TOWARDS ENVIRONMENTAL SUSTAINABILITY IN NIGERIA'S ECONOMIC DEVELOPMENT: A SPATIAL INFORMATION TECHNOLOGY APPROACH.

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ABSTRACT

A persistent challenge facing developing countries such as Nigeria is how to promote socio-economic development while upholding environmental sustainability. A need for environmental sustainability is evident in the development of various transmission lines, (crude and refined petroleum pipelines, gas pipelines, high-voltage transmission line. Such transmission line usually have a right-of- way of at least 20m wide, and along which the environment is usually totally impacted. Changes to the environment involve removal of existing vegetation and replacement with low stature (grass) vegetation or the land is left bare and prone to gullying. Environmental sustainability is now being promoted by law in Nigeria, and this paper describes a case of the determination of a 400km long high voltage (330kv) transmission line (HVTL) route for the electricity utility company in Nigeria based on the policy of environmental sustainability. Remote Sensing, involving the use of current SPOT (XS) imageries was adopted in the selection of the route. In addition, existing topographic maps and aerial photographs were analysed. Sixteen landcover categories were established from the overall interpretation. Route selection was based on the distribution of the categorized landcovers in relation to the proposed corridor, and follows where the classified cover types had either the lowest potential impact value or where an existing line route is followed. The HVTL route proposed was selected as the preferred route, in order to avoid high indemnity cost areas, such as nucleated settlements, industrial areas, prime agricultural land planted to tree crops; and avoid human and industrial hazards as could be posed by proximity of high tension lines to structures such as the NNPC Tank Farm.

1 INTRODUCTION

A persistent challenge facing developing countries such as Nigeria is how to promote socio-economic development while upholding environmental sustainability. Environmental sustainability implies such use of the environment in the present that will not compromise the ability of the environment to meet the needs of future generations (Mayor, 1988; Wolfgang, 1993). Sustainable development requires taking long-term perspectives, integrating local and regional effects of global change into the development process, and using the best scientific and traditional knowledge available. It seeks to maintain a balance between accelerated economic growth and environmental protection (World Bank, 1995). It involves the maintenance of environmental diversity and/or minimization of deleterious perturbation to the environment and the concurrent mixmization of economic growth. A need for this type of balancing is very evident in the development and management of various transmission lines (crude and refined petroleum pipelines, gas pipelines, high-voltage transmission lines) which usually have a "right-of-way" of at least 20m wide, and along which corridors, the environment is usually heavily impacted. Changes to the environment along the corridors have involved removal of existing vegetation and replacement with low stature vegetation (grass) or the land is left bare. This may inhibit environmental sustainability. Environmental sustainability is now being promoted by law in Nigeria through the mandatory carrying out of Environmental Impact Assessment (EIA) prior to construction. Section 2 of the EIA Decree No 86 (1992) states that:

"where the extent, nature or location of a proposed project or activity is such that is likely to significantly affect the environment, its environmental impact assessment shall be undertaken ..." .

The decree seeks to ensure that the likely environmental impact of implementing projects are given adequate consideration particularly during project identification and planning.

To successfully model and monitor impacts of proposed projects on the environment, the mapping of the spatial component of the environment may be crucial. This paper describes a case study of the determination of a 400 km long high voltage (330 KV) transmission line (HVTL) route for the electricity utility company in Nigeria based on the policy of environmental sustainability. Environmental impact was assessed based on vulnerability of a given environmental facet within the potential corridor to detrimental perturbations during construction of the HVTL and/or maintenance of the right-of-way. Geographical Information System (GIS) is applied in the following EIA stages: Screening and Scoping; Baseline conditions description; Impact significance: and Mitigation and Control (See also Mgendi, 1999). Indices used in the assessment include the vulnerability to gullying in particular areas of high soil erodibility and sufficient available slope); vulnerability to accelerated eutrophication of water bodies consequent upon erosion in the near - channel areas, and perturbation of streambed sediments; potential synergistic changes to physiognomy and species composition of vegetation; and, the potential loss of wildlife due to opening up of reserves.

2 STUDY AREA

The proposed corridor lies between latitude $6^{\circ}\ 20^{1}$N and $7^{0}\ 37^{1}$ N and longitude $7^{0}\ 23^{1}$ E and $9^{0}\ 01^{1}$ E, and traverses the part of Nigeria known as the eastern Nigeria Scarpland, and the western part of the Benue Trough. It covers a total distance of 400 km between Udi in the south, Enugu in the west, and Makurdi and Yandev in the north and east respectively (Figure 1). The corridor traverses the Koppen's Aw (Tropical Wet

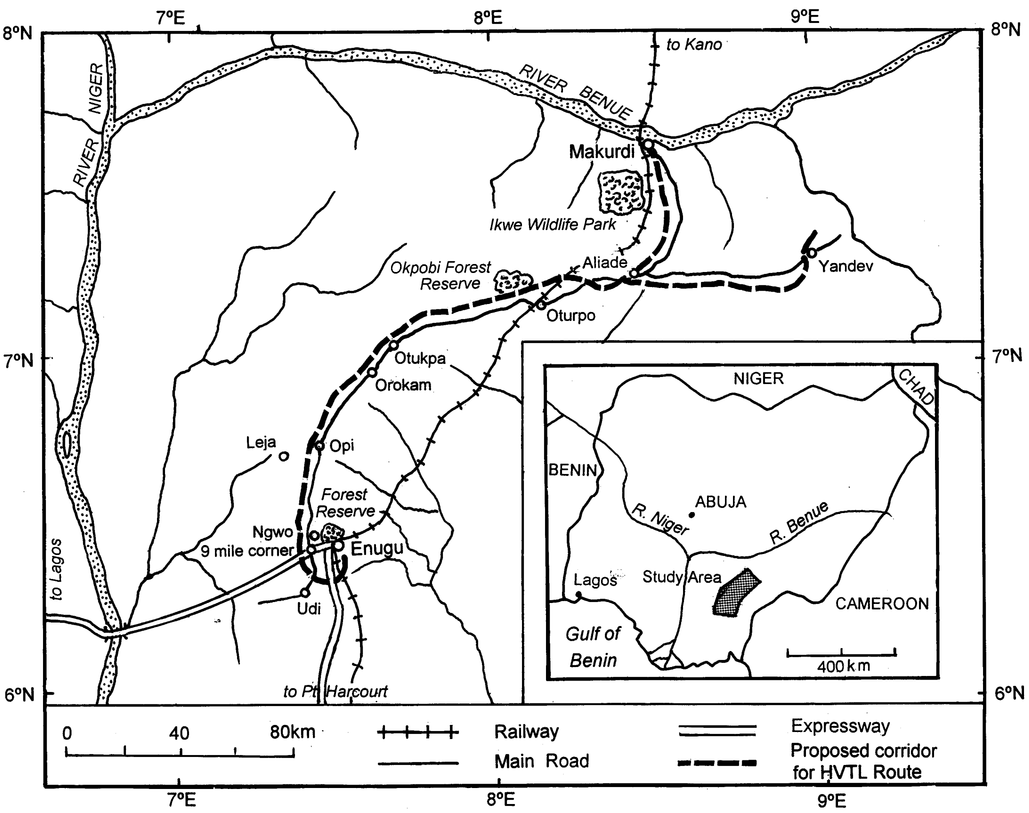


Figure 1: The Study Area showing the Proposed HVTL Route

and Dry Climate) zone also known as the Savanna climate. The onset of rains is in April and the retreat completed in October. The rains are usually heavy thunderstorms, a factor that facilitates sheet and gully erosion especially on exposed inclined surfaces.

The prominent landforms in the area include the Udi - Okigwe escarpment which trends NNE. It originates south of Enugu and the trends past to the west of Enugu, towards River Benue. Others are, the flat lowlying terrain east of the escarpment; the relatively waterless plateau, the eastern edge of which is the precipitous and often gullied escarpment; and the southwestern sections of the Benue Trough. This latter area include flat, lowlying and often waterlogged sections. The potential corridor is almost wholly underlain by weakly consolidated Cretaceous sandstones, mudstones, shales and calcareous rocks, arranged in N-S stratigraphic bands, the exception being the northeastern section (Gboko-Yandev) which is underlain by pre - Cambrian Basement Complex rocks. There is a close relationship between the geological formation and the morphological unit. Soils along the corridor appear to be closely associated with the geology and the topographical positions on which they are developed. Thus for example, soils on the plateau, i.e those developed on False Bedded Sandstones are mainly acid, have limited development of structure, and a poorly developed profile. Lateritic soils also occur on the plateau, but are localized. Alluvial soils are found along the river valleys, especially those developed on the Makurdi Shales.

The vegetation is mainly Derived Savanna in the south (Enugu area) and southern Guinea in the north (Makurdi - Yandev area, Keay 1959). A notable feature of the Derived Savanna is the presence of oil palm (Elaeis guineesis) and trees associated with dry forests such as silk cotton tree (Ceiba pentandra) and the oil bean tree (Pentaclethra macrophylla). The main grass species is Andropogon tectorum. The high density of settlements and cultural practices within the corridor have altered the natural vegetation such that economic trees (including Pentaclethra sp. , Irvingia sp. , Anocardium sp) are found only around homesteads. A number of forest/wildlife reserves are close to the potential corridor. The most notable being the Ikwe Wildlife Reserve ($7^{0}25^{1}$ - $7^{0}35^{1}$N, $8^{0}20^{1}$- $8^{0}23^{1}$E) and the Okpobi ($7^{0}11^{1}$ - $7^{0}12^{1}$N, 8^{0} 02^{1}- $8^{0}04^{1}$E) and Enugu ($6^{0}27^{1}$ - $6^{0}29^{1}$N, $7^{0}28^{1}$-$7^{0}30^{1}$E) Forest Reserves (see Figure 1). There are some sites of archaeological - cultural heritage significance in the Leja community, west of Opi (see Figure 1). These sites consist essentially of extensive surface scatter of massive, cylindrical shaped iron slag, and appear to be iron-working and smelting centres of considerable antiquity.

3 METHODOLOGY

The methodology employed is aimed at indicating potential areas of environmental impact of the construction and maintenance of the HVTL on the proposed corridor. Information used in the assessment was obtained through a combination of survey of the literature, field work, analysis of topographic maps and current SPOT (XS) satellite imageries.

The fieldwork was based on the subdivision of the proposed transmission line corridor into 5 x 2 km sampling sites. These served as baseline survey quadrats from which information on the geology, topography, settlements, ecology, socio-economics and archaeological-historical-cultural elements were derived and described. The socio-economic conditions of the populations along the proposed corridor were determined mainly through structured and informal interviews and discussions with core members of each community. This was to ascertain their reactions to possible disruption of life and property along the proposed route of the new transmission lines.

Soil samples were taken at 0 - 15 cm and 15 - 30 cm depth at each of the 20 sampling points. Soil erodibility along the potential corridor was assessed using Bouyoucous' (1935) Clay Ratio (CR) and Middleton's Dispersion Ratio (Byran, 1968). For the vegetation, the guidelines designed by Sanford and Isichei (1986) were adopted in describing the physiognomy, canopy structure, and the taxonomic composition of both the woody and herbaceous layer.

The topographic map information were updated using ground truthed information on land use/ land cover, settlement, road network and stream courses/wetland obtained from classified SPOT (XS) imageries of the proposed corridor. Colour-coded segment maps, each corresponding to 10km x 10 km subscene imageries were used to depict information on land use/land covers, etc, and constituted information base on which impacts were assessed. The choice of 10km x 10km size of subscenes enabled the efficient application of image classification techniques. The analysis of landcover type from SPOT imagery is more suited to this sample size. (Griffiths and Wooding, 1989). A total of forty-one (41) subscenes were extracted and interpreted. Production of the segment map conformed to the Geographic Information System (GIS) format through of the Dasymetric Mapping Principle. The scale of presentation is 1:50,000

For the identification of impacts, cross profiles of the terrain over which the transmission lines may pass was drawn in order to have visual bases for the proposed alignment. This led to the creation of an impact magnitude map.

4 INTERPRETATION OF IMAGERIES AND OTHER RELEVANT INFORMATION

The objective of imagery interpretation is to establish landcover classes. This provides the basis for assigning the indemnity class to which any categorized cover type belongs. Although traditional landscapes do not yield themselves to precise classification of the component landcovers, categories of land cover/land use were combined into complexes of mapping units. Attention was concentrated on those cover types which are of major ecological and social interest, e.g. built-up area (settlements); forest complexes which includes gallery forest, forest reserves, traditional groves, woodlands, settlements under tree cover typical of the Igbo (eastern Nigeria) culture; cultivated patches, burnt surfaces, eroded sandy surfaces and water bodies. From the overall interpretation 15 categories of land use/landcover were established whose mapping codes are explained in the legend below (Table 1).

TABLE 1: COMMON LEGEND FOR THE LAND COVER/ LAND USE CLASS

CODE	DISCRIPTION
S	Mainly built-up compact or open
SB	Dispersed settlements and surrounding country of woodland/ shrub with scattered farm plots, iron stone pans
BS	Predominantly short bush , with scattered farm plots and open bare spaces
MS	Mixture of economic trees, shrubby thickets and few isolated homesteads
SMB	Complex combination of cultivated areas, bare soils/ burnt-up areas, with some rural dispersed settlements
M	Predominantly forest/bush; with scattered traditional farm plots, combination of tree crops and annual crops, farm huts.
FM	Mainly forest cover, with agro-forest species
FMB	Complex combination of trees, cultivated areas, burnt-up areas and bare space.
FMS	Complex combination of agro-forestry, cultural areas, dispersed settlement.
B	Mainly bare soils, burnt-up surfaces, eroded or marginally cultivated gravelly soils/ porous soils under grazing or very marginal cultivation
D	Very shallow depression /flat surface, under dense tree/shrub cover
BU	Built-up for some kind of industrial use
E	Eroded steep slopes in Enugu landscape
W	Water body
V	Valley, gallery forests / flood plain shrub

Natural colour composite imagery of SPOT X5 data was made with the result that green on the map represents the very active (green) vegetation. The more homogenous the green, the denser the active vegetation cover it represents. At the extreme end of the vegetal cover type is the category of bare soil or very scanty vegetal surfaces. Such areas appear in red. Other non-vegetal surfaces such as bare soils and settlements also appear in the range of red, purple and violet. Built-up and other infrastructural features could be separated on the basis of their geometric shapes (see Figure 2).

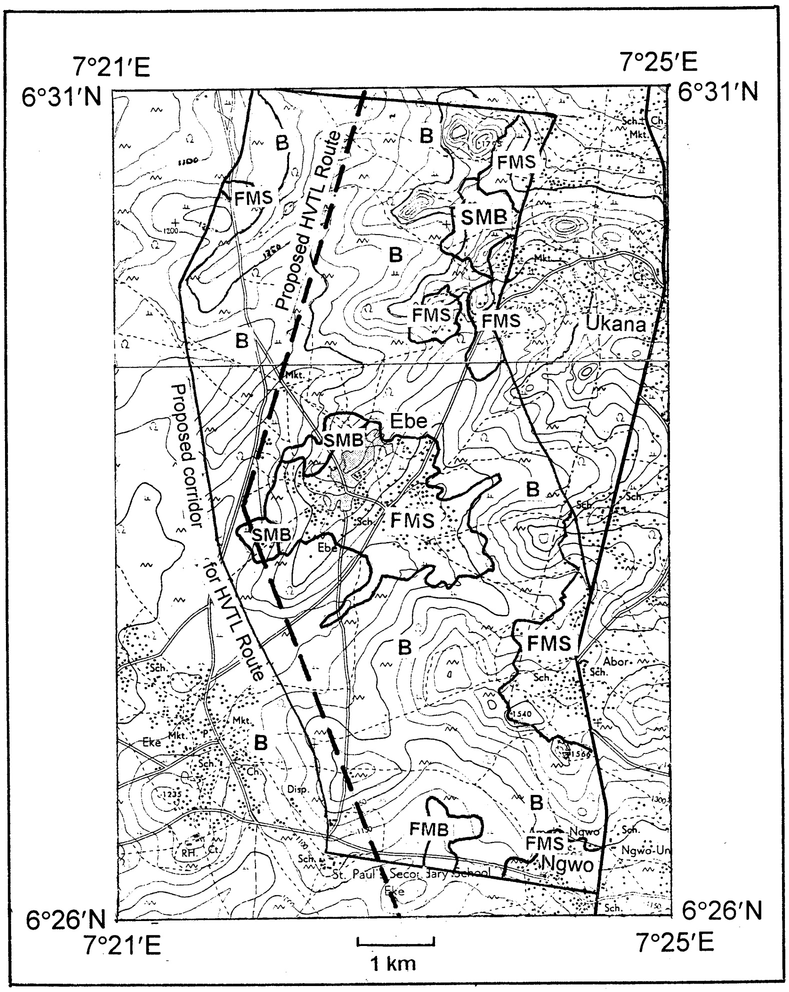


Figure 2: Classified SPOT XS and Topographical Information of Subscene 4 (Ngwo Ukana Segment)

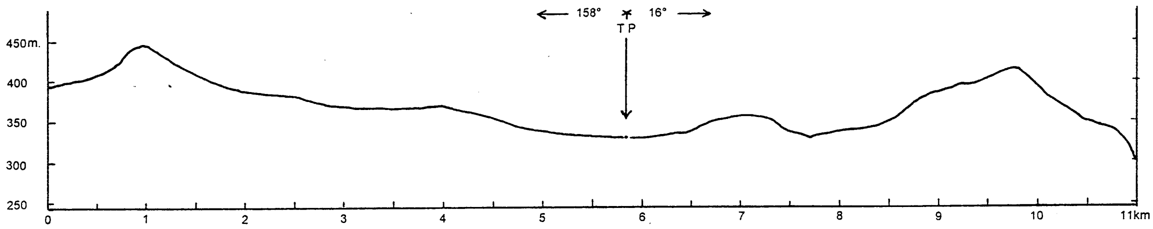
All the soils sampled are potentially erodible given the clay ratio and the dispersion ratio. Thus, areas of significant potential environmental impact will be those locations having sufficient available slope. Moreover during construction activities, heavy vehicles would create artificial furrows along tyre tracks in which runoff can concentrate, thus facilitating gullying and erosion which could lead to loss of farmland, destruction of property and reduction of a scenic environment into badland topography.

Of the various stages involved in EIA, emphasis is on impact identification and impact magnitude prediction. In order to have visual bases for the routing, the corridor was modelled using cross profiles (Figure 3). Information included in this model to enhance understanding of the rationale for impact assessment are those on geology, soil, drainage, land use/land cover, erodibility, slope class and indemnity class. The impact magnitude map was derived from the integration of the result of three erodibility classes (1,2,3); three slope classes (1,2,3); and three indemnity classes with the magnitude of class number corresponding with magnitude of impact (see Figure 4). Indemnity is defined in terms of economic, social or environmental cost of potential impact in a given area.

5 PROPOSED ROUTE

The corridor was selected based on the impact magnitude map given certain environmental and socio-economic criteria including:

- Avoidance of high indemnity cost areas i.e. land already covered by settlements, industrial areas and prime agricultural land planted to tree crops;
- Avoidance of areas prone to gullying , forest and wildlife reserves:
- Avoidance of human and industrial hazards such as could be posed by proximity of high tension lines to structures e.g. a large tank farm belonging to the Nigerian National Petroleum Company (NNPC);
- Avoidance of multiple crossings of railways lines and thus the need for special facilities at these crossings;
- Ultilization of the electric utility company's 330KV and 132KV lines existing right-of-way. Thus non duplication of such right of ways;
- Minimization of construction costs that would be incurred if corridor traversed ravines and badlands.



GEOLOGY	CRETACEOUS (UPPER - SENONIAN) FALSE BEDDED SANDSTONES (FBS)								
SOIL	S.SOIL	LATERITE	SANDY SOIL	L	SANDY SOIL	L	SANDY SOIL	LATERITE	S. SOIL
DRAINAGE	WELL DRAINED	WELL DRAINED	DRY VALE	WELL DRAINED					
LAND USE	B	B	SMB	B	B				
ERODIBILITY	3	3	3	3					
SLOPE CLASS	2	3	2	1	2	1	3	1	3
INDEMNITY	0	0	1	0	0	0			
IMPACT	LTD EROD.	HIGHLY-ERODIBLE	LIMITED TO ERODIBILITY	HIGHLY ERODIBLE	LIMITED TO EROD.	HIGHLY ERODIBLE			

L = Laterite

Figure 3: Transect Diagram of Subscene 4

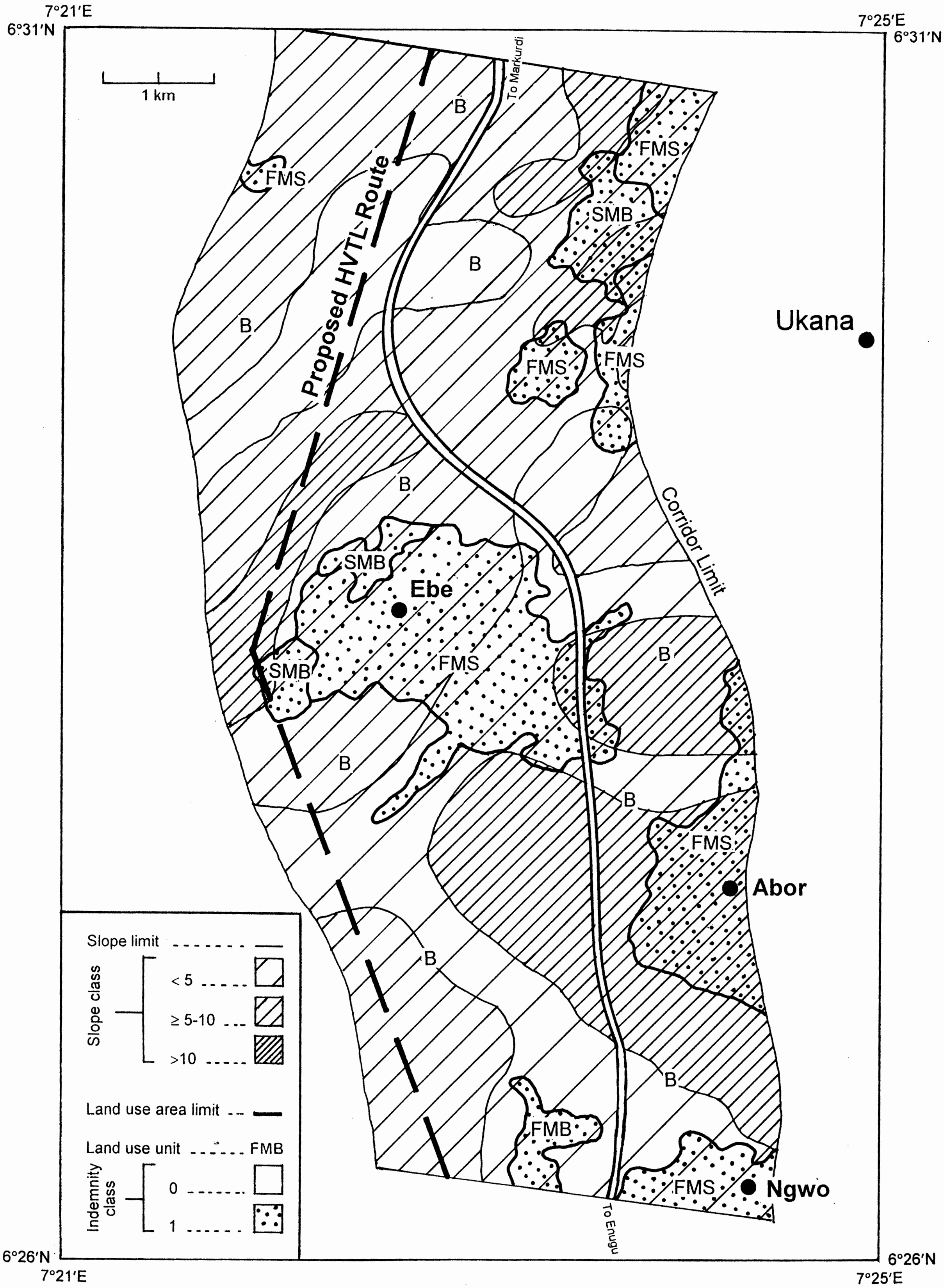


Figure 4: Impact Magnitude Map

6 CONCLUSION

The study describes the use of satellite mapping in attaining a rapid determination of an EIA for a proposed High Voltage Transmission Line (HVTL) route development. The impact on the environment was assessed within the potential corridor of the HVTL using indices such as vulnerability to gullying, synergistic changes to physiognomy and species composition of vegetation, probable loss of wildlife due to opening up of reserves, and the overall social, economic and environmental cost of the potential impact.

This study demonstrated the significance of satellite mapping in land use studies and their application in the rapid evaluation of the impact of socio-economic development on the environment.

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REFERENCES

Bouyoucous, G.J., 1935. The clay ratio as a criterion susceptibility to erosion. American society of Agronomy, 27, pp. 738 - 741.

Byran, R.B., 1968. The development, use and efficacy of indices of soil erodibility. Geoderma, 2, pp. 5 - 25.

Griffiths G.H., Wooding M.G., 1989. Use of satellite data for the preparation of landcover maps and statistics. Working paper 33/1, National Remote Sensing Centre (NRSC) , Farnborough, Hampshire, U.K.

Keay, R.W.J., 1959. An outline of Nigerian vegetation (3rd edition). Federal Government Printer, Lagos, Nigeria.

Mayor, F., 1988. GIS for managing sustainable development: the UNESCO approach. ITC Journal, 4, pp. 350 - 353.

Mgendi, M.F., 1999. The application of GISs in environmental impact assessment in Africa: Challenges and Opportunities. In: Mussio L., Cripps B., Forlani G. (eds) International cooperation and technology transfer workshop. Cotonou, Benin, pp. 330 -332.

Sanford W.W., Isichei A. O., 1986. Savanna. In: Lawson, G.W. (ed.) Plant ecology in West Africa : Systems and processes. John Wiley and Sons Inc., New York , pp. 95 - 149.

Wolfgang, S. (ed.), 1993. Global ecology and the shadow of 'development'. In: Global ecology: A new arena of political conflict, Fernwood, Canada, pp. 3 - 21.

World Bank, 1995. Definite and environmental development strategy for the Niger Delta. Report No. 14266, Vol. 1, 150 p.