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A STUDY OF THE APPLICATION OF GIS IN THE ASSESSMENT OF THE IMPACT OF INFRASTRUCTURE ON RESIDENTIAL PROPERTY VALUE IN MINNA

By

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Abstract

The provision of infrastructural facilities have been established to have direct relevance to the changes that may occur in residential property values. However, various studies have not examined the application of geograhic information system to assess the impact of the infrastructure on the property values. In this regard, this study sourced primary data on water as an infrastructre and the coordinates from the selected neighbourhood in Minna using hand held GPS and Kriging done with ARCGIS tool. The regression analysis conducted reveals that water based infrastructure with P value of 0.000 less than .005 p level a has a direct variation on rental value in the Bosso area of Minna. To this end the kriging analysis indicates that the area with darker colours possess more urban infrastructure(water based infrastructure) than those in lighter colours. This implies that the impact of provision of infrastructure that have direct influence on the residents of an area could be monitored with the use of geographic information system.The study therefore recommends the creation of a department in the geographic information system body to enable the use of GIS to monitored infrastructure development and impact on residents to enhance urban governance.

Keywords: Infrastucture facilities, Rental value, geographic information system, Residents and Kriging analysis

Introduction

Infrastructure facilities are the backbone of real estate development. Thus the provision of sustainable infrastructure to enhance the process of real estate development needs to be well coordinated.Indeed Mclellan et al (2010) opined that infrastructure is the fundamental condition for economic development.Thus, it is the network of services, usually provided by the state, that

make increasing economic development possible. However, Eisner (1991) have connected infrastructure investment to all facets of economic development. This always include an increase in property values, which is not a problem since the increase is always offset by increasing opportunities and incomes in the general vicinity. The closer a residential area is to new infrastructural projects, the higher the increase in its value. In addition they also found that the reverse relationship is true: Falling infrastructural investment is closely related to falling property values. They go so far as to hold that decaying or neglected infrastructure is a major determinant of economic decay and recession.Furthermore Canning, Fay and Prerotti (1994) states that The effects of highway infrastructure upon property values vary according to the type of construction that is already in place or currently being proposed. Roads that provide access to communities and business will increase property values. Roads that serve as barriers, or redirect traffic away from particular areas, will cause property values to fall.In Nigeria, Adebayo (2007), Ajayi (2011) Olujimi (2011) without focusing on the assessment of the impact have all concurred that the level of Infrastructure provided is a determinant of the type of residential property development and rental values within a certain location.

In all the studies, focus is on the effect of the provision of Infrastructure on the residential property value. The process of monitoring the effect either manually or in an automated manner has not been highlighted. This thus study provides an insight into the application of geographic information system as a tool in the assessment or monitoring the impact of the effect of the provision of infrastructure on residential property value

Overview of Research Variables

Infrastructural Facilities Financing and Real Estate Development

Homeless International (2010) asserts that financing is a very important tool in real estate development. Accordingliy, Canning (1994) opines that infrastructure financing refers to the means of financing the establishment, maintenance, operation and improvement of a country‘s physical infrastructure systems such as transport, water and other facilities for ensuring clean environment, communications networks and power. These infrastructure are needed to enhance the provision of housing and other physical development. Furthermore, Cities Alliance (2005) opines that Cities are in the midst of three major trends; first, increasing globalization requiring quality infrastructure to attract investments, second, decentralization of responsibilities, often not matched by delegation of powers, and third, a continual flow of poor people whose contribution to the economy is rarely matched by their access to services. To respond to these challenges cities need to be transformed into proactive developers of infrastructure rather than passive service providers. The first step towards such a transformation is a city development strategy incorporating the means of financing the city’s long term goals. Smith *et al* (1997) argued that, well- functioning infrastructure facilities and services that meet a nation's commercial and social needs are critical to economic development. In today's global economy, the ability to create modern and competitive industries and services depends on the extent and quality of a country's infrastructure

networks. Investors are fond of considering carefully the quantity and quality of a host country’s infrastructure when deciding where to locate new activities. This is supported by the World Bank’s surveys of investors carried out on economies of Middle East and North Africa. The surveys identified a number of weaknesses and which must be remedied if the region is to be

made an attractive destination for investment. Among these, poor infrastructure ranks as the third biggest constraint to investment. The first two constraints are the cost and availability of finance, and the level and administration of taxation (World Bank, 1995). Specifically, good infrastructure is essential because:

· Manufacturers require sufficient levels of power for production activities.

· International trade is not possible without advanced telecommunications.

· Distributors must be able to quickly and efficiently transport their products to market.

· Tourism operators are directly affected by the reliability, quality, and cost of a broad range of infrastructure services.

Estimating the impact of infrastructure on production costs, Aschauer (1993) found that infrastructure significantly reduces production costs in manufacturing in Germany, Japan, Mexico, Sweden, the United Kingdom, and the United States. One estimate suggests that three-quarters of U.S federal investments in highways in the 1950s and 1960s can be justified on the basis of reductions in trucking costs alone. It is important to admit however that, there is no consensus on the magnitude or the exact nature of the impact of infrastructure on growth. A particularly difficult problem remains how to determine whether infrastructure investments have promoted growth or whether the reverse is the case, implying that it is even the expansion of the economy that has led to greater demand for infrastructure. Israel (1992) inferred that the causality is likely to have gone both ways. A number of linkages of infrastructure with the rest of the economy are identified in the work of Israel (1992). Firstly, infrastructure has a lot of influence on output. It influences output from two perspectives: supply and demand. From the supply side. Secondly, infrastructure has linkages that have real, financial, and fiscal dimensions on the economy. An example of real linkage will be the employment effects in an economy.

Financial effects revolve around the implication of borrowing by public infrastructure enterprises on the availability of credit for private. The fiscal linkages include deficits of public enterprises, subsidies, user charges, and cost recovery. There are also long term-effects of infrastructure. For instance, effects of infrastructure on land use, the location of economic activities, the pace of urbanization, and the shape and density of cities. In this instsnce therefore, Ajayi(2011) empirically finds that there is a correlation between rental value which is an output of real estate developmemt and availability of infrastructural facilities in Minna, he asserts that the availability of Infrastrusture is responsible for 60% variation in rental facilities. In further affirmation of the influence of infrastructural facilities on real estate development Ajayi (2011) attest that Infrastructural faclities is responsible more than 50% variation of the land use in Ibadan North local governmnet of Oyo state. This was further confirmed by Ajayi and Adama (2011) that there is a significant relationship between the provision of infrastructure and land titling which is the attestion to the land use record in Ibadan Noth local government. However, all the studies examine the relationship of infratructure and real estate development, not the assesment of the impact with the aid of geographic information system.

Application of Geographic Information System.

In the words O'looney (1997) GIS is used mostly to streamline basic administrative tasks that were being done before, such as preparing and updating zoning maps. He also foresaw, however, the possibility for sophisticated applications at the high end, such as simulation models that could forecast various aspects of neighborhood change, although few actual examples existed near that end of the scale. Public and private organizations have a different perceptive of their surrounding, the former dealing with the people, facilities, businesses and land, the later being interested in employees, customers, facilities and the market (Huxhold and Levinsohn, 1995).

Traditionally GIS has been in use by governments departments dealing with planning, demography and topography. The users of GIS among private organizations are the departments of marketing and logistics, collecting demographic data and data on transportation and infrastructure (Gothe et al, 1994 cited in Ezra and Sunday, 2006). The growth of GIS application has been paralleled by the extraordinary gains of computer performance. The range of commercial viability and available products of information technology that users of the implementation of a GIS has widened, including Computer Assisted Drafting (CAD), Database Management System (DBMS), geo-processing remote sensing, Digital Image Processing (DIP), Global Positioning System (GPS), Multimedia, network, communication, Electronic Data Interchange (EDI). An explosion of digital data available has accompanied the technological progress to private and public organization (Masser, 1997). The implementation of GIS technology in the initial stage might produce applications that are more process oriented, while implementation during the stage of integration might produce a strategic, organization-wide application (Huxhold and Levinsohn, 1995).

The application of GIS has not only been growing in number but also in diversity. The use of time-space-model by non-geographic disciplines such as environmental science and sciences of health and economy resulted in a growing variety of areas for the implementation of a GIS. As a case of environmental management the incorporation of spatial dimension makes it possible to much better solution to problems occurring at different locations (Duoven, 1996). However, another area trend of GIS is to make data (spatial and non-spatial) accessible on the internet is opposed to a closed GIS that is exclusively built for organization. A spatial decision making on the internet on the subject of radioactive waste disposal has been designed by Marcus Blake and LanTuton. More recent development in the GIS industry is the application of 3D reality maps

which can be found on GIS satellite websites such as Google Earth, ESRI, NASA and others. ESRI design application for urban layouts in 3D for analysis and review, Model 3D environments for entertainment and simulation and quickly create 3D models using real-world 2D GIS data. 3D reality maps was commissioned in Munich to visualized the sports venue concept from the summer of 2010 up to the final decision in July 2011 in order to support Munich's Olympic bid in several presentations to the International Olympic Committee. (GIM International, 2012). Thus, Wen et al (2007) opines that to improve efficiency on the traditional paper maps and manual operation system, the office automation with a computer network system and updated GIS were thus timely to build. The system is mainly for administration, auditing and internal controls. The system adopts an approach of integrating management information system (MIS), geographic information system (GIS), and office automation (OA) and workflow. It maintains the land information databases, and provides internally the electronic (paperless) model of land management and externally needed information for clients. The aim is to establish e-governance in land management.

Sustaining Geographic Information System In Real Estate and Infrastructural Development.

A web-enabled enterprise GIS which captures all available fundamental and thematic spatial data in the state and which permits online buying and selling of products and service and also provides for massive training of manpower in GIS, GPS, Photogrammetry and Remote sensing, Web mapping, ICT etc is required to provide real estate practice framework. This will eventually create land markets, title registration framework and effective property tax base (Nuhu 2009, Nuhu, 2011). GIS can potentially play an important role in real estate research.

Particularly in the areas of spatial interaction models (Haynes and Fotheringham, 1984) and spatial diffusion models. Spatial interaction models, which are often referred to as gravity models, forecast traffic flow, store patronage, and shopping center revenue and may be used to identify optimal site locations. Clapp and Rodriguez (1995) illustrate how real estate market analysis can be improved using GIS. Spatial diffusion models study the spread of a phenomenon over space and time. They can be used to forecast the timing and characteristics of new development, the growth or decay of neighborhoods, population movement and absorption rates. GIS technology permits the study of location to be easily factored into the explanation of various phenomena.

In particular, GIS software is ideal for examining the spatial component of real estate. Within GIS, real estate data can easily be disaggregated according to existing spatial market segments. Readily available boundary files (such as line segments that inscribe census tracts, census block groups, towns, counties, states, and other areas) can be joined together to define a market area. Market segments can also be described within a GIS according to any desired shape. Such spatial segmentation is difficult to accomplish without a spatial database. GIS technology can be used to produce an unlimited number of variables that can be applied to a variety of real estate analyses. GIS supports spatial analysis in the same way that statistical packages support statistical analysis. (Mauricio, Sirmans and Allen, 1995), in Olubodun and Oluwaseun (2006) evaluated tenement rate administration using GIS tools in Lagos Mainland local government area, Lagos State, Nigeria. The study used GIS to provides the required data management capabilities for land administration, the study is also aimed at providing GIS as a spatial analytical tool for enhancement of revenue generation and administration. The researcher create a set of guides

describing procedure and methods for tenement rate administration using the GIS as a Decision Support System (DSS).

In Tanzania, Kyessi and Mwakalinga (2009) used GIS Application in Coordinating Solid Waste Collection in Kinondoni Municipality, Dar es Salaam City. The scholars opined that Geo Information System (GIS) is a tool that can provide spatial and non-spatial information for urban planning and management. According to them, it can also link this data for various uses. They therefore examined and brought knowledge on how GIS can assist in increasing information and efficiency of solid waste collection system in an urban settlement in a developing country as Tanzania.

Abel, (2010) conducted a research on application and use of GIS in small sanitation projects in developing countries. The research is part of the initial studies of KeTu and it is about how GIS can be applied in assisting decision making in small scale sanitation projects in developing countries. It tries to analyze the data obtained from the baseline survey and shows how simple information can be put to use to make important decisions such as where to build the next group toilets, where are the hot spots and cold spots. Thus, the key findings of the research are more than simply identifying the whereabouts of group toilets on maps. But it also shows how (MS can be integrated into small scale sanitation projects in developing countries with limited fund. Thereby, it greatly enhances decision making and the wise use of resources where constraint budget is an issue.

Ojigi and Kemiki (2010) used Geographic Information System in Spatial and Rental Analysis of Bosso Estate, Minna, Nigeria. The study was aimed at establishing the relationship between building quality and rental value in Bosso Estate. The Study up-date the 2005 digitized property

map of Bosso Estate, created the spatial attribute database of the Estate for Real Estate practice and also carry out the spatial query and analysis of the housing units, for the determination of the dominant bedroom units and their distributions and rental values.

Also Idu et al (2012) conducted a research of the application of Geographical Information System (GIS) to railway infrastructure in Kaduna. The study used the Railway Property Management Company Limited (RPMCL) a subsidiary of Nigerian Railway Corporation (NRC) to demonstrate the application of Geographical Information System (GIS) in the railway infrastructure in practical terms. Database was constructed and features on paper plan/map were digitized as thematic layer including attribute data and exported to ArcGis 9.2. Queries were carried out to test user's requirement definition. It provides accurate and reliable information on all lands and building and thereby enhances land management practice. The result of the study shows that application of GIS technology can improve land management in government agency. In the same vein, Kemiki (2012) analyses the effects of pollution on property value in a GIS environment, the study generated a model for determining rental value in a cement polluted environment.

Minna As a Test Bed for Application of GIS In Infrastructure Sustainace

Minna, the state capital of NigerState and a famous railway town, lies approximately on latitude $9^{0}71^{1}$ North and Longitude $6^{0}33^{1}$ East. However, the town has transformed from a small traditional settlement to an urban centre with modern facilities and amenities. Figure 1 is map of Niger State showing the location of Minna, its capital, on eastern part of the state.

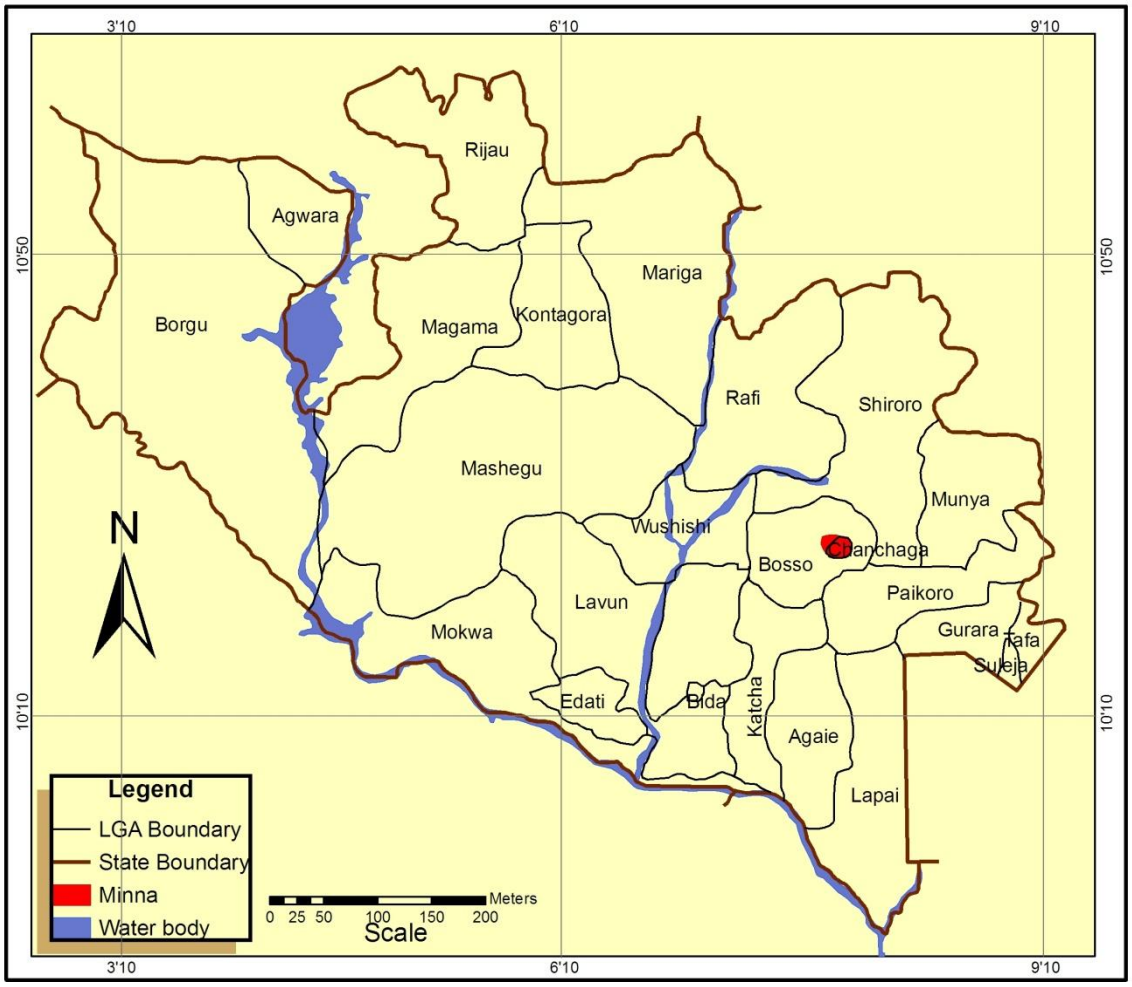


Figure 1 Map of Niger State Showing Minna

Source: Ministry of Lands and Housing, Minna (2012).

Minna has a total population of approximately 201,429 people out of the total population of Niger state, which is 3,950,249 with an annual growth rate of 2.3% (NPC, 2006). With a gradual increase of Hosehold based on the annual growth rate and the need to spread the provision of Infrastructre the State government initiated the ward Developmment project to allow community participation in the provision of such infrastructure like Borehole, Tap Water, Linkages roads. The establishment of Niger state geographic information system therefoer warrants the use of the

gis to monitor the placement of this infrastructurre and the use to enable adaptability of e-governanve assessment of the sustainability of the imapact the infrastructure provided.

Study Methodology

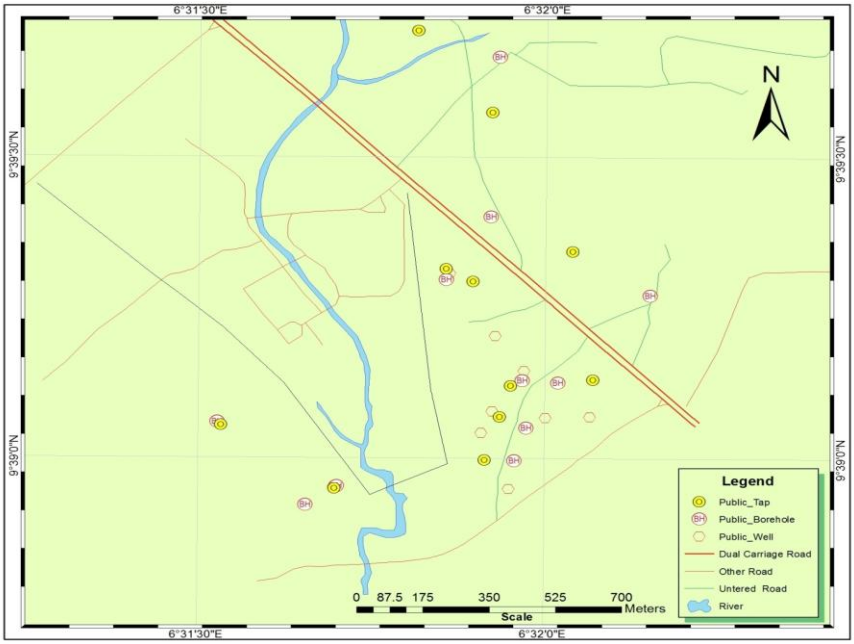
Data reqiured for this study were sourced for water based infrasrtuctural facilities. Thus study limits the data needed to Bosso area of Minna to source for the coordinates of Boreholes , Public well and Tap water in Bosso area. The position of infrastructures in terms of X and Y coordinates were taken using hand-held GPS before on-screen digitization in order to provide spatial information about the available infrastructure in the study area. The coordinates were taken using the Universal Transverse Mercator (UTM). The data used in GIS environment is usually in digital format. But most of the time, the available data (majority of maps) are in analogue format thus requiring converting them to digital format via digitizing.Using Minna as a Datum, the data were duly Georeferenced since they are spatial. The ArcGIS tool was used to display, the infrastructural facilities in the residential neigbourhoods, conditions of facilities and adequacy of those facilities.

For the relationship between infrastructure and property value, Rental value was adopted as the property value and thus the trend of rental value for ten (10) years were sourced from the practising Estate Surveyor and valuer in Minna and have transacted business in property in Bosso Area.

The selected Infrastructure were selected based on the totality of the available one while the all three Estate Surveyor and valuers were selected based on the transaction of business in real estate in Bosso.

For Data Analysis, the study adopted regression analysis to examine the impact of the relationship between provision of infrastructure facilities and rental value, while simple kriging was employed to assess the relationship between the most influential infrastructure on residential properties values in relation to distance. For this research, kriging analysis is based on weighted score of water infrastructural facilities. The weighted scores were derived from functionality of each infrastructure. Kriging is a method for interpolating the values of a variable over the geographic area from which the sample was taken by incorporating a semivariogram model for spatial correlation. A theoretical semivariogram is selected generally after examining a plot of the empirical semivariogram. In other words, one can plot the empirical semivariogram and based on its shape, select a theoretical semivariogram

Results



Source: Author's field survey, 2013.

Figure 2: Bosso Area in Minna Showing Spatial Distribution of Water Facilities

Figure 2 shows spatial distribution of water infrastructures in Bosso town. From the map it shows that the water infrastructural facilities were more available in Southern part of the area than the Northern

TABLE 1 : MULTIPLE REGRESSION OF INFRASTRUCTURAL FACILITIES AND RENTAL VALUE

Code	**Variables**	**Regression coefficient**	**Beta coefficient**	**Absolute t-value**	**Sig**
	Constant	1.851		2.363	0.019
WAT	Water Facility	1.229	0.400	5.505	0.000*
RD	Road Facility	0.795	0.234	3.447	0.001*
ELEC	Electricity Facility	0.384	0.031	0.464	0.643
RDF	Refuse Disposal Facilities	-0.299	-0.067	-1.033	0.303
DRN	Drainage Facility	0.194	0.063	0.969	0.334
	$R = 0.576$				
	$R^2 = 0.332$				
	R^2 adjusted = 0.291				
	FO.05 = 8.047				
	N = 189				

* Regression is significant

Source: Authors Survey, 2013

The empirical results of the multiple regression model are presented in Table 4.3. It shows that water facilities are the most determining variable of rental value. This is followed by provision of road facilities in the neighborhood. Next to this in order of influence are functional drainage channel, electricity facilities and availability of refuse disposal facility respectively.

The kriging analysis in the area with darker colours possess more urban infrastructure than those in lighter colours.

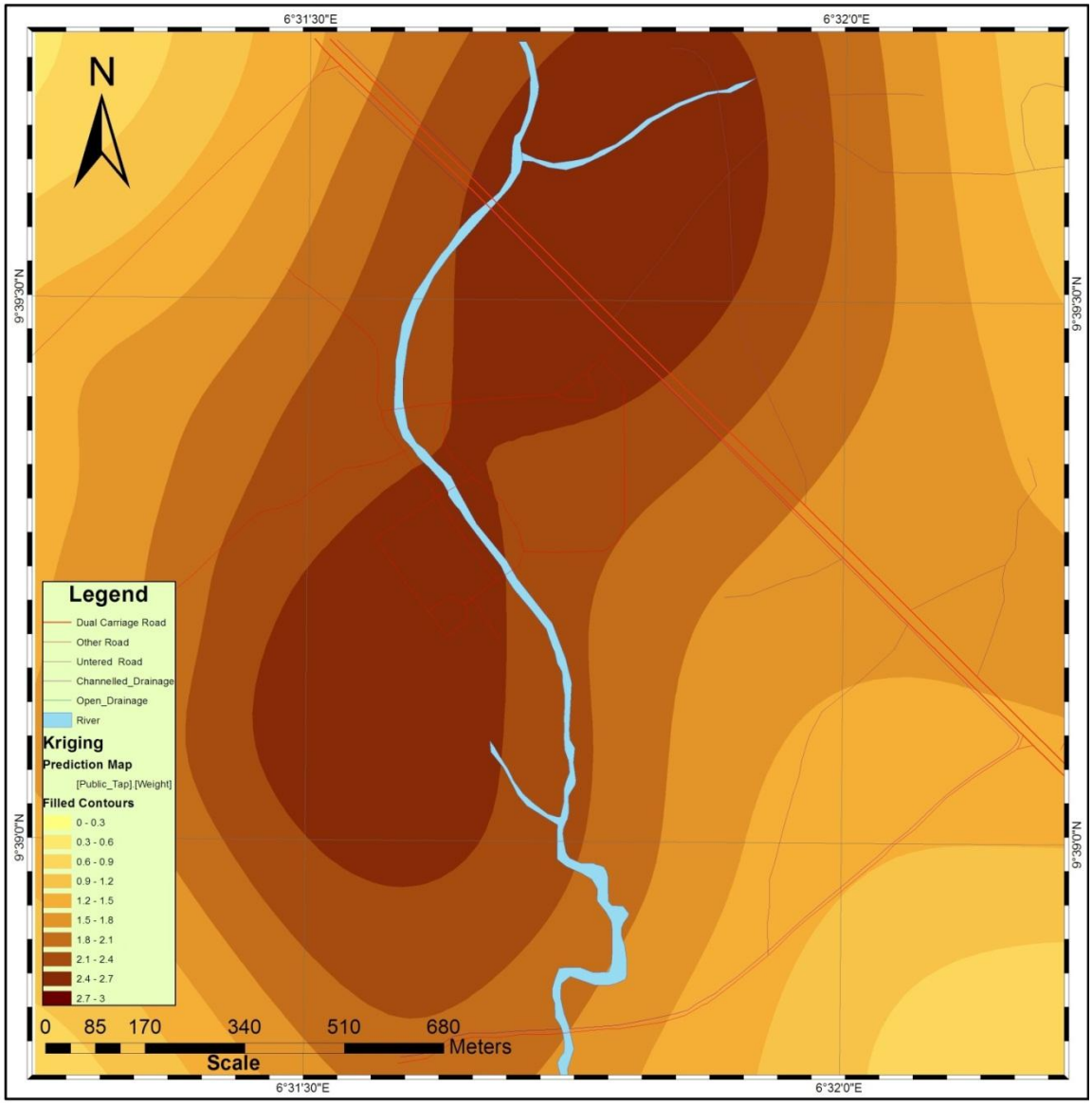


Figure 4: Kriging Analysis for Public Taps in Bosso

Source: Author's field survey, 2013

Figure 4 shows kriging analysis (prediction map) of Bosso. From the map areas with 2.7 – 3 filled contours have more public taps facilities than those with lower values and it declines to 0 – 0.3 which is the lowest in terms of public taps. From the map it can be predicted that residential property values in the areas with 2.7 – 3 should command more values than those below it.

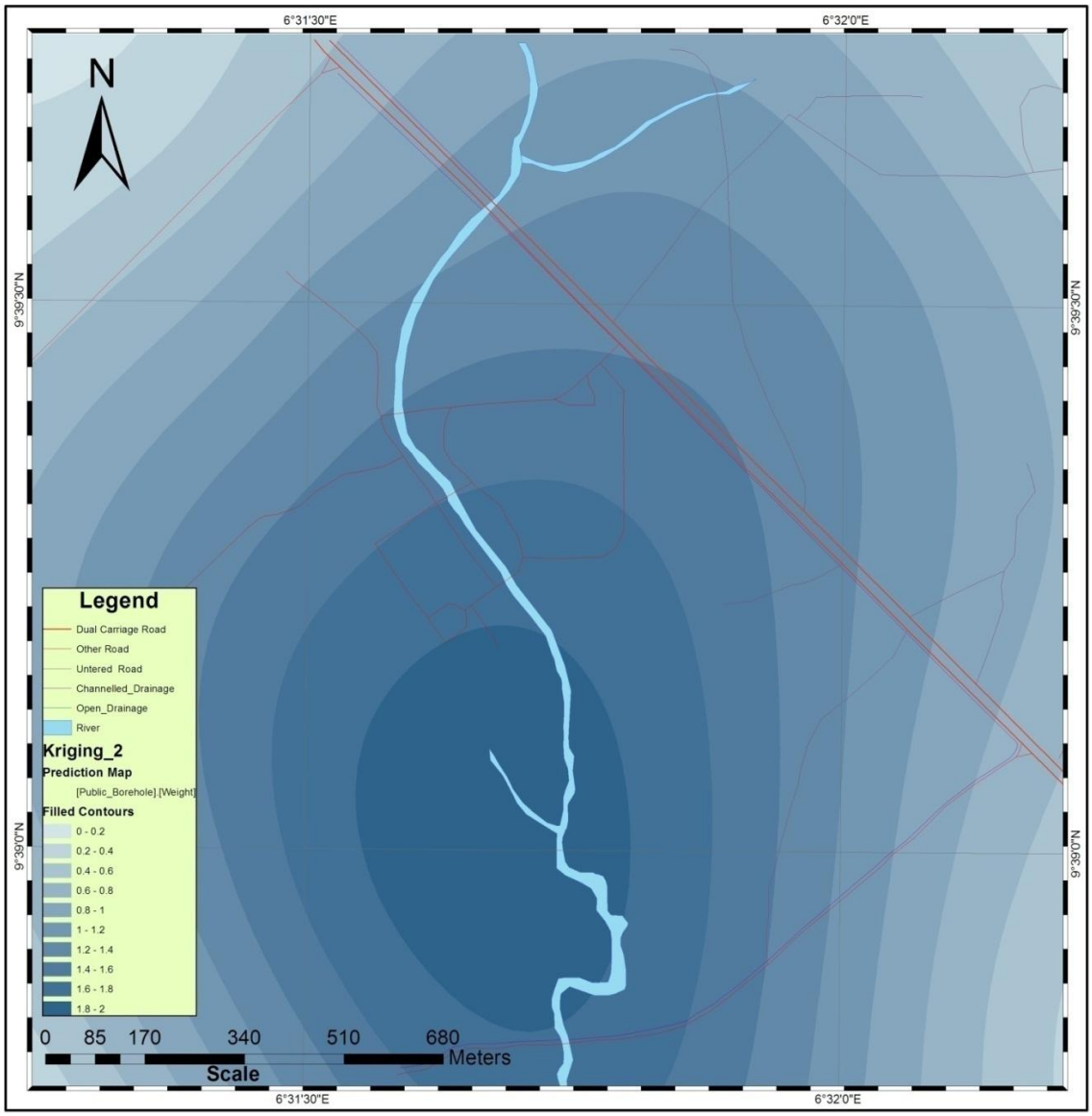


Figure 5: Kriging Analysis for Public Boreholes in Bosso

Source: Author's field survey, 2013

From Figure 5, the kriging analysis (prediction map) of Bosso shows that the areas with filled contours values with 1.8 – 2 possess more public boreholes than those with lower filled contour values and it declines to 0 – 0.2 with the lowest level of available and functional public boreholes. Since public boreholes determines residential property values, it can be deduce that the areas with higher filled contour values commands higher residential property value.

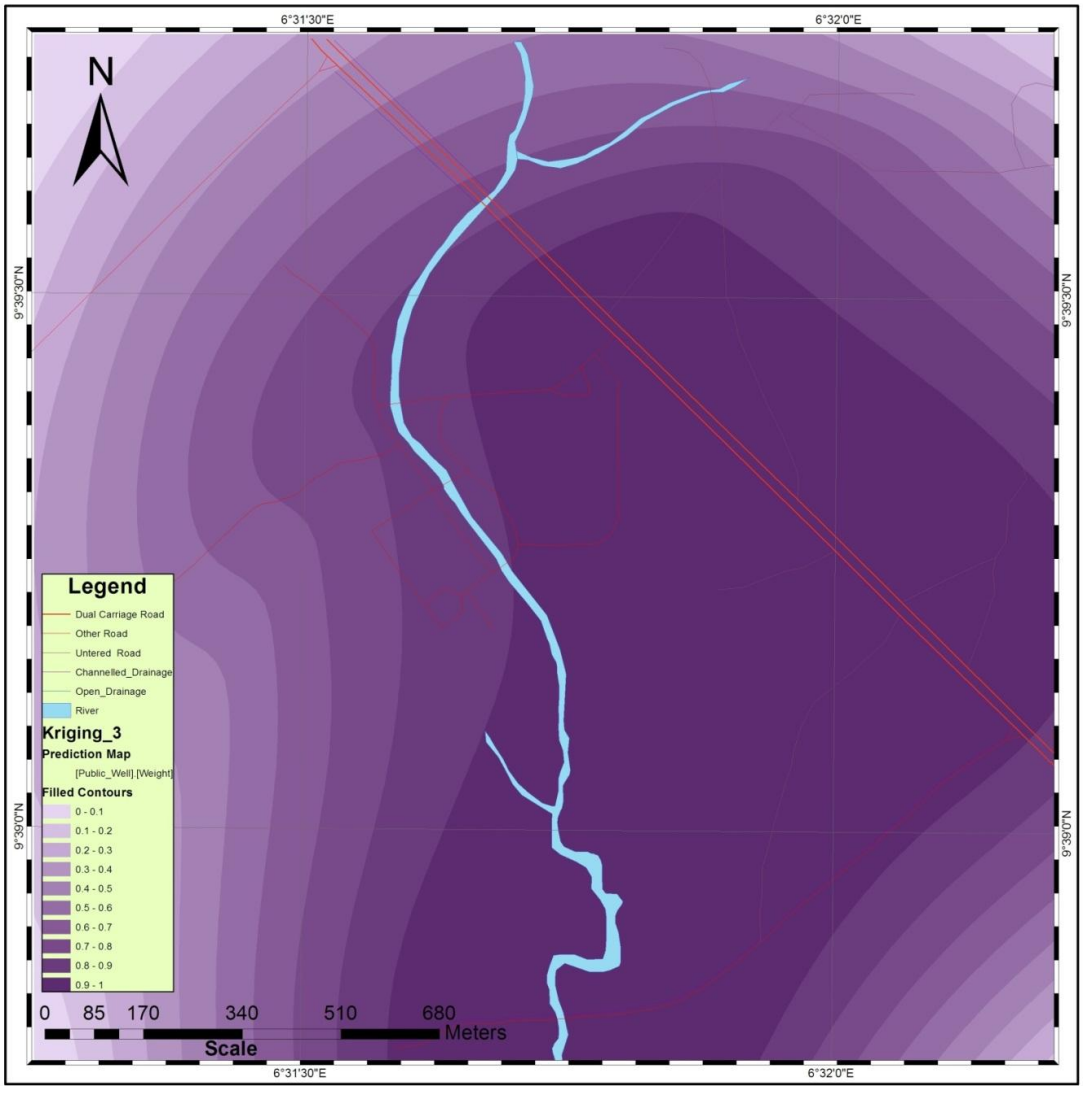


Figure 6: Kriging Analysis for Public Wells in Bosso

Source: Author's field survey, 2013

Kriging analysis of Bosso in Figure 6 shows that areas with filled contour values 0.9 – 1 has more public wells than the areas with less filled contour values. The lowest filled contour value is 0 – 0.1. It revealed that areas with high filled contour values command higher rental values than those with less filled contour value.

Recommendation and Conclusion

The study recommends that there is the need for government to establish Infrastructure Management Information System (IMIS) under the supervision of Geographic Information System (GIS) agency to look into infrastructure and related problems (urban infrastructure inclusive) in order to aid decision making (Spatial Decision Support System) and policy formulation. Also, data bank should be created for urban infrastructure in form of Geo-database that would link geographic data with its non-geographic phenomenon. Also, the level of awareness of GIS is poor and need to be enhanced. Government need to create a better awareness of this growing tool. This would help curb the present state of overdependence on such costly and isolated data sources for spatial information. The literacy levels of manpower in hardware and software usage should be critically enhanced by both the government and real estate firms. The present literacy level among the council personnel is abysmally low. Their effectiveness in the use of computer hardware and software will rub on the successful implementation of any automation system being introduced. It is suggested that staff be provided with on-the-job training program on hardware installation and maintenance as well as software usage.

From the analysis of findings and empirical observations, it is obvious that the pressure of essential infrastructure facilities and services serve as major determinants of property values. Property values tend to peak in those areas that enjoy easy accessibility (through road network), electricity, pipe –borne water and efficient drainage system. The impressive rise in property values in Bosso Town is largely attributed to the provision of these facilities. . From the analysis carried out, the study was able to see that planning for urban infrastructure can best be carried out by a system that combines non spatial and a spatial data management capabilities, like a GIS. Rental trend is best analyse using GIS statistical analyst tools. Rental values for selected type of rented apartment were entered in to attributes data table which form parts of the Geo-database reference to the study areas. From the ArcGIS application, Geo-statistical tool was used to run the trend analysis where particular location can be selected and type of residential property also selected to run the trend analysis. This is faster and more realistic than other methods.

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