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Enhancing Urban Planning and Management through the Application of Geographic Information Technology for Economic Transformation

[1]Baadom, Livinus E., [2]Deeyah, Christopher L.,[3]West, Tamunomiete and [4]Uebari, Sunday L.
1,3 Department of Urban and Regional Planning, 2 Department of Estate Management, 4 Department of Mechanical Engineering
1,2,3 School of Environmental Technology, 4 School of Engineering
Ken Saro Wiwa Polytechnic, Bori Rivers State, Nigeria.
Correspondence email: livybas@yahoo.com and chrisdeeyah@yahoo.com

Abstract: *The concept of geographic information technology is a scientific knowledge that is practically used in spatial location of elements, their sizes and relativity to others which first appeared toward ending of the last millennium. This article assesses the roles of geographic information technology toward the enhancement of urban planning and management by objectively determining four important milestones- mainframe/ server GIS, mobile GIS, desktop GIS, and internet/web GIS. These milestones have technologically formulated to address urban challenges in the areas of transportation and communication, governance, waste management, housing and land use. Others include facility provision and management, social vices, land pollution as well as environmental impact assessment. The paper recommends basic areas in which geographic information system can be applied to enhance technological turning point especially in cities of developing countries. It calls for attention in training and practice to enhance effective urban governance for economic transformation in Nigeria.*

Keywords: *Urban Planning, Geographic Information, Governance, Technology and Spatial Sustainability.*

Introduction

Information technology is one of the revolutions that have brought significant change to man and his environment. In a special way, this is manifested in the development of Computer. Recently, Computer have been applied in many and different ways such in the areas of banking, transportation, communication, marketing, distance learning (education), medicine, automobile, city design and governance and several other areas.

Presently, information technology is applied to geography and geographic features as well as the determination of the location of the features and their relativity to one another. According to De-blij and Muller (1991), geography is the study of earth's features and patterns of their variations in spatial location and time, which is mostly presented in maps. These geographic features which at times presented in map forms shape our pattern of visualization, assessment and analysis as well as psychology of spatial information. The ideology of geographic information system (GIS) is one of the very recent phenomena developed in 1960s to determine the location of features on the surface of the earth. This explanatory keynote is

narrowed to an urban setting which is one of the geographical spaces developed for human habitation, characterized by high human population, presence of urban foundations (facilities) and may mostly become administrative headquarter for easy governance (Chandna, 2012; Roberts, 1999; Onokerhoraye and Omuta, 1994).

Socially, an urban environment is viewed by Macionis and Parrillo (2010), as setting aspects of human drama: the highest learning colliding with the grossest ignorance, unimaginable wealth Juxtaposed with the most abject poverty. This view maintains that an urban area is a place of gross integration and interaction of cultures, and socio-economic classes. The placement of infrastructure whose presence actually determines the quality of human settlement (urban or rural) becomes central in the application of geographic information system in urban environment.

Definition of geographic information system

The application of geographic information system in many and different fields has grossly affected its definition and perceptions. Thus, Heywood, Cornelius and Carver (2006), maintain that to select the actual definition of GIS, various areas in which the concept of geographic information system can be derived are assessed. However, Maguire, Goodchiled and Rhid (1991) offer a list of 11 different definitions. It is significant to note that due to the dispersed concept of GIS, different fields of thought view it from areas of interest. Pickles (1995) suggests the fact that any definition of GIS will depend on who is giving it, and their background and view point and further maintains that may not be static but may likely change quickly as technology and applications develop further. GIS is essentially defined as a computer-based system that enables users to collect, store, and process, analyze and present spatial data (Prakash, 2001). A similar definition to the above is that by Burrough and McDonnel (1998), who reveal that it is a set of tools for collecting, storing, retrieving at will, transforming, and displaying spatial data from the real world for a particular set of purposes. Some of the issues that have formed the basis of clarifications for definitions of geographic information system include its functionality, genealogy, cost, size, platform application area and data model and the central focus of the current GIS: hardware and software and information processing (Maguire and Rapor, 1990; Maguire and Danger -Mond, 1991; Clarke, 1986).

In relation to urban planning, GIS is viewed as just one of the formalized computer-base information system capable of integrating data from various sources to provide the information necessary for effective decision-making in urban planning (Han and Kim, 1989). Some other information system for urban planning and management include decision management systems (DMS), decision support system (DSS), and expert systems. It is important to note that GIS serves both as a database and a toolbox for urban planning. In a database-oriented GIS, spatial and textual data can be stored and linked using the geo-relational model. Current GIS support efficient data retrieval, query, and mapping.

The discipline that deals with all aspects of spatial data handling is known as geo-informatics. A related term that is sometimes used synonymously with geo-informatics is geomatics. Sequel to the current development, the use of GIS is no more restricted to mapping, planning and survey organization. GIS enters medium and small businesses and new domains, such as geo-marketing (Ademola, 2015). The computing platforms from four important milestones are mainframe/server GIS, mobile GIS, Desktop GIS and Internet GIS.

Mainframe/Server GIS

Mainframe-based monolithic GIS programmes are GIS programmes with limited or no communication with other computer (other than transparently via, for example, use of a network file server). Programmes are used on the mainframe where the programme resides. Users need access to that machine via a login or dump terminal session. An example is early Arc/info installed on a standalone mainframe (Joseph, 2005), Canada Geographic information system developed in 1962 also ran on mainframe and was used to store, analyze, and manipulate data collected for the Canada Land Inventory (CLI). It was an initiative to determine the land capability for rural Canada by mapping information about soils, agriculture, recreation, wildlife, water flow, forestry, and land use at a scale of 1:50, 000.

The mainframe GIS is mostly used in spatial data infrastructure which is to denote a framework of technologies, policies and institutional arrangement that together facilitate the creation, exchange, and use of geospatial data and related information resources across an information sharing community. According to ESRI (2006), the mainframe GIS offers opportunity of central data control to ensure standardization. Organization of effort direct people toward the best available data, and improve the overall quality of geospatial data and information. An important aspect of the mainframe GIS is the principles of Geo-Spatial Handling is GIS which does not store map or image but rather store a relational database from which maps can be created at and when needed.

Mobile GIS

According to Scholtz (2006), the convergence of the rapidly progressing fields of wireless communication and hardware coupled with technologies, like Geographic Information Systems (GIS) and Global Positioning systems (GPS), has led to the emergence of a new field called mobile GIS. Generally, TSOU (2004) defines mobile GIS as an integrated software/hardware framework for the access of geospatial data and services through mobile devices via wireline or wireless networks. Part of its very basic function is to access geospatial data. It is also extended to displaying of geospatial data and performing GIS operations. It has the ability to display geospatial data, and receive, process and retrieve the GIS requests of mobile user more acceptable (Pundt, 2002).

Desktop GIS

Desktop geographic information system represents the real world on a computer similar to the way maps represent the world on paper and provide comprehensive and powerful GIS capabilities to assist in performing advanced spatial analysis, spatial data creation, and visualize results on professional quality maps. GIS and paper maps convey information about places. Though, desktop GIS are found to have power and flexibility in which paper maps do not possess. Desktop GIS also have the ability of storage and linkage to huge amounts of information concerning the objects been represented on maps. These objects which are geographical features as represented on maps have location, size and spatial relationship to other features.

Desktop GIS has several characteristics and affiliations such as geographic referencing concepts which performs its analyses by relating the different layers containing one information or the other to their specific or actual locations on the surface of the earth (Ademola, 2015). Another significant aspect of desktop GIS is geographic coordinate system which uses a three-dimensional spherical surface to define locations on the earth. The projected coordinate system

which is defined on a flat, two-dimensional surface is one other sub-unit of desktop geographic information system. It maintains a constant lengths, angles, and areas across the two dimensions. It is also used in map projection in which according to Rao (2003), is a mathematical transformation to create a flat map sheet from its three-dimensional surface.

Internet/Web GIS

This aspect of geographic information system evolved around 1993. It has greatly influenced the way geo-spatial information is acquired, transmitted, published, shared and visualized. Internet GIS represents a great milestone in the history of GIS (Peng, 1999). The internet is a massive network of networks that connects millions of computers worldwide. According to Douglas (2008), computers connected to the internet can communicate with one another with a number of protocols, such as Hypertext Transfer Protocol (HTTP), Simple Mail Transfer Protocol (SMTP), File Transfer Protocol (FTP), Internet Relay Chat (IRC), Instant Messaging (IM), as well as Telnet and P2P (Peer-Peer). The World Wide Web is defined as a system of interlinked hypertext documents and programmes that can be accessed via the Internet primarily by using Hypertext Transfer Protocol. Though, the HTTP is just one of the protocols the internet supports, its main attraction for a large number of users is the content accessible on the web.

Internet GIS can be viewed as a distributed, object-oriented system, portable and a cross-platform (Joseph, 2005). The internet supports many services in which, the web is one of them. It is significant to note that two capabilities are enhanced through the Web and Internet – the Web allows visual interaction with the geo-data. This will enable users to produce maps with the aid of the near ubiquitous nature of the internet; can be viewed by other users from any and different locations.

GIS Application in Urban Planning and Management

Geographic Information System is as complex as proper planning and management of cities especially in developing world. The ideology of GIS could be found to have been derived from the basic concepts of urban planning and will ever continue. Thus, Trevor and Gregory (1993), reveal that the continent has a long history of GIS application in planning and resource management dating back to the mid-1960s. Accordingly, the diffusion of GIS into the planning sphere has continued at a remarkable rate. However, no single source is yet available that enumerates the diversity and scope of GIS applications in urban and regional planning (Ademola, 2015). Early studies into the field of GIS application in planning like Wellar (1975), Ducker, (1979) and Tomlinson (1987) identified major trends and impediments to the development of GIS in the planning domain. Increasing trends in software, hardware and application area have largely been interpreted on the basis of personal involvement (Trevor and Gregory, 1993). Planning is an unstable decision-making process which is affected by forces beyond the dictates of the planning rationale or strategy. It is a heavily politicized activity ranging from physical, social, economic to political spheres. The application of GIS in planning will have effective functionality.

Urban Planning and Management involves map functions, scales, sectors and stages. These functions can be classified into general administration, development control, plan making and strategic planning. The general routine planning activities are development control and administration while other aspects such as plan and other non routine like strategies planning are not always in continuous practice by planners. Planning covers a wider scale ranging from the

regional context, a whole city, to a sub-region of a city, district, neighbourhood or a street block. Though, land use, housing, land development, transportation, and environmental management are the most frequently involved sectors of urban planning and management.

Geographic Information Systems are of many benefits to the planning of urban environment. Thus, Royal Town Planning Institute (1992) has identified the following.

- Improved mapping and better access to maps
- Improved map currency, more effective thematic mapping, and reduced storage cost;
- Improve analysis
- Greater efficiency in retrieval of information;
- Better communication to the public and staff;
- Faster and more extensive access to the types of geographical information important to planning and the ability to explore a wider range of any planning scenario;
- Improved quality of services such as speedier access to information for planning application processing.

It is therefore observed that GIS plays an important role in the enhancement of urban planning. Thus, Tomlin (1990), maintains that GIS serves both as a database and as a toolbox for urban planning. GIS support efficient data retrieval, query, and mapping. Planners can also extract data from their databases and input them to other modeling and spatial analysis programs. When these are combined with data from other tabular databases of specially conducted surveys, geographical information can be used to make effective planning decisions (Berry, 1987). Also, planners make use of map overlay which is one of the geo processing functions in land suitability analysis which is an important component in urban planning (Hopkins, 1977).

Also the use of the data management, visualization, spatial analysis, and modeling components of GIS varies according to different functions of urban planning (Levine and Landis, 1989). Data management, visualization, and spatial analysis are used more in the routine work of urban planning; spatial modeling is used more in strategic planning while general administration employs mainly data management and visualization. It is significant to know that development control which is a major aspect of urban planning and management uses the visualization and spatial analysis functions of geographic information systems. The outstanding areas of development control and general administration according to Newton and Taylor (1986) include;

- Management of land use record;
- Building control application processing;
- Land use management
- Thematic mapping
- Land availability and development monitoring
- Industrial, commercial, and retail, open space recording
- Public facilities and shops catchment area and accessibility analysis
- Social area and deprivation analysis;
- Land use/transport strategy planning;
- Contaminated and derelict land registers;
- Environmental impact assessment;
- Recreational and country side facility planning

There are many and different areas of GIS applications in the landuse, housing, transport, land development, and environmental sectors. Such are prominent in the areas of site selection and land suitability analysis. In term of transportation planning in an urban area, network analysis and route selection are frequently applied while buffer and overlay processing are used in environmental planning and management. Though according to GoodChild, Parks and Steyaert (1993), there is an increasing trend toward the integration of modeling in different sectors of urban planning.

GIS can also be applied in the different stages in the urban planning process which can be generalized as the determination of objectives, resource inventory, analysis of existing situations, modeling and projection, development of planning option, selection of planning options, plan implementation, and plan evaluation, monitoring and feedback, (Paulson, 1992; Yeh and Li, 1996; Schuller, 1992; Chuvieco, 1993; Carver, 1991; and Yeh, 1991).

GIS in Urban Management and Economic Transformation

The practice of urban and regional planning is holistically carried out at the various level of political administration especially at the national, state and the local stages. At the national, GIS is applied in the areas of Land Management, Environmental Protection, forest service and national Parks, Geological services, population and statistics, housing, transportation, power and water supply, irrigation and other regional agencies. It is expected that demographic statistics when linked to spatial information forms better ground for socio-economic database that can be regularly updated and support a range of national planning activities like population census and civil registration (national ID card, voters' registration) among many others (Ademola, 2015).

The application of geographic information systems at the state level varies like that of the national. Urban planners can use GIS to prepare development plans (like master plan) which set the standard for policy decisions regarding long-range changes to a city's physical environment. It can also be applied in neighbourhood design, identification of activities within different zones, city transportation, residential housing, city growth, location of institutions as well as migration.

The local Planning Authorities which have substantial responsibilities for day-to-day planning need incorporation of GIS into planning at the local government level. The application of GIS can be revealed in the aspects of environmental sensitive areas-wetland, floodplain, implementation of zoning, permit status and other planning information leading to improved planning image and economic development. GIS can also be used to conduct environmental review of projects, development review, analysis, and compliance, historic preservation and redevelopment. Management of land use record.

Effective application of GIS in the following areas of development control and: Building control application processing; Land use management, Thematic mapping, Land availability and development monitoring, Industrial, commercial, and retail, open space recording , Public facilities and shops catchment area and accessibility analysis, Social area and deprivation analysis; Land use/transport strategy planning; Contaminated and derelict land registrations; Environmental impact assessment; Recreational and country side facility planning ,will enhances urban management for economic transformation.

Conclusion

The content of this paper has objectively examined the ideology of geographic information systems and their usages in the planning and management of cities. GIS are increasingly being

used in planning agencies in the developed and developing countries (Worrall, 1990; Yeh, 1991). GIS and its sub-components like server, mobile, desktop and internet is increasingly becoming an important component in all aspects of planning such as in housing, transportation, forestry and recreation, comprehensive plan and neighbourhood design. Recent GIS used as planning models, visualization, enhances the effectiveness of urban planning and management toward transformation of the economy. These planning strategies are highly determined and practiced at the various administrative levels of governance.

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