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**Research Paper**

# Study on the Physical Environmental Parameters that Influence the Location of Industries in Ibadan, Nigeria: A Geospatial Approach.

Ogar P.A[1], Uyo C.N[2], Nmecha I.M[2], Ismaila M.A[2], Esomonu, I[2] and Ukpe, A.E[2]
[1]*Institute of Ecology and Environmental Studies, Obafemi Awolowo University, Ile Ife, Nigeria*
[2]*Department of Environmental Management, Federal University of Technology, Owerri, Nigeria*
*Corresponding Author: Chijioke Ndukwe Uyo*

***ABSTRACT:*** *Ibadan being the largest city in Nigeria gives rise to a large number of industrial activities. Physical environmental factors that determine the location of these industries are important considerations to urban planning and environmental sustainability. This study assesses these physical environmental parameters using geospatial techniques. High resolution satellite imagery were acquired and extraction of different layers using ArcGIS platform, acquisition and georeferencing of topography map of the study area was also carried out, features of interest were inputted into the geospatial model through Arc Catalog. In the Arc Catalog, shapefiles for each of the features with their spatial reference was created. Maps were thereafter developed for the identified environmental parameters that influence the location of industries. ArcGis 10.1 platform was used to organise datasets and to apply geospatial processing functions on a clear interface. The result of the analysis which was maps generated shows the storage and communication roles they play in industrial decision making.*
***KEYWORDS:*** *Geospatial Techniques, Environmental Parameters, Industrial Location, ArcGIS*

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## I. INTRODUCTION

The factors that determine industrial location are important considerations to urban planning and environmental sustainability. This is due to the social-economic and environmental impacts that this kind of decisions have on any territory [1]. A proper location should address a wide range of factors in order to strike a balance between socio-economic benefits and environmental sustainability. Many factors involved in the location of particular industries are of relative significance [2] example includes availability of raw materials, power resources, water, labour, markets, transport infrastructures are considered geographical factors [3]. Besides such purely geographical factors influencing industrial locations, there are factors of historical, human, political and economic nature which are now tending to surpass the force of geographical advantages [4]. Nevertheless, sustainable development requires a new formula to design and locate industrial areas in such a way that negative impacts produced by its creation and exploitation will be minimized. As an integral component of human, the environment is affected by every development effort in a particular way [5]; however, no development is sustainable if it fails to take into account geographical, socio-economic, ecological, landuse and cultural settings [6]. Environmental management is inherently a spatial endeavour [7]. For hundreds of years, explorers produced manually drafted maps which served to link "where to what" descriptors. Spatial analysis is important in formulating economic development policies. GIS is an efficient tool for economic development analysis for at least six reasons: to easily link graphics on maps to tabular records in databases; to link features based solely on spatial locations; to track quantitative data over time, such as changes in land values and quickly generate maps and graphs that 'tell the story', analyses of spatial relationships and spatial statistical methods; to analyse alternative economic development projects and policies and generating interactive maps for site selection, zoning and so on.

Previous researches have looked at variables influencing the choice of location. The important roles played by these variables often show their extensive use in studies involving the selection of industrial sites [8]. Previous researches also proposed new location models that integrate fundamental sustainable development principles. There has been no significant attempt to organise and synthesize the various sets of critical factors influencing industrial locations, nor have valid and reliable measures for those factors being shown. Maps serve as both communication and storage tools; its operational measures will be useful to both researchers and

corporate decision makers in environmental protection and development. The factors influencing industrial location include transportation, labor, raw materials and markets.

**Table 1: Critical factors of industrial location**

| **Critical Factors** | **Explanation of Critical Factor** |
|---|---|
| *Transportation* | Pipeline facilities. Airway facilities. Highway facilities. Railroad facilities. Trucking services. Waterway transportation. Shipping cost of raw material. Cost of finished goods transportation. Availability of postal services. Warehousing and storage facilities. Availability of wholesale outlets. |
| *Labor* | Low cost labor. Attitude of workers. Managerial labor. Skilled labor. Wage rates. Unskilled labor. Unions. Educational level of labor. Dependability of labor. Availability of male labor. Availability of female labor. Cost of living. Worker stability. |
| *Raw Materials* | Proximity to supplies. Availability of raw materials. Nearness to component parts. Availability of storage facilities for raw materials and components. Location of suppliers. Freight cost. |
| *Markets* | Existing consumer market. Existing producer market. Potential consumer market. Anticipation of growth of markets. Shipping costs to market areas. Marketing services. Favorable competitive position. Income trends. Population trends. Consumer characteristics. Location of competitors. Future expansion opportunities. Size of market. Nearness to related industries. |
| *Industrial Site* | Accessibility of land. Cost of industrial land. Developed industrial park. Space for future expansion. Insurance rates. Availability of lending institutions. Closeness to other industries. Community industrial development projects. Attitude of financing agents |
| *Utilities* | Attitude of utility agents. Water supply, cost and quality. Disposable facilities of industrial waste. Availability of fuels. Cost of fuels. Availability of electric power. Cost of electric power. Availability of gas. Adequacy of sewage facilities. Availability of coal and nuclear facilities. |
| *Government Attitude* | Building ordinances. Zoning codes. Compensation laws. Insurance laws. Safety inspections. Nuisance and stream pollution laws. |
| *Tax Structure* | Tax assessment basis. Industrial property tax rates. State corporate tax structure. Tax free operations. State sales tax. |
| *Climate* | Amount snow fall. Percent rain fall. Living conditions. Relative humidity. Monthly average temperature. Air pollution. |
| *Community* | Colleges and research institutions. Attitude of community residents. Quality of schools. Religious facilities. Library facilities. Recreational facilities. Attitude of community leaders. Medical facilities. Shopping centres. Hotels and motels. Banks and credit institutions. Community position of future expansion. |
| *Political Situation of Foreign Country* | Relations with the west. History of country. Stability of regime. Protection against expropriation. Treaties and pacts. Attitude in the United Nations. Type of military alliances. Attitude toward foreign capital. |
| *Global Competition and Survival* | Material and labor. Market opportunities. Availability of capital. Proximity to international markets. |
| *Government Regulation* | Clarity of corporate investment laws. Regulations concerning joint ventures and mergers. Regulations on transfer of earnings out of country. Taxation of foreign owned companies. Foreign ownership laws. Requirements on what percentage of employees may be foreign. Prevalence bureaucratic red tape. Regulations concerning price controls. Requirements for setting up local corporations. |
| *Economic Factors* | Standard of living. Per capita income. Strength of currency against US dollar. Balance of payment status. Government aids. |

These factors can be classified into three basic categories: markets, labor, and physical environment.
This study assesses the veracity of these propositions in Ibadan industrial establishments and gave a systematic representation of the physical environmental factors influencing the location of industries using maps and geospatial interpretations.

## II. METHODOLOGY

### 2.1The Study Area

The study area which was Ibadan consisted of 11 Local Government Areas (LGAs) for governance and administrative purposes. Five of the LGAs are located in the metropolis, while the remaining six are

either predominantly peri-urban or rural settlements. Ibadan's has total land area of 3123 $km^2$, about 15 percent is urban and the remaining 85 per cent is classified as peri-urban [9]. Ibadan North LGA is the largest among the urban LGAs (145.58 $km^2$) while Ibadan North West is the smallest at 31.38 $km^2$ [10]. The peri-urban LGA of Ido (865.49 $km^2$) covers the largest land area [11]. Projections for the city suggest that over the next decade or more, the number of inhabitants in Ibadan will increase by around 60 per cent. Table 2 showed the population characteristics of local government areas between 1991-2006. Similarly,[12] project that Ibadan's population will increase 68 per cent, and land conversion for urbanization will increase by 58 per cent between 2000 and 2020. The city is extending radially, and if this continues it could engulf significant areas that are currently peri-urban and transform more distant rural settlements into new peri-urban areas and industrial estates. The sharp increase in demand for land and physical development in the absence of strict urban growth regulations, will likely result in loss of important environmental services as well as a decrease in available land for agricultural and industrial activities in the city.

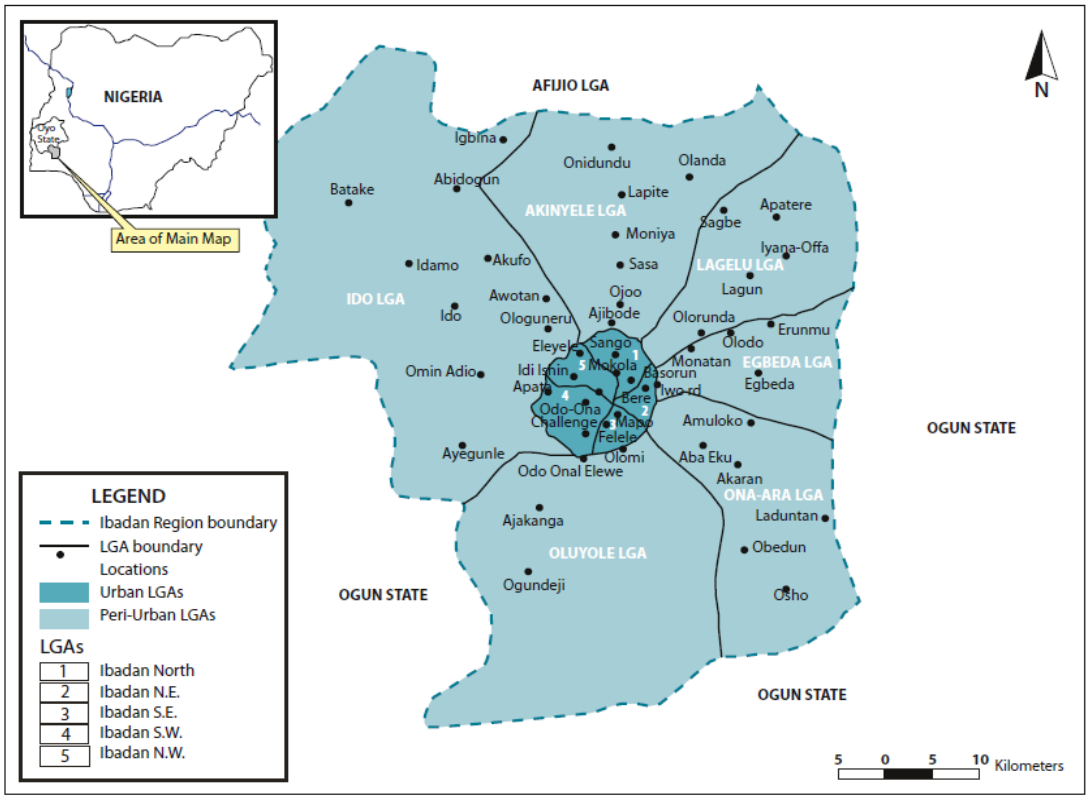


**Figure 1:** Map of the Study Area

Adelekan, 2012

**Table 2: Population characteristics of LGAs, 1991–2006**

| LGA Area | $Km^2$ | Population Growth | | Increase (%) | Rate (%) |
|---|---|---|---|---|---|
| | | Population (1991) | Polpulation (2006) | | |
| **URBAN** | | | | | |
| Ibadan North | 145.58 | 302 271 | 306 795 | 1.5 | 0.1 |
| Ibadan NE | 81.45 | 275 627 | 330 399 | 19.9 | 1.3 |
| Ibadan NW | 31.38 | 147 918 | 152 834 | 3.3 | 0.2 |
| Ibadan SE | 80.45 | 225 800 | 266 046 | 17.8 | 1.2 |
| Ibadan SW | 124.55 | 227 047 | 282 585 | 24.5 | 1.6 |
| Total | 463.41 | 1 178 663 | 1 338 659 | 13.6 | 0.9 |
| **PERI-URBAN** | | | | | |
| Akinyele | 427.26 | 140 118 | 211 359 | 50.8 | 3.4 |
| Egbeda | 136.83 | 129 461 | 281 573 | 117.5 | 7.8 |

| | | | | | |
|---|---|---|---|---|---|
| Ido | 865.49 | 53 582 | 103 261 | 92.7 | 6.2 |
| Lagelu | 283.92 | 68 901 | 147 957 | 114.7 | 7.6 |
| Ona-Ara | 369.37 | 123 048 | 202 725 | 64.8 | 4.3 |
| Oluyole | 577.10 | 91 527 | 265 059 | 189.6 | 12.6 |
| Total | 2 659.97 | 606 637 | 1 211 934 | 99.8 | 6.7 |

Source: National Population Commission (2007) and Survey Department Ministry of Lands, Housing and Survey, Ibadan.

**2.2Implementation of the Model on a GIS Platform**

The implementation of the location model was carried out via the integration of compatible tools on a GIS platform. ArcGis 10.1 provides spatial analytical functions. Through the Model Builder environment, the user is able to create graphical geoprocessing models interactively, to include cartographic datasets, user defined parameters, using an expert systems environment, Netweaver, the hierarchical structure of the location factors and their logical relationships are built. Moreover, add-in functions are used to evaluate the attributes linked to the vectorial features on the maps. Operational rules are mainly defined using linear, triangular and trapezoidal functions. Analytical tasks and cartographic outputs are performed through the ArcGis EDMS extension that joins the model built on Netweaver with the geographical database. Final evaluation is obtained by the expert system and values are classified on seven categories attending to their veracity level, receiving the label of *no support* for the less suitable and *total support* for the most suitable one. Final results are different maps that can help the decision makers to select a specific place to locate an industrial area, considering always the way in which different groups of criteria are evaluated in the model.

The collection of primary data involved: acquisition of locational data of key facilities and effluent discharge points using hand held GPS (Garmin76); obtaining attribute data through direct measurement and administering industrial assessment forms to the facilities; digitizing the data on human settlements, soils, water bodies from the high resolution satellite imagery and topography map. The secondary data collection involved: collection of Information from relevant institutions, library, archives and textbooks; visits to the industrial facilities/sites for in-situ sampling; collection of the Topography map of the study area from the Federal Surveys, University of Ibadan Geography/Geology Departments and those of Obafemi Awolowo University (OAU) and collection of High resolution satellite imageries of the study area.

Having designed a generic database structure and procured the necessary hardware and software, the overall system model was defined to facilitate ease of data exchange or networking. This involves the following: acquisition of imagery of the study area; extraction of different layers from the imagery using ArcGIS 10.1 Software. These layers include: (a) facilities (b) vegetation (c) Effluent Discharge Point (d) Human Settlement (e) Farmland (f) water bodies. Having completed the stages of the database design phase (reality, conceptual, logical and physical), the spatial database for this project was created using ArcGIS 10.1 software. In creating the database of the study area, features of interest such as facilities, Effluent Discharge Point, Human Settlement, soils of the study area were inputted into the database through Arc Catalog. In the Arc Catalog, shape-files for each of the features with their spatial reference system were created. These shape-files were integrated in the geodatabase in the Arc Catalog. Thereafter, each of the features was digitized from the satellite imagery obtained for the study area. The attribute data were used to populate the database by right clicking on the feature on the table of content, then opening the attribute table of the feature, clicking on add field, then entering the feature name, type and field precision and repeat same procedure for all the features. This enabled the database creation for the study area. The attribute data from entities in the table created in the logical phase were linked with geometric data using ArcGIS 10.1 to make the database a functional one for the purpose of the analysis to be performed. Database implementation was executed in ArcGIS 10.1 environment. Four tables were created and these include roads, adjacent roads, activity areas and water bodies. Semantic data of each feature was entered into the table for queries and other analysis carried out.

## III. RESULTS AND DISCUSSION

The result of the study established that the general critical factors of industrial location were transportation, water bodies, labour, raw materials, markets, industrial sites, utilities, government attitude, tax structure, climate, and community. These critical factors are made up of both the geographical and non-geographical factors. Given that no operational measures of the critical factors affecting a firm's industrial location decision exist, this study developed an instrument for the critical factors. The developed instrument, consisting of different dimensions, passed through a stringent empirical validation test, and is based on extensive literature search and psychometric principles. Maps were thereafter developed for the critical geographical factors that made up the environmental factors that determined the location of industries (Figures 2 - 4).

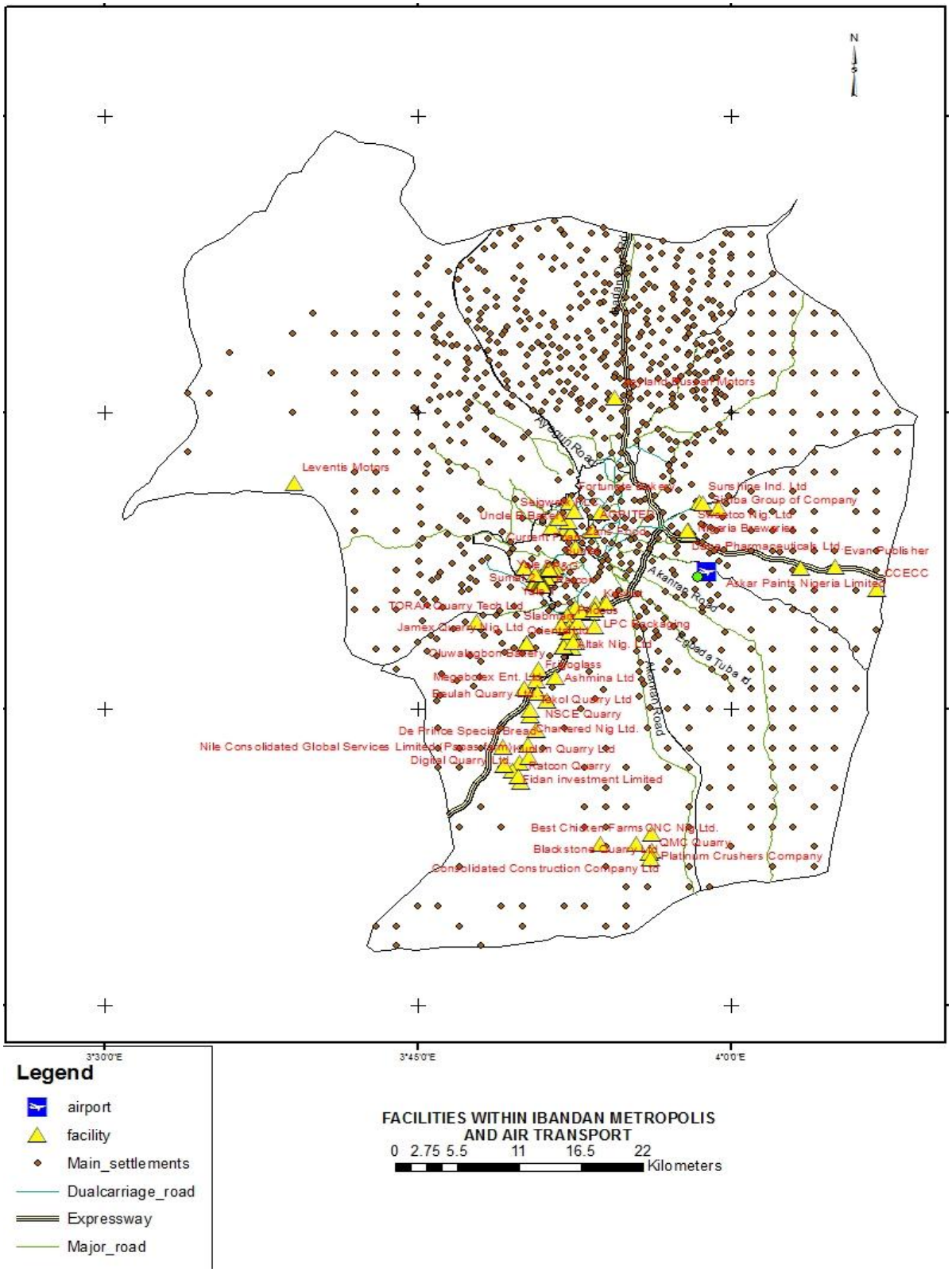


**Figure 2: map showing industrial facilities within settlements in Ibadan**

The railway line from Lagos in the South to the Northern parts of Nigeria traverses Ibadan. The railway line serves as spatial linkage between Ibadan and other parts of Nigeria which also serve a determinant to industrial establishment in Ibadan. The cities major transportation node has been enhanced and perpetuated by the convergence on it of several roads. The major roads connect Ibadan through Oyo, Ogbomoso and Ilorin to the North, Lagos to the South, Ile-Ife and Iwo to the east and northeast respectively and Abeokuta to the

southwest. These roads play a major role to the location of industries in Ibadan. There was also a functional air transport system in Ibadan which connects the city with the rest of the country aiding easy movement of personnel and light-weight industrial materials.

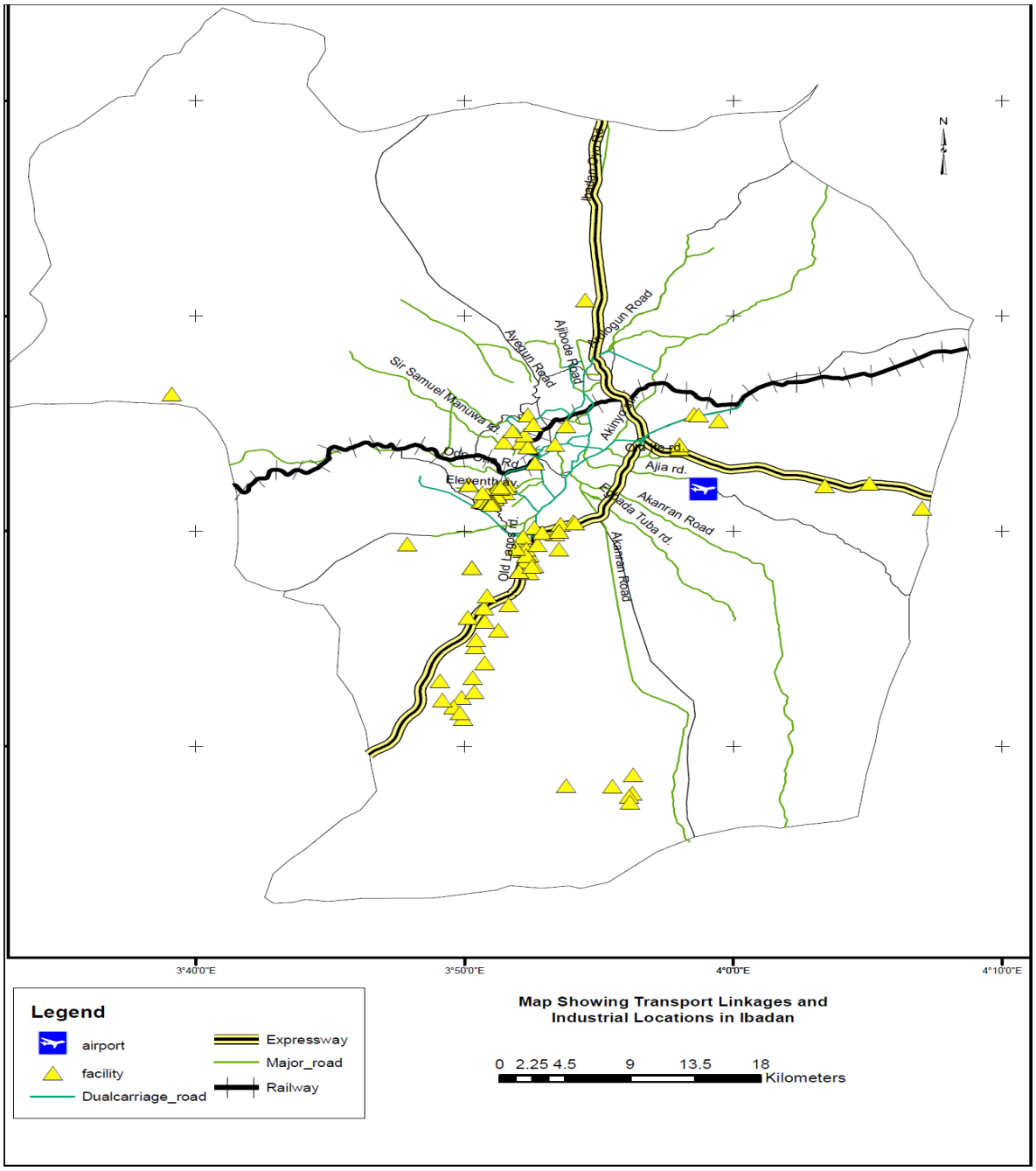


**Figure 3: Map Showing Transport Linkages and Industrial Locations in Ibadan**

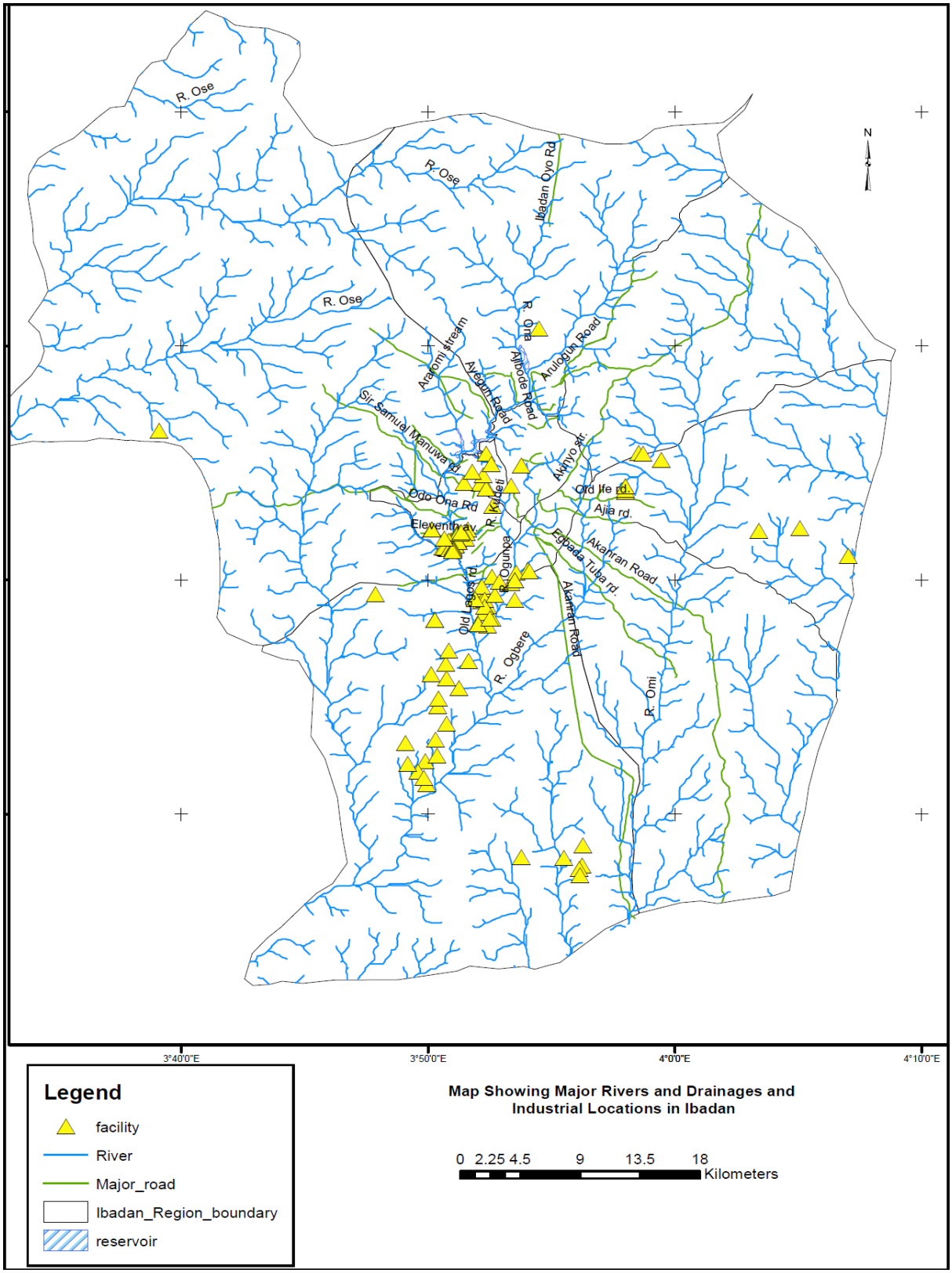


**Figure 4: Map Showing Major Rivers / Drainages and Industrial Locations in Ibadan**

The area occupied by the metropolitan area of Ibadan is drained by two important rivers viz: the Ogunpa and the Ona rivers (Figure 4). The former drains the eastern while the later drains the western parts. There are other tributary rivers such as Ogbere stream on the eastern part and Kudeti stream which joined Ogunpa at St. Lukes, Molete area of Ibadan. There are also numerous tributaries to Odo-Ona such as Yemoja in

Oluyole Estate and Alalubosa stream at Aleshiloye and many others. There is also river Omi that derived its source from Kumapayi.

## IV. CONCLUSION

The future sustainability of the industrial activities in Ibadan Municipality and the whole sustainable development within the region is a function of location of an industrial facility. The study used a geospatial interactive platform to spatially analyze and show the physical environmental parameters that influenced the continued location and existence of industrial facilities in Ibadan, with great considerations to already established positions of the location factors and distribution. ArcGIS 10.1 platform was used to organise datasets and to apply geospatial processing functions on a clear interface. The result of the analysis which were maps generated shows the storage and communication roles they play in industrial decision making.

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