USE OF GEOGRAPHIC INFORMATION SYSTEM (GIS) AS A TOOL FOR PROCESS REENGINEERING IN DELIVERING ROAD CONSTRUCTION PROJECTS IN NIGERIA

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ABSTRACT: *Geographic Information System (GIS) has permeated virtually all fields of endeavour, its enhanced features was explored by the research with a view to reengineering road construction projects in Nigeria. Road construction is a sector with enormous untapped potentials for stakeholders, having received attention by the government as a means of delivering the dividends of democracy to its populace. The research sought the use of GIS in integrating road construction processes from planning stage to decommissioning as a means of sustaining enhanced efficiency, accountability, integrated processes and teams, waste elimination (Lean) and to ultimately achieve concurrency in the process by fast-tracking the phases. Redesigning' road construction projects in Nigeria through 'radical change' by using GIS as a tool to achieve 'dramatic' improvements of the key project success criteria of quality, cost, time and speed, as identified by its guru, Michael Hammer. Questionnaires were employed to ascertain the level of awareness of CPR among construction professionals-notable of whom were Architects, Engineers, Project managers and Land surveyors, in addition to that, structured interviews targeted at other road construction industry value chain members was conducted in order to capture vital information in grey areas not covered by the survey questions. Result indicated that even though most respondents are not aware of what CPR entails, yet they are optimistic that GIS could aid the reengineering of road projects, however, most of them acknowledged peculiar challenges the proposed system may face in such a country where automation of processes is minimal. Inferred interview result suggested that there is need for an agency to serve as the provider/warehouse of GIS database (Geodatabase) - like ESRI couple with a level of standardization and enforcement by the government on all construction stakeholders to conduct their businesses using the GIS database.*

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INTRODUCTION

Road construction project is a component of highway engineering, the others being tunneling and bridge construction. The construction industry accounts to about 5.8% of Nigeria's GDP in 1981, being the third major contributor asides oil and gas, agriculture and mineral resources (Oluwakiyesi, 2011). This figure of course, has risen geometrically since the oil boom to date, though with its associated challenges. Road projects are a major part of the infrastructural development in the country, road networks a lone covers about 193,000 Km out of the total landmass of 924 Km^2 the country covers. Out of this only 37,000 Km is asphaltic road, thus, there is more to attain if road construction has to reach its peak (World Bank report, 2006).

As new strategies emerges mainly as a result of lessons learnt from the manufacturing industry in addition to recommendation of Government instituted reports like that of Sir John Egan in the UK- Rethinking construction, the construction industry is moving towards enhanced efficiency-by eliminating elements that don't add value to processes, improved productivity and standardization by using Lean thinking, process mapping, and process reengineering philosophies. Egan suggested a target of 10% annual improvement on cost reduction and project delays and a 20% annual reduction in construction waste (Rethinking construction, 2003). Information Technology is identified as a vital tool in achieving greater efficiency especially in terms of information flow, communication and coordination (Chan and Land, 1999), this study is aimed at appraising the possibility of using Geographic Information System to reengineer road construction projects in Nigeria.

For successful implementation of process reengineering, Information Technology has to be the main ingredient (Attahran, 2003). Although Information Technology is common and a key driving force in enhancing the way businesses are conducted in the developed countries, yet its use and application in most developing countries is minimal with attendant slow pace of development. The reason being that of implementation and adaptation with orgainsational and societal values, these factors as outline by Avgerou include Technological processes knowledge transfer and adaption amongst others (Avgerou, 2008).

Redesigning' a process through 'radical change' to achieve 'dramatic' improvements of the key project success criteria of quality, cost, time and speed are the keywords given in the definition of reengineering in an interview with its guru, Michael Hammer (Randall, 2007), road construction entails processes of planning, design, construction and operation each being a stand-alone process. Integration of the entire process from bidding to operation will result in enhanced efficiency as witnessed by a case study on a hospital project in Hong Kong (Chan *et al* 1999).

The use of GIS is restricted to some governments department in town planning, like the Abuja Geographic Information Systems (AGIS) and few consultancy firms, mainly because of lack of awareness and resistance to change, this research hope to investigate the utilization of GIS by construction companies in for delivering road projects in Nigeria and the possibility of integrating e-tendering, design, construction and operation of road projects using GIS.

RATIONALE

GIS is being used by town planners, border commission, AGIS and the likes in Nigeria, seen as a tool only for mapping out territorial and property boundaries. The awareness of its potential applicability in road construction amongst construction companies in Nigeria is minimal, furthermore, its use as a tool to integrate road construction processes have not been explored yet. This research work intends to explore ways by which geospatial data of a particular road fed into GIS database could be use to achieve concurrency in the bidding, design and construction process. The available data, design requirements and extent of the work for a proposed road project should be accessed by prospective bidders online (e-tendering), and be use by the winning contractor to reengineer the whole process of road construction; planning, design, construction and perhaps operation.

The main aim of the study is to appraise the possibility of using GIS as a tool in process reengineering of road construction in Nigeria by integrating the bidding, design, construction and operation processes with a view to achieving enhanced performance. As performance is a multidimensional attribute and has many scales upon which it's been measured, the confined its aim towards achieving these objectives:

- Investigate the level of awareness and use of construction process

reengineering (CPR) in delivering road projects in Nigeria.

- Review of road construction and the extent to which GIS is used by construction or consultancy companies in delivering road projects in Nigeria.
- Explore possibility of integrating the entire road construction processes with the use of GIS.
- Identify the challenges for sustaining the process in a developing country like Nigeria.
- To recommend areas for further research.

Research Structure

Literature Review

This research will study relevant literatures on the origin, evolution, historical development, use and application of GIS in various fields of study. The use of GIS in the construction industry with review of research conducted on its applicability to road planning, construction and operation.

Appraising the Process of Road Construction in Nigeria

This segment will try to grasp a general overview of road construction processes adopted by some selected Nigerian construction companies using process mapping as a tool, and explore ways of integrating such processes with GIS. This will involve interviews with construction stakeholders and available past data base on the industry's practice.

Survey Questionnaire

The aim here is to capture data as to the level of awareness by construction companies in Nigeria on the use of GIS in road construction, the extent to which they use GIS as a tool in executing other construction works aside of road and their knowledge of what construction process reengineering means to them. Is the use of construction process reengineering (CPR) a common practice to road construction companies in Nigeria or not? If yes, the level of success recorded and challenges encountered.

Interview (Personal One-On-One)

Interview will be conducted with experienced professional/employee, three (3) each from randomly sampled organisation within the road construction project/industry supply chain, one (1) each from key relevant functional department in the identified organisation and government agency, refer to Table 9. Only audio recording devices – subject to the consent of the interviewee, will be used in conjunction with notes taking by the author for complete capture.

Analysis of the Interview and Survey Questionnaire

Result of the interviews will be analysed in conjunction with the

outcomes of the survey questionnaires to come up with a general picture of the use of GIS by the Nigerian construction industry and its possible prospects towards integrating key aspects of road planning; bidding process, route selection, surveying (curve fitting, vertical and horizontal alignment, etc), environmental impact assessment etc; construction, operation and perhaps maintenance of road facility to achieve concurrency.

Report Presentation

The analysed data will be presented in documented form as the final Dissertation, in a meaningful manner. The discussion of the results will be done in reference to the set aim and objectives of the research to come up with a logical conclusion.

Research Limitation

The research is limited in scope to the following areas:

- Nigerian road construction industry- consultants and construction companies
- Applicability of GIS in road construction
- Three months of research.

Generalization of the research result should be done with caution as the firms administered the survey questionnaires are not geographically evenly distributed, because most of the firms are sited in some of major cities in the country. More so, the questionnaires were administered to a few selected construction professionals, thus, result is inclined towards some identified personnel, hence cannot be generalized.

REVIEW OF RELATED LITERATURE

Literature review/survey or review of related literatures is essential in providing a sound theoretical framework showing the relevance of the research by exploring research fields related to the topic at hand and at the same time serving as a benchmark upon which a research result could be compared with others (Creswell, 2009). Literature review is a means of expressing the Author's in-depth knowledge in a particular chosen field of research interest, its theories, most recent vocabularies, phenomena, methods, breakthroughs, and even gurus in that filed (Randolph, 2009), perhaps, with a view to laying a solid foundation for presenting the findings of the research and to serve as a validity backup for the research hypothesis.

This chapter gives a general history into the evolution of Geographic Information Systems (GIS), its developmental trends, uses, areas of

application, challenges and successes, and anticipated future developments.

The chapter further highlights, in a global perspective the use of GIS in road construction, then looked into the methods of delivering road projects in Nigeria and appraises established processes in the use of GIS to process reengineer road construction in Nigeria. Process reengineering as a new project management philosophy advocated by Michael Hammer and James Champy, is a radical change and quantum leap in the way businesses are conducted with a view to eliminating waste and enhancing productivity. Relevant literatures on that were also explored.

Lastly it assessed literatures that present the use of GIS in Nigeria generally, and specifically for road construction, otherwise the possibility of its use for road construction to aid construction process reengineering was explored.

Definition, Brief History and Evolution of GIS

GIS means Geographical Information System more commonly referred to as Geographic Information System in North America, its definition is vague and Amoebic, mostly considered differently by various group of users' base on the function it performs for them. To the general public it may mean a reservoir of maps; to a planner it is a computerized tool for solving geographic problems; or a spatial decision support system to management scientists; or an automated collection of spatially referenced features and facilities to engineers, resource and utility managers (Longley, *et al.,* 2011). A GIScience is the engine house for the progression and implementation of GIS. Other similar acronyms include GIService and GIStudies the former – coined by Michael Goodchild in an article published in 1992 is used to mean an enterprise that provides both strategic and operational consulting services to wide users in areas of planning, implementation and hardware/software sales, and the latter is defined as '…the systematic study of society's use of geographic information, including its institution, standards and procedures'. *ibid.* GIS for the purpose of this research is used to mean Geographic Information System. A common feature to all of the above is that GIS comprises of software, hardware, data, people and process of capturing, sorting, analyzing, storing, manipulating, retrieving and referring to geographic information. Thus, ESRI defined GIS as a system that integrates hardware, software, and data for capturing, managing, analyzing, and displaying all forms of geographically referenced information which enables us to view, understand, question, interpret,

and visualize data in many ways that reveal relationships, patterns, and trends in the form of maps, globes, reports, and charts (ESRI, 1st April, 2012). Due to a simultaneous evolution, GIS has no definite lineage of history.

GIS has evolved simultaneously in Europe, North America, and Australia though the first real evolution of GIS is with the Canada Geographic Information Systems (CGIS) in the mid 1960s designed as an automated mapping system. In late 1960s the US Bureau of the census used Dual Independent Map Encoding to aid compilation of census data conducted in the 1970s, later with enhanced computing capabilities, the Experimental Cartography Unit of the UK produced the first World's first computer-made map in a regular series in 1973 (Longley, *et al.,* 2011). However, some are of the view that GIS owed its origin solely from Canada at the Harvard Laboratory for Computer Graphics and Spatial Analysis when it was used as a database and for mapping and spatial analysis (Klinkenberge, 1997).

Versatility and ease of manipulation with the help of Graphical User Interface (GUI) couple with other supporting technology/data like remote sensing and GPS further advanced GIS to a tool capable of reasoning and analysis. GIS rapidly moved from descriptive to prescriptive intelligent analysis of spatial data on maps, especially with the invention of automated scanners. This made it a friendlier tool, hence, used by many professions and applied to various fields of Endeavour. Figure 1 below depicts a graphic cyclic refinement periods of GIS evolution from its discovery to date and future expected directions. It started as an ordinary computer mapping tool to modeling and database management in the 90s which was regarded as a contemporary GIS. Advances in technology saw the invention of mobile smart objects and intelligent systems like the Artificial Neural Networks which made Multimedia mapping possible in the 20th century.

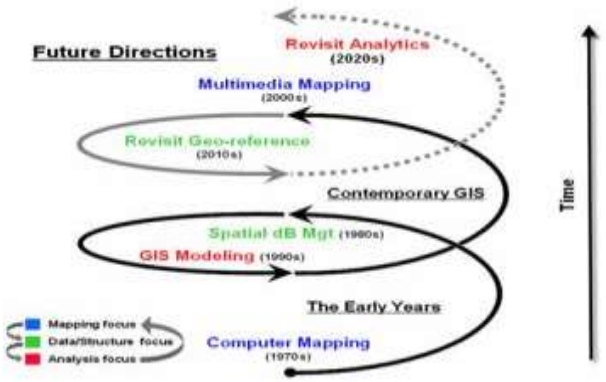


Figure 1: Graphical Representation of GIS Evolution (After Berry, 2007).

Universally, the basic parts that make up a GIS include the computer hardware, software, data, procedure and personnel. As mentioned above the network or server is the pathway that harbors interoperability, versatility and information sharing among numerous GIS users. The hardware is a typical computer component which comprises the inputting, manipulating, directing, communicating and display devices, interestingly, much more flexibility is offered by laptops, PDAs, mobile phones, wearable computers etc. the software is the deriving force with analytical capabilities. Softwares are often provided by vendors of whom ESRI, Autodesk, Intergraph and MapInfo amongst others. The user's device in a GIS network is termed the *Client;* it may be *thick* or *thin* if it performs the work either within the user's domain or a more sophisticated function than merely connecting its user to the server respectively. Databases are digital store of spatial data about specific aspects of the activities of man designed for the purpose of problem solving, reference, and scientific purposes (Longley, *et al.* 2011). A database may be designed for buried utilities, emergency route for ambulances to disaster areas, road interconnectivity between towns, cities, and states and lots more. The procedure is similar to what is obtainable in many organizations, it is necessary to fashion out standard protocol suited to an organization on handling, updating, security issues, cost, quality, and above all align with the organization's corporate objectives. Figure 1 below gives a pictorial view of the entire system.

Lastly, all thee assembled gadgets will not function except if operated by skilled personnel. There are wide categories of GIS stakeholders comprising of software developers/vendors, Database managers, Clients– mostly public authorities, and general users. Cartographers, map analysts and Geographers also need to correctly

interpret data output from GIS for application.

Figure 2: Components That Makes Up a GIS (After, Longley *et al.,* 2011)

People design the software GIS operates, they also input meaningful data into the system and interprete results. There is a lot numerous functions performed by individuals that uses GIS and these dictates the skill needed to work with the system. The industry itself is divided according to the service it offers which range from software, data, services, publishing, education and GeoWeb industries.

Application and Uses of GIS

Due to the advances made in wireless technology, space technology and enhanced efficient microprocessors that made possible small data capturing/saving devices, GIS gained wide applicability in various fields including, military, health, aviation, oil and gas, infrastructure (including road construction, communication, properties and etcetera), economic, social, political, management, agriculture, crime prevention, and importantly environmental to mention but a few.

Longley *et al.* states that irrespective of the application area, GIS applications generally set to fulfil the five Ms of GIS viz; measurement, modeling, mapping, monitoring and management (Longley *et al.*, 2011).

Application for Land Use, Natural Resources, Environmental Conservation and Pollution Control

Managing natural resources is vital to economic growth in developing countries; the use of GIS to facilitate this growth was advocated (Madon and Sahay, 1997), they studied four strategic implementation areas where the Indian government should articulate its long-term commitment strategy in using GIS to

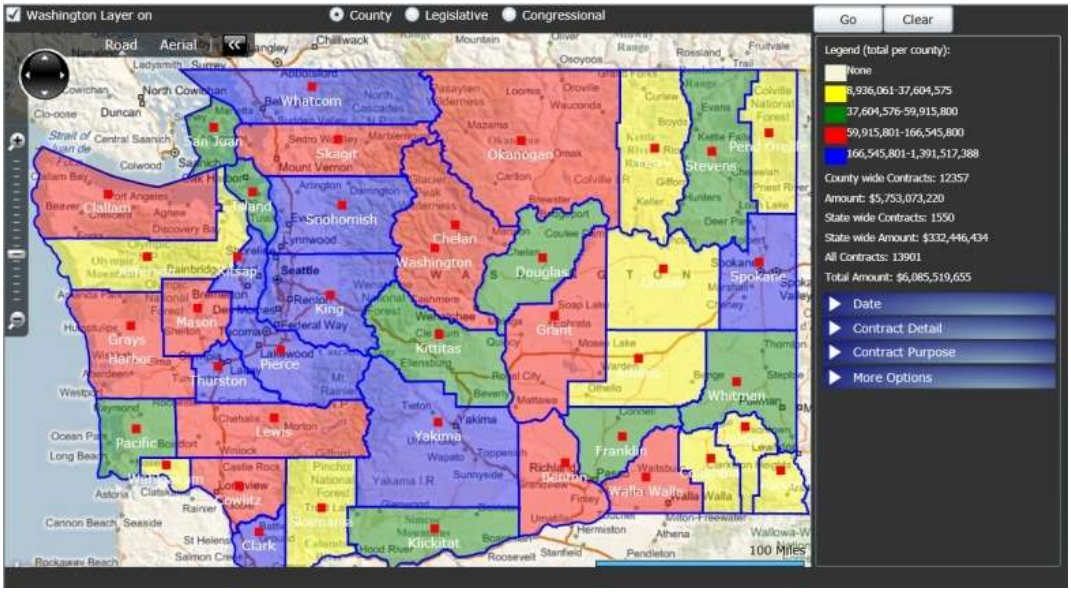
harness its natural resources. Moreover, man's quest in the exploration of these natural resources adversely alter the ecosystem, thus, conserving the Biomass is of vital importance to his wellbeing, GIS was identified as a key tool to conserving Africa's rich biodiversity by conservation scientist with a view to curb the menace of desertification, soil erosion and green house emission which affects not only food production but global climate (Swetnam, 2011). Planners are faced with daunting task of harmonizing the numerous facets of attributes of an ideal urban community, Masser in three case studies explored areas GIS could be applied for sustainable urban growth (Masser, 2005). Pollution control is vital especially in urban dwellings, critical of which is underground water pollution as it do cause serious epidemical consequences, GIS was utilized to generate ground water vulnerability maps to pesticide pollution for 90 wells in three different provinces in Thailand, results showed that these maps are effective in delineating vulnerable areas for pollution (Thapinta, 2003). A case study in Parague utilized GIS as platform, integrating GPS and remote sensing to harbor a range of pollution type data from field measurements and monitoring networks into digital map layers (Matějıček, *et al.,* 2006), results of varied ozone concentration were displayed in 3D visuals, and interestingly enough, higher concentrations were observed above cross roads characterized by heavy traffic than other locations. Recent disaster of the Japan Nuclear plant calls for a strategic real-life simulation of possible hazardous land contamination, Tang, *et al.* had explored the flexibility, ease of application and integration to varied heterogeneous systems of GIS for emergency managers, and decision or policy makers in managing environmental hazardous chemicals (Tang, *et al.,* 2011). Decision has to have strong bases, as such a research developed a Geographic Information Workshop for Windows (GIWIN) model as training software for decision makers and planners for effective decision making when utilizing GIS for a particular purpose (Ren, 1997).

Some nations are blessed with ample natural resources but lacks a robust data management and analysis system to harness its full potential, Northeast Asian countries are such nations where a decision support system for land resource management and eco-environment based on a couple of systems and international GIS software, integrating a number of databases notable of which is land resource survey to offer prediction and support system for natural resources and environment scientifically using GIS (Liu, *et al.,* 2010). A times indexing the variability in the quality of eco-environment poses challenges, thanks

to the utilization of multi-indexing tools like the Analytical Hierarchy Process with GIS to produce an eco-environmental information system database for effective evaluation of Hunan province in China (Ying, *et al.*, 2007).

Application in Infrastructure, Human Services and Economic Development

A number of government reports were initiated to fashion out modalities for smooth implementation of GIS based projects, reforms and programmes that have direct or indirect impact on people. A similar report that brought together researchers, graduate student, and other GIS stakeholders identified 19 research areas vital to human services (Harris and Weiner, 1996). The Washington State Department of Commerce (WSDOC) in bid to enhance speedy response to inquiries about their disbursement initiated an online money tracker. It is a self-service site built on Bing map platform to provide a highly visual and interactive data reporting to all constituents (www.microsoft.com/maps). It is depicted in the figure below:



WSDOC Money Tracker

Figure 3: GIS Use of Bing Map to Track Money Circulation

(Source: www.microsoft.com)

Law Enforcement and Crime Prevention

Though data on crime monitoring, reduction and prevention is often use

according to ethical rules of play in GIS sector, yet it has encroaching effect on individual privacy, hence use of surveillance on people to detect areas of possible security breaches should be done by governmental authorities. The use of GIS as a high-tech viable option in curbing the menace of the growing crime rate in Nigeria was explored and extent of applicability tested in Lagos city (Fajemirokun, *et al.,* 2006). Location and time frame of crime scene alone is not efficient in fighting crime. Efficacy of spatio-temporal trends for allowing interactive visualization as against the space-time static map was explored, though results were not fully disclosed due to the sensitive nature the data (Brunsdon, *et al.,* 2007). They call for further research to test its ability with varied data sets.

Evolving patterns of crime trends and nature of crime-linguistic data crime poses a limitation on data mining approach, an approach which is seen as useful proactive tool in detecting and preventing crime. Against this backdrop an intelligent decision-support model based on Fuzzy self-organizing map (FSOM) using GIS platform to detect crime trend patterns; a case of National Police Agency of Taiwan (Li, *et al.,* 2010). Result of the research was seen to aid police officers inn evolving law enforcement strategies for crime management.

Emergency Management, Health and General Information

Natural disasters, fire outbreak, health emergencies, rescue operations inevitably needs the presence of personnel within shortest possible of time, GIS could render self in delineating shortest routes to scenes of such incidence for prompt handling. Crucial information on which most emergency/rescue operations depends on includes precise location of the disaster, information on surrounding vicinity, and a real-time tracking for deployment of workers by rescue commanders (Hao-wei, *et al.,* 2011). French Mediterranean departments for agriculture, forest wildfire prevention, and fire fighters utilized specialized maps in GIS to revamp their efficiency of operation and keep them at alert (Sauvagnargues-Lesage, 2001). Emergency response in high-rise built areas faces significant delays more than that of ground transportation system; reduction of such delays was seen to be effective when a GIS based intelligent Emergency Response System (GIERS) was used. The GIERS, which was utilized for the Franklin County area, Ohio (USA) integrates information on the internal fabric of the buildings with the ground transportation system into a visual navigable 3D GIS was against the

backdrop of September 11 attack in the US to enhance speed of emergency response (Kwan and Lee, 2005).

In the health sector several GIS functions are available to solve a number of different healthcare service delivery issues which includes spatial decision support tool for health planners on providing healthcare base on need of people, accessibility to the hospital from remote locations, categorizing hospital patient and the extent of geographic spread of public and private hospitals. Two of such GIS tools; network analysis and overlay design were utilized in Jeddah, Saudi Arabia to provide information on accessibility of service areas to the particular hospital under study and extent of how demand was serviced respectively (Murad, 2007).

The utility company that supplies power to New York City informs customers for any possible power outage locations for the latter's decision; example a driver that heads towards a tunnel which is affected by such power outages can conveniently change his route. The figure below shows how it works:

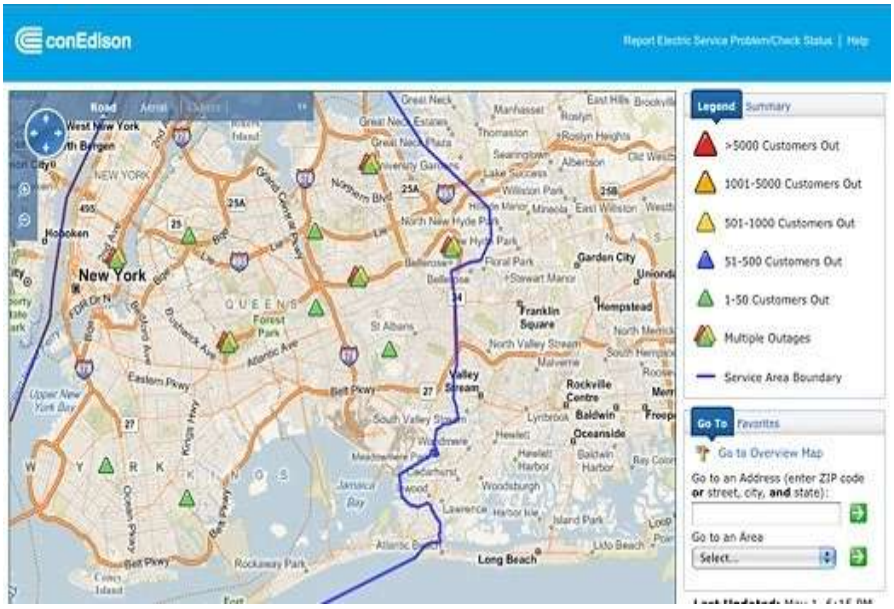


Figure 4: GIS (Bing) Map Showing Areas of Power Outage in New York

(Source: www.microsoft.com.maps)

APPLICATION OF GIS IN ROAD CONSTRUCTION

Change is a force that individuals and organizations alike naturally resists, most of the needed changes in the way

businesses are conducted in modern times is as result of technological breakthroughs to which GIS is not an exception. Implementing GIS for Road construction entails restructuring of some aspects construction organizations, mode of operation or even contractual processes. The cost benefit analysis, however, and implementation blueprint of such Information and Communication Technology (ICT) and possible integration with other enabling technologies such as GPS, Remote sensing, Genetic Algorithm and lots others needs to be presented to Contractors/Subcontractors and other supply chain members for the system to gain quick acceptance (Perkinson, *et al.,* 2010). This is essential if the industry will move away from the 'old craft' nature of operation as identified by some Government established reports, notably the Egan and Latham in UK to move towards utilizing new philosophies learnt from the manufacturing industry such as Lean philosophy, and Process Reengineering for more efficient and productive operations in different phases of construction.

Road construction is a branch of highway engineering, the others being bridge and tunnel engineering. Planning process is a bit daunting task and involves securing the right of way, soil testing, environmental impact assessment, selection of efficient alternative routes to mention but a few, hence the need for the integration of these data especially with a view to visualizing a simulated augmentation of reality using GIS is of immense benefit. Work schedules and progress could then be visualized with relative ease and accuracy (Kang and Seo, 2011). Further to scheduling complex visualizations and information integration was seen to be vital for solution of space planning to construction industry (Bansal, 2007). Selection of an economically feasible alternative route using GIS was researched, (Sadeghi-Niaraki, *et al.*, 2011), and a real-World representation allows simulation of possible drivers choice to be ascertained with appreciable accuracy.

Safety is a vital element in all construction works, because of the nature of risks associated with the job, and planning the safety of construction workers during design is an art which heavily relied on the planner's pool of experience in the type of construction at hand, his knowledge, intuition and skills. Safety planning has however, been simplified by using GIS platform to harbor geographic 4D modeling to produce a safety database for an entire construction sequence (Bansal, 2011).

A number of challenging issues and factors which includes legal, technical, economic, safety, environment,

political and serviceability must be seemingly articulated by obtaining the requisite data, analyzing and deciding on lots other parameters of the road (Banks, 2004). Important among such parameters is the route the new road will take. Though Value Management (VM) and Value Engineering (VE) couple with Risk Management is an exercise that should be carried out in all phases of project life cycle, yet its application at project brief/design stage is crucial in new road construction so as to decide on the best cost effective route a road should follow- termed as the route alignment cost optimization, so also the safety of construction personnel. Genetic algorithm and GIS in 3D in real World were utilized to enhance the selection of an optimum route among various routes in a mountainous terrain (Jha and Schonfield, 2004).

A typical roadway section comprises four layers viz; sub-grade, sub-base, base-course and wearing course. The stability of these layers is essential to achieving a good runway; this is attained by expulsion voids in the first three layers through a process called compaction. To guide the number of standard cycles the compactor has to cover for full compaction and for visual record purposes, GIS was discovered to be useful in depicting the number of coverage recorded by a compaction machine (Li, *et al.*, 1996). Measuring overall project performance is essential to make certain key decisions, Automated Data Collection (ADC) system is a means of knowing the position of workers at specified intervals hence, appraising their performance input data. Though the findings suggested that ADC could work with three different technologies-GPS, RF (Ground-base Radio Frequency) and RFID (Radio Frequency Identification) (Navon and Goldschmidt, 2002), yet a more flexible usage could be achieved if GIS visualization features were to be integrated in the system. However, tracking may be difficult with GIS, GPS or remote sensing in remote construction like tunnel and undersea construction, such situations may need the adoption of alternative methods. One of such techniques is the use of Wi-Fi-based positioning system, a case study of tunnel construction site in Guangzhou, China which used Receive Signal Strength Indication (RSSI) yielded positive result in effectively monitoring construction labour, material and machines (Woo, *et al.*, 2011).

Similar to tracking is the significance of an effective communication among the various skill sets/trades/professionals that are involved in the construction phase, this is more critical in a specialized construction types

like undersea construction and tunneling. As GIS could be used to map out features near the earth surface, it thus became a tool worthwhile integrating with wireless technology- like the one proposed by Nielson and Koseoglu, for enhanced collaboration and prompt on-site decision making by construction personnel, result of the efficacy of wireless technology for tunneling as applied in Marmaray multi-site tunneling project in Instanbul had shown promising results (Nielson and Koseoglu, 2006).

A Road in use has numerous demanding requirements to be fulfilled by an array of stakeholders, viz; users- motorists, bikers, cyclists, and pedestrians; providers-local, regional and national public authorities; those whom economic businesses depend on the easy accessibility others has to their businesses and those whom their personal life is impacted upon by the consequence of the road use (example issue of green house gas emission). It was in the light of the last point a research which uses GIS to ascertain the extent to which travel time determines amount of green house gas emission in the National Capital Region (NCR) of Canada was conducted. Result of the study proves GIS effectiveness in aiding visualization of emissions from different locations (Armstrong and Khan, 2004).

As new roads are constructed every day around the World, there is an increasing need to capture, store and update existing GIS databases of possibly, all road networks around the globe. (Mena, 2003) comes up with an automated road extraction for GIS update from satellite imagery after studying almost 250 related researches, and finally comes up with a novel classification of road extraction models that will ease referencing of geospatial retrieved data from a GIS database.

Road Construction in Nigeria and the Use of GIS

The Nigerian construction industry like any other in the World is vital to the economic development of the country. Being the most populous black nation in Africa of over 180 million people in the most recent census figures, provision of basic amenities amongst which Road is inclusive remains a major challenge and focus of past Government at state and national levels. As the nations major reliance before the discovery of oil and even to large extent after, remains Agriculture; provision of good road network for the conveyance of raw material (farm produce) to towns is significantly essential for continuous economic growth. The economy ranks 41st largest in the world, a World Bank's ranking (Kolapo, 2008) as cited in Dantata, 2008.

The construction sector accounts for 1.48 % of Nigeria's GDP in 2005 while in 1981 the figure was 5.8% and in spite rises in Nigeria's total GDP of 495 times its size in the last three decades the construction sector only rise by about 125 times its size in 1981 (Vetiva Report, 2011).

Road construction is a 'haven of opportunities' in Nigeria as described in the Vetiva Report, reason is not far fetched from the fact that 70% of the total Road network is unpaved with bulk percentage being Federal roads (Vetiva Report, 2011). Out of a total of 193,200 kilometers of Road network 34,123km are federal roads; while state and local government roads accounts for 30,500km and 129,577km respectively. This figure asserts the fact that Government is the major provider of road infrastructure, though corruption on the part of public office holders coupled with unethical professional practices makes the few paved roads to deteriorate easily due to poor workmanship and low material quality used. However, positive changes are being recorded since the going back to civilian dispensation, though with attendant challenges. These positive changes driven by laudable Government reforms like the Nigerian National Policy for Information Technology will pave way for revitalizing the way Road construction and the entire construction industry conducts its operations. With a vision to make Nigeria an IT driven country and a key player for Information and Communication Technology in Africa by the year 2005 (Nigerian National Policy for Information Technology, 2005) the use of GIS will sure find a suitably strategic position in Reengineering Road construction processes in Nigeria.

Moreover, Geographic Information System (GIS) is used in Nigeria for a wide area of application similar to what is obtainable globally. Common field of application includes ecology/environment, law enforcement, health care, economic, political, land administration and importantly road construction.

Ecological distortion in the Niger-Delta oil producing region of the country due to oil exploration impacted negatively on the wellbeing of the people in that region, though no much research or use of GIS in this area, yet, a research conducted in that regard appraises the use of GIS in similar coastal regions to that of Nigeria, however, with emphasis to Nigeria. Remote Sensing and GIS were used to map/detect degradation in the ecosystems of such region due to man's activities. The four-objective paper

further recommends conservation strategies for coastal resource managers for assessment and speedy decision making (Twumasi *et al.*, 2006).

The ever increasing economic and infrastructural activities in this region like oil exploration, power plants and road construction which leads to gas flaring, coastal erosion, pollution, ozone destruction and lots others which calls for the need of application of sustainable practices. Sustainable practice entails minimal use of non-renewable energy in efficient ways so as not to put future generations' at stake in terms of availability of such resources, vital tool to ensuring such practices is Environmental Impact Assessment of all man activities. Remote sensing and GIS were discovered to be the only means by wish total and accurate environmental impact assessment could be achieved (Abbas and Ukoje, 2009), especially with a view to achieving environmental balance for sustainable development in Nigeria. Gully erosion is one of such biomass imbalance, the phenomenon is critical in Southeastern Nigeria, the causative factors were also identified as basically due to activities of man, as such a research utilizing the long-awaited Nigerian navigational satellite (NigeriaSat-1), in addition to Landsat ETM+, SPOT 5, Quick Bird and SRTM image data from GIS was used to create a database of areas prone to Gully erosion (Igbokwe, *et al.,* 2008). This is with a view to monitor the increases and impacts Gully erosion is causing in the case study Southeastern States of Nigeria. While NigeriaSat-1 was used to curb the menace of mineral exploration in the South, it is used to explore mineral resource deposit with a view to exploration in Raffin-Gabbas, North central Nigeria by GIS lithologic mapping of the area (Ogunmola, *et al.,* 2008). The research specifically reiterated the effectiveness of GIS in to model, analyse and display complex spatial geographic data from difficult-to-access locations.

In a similar development, the effectiveness of GIS for mapping and Database creation was examined for mapping of farm parcels of Irrigation Scheme in Pampaida Millennium village, Ikara Local Government Area of Kaduna State of Nigeria (Abbas and Anger, 2011). Information on farm owner, size, location and distance from canal of each farm, and boundaries of each parcel could be retrieved from the database.

BUSINESS PROCESS REENGINEERING (BPR) – CONSTRUCTION PROCESS REENGINEERING

Construction process reengineering owed its origin from Business Process Reengineering, it is also known as Process Innovation or Process Innovation. It is defined as a "the

fundamental rethinking and radical redesign of business processes to achieve dramatic improvements in the critical contemporary measures of performance such as cost, quality, service and speed" (Project management strategic issues, 2012). It is a strategic management theory which became one of the Buzzwords in the construction industry and is based on the premise that whenever the quality initiatives aimed at Continuously Improving productivity in any given organization and ad hoc improvements tends to be revolving round the same improvements strategies without significant positive advancements, then quantum leaps are required where old theories, assumptions, and methods, then reengineering is the only answer. "That is, not small incremental changes to the process and leaving the basic structures intact, but rather, abandoning long-established procedures, conventional wisdom and assumptions from the past, to look afresh at the work required in creating a company's product or service to deliver direct value to the customer" *ibid*.

The idea behind the Dissertation is to investigate the awareness of BPR and its use by construction companies in Nigeria with a view to exploring the extent to which it can be used to facilitate Reengineering Road construction projects in Nigeria. Michael Hammer and James Champy were the pioneers of BPR, the theory was named after their book 'Reengineering the Corporation: A Manifesto for Business Revolution was published in 1993'.

Furthermore, it should be stressed here that reengineering is a strategic action like any other such as acquiring a new office building and decision to consolidate an organization's competitive edge. Thus, it requires consistency, sound business case, dynamic and vibrant project team and a commitment on the side of management on implementing entirely different methods of conducting business. This entails being ready to take on calculated risks by conducting effective Risk management exercise and ready to accept/take responsibility of its outcome. A significant strategic change reengineered solution(s) offers is an improved performance (Farrell, 2007). However, success of any reengineered process is determined by effective implementation of the changes, this involves five phases of assessment, reengineering, development, implementation and construction *ibid*.

More so, the use of state-of-the-art information and communication Technology in attaining stability in the entire reengineering programme is

emphasized by the study *ibid*. The performance of CPR like any other process must be measured, especially to compare it with the non-reengineered system so as to appreciate its relevance. Considering the recommendation of the Egan-Rethinking construction report, that for any engineering company to succeed and thrive in the harsh global challenge it must benchmark and measure its performance. This leads us to the relationship of CPR/BPR to other important management and engineering processes.

Based on the vast sources of literature consulted, it is evident that GIS has permeates almost all fields of endeavours, to the extent that a single definition for it is rather difficult. Though, its origin and development occurred simultaneously parallel in Europe, North America and Australia, yet, its real genesis was with the Canada Geographic Information system (CGIS). The literature indicated that GIS is utilized for land/environmental use, marketing- for market identification, agriculture- irrigation scheme, geology-aquifer selection, human services, infrastructural development, law enforcement/crime prevention, and emergency management, to mention but a few. In spite the fact that GIS is used in Nigeria in various aspects of road construction, yet, its potential to serve as a pivot in supporting seaming less concurrency of processes, data/information sharing among professionals and between other advance IT tools like the BIM was not seen to be explored, especially the possibility of integrating these processes to achieve a reengineered road project, hence the research. Consulted texts showed evidence of GIS utilization for road project planning, design, construction, operation, maintenance, and perhaps, decommissioning. Finally, the literature suggested that interoperability through integrated teams could only be achieved on a platform of an enhanced communication network, to which internet based GIS renders self useful.

USE OF GIS FOR ROAD CONSTRUCTION IN NIGERIA

Though no much evidence from literatures referring the utilization of GIS for road construction in Nigeria, an expository studied the possibility of employing the sophistication and increased efficiency GIS will brought to road construction and the construction industry as a whole. (Olaleye and Sangodina, 2001) highlighted some benefits and recommended ways for the adoption of Spatial Information Technology in planning, design, construction and monitoring of civil engineering structures. The research highlighted the need to create Engineering Survey Information Systems

for the Construction Industry for proper planning and digitization of a proposed construction site to be achieved through Data Acquisition, Database Management System and analysis and presentation.

Notable use of GIS is not only found in road construction, but also in government departments, large multi-national corporations and consultancy firms, all uses GIS in executing their works. The newly sworn-in civilian administration in 1999 inaugurated the Abuja Geographic Information System (AGIS) with a view to improving Land administration and overcoming the challenges posed by rapid expansion of the Federal Capital Territory which rendered the normal manual cadastral and Land registry records inefficient in Nigeria (Adeoye, 2007). This was the first giant step ever by government on the use of GIS to facilitate land administration; land valuation, cadastral system, land management, and land administration system.

Road construction falls under one arm of AGIS- the Geographic Information Systems (GIS), the other arm being the Land Information System (LIS). The GIS arm covers all aspects pertaining land use/Abuja master plan, detailed site development plans, **engineering infrastructure** – road, dams, pipe borne water, buried utilities and all other geospatial information related to infrastructure development. While the LIS deals with mostly building land allocation, certification, power of attorney and the likes.

AGIS runs three components which makes it a provider of GIS services to construction companies and consultants just like ESRI, these are; Data capture and maintenance, system administration and development, and customer services. Due to minimal awareness by stakeholders in the country on the potential benefits of using GIS for road construction, AGIS devised two adapted implementation strategies viz; scientific, and operational approach. It ultimately serves as an e-governance platform for achieving accountability, efficiency, transparency and rule of law.

GIS/GPS were used to create an electronic data map of the road network in Nigeria with a view to simplifying data access for planning, construction, management, administration, safety, sustainability and operation of basically the road networks system (Akomolafe, *et al.,* 2009). The GIS developed digitized map could help actualize the e-contracting/e-tendering proposed in this research.

In Katsina state, one of the North-Western states, the use of an ICT driven system- GIS is recommended to curb the menace of rising accident rate in the state (Ladan, 2011). It is the view of the Author of this research that GIS could be extended to tackle the issues of desertification in the North similar to what was employed in a research which studied changes in the Coastal region of the Niger-Delta region by employing GIS and Remote sensing to fill the gap for the non-existence of such initiatives. The problem of socio-economic activities like oil exploration, gas flaring and lots others which leads to the degradation of ecosystem notably in tropical coastal zones lead to a research that explores the potential of using GIS and remote sensing with main objectives of studying the impacts of coastal degradation. Findings of the study revealed that GIS/Remote Sensing could serve as a decision support tool in studying coastal changes by coastal resource managers whilst contributing to the literature to fill the gap of none-existent data on similar research (Twumasi, 2006). Because road construction in coastal region depends on the availability of land to build on, this is why the result of the research became relevant to road construction.

Key findings of the aforementioned appraisal indicated that GIS is merely used as a decision tool for land allocation/administration, and ecosystem conservation by the government, road design by consultants and to a lesser extent by contractors in delivering their projects.

Furthermore this research aim to present the good potential for incorporating GIS technology in delivering road construction projects in Nigeria, with a view to actualizing construction process reengineering by most contractors.

RESEARCH STRATEGY

Quantitative research strategy was adopted for the purpose of this research, this entails a more specific focused study using what (Campbell and Stanley, 1963) as cited in (Creswell, 2009) described as quasi-experiments and correlational studies (Creswell, 2009). More specifically, *Survey Research* that uses questionnaires and *Contact method*-structured interviews was used among the two notable strategies presented by Creswell, the other being *Experimental Research.* However, mixed research approach will be seen to take precedence in terms of interviews to be administered to respondents.

Adopted Methodologies

Though the research focuses on Nigeria specifically, the question of 'why' of a case study research question as

identified by (Yin, 2003) was not be considered here, reason being that it is the elements that is not present in a Survey research method whilst all its other qualities are shared with a case study research. This quality answers the questions; does the research require control of behavioral events? And does it focuses on contemporary events? The answers are both same for a Survey and a Case study research, that is, a 'No' and a 'Yes' respectively (Yin, 2003).

Sample size for the research covered wide audience, but restricted to Contractors (Roads), Consultants and Government departments. The structured interview was targeted to other road construction supply chain members in addition to a limited audience within the aforementioned identified groups with a view to achieving clear, concise and accurate results. The interview will be personal one-on-one interview, unless otherwise not feasible due to some constraints, then such limitations will be presented herein if they occur, perhaps.

Literature Review

Reviewing existing published and unpublished literature sources in the area of a particular research interest serve the purpose of portraying the in-depth knowledge a research Author has in his chosen research field (Naoum, 1998). Published sources consulted were academic research journals, previous Government reports and dissertations, whilst secondary sources included trade journals, magazines and textbook. Sources consulted included primary, secondary, and reference guides- encyclopedias, dictionaries and handbooks, by critically appraising almost all the relevant areas of GIS application, the literature reviewed elucidated the flexible and adaptable nature of GIS, with potential of being adapted to integrate road construction processes and personnel. The aforementioned will aid in reengineering the delivery of road projects in Nigeria. The survey was used to achieve the objective of exploring the level of awareness of CPR among construction professionals and the extent to which GIS is used for road projects in Nigeria.

Questionnaires (Delivered Personally by the Author – Household Drop-Off)

Questionnaires were administered personally by the researcher for efficiency and prompt response, considering the limited timeframe allotted for the Dissertation. This is due to the Author's past experience of delays encountered by postal questionnaires to reach their targeted audience and a reluctance to repost it back to the researcher after filling, in the case of those that the questionnaire has reached.

Questionnaires used will take the form of 'closed-ended' questions and scaled according to the Likert scale as published in 1932 (Wilkinson *et al.* 2003). The respondents are offered with options to the statements (questions) from the most positive to a most negative response, with a neutral response in the middle of the scale. However, some Likert questionnaire types like that used by Hertfordshire Insurance Consultants in seeking their customer's views on the service they received from the company do not give room for a neutral response to the respondents *ibid*.

There are a good number of advantages to be derived by delivering the questionnaires personally, though; services of other individuals was sought where necessary by the Author in administering the questionnaires due to geographic spread of expected respondents. These advantages includes prompt response, accuracy of data- because of the importance a respondent will place on questionnaires delivered by the author, and the fact that the Author will be available to clarify vague issues in the questionnaires. This last point is believed to be a factor jeopardizing the accuracy and relevance of most answered research questionnaires, hence, such a pitfall was avoided by the method adopted by this study.

Structured Interview

Interview questions used were structured, with predefined questions answered by the targeted audience; this is believed to be one of the most accurate means of gathering relevant data regarding a research survey. It give room for any misconception(s), ambiguity, and technical terms used in the research/structured questions to be explained further by the interviewer.

Details to be incorporated in the interview- the **interview protocol** (Creswell, 2009) will include a heading containing information about the place, interviewer, and interviewee; a standard procedure to adopt for all interviews; an introductory question followed by four to five sub-questions and a concluding question; spaces between the questions to record responses; and an acknowledgement (Thank-you) section for the time the interviewee spent to answer the questions (Creswell, 2009).

The other notable interview formats which are however, not considered for the purpose of this research are; unstructured and semi-structured interviews.

SAMPLING METHOD

In spite the fact that the construction team/industry has numerous stakeholders/professions and supply chain members, the sample size of the research

was restricted to Contractors, Subcontractors, Government agencies and Consultant, especially in terms of the survey questionnaires. Moreover, consideration was given to how the other supply chain members could be integrated within the GIS database for a complete Reengineered system to be achieved, thus, the interview randomly covers diverse supply chain members within the road construction, like specialist subcontractors, suppliers, fabricators and perhaps, the immediate community usually affected by construction works.

GENERAL OVERVIEW / ATTRIBUTES OF THE RESEARCH

In the course of this research, a total of thirty (30) questionnaires were distributed, two (2) each to fifteen (15) different organizations which consisted of five (5) construction firms, five (5) consulting firms, and five (5) government agencies/departments. Twenty seven (27) out of the thirty (30) administered were properly completed and returned, this indicates a 90 per cent return rate- meaning that ninety per cent (90%) of the total number of questionnaires administered were returned. Furthermore, a constructive interview was conducted with experienced professional/employee, three (3) each from randomly sampled supply chain organisation involved in road construction and one (1) each from key relevant functional department within the identified organisation and government agency.

Characteristics of the Respondent

Based on the responses obtained from the questions raised in the questionnaires, below are tables which show the individual composition of the respondents. The table indicates the respective number of key professionals that uses GIS in their departments in the three category of organizations considered. The professionals are Engineers, Architects, Project managers, and surveyors as in table 1 below:

Table 1: Analysis of the Respondents

Type of organisation	Type of Profession				Total by Organisation
	Architects	Civil Engineers	Project Managers	Surveyors	
Consulting firm	3	2	2	2	9
Construction firm	4	2	3	1	10
Government agency	2	2	2	2	8
Total by No. of Respondent	**9**	**6**	**7**	**5**	**27**

Source: Survey Data, 2012

The table above presented a composition of the total number of respondents on the basis of their field of specialization and the type of organization they belong. A total of nine (9), ten (10), and eight (8) respondents were received from consulting firms, construction firms and government departments respectively. A further analysis and graphical representation of the respondents based on their organizations is given in table 2 below:

Table 2: Composition of Respondents by Type of Organisation

Type of Organisation	Number of Respondents	Percentage (%)	Degree on Pie Chart (°)
Consulting firm	9	33	120
Construction firm	10	37	133
Government agency	8	30	104
Total	**27**	**100**	**360**

Source: Primary Data, 2012

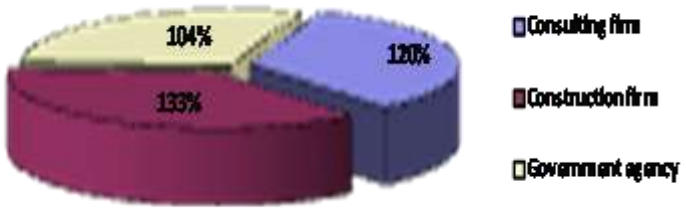


Figure 1: Pie Chart Showing Composition of Respondent by Organisation

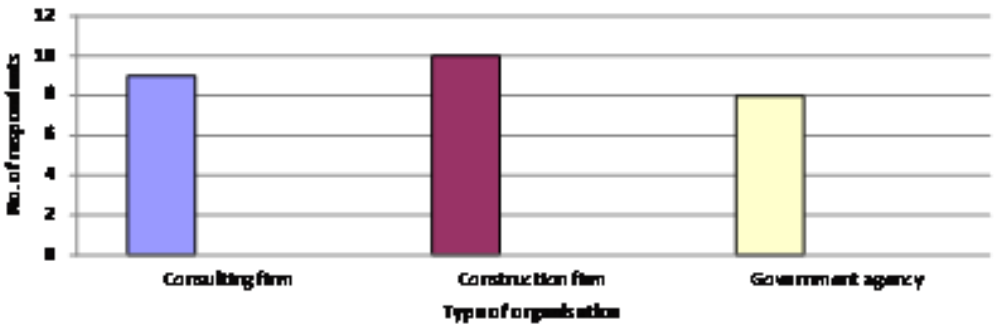


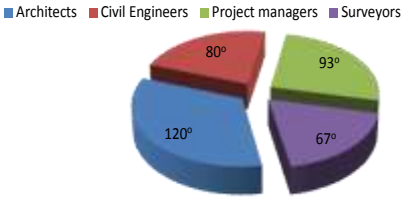
Figure 2: Bar Chart Showing Composition of Respondent by Organisation

Furthermore, table 2 above depicts how the respondents are distributed across the four (4) field of specialization identified. The specializations identified are; Architecture, Civil Engineering, Project management, and Surveyors to which the respondents were distributed in the order 9, 6, 7 and 5 respectively.

Table 3: Composition of Respondents by Specialization

Specialization	No. of Respondents	Percentage (%)	Degree on Pie Chart
Architects	9	33	120
Civil Engineers	6	22	80
Project managers	7	26	93
Surveyors	5	19	67
Total	**27**	**100**	**360**

Source: Survey data, 2012



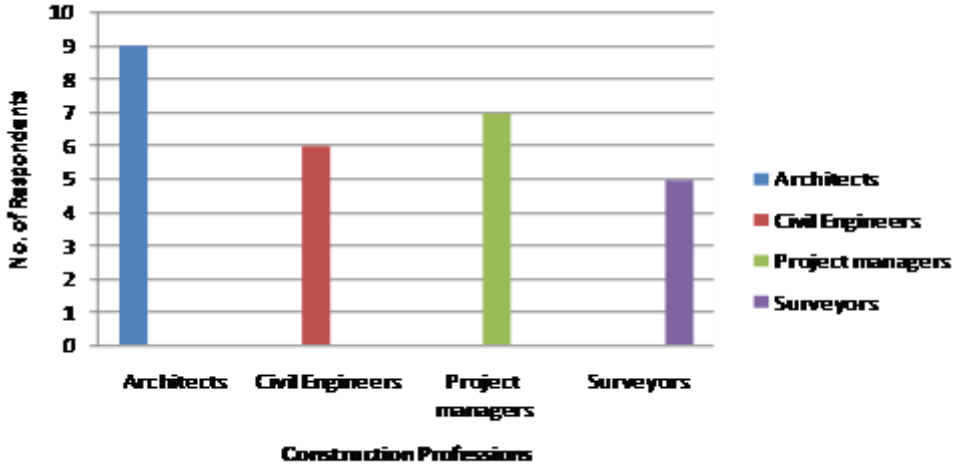


Figure 3: Pie Chart Showing Composition of Respondent by Profession

Figure 4: Bar Chart Showing Composition of Respondent by Profession

Table 4: Respondents' Practical Years of Experience

Range of years of practical experience (Years)	Field of Specialisation				Total (by Experience)
	Architects	Engineers	Project Managers	Surveyors	
1-5	-	1	2	-	3
6-10	6	4	4	2	16
11-20	3	1	-	1	5
20 and above	-	-	1	2	3
Total (by Specialisation)	9	6	7	5	27

Source: Survey data, 2012.

The table above presented the composition of the respondents on the basis of their field of specialization and years of practical experience in the field. The research established four (4) ranges as: 1-5 years, 6-10 years, 11-20 years and 20 years and above into which the respondents fall in the order 3, 16, 5 and 3 respectively. Thus, most respondents are within 6-10 years of experience. Further analysis and graphical representation are depicted below:

Table 5: Further Analysis on Respondents Years of Experience

Ranges of Years of Practical Experience (Years)	No. of Respondents	Percentage (%)	Degree on Pie Chart (°)
1-5	3	11	40
6-10	16	59	213
11-20	5	19	67
20 and above	3	11	40
Total	27	100	360

Source: Survey data, 2012

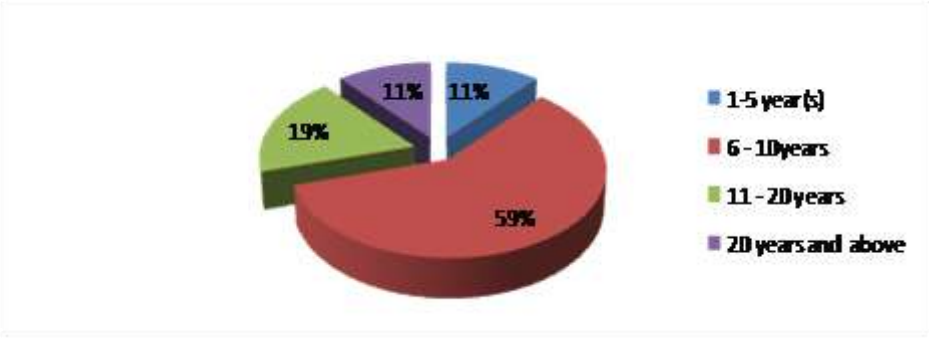


Figure 5: Pie Chart Showing Composition of Respondent by Years of Experience

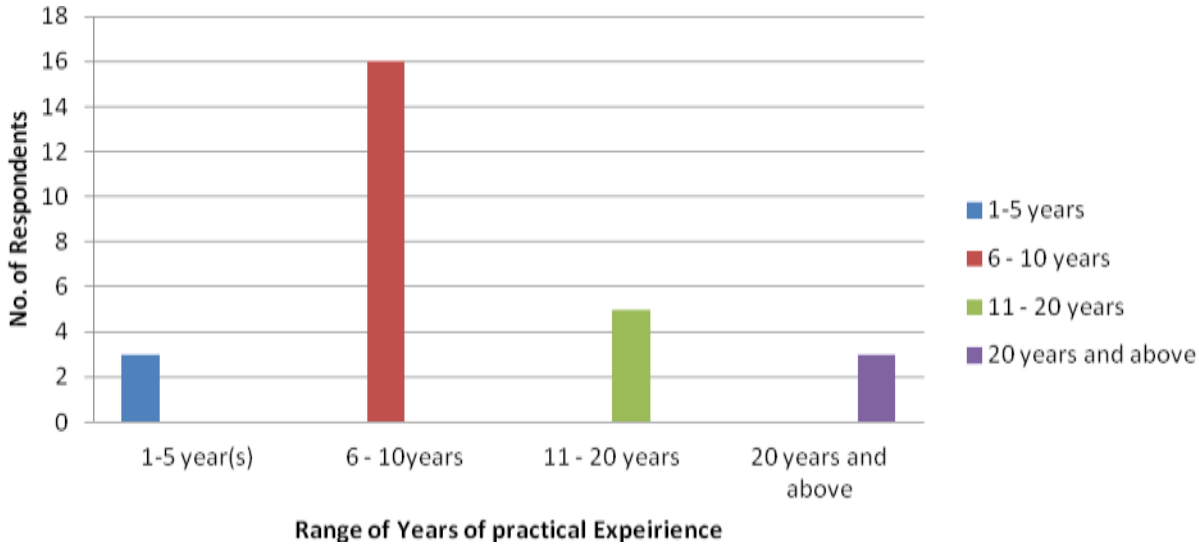


Figure 6: Bar Chart Showing Composition of Respondent by Years of Experience

Characteristics of the Interview Respondents

Apart from the data obtained from the questionnaire responses, an interview was also conducted with separate individuals, three (3) each from the departments that uses ICT/IT/GIS in their departments purposely to share more light on areas that require elaboration and clarification that is not covered by the survey questions. The characteristics of the interviewees, though not exhaustive are hereby presented in table 6 below:

Table 6: Composition of Interview Respondents

Category	Planning and Design	Construction and Maintenance	Urban Planning- the Abuja Master Plan	Subcontracting
Specialisation	GIS expert	Highway engineer	Surveyor	Road Furniture
Name of organisation	Integrated Engineering Associates	Habibu Engineering Nigeria Ltd.	Abuja Geographic Information Systems	Gayaco Nigeria Limited
Type of organisation	Consulting firm	Engineering firm	Government Agency	Subcontracting firm
Years of practical experience	7 years	11 years	9 years	18 years

Source: Survey Data 2012

Characteristics of the Instrument

The instrument used in collecting primary data is a Likert-type questionnaire with a total of eighteen (15) questions. A structured interview aimed at collecting personal details of the respondents and further collect pertinent information to support valid conclusion to be drawn in conjunction with the data gathered from the questionnaires was administered to a wider category of professionals. For the purpose of the interview the respondents were randomly drawn from the management and employees of most stakeholders in Road construction in Nigeria.

The responses obtained there from the Likert-type statements were rated using a five (5) points Likert-type rating scale in which Strongly Agreed is scored = 5, Agreed is scored = 4, Undecided scored = 3, Disagree scored = 2, while Strongly Disagree is scored =1. Numbers of respondents were multiplied with corresponding weight to obtain the aggregate weighted scores.

PRESENTATION OF THE DATA COLLECTED

This segment is aimed at satisfying the research objectives (particularly those which have not been taken care of in the literature review) through analyzing the

questionnaire responses and presenting same in tables and graphs.

Table 7: Responses Indicating the Level of Awareness of Construction Process Reengineering

S/No.	Statements	Strongly agree	Agree	Undecided	Disagree	Strongly disagree	Weighted Score	Ranking
1	I am familiar with the term Construction Process Re-engineering (C.P.R)	3	4	3	6	11	63	4th
2	I do understand what Construction Process Re-engineering entails	1	4	0	13	9	56	5th
3	Our organization had once re-structured (re-engineered) its construction delivery processes	2	5	3	12	5	68	3rd
4	I consider GIS an effective tool for Reengineering Construction Processes in my organisation	9	8	0	7	2	93	2nd
5	Our organisation has been using GIS in delivering Road construction/consultancy projects for quite some time now.	14	8	0	3	2	110	1st

Table 7 above showed the level of awareness of what Construction Process Reengineering (CPR) is among consulting and construction professionals in Nigeria, which shows a low level of awareness of the terminology, but there seems to be a practical application of the concept in the various organizations asked as further indicated below:

Figure 7: Bar Chart Showing Level of Awareness of CPR Among the Respondent

Question 6 to 10 in the questionnaire addresses the second objective of the research dealing with the possibility of integrating the numerous stages in a road construction project from the planning, bidding, award, construction, operation, through to decommissioning if applicable with GIS or in a GIS database. This is with a view to achieving integrated teams advocated by Sir John Egan and interoperability between various stakeholders in Road projects. Result of the respondents is given in table 8 below:

Table 8: Possibility of and Efficiency of Integrating Road Construction Process with GIS

S/No.	Statements	Strongly agree	Agree	Undecided	Disagree	Strongly disagree	Weighted Score	Ranking
6	The use of GIS enhances efficiency and productivity in project delivery.	3	13	1	8	2	88	4th
7	My organisation can still be efficient and have a competitive edge among competitors without the use of GIS.	3	6	0	7	11	64	5th
8	I am of the view that a GIS reengineered process will aid achieve concurrency in road construction process.	4	17	0	4	3	99	2nd
9	GIS can help achieve enhance the performance of consultancy/construction firms a like.	16	4	2	1	4	108	1st
10	GIS could help integrate road planning, design, construction, operation and management.	5	13	0	3	6	89	3rd

Source: Survey Data 2012

Base on the data presented in table 11 above, it is evident that most of the respondent believed in GIS as a tool for enhancing performance and efficiency in delivering road projects by ensuring overlap and fast-track of Road Construction processes from the preliminary planning stage down to commissioning, operation, maintenance and perhaps decommissioning, thus, ultimately integrating the entire system. Graphically depicted in figure 13 below:

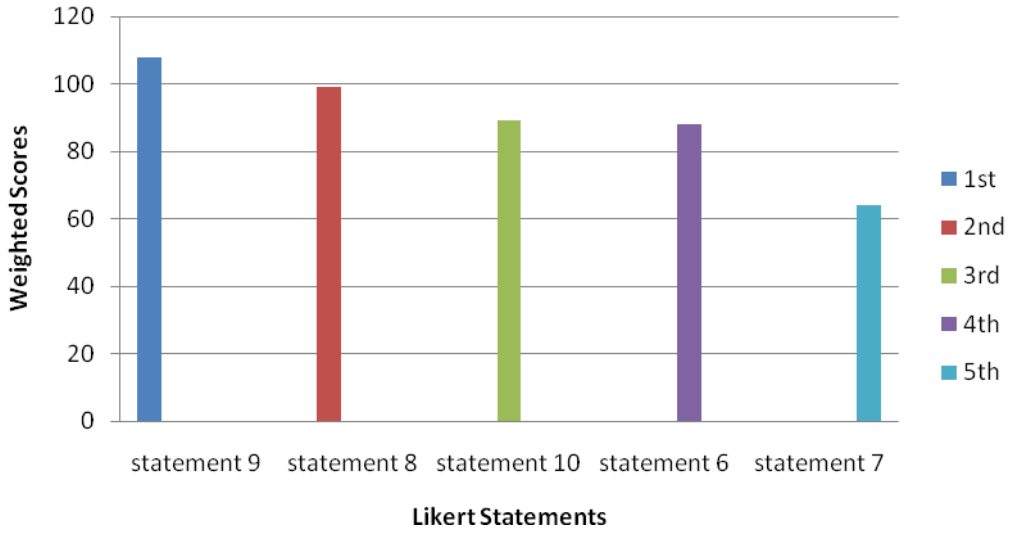


Figure 8: Bar Chart Showing Possibility and Efficiency of Integrating Road Construction Process with GIS

Any system that has its upsides has certain bottlenecks militating against its smooth implementation or execution. These factors may vary in nature, form, severity and ease of eradicating or mitigating depending on the technical, political, socio-economic, cultural and geographic location of the project associated with such problems.

Table 9: Challenges for Sustaining the GIS-CPR Process in a Developing Country like Nigeria

S/No.	Statements	Strongly agree	Agree	Undecided	Disagree	Strongly disagree	Weighted Score	Ranking
11	Among the challenges encountered, training of personnel poised the greatest of them all	17	5	0	3	2	113	1st
12	I consider Unethical practices in the Nigerian construction industry as one of the major challenge that could hinder smooth GIS implementation	7	13	4	3	0	105	3rd
13	Nigerian construction industry is going at a universal pace in using ICT, and state-of-the-art technology in road project delivery.	3	6	0	14	4	71	5th
14	There are problems encountered by my organisation in using GIS	9	11	2	4	1	104	4th
15	In spite the numerous challenges, I would recommend GIS to other construction/consultancy firms as a tool for Construction Process reengineering.	10	14	0	3	0	112	2nd

Source: Survey Data 2012

Table 9 above indicates possible challenges over the sustainability of CRP-GIS processes in construction industry, particularly in a developing country like Nigeria. The responses indicated variant challenges among which personnel training is considered most eminent. However CRP-GIS process seems to be recommended by most respondents despite the challenges associated with it. Graphical representation of the data collected is depicted below:

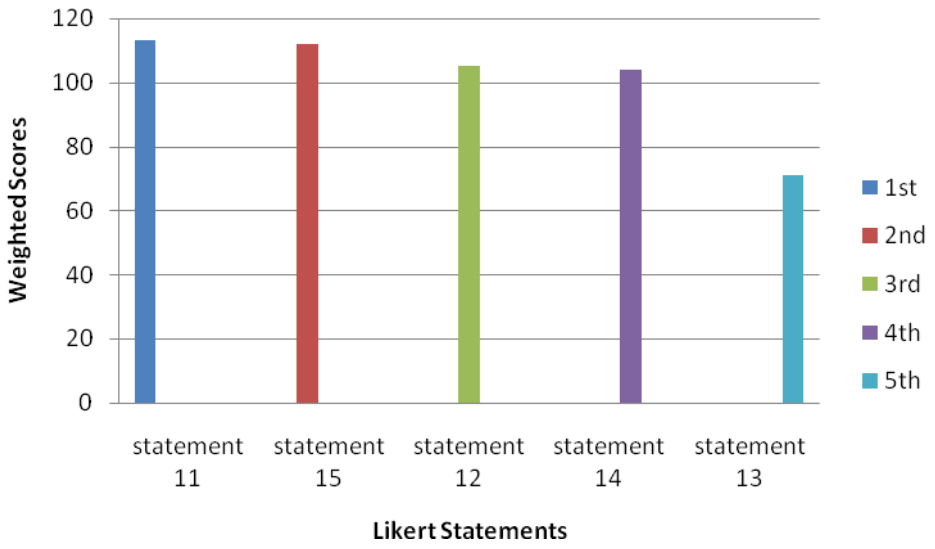


Figure 9: *Challenges for Sustaining the GIS-CPR Process in a Developing Country like Nigeria*

Conclusively, this chapter presented and analysed the data collected from the administered questionnaires by categorizing and treating answers to the various Likert statements according to the relevant identified objective set at the beginning of the research. The subsequent section concisely summarised all the key findings.

SUMMARY OF FINDINGS

The data being obtained, presented and analysed in the previous chapter is hereby summarized. Out of the three application categories of GIS; Corporate, Multi-department and Independent, the construction and consultancy organizations studied notably uses

Corporate GIS which entails the use of GIS in an entire organisation from top management to various departments. It facilitates data sharing, accurate decision making among all functional departments, it is used by large organizations like government departments and large contracting firms.

Respondents comprised of Architects, Project managers, Engineers, and surveyors (Land surveyors) in variant proportions from construction, consulting and government agencies. Construction firms have the highest number of respondents followed by consulting firms, then government agencies. It is evident that professionals within the range of 6 – 10 years of experience have the highest number of respondents, while those with 20 years and above years of experience has the least respondents. Reason being that IT in the country and specifically in the road construction sector has gained applicability in the late 19^{th} century, perhaps pretty much to end of the period, or the pioneer construction workers (with such years of experience) are expatriates whom had relocated back to their respective countries due to some 'unfavourable' government policy like the local content Act, which requires the involvement of indigenous expertise in science, technology and infrastructural sectors.

The professionals that answered the questionnaires are of medium experience between 11 – 20 years, randomly selected from various industry sectors to satisfying the research objective of exploring the possibility of using GIS as a tool for reengineering Road construction projects in Nigeria.

Geographic Information System has permeates almost all fields of Endeavour resulting in the utilisation of its vast features by opportunistic users to enhance the performance of their work. These category of users shoulders optimum cost and security risks, pioneers and routine GIS users' faces most and least risks respectively. Aside users (humans), GIS has four other important components; data, procedures, software, hardware all of which needs to works as a single entity, this makes the GIS a robust entity in enhancing project delivery. It is in this light the research seeks exploring the extension of GIS as a tool for reengineering road construction in Nigeria. Findings of the research which is aimed at appraising the possibility of using GIS as a tool in reengineering road construction projects in Nigeria by integrating the bidding, design, construction and operation phases with a view to achieving enhanced performance yielded a rather mixed views from respondents.

CONCLUSION

GIS as a system and technology has been used as a stand alone solution to various mapping, cadastral and boundary problems, mainly by AGIS and some few consulting firms in Nigeria. GIS use in the construction industry revolves round land administration, boundary delineation, land administration and in mapping-out population density spread, and water resources. In road construction it is used casually as a spatial tool for locating a proposed project site on a map for feasibility studies needed to make a strategic decision of whether or not to tender for a particular project, its potential to serve as a platform of integrating key road construction stakeholders, processes and organisations for enhanced efficiency through interoperability could be achieved by creating awareness amongst personnel of its versatility, especially towards attainment of CPR, standardization and empowering a regulating body like the AGIS to curb misuse and security issues. Most respondent, which comprised of Engineers, Architects, Project managers, and surveyors acknowledged awareness of CPR as a principle in achieving significant improvement in contemporary critical success factors, however, majority are not aware of the term CPR, yet they employ its concept in their organization at one point or the other in delivering their work. Furthermore, outcome of the survey questionnaire indicated the efficacy of using GIS as a tool for enhancing performance and efficiency in delivering road projects by ensuring overlap and fast-track of Road Construction processes from the preliminary planning stage down to commissioning, operation, maintenance and perhaps decommissioning, thus, ultimately integrating the entire system.

Though, respondent of the questionnaire were mostly that of mid carrier category, yet, result indicated a high optimism amongst them, of achieving fast track and greater efficiency using an appropriate Geodatabase. A geodatabase allows multi-user editing and version management using Arcinfo 8 or ArcSDE which harbours many users with varying functional requirements. There was a mixed opinion among those interviewed as to how GIS could serve to integrate teams, processes and tools (technologies/gadgets) employed on a road construction site, and the issue is that of planning and implementation. Generally, implementation of a unified GIS Database consists of three distinct phases viz; Data conversion specification, Data migration and Application development. Data conversion specification involves collecting data from all functional departments in an organization to convert it to a data model,

or symbol required for each identified feature to be converted from an attribute to a spatial data model for easy identification by a GIS application. Arguably, even if initiating such a system became possible, several peculiar problems such as unethical practices, training-technical know-how of using the new system, and lack of efficient change management could significantly mar its sustenance. The interviewees indicated a number of key challenges to a smooth GIS implementation which falls into two categories; technical and human factors. Challenges that could mar successful implementation of GIS in the construction industry as identified by some interviewees include lack of proper Database management and record keeping system, security/secrecy and ownership. Lack of a GIS data standard as presented in section 2.5 table 1 of this dissertation exacerbates the integration of an existing ICT infrastructure in an organisation with a new GIS (software/hardware), more so, the technical issues of selecting the most appropriate data model, an effective data input method and a flexible analysis procedure must be strategically addressed for successful GIS implementation in any organization.

RECOMMENDATIONS

- There should be greater sensitization of all road construction operatives as to what CPR means and how it could be achieved by using GIS.

- All contracts to be released by the government above one million Naira should be tendered for via e-tendering on a GIS platform whilst establishing an enabling database which contains both alphanumeric and spatial datasets like ORACLE.

- All inter-organisational transactions by suppliers, client advisor, specialist subcontractors and regulatory authorities should be made via GIS platform.

- The proposed GIS reengineered construction process should serve to integrate all other IT tools used by stakeholders for the entire project duration through a central database hub to promote e-governance.

- The research dealt with appraisal of using a GIS only, thus, further research in the area of technical viability of the system should be conducted.

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