

The Use of Remote Sensing/GIS in Planning of Sustainable Land Management in Nigeria

RECTAS Experience

J.A. OGUNLAMI

Director
Regional Centre for Training in
Aerospace Surveys, (RECTAS)
Ile-Ife, Nigeria.

1. Abstract

In line with modern technologies, the Regional Center for Training in Aerospace Surveys (RECTAS), Ile-Ife, Nigeria has invigorated its consultancy services in the areas of the applications of modern technologies of Remote Sensing and Geographic Information Systems (GIS) for Digital Topographic Base map production, Thematic mapping, Base line data production for environmental monitoring and protection, urban and regional planning. They also deal with sustainable urban management programs including planning for sustainable land management to enhance the training and critical mass of African manpower development at the Center that are relevant to current demands for digital spatial data.

Only recently RECTAS was commissioned to carry out "A Map Situation Survey of Ibadan" and produce a Digital Base map of Ibadan, Oyo State, Nigeria at the scales of 1/25,000 and 1/50,000 covering the entire Ibadan city and environs - the said largest city in Africa South of the Sahara. This is one of the twelve cities one each in twelve countries of the world, selected as demonstration models in preparation for the World Summit, Habitat II in Istanbul, Turkey in June 1996. This project was christened "Sustainable Ibadan Project" (SIP) under the World Bank, UNDP, and the UNCHS (Habitat) funded Urban Management Program (UMP) for the entire world.

This was to provide decision makers, engineers, planners and other map users, all together called "stake holders", with better tools for planning of sustainable land management using the bottom-up approach.

This paper presents the RECTAS experience in this Digital Mapping project, amongst others, in providing various digital layers for various features and various attributes using the Arc/Info software in combination with the ILWIS software (GIS) systems.

The interesting result of the Ibadan experience is presented here to illustrate the Nigerian example in the use of Geo-information Systems for planning sustainable land management because. As a result of the success of the Ibadan experiment, the Nigerian Government has already planned to replicate the same project in other state capitals and major cities in Nigeria. RECTAS was happy to be part of this success story.

2. Introduction

One of the greatest challenges to decision-makers, engineers, planners and managers is the assurance of Sustainable Land Management (for both Urban and Rural Lands). This concerns exploration and exploitation of a Nation's natural and Environmental resources, provision of food, social services, education, health, infrastructure development, transportation (road and railway networks), communication and telecommunication, industrial development, population control and protection of the environment for the accelerated and orderly development of a country and its economic recovery efforts without destroying the environment for the generations to come.

The emergence and use of the modern technology of Geo-information has been found to be invaluable in developing an Environmental Information and Land Management Database as one of the vehicles for Sustainable Land and Environmental Information Development and Management for both urban and rural lands. A good part of the infrastructure in Ibadan is old, under-developed, not adequately developed and also under increasing pressure as it does not measure up to the advanced technologies of the present age thereby reducing its capacity for global interaction and interdependence for development.

This paper deals with the scope of Land Management and the challenges of urban planners and managers in ensuring that towns and cities remain both economically and environmentally sustainable. Ibadan in Nigeria a sprawling and not properly planned city, is a model under the Sustainable City Program of UNCHS (Habitat) program for the whole world.

Urban sustainability is highly correlated with the natural resources capacity of the environmental system. Long-term sustained development cannot occur in a situation of deteriorating environmental circumstances, while unplanned and unmanaged urban growth can lead to irreversible destruction of the natural resources environment. Population pressure on the productive capacities of the natural environment have resulted in an increasing number of displaced people as environmental refugees in addition to economic refugees.

In recognition of this development - environment relationship, the United Nations Center for Human Settlements (UNCHS) - Habitat launched a global concern "The Sustainable Cities Program" (SCP) as the operational arm of the Global World Bank/UNDP/UNCHS joint Urban Management Program (UMP) for the entire world. The principal goal is to deal with the challenges of achieving sustainable urban development.

To demonstrate the practicality of this (SCP) initiative and in preparation for the World Summit Habitat II in Istanbul, Turkey, in June 1996 twelve countries were selected in the whole world (with one city per country) as demonstration models. The experiences gained from these were to be replicated in other cities of the world. Nigeria was lucky to be one of these twelve countries and Ibadan in Oyo State was the city chosen in Nigeria. The SCP has, therefore, been adopted for the development of the city of Ibadan said to be the largest city in Africa South of the Sahara with a sprawling built-up space of about 20km by 20km and a population of about 5million. This program was christened "Sustainable Ibadan Project" (SIP). The experience gained here, if successful, will be replicated in other cities in Nigeria.

3. The Need for a Digital Base Map of Ibadan

The Regional Centre for training in Aerospace Surveys (RECTAS), Ile-Ife, Osun State, Nigeria under the auspices of the Economic Commission for Africa (ECA) was commissioned by UNCHS - Habitat, Nairobi, Kenya to carry out "A Map-Situation Survey of Ibadan", ultimately producing a Topographic "Digital Base Map of Ibadan". Map Revision were done using SPOT satellite imagery at the scales of 1/25,000 for the core areas of Ibadan and 1/50,000 covering the entire Ibadan city and environs to provide an up-to-date Digital baseline data (on digital files CCT & CD-ROM). Several feature layers were created using ARC/INFO GIS software serving as a powerful Geo-information tool for sustainable urban land management for Ibadan. About eighteen (18) layered files were created (these included vegetation types, road networks, hydrographic network, urban growth pattern, land use types, contours, composite maps etc.). This was to provide decision makers, engineers, urban planners and managers as well as various map users (including Inter-Governmental Organizations (IGOs) Non-Governmental Organizations (NGOs), Community based organizations (CBOs), Local Government Organizations (LGO) politicians, etc.) all together called "Stake holders" better tools for planning for Sustainable Land Management using the "bottom-up approach". This is a method of involving all stakeholders in the planning, funding and execution of a project from the beginning as a co-operation/collaboration effort between all beneficiaries Government and the private sectors, with the latter as the engine of growth rather than leaving Government alone for the planning. Expectation of Top Government funding and execution has been discovered to be the cause of failure of most projects. Therefore, they were found not to be a very successful strategy for project execution in modern times with dwindling Government resources due to the bad economy as a result of bad planning and management of resources, particularly in developing countries.

4. Terms of Reference for Map Revision and Digital Production for the Sustainable Ibadan Project (SIP)

The city of Ibadan and its environs needed to be digitally mapped, the product from which was to be a working base map for the eleven (11) local governments of Ibadan. The revised map was to cover the inner and the outer zones including the rural region of the metropolitan space. It was expected that the digital product would be used not only by the physical planning department of the eleven local governments of the metropolis for land management and environmental monitoring, but also by all other individual and group interests concerned with the development of the metropolis. Thereafter this will be replicated in other cities in Nigeria and other African countries.

The scope of the mapping project was the following:

- Review of the existing base maps covering IBADAN with a view to selecting the appropriate ones for revision to 1995 level.
- Use of SPOT satellite data (Panchromatic mode, imaged in December 1993), to effect the map revision that was requested for.
- Production of the revised map at two scales; one map was initially requested for at 1:25 000 covering the inner part and later four (4) map sheets were requested for to cover the eleven (11) Local Government Organizations in four adjoining sheets which when adjoined extend to just above 27.6km x 27.7km; and one sheet at 1:50 000 covering a larger area of about (34 km x 37 km) of Ibadan and environs.

- Undertaking the map production in conformity with the standards and regulations for map production as laid down for production of maps by the Federal Survey Department of the Federal Government of Nigeria.
- Referencing the revised map to geographic and UTM co-ordinates, and also providing the appropriate reference to the map sheets.
- Digitization of the revised map in layered features, using ARC/INFO and any other functional GIS software, and presentation of the outputs in layered files, to include files of high accuracy digital terrain model (DTM). About eighteen (18) layered files were created at the two scales on AO format and are also available on A4 sheets

5. Map Situation Assessment and Base Map Selection for the Revision

5.1 The Rational for the Survey

To prepare a Working digital base map for multi-sectoral and cross-sectoral uses it is necessary to review the available maps for two reasons, one to determine the existing information and gaps and the other to select from the existing base maps the most appropriate ones as revision documents. A comprehensive survey of the map situation of Ibadan City was, therefore, carried out by RECTAS, which helped to determine the following:

- the responsibilities of the institutions which are active in the mapping as well as a general assessment of their capabilities regarding equipment (including modern digital equipment) and staffing;
- available maps over the city, their dates of compilation and revision, scale, format, area of coverage, number of sheet compiled, information content, quality, sources of mapped information, as well as base-map used, its source and map projection etc.

The survey also helped to identify the on-going or planned mapping projects, and agencies or institutions or companies involved; date and output; the available aerial photographs and satellite imageries, the scale, date, type, format, the area covered and the coverage gaps that need to be addressed etc.

5.2 Selection of maps for revision and information on maps to be produced.

In the assessment of the existing base maps two of them were found suitable for integration and revision to produce the SIP working base map. These were the National 1: 50 000 Topo maps of the 1964/67 series and the 1: 10 000 scale of 1991 with limited contours in the central core areas only. The maps to be produced were to carry the following information: water bodies, (lakes, rivers, ponds, etc.); contours with a vertical interval of 10m; digital terrain model (DTM); built-up areas with indication of urban growth patterns since the last Ibadan base map was produced in 1964/67; highways and arterial roads, railways; industrial areas; special institutional land uses; health and educational facilities; special environmental features (open spaces, water resources, main environmental hazards like waste disposal or dump sites, etc.); hazardous lands (slopes, flooding areas, etc.); agricultural lands; place names etc.

6. Digital Map Revision using Satellite Imagery

6.1 Data Processing and Interpretation

The revision was to reflect the 1995 situation at two scales: 1/25 000 for the inner area of about 27.6 km x 27.7 km and an inner outer space 34 km x 37 km at 1/50,000 scale. SPOT Panchromatic data was considered to be most appropriate for the revision because of its higher resolution for topo mapping but the data was supplemented with spot XS to enhance thematic feature interpretation and extraction for better quality.

The digital image processing was effected at RECTAS with the Multiscope software. The processing had mainly to do with spectral feature enhancement of linear and aerial topographic images (roads, transmission lines, rail lines, buildings, agricultural fields, vegetation types, watersheds etc.). Subscenes of the enhanced images were printed on A4 format thermal (heat-resistant) wax-coated paper and transparency, at the two mapping scales. Each subscene image area being 20cm by 20cm adjoined to make a mosaic to cover the map frames of the UTM projection prepared as revision overlay. Three advantages for feature identification and change detection were offered by the combined use of the two satellite data sets (SPOT and X5 modes). To conform to the standard regulations for the production of topographic maps the four adjoining sheets of the inner coverage each have a square map area with the dimension 55.3cm by 55.3cm while the outer coverage was 70cm x 74cm.

6.2 Field Truthing and Editing

There were two levels of field checking, namely: (a) checking the details of the areas covered by the 1991 map sheets at scales 1/10 000 for any changes which might have occurred in the last 4 years; and (b) looking for possible misinterpretations, wrong annotations, object misplacement, object omissions, feature and place names etc. with the 1964/67; checking the details of areas not covered by the 1991 map sheets used along with the basemap at 1/50 000 scales. In case of the latter, the reference basemap was the 1964 to 1967 topographic maps, the information of which was considered grossly outdated. Field editing required that all functional public features/structures be identified in the field and marked on the imagery and these were carried out extensively by RECTAS.

7. Manual Drafting and Photographic Reproduction

To obtain a good manuscript for digitizing and at the same time a set of interim deliverables for use by the SIP pending when the digital products would be ready for use, the following cartographic map drafting processes for conventional topographic map revision were passed through scribing sheet on overlay:

- scribing black information (frame lines, planimetric features like roads, transmission lines, etc.)
- scribing the blue information (hydrographic lines e.g. rivers, lake borders, etc.)
- scribing the brown information (contour lines, other landform features, e.g. rock outcrop, etc.)
- add black text (title, graticule value, legend, scale, etc.)
- cut and peel for screen of 60% dot screen for dense built-up and 40% dot screen for light built-up
- add blue text, grid values and legend
- cut and peel river and lake infill for 40% dot screen in blue

- mount the brown text of contour values, fill in the three classes of roads and add the brown legend
- mount the forest names and symbols, and add legend; cut and peel for light forest, and savanna woodland and open grassland/shrub, limit of Forest Reserve/plantation for 40% dot screen (all these cartographic processes were carried out at RECTAS)
- reproduce photographically on negative line film and duff out mistakes
- obtain combined positive film for each layer of grouped map information, namely, BLACK information, BLUE information, BROWN information and GREEN information.

The photographic reproduction was carried out at a private survey firm in Lagos, Nigeria called “Pan-African Surveys”.

8. Ibadan City Forum and “Ibadan Declaration”

In order to sensitize and create the necessary awareness in a good cross-section of all the “Stake holders” in the Ibadan community and to ensure carrying most people along on the (SIP) project, a city Forum/Consultation was held during 23 - 27 October 1995. It focussed on environmental issues for managing the Sustainable Growth and Development of Ibadan and introducing the new “bottom-up approach” principles to the passing of a declaration tagged “Ibadan Declaration” in which some key development and environmental issues were raised.

During these City Consultations participants had the opportunity to evaluate the Base map and criticize it in order to improve on the accuracy. The need to address these issues was expressed to be focused on the principles of the SCP. The priority issues stated in the Ibadan declaration include the following: water supply, electricity, urban waste management, food security, drainage and flood control, hydrological surveys, protection of urban water sheds, provision of roads, rails, communication, urban poverty alleviation, neighbourhood upgrading, transportation and air pollution, elimination of street trading, development of a comprehensive metropolitan plan, and an environmental and land management information system by creating a digital data base for their management.

9. The Digital Base Map Production

Again in order to harness available local capacities and capabilities to enhance efficiency to enable the project to be completely executed using 100% indigenous capacity and also demonstrate the advantage of co-operation and collaboration of the public sector and private sector, this aspect of the job was executed between RECTAS and a private Survey Firm in Ibadan, the “Niger Surveys and Consultants”.

Digitizing was done at both RECTAS and Niger Surveys and Consultants. Digital files were created on a theme-by-theme basis and then separated into sub-thematic layers. The road coverage was separated into six separate thematic layers, each depicting one of the six road classes. The vegetation and the built-up areas layer had the following sub-classes: *light forest, *savanna, *open grassland, *built-up. The hydrographic information was given two coverages, namely, the stream network and the lakes. There were also some principal land uses presented on different files, namely: *industrial, *agricultural, *recreational, and *solid waste dumping sites, etc.

These were put on separate layers as thematic base for any secondary and tertiary studies relating to the main theme of sustainable development. The whole task was made possible by the use of the logical selection capabilities of the ARC/INFO and ILWIS software in combination. A digital terrain model (DTM) was created for possible uses for engineering and land capability and sensitivity analyses. For areas with sufficient spot heights, contours were interpolated and used as supplementary data to fill the major gaps in the central core area. This was done to reduce the discontinuity in the terrain model generated. The DTM generation was performed using the ILWIS software. (This demonstrates the practical use of ILWIS software capability in combination with ARC/INFO software for capacity enhancement).

10. Dynamics of Digital Maps for Sustainable Urban Land Management

By creating the digital files it became feasible to manipulate the soft version in many ways. For example the four separate adjoining sheets could be merged easily to enable the extraction of portions of particular interest; a global picture of the urban and peri-urban areas could be presented theme by theme or in polythematic way by overlaying the various files. Scale variation for the presentation of features in the same format becomes possible and this offers the possibilities for enlarging and for insertion of additional value added information as and when desired.

Presented in this paper are whole-scene print-outs of the city and its immediate environs for the various themes on A4 Format at a scale of 1/150 000, and on the same AO format at a scale of 1/50 000 or 1/25,000. However, the information content will still be at the level of detail corresponding to the original scale of the digital compilation. The automated scale variation however facilitates any type of revision either by densification of map new details or by updating with recent changed information. For these reasons it has the requisite dynamism that a map for efficient multi-purpose, multi-sectoral and cross-sectoral land use planning should have to be a tool for planning sustainable land management with emphasis on urban land management as in the project presented here.

11. Some Common Areas of Environment - Sustainable Development Priorities in West Africa

The post UNCED period has seen concerted efforts at the African regional, subregional and national levels of intersectoral sustainable development activities under the umbrella of Agenda 21 and other outcomes of RIO.

Some common areas of environment and land sustainable development priorities in Africa in general and West Africa in particular include: food security, combating desertification and related environmental degradation, pollution control, urban waste management, coastal management, management of fresh water resources, mitigating the impact of severe drought, deforestation and related environmental degradation.

The wide geographical spread and diversity of the African member States are worthy of note ranging from equatorial rain forest to a hot desert belt and representing a large variety of ecological conditions.

The member States of West Africa can be categorized in whole and in part, on these geographical lines into geo-environmental categories and sustainable development priorities as indicated below: (Table 1)

Table 1. Some common areas of sustainable environment-development priorities

Zone	Countries	Characteristics	Environment & Sustainable development issues
Arid (desert)	Mauritania, Mali, Niger.	Hot desert rain-fed economic activities seldom and agriculture only in the oasis.	Food security; Combating desertification and related environmental degradation; pollution control and urban waste management; coastal management.
Semi arid	Burkina Faso, The Gambia, Ghana, Mauritania, Mali, Niger, Nigeria and Senegal.	Rain-fed economic activities for very limited periods of the year; prone to desertification but irrigated agriculture and nomadism and transhumance a way of life.	Food security; Combating desertification and related environmental degradation; pollution control and urban waste management; coastal management.
Tropical savannah and woodlands	Benin, Burkina Faso, Côte d'Ivoire, Ghana, Guinea, Guinea Bissau, Liberia, Niger, Nigeria and Togo.	Rain-fed economic activities for most of the year, prone to desertification & deforestation; irrigated agriculture to support all year crop production, nomadism and transhumance; forest products.	Food security; Mitigating the impact of severe droughts; Combating desertification and related environmental degradation; pollution control and urban waste management.
Equatorial zone	Benin, Côte d'Ivoire, Ghana, Guinea, Guinea Bissau, Liberia, Nigeria and Sierra Leone.	Rain-fed economic activities all year round; plantation agriculture; prone to deforestation and incipient desertification; forest products, including timber.	Food security; Deforestation and related; environmental degradation; pollution control and urban waste management.

12. Recommendations and conclusions

12.1 Recommendations

In order to achieve the objectives of efficient use of Geo-information Management for sustainable urban land management, Member States need to:

- Provide assistance to each other with the view to identify possible awareness of co-operation, co-ordination and harmonizing their work programs as well as providing technical backstopping and identifying their training needs to facilitate the achievement of collective self-sufficiency at the regional level.
- Mobilize human and financial resources from outside the region to implement training programs at the three levels of strategic, tactical and operational requirements and on critical mass basis and to execute development projects for the countries of the region.
- RECTAS is serving and can still serve more States as a forum for the exchange of substantive information and experiences among the countries as a "Center of Excellence" in critical mass manpower development in Geo-information production and actual project execution for sustainable land management. This will help to enlarge the focus from ecological conservation and protection to encompass development management. African member states are advised and now invited to patronize the critical capacity

established at RECTAS with the technical and financial assistance of the European Union, the Netherlands and French Governments etc. and Member States contributions to the Center.

- Ensure inter-country co-operation in management of these problems as essentials for regional integration.
- Take advantage of the immense capability and flexibility of Geo-Information for efficient urban land management.

12.2 Conclusions

1. Digital mapping/map revision for the production of Geo-Information for database creation for sustainable urban land management with the bottom-up approach with the stakeholder involved is highly recommended and indispensable for efficient and sustainable urban land management. In this Ibadan project, the eleven (11) local government each had a stake in the presentation of its resources and land use for the efficient operation of the sustainable land management in the achievement of all the above stated objectives amongst other map users. The Consultants had the problem of resolving many multi-dimensional interests while at the same time keeping to the terms of reference (TOR) of the contract.
2. The reality of having to produce an interim product for the stakeholders to use and criticize the map and offer suggestions for relevance improvement is unavoidable and advantageous for accuracy and correlation enhancement. Especially where the stakeholders are very politically alive, democratically and economically active as in the case of the populace of Ibadan. In the case of Ibadan project all these were encountered but when the final product was eventually delivered the beneficiaries and the client were very appreciative.
3. The project demonstrated indigenous capability and capacity building at a Regional Center through the Center's involvement in execution of a real life project with external funding for African countries and execution by entirely indigenous African experts. It can be done again by RECTAS for other cities and towns in Nigeria as well as other cities in member countries.
4. These are the issues and challenges RECTAS must take up efficiently in the area of cross-sectoral and multidisciplinary Geo-information production of manpower development and utilization program concept and implementation in order to contribute in pulling Africa out of the doldrums of poverty and underdevelopment production of manpower development and utilization.
5. No doubt the approach has created another sense of hope for facilitating capacity building and promote the transfer of appropriate technology and know-how for development of sustainable human settlements and land management where all human kind can live in happiness in an efficient home, lead a decent standard and quality of life and enjoy good health in a safe environment. RECTAS was happy to be part of this success story in serving Africa.