

Fuzzy Logic an Effective Tool for Environmental Impact Assessment of Mining Projects

Mukund Phatak¹, Narendra Kanhe²

¹Associate Prof., Deptt. of Civil Engg.,

VNS Institute of Technology, Bhopal (M. P.) India.

²Professor, Deptt. of Civil Engineering, Gurunanak Institute
-Engineering & Management, Nagpur (Maharashtra) India.

ABSTRACT

Evaluation of the Environmental Impact Assessment (EIA) report of a mining project is required to ensure the environment friendly development. Experts draw conclusion not only on the basis of the scientific data but their decisions are influenced by political and social values. Impact significance is at the core of probable impact identification, prediction, evaluation and decision making in Environmental Impact Assessment (EIA). Degree of subjectivity is high in the present EIA decision making process. It is difficult to model the qualitative human thinking process for decision making. Fuzzy logic is a recognized tool which has ability to model qualitative human thinking process using words. This paper attempts to use fuzzy logic as a decision making tool for mining projects proposed in the state of Madhya Pradesh.

I INTRODUCTION

Environment Impact Assessment (EIA) of a mining project involves impact prediction and assessment of significance of the project on environment. The EIA involves scoping, studying baseline data, identifying possible impacts of the proposed project and suggest a Environmental Management Plan (EMP). The baseline condition (i.e. existing environmental condition) is referred as a basis for evaluation of impacts. The idea of impact prediction is to forecast the effects of an identified impact through methods like subjective judgment (commonly used), mathematical models and statistical models etc. Significance of environmental impact is evaluated on the basis of forecasted impact by the State Level Environmental Impact Assessment Authority (SEIAA) of Madhya Pradesh for the proposed mining projects having mining area up to 50 Hect., in the state.

II CONCEPT OF SIGNIFICANCE

Impact significance is at the core of probable impact identification, prediction, evaluation and decision making in Environmental Impact Assessment (EIA). The ultimate aim of EIA, is to arrive at a conclusion whether a project is likely to cause significant environmental effect or not. Concept of significance has been widely discussed and many authors have proposed

various definitions. Even though a number of definitions of the concept of significance exist, there is some degree of commonality found in these definitions. Following common elements are recognized [3].

- Environmental significance is a value judgment.
- The degree of environmental significance depends upon the nature of the impact.
- The importance is rated in terms of both biophysical and socioeconomic values.
- Determining significance involves the amount of change to the environment perceived to be acceptable to affected communities.

III OVERVIEW OF PRESENT PROCESS OF CLEARANCE

The EIA notification of 14th September 2006 states that a mining project requires a prior environmental clearance from a regulatory authority of the Ministry of Environment and Forest. With a view to speed up the clearance process a national level regulatory authority for clearing "A" (More than 50 Hect. area) category projects have been constituted at Ministry level whereas for the clearance of "B" (Area between 5 to 50 Hect.) category projects, the regulatory authorities have been constituted at state level consulting the concerned State Govt. These SEIAAs have been delegated powers to accord prior environmental clearance to B category Projects at state level. The SEIAA will base its

decision on the recommendations of state level expert appraisal committee (SEAC) constituted as per the provisions of the same EIA notification. The SEAC will comprise of the experts from various fields, who can assess the possible threats to the environment by proposed mining activity. The environmental clearance process will comprise of four stages namely [1]:

- a. Screening (only for "B" category projects)
- b. Scoping.
- c. Public consultation.
- d. Appraisal.

(a) Screening

This stage deals with the scrutiny of the application submitted in the prescribed form I for determining, whether the project requires further environmental studies for preparation of environmental impact assessment (EIA) before granting a prior environmental clearance to the project. This will further categorize the project into B1 or B2 (B1 requiring EIA report while B2 does not require it).

(b) Scoping

All the B1 category projects need to be suggested a comprehensive terms of reference (TOR) addressing all relevant environmental concerns in respect of the proposed activity. The SEAC will finalize the TOR on the basis of the information furnished by the project proponent.

(c) Public Consultation

It is the most important step involved in the whole process. The public consultation has been included in the process to ascertain the concerns of the affected local people and others who have a possible stake in the environmental impacts of the proposed project. In the public consultation process objections and suggestions are collected from the public during meeting at proposed site or received in writing.

(d) Appraisal

It means the detailed scrutiny of the application, final EIA report submitted by the proponent and the objections and suggestions raised during public consultation. The expert appraisal committee has to take a final decision about granting or rejecting the prior environmental clearance on the basis of above information. The committee can also call the proponent or his representative for any clarification if required. The committee shall make categorical recommendations to regulatory authority for grant of prior environmental clearance on

necessary terms and conditions or rejection of application mentioning reasons for same.

IV GRANT OR REJECTION OF PRIOR ENVIRONMENTAL CLEARANCE

- (i) The regulatory authority shall consider the recommendations of the appraisal committee and convey its decision to the proponent.
- (ii) In normal circumstances, the recommendations of the expert appraisal committee shall be accepted by the regulatory authority. In case of disagreement, the regulatory authority can send the proposal back to the expert appraisal committee for reconsideration.
- (iii) The expert appraisal committee shall reconsider the proposal and will send its views to the regulatory authority.
- (iv) The decision of the regulatory authority after considering the views of expert appraisal committee shall be final and communicated to the proponent. If the proponent has not been communicated the decision by the regulatory authority within the stipulated time period mentioned above; the applicant is free to proceed as if the environmental clearance has been granted / denied as per the final recommendation of the expert appraisal committee.

V CHALLENGES BEFORE THE DECISION MAKERS

SEIAA and SEAC are functional in the state of Madhya Pradesh for about last five years. During this period many projects were accorded prior environmental clearance. After detailed study of the working of SEIAA & SEAC, it was realized that following challenges are faced during EIA appraisal at state level.

(a) Non availability of guidelines for classification in to B1 and B2

It is mentioned in the EIA notification of 14th Sept. 2006 that the Ministry of Environment and Forest will issue guidelines to SEIAAs and SEACs for classification of B cat. projects in to B1 or B2. It should be decided on the basis of probable impact of the proposed project. If a project requires further environmental studies for preparation of environmental impact assessment (EIA) before granting a prior environmental clearance to the project, it should be classified as B1. Other projects expected to put lesser impact

on environment should be kept in B2 category [6].

In the present process of environmental clearance, the SEIAAs and SEACs do not have a clear guideline or a tool even after the existence of EIA Notification for the last more than six years. The author of the paper made a presentation before State Level Expert Appraisal Committee (SEAC) of Madhya Pradesh on 10th April 2013. The concept of developing a comprehensive mathematical model for assessment of EIA report was discussed with the members of SEAC. It came up during discussion that the model which is being developed will be an effective tool for categorizing projects in to B1 or B2. It will show the impact significance factor of various parameters due to proposed project. The model is based on Fuzzy Logic.

(b) Inadequate and non authentic baseline data

The accuracy and authenticity of the EIA report depends on the base line data. In the absence of a central data bank, the proponent collects the data on his own to suit his convenience. The decisions of SEAC and SEIAA are based on the EIA reports generated on the basis of this data. It is learnt that most of the existing units are conducting periodic monitoring and maintaining the data for their own requirement. But the availability and reliability of this data is again doubtful [2].

(c) Improper monitoring and compliance by proponent

Environmental Management Plan (EMP) is an out come of the EIA study, proposed to mitigate the impacts of the activity on the environment [7]. Strict follow-up of the provisions of EMP depends on the sincere efforts of the project management towards the society. Most of the EMP does not spell out clearly the activities in details and the fund allocation for the same. Regulatory authorities have been assigned the duty of monitoring and compliance of EMP and the conditions imposed during grant of the clearance. But it is observed that due to lack of resources and manpower the above job has not been carried out to the extent required [7]. The proponents take undue advantage of the situation, in implementing the conditions of EC and EMP to suit their convenience.

(d) Ineffective public participation

Public consultation has been made mandatory in almost all the activities covered under the EIA Notification of 2006. It is envisaged that the

public consultation is an effective tool in the process of decision making. The socio economic conditions of our country is different, as compared to the developed countries like US, where public consultation has been introduced at all levels i.e. screening, scoping, decision making etc. Most of the population is not aware about their environmental problems. The one time public consultation has not proved to be effective in Indian context at present. It seems to be simply a bureaucratic requirement [2].

(e) Poor quality EIA reports

Earlier the process of EIA was centralized at national capital. In due course of time the national level consultants developed the skill of producing a fair quality EIA, which is a basis of decision making. After the introduction of the EIA notification of 2006, the power of granting environmental clearance was decentralized. The state authorities (SEIAAs) were constituted at state level. It is observed that there was a drastic increase in the no of projects to be cleared by SEIAA, while in proportion no of qualified and skilled consultants did not increase. The persons doing liaison work started environmental consultancy at state level. EIA produced, were merely compilation of data with extensive use of cut and paste facility available in the computer. Interpretation and analysis of the data was hardly present in a report. The above observation was made public by the then Union Minister for, Environment Shri Jairam Ramesh in Hyderabad (Times of India Nagpur report dt 20/03/2011) [2].

(f) Lack of coordination and poor decision making

It is observed that lack of coordination between SEIAA, SEAC, State Pollution Control Board, MOEF's Regional office and the State Govt. results in delay in decision making. Most of the members of SEIAA and SEAC are retired personals. The process of their selection is also not very clearly defined in the notification. As per the provision, the State Govt has to recommend the names of chairman and members of SEIAA and SEAC to MOEF for their nomination. The above process has made SEIAA and SEAC as the rehabilitation centers of the retired bureaucrats. In Madhya Pradesh SEIAA was not functional from Aug 2010 to Nov 2010 due to delay in finalization of names. Present process exerts great political and bureaucratic pressures, each time SEIAA and SEAC is reconstituted. Lack of availability of a decision making tool and non availability of the subject specific experts in SEIAA/SEAC result in poor

quality decision making. All sectors are not represented by an expert in SEAC.

All the above challenges have bearing on the decisions of SEAC and SEIAA of Madhya Pradesh. Most of the decisions regarding issue of TORs are common in almost all the mining cases. Very rare case specific TORs are issued to the proponents. While each case should be specifically assessed for the possible impacts and its significance. In the absence of clear guidelines issued by the ministry or a tool which can guide SEAC to assess the impacts, decisions are taken by the experts on the basis of their experience. This gives rise to high degree of subjectivity in the whole process. If a mathematical model is developed for EIA evaluation, a quick scientific decision with a high degree of objectivity can be achieved.

VI WHAT IS FUZZY LOGIC

In recent years, the use of Fuzzy Logic has increased significantly. It is widely used in consumer products like camera, washing machine, microwaves, industrial process control, decision support systems etc. In narrow sense, fuzzy logic is a logical system, which is an extension of multivalued logic. However in wider sense, fuzzy logic is almost synonymous with the theory of fuzzy sets, a theory which relates to classes of objects with unsharp boundaries in which membership is a matter of degree [4].

VII USE OF FUZZY LOGIC

Two sources of subjectivity in EIA originate in estimating the relative importance of environmental factors and evaluating the impacts induced by a project. Both are concerned with balancing economic developments, environmental risk and social values, in which considerable subjective judgment are required because expertise, in addition to political values and social acceptability, has a significant role. Therefore some degree of subjectivity is inevitable in EIA [8]. Looking to the high degree of subjectivity in the present process, it was decided to develop a comprehensive mathematical model so that a high degree of objectivity in the process may be achieved. To develop the model, EIA reports of various mining projects proposed in the state of Madhya Pradesh were studied. Various important parameters responsible for considerable impact

on the environment were selected. It was realized that the overall impact of a mining project on environment can be assessed by evaluating following three important factors.

1. Environmental factors
2. Ecological factors
3. Socio Economic factors

To arrive at the overall impact of a mining project on environment, these three major factors were divided in to few important indicators. The overall impact on environmental condition of a mine site will depend on the following 8 indicators. Air, Water, Noise and Soil and Solid waste will be covered under environmental factor. Terrestrial and Aquatic animals and species will be covered under ecological factors while economic and societal conditions will be covered under Socio economic factor.

Sr. no.	Factors	Indicators
1.	Environmental	1.Air
		2.Water
		3.Noise
		4. Soil and Solid waste
2.	Ecological	5.Terrestrial
		6.Aquatic
3.	Socio Economic	7.Economic
		8.Societal

These indicators are further divided in to 19 sub indicators listed below-

- a. SO₂
- b. Nox
- c. PM 10
- d. pH value
- e. Total dissolved solids (TDS)
- f. Occupational noise
- g. Community noise
- h. Fertility of soil
- i. Overburden
- j. Threatened plants
- k. Threatened animals
- l. Endangered species
- m. Threatened animals
- n. Endangered species
- o. Land use
- p. Rehabilitation & Resettlement (R&R)
- q. Employment generation
- r. Community facility
- s. Occupational health

Out of the above 19 sub indicators, some are quantifiable while the others can be assessed in linguistic terms. A decision support framework for EIA of a mining project has been envisaged on the basis of the study of various EIA reports of mining projects. This frame work considers all the above factors / indicators and sub indicators. Fuzzy logic is employed to infer the significance of impact, because it can imitate human thinking process. An impact significance factor for all these indicators has been evaluated to arrive at the overall impact significance of the proposed project. The level of significance (Sigf.) is represented as a score ranging from 0 (i.e. insignificant) to 100 (i.e. very significant). A decision support

framework for EIA of a mining project using fuzzy logic (Fig. 1) has been proposed.

The proposed model for EIA evaluation based on fuzzy logic is derived on the basis of study of various EIA reports of mining projects considered by SEAC and SEIAA of Madhya Pradesh. This model has a possibility of improvement / change realized by the experts. There is always a possibility of inclusion of new parameters, deletion of already considered parameters, redefining their range, patterns and of course the if-then rules.

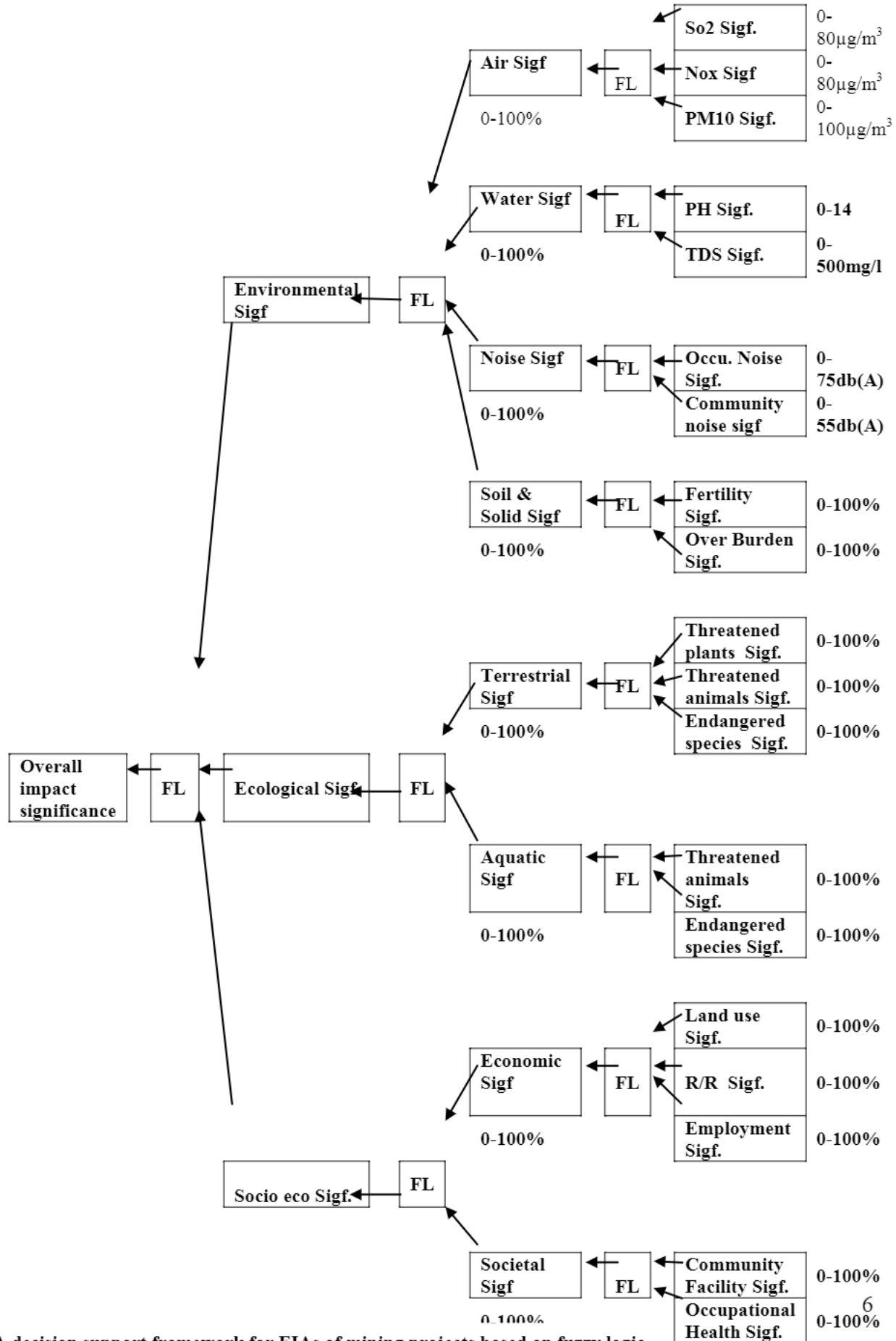


Fig 1 A decision support framework for EIAs of mining projects based on fuzzy logic

To determine overall impact significance of a mining project, 12 rule bases containing 252

fuzzy rules were produced: 27 rules for air; 9 rules for water; 9 rules for noise; 9 rules for soil and solids; 27 rules for terrestrial; 9 for aquatic; 27 rules for economic; 9 rules for societal; 81 rules for environmental; 9 rules for ecological; 9 rules for socioeconomic; 27 rules for over all impact significance. These 12 rule bases and their corresponding membership functions are constructed on the basis of experience and these fuzzy inference systems are evaluated using MATLAB Fuzzy Logic Toolbox [4].

VIII HOW IT IS EFFECTIVE

The proposed process of EIA evaluation is based on the probable impact on environment due to a particular mining activity. Various important indicators and sub indicators will be studied in a specific EIA report and its significance shall be evaluated using this scientific model. At each step, we would know the impact significance of a particular sub indicator or indicator. In other words it is possible to assess the contribution of an individual indicator or sub indicator in the overall impact significance due to a specific mining activity. This can be a guiding factor to finalize TORs initially and the conditions to be imposed while granting environmental clearance to the project finally.

IX CONCLUSION

The current general practice of EIA evaluation adopted by SEAC and SEIAA of Madhya Pradesh is based on combination of scientific methods and experience and judgment of EIA evaluation team. The evaluation of significance will remain contentious even when based on above things. Therefore prediction of impact and assessment of its significance should include consideration of value judgment. The proposed model for EIA evaluation based on fuzzy logic is derived on the basis of study of various EIA reports of mining project. It is being used for assessment of few mining projects as case study and will be published in subsequent papers. This model has always a possibility of improvement / change realized by the experts. There is always a possibility of inclusion of new parameters, deletion of already considered parameters, redefining their range, patterns and of course the if-then rules.

The present environmental clearance (EC) requirement seems to be considered as a bureaucratic requirement only. Because the proponent feels that without getting it, the project can not be executed. A sense of social responsibility towards the protection of environment is missing in most of the cases. This proposed new model will bring a sense of faith among the proponents about the process of EIA evaluation, ultimately giving it a high degree of acceptability by all the stake holders.

REFERENCES

- [1] Mukund Phatak and Dr. Narendra Kanhe, Status Report on Post Environmental Clearance Monitoring of Mining Projects in Madhya Pradesh A Case Study.
- [2] Mukund Phatak and Dr N. M. Kanhe Evaluation of EIA practice adopted by SEIAA in Madhya Pradesh using SWOT analysis
- [3] Nigel Rossouw, A review of methods and generic criteria for determining impact significance, AJEAM-RAGEE, vol. 6 June 2003 p 44-61
- [4] The Math Works, Fuzzy Logic Toolbox User's Guide.
- [5] K.F.R. Liu, H. H. Liang, K. Yeh and C. W. Chen, A qualitative decision support for environmental Impact Assessment using Fuzzy logic.
- [6] MOEF, The Environment Impact Assessment Notification S O 1533, Ministry of Environment and Forest, Govt. of India, Dt. 14th Sept.2006.
- [7] Mukund Phatak and Dr N. M. Kanhe ,Evaluation of EIA practice adopted bySEIAA in Madhya Pradesh using SWOT analysis.
- [8] Kevin Fong-Rey Liu and Jia-Hong Lai, An Integration of Quantitative and Qualitative Decision Support for Environmental Impact Assessment (July 2007)
- [9] Andre de Siqueira Campos Boclin and Renato de Mello, A decision support metho for environmental impact assessment using a fuzzy logic approach (Sept. 2005).
- [10]Kevin Fong-Rey Liu, Jia-Shen Chen, Han-his Liang, Cheng-Wu Chen and Yung-Shuen Shen, Combining Fuzzy Logic and Data Mining to Predict the Result of an EIA Review (2010)