



MONITORING & CONSERVING NIGERIA'S WETLANDS FOR OPTIMUM BENEFITS: THE CHALLENGES

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ABSTRACT

Wetlands provide numerous invaluable agricultural, social and economic benefits to society. This paper outlines some of these benefits, in the main highlighting the place of satellite remote sensing for mapping, monitoring and inventorying of the nation's wetlands to conserve and derive maximum benefits from them. The key steps of environmental remote sensing such as image enhancement and classification to accurately map and delineate wetlands for their protection, proper management and use are discussed. Challenges limiting the uptake of remote sensing technology in Nigeria as opposed to other countries (sometimes less developed ones) are further outlined whereas recommendations are proffered for the authorities to establish working mapping policies and adequately fund remote sensing experts and mapping and GIS projects.

KEYWORDS: Wetlands, Remote Sensing, Monitoring, Mapping, Conservation

1.0 INTRODUCTION

Wetlands, commonly known as marshes or swamps are among the most important ecosystems in the world. They are of very high interest for agricultural development and for environmental conservation. They occur everywhere from the tundra to the tropics. A global estimate of their size is given at somewhere in the region of 6% of the Earth's land surface or 570 million hectares, with some reports suggesting this could be considerably more (Ekebuike, 2011). They support high concentrations of birds, mammals, reptiles and amphibians and reproduction of plant genetic material such as rice, a staple more than half of humanity. In addition, they provide tremendous economic benefits; water supply; fisheries (over two-thirds of the world's fish harvest are linked to the health of wetland areas); agriculture; timber production; energy resources, wildlife resources; transport; and recreation and tourism opportunities. In the last few decades there has been a greater awareness of the values and benefits of wetlands to society. At the same time wetland areas are under increasing pressure from development and other anthropological activities. In spite of important progress made in recent decades for their conservation, wetlands continue to be among the world's most threatened ecosystems. This is attributed mainly to drainage, conversion, pollution and over-exploitation of their resources. The Millennium Eco-system Assessment (2005) emphasized that loss of wetlands globally is more rapid than those of any other ecosystem. Governments the world over have been working to assess and maintain the ecological character of wetlands. The Ramsar convention is an international treaty dedicated to the conservation and suitable use of wetlands and the Ramsar Bureau maintains a list of 1,838 sites across the world in 159 countries. A new academic field —wetland ecology has also arisen to

better study wetland values and biology (Wright, 2004), yet it is hardly true that any commensurate efforts exist in

Nigeria or that these can be found in the curriculum of any of the Nigerian Universities. It can well be rightly asserted that successive Governments in Nigeria have not paid adequate attention to monitoring and conserving of the nation's wetlands. The river basin development authorities formed in the 1980s have almost completely gone moribund. The problems and others associated with wetlands and their conservation are to a large extent attributable to lack of proper mapping, inventory and monitoring activities on the nation's wetlands as in other countries.

2.0 Wetlands Defined

The definition of wetlands has been identified as the key to proper wetland mapping and inventory. As Mitch and Gosselink (1993) observed, there have been many definitions ascribed to wetlands over the years, and these definitions can often be confusing and even contradictory. In the Wetland strategy, wetland is defined as; —Areas of permanent or periodic/intermittent inundation, whether natural or artificial, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six meters. The definition in the Wetland Strategy is based on the definition of the wetlands of International Importance. Similarly, following the RAMSAR convention on wetlands (RAMSAR, 2004), —wetlands are areas of marsh, fens, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six meters. As can be seen, both definitions include elements such as shallow marine waters, estuaries, rivers, streams and creeks, lakes, pools, marshes, peatlands and

springs. Notably, almost all definitions ascribed to wetlands consist of three main components: a permanent or temporary inundation of water, hydric soil conditions, and flora that is specifically adapted to those conditions.

The Ramsar definition of wetlands was amended in 2003 (Article 2.1) to include: —may incorporate riparian and coastal zones adjacent to the wetlands and islands or bodies of marine water deeper than six meters at low tide lying within the wetlands. Furthermore, in the U.S Army corps of Engineers (USACE, 1987) —wetlands delineation manual, wetlands are defined as —Those areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances support, a prevalence of vegetation typically adapted for life in saturated soil conditions.

If this definition were strictly applied, it could be argued that many landscapes that shed water are wetlands, and it is clear that such an approach would not appropriately identify those wetland areas that have characteristics that require inventorying, monitoring and significant management intervention. Hence the definition of wetlands in accordance with the RAMSAR convention and for the purpose of mapping, classification and inventory for their proper management has been offered as:

Wetlands are Areas of permanent or periodic/intermittent inundation, with water that is static or flowing, fresh, brackish or salt. To be a wetland, following the above definition, the area must have one or more of the following attributes:

- i. At least periodically, the land supports plant or animals that are adapted to and dependent on living in wet conditions for at least part of their life cycle or
- ii. The substratum is predominantly undrained soils that are saturated, flooded or ponded long enough to develop anaerobic conditions in the upper layers, or
- iii. The substratum is not soil and is saturated with water, or covered by water at some time.

In the broadest sense however and as usually perceived by the general public, wetlands may be said to generally include swamps, marshes, bogs, and similar areas. For clearer understanding, wetlands can be considered the transition zone between terrestrial and aquatic ecosystems. They maintain qualities of both, often being under water part of the year and dry at other times, and so have always been difficult to identify and properly define.

3.0 Protection of Wetlands

In a study, Dahl (1990), observed that even since Government policy began to regulate wetland loss, the trend of wetland destruction has continued in the United States and much of the world. In some areas, much of these losses are confined to smaller, less conspicuous wetlands, especially riverine and isolated wetlands (Kundell and Woolf, 1986), which are the most prevalent types. Often, in some countries, wetlands are only regulated solely by federal policy, as no state laws are applicable to them or vice-versa. Currently, the basis for protection of wetlands in many countries only derives from other legislation. In the US state of Georgia for example, the Federal Clean Water Act (CWA) of 1972 provides the basis for protection of isolated and riverine wetlands.

4.0 Wetland sites in Nigeria

Reputed as the most populous black nation and the eighth most populous country in the world with a population recently hitting the 167 million mark. Nigeria has a surface area of about 923,768 km² of which the land area is about 910,768 km² and 13,000 km² is water. It has coastal line of about 853 km (Atilola, 2010). Nigeria, is so highly blessed with abundant land and natural resources including wetlands and river basins. Nigeria presently has 9 sites designated as wetlands of international importance, with a surface area of 1, 076, 728 hectares (Moloko, 2008). The table below gives a quick statistics of the nine wetland sites.

TABLE 1: Statistics of Nine Wetlands in Nigeria

S/No	Wetland Name	State	Surface Area	Geog. Location	Current Use	Ramsar Site No.
1.	Apoi Creek Forests	Bayelsa	29,213ha	05° 47'N 04° 42'E	Forest Reserve	1751
2.	Baturiya wetland	Kano	101,095 ha	12° 31'N 10° 29'E	Game Reserve	1752
3.	Dagona Sanctuary Lake	Yobe	344 ha	12° 48'N 10° 44'E	National Park	1753
4.	Foge Islands	Kebbi, Niger State	4,229 ha	10° 30'N 04° 33'E	National Park	1754
5.	Lower Kaduna-Middle Niger Floodplain	Kwara, Niger State	229,054 ha	08° 51'N 05° 45'E	Floodplain	1755
6.	Maladumba Lake	Bauchi	1,860 ha	10° 24'N 09° 51'E	Forest Reserve	1756
7.	Oguta Lake	Imo	572 ha	05° 42'N 06° 47'E	Freshwater Lake	1757
8.	Pandam & Wase Lakes	Nassarawa	19,742 ha	08° 42'N	Wildlife	1758
9.	Upper Orashi Forests	Rivers	25,165 ha	04° 53'N 06° 30'E	Forest Reserve	1759

Adapted from Moloko, 2008

Taken together, these sites present a fascinating array of wetland types, including swamp forests, river flood plains, mangroves, and lakes and all of them are extremely important for their support for flora and fauna and for the ecosystem services they provide for the local communities. Most of them are formally state-owned but in practical terms under the customary control of local families and communities. Aside these, with almost all the 36 states deriving their names from different rivers, there are believed to be numerous other wetlands far more in size than the those as designated above which are not accounted for in these classification.

5.0 Wetland mapping, monitoring and inventory by remote sensing

Given the physical inaccessibility of wetlands in general, synoptic inventories of wetlands have typically required some degree of remote sensing, by aerial photography or from satellite imagery. For this reason, the remote sensing approach is seen as an important way for consistent mapping of overwhelming proportion of the wetlands of the world; for their rapid delineation, to map their spatial distribution, and to identify their specific characteristics such as biophysical, ecological, hydrological, and socio-economic values. Thenkabail et al., (2000), have also rightfully identified the potential of satellite remote sensing data and techniques for mapping different types of wetlands at different spatial scales covering large areas. Remote sensing has in fact in recent times proved a fast and effective means for general mapping of the entire earth's surface (Igbokwe, 1996),

Wetland mapping by satellite remote sensing have the following distinct steps (Ekebuike, 2011):

- i.. Image enhancement techniques to highlight the wetlands from the neighbouring landscape.
- ii.. Image display techniques involving the use of various false colour composites (FCCs) of imagery of area under study.
- iii.. Onscreen digitization to delineate wetlands from non-wetlands.

Screen digitization should be done on the colour enhanced and —zoomed in images. Following image enhancement techniques would be found to provide best distinguishable features that facilitate accurate delineation of wetland boundaries when —zoomed in and viewed onscreen. Using a Landsat ETM+ imagery for mapping as an example, the following combinations gives good results (Ekebuike, 2011).

(a) FCC of Landsat ETM+ band ratios - NIR/SWIR2: NIR/red: NIR/green;

(b) FCC of NIR: Red: SWIR1; and

(c) True Colour Composite (TCC) of Red: Green: Blue.

Where, band 1 = blue, band 2 = green, band 3 = red, band 4 = NIR, band 5 = SWIR1, and band 7 = SWIR2.

5.1 Wetland Classification

After image processing and wetland boundary delineation in the process described above, delineated wetlands are then classified to group identified wetland types to appropriate classes for better interpretation for decision making, agriculture venture and general development planning. Hierarchical class grouping can be adopted to label and identify the classes.

Depending on the location and climate of the area under study, common wetland feature types often identifiable from wetland areas, riparian zones, and river basins include

- Waterbodies dominant wetlands
- Grass dominant wetlands
- Farmlands-natural vegetations mixed wetlands
- Riparian natural vegetation wetlands

This can be seen in the following hierarchical classifications adapted from Kulawardhana et al, (2007), which reported wetlands of a study area at four level with four classes reduced from initial 24 classes. A second classification example by hierarchical system (Islam Md et. al., 2008), in a study conducted in a different location gave four major classes reduced from fifteen initial classes as:

- Water body
- Seasonal wetlands
- Vegetation
- Irrigated agriculture

Other wetland class types as found from other studies include: deep or shallow fresh water body, deep or shallow lagoon, deep/shallow salt pan, seasonal wetland with high moisture, seasonal wetland with low moisture, permanent marshes/water body with high density vegetation, permanent marshes/water body with low density vegetation, high and low density mangrove, natural vegetation high density, natural vegetation low density.

TABLE 2. Classes of wetlands based on hierarchical classification system. Land use\land cover (LULC) characteristics of wetlands reported at 4 levels of aggregation.

Level I: 24 classes			Level II: 15 classes			Level III: 8 classes			Level IV: 4 classes		
Class #	Class Name	Land extent	Class #	Class Name	Land extent	Class #	Class Name	Land extent	Class #	Class Name	Land extent
1	Wetlands, water-bodies dominant		1	Wetlands, water-bodies dominant		1	Wetlands, water-bodies dominant		1	Wetlands, water-bodies dominant	
2	Wetlands, riparian zone-water (shallow) significant-mixed with grass and shrubs										
3	Wetlands, grasslands		2	Wetlands, seasonally		2	Wetlands,		2	Wetlands,	
	in moist flood plains covered with vigorous grass mixed with water bodies			flooded grasslands-grass dominant vegetation cover in riparian zone			grasslands dominant			grass dominant	
4	Wetlands, grass dominant riparian natural vegetation – water significant										

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5	Wetlands, grasslands in moist flood plains covered with vigorous grass		3	Wetlands, grasslands moist/wet lowlands vigorous grass cover						
6	Wetlands, riparian natural vegetation – grass dominant very low NDVI		4	Wetlands, grasslands covered with less vigorous grass-low NDVI						
7	Wetlands, grasslands dominant –short grass less vigorous and disturbed natural vegetation in riparian zone		8	Wetlands, riparian vegetation (grass dominant, less vigorous and dry) with some farming		7				
14	Wetlands, grasslands-riparian natural vegetation-farmlands mixed						Wetlands, grass dominant, natural vegetations			
17	Wetlands, riparian natural vegetation grass-shrub dominant-very high NDVI		11	Wetlands, riparian natural vegetation grass-shrub dominant-very high NDVI						
18	Wetlands, riparian natural vegetation-grass dominant-moderate vegetation cover		12	Wetlands, riparian natural vegetation-grass dominant-moderate vegetation cover						
8	Wetlands, grasslands in moist floodplains with significant farming and water bodies		5	Wetlands, grasslands (moist) farmlands significant (low vegetation cover)		3			3	Wetlands, farmlands-natural vegetation mixed
9	Wetlands, grasslands in moist floodplains with significant farming						Wetlands, grasslands farmlands significant			
10	Wetlands, farmland mixed with grasslands in moist floodplains									
11	Wetlands, grasslands (moist) farmlands significant (high vegetation cover)		6	Wetlands, grasslands (moist) farmlands significant (high vegetation cover)						
15	Wetlands, farmland (less intensive farming), open lands/fallow farmlands dominant		9	Wetlands, farmlands significant/fallow/barren mixed with short grass-very low vegetation cover		5	Wetlands, natural vegetation farmlands mixed			
16	Wetlands, farmlands (intensive farming)		10	Wetlands, farmlands significant (high vegetation cover)						
12	Wetlands riparian vegetation-grass, shrubs and farmlands mixed (high vegetation)		7	Wetlands riparian vegetation-(grass, shrubs and trees mixed) with some farming		4	Wetlands riparian vegetation-(grass, shrubs and trees mixed) with some farming		4	Wetlands, riparian natural vegetations
13	Wetlands riparian vegetation-less vigorous and sparse-grass and shrubs dominant with some farming									
19	Wetlands riparian natural vegetation-sparse vegetation cover		13	Wetlands, riparian zone covered with sparse cover of trees shrubs and grass-very low vegetation cover		6	Wetlands, riparian zone, sparse vegn cover			
20	Wetlands riparian natural vegetation-barelands significant									
21	Wetlands riparian natural vegetation-minimum vegetation cover		14	Wetlands riparian natural vegetation-open lands dominant		8				
22	Wetlands dry streambed: sandbeds dominant with few vegetation cover						Wetlands riparian zone-minimum vegetation cover			
23	Wetlands, moist streambed sandbeds/rocks/open lands dominant with minimum vegetation cover		15	Wetlands, streambeds, open lands, sand, rocks dominant						
24	Wetlands, dry streambed sandbeds/rocks/open lands dominant									

Source: Adapted from Kulawardhana *et al.* (2007).

5.2 Class identification and labeling

Class identification and labeling process follows after classification and this specifically involves following steps.

A. Bispectral plots:

Where a Landsat ETM+ image has been used, band 4 (near-infrared) versus band 3 (red) would be plotted to obtain the bi-spectral plots. This provides one of the key steps in class identification process.

B. Ground truth data

The quantitative and qualitative observations made during ground-truth including digital photos are used in class identification and labelling process.

C. Normalized Difference Vegetation Index (NDVI)

The NDVI values of the unsupervised classes are also plotted to assist in class identification process. Wetlands with barren lands and/or with sparse vegetation have lower NDVI as a result of soil moisture that is relatively higher than the surrounding uplands. When wetlands have natural vegetation or crops the NDVI will vary depending on vegetation density and vigor. The NDVI values are used in conjunction with ground-truth data to assist in interpretation.

D. Hydro-geomorphic and topographic features

Valley bottoms along the lowlands (e.g., inland valleys) are easily tracked on high resolution satellite imagery from their neighbouring uplands. Data from topographic maps

(especially from 1:50,000 or better), where available could be used.

E. Contextual and textural characteristics

False color composites (FCCs) are used to identify distinct features on the imagery that help distinguish lowlands from uplands. These differences mainly result from the differences in vegetation type and conditions as well as the moisture differences between the uplands and lowlands.

F. Hierarchical classification scheme

Based on the above information (point A to E), stepwise aggregation of identified classes are performed for the images. The most disaggregated classes and most aggregated classes are shown accordingly. Wetland class names are refined with the equivalent Ramsar Classification names where appropriate.

5.3 Accuracy assessment of the wetland classes

The ground sample points are overlaid on each of the land use/land cover (LULC) maps to determine the classification accuracies and errors of each class. Correspondence between classified and ground verified cover types are determined using a confusion matrix approach in ArcGIS software package. The levels of accuracies and errors at different classification levels are estimated and compared amongst different hierarchical classification levels. The following equations are used to derive percentage accuracies, errors of omissions, and errors of commissions (Ekebuike, 2011).

$$\text{Overall accuracy (\%)} = \frac{\text{Total no. of GT points of class 'X' that falling on class 'X'}}{\text{Total no. of GT points of class X}} * 100$$

$$\text{Error of omission (\%)} = \frac{\text{Total no. of GT points of class 'X' not falling on class 'X'}}{\text{Total no. of GT points of class X}} * 100$$

$$\text{Error of commission (\%)} = \frac{\text{Total no. of GT points of other classes falling on class 'X'}}{\text{Total no. of GT points of class X}} * 100$$

Below is a brief summary of the spectral characteristics of some of the features of the land surface (especially those related to wetlands) observed by remote sensing.

Water bodies

Water bodies (ponded wetlands) form most parts of wetlands. Determination of the land – water body is usually easiest in the near infrared region where land especially if vegetated is bright and open water dark. Usually, it is possible to determine a sharp contrast between the two. With landsat 1 to 3 MSS data, the contrast is usually clear on bands 6 or 7. With photography, black and white infrared film is usually satisfactory. CIR film is suitable if the water is free from sediment. However, because CIR film is sensitive to green light, turbid water will appear bright, thereby preventing clear discrimination of land – water boundary.

Philipson and Hafker (1981) studied application of Landsat MSS data to delineation of flooded areas. They concluded that simple visual interpretation of MSS band 4 images was as accurate as manual interpretation of multiband composite images and as accurate digital

analysis of MSS band 4 and combinations of both bands 2 and 4.

Vegetation

For living vegetation, which also form large parts of wetlands and river basins, band ratioing strategy can be especially effective because of the inverse relationship between vegetation brightness in the red and infra red region. That is absorption of red light (R) by chlorophyll, and strong reflection of infra red (IR) radiation by mesophyll tissue ensures that the red and near infra red values will be quite different and that the ratio (IR/R) will be high. These include: simple ratios – (NIR/Red) and Normalized Difference Vegetation Index (NDVI). Non vegetated surfaces including open water, manmade features, bare soil and dead or stressed vegetation will not display this specific spectral response, and the ratios will decrease in magnitude. Thus, the IR/R ratio can provide a measure of the importance of vegetative reflectance within a given pixel. The IR/R ratio is only one of many related measures of vegetation vigour and abundance. The green/red (G/R) ratio is based on the same concepts as used for the IR/R ratio although it is considered less effective.

Soil

Soils observed in the field display spectra with peak reflectances in or near the red portion of the spectrum, and it is in this region that the greatest spectral contrasts in soil types are observed. Condit (1970) studied spectral properties of 160 soil samples from the United States and found that the spectral properties could be characterized by measurements at only five wavelengths: 0.45 μm (in the blue), 0.54 μm (in the green), 0.64 μm (in the red), 0.74 μm (near infrared), and 0.86 μm (also near infrared). Some of the diverse research concerning spectral properties of soils can be summarized by noting the nature of the materials studied and the contributions of the studies to the effort to measure soil properties by remote sensing.

Artificial materials

Zwermann and Andrews (1940) studied ceramic powders to determine the influence of particle size on reflectivity. By using identical materials ground to different sizes, the effect of particle diameter on reflectance could be isolated. Fine textured particles tend to have brighter surfaces than coarse particles due to the smoother surface, with less shadowing by particles at the surface. In nature, fine textured soils are often associated with high moisture or organic matter content, both of which cause lower reflectivities and therefore counteract the effect of small size alone.

Remote Sensing Wetland Delineation

Accurate delineation of the wetland boundaries is the major challenge in wetland mapping. As noted, various enhancement models are often tested to determine the best technique for obtaining a better contrast among wetland versus non-wetland land cover types across wetland areas and different regions over a basin. When Landsat ETM+ is used, the most useful displays of image enhancements (e.g., ratios) and band combinations that highlight the wetlands from non-wetlands, when displayed as RGB (red, green, blue) false color composite (FCC) combinations are (Ekebuike, 2011).

- ETM+4/ETM+7, ETM+4/ETM+3, ETM+4/ETM+2 (or simply: 4/7, 4/3, 4/2);
- ETM+4, ETM+3, ETM+5; and
- ETM+4, ETM+5, ETM+2.

The wetland boundaries are digitized directly off screen using these enhancements and displays. The 4/7, 4/3, 4/2 (NIR/SWIR2, NIR/red, NIR/green) combination captures most of the wetlands, but when the above technique fails to distinguish wetlands from other land cover classes, other combinations are scanned to digitize any missing wetlands. Every other possibility such as the SRTM slope threshold is used to add wetlands that are missing from combinations displayed above. The same band combinations are also remarkable for delineating both fresh water and salt water pans. Studies have shown that the use of contextual and textural characteristics as seen on Landsat and SPOT images as desirable to map vegetation communities in wetland environments, especially for those with highly heterogeneous structural composition where similar vegetation communities occur in different forms and densities (Igbokwe, 2010).

The stream density (Sd) and stream frequency (Sf), the two indicators of wetlands, delineated by semi-automated methods using Landsat ETM+ data can be compared with

the Sd and Sf obtained from the topographic maps. The results often show that when compared with 1:250,000 topographic maps the Sd and Sf values are comparable. There are 2 important advantages in the Landsat ETM+ derived wetlands when compared with topographic map derived wetlands (Ekebuike, 2011); (a) areas of wetlands: presence of stream width helps derive areas of wetlands; and (b) Land use\ land cover (LULC) characterization of wetlands: availability of data in multiple bands will help derive land use\ land cover (LULC) characteristics of the wetlands.

7.0 GIS Application in wetland studies

Processed remotely sensed imagery is used for the construction of GISs of wetland areas and river basins which can be made accessible to stakeholders or to the public in web-based GISs. The United States Fish and Wildlife Service maintain websites <http://www.fws.gov/wetlands/Data/Mapper.html> and <http://137.227.242.85/wetland/wetland.html> where the computer-using public can assess online the conditions and activities on US wetlands for better understanding and suggestions for optimum benefits. Wetland GIS is a milestone which is indispensable for monitoring and use of the nation's wetlands. Benefits derivable from such a GIS would include but not limited to the following;

- to know the exact geo-spatial location of each of the wetlands
- to have a good knowledge of the spatial extents of the wetlands
- to know the conditions of the nation's wetlands
- to plan agricultural and developmental activities on wetlands
- what agric venture best suits each wetland site?
- prediction of crop yields from wetlands
- monitoring of the health of crops
- prevention of famine with early warnings

8.0 Challenges in Wetland Monitoring and Conservation in Nigeria

The lack of suitable large scale maps has been a long standing threat not only to wetlands but to entire geoinformation dissemination in the country. In cases where they are provided they are mostly inadequate and not properly managed. Funding for mapping purposes has been inadequate at both Federal and State levels. Manpower development has not kept pace with changing technology and a gap exists in technology even with the procurement of some modern equipment. In the current situation in Nigeria, out of more than 120 urban centres, and 774 local government headquarters less than 10 cities/centers and 20 local government headquarters have up-to-date large scale maps (Oboli and Akpoyoware, 2010), let alone wetland maps. This situation has affected agricultural and development projects and planning nationwide at all levels.

GOVERNANCE

Good governance refers to the manner in which power is exercised by government in managing a country's social, economic, and spatial resources. The following qualities have been identified (adapted from FAO 2007): Sustainable and locally responsive, legitimate and equitable, efficient, effective and competent, transparent, accountable and predictable, participatory providing

security and stability and dedicated to integrity. Sadly, almost all of the above are lacking in the Nigerian situation. Since good governance is a cornerstone in development, surveyors need to be more active in politics to be leaders as to make the required changes.

Challenges of Governance: Good governance stemming corruption, attitudinal change in leadership; the deplorable state of mapping, the Cadastre and Land Management has impacted negatively on governance in Nigeria. Land use administration is poor. Activities on land are carried out with inadequate data and organization which has led to poor utilization of the land especially the wetlands. Collection of taxes and other revenue from land is not properly monitored. Government does not receive due revenue since citizens do not pay appropriate land taxes as a result of the poor cadastre. The land and immovable landed property are not properly evaluated.

Other challenges being contended with include;

Capacity building especially human capacity: Effective Implementation of global computerization would require capacity building in terms of continuous manpower training and development as well as the provision of essential technological environment. The Surveyors Council of Nigeria (SURCON) and Nigerian Institution of Surveyors (NIS) could offer fellowships to deserving academic staff for research and further studies. The problem in Federal and State Universities, Private Tertiary educational institutions, where there are few equipment, incessant breaks in public schools in studies and insufficient lecturers and private tertiary institutions are expensive and this leads to restriction in the number of students who can take advantage of higher education.

The need to boost agro-allied industry and solid mineral development has been highlighted.

Need to have a reform in Agriculture: Agricultural Cadastre and optimum use of the nation's wetlands need to be initiated to enable farmers have title to their wetland farm holdings and use same as collaterals for funds to introduce mechanized agriculture, and boost food production as well as raw materials for agro-allied industries. This will help alleviate poverty especially in the rural areas.

SECURITY ISSUES

Needs to be attended to ensure safety to lives and property-survey and mapping can facilitate this through large scale maps which can help in neighborhood policing and crime prevention, effective monitoring of international boundaries by the Customs and Immigration authorities. Well-built customized GIS comes handy in security issue.

FUNDING

- I. Funds would be required for the following:
- II. Procurement and maintenance of remote sensing and GIS hardware, peripherals and software.
- III. Providing technical support to remote sensing and GIS experts, agencies and trained professionals who embark on mapping projects.
- IV. Training and capacity building both within Nigeria and in friendly donor countries
- V. Providing and maintaining technological infrastructure.

INFRASTRUCTURE

The World Economic Forum indicates that Nigeria's infrastructure is one of the worst in the world. Ranked 94th of 134 countries in the world, it has been rightly noted that Nigeria has not taken advantage of oil revenue to upgrade citizen's access to education or to improve infrastructure for agriculture development, let alone in mapping and GIS for agricultural development.

9.0 RECOMMENDATIONS

Maps should be produced adequately to meet users' needs and updated periodically for sustainable and successful land administration in Nigeria. This effort should focus more vigorously on the nation's wetlands.

Standing Committee on Surveying and Mapping to oversee effective implementation of the National Mapping Policy. Attention should be given to compulsory retention of all cadastral and mapping data produced by both the indigenous and multinational companies in the National Depository to avoid the pitfalls of the past in land administration and agricultural strides. recommend by the United Nations.

Success in this exercise could be based on building effective partnerships between surveyors, Governments and Government Agencies in the new private public partnership (PPP) policy being recently advocated and the ability to approach the studies with an outstanding multi-disciplinary team of surveyors, scientists, engineers and planners.

Capable and qualified remote sensing and GIS analysts could be engaged in mapping of the nation's wetlands in periodic snapshots.

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