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ENVIRONMENTAL IMPACT ASSESSMENT - A GIS BASED APPROACH

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भारतीय खनिज उद्योग में (खनिजों के निष्कासन एवं संसाधन में) साधारणतः कम्प्यूटर का उपयोग, कुछ क्षेत्रों को छोड़कर जहाँ इसका व्यापक उपयोग हो रहा है, अभी तक प्रारम्भिक अवस्था में ही है। खनन और खनिज के निष्कासन में कम्प्यूटर के उपयोग की महत्ता सर्वविदित है पर भारत में अभी तक हमारे पास उपलब्ध इस तकनीक में कार्यान्वयन एवं व्यवहार सुखद स्थिति में नहीं है।

ऐसे प्रमुख क्षेत्र जहाँ कम्प्यूटर तथा इससे संबंधित पैकेजों का प्रयोग भारी बदलाव ला सकता है, उनमें से एक है पर्यावरण प्रभाव के आकलन के लिए भूवैज्ञानिक सूचना पद्धति का उपयोग। यद्यपि पर्यावरण आकलन के बहुत सारे तरीके हैं, पर अभी तक पर्यावरणीय आकलन की कोई भी प्रणाली पूर्णतया तकनीकी एवं किसी भी परिणाम के लिए सर्व समाकलित नहीं पाई गई है। एक सही तरीके से डिजाइन की गई भूवैज्ञानिक सूचना पद्धति आधारित प्रणाली अन्य परम्परागत प्रणालियों से कहीं बेहतर परिणाम दे सकती है क्योंकि यह क्षैतिज तथा प्रतीकात्मक दोनों प्रकार के आँकड़ों का बिना किसी व्यवधान के आकलन कर सकती है।

इस आलेख में दामोदर नदी बेसिन के एक केस स्टडी के संक्षिप्त वर्णन के साथ ही भूवैज्ञानिक सूचना पद्धति आधारित एक पर्यावरणीय प्रभाव आकलन (EIA) के अध्ययन के ब्यौरे को प्रस्तुत करने की कोशिश की गई है।

INTRODUCTION

Environmental Impact Assessment (EIA) is an useful predictive exercise required for assessing the environmental background of the area and pollutional impact of the project under consideration. Identification of major impact of the environment forms the guideline to prepare the necessary plan for environment management. Directives are identified in regard to the manner of handling the impacts in terms of environmental protection, conservation and preservation.

The environmental Impact Assessment can be done through various methods and means. One of the latest tools being used is Geographical Information System (GIS). A properly designed GIS based system can achieve better results than the other conventional systems, because it (GIS) can use satellite imageries to augment its database. The digital database can aid in :

i) Study of human settlements, industrial and mining growth centres along with all related issues and projections of regional growth scenarios for the future.

ii) Study specific issues of the region.

iii) Prepare guidelines for decision making.

iv) preparation of short-term and long term plans.

OBJECTIVES OF EIA

Broadly the objectives of EIA is to estimate the likely impact of any developmental project / activity on the various environmental components. Hence it is imperative :

- To find out the suitability of the area for mining reference and to delineate areas where mining should not be done.

- To devise the mining standards to be followed in respect of suitable mining methods which can be applied with minimum degradation.

ENVIRONMENTAL IMPACT ASSESSMENT (EIA)

Recently Government of India has enforced the Environmental Impact Assessment Notification, 1994. Fig 1 illustrates the different phases of impact assessment.

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Environmental Impact Identification

EIA is a description of the existing environment and estimation of the potential effect due to mining activities. Impact identification is the procedure for bringing out the human activities on environmental system (Mehta, 1990). Identification is made for inter-comparison of the development options and screening of alternate sites for locating the project (Jones, 1993). For identification of impacts it is useful to draw a list of parameters, relevant to the type of projects under consideration (Sahu, 1988).

Among the available methodologies it is obvious that no one system of environmental assessment is applicable to all types of project through out the country (NEERI, 1993; Maudgal, 1990). No given system has overall flexibility and comprehensiveness to cover every eventuality.

Impact Prediction

To predict the expected impacts of the various mining activities on the different environmental parameters, a detailed survey of each factor is performed and identification of probable impacts are done by different prediction techniques.

The techniques vary with type of parameter. Number of models are available to predict the air quality, water quality, etc., but all the available models are site specific in nature.

Impact Evaluation

Number of EIA methods are available and they are as follows:

(i) Adhoc

It is a old and crude method which can only bring out broad impacts on forests, human population, etc. secondary impacts are rarely addressed.

(ii) Check Lists

A check list is a list of environmental parameters in which an adverse, beneficial or no effect is time marked. They are usually very large and subjective and is of little use in decision making.

iii) Matrix Method

A matrix format is used to relate project actions with environmental parameters. The column of the matrix consists of 100 project actions (could be reduced as per requirement) and the rows of the matrix consist of 88 environmental components, which too could be suitably altered depending upon the requirements of the project. If any particular activity of the project affects one environmental component, the appropriate column is assigned a score depending on the magnitude and importance of the impact. A (+) or (-) is also put to designate harmful or beneficial impact.

Row totals of the matrix reflect the cumulative impact of all project actions on one environmental component while the column totals reflect the impact are project activity on all the components of the environment. The matrix total gives the total environmental impact.

iv) Mathematical Matrices

Two such matrices have been developed namely, the Peterson's Matrix and Component Interaction Matrix in the year 1974. The later was developed by Ross.

The Peterson's matrix is constructed to evaluate the effects of environmental action on various components of the environment on a scale of +3 and -3. Another matrix is constructed to evaluate the effects of the impacted physical components on human environment matrices as developed in the earlier two steps are then multiplied to produce a third matrix which brings out the effect of project activities or actions on the human environment. The production matrix is operated by a vector of relative weight of human impacts to yield a weighted vector of human impacts. The weighted vectors are then summed up to arrive at the total value of the impact of the project.

The Component Interaction Matrix was developed to assess major impacts of five alternative sites for transhipment of number on a estuary. The following steps are involved :

i) Construction of a matrix with environmental components on each and identifying first order dependencies.

ii) The matrix is powered to determine all higher order dependencies.

iii) A disruption matrix is then constructed to score impacts of each project alternatives on primary dependencies.

Mathematical matrices suffer from too much of mathematical aggregation, tends to be unwieldy and basic inputs are still subjective.

(v) Network Approach

The objective of such a method is to bring out in an easily understood format, the intermediary links between projects and its ultimate impacts. Since the environmental system is dynamic, an action or activity impacting any particular environmental parameter is capable of causing a series of impacts on a number of other

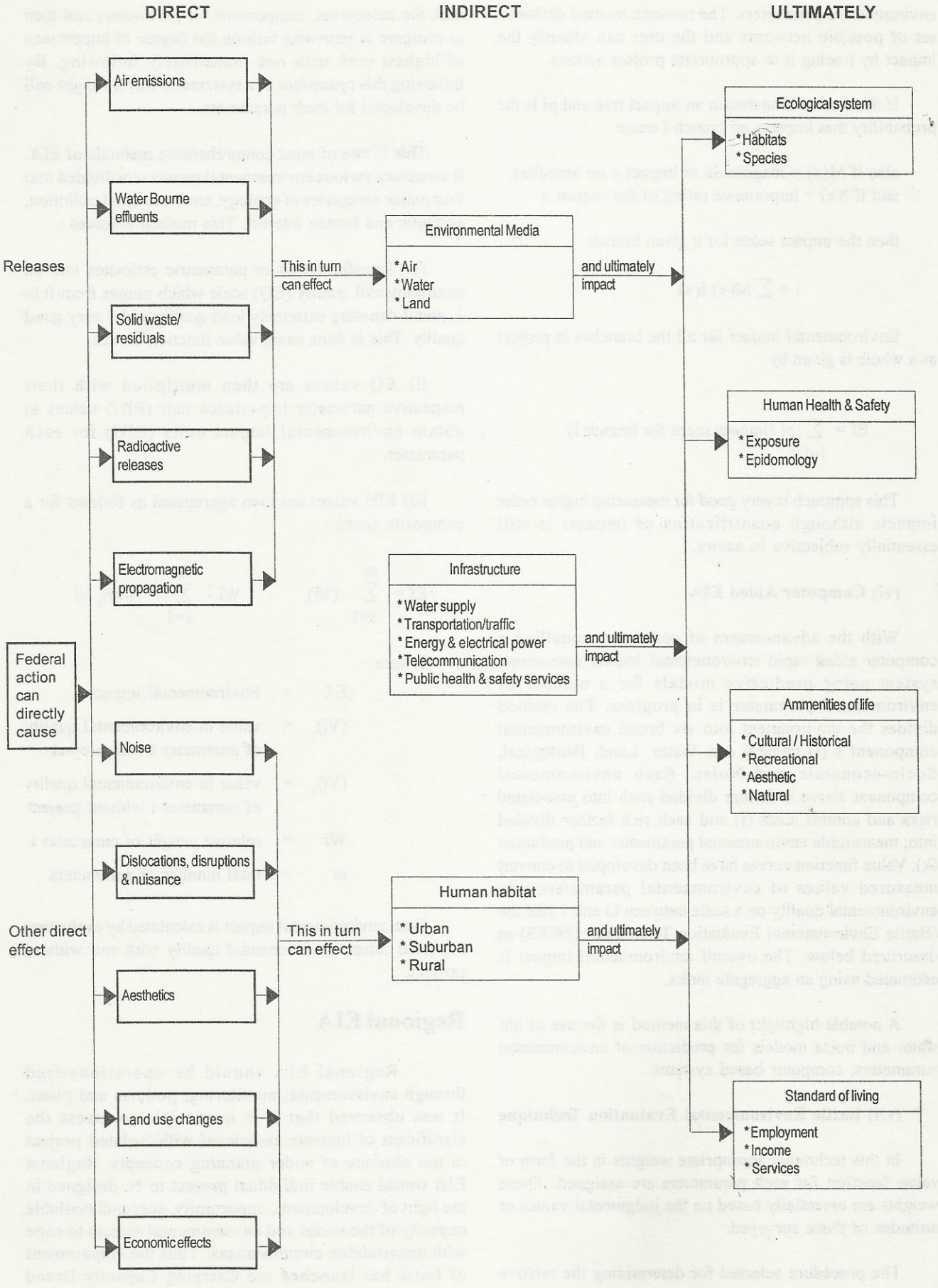

Fig. 1 : Systematic approach for Impact Identification

environmental parameters. The network method defines a set of possible networks and the user can identify the impact by tracing it to appropriate project actions.

If there are n branches in an impact tree and pi is the probability that impacts an branch i occur

also if M(x) = magnitude of impact x on branches.
and if I(x) = importance rating of the impact x

then the impact score for a given branch

$$i = \sum M(x)\, I(x)$$

Environmental impact for all the branches is project as a whole is given by

$$EI = \sum_{i=1}^{n} pi \text{ (impact score for branch i)}$$

This approach is very good for measuring higher order impacts although quantification of impacts is still essentially subjective in nature.

(vi) Computer Aided EIA

With the advancement of computer modelling a computer aided rapid environmental impact assessment system using predictive models for a number of environmental parameter is in progress. The method divides the environment into six broad environmental component s (i) namely Air, Water, Land, Biological, Socio-economic and Noise. Each environmental component above is further divided each into associated risks and control costs (i) and each risk further divided into; measurable environmental parameters and predictors (k). Value function curves have been developed to convert measured values of environmental parameters into environmental quality on a scale between O and 1 like the (Battle Environmental Evaluation Technique) (BEES) as described below. The overall environmental impact is estimated using an aggregate index.

A notable highlight of this method is the use of air, water and noise models for prediction of environmental parameters, computer based systems.

(vii) Battle Environmental Evaluation Technique

In this technique appropriate weights in the form of value function for each parameters are assigned. These weights are essentially based on the judgmental values or attitudes of those surveyed.

The procedure selected for determining the relative importance of each parameter consist of a ranking and pair wise comparisons. Each of the individuals is required to rank the categories, components, or parameters and then to compare in pair-wise fashion the degree of importance of highest rank with one immediately following. By following this procedure in a systematic way a weight will be developed for each parameters.

This is one of most comprehensive methods of EIA. It visualises various environmental parameters divided into four major categories of ecology, environmental pollution, aesthetic and human interest. This method involves :

i) Transformation of parametric estimates into an environmental quality (EQ) scale which ranges from 0 to 1, and 0 denoting extremely load quality and 1 very good quality. This is done using value function curves.

ii) EQ values are then multiplied with their respective parameter importance unit (PIU) values to obtain environmental impact units (EIU) for each parameter.

iii) EIU values are then aggregated as follows for a composite score :

$$EI = \sum_{i=1}^{m} (Vi)_1 \qquad Wi - \sum_{i=1}^{m} (Vi)_2\, wi$$

Where,

EI	=	Environmental impact
$(Vi)_1$	=	value in environmental quality of parameter i with project
$(Vi)_2$	=	value in environmental quality of parameter i without project
Wi	=	relative weight of parameter i
m	=	total number of parameters

Total environmental impact is calculated by evaluating expected future environmental quality with and without project.

Regional EIA

Regional EIA should be operationalised through environmental monitoring, policies and plans. It was observed that it is impossible to assess the significant of impacts associated with isolated project in the absence of wider planning concepts. Regional EIA would enable individual project to be designed in the light of development, opportunity, cost and available capacity of the social and environmental system to cope with unavoidable circumstances. Thus the Government of India has launched the Carrying Capacity Based Planning Process for sustainable development of the region.

GIS FOR EIA STUDY

Objectives and Approach

The foremost objective of the GIS based impact study is the identification of hotspots / problem areas with respect to the different environment pollution aspects (Pal, et al., 1999). The approach adopted consists of the following major activities :

i) Design of digital geographic database complete with both spatial (geomatic data) as well as corresponding attribute data.

ii) Interpretation of satellite imageries and ground truthing to arrive at the latest status of resource / wastes.

iii) Creation of micro database pertaining to individual areas (coalfields, urban centres, etc.)

iv) Amalgamation of spatial data, attribute data, satellite imageries and micro databases to create a comprehensive macro-level database.

v) Analysis of the data using different modelling and overlay techniques to identify the hotspots / problem areas.

ANALYSIS / MODELLING

The goal of GIS analysis / modelling is to find solutions to real life problems related to the study area i.e. identification of hotspots w.r.t. the different pollutants and to formulate alternative developmental plans based on "what if" scenarios. Analysis and modelling of geographical data can be carried out on both the spatial as well as attribute data. Apart from the conventional overlay analysis the other major analytical techniques (Auren Hammer, et al, 1991; Burrough, et al, 1986) that can be used are as follows :

a) GIS theme operation
b) Formula application
c) Qualitative analysis
d) Change detection analysis
e) Influence zone models
f) Multi-parameter analysis

CONCLUSIONS

As a results of increased concern over the impact of human activity on the environment, a number of countries have adopted legislation requiring that the potential efforts of certain projects should be assessed.

In case of case study of Damodar River Basin:

1. the air quality index map shows that the mining areas are the major hotspots (problem areas) w.r.t. air quality, and

2. GIS theme analysis of geological map with the landuse map shows that most of the future mining activity will be located in the remaining good forest areas of the basin.

It is suggested that restoration and bio-reclamation work should be adopted simultaneously with mining to reduce the adverse impacts on the different environmental parameters viz. air, water, land and bio-diversity (Singh, et al., 1996).

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