.

2 GIS AND SITE SELECTION

Industrial site selection is a tactical judgement which encompasses all spheres of sustainable development goals with expert knowledge from various disciplines. These factors are largely described using numerous different environmental and socioeconomic parameters, presented in quantitative and qualitative techniques with some potential level of ambiguity (Rikalovic *et al.,* 2015). Site selection of iron and steel industry like any other industrial site selection is posed with multifaceted challenges which require multi-criteria decision analysis relating to environmental and socioeconomic parameters. Geographic information system (GIS) is a common Decision Support System (DSS) that includes the assimilation of georeferenced data in a solution-seeking environment, while Multi-

Criteria Decision Analysis (MCDA) presents systematic methods and measures for organizing, planning, weighing and ranking best decisions (Baseer, 2017). Analytical Hierarchy Process (AHP) can be utilized for assigning weights to various criteria in MCDA (Piri *et al.*, 2018) with a view for optimization based on several factors (Ohri *et al.*, 2010). The AHP is a concept of weighing with respect to the pairwise comparisons that depends on the decisions of experts to get preference scales. The evaluations are completed by utilizing a scale of best preference that characterizes to what extent one factor dominates one another with regards to the assigned value (Saaty, 2008). Tools such as Expert Systems (ES), Geographic Information Systems (GIS), and Multi Criteria Decision Analysis (MCDA) methods (Malczewski, 2006) are used to select suitable location for infrastructures. Appropriate geographic Database Management System (DBMS) is vital although each of the tools has its own limitations in addressing geospatial data. Geographical Information System (GIS) is a tool for gathering, storing, retrieving when needed, manipulating and displaying geospatial data for a specific set of purposes, and it equally provide all desirable requirements (Agrawal and Dikshit, 2002). GIS query is deployed to identify which location(s) satisfy certain conditions for the siting of iron and steel industry (Mousa *et al.*, 2015). Rivalovic *et al* (2015) proposed a novel Comprehensive Method for Industrial Site Selection (CMISS) that provides an innovative approach to decision making which prevents uncertainties in the input data by joining several complex interrelating decision support systems in a collaborative manner. GIS as a system that integrates remote sensing data, manipulates and equally analyses such data makes use of several tools and extensions for achieving the purpose of selection of suitable site for the location of iron and steel industry (Dangermond and Baker, 2010). It offers the decision-maker with a powerful set of tools for the manipulation and analysis of geospatial data. To this extent, GIS has the capability to undertake site suitability studies by overlaying a number of factor maps or layers. In the work of Baseer (2017), the final suitability indices for the entire country were determined by reclassifying the scores derived from the weighted overlay into six classes. Weighted overlay is the tool that overlays multiple layers of raster datasets by utilizing a common measurement scale and weights according to the importance of layers. The tool is usually applied to produce a custom model for evaluating the suitability of a site during selection process (Jamshed *et al.*, 2018). GIS is a convenient and powerful platform for performing land suitability analysis and allocation for the selection of iron and steel fabrication site because of its capabilities.

2.1 Iron and Steel Regulations and Legislations in Nigeria

In 1958, activities for the modern-day iron and steel began with actual planning for the steel industry, though exploration started at the Itakpe iron ore deposits (Ohimain, 2013). Throughout the period of 1960 – 1970, the federal government directly coordinated the iron and steel sector in Nigeria (Eyre and Agba, 2007).

The actual commencement of iron and steel development in Nigeria started with the Second National Development Plan of 1970. The development plan began with the establishment of the Nigerian Steel Development Authority (NSDA) which was charged with the functions of planning, construction and production of steel; and also to undertake geological and market surveys, and metallurgical capacity building (Ohimain, 2013). During the 3rd National Development plan of 1975 – 1980, various agreements were signed by the government between 1976 – 1978 to construct two integrated steel plants (Delta Steel Company and Ajaokuta Steel Company) and three rolling mills at Oshogbo, Jos and Kastina (Mohammed, 2002).

The National Steel Council Act enacted following the dissolution of NSDA in 18th September 1979 was responsible for the central planning of the iron and steel industry, exploration for iron ore and other related minerals and for other supplementary matters thereto (NLIP Watch, 2017). The Ajaokuta Steel Company Limited, Delta Steel Company Limited, Batagarawa Steel Company Limited, Jos Steel Company Limited, Oshogbo Steel Company Limited, and Associated Ores Mining Company Limited were all established by the Federal Government of Nigeria (Mohammed, 2002). However, the Minister may, by order published in the Federal *Gazette,* add to, delete from or otherwise amend the previous list of companies and references to companies charged with the responsibilities to:

i. mine iron ore, cooking coal and related minerals, necessary for the production of steel; or
ii. produce steel or by-products thereof (NLIP Watch, 2017).

During the period 2002 -2012, the government implemented the backward integration policy, in which import licenses for steel products were only granted to companies that have plans for domestic steel productions. In 1999 the government instituted the National Council on Privatization (NCP) and Bureau of Public Enterprises (BPE) that supervised the sale of ASC, DSC, National Iron Ore Mining Company (NIOMCO) and the rail track from Itakpe to Aladja to Indian companies, whereas the three inland rolling mills were sold to Nigerian investors. The privatization that was done was not transparent and was unable to resuscitate the steel sector (Mohammed, 2008). The Vision 20: 2020 was another economic blueprint as approved by the federal executive council that obviously recommended that the nation shall produce 12.2 million tons of steel per annum by the year 2020 out of which Ajaokuta steel plant was to manufacture 5.2 million tons per year, DSC to produce two million tons per year and the remaining by private entrepreneurs if Nigeria was to be part of the league of 20 industrialized nation by 2020. The inconsistent policy framework, corruption and poor contracting strategy led to the failure of the iron and steel sector in Nigeria. Currently, there is no government regulation and or policy regarding the recycling of iron and steel in Nigeria as at today (Ohimain, 2013).

2.2 Environmental Issues of Concern and Regulations to Steel Manufacturing

Environmental protection and regulation continued to be recurring requirements in human well-being given the ŧ significance of the environment to human continuous survival and the effect of the actions of humans on the natural environment. This has influenced several coordinated efforts to stabilise the connection between human and the environment all over the world in recent time. The Agency responsible for environmental regulations and standards enforcement in Nigeria is known as National Environmental Standards and Regulations Enforcement Agency (NESREA). Sequel to the promulgation of the National Environmental Standards and Regulations Enforcement Agency (Establishment) Act 2007 (NESREA Act, now Cap N164, Laws of Federation of Nigeria 2010), a number of National Environmental Regulations have been made to give effect to the aim and objectives of the Act (Adeoluwa, 2018). The relevant laws of NESREA on the environment for iron and steel are National Environmental (Base Metals, Iron and Steel Manufacturing/Recycling Industries) Regulations, S. I. No. 14 of 2011. These regulations have the principal thrust of preventing and minimising pollution from all operations and ancillary activities of the sector in the Nigerian environment. The Regulations also provide for polluter-pay principle, where there is pollution in the course of operation of any facility. Under Regulation 8, every facility, corporation or organisation shall prepare a voluntary action programme for global warming control measures. Penalty for violating any of the provisions of the regulations is provided for under regulation 56. The penalty includes (two hundred thousand naira only) N200,000 fine or a term of imprisonment not exceeding 6 months or both in the case of individual, and (one million naira only) ₦1million in case of corporate body. Under these regulations, facility means iron and steel industry (Ladan, 2012). Through a holistic waste recycling campaign on the shop floors of the steel mills, some of the processed by-products and outright wastes can be re-processed to useful products. This has the capacity to increase the country's Gross National Product (GNP) and ensure cleaner environment (Lawal, 2015).

2.3 Standards of Steel

The International Organisation for Standardisation (ISO) issued a standardised method for calculating CO_2 emission intensity from iron and steel production in March 2013, which was the first standard in the world to delimit the sector-specific method of calculating CO_2 emission. ISO14404 is based on the energy performance indicator established under APP (Asia-Pacific Partnership on Clean Development and Climate) and world steel CO_2 data collection. Innovative methodology of APP and world steel was optimized for blast furnace (ISO14404-1) and electric arc furnace (ISO14404-2). In addition to calculating CO_2 emission, users may apply ISO14404 to assess energy intensity. ISO14404 is effective particularly in the developing countries where steel production and energy consumption in the steel industry is on the rise. Steel plants will regularly review energy saving condition and thereby establish energy management structure once such steel plants adopt ISO14404 (Jones, 2012).

2.4 Electric Arc Furnace Steel Making

The Electric Arc Furnace (EAF), which was originally developed just after the turn of the 20th century, is still used to this day. Electric arc was first experimented with to melt iron as early as 1810. However in the United States in 1907, Frenchman Paul Héroult was the first to produce steel with a manufacturing plant using EAF. The EAF passes an electric current through a charged material, with the iron heated up to a temperature of 1800°C (Liu *et al.*, 2018). Low financial costs are attributed to EAFs because they utilize the minimill in contrast to the more costly integrated mills. The electric arc furnaces are operated as a batch process that comprises charging scrap and other raw materials typically scrap metals and iron units like pig iron, direct reduced iron (DRI), and HBI, melting, removing slag ("slagging"), and tapping for carbon and alloy steels production. The cylindrical refractory-lined EAF are equipped with carbon electrodes which can be raised or lowered through the furnace roof. As the electrodes retract, the furnace roof can be rotates aside to permit the charging of scrap steel by overhead crane. After ferrous scrap and other materials are charged to the EAF, the melting phase starts when electrical energy is supplied to the carbon electrodes (Rahman, 2010). This process can be achieved within or less than 60 minutes tap-to-tap time for newer EAFs. The electric current of the opposite polarity electrodes produces heat between the electrodes and through the metal scrap. Oxy-fuel burners that employ convection and flame radiation to transfer heat to the scrap metal, and oxygen lances could equally be used to supply chemical energy that produces the exothermic reactions with iron and other components that help in melting iron scraps and removal of excess carbon. The alloying agents and fluxing materials are normally added through the doors on the side of the furnace to attain the desired composition (Jones, 2012). The furnace is then tipped forward, and the steel is poured ("tapped") into a ladle (a refractory-lined vessel designed to hold the molten steel) for transfer to the ladle metallurgy station. Bulk alloy additions are made during or after tapping based on the desired steel grade (Delport, 2010). Some EAF plants, primarily the small specialty and stainless steel producers, employ the argon-oxygen decarburization (AOD) for additional purification of molten steel to produce low-carbon steel (Saqlain *et al.*, 2018). The EAFs have the advantages to start and stop production as wanted which allows them to vary production according to demand, in

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which however, the blast furnaces generally cannot do. The EAFs again allow for the production of steel from 100% scrap metal. This greatly reduces the energy required to produce the steel compared to steelmaking operations from iron ore (Bell *et al.,* 2006). Currently, Egypt and Libya are successfully running iron and steel companies in North Africa. The Ezz Steel and Lisco owned by the governments of Egypt and Libya respectively, both employ electric arc furnace technique (Libyansteel, 2019). ArcelorMittal is the number one steel company in the world, which operates in more than 60 countries, is headquartered in Avenue de la Liberte, Luxembourg, in which South Africa is one of them (Steel Technology, 2019). It has been well established that iron and steel industry is one of the key driving forces for the increase in the economic growth of South Africa (Trapido, 1971). Gibela is owned by Alstom SA. A joint venture owned by French and South African rail fabrication Company built on 78 hectare of land with a total cost of $133 million. The Company majors in revitalization of South African Rail System with a contract sum of $3.3 billion to boost passenger train service in the country. The major raw materials for production by Gibela are 90% recyclable materials and other materials which are locally sourced. This company will serve as a motivating hub for African countries' GDP growth and economic empowerment for locally produced trains (Bailey and Scott-Clarke, 2019). Similar to this economic development and empowerment is the Kajola Real Wagon plant under construction in Ogun State, Nigeria that is a private-sector financed asset to be carried out by Messers CCECC. The plant aims to support the National rail transformation plan by constructing and maintaining all components required to boost the development of rail services in Nigeria and other African countries (Punch, 2019b).

2.5 Theories and Models of Site Selection

The location of secondary industries depends to an important extent on human behaviours and decision-making process, on cultural and political as well as economic factors, and even on intuition and whim (Faundez, 2016). Several theories and models have been enunciated for the optimum location of industries. Some of the theories considered in this study include the least cost theory of Alfred Weber, locational interdependence theory proposed by Harold Hotelling (Michel, 2003), Smith and Palander theory (Jones, 2012), and the August Lösch theory which is a bottom to top approach unlike the Christaller that is a top to bottom approach (Hartwick, 2006). Sub-Saharan African city model (1968) by De Blij proposed three central business districts at the core of the city which are found in most African cities like Ibadan and at the outskirt are located with mining and manufacturing zones that are best suited for iron and steel fabrication plant. The model also recognizes the importance of transportation network to connect all the major sectors identified in the zones (Fouberg *et al.,* 2009). All the theories have their assumptions and criticisms alike.

3 METHODOLOGY

3.1 Study Area

Ibadan City is located approximately between latitude 7° 15' 00'' N and 7° 34' 00'' N, and longitude 3° 45' 00'' E and 4° 05' 00'' E (Oladele and Oladimeji, 2011). Ibadan is located at approximately 145 km north of Lagos and at 156 km by rail (Osowole *et al.,* 2013). It is made up of 11 local government areas.

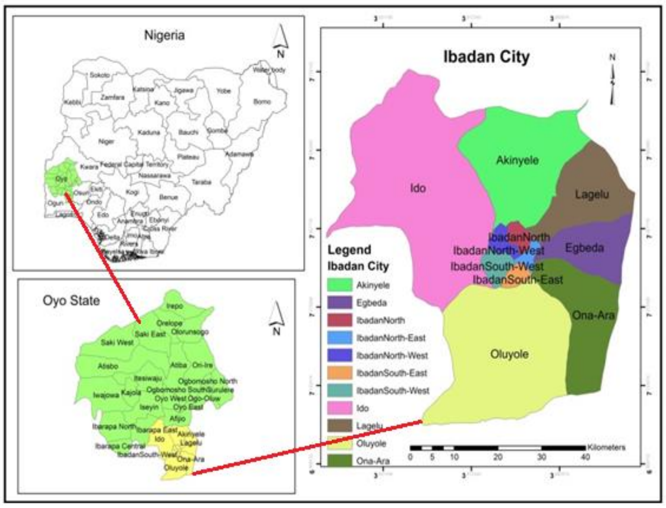

Fig 3.1 Map of Ibadan

3.2 Evaluation and Standardization of Criteria

In this study, the effective criteria were primarily identified in determining optimal locations for the selection of iron and steel fabrication plant in Ibadan. The criteria were carefully chosen from the models adopted for the study which then formed the data. They are railway line, power substation, power transmission line, settlement, slope, road and river. The various criteria used for the study were then standardized according to the expert knowledge and the pairwise comparison was assigned using the percentage influence and the scale value suitable being 1, and most suitable being 9).

3.3 Weighted Overlay

The weighted overlay was carried using the criteria as shown below:

1. The evaluation scale was selected on a default evaluation scale from 1 to 9 in increments of 1 (with least suitable being 1, and most suitable being 9).
2. The input rasters were added one after another.
3. The scale values were set as the default values were assigned to each cell according to importance or suitability.
4. The weights to input rasters were assigned accordingly on a percentage influence based on their respective importance. The sum of total influence was 100%.
5. The weighted overlay tool was run as the cell values of each input raster were multiplied by the raster's weight (or percentage influence). The resulting cell values were added to produce the

final output raster.

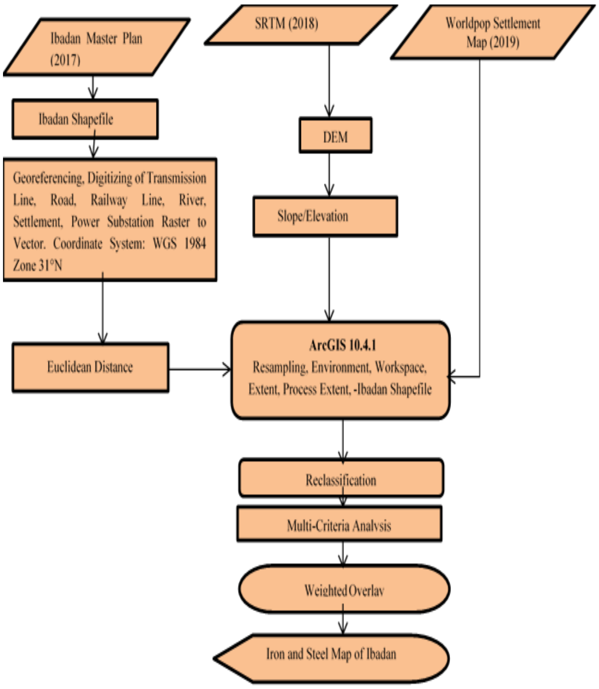

Figure 3.2 Methodology adopted for the study (Adapted with slight modifications from Rikalovic *et al.*, 2015).

4 RESULTS AND DISCUSSION

Exactly seven parameters were evaluated for the research viz. railway, rivers, settlement, power substation, slope, roads and power transmission line. Each of the criteria was assigned a weight and ranks for its fields depending on its percentage influence on the siting of iron and steel fabrication plant. The individual thematic layers were multiplied to the respective priority vectors obtained from pair wise comparison matrix of Analytical Hierarchy Process. Suitability map of the region was classified into classes from mostly unsuitable to optimally suitable based on the cumulative evaluation of the criteria and weights given to them at criteria level.

4.1 Data Processing of Vector Layers

Vector data used for this study were digitized from the Ibadan Master Plan (Dar, 2017) scanned maps using ArcGIS 10.4.1 to create the vector layers (Fig 4.1). The Euclidean distance analysis was carried according to the work of Dokmanic *et al* (2015) as shown in figures 4.2, 4.3, 4.4, 4.5 and 4.6 below to create distances to several criteria. The Euclidean distance output raster contains the measured distance in kilometers from every cell to the nearest source.

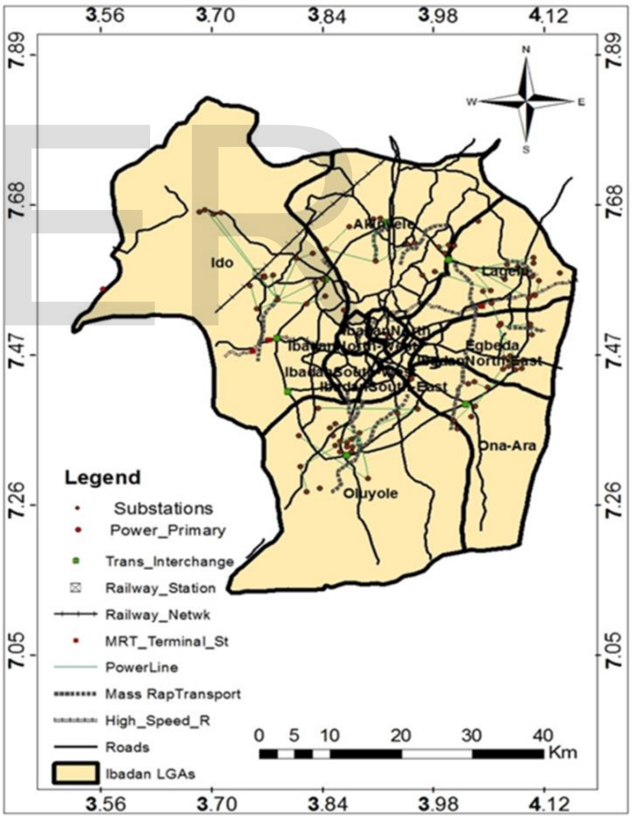

Fig 4.1 Map showing digitized vector layers.

4.2 Settlement Reclassification

As a result of the pollution effects arising from the production processes of iron and steel industries, it is usually better to locate the industries far from the residential areas of human settlement. Ibadan has been a fast-growing city with high urban growth rate and this study centred on siting the iron and steel fabrication plant in the areas that conform to the Ibadan Master Plan 2017 for industry. The areas equally meet the basic requirements for siting iron and steel fabrication plant as the areas agree with various theories of site selection of iron and steel industries reviewed in the literature. These areas have minimal environmental issues with respect to the pollution impact of the urban and rural settlements that would be generated by the iron and steel plant Figure 4.2 shows the map of the reclassification of the settlement of Ibadan. The classification of two land-use parameters was done, as settlements are marked unsuitable and vegetation area and open land are marked suitable with high class influence.

4.2 Slope Reclassification

The slope of Ibadan was generated from the SRTM (shuttle radar topographic mission) data and ~~used~~ ArcGIS 10.4.1 was used to perform the slope analysis. The reclassification was further done in which slope was reclassified into three (high, moderate and low). The iron and steel fabrication plant were to be sited in areas with moderate elevation amidst other criteria considered in this study. The percentage influence of the slope dataset was 14 % with field values of 1, 2 and 3 and scale values of 1, 2 and 5 respectively. The scale value represented the analytic hierarchy process (AHP) value in this study. This is in line with work of Piri *et al* (2018) that made use of analytic hierarchy process (AHP) and geographic information system (GIS) to carry out their spatial suitability assessment. The slope map is presented in figure 4.3. The map shows that the areas with high elevation are the least while the areas with moderate elevation are the best location for siting iron and steel fabrication plant. However, areas with low elevation are moderately suitable. This is so as Ibadan is found in the almost the southern-most part of Oyo State with total elevation of approximately 234 meters above sea level (Osowole *et al*., 2013).

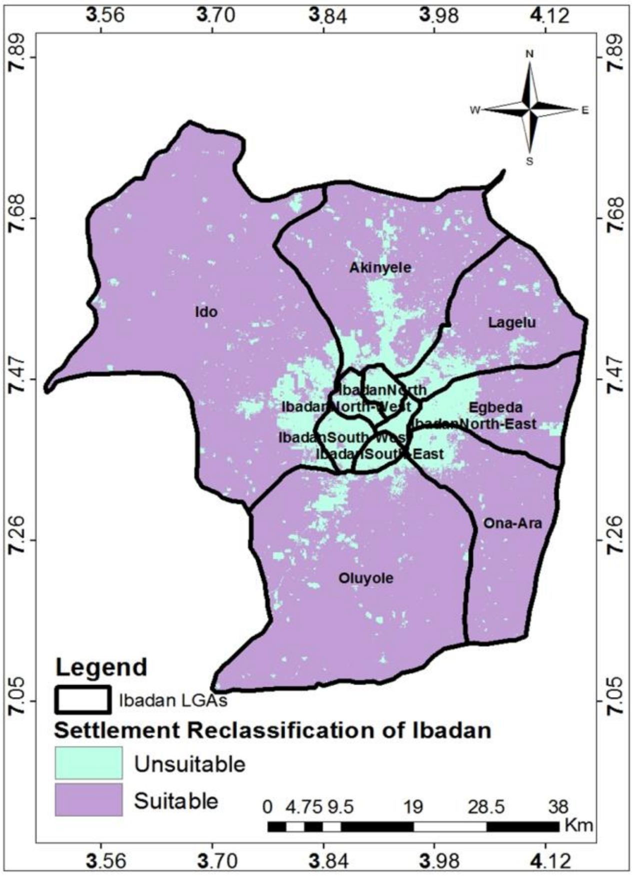

Fig 4.2 Settlement Reclassification of Ibadan

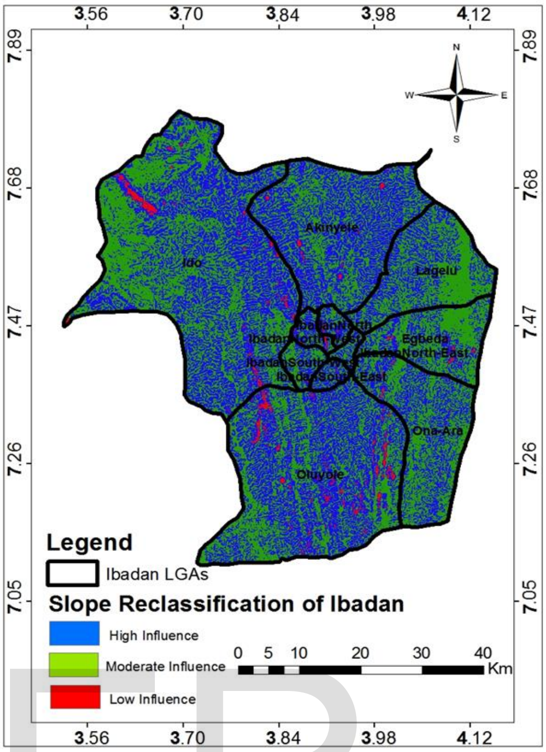

Fig 4.3 Slope Reclassification of Ibadan

4.3 Reclassification of Railway and Roads

Proximity of the iron and steel industry to efficient transport network is a very important criterion to be considered in selecting the fabrication plant. Closeness of the industry to the efficient transport network will go a long way in conveyance of the raw materials from the port to the fabrication plant and then aid also the transportation of finished steel from the industry to the port and to the markets. Table 4.1 shows the pairwise comparison for both the transportation criteria considered in this study. Figures 4.4 and 4.5 present the reclassified maps of railway and roads respectively.

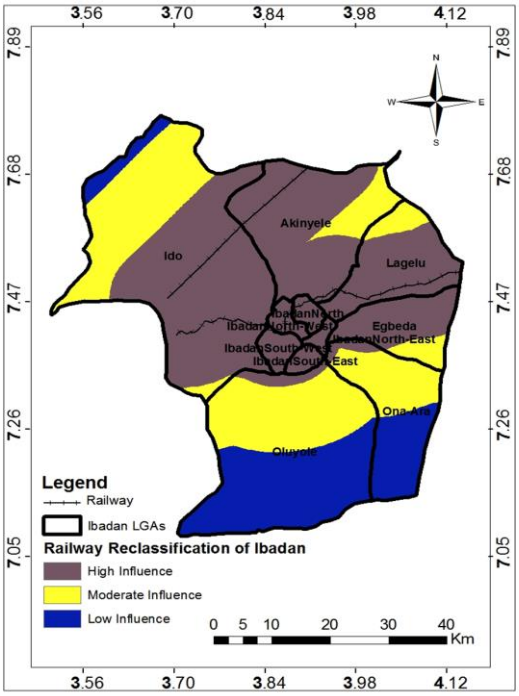

Fig 4.4 Railway Reclassification of Ibadan

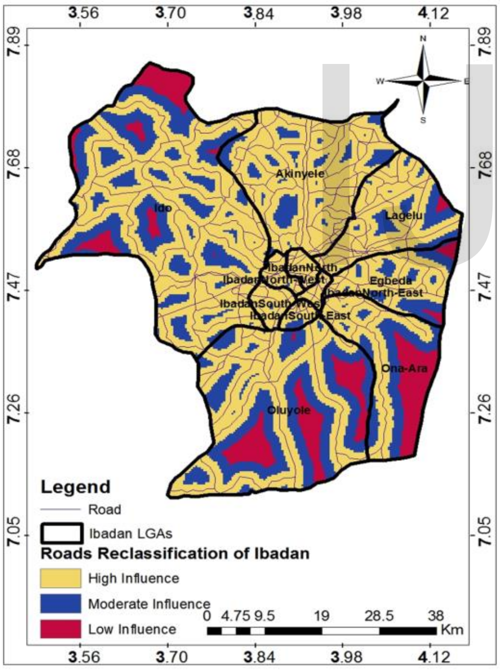

Fig 4.5 Road Reclassification of Ibadan

4.4 Reclassification of Power Substations and Power Lines

Power substations and transmission lines make up electricity which is a very important factor of production of steel from iron and steel industry. Following the theories and models of site selection considered in this study, and for there to be reduced cost of production, the fabrication plant for steel must be located very close to the power source. This is shown in Table 4.1, the percentage influence for power substation was 14% while that of power line was 16%. The power line has the highest scale value of 9 for the field value of 3 with "high influence" of suitability, whereas, the power substation had scale value of 5 for the field value of 3. The reclassified maps of power substation and power line are shown in Figures 4.6 and 4.7. The maps showed three different classes of low influence, moderate influence and high influence on the selection of iron and steel fabrication plant in Ibadan.

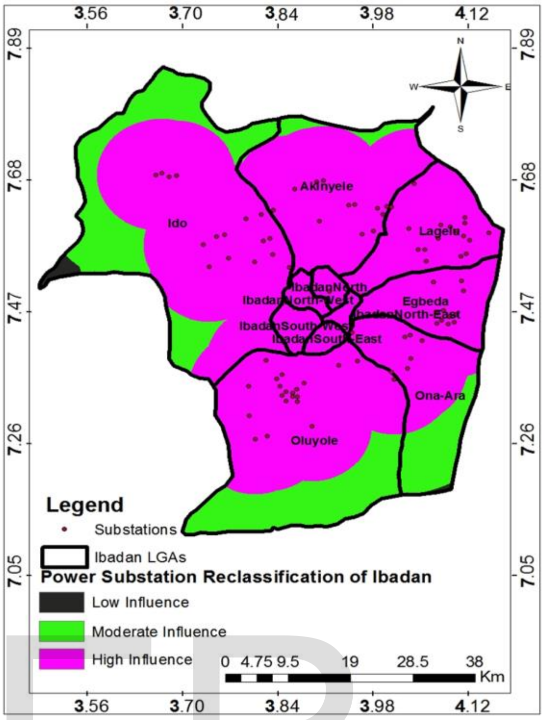

Fig 4.6 Power Substation Reclassification of Ibadan

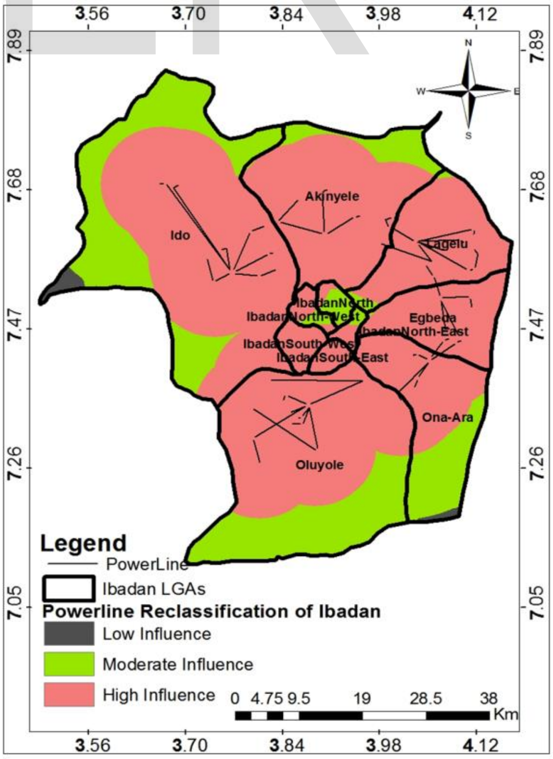

Fig 4.7 Power line Reclassification of Ibadan

4.5 Reclassification of Rivers

Water generally is very important in production of iron and steel products. However, due to the importance of water to mankind, contaminations and pollutions of water bodies are inevitable if serious measures are not put in place during site selection of iron and steel fabrication plant. For this reason, rivers and other water bodies were given due consideration in the course of this study in order to select the areas that are not too close to the water bodies. Table 4.5 shows the percentage influence for the river layer was 14% and the areas close to rivers are given a field value of 1 and the scale value was restricted to prevent the iron and steel fabrication plant from being too close to the river.

Therefore, any area close to the river had low influence on the site selection result as shown in figure 4.8.

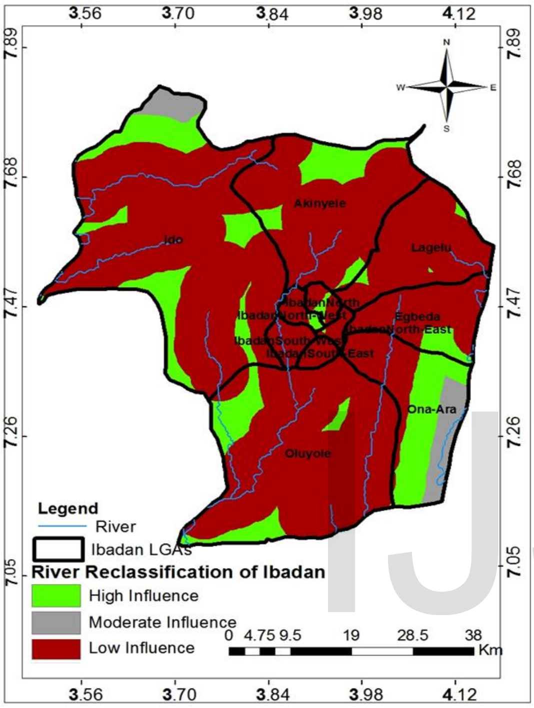

Fig 4.8 Rivers Reclassification of Ibadan

4.6 Suitability Analysis

At this point weighted overlay analysis was performed; all the seven criteria considered and used for the selection of iron and steel plant in Ibadan were used to run the analysis. The weightages influences that are assigned to the layers were taken into consideration so as the field value and the scale values and the level of suitability, see Table 4.1 for details. The reclassification was earlier carried out into appropriate classes according to Reid (2016) before doing the weighted overlay analysis. The integration of various thematic layers describing criteria for the selection of the iron and steel fabrication plant was used for the optimal site selection of iron and steel fabrication plant in Ibadan (Figure 4.9). This is in line with the work of Al-Anbari *et al* (2018). The optimal locations **A, B and C** for the siting of iron and steel fabrication plants takes about 6545 hectares of land representing only approximately 2% of the total land area of Ibadan. Figure 4.9 reveals that Ido and Akinyele have the optimal locations **A, B and C** that are closest to both the railway lines in Ibadan and at the same time farthest from the city centre with almost no settlement in the area among other factors considered.

Table 4.1 Details of Weighted Overlay Analysis

S/N	Thematic Layer	Weightage	Field Value	Scale Value	Level of Suitability
1	Settlement	12	1 2	1 2	Unsuitable Suitable
2	Slope	14	1 2 3	1 2 5	High Elevation Moderate Elevation Low Elevation
3	Rail	16	1 2 3	1 2 9	Low Influence Moderate Influence High Influence
4	River	14	1 2 3	Restricted 2 5	Low Influence Moderate Influence High Influence
5	Substation	14	1 2 3	1 2 5	Low Influence Moderate Influence High Influence
6	Road	14	1 2 3	1 2 5	Low Influence Moderate Influence High Influence
7	Power line	16	1 2 3	1 2 9	Low Influence Moderate Influence High Influence

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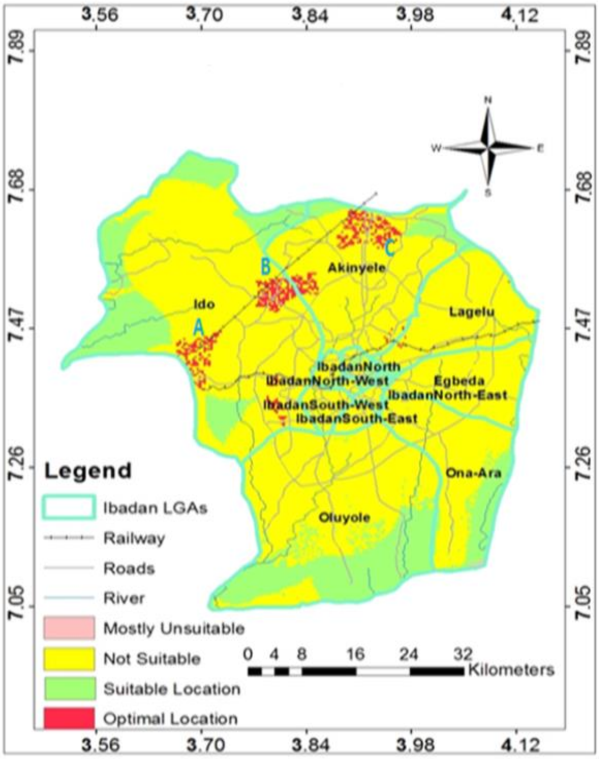

Fig 4.9 Optimal Locations Map of Iron and Steel Fabrication in Ibadan

5 CONCLUSION

The result of this research work shows that applying GIS-based multi-criteria decision making analysis for iron and steel site selection was both helpful and effective, and equally achievable. Exactly seven parameters were considered according to literatures and established theories of site selection for industries in the course of this study. The criteria were railway, rivers, settlement, power substation, slope, roads and power transmission line. Each of the criteria was assigned a weight and ranks for its fields depending on its percentage influence on the siting of iron and steel fabrication plant. Reclassification of the Euclidean distance, multi-criteria analysis and analytical hierarchy process were all employed during the weighted overlay analysis in order to select the optimum site for iron and steel fabrication plant in Ibadan. Precisely three optimum sites were selected from the final map of the result of the project located in Ido, and Akinyele local government areas of Oyo State. All these locations can be used for iron and steel related fabricated activities and location **A** closest to two railway lines is best suited for iron and steel fabrication plant in Ibadan. All the locations take about 6545 hectares of land representing only approximately 2% of the total land area of Ibadan. It can then be inferred from this research that, with the help of remote sensing and GIS technologies, the process of site selection for industries and urban planning in general can be done in a more effective and scientific manner.

In line with The United Nations Sustainable Development Goals especially goals 9 and 12 which focused on industry, innovation and infrastructure as well as recycling of metals respectively, siting of iron and steel fabrication plant in Ibadan will help to elevate Nigeria's status on her path to industrialization. With the use of modern electric arc furnace for iron and steel production, employment opportunities will be created and pollution due to metal scraps will be reduced. Also, pollution of the environment as registered experienced using ordinary blast furnace will be done away with using the EAF.

5.1 Recommendations

In order for Nigeria to truly achieve her objectives of diversifications of her economy and also for her to actualize her age long dream of industrialization through iron and steel manufacture, the siting of modern iron and steel fabrication plant in Ibadan is not only timely but also must be done with all seriousness that such project demands. With the successful location of optimum sites for iron and steel fabrication plant in Ibadan following the various criteria used, we hereby call on the federal and state governments, private sectors and venture capitalists to consider the option of establishing the iron and steel fabrication plant in the area. Also, with the Federal Government of Nigeria's recent agreement at the Russian African Summit in Sochi, 2019 to bring back the original Russian Company that constructed the Ajaokuta Steel Complex to come and revitalize it, there is no doubt that iron and steel fabrication remains a central economic focus for Nigerian development. This effort should encourage the establishment of minimills electric arc furnaces across Nigeria. This work serves as a model that can be used to select optimal site for iron and steel fabrication in other parts of Nigeria.

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