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Application of Remote Sensing (Rs) and Geographic Information Systems (Gis) to Environmental Impact Assessment (Eia) for Sustainable Development

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Abstract: A new paradigm that is fast gaining ascendancy the world over is the concept of sustainable development. Sustainable development in its simplest form advocates that the present generation develops (manage) the available resources to achieve growth and social and economic well-being in such a manner that will not jeopardize the chances of generation yet unborn in meeting their own needs. But then, how do we attain sustainable development? Well, this can be achieved through Environmental Impact Assessment (EIA). Environmental Impact Assessment in turn can be done holistically only through the technique of Remote Sensing (RS) and Geographic Information systems (GIS). This paper therefore discusses sustainable development through environmental impact assessment; and the best approach to studying environmental impact assessment in remote sensing and geographic information systems technique are also discussed.

Key words: Remote Sensing, Geographic Information System, Environmental Impact Assessment, Sustainable Development

INTRODUCTION

The environment virtually encompasses everything in the world around us. This includes both natural, physical, biotic and abiotic as well as human socio-economic features. Geographers have long claimed interest not only in the unity that exists in the biosphere (ecosystem concept), but also in the intrinsic quality of individual places. Hence, geographers as resource analyst seek to understand the fundamental characteristics of natural resources and the process through which they could be and should be allocated and utilized to meet the needs of today and tomorrow.

Sustainable development is a brain child of Gro Harlem Brundtland's World Commission on Environment and Development (WCED, 1987). The concept recognises that the available resources on earth are enough to meet the needs of the present world generation and that humanity has the ability to make development of these resources sustainable. Eedy, (1995) said sustainable development management is a concept we all discuss but seldom know how to attain. Resource development is a form of economic process that could result in increase in social and economic well-being (quality of life) of a people. However, resource development is often accompanied by externalities. These deleterious effects which may be very heavy at the initial stage may taper off on the long run (in some cases) or may remain permanently with the resource exploitation and therefore put the overall benefit-cost analysis in a serious questionable equilibrium. Hence, in resource development it is required that the overall or aggregate effect of the proposed development on the biophysical basic life constituents (air, water, soil, biodiversity, wildlife e.t.c) as well as socio-economic constituents (people and their livelihood, lifestyle, aesthetics, perception cultural heritage, security e.t.c.) be put into consideration in the benefit-cost analysis. This consideration of the benefit-cost analysis is known as environmental impact assessment.

Case Study: The proposed dredging of Lower Niger River (Warri to Bifurcation at Onyia segment) using Remote Sensing and GIS techniques.

The proposed dredging of lower Niger River from Warri (Delta State) through the Forcados/Warri River to Baro (Niger State). The 592 km have been divided into five segments:

- Warri to Bifurcation at Onyia 155 km
- Bifurcation at Onyia to Onitsha 120 km
- Onitsha to Idah 115 km
- Idah to Kotonkarfe 105 km
- Kotonkarfe to Baro 097 km

MATERIALS AND METHOD

The EIA of the Forcados segment dredging on the area was conducted using Landsat TM (1994); topographic maps; vegetation and landuse/landcover maps of the area. The image was georeferenced, processed and resampled for visualization in a GIS environment. The tonal values recorded in the image with the features on the ground were validated by ground truthing. Arch/info 3.5.1 software was used for the analysis.

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RESULT AND DISCUSSION

After the analysis, this result was obtained: From Table 1, a total of 17 settlements of about 6.03048 km2 (25%) of the total built up area will be impacted; 7 major roads covering 36.078 km2 (67%) out of 54.3616km2 will be impacted; about 634.60708 km2 of various vegetation types will be impacted in the area. The analysis also showed that 7 fishing camps will also be lost thus an important means of livelihood will be destroyed.

Table 1: Likely features to be Impacted

Feature Class	Impact(km2)
Built up Areas	6.03048
Cultivation	215.13124
Different Types of Vegetation	634.60708
Roads	36.078

Source: GIS analysis

Environmental Impact Assessment: Environmental Impact Assessment (EIA) has been defined by Munn (1979) as an activity designed to identify and predict the impact on the biogeochemical environment and on man's health and well being of legislative proposals, policies, programs, projects and operational procedures and to interpret and communicate information about the impact.

Mitchell (1989) opines that EIA represents a legislative or policy based concern for possible positive or negative short or long term, effects on our total environment attributable to proposed or existing projects, programs or policies of a public or private origin. Hence, EIA is a planning tool, a formal study problem used to predict the environmental consequences of a proposed major development project. EIA thus epitomizes the value of holistic approach to studying environmental problems (Mitchell, 1989) and a clear example of the emphasis on preventive, holistic, strategic approaches to environmental protection which acknowledge environmental limits (Morris and Therivel, 1995).

Ibe (1988) recognizes that an integrated approach (to environmental management) ensure that all problems, at least those known but also those foreseen are put on table at the same time and the linkages established as far as the eye can see before recommending or adopting solutions. Hence, an EIA study agenda of a resource proposal would consider impacts upon natural economic efficiency, income redistribution, preservation and aesthetics, political equity as well as environmental control (Mitchell, 1989).

Various authors have expatiated on what should be the concern of an EIA.

A synthesis of Mitchell (1989)), Morris and Therivel (1995), Munn (1979) shows that EIA should be all encompassing. It should consider both the biophysical and socio-cultural environments. Hence, an EIA is designed to concentrate on the problems, constraints that could affect the viability of the project. It examines impacts of proposed projects on people, homelands, physical and biophysical resources, livelihoods and nearby developments.

An EIA should consist of analyses of impacts on physical resources - ground and surface water, air, land resource, beach and coastal waters, biological resources and aquatic and marine lives, economic development of the people, infrastructure, transportation, quality of life, aesthetics, population and ethnic patterns, perceptions, religions, preferences, public health, local economy, employment, income, and host of other socio-cultural attributes of the inhabitants. It should also describe the proposed action or impact, what changes will occur without intervention, describe alternatives including 'no project' option, describe the nature and magnitude of environmental effects, identify remedial action, identify any positive results that can be developed by direct indirect spin-off from the project, identify any trade offs necessitated and as well develop a baseline inventory capable of conversion to a monitoring system, (Mitchell, 1989).

Therivel and Morris (1995) in Methods of Environmental Impact Assessment outlined the procedures for carrying out an EIA. The components are:

- Preliminary assessment of existing environment and proposed project.
- Preliminary assessment of impact areas and impacts.
- Selection of environmental parameters
- Collection of information and field surveys
- Description and evaluation of environmental systems
- Description of proposed project and design and alternatives
- Prediction and evaluation of direct, indirect and cumulative impacts
- Proposed monitoring measures
- Proposed mitigation and enhancement measures
- Assessment of the components and associated proposals in relation components and incorporation of the relevant information in Environmental Impact Survey
- Monitoring and assessment of residual impacts.

Omojola (1988) defines an impact (in environmental impact assessment) as 'any alteration of environmental conditions or creation of a new set of environmental conditions adverse/beneficial, caused or induced by the action or set of actions under consideration. Hence, impact simply refers to change in sets of conditions - physical, natural, human etc.

Therivel and Morris (1995) have therefore divided these changes or impacts into three: direct, indirect and cumulative. Direct impacts are first order and are caused by projects at the same time at the same place (localised). Indirect impacts are second order and they affect the environmental component under consideration as knock-on effects between sub-components or through other components. Cumulative impacts are sum of project's impacts when added to those past, present or future projects. They can be additive (individuals), synergistic (interacts to produce stronger impact), or neutralising/antagonistic (counteracting) (Therivel and Morris, 1995).

Mitchell, (1989) basically divided EIA procedure into two: Pre-project Analysis and Post-project Analysis.

- The Pre-project analysis is a stage of collecting, collating and analyzing baseline environmental data on abiotic, biotic and cultural components of the environment with a view to measuring or estimating the magnitude of impact on human, material and cultural values; identify both primary and secondary impacts as well as impacts arising from interactions of two or more separate impacts. Pre-project analysis is carried out using either or combination of checklists, overlay, matrices and network methods.
- Post-project analysis deals with the analysis of impacts (intended and unintended) which are function of initial social and environmental objectives. It is an analysis of what the environment would have been without the project and separating those changes that are due to or attributable to natural and cultural processes (which are project independent) and those that are due to the project; and also examine legislative and administrative structures to determine liability/responsibility and constrains on actions.

Hence, we should know what happens after the bulldozers have withdrawn because heightened historical-temporal perspective in environmental research can only be obtained by monitoring a project throughout its lifetime. This is important because several studies have shown that unintended impacts have in most cases outweigh the intended impacts.

Remote sensing and Enviromental Impacts Assessment: Remote Sensing according to Campbell (1987) is the science of deriving information about the earth's land water areas form images acquired at a distance. It relies upon measurement of electromagnetic energy reflected or emitted form the features of interest.

Lillesand and Keifer (1979) defined Remote Sensing as the science or art of obtaining information about an object, area or phenomenon through the analysis of the data acquired by a device that is not in contact with the object, area or phenomenon under investigation. Regardless of the orientation of the various definitions of Remote Sensing, the acquisition of images of earth surface features, using sensors, through the electromagnetic spectrum, the synoptic view advantage and Remote Sensing's ability to provide data for scientific technological and sustainable management and monitoring of the environment offer a convergence.

The Electro-magnetic spectrum (EMS) is the physical basis for Remote Sensing. It is an abstract idea and diagram of forms of electromagnetic energy for illuminating earth surface features. The source of energy is divided according to wavelengths. The most widely used part of the spectrum is the visible portion (O.4u-O.7u) where the presence of atmospheric window reduces attenuation of energy to a considerable level.

Hence, briefly stated, the process of Remote Sensing involves making observation using sensors (camera, scanners, radiometers, radar, and lasers) mounted on platforms (ground, aircraft, satellites, balloons) which may be at considerable height from the earth surface. Then, recording the observations on a suitable medium (photographic films and magnetic tapes) or transmitting/down linking the data to a ground receiving station where the data are corrected for geometric and radiometric distortions. Output products can be provided in computer compatible tapes (CCT) for users that made requests for the data.

Remote sensing serves as a tool for environmental resources (biotic, abiotic and cultural) assessment and monitoring. Remote sensing has some fundamental advantages that make it a veritable tool in environmental monitoring and management and impact studies. These have been listed by Barret and Curtis (1976) to include:

- A capability for recording more permanently detected patterns
- Play-back facility at different speeds
- Opportunity for automatic (objective) analysis of observations to minimise personal peculiarities of observers
- Means of enhancing images to reveal or highlight selected phenomena

To these can be added:

- The synoptic view advantage offered by raised platforms ci Ability to record data on otherwise inaccessible areas
- Ability to produce accurate data on large areas at desired time intervals and at relatively lower cost compared to the cost that would be incurred through ground survey methods
- Ability to record images in multispectral fashion at different stages, at different scale and spatial resolutions
- Remote sensing data also possess high geometric precision detail, consistency, cost effectiveness and adaptation to highly difficult terrains.

All these combine to make Remote Sensing a veritable tool for obtaining baseline information for establishing baseline conditions of an area at the pre-project analysis stage, as well as monitoring changes in the environmental conditions of such area after the project has been dc-commissioned.

This was recognised by Linden (1997) in his classical article: A World Awakens (Time, November 997). He wrote: Another crucial shift in thinking came courtesy of space programs. Earthbound mortals now have a new perspective from which to interpret their obligations to the biosphere. Lofty images of the home planet, a growing awareness of our power to undermine vital systems and concern about pollution and endangered wild lands have combine to make safeguarding natural resources a broadly shared value'.

The field of GIS and Remote Sensing has been referred to as the technology of today. Jones (1997) has observed that the largest primary source of digital data for use in GIS is undoubtedly that created by Remote sensing technology on board of satellites and other aircrafts. The discipline of Remote Sensing is therefore an important relative of GIS and from some point of view regarded as a sub discipline of GIS Jones (1997). The two are thus highly amenable to the study and conduct of environmental impact assessment.

GIS and Environmental Impacts Assessment: Different schools of thought have had different and varied definitions for Geographic Information system (GIS). Tomlin (199O) defines a GIS as 'a configuration of computer hardware and software specially designed for the acquisition, maintenance and use of cartographic data'. Burrough (1986) sees a GIS as a powerful set of tools for collecting, storing and retrieving at will, transforming and displaying spatial data from the real world.

Intera Tydac Tech Inc (1993) - the producer of SPANS GIS defines a GIS as a rapidly advancing computer based technology where information is organised, analysed and presented with reference to location.

The point of note is that a GIS is a computer-assisted system for the acquisition, storage, analysis and display of geographically are spatially referenced data. The power of a GIS lies in its ability to bring both the spatial and attribute data within a common framework to form a unified database system; and its ability to compare different entities based on their common geographic occurrence through the overlay process.

GIS is indeed a new application-based field that has lend itself to varieties of human endeavours ranging from business, facility management to environmental management and resource application areas.

Eedy (1995) has described GIS as a veritable tool in environmental assessment because it:

- Stores large multidisciplinary datasets.
- Identify complex interrelationship between environmental characteristics.
- Evaluate changes over time.
- Can be systematically updated and used for more than one project.
- Serve as a dataset for a variety of mathematical models.
- Store and mampulate3D in addition to 2D files.
- Serve the interests of the general public as well as technical analyst.

An important aspect of an EIA is the public consultations and social surveys. This in addition to the biophysical survey results can be imported into a GIS.

GIS also have the capability for site impact prediction (SIP), wider area prediction (WAP), cumulative effect analysis (CEA), and environmental audits and for generating trend analysis within an environment.

Jones (1997) observed that GIS is highly indispensable because of its ability to conduct spatial analysis on input data. Rodriquez -Bachiller (1995) commenting on its application in ETA studies submits that it is a veritable tool for generating terrain maps for slope and drainage analysis, land resources information system for land management, soil information system, geo scientific modelling of geological formations, disaster planning related to geographically localised catastrophe monitoring development, contamination and pollution monitoring, flood studies, linking of environmental database and constructing global database for environmental modelling.

Erickson (1994) suggested 4 four ways of using GIS for EIA. These are:

- **Overlay method:** This involves overlaying of different layers of interest of the study area to achieve the needed result.
- **Checklist method:** This is the listing of environmental components, attributes and processes categorized under different groups.
- **Matrix method:** This is the relating of specific project activities to specific types of impacts.
- **Network method:** This defines a network of possible impacts that may be triggered by project activities. It involves project actions, direct and indirect impacts.

CONCLUSION

We should note that the whole life support system air, water, soil faunal, floral, in short all biophysical and ecological constituents of nature are useful to man. The actual exploitation or use of resource during the transformation of neutral stuff into commodity or service to serve human needs and aspiration called resource development (Mitchell, 1989) should be met with environmental impact assessment that is focused on the agenda of a resource proposal with regards to impacts upon natural economic efficiency income redistribution, preservation and aesthetic, political equality and above all, environmental equilibrium and control. Remote sensing and geographic information systems is the only technique that can provide holistic approach to the study of total environment while still make visible the different process ort interrelationships that exist within the different biophysical components as shown in the case study above. When all of these are done, we will have eco-development (Falkenmark, 1983), and balance environment (Tolba, 1988).

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