Application of Remote Sensing Techniques for Environmental Impact Assessment

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ABSTRACT: *Environmental Impact Assessment (EIA) is potentially one of the most valuable, inter-disciplinary, objective decision-making tools with respect to alternate routes for development, process technologies and project sites. The major methodological limitation of EIA relates to resource requirements for data collection. While elaborating the role of EIA in developmental planning, the paper discusses the role that remote sensing techniques could play in data collection for vegetation and land use mapping with the help of a case study.*

INTRODUCTION

Our developmental imperatives make it essential that environmental concerns be internalised in the overall process of planning for economic development. Environmental Impact Assessment (EIA) could form a major instrument in decision-making related to developmental projects. In India, the Ministry of Environment and Forests has identified the sectors requiring clearance from the environmental angle. A formalised procedure for EIA now exists in the country. The major methodological limitation of EIA relates to resource requirements for data collection. While elaborating the role of EIA in developmental planning, the paper discusses the role that remote sensing techniques could play in data collection for vegetation and land use mapping with the help of a case study.

ENVIRONMENTAL IMPACT ASSESSMENT

EIA is potentially one of the most valuable, inter-disciplinary, objective decision-making tools with respect to alternate routes for development, process technologies and project sites. It is an anticipatory mechanism which establishes quantitative values for parameters that indicate the quality of the environment and natural systems before, during and after the proposed developmental activity, thus allowing measures ensuring environmental compatibility with economic efficacy.

EIA could form a major instrument for the assessment of developmental activities in the context of regional carrying capacity, provided the conceptual framework is extended to the cumulative assessment of policies, plans and projects on a regional basis.

EIA should ideally be undertaken at the policy and planning levels as the environmental consequences of projects often arise due to higher-level decisions[1]. Policy EIA, however, is viewed as an extremely complex issue, largely due to the fact that the potential range of alternatives to achieve a desired goal can be almost unlimited. This problem may be resolved through a hierarchical approach in which the number of alternatives are reduced by defining the problem in terms of a series of choices as illustrated in figure 1.

The most appropriate stage for implementing EIA is at the level of district planning, since at this stage a reasonable number of alternatives are available to the developer. The assessment of regional supportive and assimilative capacities during the formulation of development plans could greatly reduce the requirement for project EIA[2].

Most ecological problems are the cumulative result of environmental and social impacts of human activity in the region. Planning for sustainable

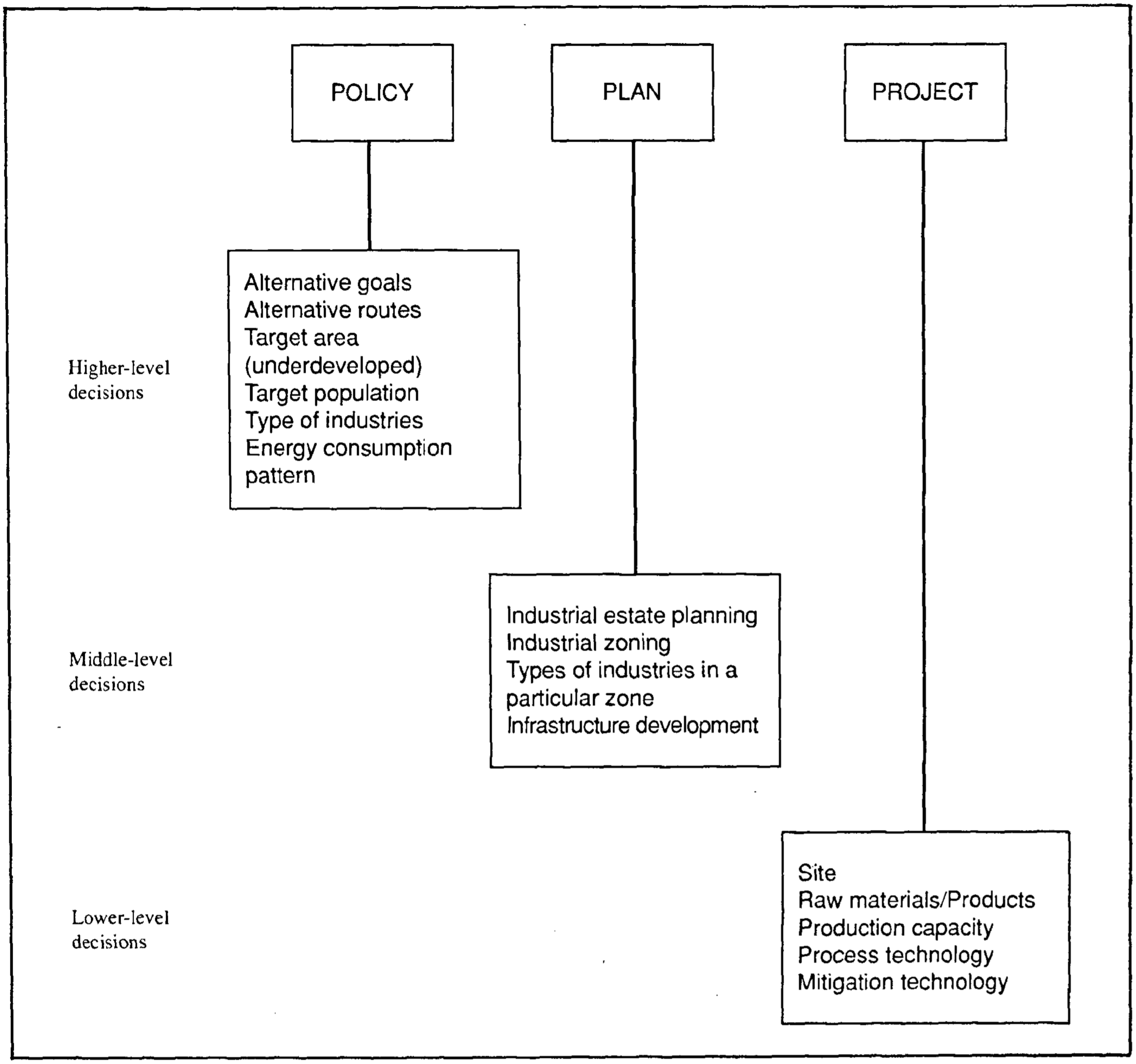

Figure 1 · Hierarchy of decision making related to industrial development

development in the context of ecosystems carrying capacity thus requires systematic identification, quantification and management of cumulative trends in significant environmental variables on a regional basis. Functional planning regions need to be identified based on ecological criteria, such as climatic, vegetation patterns and soil classification; airshed and watershed boundaries rather than political jurisdictions.

Application of remote sensing techniques

Experience over the years has shown that EIAs are always conducted under severe limitations of time, manpower, financial resources and data. India has unique problems in this respect due to its vastness, variety of climate, culture and custom resulting in widely diversified lifestyle, varying nature of terrain, flora and fauna, etc. No reliable comprehensive environmental information base exists and the need for extensive data collection makes EIA an extremely cumbersome and time consuming exercise.

Accurate and reliable information on the distribution of various earth resources, such as soil, water, vegetation, mineral, human settlements, etc. form the backbone of any EIA study. The remote sensing techniques through satellite-based earth observations in judicious conjunction with traditional techniques offer an efficient, rapid and cost-effective method of survey, monitoring and management of resources; their depletion, degradation and contamination.

The spatial resolution and the spectral bands in which the sensors collect the remotely sensed data are two important parameters influencing the choice of remotely sensed data consistent with categoric extraction and scale of mapping. These reflect the specific objectives, that the mapping is intended to serve. The microlevel land use mapping with level-II categories is considered an appropriate input for EIA study. Visual and digital are the two major analytical approaches available to remote sensing application scientists. Between the two, the latter is preferred, as it allows correct radiometry, maximum spatial resolution and freedom from the hazard of subjectivity.

Application of Remote Sensing to Vegetation Mapping

A linearly stretched standard False Colour Composite (FCC) is first generated for a general view of the major land use categories of the area. It also reveals the contextual relationships among them. Normalised Difference Vegetation Index (NDVI) image is generated to investigate distribution of vegetation in the project area. Expressed as NIR-VISR/NIR+VISR, NDVI facilitates consistent discrimination of vegetation. Its higher values are associated with denser vegetation, larger leaf area and more green biomass. NDVI output is subjected to Gaussian post-normalisation. Supervised classification using all the spectral bands and employing maximum likelihood algorithm is performed to achieve land use categoric abstraction at level-II. Classification accuracy is achieved through interactive iteration and referential refinement. Proper selection of training sets is aided by FCC and NDVI outputs. Part of the ground truth collected is used for assessment of the results.

Application of Remote Sensing for Land use Mapping

Land cover denotes the vegetational and artificial formations on the land surface, encompassing biotic and abiotic components of the environment. Land use, on the other hand, refers to man's utilitarian activity on land. The remote sensing data enable information essentially on land cover from which land use is inferred. The land use land cover classification system standardised in conjunction with the methodology developed at RRSSC, Nagpur for generating districtwise land use/land cover mapping could be followed[2,3]. It has 6 land use classes (Built-up land, Agricultural land, Forest, Waste land, Water bodies and others) at level-I and 28 at level-II.

CASE STUDY

An industrial complex has been proposed at Hazira to manufacture various petrochemical products. The site is located on low lying barren track close to the saline estuarine zone of Tapi river at village Mora. Land use data in conjunction with ancillary information, such as demographic data, existing distribution of pollution, projection of new developmental activities, etc., is needed to provide a framework for analysing the environmental processes and problems. An impact zone of 10 km radius around the proposed site has been identified for EIA as per the existing guidelines for this purpose.

The IRS LISS-II data with a spatial resolution of 36.25 metres was a logical choice. Temporarily, September-October being the period of maximum vegetation cover, cloud free October data was preferred over cloudy September scene. The digital image processing was performed in VIPS-32 environment on Pericolour- 2001 workstation, configured around VAX-11/780 computer system at RRSSC, Nagpur.

Splitting of Tapi into three streams and a number of bars, before it enters the Arabian sea, is conspicuous on the false colour composite image (Figure 2) representing 18.56 km^2 area. Visually, three to four classes of water could be identified based on turbidity and depth in the estuarine region. Considerable coastal area seems to be covered by mudflats and saline/sandy waste lands from Tena Creek to Tapi estuary. Changes in the turbidity of Tapi water are conspicuous, increasing from the north-eastern end of Kadia belt (25 NTU) to its southern tip (215 NTU). Further from the coast, turbidity seems to decrease again due to dilution. In contrast, small artificial inland water bodies show clear water. Vegetation cover corresponding to the month of October in the neighbourhood seems to be good due to the healthy growth of crop, grass and scrubs. There is no notified forest in the vicinity of the project site.

Colour coded classified output showing 14 land use classes for an area within 10 km radius from the project site is illustrated in figure 3. Water, which occupies 24 per cent of the project area is differentiated into three categories based on sediment loading and depth. Waste lands comprising salt affected areas, scrublands, mudflats and inland sand bars cover 27 percent of the project area. Unvegetated coastal mudflats could be divided into two categories based on their moisture status. The first category is located adjacent to the seashore, whereas the second extends deeper along the creeks and stream and covers a considerable area around Tena, Vasava, Damka and Suvali. Small salt affected land units are associated with mudflats and in Hazira-Mora-Kawas belts. These are being developed for industrial activities. Grass lands cover most part of the Kadia belt and are scattered over north of Tena creek. Croplands are spread over 15 per cent of the area; the main crop being rice. Fallows are divided into two categories. Category 1 relates to real fallows, whereas category 2 comprises fallows infested with weeds and pseudo-fallows. Pseudo-fallows are areas that were sown to be crops, but incipient vegetative growth did not allow their spectral discrimination from real fallows.

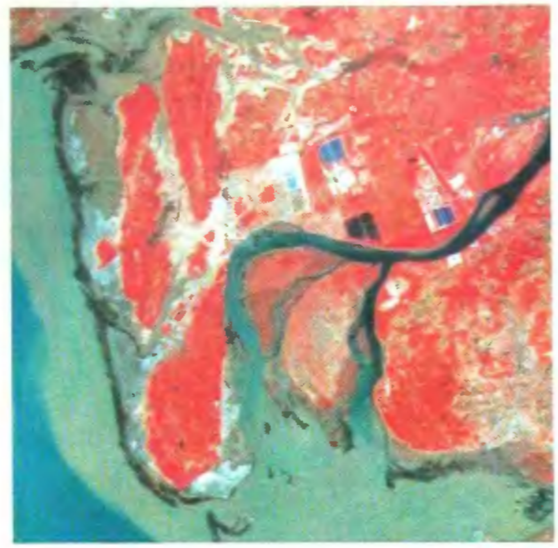

Figure 2. Linearly stretched FCC of the neighbourhood of the proposed site.

Figure 3. Land use map of the probable impact area.

CONCLUSIONS

Baseline information on land use pattern is a prerequisite for identification, prediction and evaluation of impacts on physico-ecological and socio-economic environment. The mathematical models used to quantify air and noise pollution take into account attenuation due to vegetation mapping. The remote sensing techniques are being applied in these areas for EIA, and research is in progress for identification of isolated and endangered ecosystem as also quantification of pollution.

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