Geographic Information System (GIS) Based Land Information System for Efficient Land Administration in Abuja, Nigeria

SALEH AMEERAH MUSTAPHA[1], U. S. LAY[2]
[1, 2]*Department of Geography, Faculty of Environmental Science, Nasarawa State University, Keffi, Nasarawa State, – Nigeria*

Abstract- ***Geographic Information System is essential in urban planning. The fuel driving the engine of growth and sustainable development of any nation is the nation's access to reliable and sufficient geo-information. This study evaluates GIS based land information system for efficient Land Administration in Abuja. Simple descriptive statistics such as frequency analysis, percentage distribution and content analysis were adopted for the study. Questionnaires were distributed using a simple random sample technique, ensuring that a reasonable number of the population had an equal chance of being chosen for the sample. The study found out that, there are existing land tenure systems in AGIS which includes; the existing land tenure systems in this region are well-defined and easy to understand; the current land tenure systems ensure equal access to land for all; traditional land tenure systems are more effective than statutory systems in managing land disputes. Furthermore, land information system in GIS is reliable and up-to-date. The also sort that there are procedures for land registration and documentation which shows how Government agencies provide adequate support during land documentation processes. The study recommends that, there is need to enhance public awareness and simplify procedures, regular community sensitization campaigns should be organized to educate stakeholders on the clarity and benefits of land tenure systems. Furthermore, the registration procedures should be simplified to accommodate diverse literacy levels and encourage broader participation. Improving the accessibility and reliability of the Land Information System (LIS) is crucial. This can be achieved by investing in upgrading the LIS infrastructure to enhance reliability and stakeholder accessibility. Additionally, expanding training programs tailored to diverse user groups will help build capacity and increase system usage, while addressing the technical and financial barriers identified. Tackling corruption and promoting affordable processes is essential. Robust anti-corruption measures should be implemented within land management agencies, including transparent fee structures and accountability mechanisms. Moreover, subsidizing land registration fees for vulnerable groups will improve affordability and equitable access to land registration services.***

Keywords— Geographic Information System (GIS), Based Land Information System, Efficient Land Administration, Nigeria.

I. INTRODUCTION

Nigeria has a very poor land administration system (Ukaejiofo, 2020). Among many other authors, he observed that although Nigeria is endowed with a vast land mass of about 924,768 sq km, it does have the appropriate infrastructure to enable her reap optimum benefits from its administration. It is endowed with enviable land resource yet the potentials of such land as a veritable means of sustainable development have not been fully explored. Mabogunje (2016) argued that because more than 70% of lands are not surveyed and registered in the State Ministries and that because only about 3% of the 20% in the urban areas is mapped, there can be no proper land administration in the country. Ukaejiofo (2019) had earlier identified that as at 2010-2015, less than 10% of the total land area can be tied to a well-documented record of the use and user, that is there are no comprehensive cadastral map of our cities and towns and therefore a substantial part of the land under use is yet to come under the purview of government system, the ones in charge of managing it. Open and transparent land administration systems can help to reduce the need for court resolution in instances of dispute by simple, evidence based, administrative dispute resolution processes (Streudler, 2014).

Geographic Information System is essential in urban planning. The fuel driving the engine of growth and sustainable development of any nation is the nation's access to reliable and sufficient geo-information. In most developed countries, over 80 percent of rational and prospective allocation and environmental

management decision is based on quality and accurate information. Achard *et al* (2015) believe that the use of GIS to monitor environmental changes like deforestation and urbanisation saves time and money. They pointed out some benefits of GIS use which includes that environmental change be measured on many scales and regularly. Anastatsio and Bodzin (2006) supports this by asserting that overall GIS is described to be a valuable tool in understanding the environment and making responsible environmental decisions. They concluded by saying that without GIS, the measurement and assessment of forest and land cover would be less accurate and take up much more time. Wilkie & Finn (2016) Remote Sensing and Geographic Information System (GIS) is a powerful tool in the study of changes in Land use and Land cover, as well as terrain analysis. The advantage of GIS over former approaches is in its ability to analyse spatial relationship between land use and forest geographies over an area in a single image capture. It can also be used to assess data Information products such as elevation, slope, and aspect which can quite easily be derived from digital terrain models (DTM). Remotely sensed data facilitates the synoptic analyses of Earth - system function, patterning, and change at local, regional and global scales over time; such data also provide an important link between intensive, localized ecological research, regional, national and international conservation and management of biological diversity.

In geographical terms the 20th century should be seen as the century of urbanization, even if the movement had started earlier in some places it now became a global phenomenon. Urban populations of the world grow almost twice as fast as the general population and approximately half of the population on our planet in 2010 lives in urban areas compared to less than 5 percent in the 1800s. Several factors have led to this development but the main reason is the shift in our society from an agricultural to a service- and market based (Knox et al, 2023). A shift in the urbanization trend during the latter parts of the 20th century could be seen; from being a movement primarily taking place in the developed world it changed to becoming a phenomenon in the developing world. In fact the rate of urban growth in many developing countries is the fastest urban growth ever seen on our planet. In the 1950s, 20 of the world's 30 most populated cities were located in the developed world (Knox et al, 2023); in 2010, 18 of these cities were instead situated in the developing world (Demographia World Urban Areas & Population Projections, 2010). Prognosis show that the urban population is expected to continue to grow all over the world and is predicted to almost double from 2010 till the year 2050 when 64 billion people are estimated to live in urban areas, an increase that almost entirely will take place in the developing world (World Urbanization Prospects, 2017).

Statement of the Problem

The roots of under development of third world countries, such as Nigeria emanated from a number of factors which include poor quality data collection, organization, and management practices; and, lack of adequate knowledge to develop the area and manage the environment in a sustainable manner. The consequences of all these are obvious from air and water pollution, environmental degradation, diseases and death. These are the challenges of land information and data management in Nigeria. As a result of the aforementioned problems the researcher intends to explore on Geographic Information System (GIS) as it relates to land information system and its effect on land administration.

With this rapid expansion, manual recordkeeping became inefficient, time-consuming and prone to abuses. Several unsuccessful attempts were made in the past to solve the problems. The attempt failed because of the gross under estimation of the gravity of the problems and the ill-defined scope of the project. The primary reason that has hindered the computerization of the Cadastral and Land Registry records in the past is lack of a strong political will on the part of the authority.

Effective land information management not only provides the necessary information on the land title and records for the use of the stakeholders but also does that with dispatch. The current systems and practices of land administration in the states of the federation and Federal Ministry of Works, Land and Housing are mainly analogue systems. The systems are fraught with bureaucratic bottle-necks and human-engendered hiccups that inhibit timely completion of land title perfection. The systems are frustrating and seriously put off prospective investors; they invariably militate against national economic development. Though some states and the Federal Ministry of Works, Land and Housing have ventured into computerizing their cadastral records, their levels so far very much fall below what a good land information management system should provide to the stakeholders.

Ifeanyichukwu et al (2022). noted with dismay that despite the benefits of computerization of land information, only about 20% of the states in Nigeria have commenced the application of ICT in their land administration system. The need to leverage and

improve on the land information management system cannot be overemphasized especially in the contemporary age of information and communication technology (ICT) driven global economy. Computerizing land administration can ensure speedy processing of first registration of title, prevention of unnecessary duplications, and facilitation of access to land-related data as well as in-built quality control measures, among others. Securing land title in Nigeria today is still shrouded in secrecy; prospective investors outside the country can hardly contemplate investing in Nigerian real estate due to this obvious predicament. Access to land information is still very difficult and the government is invariably losing enormous revenue from the sector. The few states that have ventured into computerization of their land information system only automated a fraction of the entire sector which still makes them face challenges of delays and hiccups in processing and perfecting land titles (Zevenbergen and Ploeger, 2019). There is therefore a dire need in today's Nigeria to reduce the time it takes to process land titles and their documentation. The Ministry of Lands and Urban Development in most states comprises different departments which complement each other in the discharge of their core functions to the public. Improvement in their working relationships is imperative for better service delivery. But before such improvement is considered, review of present processes is very necessary. Such a review will identify the existing gaps and likely areas that require improvement. This work seeks to assess the GIS based land information system for efficient land administration in Abuja.

Research Questions

This research work seeks to address the following questions:-

i. What are the existing land tenure systems?
ii. What are land information system?
iii. What are the procedures for land registration and documentations?

Objectives of a Study

The objectives of this research work are; to

i. identify and examine the existing land tenure systems;
ii. evaluate land information systems; and
iii. examine the procedures for land registration and documentations.

II. RELATED WORK

Conceptual Framework

Improvements in the study of Cadastral Information System have been witnessed over time. In some countries some projects have been undertaken to extend the conventional system to cover new issues such as: Automation of administrative tasks. Development of applications for managing the cadastral registers. Development of analytical tools for setting up digital cadastral maps and plans. Automation of land management for consolidation. Implementation of land information system.

According to Elayachin and El-hassane (2015) the design and implementation of a digital cadastral system which require an approach that enables the integration of cadastral operations with GIS packages and a tool that should be of use in a multipurpose system can be achieved through three levels. In the first level, the existing cadastral applications must be understood and all projects conducted for modernizing cadastral system should be analyzed; In the second level, it is necessary to outline different methods for linking cadastral data models to GIS software, where the existing methods, their strengths and weaknesses are discussed; The third level is concerned with the manner by which the conceived system is implemented.

Buragohain, et al (2012) developed a land information system using integrated remote sensing and GIS Technology for Guwahati city, India, in order to come up with an advanced database management system (DBMS) for the city. The methodology adopted in the study was the map of Guwahati city and its surrounding areas were digitized. The industrial data comprised of the characteristics of the draining network, road and railway network as well as infrastructure facilities in the city.

Also, satellite data are processed and classified using supervised classification method to prepare the land use land cover map. The spatial and temporal changes in growth pattern are recognized from the digital data. At the end, plot- wise urban land use map was prepared and attributes were assigned for every plot with full ownership information. The result of the research was ended by developing a decision support system created to supply information regarding every plot and its attributes. A database was converted into a web supported format and, customized to provide query facilities for immediate and ready extraction of information through the web.

In 1925 Turkey's cadastral system was formed by the state with several legal and organizational modifications. These modifications have resulted in a lack of standardization and inconsistency in the geometric aspect of the cadastral data, such as the cadastral maps without a co-ordinate system or

indifferent coordinate system. The problem arising from data standardization, data quality, data inconsistency, digital archiving and the slowness in cadastral services forced Turkey to reform its cadastral system to a computerbased cadastral information system. In the study, the requirements of a cadastral database were analyzed and a spatiotemporal database was designed and developed to fulfill the requirement for spatial, temporal database and spatiotemporal queries for cadastral data. The Spatiotemporal uses Entity- Relationship (STEP) model in combination with the Enhanced Entity Relationship (EER) model. Oracle 8i spatial was chosen because it provides spatial data handling capability. The result of the study was a creation of database tables defined in logical schema using Oracle 8i spatial, where the cadastral and land registry data of the study area were loaded into the database tables created. Oracle 8i does not provide graphic edit and display function for spatial data, map info 6.0 GIS software was used to retrieve, display, manipulate and analyze the cadastral data. Tella and Rably (2021) was a study that merged the old cadastral records with the new cadastral records, creating a robust cadastral database named VMDS. The VMDS contained both the geo-referenced spacial data and the attribute data. Reghavendran (2022) described how an automated cadastral mapping and land information system could be created. He outlined two main issues of concern for setting up a cadastral information system, i.e, Spatial component/survey data describing the spatial disposition of the parcels in the real world cadastral maps and Non-spatial component describing details such as ownership, tax value, e.tc. He uses spatial database (SDE) for the spatial components and micro station geographic for the non-spatial data. For customized query and reported generation, the database was put in Oracle format. At the end, analysis with the new CIS was unlimited, though it depended on the data that has been put as well as the user requirement.

In his work, "Cadastral Land Information System for Sustainable Land Conveyance in Bauchi state", Shuaibu (2008) used the existing analogue map which he converted to digital format using a digitizing tablet in ILWIS environment. An automated attribute database for the spatial database was created in an Arc view environment which was subjected to query and analysis. He was able to show land covered by certificate of occupancy, number of plots for residential, recreational and commercial purposes in the digital map he produced. In 1996 the government of New Zealand instructed the land information Zealand (LINZ) to develop a proposal to automate the nation's survey and tittles system; to integrate all survey and title processes; to digitize them and reduce the cost of both provision and compliance; to utilize technological development; and to meet the growing community demand for improved quality of cadastral works (Bevin, 2019). The establishment of Abuja Geographic Information System (AGIS) in the Nigeria Capital city has changed the general approach to land administration in the city. The analogue cadastre was converted to digital format and accordingly, new certificate of occupancy were issued out to former holders of land titles within the capital territory. Prior to the creation of AGIS land transactions in the city was characterized by duplication of titles, delay in searches and land conveyance not properly registered.

Land Administration

Despite the lack of official recognition for customary land administration in Nigeria's Land Use Act of 1978 (LUA) and the Constitution of the Federal Republic of Nigeria, 1999 (hereafter called the Nigerian Constitution), customary land administration systems (LAS) is resilient in Nigeria. In urban areas, the LUA provides an adequate basis for land administration (Babalola and Hull, 2019a; 2019b), but this does not extend to the rural and peri-urban areas (Babalola and Hull, 2019a). Rural and peri-urban dwellers occupy and use land according to African customary law (which includes customs that are certain, reasonable, observed, and have existed for a long time) (Ndulo, 2011).

These communities depend on traditional authorities to access land. Customary law is not recognised in the Constitution and hence occupies an informal space from a legal perspective. Customary and statutory land administration processes and associated institutions in Nigeria operate as a hybrid administration system with little communication or mutual acknowledgement of their roles in society. Effective and efficient LAS with an appropriate legal framework are essential to ensure tenure security (Subedi, 2016; Ghebru and Okumo, 2016; 2017; Otubu, 2018). To achieve this in land reform projects, researchers and practitioners aim to understand the LAS of a country in context using a conceptual framework to guide cadastral system development (Hull and Whittal, 2019). The 3S conceptual framework was developed to ensure the three goals of success, sustainability, and significance are present in developing a cadastral system (ibid.). It is centred on human rights, pro-poor policies, and good governance. These triple components of the framework help guide cadastral system development in terms of customary land rights.

The land administration system (LAS) in Nigeria has evolved over the years. Stakeholders, including

service providers, beneficiaries, and professionals, have different perspectives on the system. Their views of what constitutes an effective and robust LAS, in terms of how it is designed, built, and operated, are fundamental to national development. Choices made over the years have left several gaps in land administration service delivery. This is complicated by the fact that the environment in which land administration is carried out is subject to changes in the social, cultural, political, legal, and economic systems that influence how government and stakeholders perceive land administration service delivery. The institutions charged with land administration in Nigeria face a range of challenges and constraints that hamper the effective delivery of land administration services to citizens. These challenges include, but are not limited to, hierarchical and outdated organizational structures, bureaucratic processes, and high costs and fees for service. Taken together, these constraints ensure that only a small percentage of the population is engaged with the formal land sector that is supported by LAS. Because of the bureaucratic nature and cost of the current land registration, only 3 percent of land in Nigeria has formal property title. The long and expensive land registration process damages the business environment and disproportionately affects women and low-income groups. This creates major roadblocks to the country's economic development. The failure to register property ownership also has consequences for governance, growth, and development. For example, lack of proper title makes it difficult for people to use their land as collateral, which in turn reduces their access to finance. The lack of a coherent system for recording land ownership leaves the government be it federal, state, or local with little knowledge about who owns what, in which area, or how the land is used. The Land Use Act of 1978, which was an attempt to unify the operational land laws in Nigeria and validate citizens' property rights through the issuance of statutory or customary certificates of occupancy, has been subject to different interpretations in different states primarily because it did not repeal the existing land laws. Several studies, including by the World Bank, rank Nigeria as the most difficult and expensive country in the world in terms of registering property.

Many of the challenges arising from the poor state of land administration in Nigeria are a result of poor interpretation and implementation of the Land Use Act (LUA) 1978. Landowners and occupiers are left vulnerable to the claims of third parties, who may succeed in obtaining statutory or even customary right of occupancy over the land. This study investigates land administration service delivery in Nigeria. The paper identifies opportunities for reform and ways to efficiently provide reliable land administration services and, thereby, develop a sustainable LAS in Nigeria that will benefit citizens, business, and government. In an effort to fashion a robust land reform policy for the country, the Presidential Technical Committee for Land Reforms (PTCLR) was inaugurated on April 2, 2009. This committee has the following terms of reference: to help reform the Land Use Decree of 1978; to collaborate and provide technical assistance to states and local governments to undertake land registration nationwide; to determine individuals' "possessory" rights using best practices and the most appropriate technology for identification of locations and registration of title holdings; to ensure that land cadastral boundaries and title holdings are demarcated in such a way that communities, hamlet villages, village areas, towns, and so on are recognizable; to encourage and assist states and local governments to establish an arbitration mechanism for land ownership conflict resolution; to make recommendations for the establishment of a National Depository for Land Title Holdings and Records in all states of the country and the Federal Capital Territory (FCT, Abuja); to make recommendations for the establishment of a mechanism for land valuation in both urban and rural areas in all parts of the Federation; and to make any other recommendations that will ensure effective, simplified, sustained, and successful land administration in Nigeria.

Following implementation of a systematic land titling and registration pilot program in Ondo and Kano states and given the contextual differences (due to religion, culture, tradition and social contexts) in implementation of land management policies amongst states across the nation (Otubu, 2018), the PTCLR commissioned a study to collect evidence from 12 states (two states in each of the six geopolitical zones), plus the FCT, on how land is administered by the federal and state governments. For this purpose, interviews were conducted with key stakeholders in the Federal Ministry of Lands, Housing and Urban Development and other appropriate ministries and agencies. The study states were selected so as to gain a broader perspective on the procedures for public engagement; land valuation and taxation procedures; manners of dispute resolution; systems for recording land rights, rights-holders and parcels; and procedures to governing land transactions, including sales, mortgage, leases, and disposition.

A strategic review of the status of land administration and land administration service delivery was undertaken, followed by a more detailed examination of land administration practices, procedures, and service delivery at state and local government levels.

Overall, this study commissioned by PTCLR was designed to assess: the roles and responsibilities for land administration in Nigeria at federal, state, and local government levels under the existing policy and legal framework; the extent that real practice on the ground differs from what is called for by the law; the financing and revenue generation of the sector, including investigating current fees and taxes levied on land and land transactions; documentation of the major land administration processes (that is, a clear understanding of generic processes, rather than detailed documentation of processes as applied in the various jurisdictions) and options where these processes might be streamlined; existing land administration technology and administration systems and determination of the point of entry to develop a unified national platform and standards for land administration; current practice by all levels of government in relation to large-scale land acquisitions (potential or actual investments in agriculture or the housing sector, for example); and the institutional architecture available to provide education and training in the land sector and proposals to strengthen or support these institutions in building capacity to support the strengthened national program.

The Concept of Geographic Information System (GIS) GIS IS an acronym for Geographic information Systems, it refers to existing computer system that captures, records, stores and analyses information about features on earth's surface (James, 2014). It is also characterized by procuring information relating to features and there locations on earth surface such as highway, monitors events as they happen, retrieval and display of special data, as well as, mapping. GIS relies heavily on remote sensing which involves aerial sensor technologies that detects and classify objects on earth by means of propagated signal from either aircraft or satellite or both (Ahmed & Salihu, 2013). It also involves geographic profiling where locations are digitally entered by address, analysed with patented algorithm that produces a probability surface showing likelihood address of targets (Rossmo, K. 2018). GIS emerged with the rise of automated computer technological revolution and has so far proved to be very effective in solving many complex social, economic and political problems of mankind. Already, it has resolved many crime issues in the advanced world (Radoff, D. 2023).

Nowadays, the Geographic Information System (GIS) technology has become more popular and is now widely used in earth sciences and environmental. It is a huge and rapidly growing industry and market all over the world, with huge demand for knowledge, experience, information, data, and GIS software products. Project managers, environmental scientists, legislators, activists, and the public are curious about what is the technology of the GIS, and how it can help them with cases or projects. Professionals of GIS are interested in learning of basics of earth sciences and environmental to apply GIS technology in these sciences and other related disciplines. The main difficulties that we face in the world now pollution, overpopulation, deforestation, natural hazards, all have a decisive geographic dimension. also, the problems locale, have a geographic ingredient that can be expressed using the technology of geographic information systems, whether getting on the best soil for crops growing, determining the range of home for imperiled species, or exploring the reliable system to dispose of dangerous waste. On the other hand, determine the best location for schools, choose the best way, and know the extent of disease. The precise analysis of spatial data by geographic information systems can provide insight into these difficulties and propose methods in which they can be treated (Kabiru, 2021).

Geographic information systems are considered the most accurate and exciting technology. Geographic information systems are a special type of information system in which the data source is a database of spatially feature and procedures to collect, store, retrieve, analyze, and display geographic data. Also, geographic information systems are a group of software, hardware, and processes that are used for collecting, storing, and analyzing geographically referenced data. Then, this data will be presented through the geographic information systems system. Another definition for geographic information systems, that it is a tool used for saving, regaining, and offering together non-spatial and spatial data in a rapid, proficient, and organized manner. In other terms, geographic information systems are defined as a data-base system kind, a computer-supported cartographic application, and mapping, a comprehensive tool for spatial analysis (Jebur, 2022). The data acquired through the GIS is then utilized to represent different issues. An additional definition of a geographic information system is a program used for presenting, interpreting, and preparing the results that relate to the surface of the earth. This program will maintain the process, analysis, making, and display of the maps. Making of the maps and geographical analysis is not new, but geographic information systems work these tasks properly and quicker than do the conventional methods. And, before using geographic information systems (GIS), only some persons had the skills to use geographic information to help for decision making and solving problems.

Nowadays, geographic information systems are employing hundreds of thousands of people globally, geographic information systems are learned in high schools, colleges, and universities everywhere of the globe, hence considered as a multi-billion-dollar industry. The principal aim of this research is to review the researches that have examined the applications and uses of Geographical Information Systems (GIS) in many different fields such as, determining the best location for schools, choose the best way, know the extent of disease, distribution of the schools, and the hospitals, furthermore other services (Ahmed, 2019).

Applications of Geographic Information Systems
Overlay of Layers
Geographic information systems can use to joining the layers that available for any area, to create an overlay that can be used and analyzed using the same system. Such overlays and their analysis entirely and process of the decision-making that involves, among others: Selection of sites, Make of simulation to environmental impacts such as creating a view of the perspective of the terrain, Planning of response emergency, such as link the network of the roads and information of earth science to explain the effects of a possible earthquake (Kabiru, 2022).

Geographic information systems can manage land information via the enabling of data generation and preservation of these data for records, planning, and use of land. Geographic information systems make input, retrieval, and updates, of data such as records of tax, land-use plan, and zoning codes more accessible than the paper-map era. The typical uses of geographic information systems in the management of land information, involve register of land managing, registering the titles to land holdings, creating a plan of land-use and cadastral mapping (as shown in the figure below) and zoning maps, etc. It also involves political and administrative boundaries, the cover of soil, and transportation (Jebur, 2021)

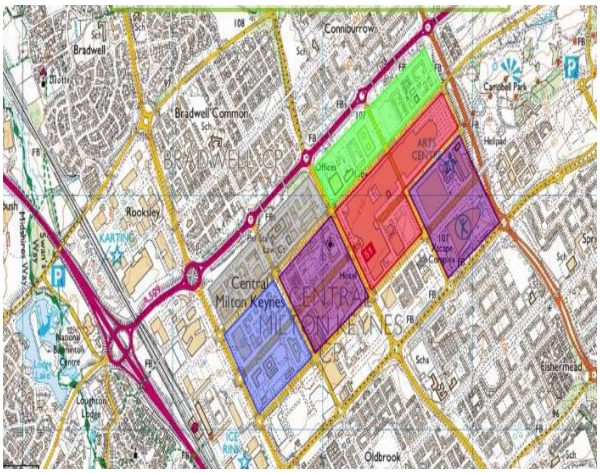

Fig. 1: A plan of land-use and cadastral mapping
Source: Abuja Geographic Information System (AGIS, 2024).

Technologies of geographic information systems are widely used for the planning and management of public services (as shown in the figure below). The typical uses of geographic information systems involve the management of the following utilities: gas, electric, water, telecommunication, roads, sewering network (as shown in the figure below), facilities of TV/FM, analysis of hazards, dispatch, and services emergency. Typical data that input involves a street network, demographic data topographic data, and boundary of the local government (Jebur, 2021).

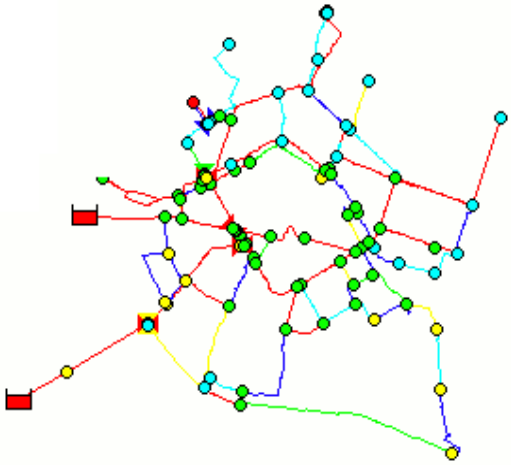

Fig. 2: A plan of sewering network.

Source: Abuja Geographic Information System (AGIS, 2024).

The geographic information systems have the ability for applying a variety of applications of the environmental field that extend from the simple query, inventory, analysis of map and overlay, to decision-

making systems that be complex. Include such as modeling of the forest, monitoring, air/water quality modeling, mapping of the environmental zones, analysis of the interaction economic, change geological & hydrological, and meteorological. The data environmental that must be input into geographic information systems involve elevation, the cover of the forest, hydrogeology coverage, and soil quality (Jebur, 2021).

Archaeology has used geographic information systems in a variety of ways as a spatial system, where, use the applications of geographic information systems as database management for records archaeological, with the added advantage of being handy to design instant maps in the simplest level, It has been performed in the management of cultural contexts, where sites of archaeological are foretold using statistical models based on-site locations that previously identified. Also, it has been used as a tool in intra-site analysis and to simulate changes in past landscapes (as shown in the figure below) (Ahmed, 2019).

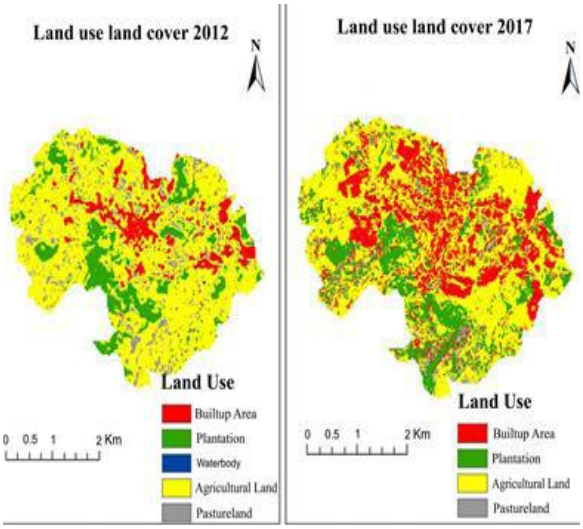

Fig. 3: Changes in past landscapes for five years

Source: Abuja Geographic Information System (AGIS, 2024).

The geographic information systems can study areas exposed to floods (as shown in the figure below), earthquakes, storms, cyclones, fire, drought, volcano, soil erosion, and landslides, therefore, it can accurately predict future accidents.

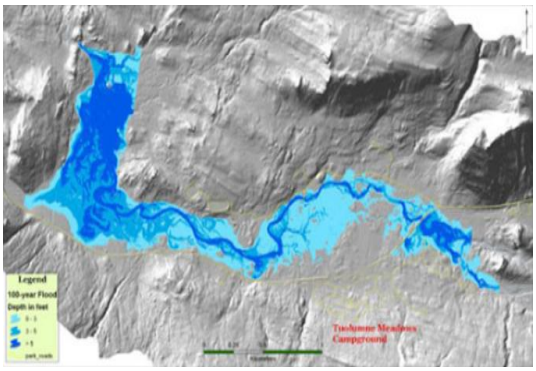

Fig. 4: Areas exposed to floods

Source: National Emergency Management Agency (NEMA, 2024).

Geographic information systems offer a practically unique ability to combined geographical data and analyze them, which further enhances and develops the intelligence base for operations of defense.

Geographic information systems enable the study of the change of sea-level (as shown in the figure below), the temperature of the sea surface, marine population, and coral reef ecosystem.

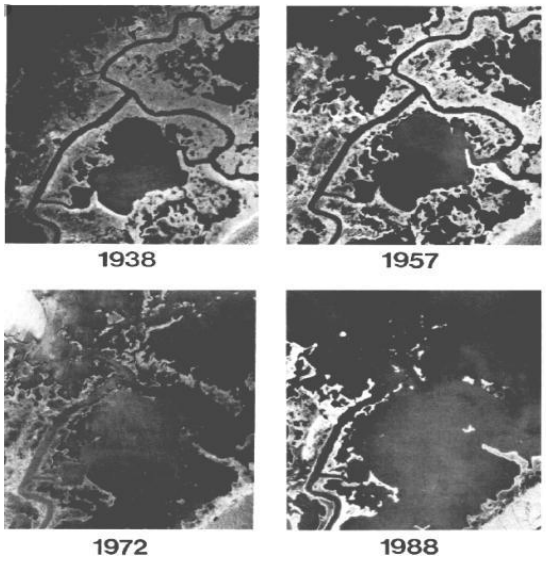

Fig. 5: Sea-level for deference years

Source: Global Sea Level Change Map (1938-1988).

Geographic information systems enable the spatial representation of resources of groundwater, quality of waste, management of the watershed, water pollution, and surface water management (Jebur, 2021).

The use of geographic information systems and GPS in the production of agriculture. Exactness agriculture

is a catch-all expression that describes using technologies of geographic information systems and GPS to manage specific field areas. Technologies of exactness agriculture use information from various sources to aid farmers in decisions making about crop production and management based on the variability of the potential of production inside fields.

III. THEORY/CALCULATION

Modernization theory

This theory means that urbanization in the developing world is taking place because these countries are now starting their industrialization with innovations and economic development that will start and spread from urban centers (Pacione, 2015). Modernization theory emphasizes economic development and growth. GIS can facilitate development by providing spatial analysis, mapping, and planning tools for infrastructure development, resource allocation, and urban planning. Modernization theory focuses on social and economic progress. GIS can help track progress by analyzing spatial data on health, education, poverty, and other socio-economic indicators. Modernization theory highlights technological advancements as drivers of progress. GIS represents a significant technological advancement in spatial data analysis and visualization. Modernization theory emphasizes efficient resource allocation. GIS enables spatial planning and management, optimizing resource utilization and decision-making. Modernization theory advocates for data-driven decision-making. GIS provides a platform for analyzing and visualizing spatial data, informing evidence-based decisions. Applications of Modernization in GIS, Urban Planning and Development: GIS aids in designing efficient urban infrastructure, transportation systems, and public services. Resource Management: GIS helps optimize resource allocation, monitoring, and management in sectors like agriculture, water, and energy. Disaster Management: GIS enables emergency response planning, risk assessment, and damage evaluation. Environmental Sustainability: GIS supports environmental monitoring, conservation, and sustainable development initiatives. Economic Development: GIS facilitates business location analysis, market research, and investment planning.

4. Experimental Method/Procedure/Design

Study Area Location and Size

Abuja is the Federal Capital Territory of Nigeria. Abuja (FCT) which covers a total land area approximately 7,315 sq. km. As at now, the Federal Capital City (FCC) is planned to cover an area of about 250 km sq, while the rest of the Territory of the city region covers about 7,065 sq kms (AGIS, 2024). It is located between latitudes 8° 50’ and 9°10' N; and between longitudes 7° 15' -- 7° 32' E. FCC is a planned city, and it is the heart of the FCT as it was built in the 1980s and officially became Nigeria's capital on 12 December 1991, replacing the role of the previous capital Lagos (Wikipedia, 2018). Federal Capital Territory (FCT) was carved out of then, states of Niger, Plateau, and Kwara. The F.C.T (Abuja) is almost predominantly underlain by high grade metamorphism and igneous rocks of Precambrian age generally trending NN-E-SSW, these rocks consists of gneiss, migmatites, granites and schist belt outcrops along the eastern margin of the area. The lowest elevation in the Federal Capital Territory (Abuja) is found in the extreme southwest where the flood plain of the river Guraja is at an elevation of about 10m above sea level from there, the land rises irregularly eastward, northwards and north westwards. The highest part of the territory is in the northeast where there are many peaks over 760m above sea level. Land Administration in Abuja includes processes of land registration, cadastre, valuation and land inventory (AGIS, 2024). Traditional approaches to land administration result in design and implementation projects that take a long time. However, the introduction of innovative technology such as GIS has been playing a leading role. The Abuja Geographic Information Systems offers a very challenging and unique opportunity to reverse the unused and untapped opportunities in Nigeria.

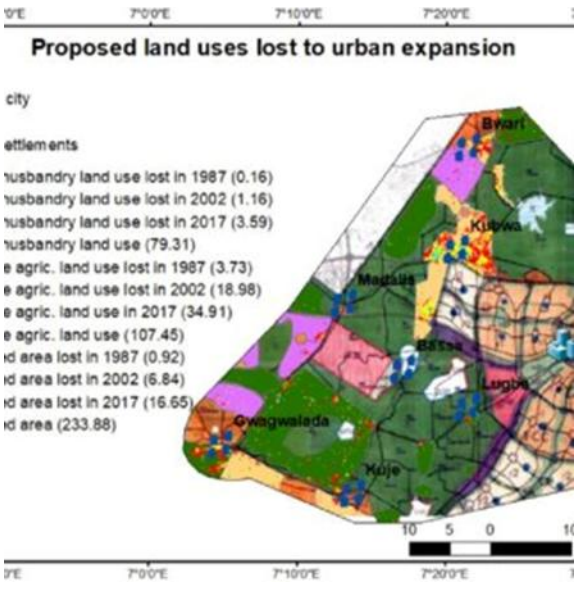

Fig. 6: Map of the Study Area

Source: Abuja Geographic Information System (AGIS, 2024).

Climate and Rainfall

Abuja experiences three season from April to October: a hot and rainy season from April to October; a dry season from October to April and a brief windy season in between known as the Harmattan season i.e. when the dusty and dry West African trade wind blows through the city, coupled with intense cold. During the rainy season average daytime temperature reach around 86F (300C) while nights are relatively warm. In the dry season, daytime temperature in Abuja can soar as high as 104F (400C) and evening can be chilly with temperatures dropping as low as 54F (120C). Abuja under Koppen classification features a tropical wet and dry climate (Koppen: Aw) (tripreport.com, 2024). During the rainy season, temperature drop considerably due to dense cloud cover. The annual range also drops to around 200C, especially between July and August. The F.C.T records a relative humidity in the dry seasons of some 20% in the afternoon at higher elevations and at more northern locations but also 30% in the extreme south.

Soil and Vegetation

The region is underlain by crystalline rocks consisting of granites and gneisses. The vegetation is mainly savanna with limited forest (Pop, 2016). The soils of the territory (Abuja) are generally shallow and sandy in November, especially on the major plains such as iku-Gurara, Roboes and Roubochi. The high sand content makes the soils to be highly erodible. The shallow depth is a reflection of the presence of strong lower horizons. Those on the famous Gwagwa plains are however deep and clayey, perhaps reflecting the influence of parent materials gabbro and fine to medium textured biotite granite. Thus, the soils rich of the Gwagwa plains are the most fertile and productive. In addition, their being more or less from all exposed interfluves summits, makes them ideal for urban development. The F.C.T (Abuja falls within the guinea savanna vegetation zone of Nigeria. The 2012 estimates the population of the FCC Area Council is 979,876 (NPC, 2012).

Research Design

To make the research easier and more reliable, the researcher decides to employ a descriptive cross-sectional survey design to obtain data (the research used basically primary data based). In this regard the research designed a questionnaire to obtain first-hand data from legal land owners within Abuja and GIS related ministries and agencies.

Types of Data Sources

Both qualitative and quantitative methods were employed to collect the data. This is because; qualitative approach enables the researchers to freely interact with the respondents, and gives them freedom to express their feelings without any predicament. Quantitative method on the other hand makes it clearer in analyzing the data, and it also provide the researcher a standard scale in the data collection.

Data Collection Method

Questionnaire were used in collecting data, and the methodology that was adopted is descriptive cross sectional approaching, using charts, graphs and measures of central tendencies in data analysis.

Population of the Study

The current population of Abuja according to Macrotrend (2024) is estimated to be 3,840,000 (Three Million, Eight Hundred and Fourty Thousand). A sample was drawn from this population, and the instrument was administered mainly on legal land owners and staff of land administration agencies and ministries.

Table 1: Population

Serial Number	Name of Target	Number of Questionnaires Allocated
1	Federal Ministries Associated with GIS and Land administration.	80
2	Legal Land Owners	160
3	Licensed Land Consultants and Agents	60
4	TOTAL	400

Sample Size and Sample Technique

Taro Yemeni's formula is been used to draw the sample. The derivation goes thus:

$N= n/(1+n(e)2)$

Where; N= Sample size, n= population under study, e= margin of error (0.05).

Therefore:

N= 3,840,000/(1+3,840,000(0.05)2)

= 3,840,000/9600.0025

= 399.999998

= 400

Four hundred (400) questionnaires were administered to the respondents and all were retrieved. On this note the researcher decides to distribute the questionnaires as scheduled below:

Serial Number Name of Target Number of Questionnaires Allocated

Federal Ministries Associated with GIS and Land administration. 80

Legal Land Owners 160

Licensed Land Consultants and Agents 60

TOTAL 400

Method of Data Processing
The data will be process by the use of structured design questionnaire which was administered to the respondents in the study area to solicit relevant/useful information in relation to the research topic from various stakeholders and sources.

Method of Data Analysis
Data collected was analyzed using descriptive statistics. These best suits non-experimental survey research.

IV. RESULTS AND DISCUSSION

The Existing Land Tenure Systems

Table 2: Responses on the Existing Land Tenure Systems

S/N	Statement	Percentage (%)
1	Existing land tenure systems are well-defined and easy to understand	22
2	Current land tenure systems ensure equal access to land for all	16
3	Traditional land tenure systems are more effective than statutory systems	22
4	Government provides adequate support for land tenure systems	16
5	Existing land tenure systems protect vulnerable groups (women and youths)	24

Source: Author's Survey (2024)

The study identifies and examines the existing land tenure systems and significant impact in GIS as reflected in the responses from individuals involved in land tenure system. The results shows that there is a strong relationship between the existing land tenure systems geographic information system with 22% shows that the existing land tenure systems in this region are well-defined and easy to understand. The results indicate that 16% shows the current land tenure systems ensure equal access to land for all. Furthermore, 22% revealed that, traditional land tenure systems are more effective than statutory systems in managing land disputes, 16% states that government has provided adequate support for implementing land tenure systems whereas 24% pointed out that, the existing land tenure systems protect the rights of vulnerable groups (e.g., women and youths).

This finding aligns with existing literature of Adeniyi (2023) who pointed out that informed communities with the knowledge on the existing land tenure system, means of acquiring it for both women and youths all have equal rights to ensure equally access to land for all.

Fig. 7: The Existing Land Tenure Systems
Source: Author's Survey (2024)

Land Information Systems

Table 3: Responses on Land Information Systems

S/N	Statement	Percentage (%)
1	Land information systems contribute to efficient land management	75
2	Land information systems are reliable and up-to-date	40
3	Land information systems are easily accessible to stakeholders	45
4	Land information systems have reduced land disputes	50
5	Training programs on land information systems are adequate and effective	60

Source: Author's Survey (2024)

The results indicate a positive trend in the effectiveness and reliability of land information systems in the region. A significant majority of respondents (75%) agree that land information systems contribute significantly to efficient land management, highlighting the crucial role these systems play in streamlining land administration.

Furthermore, the results show that land information systems are reliable and up-to-date (40%), easily accessible to all stakeholders (45%), and have reduced cases of land disputes (50%). These findings suggest that the land information systems in place are having a positive impact on land administration, making it more efficient, transparent, and accountable. However, it is worth noting that while a majority of respondents (60%) believe that training programs on land information systems are adequate and effective, there is still room for improvement. This suggests that ongoing training and capacity-building programs are necessary to ensure that stakeholders are equipped to effectively utilize these systems.

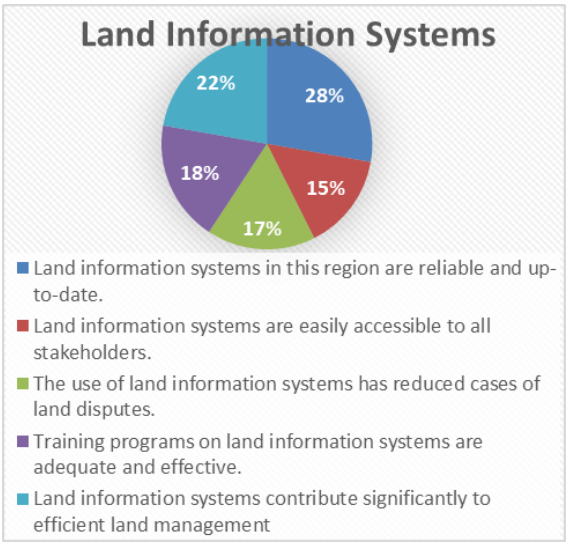

Fig. 8: Land Information Systems

Source: Author's Survey (2024)

The Procedures for Land Registration and Documentation

Table 4: Responses on Procedures for Land Registration and Documentation

S/N	Statement	Percentage (%)
1	Procedures for land registration are clear and straightforward	55
2	Corruption is a major challenge in land registration and documentation	61
3	Land registration procedures are affordable to the average citizen	52
4	Digitization has improved efficiency of land registration	50
5	Government agencies provide adequate support during documentation	40

Source: Author's Survey (2024)

The results provide insights into the land registration and documentation processes in the region. While a majority of respondents (55%) agree that the procedures for land registration are clear and straightforward, indicating a well-structured system, there are still some challenges that need to be addressed. One of the significant challenges is corruption, which 61% of respondents identified as a major obstacle in land registration and documentation processes. This suggests that despite efforts to streamline the process, corrupt practices continue to undermine the integrity of the system.

Another challenge is the affordability of land registration processes. While 52% of respondents believe that the processes are affordable for the average citizen, this still leaves a significant proportion of respondents who find the costs prohibitive. This highlights the need for measures to make land registration more accessible and affordable for all. Furthermore, on a positive note, the results indicate that digitization has improved the efficiency of land registration and documentation (50%). This suggests that efforts to modernize the system are yielding positive results. However, there is still room for improvement in terms of support provided by government agencies during land documentation processes. Only 40% of respondents believe that government agencies provide adequate support, indicating a need for increased capacity building and support mechanisms.

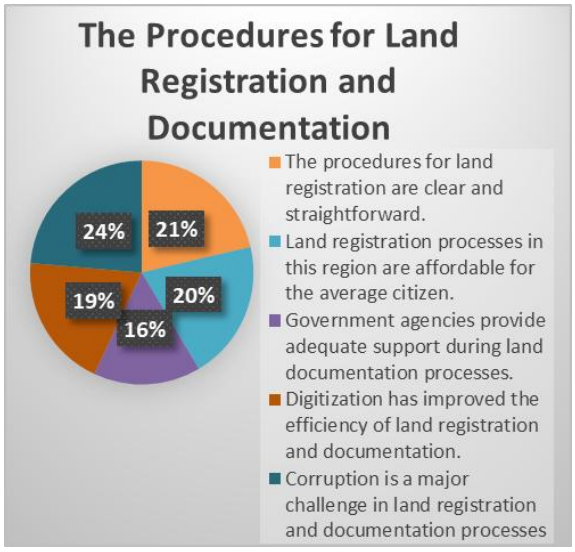

Fig. 9: The Procedures for Land Registration and Documentation
Source: Author's Survey (2024).

V. CONCLUSION AND FUTURE SCOPE

Conclusion

It is concluded based on the findings that the existing land tenure systems as well-defined and relatively easy to understand. However, it is suggested that a substantial proportion of the population still finds the systems complex or unclear. Equal access to land under the current land tenure arrangements appears to be another area of concern. While some respondents acknowledge progress, the substantial number of undecided and negative responses indicates persisting inequalities and challenges in implementation. Traditional systems were highlighted as more effective than statutory systems in resolving disputes, suggesting that customary practices continue to play a crucial role in land management in the region.

Lastly, government support for land tenure systems and protection of vulnerable groups were recognized by some respondents, but the overall responses

suggest that these areas require improvement. The undecided responses highlight a lack of awareness or inconsistent experiences with government interventions. A concerted effort to address these gaps, including enhancing public engagement and support mechanisms, is critical for improving the effectiveness of the land tenure systems.

Recommendations

Based on the proceeding research work the following recommendations are therefore made:

Enhance Public Awareness and Simplify Procedures: Organize regular community sensitization campaigns to educate stakeholders on the clarity and benefits of land tenure systems. Simplify the registration procedures further to accommodate diverse literacy levels and encourage broader participation.

Improve Accessibility and Reliability of LIS: Invest in upgrading LIS infrastructure to enhance reliability and stakeholder accessibility. Expand training programs tailored to diverse user groups to build capacity and increase system usage, while addressing the technical and financial barriers identified.

Tackle Corruption and Promote Affordable Processes: Implement robust anti-corruption measures within land management agencies, including transparent fee structures and accountability mechanisms. Subsidize land registration fees for vulnerable groups to improve affordability and equitable access to land registration services.

Contribution to Knowledge

This study contributes to the understanding of how well-defined land tenure systems are perceived by stakeholders. With 55% of respondents agreeing that these systems are clear and accessible, the research highlights the relative success of existing frameworks while also identifying a notable gap for improvement as evidenced by 25% who find them complicated.

The findings provide valuable insights into the effectiveness of traditional land tenure systems in managing disputes. A significant portion of respondents believes traditional systems outperform statutory ones, suggesting the need to integrate customary practices into formal land management frameworks. The study underscores the inadequacy of current land tenure systems in ensuring equal access and protecting the rights of vulnerable groups. The feedback suggests areas for policy development and the need to focus on inclusivity, particularly for women and youth.

This research reveals a critical gap in institutional support for implementing land tenure systems. This information can guide future initiatives to strengthen governmental roles in land administration. The significant proportion of undecided respondents indicates a lack of awareness or understanding of land tenure processes. This points to the necessity of educational programs and public sensitization campaigns to enhance stakeholder engagement.

Suggestions for Further Studies

Based on the proceeding research work, the following were suggested as for further studies:

Further research should be focus on a comparative analysis of traditional and statutory land tenure systems, exploring their strengths, weaknesses, and potential synergies. Studies could also examine the cultural, legal, and socio-economic contexts that influence the effectiveness of these systems, particularly in dispute resolution and equitable access to land.

Investigating the role of government support in the implementation and enhancement of land tenure systems would provide insights into gaps in policy and practice. This research could assess the adequacy of resources, education programs, and infrastructure provided by the government to ensure that land tenure systems protect the rights of all stakeholders, especially vulnerable groups such as women and youth.

Future studies could explore the levels of public awareness and understanding of existing land tenure systems, identifying barriers to knowledge dissemination. Additionally, research on how to improve accessibility both in terms of physical processes and comprehensibility could offer practical solutions to address the challenges faced by undecided or dissatisfied stakeholders.

Author’s statements - Disclosures

Acknowledgements- We gives thanks and praise to God for His guidance. Our heartfelt appreciation goes to our families for their unwavering support, as well as the staff of the Faculty of Environmental Science, Nasarawa State University, Keffi, Nasarawa State - Nigeria, for their encouragement throughout the course of our study.

Funding Source- No external funding was received for this study.

Authors' Contributions- All authors contributed equally to the completion of this research paper. Each author reviewed and approved the final version of the manuscript.

Conflict of Interest- This manuscript is not under consideration for publication elsewhere and has not been previously disseminated. There are no conflicts of interest to disclose.

Data Availability- Questionnaire were used in collecting data, and the methodology that was adopted is descriptive cross sectional approaching, using charts, graphs and measures of central tendencies in data analysis.

REFERENCES

[1] Adeniyi, P. (2023). "*Improving land sector governance in Nigeria-Implementation of the land governance assessment framework".* Synthesis Report, Lagos, Nigeria. http://siteresources.worldbank.org/INTLGA/Resources/LGAF_Nigeria_Final_Report-November2011.pdf .

[2] Agili, F., Bartolomei, A., (2014). *Coupling traditional methods and new technology contributions to landslide risk assessment in the Arno river basin. In W.A. Lacerda, M. Ehrlich, S.A.B. Fontoura, and A.S.F. Sayao (eds.), Landslides*: evaluation and stabilization. Balkema, Taylor & Francis Group, London, 151–155.

[3] Ahmed Kareem Jebur., Saudi J Civ Eng, Mar, (2021); Agent-based modeling for community resource management: Acequia-based agriculture. *Computers Environment and Urban Systems*, 36(6): 562- 572.

[4] Aiello, V., Barile, A., Silvestri, F., Pescatore, T.S., Pinto, F., (2018). *An application of a GIS based methodology for the seismic zonation of slope stability.* In W.A. Lacerda, M. Ehrlich, S.A.B. Fontoura, and A.S.F. Sayao (eds.), Landslides: evaluation and stabilization. Balkema, Taylor & Francis Group, London, 327–335

[5] Aliyu, Y. A. S., & Youngu, T. T. (2012). Application of Geospatial Information System to Assess the Effectiveness of the Mdg Target in Amac Metropolis-Abuja, Nigeria. *Research Journal of Environ and Earth Sci*. 4(3): 248-254.

[6] Al-Jubouri. & Diboun, H. A. (2005). *Spatial analysis of educational services in the city of Diwaniyah, a study in the geography of cities.* A master's thesis College of Arts - University of Qadisiyah.

[7] Al-Rasheed, K., & El-Gamily, H. I. (2013). *GIS as an efficient tool to manage educational services and infrastructure in Kuwait.* Star Publishers, Lebanon.

[8] Andrews, B., Gares, P. A., & Colby, J. D. (2012). Techniques for GIS modeling of coastal dunes. *Geomorphology, 48*(1-3), 289-308.

[9] Anselin, L. (2005). Spatial statistical modeling in a GIS environment. In I. M. B. Davis & J. Maguire (Eds.), *GIS Spatial Analysis and Modeling* (pp. 93-111). New York: ESRI Press.

[10] Balogun, I. A., Adeyewa, D. Z., Balogun, A. A., & Morakinyo, T. E. (2011). Analysis of urban expansion and land use changes in Akure, Nigeria, using remote sensing and geographic information system (GIS) techniques. *Journal of Geography and Regional Planning, 4*(9), 533-541.

[11] Barder, O. (2012). *Development and Complexity. Retrieved 21/05/2022, from Centre for Global Development* http://www.owen.org/wp-content/uploads/Development-and-Complexity-Slides.pdf.

[12] Bevin, A. J. (2017). *Cadastral Reforms in New Zealand.* Proceeding of FIG commission VII AGM, Waitingi, pp99.

[13] Birner, R, K. Davis, J. Pender, E. Nkonya, P. Anandajayasekeram, J. Ekboir, A.N. Mbabu, D.J. Spielman, D. Horna, S. Benin, and M.J. Cohen. (2016). *From Best Practice to Best Fit: A Framework for Analyzing Agricultural Advisory Services Worldwide*. Development Strategy and Governance Division Discussion Paper no. 39. Washington, DC: International Food Policy Research Institute (IFPRI).

[14] Birner, R., and A. Okumo. (2021). *Challenges of Land Governance in Nigeria: Insights from a Case Study in Ondo State*. Nigeria Strategy Support Program (NSSP) Working Paper 22. Abuja: International Food Policy Research Institute.

[15] Booth, R., & Rogers, J. (2001). Using GIS technology to manage infrastructure capital

assets. *Journal-American Water Works Association,* 93(11), 62-68.

[16] Dale, P. and Mclaughlin, J. D. (2019). *Land Administration system.* Oxford University Press, London.

[17] Dale, P.F. (2019). "*Cadastral and land administration systems in countries in transition*." Lecture to the Department of Geomatics, University of Melbourne. Accessed August 27, 1999. http://sunspot.sli.unimelb.edu.au/subjects/451/418/lecture10PPT/ppframe.htm

[18] Doeveren, V. 2011. "Rethinking Good Governance," *Public Integrity* 13(4): 301-318.

[19] Douglas, W. (1994). *Environmental GIS Applications to Industrial Facilities* (Vol. 3). CRC Press.

[20] Elayachin, E. and El-hassane, S. (2011). *Digital Cadastral Map: Multipurpose Tool for Sustainable Developments. International Conference on Spatial Information for sustainable development.* Narobi, Kenya.

[21] Enemark, S. 2009. "*Land Administration System, managing rights, restrictions and responsible in land."* Map World Forum, Hyderabad, India, February 10-13, 2009. http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.483.9398&rep=rep1&type=pdf

[22] Fabiyi, Y.L. (2013). *Land Administration in Nigeria: Case studies of the implementation of the Land Use Decree (Act) in Ogun*, Ondo and Oyo state of Nigeria.

[23] Food and Agricultural Organization (2017). "*Good governance in Land tenure and Administration".* FAO Land Tenure Studies No.9. Rome: FAO.

[24] Francis, P. 1984. "For the Use and Common Benefit of All Nigerians': Consequences of the 1978 Land Nationalization." Africa: *Journal of the International African Institute* 54: 3 5-28.

[25] Ghebru, H., H. Edeh, D. Ali, K. Deininger, A. Okumo, and S. Woldeyohannes. 2014. Tenure Security and Demand for Land Tenure Regularization in Nigeria. Nigeria Strategy Support Program (NSSP) Working Paper 25. Abuja: International Food Policy Research Institute.

[26] Greene, R. W. (2002). *Confronting catastrophe: A GIS handbook.* ESRI, Inc..

[27] Hazrin, M., Hiong, H. G., Jai, N., Yeop, N., Hatta, M., Paiwai, F., ... & Othman, W. (2016). Spatial distribution of dengue incidence: A case study in Putrajaya. *Journal of Geographic Information System,* 8(1), 89-97.

[28] Hilhorst, T. 2008. "Local governance institutions for sustainable natural resource management in Mali, Burkina Faso and Niger." KIT Working Paper Series. WPS.G1, Amsterdam, the Netherlands.

[29] Ifeanyichukwu, V.N., Raphael, O. S, and Inipami, P.J. (2022). A Review of Land Information Management Systems. *African Journal of Economics and Sustainable Development, 5(1), 109-125.*

[30] Jebur, A. K., Tayeb, F. A., & Jawad, Z. S. (2018). *Show the Potential of Agisoft Photoscan Software to Create a 3D Model for Salhiyah Residential Complex in Baghdad Based on Aerial Photos.* Bright Publishers, Ibadan.

[31] Kalogianni, E., Oosterom, P., Dimopoulou, E., & Lemmen, C. (2020). 3D land administration: A review and a future vision in the context of the Spatial development lifecycle. *International Journal of Geo-Information*, 9(107): 2-25.

[32] Lanter, D. P. (1991). Design of a lineage-based meta-data base for GIS. Cartography and *Geographic Information Systems*, 18(4), 255-261.

[33] LUA (Land Use Act). 1990. "Land Use Act 1978, chapter 202 laws of the Federation of Nigeria." Abuja: Federal Republic of Nigeria. http://www.nigeria-law.org/Land%20Use%20Act.htm

[34] Lusthaus, C., M.H Adrien, G. Anderson, F. Carden, and G.P. Montalvan. 2022. "Organizational Assessment – A framework for Improving Performance." Ottawa. http://www.idrc.ca/en/ev-23987 - 201-1-DO_TOPIC.html: The International Development Research Center (IDRC).

[35] Makino, Y., & Watanabe, S. (2002). *The application of GIS to the school mapping in Bangkok. In Asian Association on Remote Sensing (AARS) with collaboration Survey Department*, the 23rd Asian Conference on Remote Sensing Proceeding (pp. 25-29).

[36] Mamman, A.B. 2004. "Land Use Policies Since 1960." Available at

http://www.onlinenigeria.com/land/?blurb=529 Otubu, T. 2010. “Land reforms and the future of the land Use Act in Nigeria.” Nigerian Current Law Review (NIALS) 2007-2010. Uchendu, V.C. 1979. “State Land and Society in Nigeria. A Critical Assessment of Land Use Decree of 1978.” Journal of African Studies 6: 71.

[37] McEwen, J. W. (2017). *GIS Technology Applications in Environmental and Earth Sciences*. Star Publishers, London.

[38] Raghavendran, S. (2012). *Cadastral Mapping and Land Information System.* GIS, Pixel infortek Pvt. ltd. www.GIS development.net.com

[39] Royer, J. J., & Shtuka, A. (1997). *Stochastic imaging of environmental data. In Geosciences and Water Resources: Environmental Data Modeling* (pp. 101-114). Springer, Berlin, Heidelberg.

[40] Sayao, D. (2023.), *Landslides: evaluation and stabilization*. McGrahills Publishers.

[41] Sbalkema P, Taylor C. & Sarah F (2022), . *Use of satellite data to map landslides. 9th Asian Conf. on remote sensing,* Bangkok, Thailand, 23-29 November .

[42] Shuiabu, U. (2008). *Cadastral Land Information System for Sustainable Land Conveyance in Bauchi State.* M.tech Project Department of Surveying and Geoinformatics. Federal University of Technology Yola.

[43] Spieker, E.C., Gori, P.L., (2003). *Partnerships for reducing landslide risk: assessment of the national landslide hazards mitigation strategy.* The National Academy of Sciences Press,

[44] Spizzichino, D., Falconi, L., Delmonaco, G., Margottini, C., Puglisi, V., (2014). *Integrated approach for landslide risk assessment of Craco village* (Italy).

[45] Tella, F. and Rably, P. (2022). *An ILS White paper on Integrated Registry and Cadastral System*. International Land System inc.

[46] UN-GGIM. (2015). “*The Application of Geospatial Information –Land Administration and Management.”* UN-GGIM Version 3.1. Available at http://ggim.un.org/docs/meetings/GGIM5/land%20admin%20and%20mngnt%20background%20paper%203.2%20final.pdf Yakubu, M.G. 1985.

[47] Van Zuilekom, K., van Maarseveen, M., & van der Doef, M. (2005). *A decision support system for preventive evacuation of people.* In Geo-information for disaster management (pp. 229-253). Springer, Berlin, Heidelberg.

[48] Wanjohi, G. and Mutua, F. (2023). Developing a web based integrated land information system for ownership, value and taxation: Case study of the ministry of lands, housing and urban development, Kenya. *International Journal of Science and Research,* 4(9): 984-991

[49] Washington, DC. Spieker, E.C., Gori, P.L., (2003b). *National landslide hazards mitigation strategy: a framework for loss reduction.* USGS Circular 1244. US Department of Interior, U.S.G.S. Reston, Virginia, 56p.

[50] Zevenbergen, J. & Ploeger, H. (2019). *What Would Title Registration Bring to A Deeds System with High Quality Land Information.* Paper presented FIG Working Week, Geospatial information for a smarter life and environmental resilience. Hanoi, Vietnam. Retrieved from https://www.fig.net/resources/proceedings/fig_proceedings/fig2019/papers/ts02g/TS02G_zevenbergen_ploeger_9972.pdf.