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Remote Sensing and Land Use Management in Nigeria: a Review

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Abstract. Land is essential for man's existence, and its use involves the management and modification of the natural environment into built environments such as recreational, transportation, agricultural, residential, and commercial. The global population increase is exerting more pressure and demand on this limited natural resource. Accompanying man's need is the grievous depletion of the natural environment and the extent of this depletion and conversion has yet to be fully determined by the application of traditional approaches. Therefore, the focus of this study is on how to apply remote sensing principles to land use and its management in Nigeria. Secondary data, the literature on land use, and remote sensing were adopted in the study. The study revealed that in the South West land use for settlements increased from 107.3ha in 1986 to 210.96 in 2003, while other land uses reduced in sizes – cropland (6021ha to 5,351.10ha). In Abuja, urban/built-up land increased from $36.8km^2$ (1987) to $385.4km^2$ (2017). The study further revealed that land management, using remote sensing, fosters inventory and management, periodic monitoring, and effective allocation and coordination of land resources. It provides automated techniques for integrating both quantitative and qualitative data in land information management that helps better decision-making processes, efficient policy formulation, and monitoring in land-related problems across local and global scales. The study therefore recommends the integration of remote sensing into land management and policy decision in Nigeria.

Keywords: Land Use, National Development, Nigeria, Policy, Remote Sensing, Planning

1.   Introduction

Man's continued existence is a function of his relationship with his natural environment. The way he uses and manages it will determine what he gets back from it. Man modifies his natural environment into built environment, including recreational, transportation, agricultural, residential, and commercial. Man everywhere is a disturbing agent; his activities have adverse effects on his environment. Wherever he plants his foot, the harmonies enjoyed by nature are disturbed [1]. To maintain a balance between man and nature, it is essential to examine and monitor the effects of his activities on how he uses and manages the land. This has resulted in various changes in the environment that require more than traditional approaches to identify.

Traditional approaches to data gathering, like sample surveys and systematic land-use surveys, had been found to be too expensive and time-consuming [2]. According to [3] digital change detection has to be of immense help in the identification and determination of the changes associated with land use, both in developed and developing countries, regarding geo-registered multi-temporal remote sensing data. Land use mapping is pertinent in the estimation, management, and conservation of ecosystem resources of a nation. Also, the mindfulness of the subsisting land use is one of the primary requirements in the formulation of a better use of land and its management. Remote sensing can be implemented in tracking

deforestation, agro-ecologic zones, ozone layer depletion, and early flood warning structures. It may additionally be adopted in monitoring full-size atmospheric-oceanic anomalies such as climate and weather prediction, ocean mapping and monitoring, plants mapping, wetland degradation, soil mapping, natural catastrophe, and risk assessment and mapping, and land cowl maps for input to worldwide climate models.

"Remote sensing is the science and art of obtaining information about an object, area, or phenomenon through the analyses of data acquired by the sensor that is not in direct contact with the target of the investigation" [4, 5]. This may be accomplished with the aid of the use of both recording and/or real-time sensing device(s) set up on aircraft, spacecraft, satellite, buoy, or ship. Application of remote sensing, coupled with geographic information systems (GIS) techniques, can be used to view, interpret, and analyze geographically referenced data. They have opened up a wide array of avenues that help in effective land-use and land management. Data collected through remote sensing coupled with field survey data are unique and provide a hybrid database for optimal mapping of land use, thereby helping proper land management. In recent decades, the rapid population in Nigeria, as a result of migration from rural to urban areas and improved economic conditions within the cities, has culminated in unheard of land-use modifications and urban expansion rates.

2.   Literature Review

Different authors had defined land use variously. It has been defined as the manner wherein land has been used by man and his habitat, with typical emphasis on the roles that land play in his economic activities. As an example, in relation to the process of urbanization, a massive expanse of agricultural and/or forest land has been converted into urban activities (land), while mining activities and/or oil exploration and exploitation have occurred globally so as to fulfill human demands and hence, has resulted directly and obviously to the land use change [6, 7, 8, 9]. Tropical regions like Nigeria have experienced a high rate of change in the spatial distribution and characteristics of their forests, particularly conversion from forest to non-forest uses. In their study, [10] stated that a large expanse of tropical forests have been converted to agricultural use due to increasing population coupled with lack of economic opportunities to engage the teaming population.

Increased growth in urbanization/industrialization and large-scale agriculture and critical changes in human population and diverse activities are the major reasons for the dramatic modifications in land cowl and land use patterns at national, regional and global scales. Remarkable land cowl and land-use changes that would have hitherto taken centuries to take place are now occurring within few decades [11]. According to [12], the green belt is facing a lot of alterations due to conflicting demands of land for industrial and residential development. The various human use of land resources gives rise to "land use". Alteration of land surface characteristics is dynamic and must be monitored periodically to determine the rate of cities growth, infrastructural planning and ensure orderly society. The use of satellite imageries has proven to be a veritable method of environmental change detection, analysis, monitoring and planning for land resources utilization.

Agricultural land use is just one of the land uses that impact on land management. Other land uses such as residential, commercial, cultural, recreational etc. take their tolls on land management and to achieve the policy objective suggested by [13], the role of remote sensing would be highly required.

According to [14] digital change detection is the process that facilitates instant determination of the changes related to land use and land cover (LULC) properties with reference to geo-registered multi temporal remote sensing data. Inventory and monitoring of LULC changes are indispensable aspects required for further understanding of change mechanism and modeling the impact of change on the environment and related ecosystems at different scales [3, 15]. Massive scale changes are challenging and ultra-expensive to quantify through fieldwork i.e. the use of traditional approaches. However, there is nothing wrong if both remotely sensed data and field observations are collaboratively used together as doing this will greatly help in accomplishing land cover classification and change detection faster and cheaper.

Availability of up-to-date land-use/land cover change map would enhance the understanding of landscape dynamics, utilization of integrated remote sensing and geographic information systems (GIS) would enhance the ability to have adequate inventory of land resources on which all other developments take place. The development of land use classification is necessary for tax assessment, clarity enhancement and maintenance of standards which is lacking in many parts of Nigeria. Golmehr [16] opined that observing land use pattern is vital not just in agriculturally dominated, over populated developing regions but throughout the world because of its relationship with distinctive human phenomena.

Land use mapping is crucial for the purpose of appraising, management and conservation of environmental assets of any nation and the information on the prevailing land-use is required in forming and opinion for better and sustainable land-use. Golmehr [16] concluded that remote sensing approach to land use management is a good scientific tool that can be used alongside ground truth and topographical sheets for series of spatial records and really useful in identification, typology and mapping of the land-use units. In other words, the two authors were of the view that to gain accurate knowledge of the prevailing land use, remote sensing comes handy.

In a study carried out on Debre Markos Town, Ethiopia, [17] classified land use into five (5) main groupings in line with the classification system developed by [18]. The groupings are open area, built-up are, farm land, vegetation and water body. However, [17] noted that this classification scheme has been generally adopted by various Federal agencies involved in land use inventory and mapping such as Ethiopian Mapping Agency. The study that covered the period between 1987 and 2016 showed that while open area was diminishing in size (-377.01ha), built-up are drastically increased astronomically (916.83ha). It could generally be seen from Table 1 that while the spaces available for other land uses was decreasing, except for waterbody, the built-up area was increasing.

Table 1: Area Statistics of the Land Use and Land Cover Units from 2003 – 2016

Class	1987		2016		change 1987 – 2016	
	ha	**%**	**ha**	**%**	**ha**	**%**
Open area	2369.97	36.1	1992.96	30.4	-377.01	-16%
Built up areas	751.5	11.46	1668.33	25.4	916.83	+122%
Farm land	2429.01	37	2399.04	36.6	-30.07	-1.24%
Vegetation	982.8	15	466.74	7.1	-516.06	-52.547%
Water body	23.49	0.4	29.7	0.5	6.21	+26%
Total(ha)	**6556.77**	**100**	**6556.77**	**100**	-------	------------

In investigating the changes in LULC over a period of 16 years in Southwestern Nigeria, [19] adopted remote sensing and GIS techniques and this has enabled them to identify the factors responsible for the diverse changes identified and the concomitant adverse outcomes of the changes on the subsistence of the people and the local environment. On their parts, [20] viewed remote sensing as making important contributions to the documentation of the real change in land-use and/or land cover from regional through global levels all the way from the mid-1970s. In the case of Nigeria, with all the continuous research works on LULC patterns; there is still the gap in developing the required datasets that can help in providing quantitative and spatial land-use/land cover information. Furthermore, there is still a gap yet to be filled by the available information both at national and local scales that could be adopted in regional and national decision-making process and logical planning. Corroborating the above, [21] said the same is true in the Southwestern part of Nigeria. They went further to state that regardless of the fantastic economic importance of the region, there seems no longer to be any systematic studies of land use/land cowl adjustments. In an earlier study by [22], the authors mapped vegetation/land-use associations in the Ife area on a scale of 1:40,000 panchromatic aerial photographs. Using a satellite image of the same region, [23] focused on how to differentiate the developed from the undeveloped land use, with a view to revising the population census base map. In another vein, [24] conducted similar studies in respect of the region but using the data from LandSat satellite imagery captured in December, 1986 and the then operational NigeriaSat-1 satellite imagery of December 2004 yet came up with similar results. All these revealed the need to do more on this in other to enhance land use and management in Nigeria.
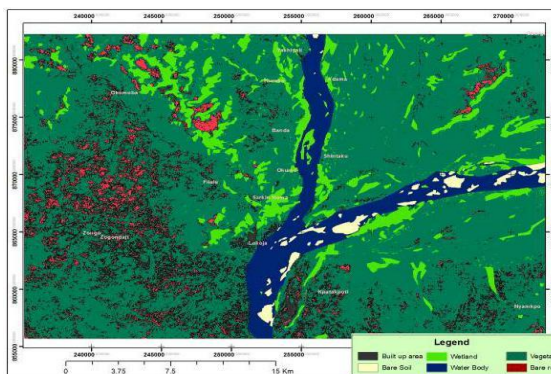

Figure 1 Land use/cover in 1986
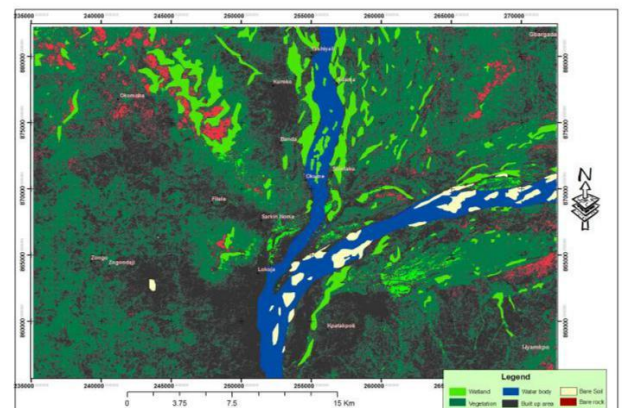

Figure 2 Land use/cover in 2001
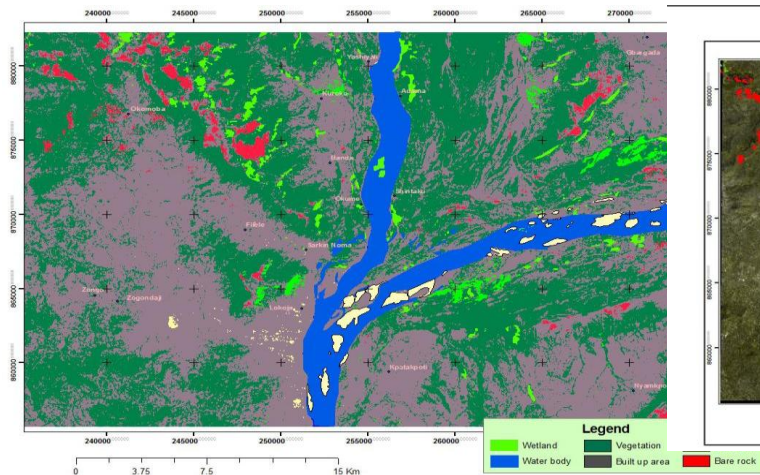
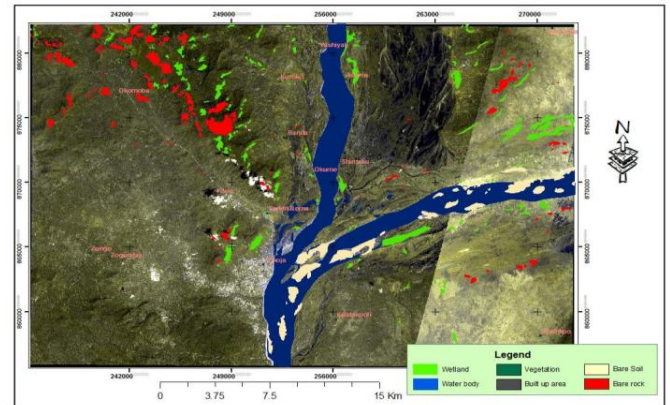Figure 3 Land use/cover in 2006   Figure 4 Land use/cover in 2007

A cursory look and comparison of the pairs of figs 1, 2 and 3, 4 revealed that the hitherto luxuriant land use had given way to developed areas. While the change was not sporadically pronounced in the pair of figs 1 and 2, it is drastically evident in the pair of figs 3 and 4 where, as at 2007, the luxuriant land had been totally lost to development and other human activities.

While monitoring the transformation of LULC between 2001 and 2006, [25] posited that developed areas had eaten deep into the areas under agriculture. This has resulted into vegetation and wetland vegetation experiencing loss of large expanse of land to cultivated land. The import therefore is that with high pressure of demand for construction purposes, on the cultivated land, vegetation and wetland vegetation suffers drastically. In other words, the situation in the Federal Capital City, is not totally different from other parts of the country. The land use that was predominantly characterized by farmlands and vegetation in 1987 has almost been eaten up by built-up areas in 2006. As evident in Table 2 and fig 5 open areas, farmlands, vegetation and water bodies are fast giving way for built-up areas. Table 2 was the result of the study conducted on Abuja in 1987, 2002 and 2017 by [26] while fig 5 was produced from the study by [25] and therefore corroborated what was contained in Table 2.

Table 2. Calculated Area of Land Cover of Abuja in 1987, 2002, and 2017

Land Cover Classes	1987	2002	2017
	Area km^2 (% of Study Area)	Area km^2 (% of Study Area)	Area km^2 (% of Study Area)
Urban/built-up	36.8 (1.8%)	198.8 (10.0%)	385.4 (19.3%)
Vegetation	1455.6 (73.0%)	1262.5 (63.3%)	1011.9 (50.8%)
Bare land	491.9 (24.7%)	522.1 (26.2%)	522.1 (26.2%)
Water	9.3 (0.5%)	9.6 (0.5%)	7.7 (0.4%)
Total	**1993.6 (100.0%)**	**1993.0 (100.0%)**	**1993.6 (100.0%)**
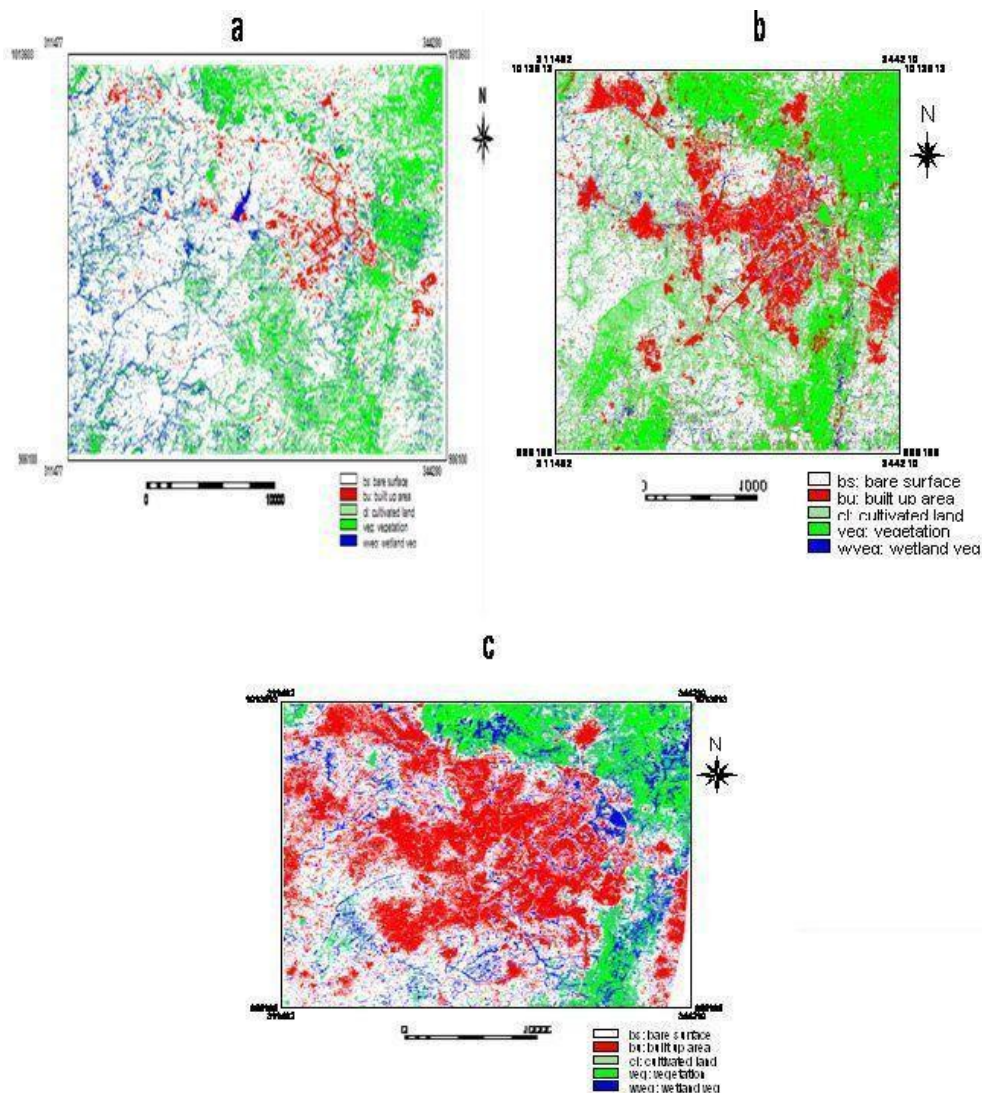
Figure 5:   LULC Maps of Federal Capital City in: (a) 1987; (b) 2001; and (c) 2006
Source: Fanan, Dlama and Oluseyi [25]

In South Western Nigeria, [27] carried out a study to identify Land Use Change adopting Remote Sensing and GIS Techniques. The study examined the environmental changes between 1986 and 2003. The satellite images made it possible to quantify the effect of LULC. Land use change detection therefore made it possible to identify the major processes of change and, by deduction, the characterization of land use dynamics. This outcome was due to the over-dependence on primary resources which have immediate

effect on biodiversity; land use and land cover dynamics, terrestrial ecosystem and climate. This is as presented in Table 3.

Table 3: Comparison of areas and rates of change of the six LULC between 1986 and 2003

LU/LC Types	1986 LU LC Areal Extent		2003 LU LC Areal Extent		Change between 1986 and 2003	Av. rate of change
	Ha %	%	Ha	%	Ha	ha/yr
Wetlands	19.71	.019	1054.0	9.19	+1034.29	+60.84
Forestland	6021	56.96	5351.10	46.65	-669.9	-39.40
Cropland	3833.34	36.30	3943.80	34.38	+110.45	+6.49
Grasslands	533.35	5.10	708	6.17	+174.65	7
Settlements	107.30	1.91	210.96	1.83	+103.66	+6.09
Otherlands	54.81	0.52	201.78	1.76	+146.97	+8.65
Class Total	**10569.51**	**100**	**11469.67**	**100**		

The result, as contained in Table 3 showed that the dam constructed in the study area resulted in flooding which in effect culminate into the increase in the extent of wetlands and this has led to bio-richness that created ecological conditions resulting in unprecedented environmental and ecological implications. The LU/LC changes coupled with the environmental changes and social disruption from the construction and operation of large dams and the associated infrastructure developments such as irrigation schemes can have significant adverse health outcomes for local populations and downstream communities. There has been a progressive increase of wetland in the communities within the study area between 1986 and 2003. It is clear from the table that while expansion of wetlands increased astronomically from 19.71ha (1986) to 1,054ha (2003), increases in other land uses were not that rapid.

3.   Sustainable Land Use Management

The focus of sustainable land management (SLM) is on the practices and technologies integrating the various factors such as land management, water, biodiversity, and other environmental resources in order to meet critical human needs without compromising the long-term sustainability of ecosystem services and human sustenance. In the opinion of [28], SLM is a knowledge-based approach with the capacity to integrate land, water, biodiversity, and environmental management such as input and output externalities with the aim of meeting the ever increasing demands for food and fiber, and at the same time ensuring sustainability of ecosystem services and livelihoods. In the report, two major areas of SLM involvement were identified as:

❖ Preserving and enhancing the productive capabilities of land in cropped and grazed areas
❖ Actions to stop and reverse degradation

Sustainability is an intrinsic requirement for the continuing human existence. The quest for sustainable land-use has burgeon importance due to accumulated environmental problems such as ever growing demand for ecosystem resources, climate change, regional climate extremes, threatening environmental pollution, to mention just a few [29]. Sustainability is the underpinning for the main global

framework for worldwide collaboration, as described within the 2030 Agenda for Sustainable Development alongside its Sustainable Development Goals [30].

The focus of this paper specifically is on SDG goals 11 and 15 i.e. "Sustainable cities and communities" and "Life on land" respectively, for sustainable land use. This is necessary since sustainable land use helps in preventing and at the same time reversing land degradation and natural hazards. It also helps in preventing biodiversity loss and equally supports the stability of our landscape.

Considering the importance of land use planning in achieving sustainability, [31] opined that land use planning is the systematic appraisal of land and water capability, alternatives for land use, and economic and social situations so as to pick and undertake the best land use options. The author went further to explain that the main goal of land-use planning is to select and implement the land use practices that best suites the needs of the people and at the same time safeguarding resources for the future. The implication therefore is that land should be used in such a way that will ensure availability of land for future uses. This opinion was corroborated by [32]

4.   Benefits of Remote Sensing to Nigeria

Inappropriate land planning and administration is making Nigeria among other nations of the world not to fully tap the inexhaustible potentials of her land resources. Integrated technologies of Remote Sensing and GIS would enhance the adequate generation and keeping of land property record such as titles, deeds, securities etc. and be able to continually track them.

The benefits of remote sensing cannot be over emphasized, its ability to provide information about resources both above and under the earth made it useful in natural resources management. Using Aeromagnetic surveys, it is possible for researchers to explore and estimate the abundance of minerals deposits beneath the earth surface. Ability of remote sensing to provide repetitive view of the earth surface has made it possible for us to determine how our environment is changing over time and space. It is equally possible to monitor desert encroachment and determine the extent of land resources degradation, monitor the level of deforestation and land exposure to harsh influence of other weather elements. Recently, Lidar technology has made it possible to have three dimensional view of terrain which has enhanced our ability to perform flow analysis, infrastructural planning and equipment staging. Satellite imagery is useful in hazards mapping, natural and manmade disasters management such as landslide, earthquakes, erosion control and flood management, rescue and relieve operations.

The importance of integrated remote sensing and GIS techniques for periodic land use and land cover mapping and change detection cannot be overemphasized. This integrated technologies has the capacity of providing solutions to paucity of environmental data, enhance rapid environmental change monitoring. It has also been observed that both natural and anthropogenic factors have been contributing to the shapes and forms of land use/land cover in different parts of the world in form of flooding, erosion, induced soil infertility and degradation, deforestation, and many others with negative consequences on agricultural productivity and sustainable development. Unavailability of updated land use land cover maps or digital data have the capacity of producing haphazard planning or wrong decision making on land resources allocation and utilisation.

One of the advantages of remote sensing and geographic information systems is its ability to collect information over a large area that can enable resource inventory on a local, national and regional

levels, full engagement of this technologies even at the local government level is still at a very low level in Nigeria. We can plan for remote and inaccessible locations using this technology, resources and facilities management become easier in Nigeria.

5.   Methodology

This study is exploratory in nature hence, secondary data techniques were relied upon in the conduct of the study. It adopted the use of literature on land use, remote sensing and maps from earlier researches. While the literature on land use helped in identifying the land use patterns alongside the changes and the techniques adopted in managing them, the literature on remote sensing helped in establishing how remote sensing techniques has helped in the management of land use in other climes and how they could be employed in the study area. A few maps that lend credence to resolving land use problems are included in the study. Some of the sources employed in the study include: land use [6, 7, 8, 9, 13, 17, 25]; remote sensing [3, 4, 5, 15]; land use and remote sensing [18, 19, 21, 27]. All these sources are well reflected in the reference section of the study. Also, the figures used are all included in the study.

6.   Conclusion and Recommendations

It is evident from the study that traditional approaches to data gathering such as sample surveys and systematic land use surveys are too expensive and time consuming hence; they could not be carried out on continuous basis. The study also revealed that land management, using remote sensing could foster land resources inventory and management, periodic monitoring, societal orderliness and effective allocation and coordination of land resources. From the study, it is clear that remote sensing also provides automated techniques for integrating both quantitative and qualitative data in land information management thereby making room for better decision making process, efficient policy formulation and monitoring that help in solving myriads of land related problems that cut across local and global scales. The study found that no mention was made about remote sensing being necessary tools for sustainable land use management. Following from the conclusions drawn from the study, necessary recommendations made are as follow.

For planning, policy formulations and decision making, on land use management, to be realistic, effective and sustained, there is need for qualitative and quantitative information on existing land uses. This is necessary even where drastic changes in the land uses are neither feasible nor warranted, so as to develop suitable packages that are consistent with bioclimatic and geopedologic environment for optimizing production. Such information required are related to the built-up areas, cropped areas, current fallows, plantations, forest, grasslands, wastelands.

More still needs to be done in the area of awareness creation and capacity development in Remote sensing and GIS applications in Nigeria e.g. very few universities in Nigeria offer courses and training programmes in remote sensing and Geographic Information Systems related areas.

The awareness on efficacies of Remote Sensing and GIS applications is necessary for the general public and national policy makers because the need for spatial facts and spatial evaluation is not in the purview of the earth scientist alone. Urban planners and cadastral agencies require detailed information in respect of the distribution of land and resources in both rural and urban areas, Civil Engineers also need to design and plan the routes for roads and canals and for estimation of costs of construction including cut and fill analysis. Law enforcement agencies would equally need to be on top with the spatial distribution

of various crimes. For the purpose of disease control, it is important for medical personnel to be armed with the spatial distribution of sickness and disease.

Integrated and multidisciplinary approach must be applied in geospatial education because different aspects of the earth's surface did not function independent of each other. It could therefore be seen that the use and application of Remote Sensing and GIS requires collaborative efforts of different scientific experts, this is in line with [33] conclusion. In addition, improvement of plans and infrastructure for data access, analyses and sharing of best practices, information technology applications in solving spatial problems, hardware and software would go a long way in the increment of users in the developing countries in which Nigeria is a part.

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