Community-based GIS Approach to natural resource mapping and socioeconomic considerations in Impact Assessment: case study of Bayelsa Greenfield Airport Development in Niger Delta, Nigeria

By

OJILE, M.O., Bodude, D. and Okhade, R.

Department of Geography & Environmental Management

Niger Delta University, Wilberforce Island

PMB 071, Yenagoa, Bayelsa State, Nigeria

Email: mesh_owho@yahoo.com

Tel.: +234-8033410061

ABSTRACT

A geographical information system (GIS) is a computer-based tool for mapping and analysing spatially referenced data. GIS can facilitate the understanding of spatial aspects of social and economic development by relating socio-economic variables to natural resources and the physical world; providing a tool for targeting interventions and monitoring impacts at various scales and over wide areas. GIS also potentially puts planning and research technology into the public domain to enrich – and enhance access to – information, to promote discussion and improve understanding of conflicting viewpoints. Above all, GIS has an important role to play in natural resources research to support rural livelihoods. The Bayelsa State Government in Nigeria proposed a Greenfield Airport in proximity to the State capital, Yenagoa. The need to strike a balance between socioeconomic and environmental considerations as well as comply with national and international regulatory requirements was a driver for comprehensive ESHIA studies. A community/stakeholder integrated participatory GIS study was undertaken as part of the SIA, which involved a detailed resource inventory, mapping and sensitivity of the environment to project activities. Significant impacts including land acquisition, land-take and on agriculture-based livelihood systems, particularly fisheries which rely on lakes, ponds, streams and seasonally flooded swamps in the Project area were identified. Possible economic displacement and resettlement issues were also revealed. The participatory GIS-based approach and the visualization capability of the tool provided a platform for a better understanding of project's impacts. To avoid significant adverse socioeconomic impacts and resource losses, a change in project location was canvassed.

Key words: Participatory-GIS, Greenfield Airport, socioeconomic considerations, ESHIA, Livelihood systems, Resource inventory/mapping/sensitivity, economic displacement/resettlement

1. Introduction

Geographic information systems (GIS) refer to systems used for storing, retrieving, analyzing, and displaying spatial data (Joao, 1998 as cited by Atkinson, et al. 2008). According to ESRI (2008), Geographic Information System (GIS) is a special type of ICT that integrates hardware, software, and data for capturing, managing, analysing, and displaying all forms of geographically referenced information for comprehending geography and making intelligent decisions. Since their initial usage in the 1960s, GISs have evolved as a means of assembling and analyzing diverse data pertaining to specific geographical areas, with spatial locations of the data serving as the organizational basis for the information systems. The structure of GISs is built around locational identifiers and the methods used to encode data for storage and manipulation (Atkinson, et al., 2008).

GIS have an important role to play in natural resources (NR) research to support rural livelihoods, in particular, and pro-poor development more generally (Quan, et al., 2001). As a computer-based tool for mapping and analysing spatially referenced data, GIS can facilitate the understanding of spatial aspects of social and economic development by: relating socio-economic variables to natural resources and the physical world; providing a tool for targeting interventions and monitoring impacts at various scales and over wide areas; and potentially putting planning and research technology into the public domain to enrich – and enhance access to – information, to promote discussion and improve understanding of conflicting viewpoints

Within recent years the application of GIS technology to the EIA process has steadily increased. Relative to typical EIA phases, GIS can have application, either directly or as a supporting tool, to all of them. Although GIS has been widely adapted for the management of natural resources as well as managing the impact of various development activities on the natural environment (Geneletti, 2002; Joao & Fonseca, 1996; Treweek & Veitch, 1996), Gontier (2006), argues that in

today's Environmental Impact Assessment (EIA) reports, the use of GIS within the ecological assessment is often limited to its display functions and seldom used for its analytical capacities. Gontier claims that GIS in general and three-dimensional visualisation in particular are powerful tools that can serve the communication objectives in EIA, Strategic Environmental Assessment (SEA) and physical planning in general. Graphical modelling means making representations of selected features on media such as maps and drawings or using computers to manipulate data and creating images to represent existing or future states of existing phenomena. Ficenec and Posner (2003), Eyerman et al. (2003), Craig et al. (2002) agree that the public can significantly contribute to the success of resource management efforts by actively participating in the process of GIS application.

Participatory mapping uses a range of tools, including data collection tools that are commonly associated with participatory learning and action (PLA) initiatives. These tools include mental mapping, ground mapping, participatory sketch mapping, and transect mapping and participatory three-dimensional modelling. Recently, participatory mapping initiatives have begun to use more technically advanced geographic information technologies, including Geographic Information System (GIS), satellite imagery, Global Navigation Satellite Systems (GNSS) like the commonly used Global Positioning Systems (GPS), and other digital-based technologies (IFAD 2009).

There are however, a number of challenges related to the use of GIS (and remote-sensing) tools and applications. Overall the most important ones are: affordability, capacity issues, lack of modern telecommunication infrastructure (e.g. Internet) and limited access to competent technical advice and support services. Since GIS and remote-sensing tools and applications are generally expert-driven and centrally controlled by state agencies, scientific research institutions and private corporations, a number of risks have been associated with its deployment in the service of people-centred development (Quan *et al*, 2001). Some of the key challenges in Africa and Nigeria inclusive are that fundamental data sets are not available, outdated map production technologies are used, institutional frameworks create difficulties, and funding and human resource capacities are lacking (GLTN, 2012).

This paper deals primarily with participatory GIS (P-GIS) for socioeconomic investigation to characterize and present resources' sensitivities to a proposed Airport Project in a naturally sensitive environment in the Niger Delta, Nigeria. The paper presents the field experience of a practitioner. In the subsequent sections, the Nigeria EIA system is briefly explored and a presentation of the P-GIS approach is discussed, including a summary of project impacts detailing land use and resource losses, and concludes with summary/recommendations for an improved and enhanced use of the GIS for practitioners and related users. This way, a balanced view and understanding of social and economic development efforts can be undertaken.

2. EIA System in Nigeria

The main legal instrument for EIA in Nigeria is the Nigerian National Policy on the Environment, promulgated in 1989. National requirements for public participation and consultation as part of the conduct of EIA are further outlined in the procedural guidelines that contained a systematic and semi-comprehensive approach to the conduct of EIA and details about the stages of the EIA process, including categorization of projects into classes I, II and III (FEPA, 1995).

The EIA Act No. 86 of 1992 made the preparation of Environmental Impact Assessments mandatory for all industry planning new projects. This involves the assessment of environmental, socio-economic, health aspects (ESHIA) of the project area and production of a report. The Federal Ministry of Environment (FMENV), established in 1999 alongside democratic governance structures is the main regulatory environmental body while the Department of Petroleum Resources (DPR) in the Ministry of Petroleum Resources is empowered to look after the petroleum industry in particular. Before then, the Federal Environmental Protection Agency (FEPA) was in charge of the protection of the Nigerian environmental policy instruments, itself established in 1988. A review of the Nigerian EIA system for improvement has long been overdue and on the drawing board for a long time now.

3. Participatory GIS for Resource Mapping and Ecosystem Sensitivity: Case of Bayelsa State Greenfield Airport Project, Niger Delta

The Project and its EIA Premise

The Bayelsa State Government in collaboration with the Federal Government of Nigeria initiated and proposed to build a Greenfield Airport in the Zarama area in proximity to the State capital, Yenagoa. Strategically placed near Yenagoa, the proposed airport is approximately equidistant between Warri and Port Harcourt. It is anticipated that the airport will act as a hub for the oil and gas industry conglomerates in the region, playing a major role in linking the state to the rest of the country, improving the State's economy, and attracting investments to the state. Overall, therefore, the airport is intended to serve the state, the Niger Delta region and Nigeria, in general.

In compliance with existing national and international environmental regulations (FMENV EIA Act No. 86 of 1992 and IFC/World Bank Guidelines, 2006), impact assessment studies relating to the project were commissioned and carried out. Arising from a comprehensive ESHIA Study of the Project activities, and particularly, from the land acquisition and land take and construction perspectives, it was identified that the Project will have a significant impact on the agriculture-based livelihood system, including the fisheries aspect which relies on lakes, ponds, streams and seasonally flooded swamps in the Project area (Ojile, 2011). In compliance with national and international environmental regulations, including the Equator Principles (July 2006) and the IFC Performance Standards, (PS) (April 2006), which include identifying all those who are affected by the Bayelsa Greenfield Airport Project, especially as the effects relate to possible economic displacement and resettlement, further studies were deemed necessary. Undertaking a detailed resource mapping using the Geographic

Information System (GIS) approach was part of the appropriate measures identified to proffer appropriate mitigation for adverse impacts that may arise from displacing persons whose livelihoods are dependent on fisheries.

Project Location, Area of Influence and Affected Communities/Population

Geographically, Bayelsa State is centrally located in the heart of the Niger Delta. It is dissected centrally by Longitude 6^0 E and Latitude 4^0 30'' N (Figures 1 and 2). The proposed project site is located in Okordia-Zarama area in Yenagoa LGA of the State (Figure 3). The site is bounded to the north by the River Nun, to the West by Kolo Creek, to the East by Taylor Creek and to the south by the strategic Warri to Port Harcourt East-West Road. The project site covers approximately **2,400ha** area of land comprising secondary vegetation and wetlands.

There are several settlements and human habitations that are located within and around the proposed airport project area, 11 of which were considered to be *''land-holding communities''* and ***primary impact communities*** (See Figure 4). Many of these communities also have satellite villages located inside the swamp and thick tropical rainforest, harvesting both the fisheries and agricultural produce of the area. A detailed socioeconomic impact assessment (SEIA/SIA) of project environment was undertaken as a first activity (Ojile, 2011), which involved the use of both qualitative and quantitative methodologies. All 11 project affected communities (PACs) were visited and participatory methodology that employed a mix of techniques, including community-wide meetings (town hall meetings), focus group discussions, key-informant interviews and semi-structured interviews were used for socioeconomic baseline data collection (Akpofure and Ojile 1999). Quantitatively, almost 300 copies of the structured copies of the questionnaire were also administered face-to-face to the affected population across the 11 PACs as a complementary data collection tool. A summary socioeconomic statistics of the affected communities from the sample survey include the following:

i) Age: < a third aged below 30 years and those aged 30-59 make up 64.9% and aged (60+) constituted 8.9%);
ii) Marital status: single-21.8%, married-72.3% and divorced/separated/widowed-5.9%;
iii) Education: Modal attainment, secondary-44.5%; tertiary-25.1%, primary-15.1, others-15.3%;
iv) Mean household size: 6.5 and average number of children per married woman-4.7;
v) Primary occupation: agriculture (farming and fisheries -54.9%; varied income sources-45.1;
vi) Monthly income: modal-N50,000;
vii) Population of affected communities: 30,000 (2012)

Participatory GIS-Approach for Socioeconomic Data Collection and Impact Identification

A crude but related Geographical information systems (GIS)-based approach was utilized in capturing resources in the project area. To the extent that, the study was participatory, involving owners of resources in the affected communities, it also falls within the ambit of participatory–GIS (P-GIS). P-GIS is the integration of local knowledge and stakeholders' perspectives in the GIS. The principal applications of GIS in rural development are *community land and resource mapping, the integration of local and scientific spatial knowledge, community-based natural resource management (CBNRM),* area planning and environmental management and the management of pests and natural hazards. The applications may be more, or less, participatory according to the data collection and analysis techniques, the degree of stakeholder consultation and feedback and the level at which any management decisions are taken (Quan *et al*, 2001).

The type of data needed, and the methodology and sequencing of data collection techniques depend greatly on the type and objectives of a particular project and what the outcomes will be used for. The techniques for data collection include: *Participatory mapping; Semi-structured interviews; Key informants interviews;* and *Field visits and transect walks.* All of the techniques were employed in combination to achieve study objectives of resource inventory and mapping.

Based on the perceived assessed potential impacts on the water and land resources of the project-affected communities and population during the ESIA studies, the P-GIS study was initiated to actually find out, *what where*, and *to what degree/extent* the assessed resources may be affected by the proposed airport location and construction activities.
To achieve study objectives, the traditional knowledge base was extensively utilized. The following actions/steps were followed: 1) Community members who own some resources, know where the resources are located (perceptual and real), and have some knowledge about the land boundaries of the proposed airport project site were nominated from affected communities to join study team; 2) a reconnaissance survey was firstly carried out by the team of 10 members (SIA expert, 2 technical assistants,' 1 regulator, and 6 community members); 3) a detailed follow-up survey by an enlarged team of the SIA expert and 2 assistants, 1 GIS expert, 1 regulator from state ministry of environment and 8 community members (12 persons) was then undertaken; 4) on the two separate occasions, team made extensive walks through the forest, one without a GPS and the other with a handheld GPS instrument and on both counts for three days each identifying the lakes, ponds, streams and camps/farmsteads, their ownership, when resources are harvested, profits from resource harvesting and then mapping the resources (geo-location) with respect to the proposed airport site area and; 5) GIS expert prepares maps for report writing, showing relation positions of natural and cultural resources within project environment.

Summary of Significant Negative Socioeconomic Impacts

Space requirements will not permit detailed outlining of identified social impacts. Integration of earlier assessed impacts with the P-GIS yielded concrete results. A table detailing the numbers, names of the lakes/ponds/streams and camps (which hitherto were called satellite settlements), and ownership of the resources and estimated potential/size of the resources and associated losses were the outputs. Pictorials of the resources were also included to convey the visual importance of the resources. A summary of the impacts include:

i) Airport Impacts Due to Location: Just as benefits were perceived to be associated with the siting and operation of the airport, some potential undesirable consequences that may derive from the proposed project, include: loss of farm land, lakes and ponds and associated biodiversity; decreased food and fisheries production as a result of the loss of farm land/lakes and ponds; displacement/loss of accommodation by those in satellite villages/farmsteads.

ii). Loss of Land (land take), Land use Effects and Biodiversity Resources: The proposed airport project site is estimated to cover approximately **2,400ha** area of land comprising secondary vegetation and wetlands. This land take is substantial in itself; but that the proponent was unable to present a site layout as at time of study may mean that they are yet to know the actual extent of acquisition. Field findings revealed *satellite villages or farmsteads with inhabitants permanently settled by the lakeside carrying out their fishing activity.*

iii) Relocation/Resettlement issues and socio-cultural resource losses: The project site and its land acquisition have the potential of infringements on existing settlements (farmsteads/fishing camps) tucked away in the thick forest where lakes and ponds are located. The P-GIS survey confirmed the largest lake in Bayelsa, *''Akamedunor''* estimated to be as long as 6km and 3 km wide fished regularly, and ''providing as much as N15M annually ($71,770.34 at current exchange rate) to the community's purse'' as perhaps the greatest socioeconomic and cultural impact that may be expected from the airport location in the area. Lake *Abanigina* in Zarama, 2nd largest, measuring 61m in length and 3 km in breadth and the *Opoi Ibudo, Ibudo-Onomo, Ishita, Esam, Ereori,* and *Oyoli* lakes are other natural lakes that are veritable fishing grounds for fishers and actually sustain the population that live by the lakesides. The *Lululu, Tamodunor* and *Samnu* were other lakes with cultural and historical importance to the communities. In all, some 16 lakes of differing sizes, 5 ponds, 8 fishing camps and 2 farmsteads were found located within the perimeter of the proposed Airport Project environment.

4. Conclusion and Recommendations

The socio-environmental consequences of ill-conceived developments can have significant impacts. But emerging and new technologies are influencing and playing vital roes in promoting impact assessment for better decision-making. Participatory-GIS (P-GIS), though long in use in advanced countries have had little utility in developing countries like Nigeria. The challenges and opportunities associated with GIS and remote sensing are immense but are gradually been overcome. This paper presented a case in point. A government-proposed airport development in part of the Nigeria Delta, Nigeria predicted significant resource losses and impacts on livelihoods. For better decision-making, a P-GIS and embedded visualization techniques as suitable tools were employed. Results depicted serious concern of resources on account of the airport location if allowed. Agriculture-based livelihood is most significantly affected; fisheries, loss of lakes, ponds, brooks and fishing grounds are substantial. Farmlands and economic crops and trees, loss of farmsteads and secondary settlements with little or no compensation are envisaged.

In recognition of the high impact significance, recommendations were made for proponent to trigger the IFC/WB Policy on Involuntary Relocation and Resettlement to settle the issues involved including further detailed socioeconomic study to be able to decide on compensation issues. As a flood-prone and wetland environment, alternative site(s) were also recommended. As at time of the report, the proponent has shifted the airport location to a more suitable location with less socio-environmental impacts. The conclusion can be drawn that P-GIS has positive utility in informing better decisions but enhanced use and participation by both IA practitioners, experts and the public could do more.

References

Antenucci, J.C., Brown, K., Croswell, P.L., Kevany, M.J. and Archer, H. (1991), Geographic Information Systems: A Guide to the Technology. Van Nostrand Reinhold, New York, New York.

Atkinson, S.F., Canter, L.W., and Mangham, W.W. (2008) "Multiple Uses of Geographic Information Systems (GIS) in CEA", Special Topic Meeting on Assessing and Managing Cumulative Environmental Effects, International Association for Impact Assessment, November 6-9, Calgary, Alberta, Canada.

Atkinson, S., Kennedy, J., Slye, J., Johnson, D.R., and Venables, B., (2008) "Aquatic Habitat Modeling via Watershed Data Using GIS Modeling", Special Topic Meeting on Assessing and Managing Cumulative Environmental Effects, International Association for Impact Assessment, November 6-9, Calgary, Alberta, Canada.

Bonham-Carter (1994) Bonham-Carter, G.F. (1994) Geographic Information Systems for Geoscientists: Modelling with GIS, Computer Methods in the Geosciences, No. 13. New York: Elsevier Science.

Craig, W.J., Harris, T.M. and Weiner, D. (Eds.) (2002) Community Participation and Geographic Information Systems. London: Taylor & Francis.

ESRI (2008). What is GIS? http://www.gis.com/whatisgis/

Eyerman, M., Coxe, H. and Colby-George, J. (2003) Developing a GIS Interface to Enhance Public Participation in Local Land Use Planning. The 2nd Annual URISA PPGIS Conference. Portland (OR): URISA.

FEPA (1995) Environmental Impact Assessment (Decree 86, 1992), Procedural Guidelines, Federal Environmental Protection Agency, Abuja.

Ficenec, C. and Posner, J. (2003) Applying GIS to Participatory Watershed Management in the Peruvian Andes. The 2ndAnnual URISA PPGIS Conference. Portland (OR): URISA.

Geneletti, D. (2002) Ecological Evaluation for Environmental Impact Assessment, Netherlands Geographical Studies, No. 301. Utrecht: Proefschrift Vrije Universiteit Amsterdam.

GLTN (2012). "Regional Learning Workshop on Land and Natural Resource Tenure Security": Final proceedings. Global Land Tool Network, Nairobi.

Gontier, M. (2006) Integrating Landscape Ecology in Environmental Impact Assessment using GIS and Ecological Modelling, in Trees, B., Trees, G., Fry, G. and Opdam, P. (Eds.), From Landscape Research to Landscape Planning: Aspects of Integration, Education and Application. The Netherlands: Springer.

Gorr, W. and Kurland, K. (2006) Learning and Using Geographic Information Systems: ArcGIS edition. Texas (TX): Thomson Course Technology. http://www.course.com/catalog/product.cfm?isbn=978-1-4188-3558-3&CFID=6722843&CFTOKEN=23662274

IFAD (2009). "Good Practices in Participatory Mapping". International Fund for Agricultural Development, Rome.

Joao, E.M. (1998), "Use of Geographic Information Systems in Impact Assessment," Ch. 18 in Environmental Methods Review; Retooling Impact Assessment for the New Century. Porter, A.L. , and Fittipaldi, J.J., editors, U.S. Army Environmental Policy Institute, Atlanta, Georgia, and International Association for Impact Assessment, Fargo, North Dakota, pp. 154-163.

Joao, E.M. (1994), "Using Geographical Information Systems for Environmental Assessment," Environmental Assessment. Vol. 2, No. 3, September, 1994, pp. 102-104.

Joao, E. and Fonseca, A. (1996) The Role of GIS in Improving Environmental Assessment Effectiveness: Theory vs. Practice, *Impact Assessment*, 14, 4, 371-387.

Latu, S. (2009). Sustainable Development: The Role of GIS and Visualisation, EJISDC, 38, 5, 1-17, The Electronic Journal on Information Systems in Developing Countries. Available at http://www.ejisdc.org, Accessed on January 5, 2014

Loh, D.K., Holtfrerich, D.R., Choo, Y.K. and Power, J.M. (1992) Techniques for Incorporating Visualisation in Environmental Assessment: An Objected-Oriented Perspective. Landscape and Urban Planning, 21, 4, 305-307.

Ojile, M. O. (2011). Baseline Socioeconomic/SIA Baseline Report for the Bayelsa Greenfield Airport Project, submitted to Global Environmental Technology Limited. Pp77.

…….. (2012). Draft Report on Resources' Inventory and Sensitivity to Effects from proposed Location of Bayelsa Greenfield Airport Project Activities: *Lakes, ponds, streams and Fishing Camps in Okordia-Zarama Project-Affected Area, pp. 25.*

Quan, J., N. Oudwater, J. Pender & A. Martin (2001). "GIS and Participatory Approaches in Natural Resource Research". Natural Resources Institute, University of Greenwich, UK.

Treweek, J. and Veitch, N. (1996) The Potential Application of GIS and Remotely Sensed Data to the Ecological Assessment of Proposed New Road Schemes, *Global Ecology and Biogeography Letters*, 5, 45, 249-257.

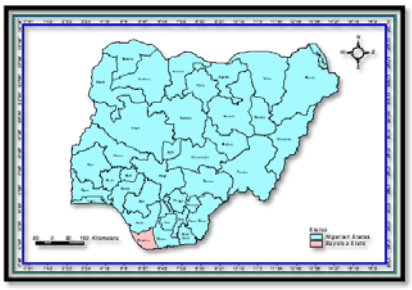
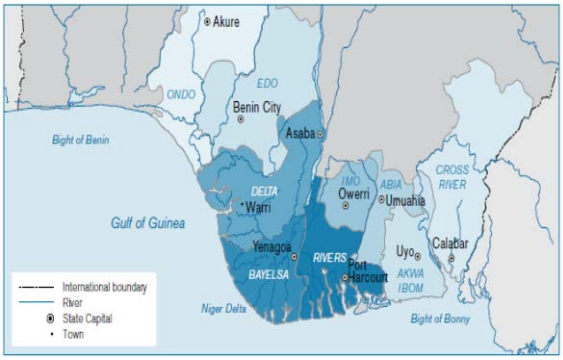


Figure 1: Map of Nigeria showing Bayelsa State highlighted among the other States in Nigeria



Map 2: States of the Niger Delta

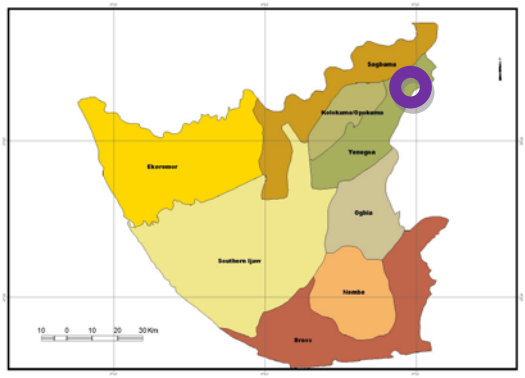


Fig 3: Administrative Map of Bayelsa State (approximate project-affected area circled)

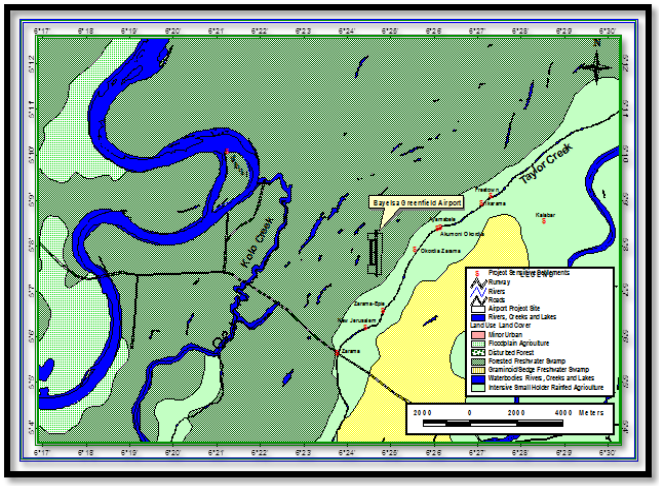


Figure 4: Map showing the Proposed Airport and the Project Sensitive Communities/Built-up areas