Use of GIS and Remote Sensing Technology as a Decision Support Tool in Land Administration – The Case of Lagos, Nigeria

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Key words: Urbanization, Land Management and Administration, GIS and Remote Sensing.

SUMMARY

In the last several years, Lagos Metropolis has emerged as one of the fastest urbanizing cities in the West African Sub-region. In the absence of a regular use of information management systems, limited effort has been made to keep track of change in the rapidly growing city for policy making in land administration. The ubiquitous energy radiated by the rapid urbanization rate in the area not only created unprecedented consequences by diminishing the quality of the environment but it raises serous implications for land management in the region. The factors fuelling the land crisis in the area which are not far fetched consists of socio-economic, ecological and policy elements. Being a mega city and To tackle these issues, up-to-date knowledge and skills would be required to capture and analyze land information in order to steer and control city's expansion as well as infrastructure development, make well-motivated choices in planning and (spatial) designs. This study investigates the implications of the rapid expansion of metropolitan Lagos for land administration using Geographic Information Systems (GIS) and Remote sensing technology. It provides a major tool for enabling planners and policy-makers contribute to improved land administration by sharpening their competence in decision-making.

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1. INTRODUCTION: BACKGROUND INFORMATION AND THE ISSUES

In the last several years, Lagos Metropolis emerged as one of the fastest urbanizing areas in the West African Sub-region. Considering its population of over 13 million (Chiazor 2005), Lagos share the attributes of emerging mega-cities of the 21st century ((Fajuna and Omojola 2004). Brockerhoff 2000). As a major urban center, Lagos experiences abundant problems in the domain of land administration. The problems include an unreliable and chaotic land market in which the poor inventory of land records and inadequate update of the topographical mapping of Metropolitan Lagos hinder effective planning for both real estate and other urban services (Speer 1997; Chiazor 2005). This has been worsened by the lack of essential databases for accurate land information for planning and development purposes (Chiazor 2005). In the absence of a regular use of land information management system limited efforts were made to keep track of change in the rapidly growing city for policy making in land administration. The ubiquitous energy radiated by the rapid urbanization rate in the area not only created unprecedented consequences by diminishing the quality of the environment but it raises serous implications for land management in the state (Merem 2003; Fajuna and Omojola 2004; Iwugo 2003).

The factors fuelling the land crisis in the area which are not far fetched, consist of socio-economic, ecological and policy elements. The establishment of sophisticated remote sensing centers, with advanced hardware and software packages and highly equipped remote sensing aircraft demands significant investment, high level training, numerous years of committed effort to attain most efficient means of operation in the use of such sophisticated equipment (Abdel Rahman 2005). However, in such places as Lagos the use of information technologies in land administration is marred due to lack of spatial information tools and infrastructure, inadequate training, lack of coordination between agencies (Fajuna and Omojola 2004). There have also been widespread concerns about the activities of registered land surveyors who rubber stamp land documents carried out by inexperienced survey assistants without proper supervision on the job (Alao 2005). Additionally, the departments of survey still rely on obsolete land management approach not designed in meeting the current challenges of sustainability and management of land resources. More so, the centralized style of land administration in force since 1978 under the Land use act operates under a process that vests land controls in the hands of the state governor (Fajemirokon 2000; Taylor 1998; Omoeweh 2002). This legislation that overlooked the use of geospatial information systems as decision support system for land managers, not only inhibits public participation but it hampers efforts to promote public access to land information system.

Being a mega city and to tackle the issues (Strom 2003; United Nations 2004), up to date knowledge and skill would be required to capture and analyze land information in order to steer and control the city's expansion through infrastructure development. This will enable planners to make the right choices in planning and (spatial) designs (Ikhuoiah 1999; Fajuna and Omojola 2004; Mursu 2001). Because the basic land-use management problems are unsolvable without considering the basic geo-spatial approaches (Sodeiende 2002; Adeoye and Okunlande 2002), the Lagos Government is launching a trademark electronic devise for accessing land titles in an attempt to end current difficulties in ascertaining the authenticity of titles (All Africa 2005). The expectation is that the proposed approach will eradicate several difficulties including an environment for the perpetuation of fraud on land title documents'; an inability to meet the demands of the prospective land owners, and an inefficient administrative process which causes long queues. Accordingly, the Association of Professional Surveyors in the state of Lagos has expressed interests in modifying land information systems for meeting the needs of planning. The belief is that access to digital maps and detailed geographic information technologies will enable the association confront the challenges facing land administrators in the area of physical planning involving infrastructure, roads, environment and others (Alao 2005).

In this setting, remote sensing and Geographic information systems (GIS) have the capacity to provide valuable and timely information about natural resources, urban change and the extent of environmental change being experienced in Lagos as an important basis for sustainable planning for land management and decision making in the state. While both devices can provide effective tools for decision makers, they are important geometric tools, which are used extensively in land management (Abdul Rahman 2005). With the type of problems currently faced by land administrators in the state of Lagos coupled with the rapid pace of urbanization leading to environmental decline (Merem 2003; Fajuna and Omojola 2004; Iwugo 2003), a GIS and remote sensing approach is a highly favored approach to the effective management of land use and land resources in the state. With spatial information technology tailored in such a way to suite a particular geographic area, critical indicators of change from activities like agriculture, housing road design can visually be captured for use in land administration and policy (Sodeinde 2002). Considering the benefits of spatial technologies, it is therefore paramount that such an improved approach be designed for land management in the Lagos area.

2. PURPOSE AND ORGANIZATION

This study investigates the implications of the rapid expansion of metropolitan Lagos for land administration using Geographic Information Systems (GIS) and Remote sensing technology. This is intended to enable planners and policy-makers contribute to improved land administration and enhance their competence in decision-making. The study contains three sections. Section one offers a description of the methodology and the study area. Section two presents the results and data analysis while section three discusses findings and their significance to land administration. The fourth section offers recommendation for change in land administration policy. The final section summarizes the importance of the study to the

future of land management in the study area. This study has three objectives. The prime objective is to update the literature while the second objective is to design a decision support tool for land administration. The third objective is to demonstrate how latest advances in geo-spatial information technology can guide planners and policy makers towards an improved land administration.

3. MATERIALS AND METHODS

3.1 The Study Area: The State of Lagos

Lagos state is situated in the South Western Nigeria within latitudes 6 degrees 23'N and Longitudes 2 degrees and 3 degrees 42 E. The state is bounded from the North and East by Ogun State, in the West by the Republic of Benin and the South by the Atlantic Ocean. The total land mass of the state stretches over 3,345 kilometers. While the state appears physically smaller, it is ranked as the most highly populated state in the country with an estimated population of about 10 million inhabitants representing 10 % of the total population of Nigeria. Because water is the most significant topographical feature in Lagos State, water and wetlands cover 40% of the total land area in the state. Other notable features in the state consist of Lagoon and creeks, wetlands, barrier islands, beaches and estuaries (Iwugo 2003).

Lagos consists of two main regions, namely the Lagos Island and mainland, the original city and Ikoyi, Victoria Island, and the Lekki corridor areas are referred to as Lagos Island while the mainland encompasses other parts of the state. The more built up mainland and Lagos Island, which make up what is referred to as the Metropolitan Lagos is inhabited by about 80% of the population of the state. Major developments on the area in the middle of last century show that the area not only experienced a rapid expansion, but it engulfed adjacent towns and villages (Abiodun 1997; Iwugo 2003; Ogunleye 2001). Considering the previous growth trends, Metropolitan Lagos at present extends to over 1,068 (km^2).

Current projection in 1996 regarding the hierarchy of Global cities ranks Lagos as the fifth largest city with 12 million inhabitants. At the same time, other studies put future population of Lagos by 2015 at 24.6 million as third largest city of the world with implications for international capital and Sub Saharan Africa (United Nations 1996 and 2001); Alkali 2005). Based on this concept, global capital utilizes urban areas such as Lagos as the organizing node in the spatial organization of international production and markets (Freidman1986). The population of the Lagos urban agglomeration stayed at 10.3 million in 1995 at a growth rate of 5.8% annually. It went up by more over 300,000 persons per year during the 1980's and 1990's (United Nations 1996). The population density along the built-up metro section also ranges from 20,000 persons/sq km. The rapid expansion of Metropolitan Lagos with its role as a center of global capital seems to have surpassed efforts in physical planning as well as the development of infrastructure facilities in meeting the needs of the inhabitants. See Table 1a for the population monitor of the state.

Under this setting, the area's rapid expansion continues at an alarming rate with sporadic engulfment of adjacent towns and villages through dredging of land previously covered by water and mangrove swamps. This in turn puts enormous strain on the areas scare land base and the aquatic ecosystem. This is evident considering the growing discharge of wastewater into the Lagoon due to a growing population (Iwugo 2003; Table 1b). While previous efforts to address land management resulted in land reclamation, which was used in providing thousands of hectares of land in Lagos, and housing for many residents (Table Ic and 1d). Insufficient attention was paid to periodic geo-spatial inventory and assessment of available scarce land resources for policy and sustainable management of these lands with the latest advances in management information systems for land administration. To keep track of the rate of urban expansion onto available land area in the state, there is a need for the use of latest advances in spatial information technologies such as GIS and Remote sensing technologies in order to guide policy makers towards effective land management in the state (Fajuna and Omojola 2002 Sodeiende 2002; Chiazor 2005).

Table 1a Lagos State Population Monitor

Year	Population	Global Ranking
1997	11.5	12th
1998	12.1	10th
1999	13.4	8th
2015	24.5	3rd

Source: United Nation World Population Monitor 1998/1999

Table 1b Wastewater Flows From Metro Lagos to The Lagoon 1995-2010

Environmental Indicators	Year 1995	2010
Population in million	7.01	27.6
Domestic Wastwater	437,490 (54%)	?
Total Waste Water (m3 /dy)	811,300(115.71/ c/d)	1,663.087

Source: Lagos Ministry of Environment and Physical Planning 1996

Table 1c Planned housing schemes in metropolitan Lagos

Housing agency	Scheme	Remarks
Lagos Executive Development Board, 1955 -1975	Slum clearance of Central Lagos, 1955 to early 1960s, Olowogbowo Rehousing Scheme, Lagos Housing Scheme	1,847 families housed in Surulere. 1,337 families resettled in low-income rented houses. Subsidized by Ministry of Lagos Affairs
	Other housing schemes in Surulere	14,537 family units (dwellings) provided. In all, 128,800 people were provided with housing
Lagos State Development and Property Corporation (LSDPC), 1972-1979	Resettlement of slum dwellers from Central Lagos to Ogba and low-income housing in Isolo	1,000 families housed
Federal housing	Under 1975-1980 and 1981-1985 plan periods	6,000 housing units[a]
LSDPC, 1979 to date	Low-income housing	16,878 housing units
	Medium-income housing	1,790 housing units

Source: Lagos State Development and Property Corporation Various Years

Table 1d Units of Planned Houses For State

Units	Locations
1,500	Abraham Adedsanya Estates -Aja
152	Ayangburen Phase II Ikorudu
112	Lekki Phase 1 Oba Adeyinka Oyekan
336/304	Ojokoro Housing Schemes Phases I and II
79	Lekki II
56	Amunwo-Odofin
150	Ibeshe

Source Lagos State Government 2004

3.2 Methods Used

This paper stresses a mix scale approach involving the integration of primary and secondary data provided through government sources and data bases from other organizations. The raw spatial data and satellite images used in the research came from The United States National Aeronautical and Space Administration NASA. This information was analyzed with ARC View GIS and remote sensing technology.

3.3 Data Acquisition and Processing

Landsat Thematic Mapper (TM) and Enhanced Thematic Mapper (ETM+) data pair of December 18, 1984 and February 6, 2000 covering Lagos, Nigeria was acquired from the University of Maryland free Online Data Services. The images were imported into ERDAS Imagine Image Processing Software for further processing. Since the images were in single bands, layer stack technique was performed to group the bands together. This was followed by performing further Geometric corrections of the images to remove few scattered clouds in the image. Both images were projected to the Universal Traverse Mercator (UTM) coordinates zone 31. The spheroid and datum was also referenced to WSG84. Histogram Equalization enhancement technique was performed on all the images, and subset to an area of approximately 2,383.994 km^2 to cover Lagos and its vicinity. The images were later displayed as false-color composites with band combination of red as band 7, green as band 4, and blue as band 2. All the images were later categorized using unsupervised classification technique.

4. RESULTS AND DISCUSSION

Table 2 and figures 1 and 2 shows the results of the classification for 1984 and 2000 images. From table 2, land area under water declined from the initial estimate of 29,040 hectares (ha) in 1984 to 24,708 in 2000. This represents an overall decrease of 14.91 percent. The size of area covered by vegetation, which include coastal mangrove, forest and grassland areas experienced a significant decline from 180,384 ha in 1984 to 140,568 ha in 2000. While the area of Lagos containing water and vegetation were experiencing a decline, agriculture and settlement was increasing. For example, between 1984 and 2000, agricultural activities

increased from 4,615 ha to 9,806 representing an overall change of 112.48 percent. The size of land designated as settlement also showed a change of 159.02 percent in the same time.

Figures 3 and 4 also show the results of the false-color composites for 1984 and 2000 images. In these images, the relatively dark-brown areas represent the built up and heavily populated area, whereas greenish areas are vegetation. The deep blue regions are the water bodies. While these figures show the tremendous rate of urban expansion between 1984 and 2000, it is safe to say also based on figures 1-4, that the population of the Lagos seems to have doubled between 1984 and 2000. This not only puts a tremendous pressure on the resources of the city, but it has the potentials to aggravate flooding of the Lagos area due to its location on a floodplain.

These results suggest that the state and national administration should adopt policies that would protect the land mass of this vulnerable city by taking advantage of the latest advances in geospatial information technologies given their usefulness as advanced warning information devices for boosting decision support system in land management in the area. The result also indicates that geospatial information technologies are the key to planning, management and administration of land in areas such as Lagos. This study serves as a road map towards the development of the much needed geospatial information infrastructure for the effective administration of land areas under the pressures of urbanization.

Table 2: Results of the classified 1984 and 2000 images

Classes	Area (ha) in 1984	Area (ha) in 2000	% change (1990-2000)
Water	29,040	24,708	-14.91
Settlement	24,360	63,317	159.92
Vegetation	180,384	140,568	-22.07
Agriculture	4,615	9,806	112.48

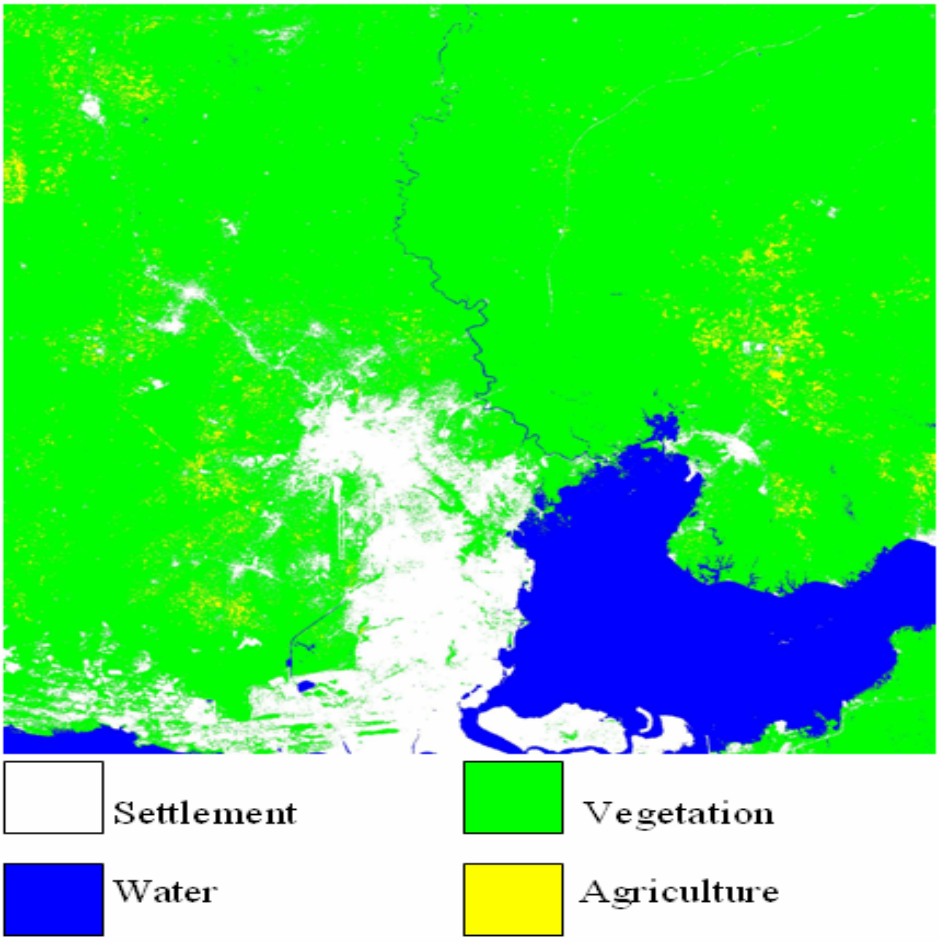

Figure 1: 1984 Classified Landsat Image of Lagos and its Vicinity

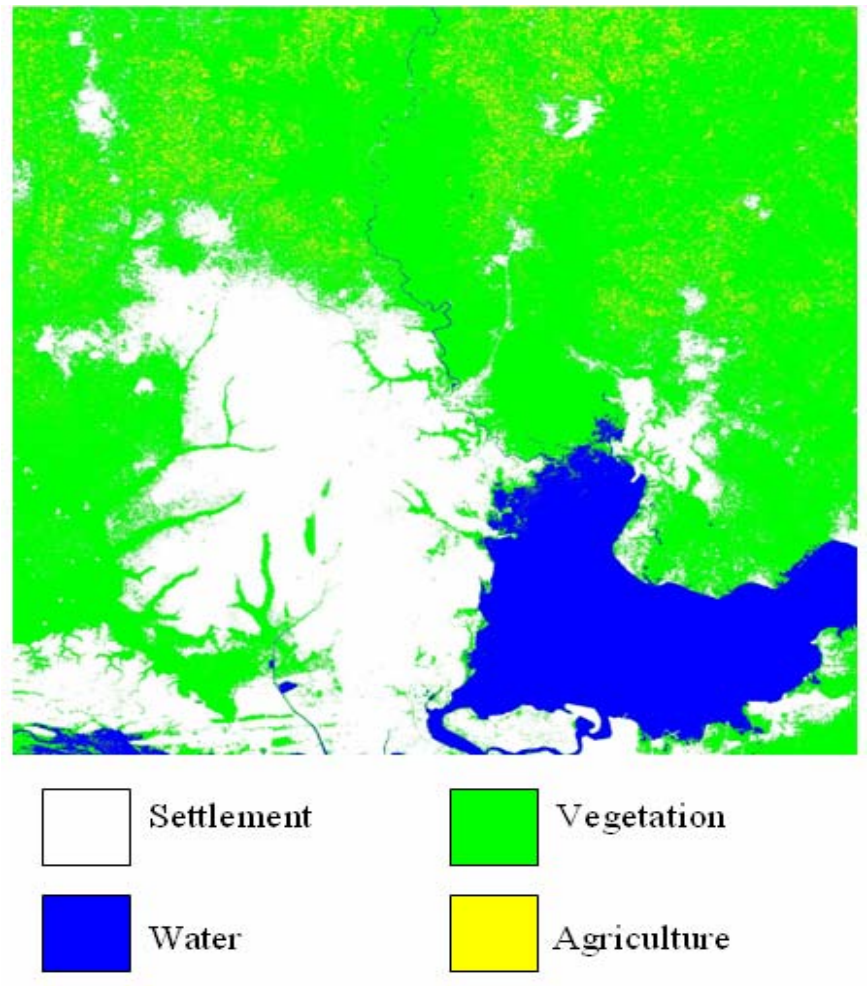

Figure 2: 2000 Classified Landsat ETM+ Image of Lagos and its Vicinity

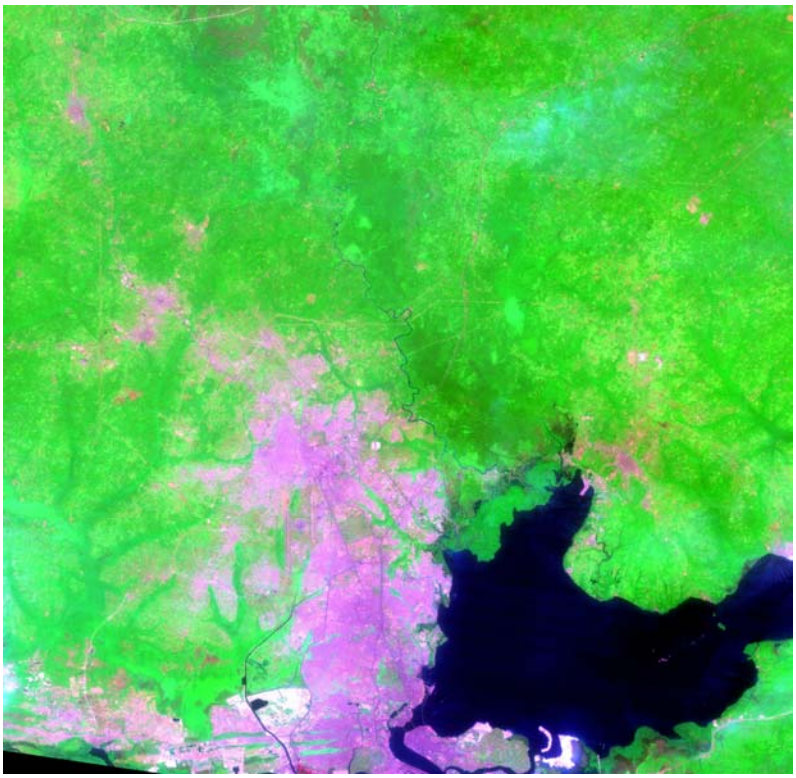

Figure 3: 1984 False-Color Composite (742) Landsat Image of Lagos and its Vicinity

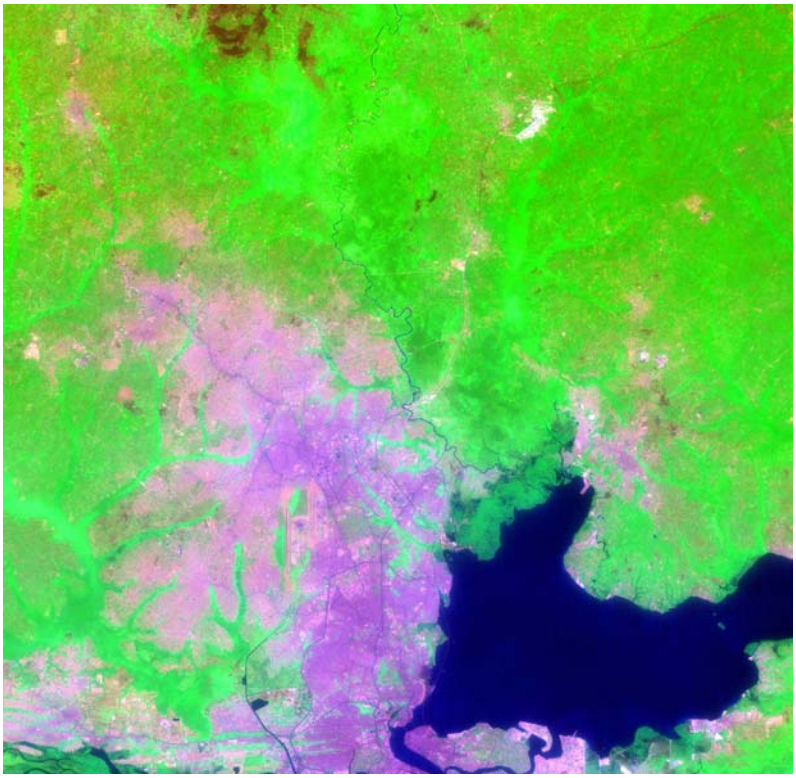

Figure 4: 2000 False-Color Composite (742) ETM+ Image of Lagos and its Vicinity

5. POLICY RECOMMENDATIONS

Five recommendations for land management strategies and decision-making are listed below

1) Encourage Community Involvement in Land Management and Administration

Experiences show that communities are most often at the receiving end of land problems confronting the state of Lagos. This is evident with the pace at which the rapid expansion of Metro Lagos into rural communities has affected community land base over the years. Because communities are much closer to these problems, efficient land management under the current circumstances demands active involvement of local communities in maters associated with land administration. This is attainable through the provision of technical assistance that gives local entities and community organizations such as non-profit organizations real involvement in planning and implementation of novel land programs on areas adjacent to their communities.

2) Provide Support for the Education and Training of Land Administrators

With too few trained people to upgrade obsolete spatial data infrastructure, land administrators are unable to carry out their assigned tasks. As a result, decision-makers lack access to valuable information and the appropriate decision support tools for land administration. To tackle these issues, up-to-date knowledge and skills through education for land administrators would be required to capture and analyze spatial information in order to steer and control the city's expansion. This will enable land managers make the right choices in planning and (spatial) designs associated with land use. In light of this, there is a need for training in order to boost the skill acquisition that is necessary in meeting the challenges facing land administrators. Modest investment in education of land administrators can make big improvement in the capability of decision makers in tackling complex land issues.

3) Allocate Funds For Upgrading Spatial Data Infrastructure

The current assessment of the state of land information data in the state and other parts of the country point to a continuous reliance on obsolete data infrastructure that serves little purpose in the information age. With the socio-economic relevance attached to land under the aegis of global cities, the state of Lagos should encourage funding programs that promote the rapid upgrade of spatial data infrastructure for the efficient management of land information. Government funds should be directed at the procurement of sophisticated modern technologies to sustain decision making in the land sector for the public.

4) Strengthen Existing Policy With Emphasis on Periodic Geospatial Inventory of Land

For decades, land managers operated under a command and control mechanism which vests authority on allocation on the state executive branch. This made the modernization of land information system difficult. Accordingly, insufficient attention was paid to a periodic geo-

spatial inventory and assessment of available scarce land resources for policy and sustainable management with the latest advances in management information systems. Considering the defects in policy and concerns about the unreliability of land information system, and the current move to boost land management, this paper suggests that the state of Lagos strengthen its current programs with policy emphasizing the commissioning of periodic geospatial inventory of land resources in order to evaluate the current and future needs.

5) Design a Regional Land Information System for Monitoring of Change

In recent years, the United Nations through its document Agenda 21 reiterated the essence of geospatial information system for planning and development in developing nations. However, the recourse to geospatial information as suggested in Agenda 21 of the United Nation has not fully been integrated into the administrative framework of land management in state of Lagos. Yet considering the rapid urbanization of the state, the design of a regional land information system along the lines of Agenda 21 is highly needed. Monitoring the extent of change and keeping track of land use trends in the state must be the main aim of the proposed Regional Land Information System. This will not go a long way in sustaining land management, but it will augment the decision support system guiding land administration with the latest advances in spatial information technologies

6. CONCLUSION

This paper has shown that Geospatial information technologies are the key to planning, management and administration of land in areas such as Lagos. The tools and methods used in the study serves as a road map to the development of the much needed geospatial information infrastructure for the training of land managers and the effective administration of land areas under the pressures of urbanization. Geospatial information technology as used in this paper also stands as a necessary tool in the design of decision support systems in sustainable management of land resources and policy development. Not only is the combined use of GIS and remote sensing technologies essential for the development of an innovative spatial data infrastructure, it is an indispensable device for decision making across all sectors of land management and the environment in the area. Other findings in the paper point to the pace at which insufficient attention were paid to a periodic geo-spatial inventory and assessment of available scarce land resources for policy and sustainable management of these lands with the latest advances in management information systems for land administration. To deal with these problems the paper offered several recommendations that ranged from community involvement to education. The idea behind the emphasis on education stems from the relevance of up-to-date knowledge and skills that would be required to capture and analyze information in order to steer and control city's expansion as well as infrastructure development so that land administrators can make the right choices in planning and (spatial) designs in the area.

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BIOGRAPHICAL NOTES

Dr. **Albert J. Osei** is an Associate Professor of Physics in the Department of Mathematics, Physics and Computer Sciences at Oakwood College in Huntsville, Alabama. He obtained his BS degree in Physics from the University of Science and Technology in Ghana and his MS and Ph.D. degrees in Physics from Queen's University (Canada) and Alabama A&M University respectively. During his tenure at Oakwood College, he has taught a range of courses in Physics, Mathematics and Computer Science. Dr. Osei has received several summer research fellowships which have made it possible for him to work with high caliber scientists and engineers in reputable national laboratories in the United States. He has also received grants from federal and private agencies for research and educational purposes. Dr. Osei's research interests include: (1) Modeling of ecosystems for sustainability (2) Monitoring of urban growth using remote sensing, GIS and spatial metrics (3) Optical methods for monitoring soil moisture (4) Remote sensing of ocean and atmosphere properties and (5) Use of remote sensing and GIS technology in managing natural resources. Dr. Osei has published in refereed journals and made several presentations. He is a member of the Optical Society of America (OSA), The International Society for Optical Engineering (SPIE), Biophysical Society, American Mathematical Association (AMS) and the Alabama Academy of Science (AAS).

Dr. **Edmund Merem** completed his B.A. and M.E.S. at York University, Toronto and then his M.A. at Pontifical Lateran University. Vatican City. He graduated with a Ph.D. from Jackson State University, Mississippi. Dr. Merem has 10 years of experience in Global environmental planning and environmental accounting for oil and gas in Canada and the US, and hydro-politics of the Middle East and Africa. He has written several research monographs and papers that have been published in academic journals and major conference proceedings. His new book entitled *"Environmental Accounting For Changes In Farmland Use: A Canadian Case Study"* was recently published by Edward Mellen Press. He worked as an Environmental Analyst in the Environment Bureau of Agriculture and Agric-Food Canada and he also worked briefly as an accounts clerk in the Federal Ministry of National Planning in Lagos Nigeria. He is very fluent in Italian and a number of European and African languages. Dr. Merem is currently an Assistant Professor of Environment and Land Use in the Urban and Regional Planning Department at Jackson State University.

Dr Merem's research interests which is always at the epicenter of his teaching is anchored in bio-centric discourse, intergenerational fairness, environmental modeling and the application of geo-spatial information systems with a view to securing a better solution for global environmental decline and development issues in Africa without negating interspecies rights and dignity in natural resources management in the region. This interest grew out of his early educational experience in Canada and the Vatican City, where he pursued an inter-

disciplinary program in Environmental Planning in International Development, Moral Philosophy and Ethics.
Accordingly, his current research interest upholds the inter-linkages between society, environment and economy under the aegis of ecosystem approach, sustainability, social-justice and the use of geographic information systems and remote sensing technologies in informing decision making in the management of environmental resources such as sensitive wetlands, land cover, cultural landscapes, water bodies and other types of natural resources in Sub-Saharan Africa. Under this setting, his goals in research are aimed at fostering a better understanding of the benefits of contemporary valuation tools in the area of international environmental planning, environmental and natural resources accounting and particularly agricultural land use change, oil and gas depletion. Working in this area has led him to develop a strong interest in research involving the application of valuation tools to land use change and natural resources depletion. Developing the appropriate tools that identify the driving forces of land use change and natural resources depletion can help guide future policy makers towards conservation and minimization of resource degradation.

Growing interests in this specialty has also strengthened his core beliefs in research that recognizes the role of ethical values in decisions we make concerning the use of geo-spatial representation of the state of the environment and society, nature of trans-boundary water conflicts and equitable access to common resources among nations in Africa. Considering the recurrent debates shaping the legality of trans-boundary access to common resources in the region, it is his belief that current research in environmental planning has an obligation in projecting a much humane use of latest advances in geo-spatial information technologies as worthy tools for encouraging the multinational management of shared resources in a needy region. Overlooking this concern to some degree fuels the embers of environmental conflict and information domination at the expense of poor nations in an already fragile environment. All these attributes make the task of land cover mapping using satellite-derived imagery and GIS particularly challenging. Instilling this awareness as he has always done in his teaching and research while developing the right ethical parameters to guide our conduct in these instances can persuade policy makers and future leaders to reconsider the way we act collectively in our relationship with nature and the welfare of other humans in an ever-changing world in places such as Africa.

Dr. **Yaw A. Twumasi** is currently a Reserach Assistant Professor of Remote Sensing and Geographic Information Systems (GIS) at Alabama A&M University. He received his Bachelor of Arts degree in Geography and Master of Environmental Studies with concentrations in Environmental Planning and GIS both from York University, Toronto, Canada. He also holds a Ph.D. degree from Alabama A&M University, U.S.A. Dr. Twumasi is an author, experienced researcher, scholar and analyst in a number of areas such as protected area planning, environmental management and the application of remote sensing and GIS technology in natural resources management. He has published and authored or co-authored several publications in a variety of refereed journals and international conferences and symposia proceedings addressing the use of remote sensing and GIS technology in assessing and managing Earth's natural resources. His recent book on "Park Management in

Ghana Using Geographic Information Systems (GIS) and Remote Sensing Technology" published by Edwin Mellen Press, New York, addresses the use of both technologies in managing Park resources in Ghana. Dr. Twumasi has also been inducted into this years' Marquis Who's Who in America award for his outstanding publications. He is currently involved in the study of National Parks planning and management, environmental degradation, vegetation assessment and urban sprawl using satellite imagery and aerial photograph in Niger, Burkina Faso, Mali and Ghana. Dr. Twumasi is also involved in the use of remote sensing data to assess land use and land cover change study in other sub-Saharan African countries. He is also proficient in image processing, classification and analysis, GIS database construction as well as the development of policies using GIS and remote sensing techniques to guide natural resource managers. Dr. Twumasi is a member of the American Society for Photogrammetry and Remote Sensing (ASPRS), the Remote Sensing and Photogrammetry Society of Great Britain (RSPSoc), African Association of Remote Sensing and the Environment (AARSE), IEEE Geoscience and Remote Sensing Society (IGARSS) and the Alabama Academy of Science (AAS).

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