Chapter Four

4. EIA Methodologies

4.1 Introduction

- Many times an EIA analyst or the person charged with the preparation of an EIA report, is faced with a vast quantity of raw and usually unorganized data. Hence, each technique and method for the evaluation of impacts should have the following qualities and characteristics:

1. It should be systematic in approach;
2. It should be able to organize a large mass of heterogeneous data;
3. It should be able to quantify the impacts;
4. It should be capable of summarizing the data;
5. It should be able to aggregate the data into sets with the least loss of information because of the aggregations;

6. It should have a good predictive capability;
7. It should extract the salient features, and
8. It should finally be able to display the raw data and the derived information in a meaningful fashion.

4.2 Criteria for the Selection of EIA Methodology

- Each of the different methodologies for the assessment of environmental impacts of development projects have their advantages and disadvantages and their utility for a particular application is largely a matter of choice and judgment of the analyst.
- Nevertheless, some objective criteria exist in making such a choice and these are stated below under the key areas that involve the assessment process.
- **4.2.1 General**
- **(a)** ***Simplicity:*** *The methodology should be simple so that the available manpower with* limited background knowledge can grasp and adopt it without much difficulty.
- **(b)** ***Manpower, time and budget constraints:*** *The methodology should be applied by* a small group with a limited budget and under time constraints.

Criteria cont…

(c) *Flexibility:* *The methodology should be flexible enough to allow for necessary* modifications and changes through the course of the study.(iddo fakachu)

4.2.2 Impact Identification

(a) *Comprehensiveness :* *The methodology should be sufficiently comprehensive to* contain all possible options and alternatives and should give enough information on them to facilitate proper decision-making.

(b) *Specificity:* *The methodology should identify specific parameters on which there* would be significant impacts.

(c) *Isolation of project impacts:* *The methodology should suggest procedures for* identifying project impacts as distinguished from future environmental changes produced by other causes.

(d) *Timing and duration :* *The methodology should be able to identify accurately the* location and extent of the impacts on a temporal scale.

4.2.3 Impact Measurement

(a) ***Commensurate units:*** *The methodology should have a commensurate set of units so* that comparison can be made between alternatives and criteria.(kan safarun)

(b) *Explicit (ifaa)indicators :* *The methodology should suggest specific and measurable* indicators to be used to qualify impacts on the relevant environmental parameters.

(c) *Magnitude:* *The methodology should provide for the measurement of impact* magnitude, defined as the degree of extensiveness of scale of the impact, as distinct from impact importance, defined as the weighting of the degree of significance of the impact.

(d) *Objective criteria:* *It should be based on objective criteria and the criteria should be* stated explicitly

4.2.4 Impact Interpretation and Evaluation

(a) ***Significance :*** *The methodology should be able to assess the significance of* measured impacts on a local, regional and national scale.

(b) *Explicit (ifaa)criteria* *: The criteria and assumptions employed to determine impact* significance should be explicitly stated.

(c) *Portrayal of "with" and "without" situation :* *The methodology should be able to* aggregate the vast amounts of information and raw input data.

(d) *Uncertainly :* *Uncertainty of possible impacts is a very real problem in* environmental impact assessment. The methodology should be able to take this aspect into account.(not used)

(e) *Risk:* *The methodology should identify impacts that have low probability of* occurrence but a high potential for damage and loss.(minimize or avoid)

Criteria cont…

(f) ***Depth of analysis :*** *The conclusions derived from the methodology should be able* to provide sufficient depth of analysis and instill confidence in the users, including the general public.

(g) ***Alternative comparison*** *: It should provide a sufficiently detailed and complete* comparison of the various alternatives readily available for the project under study.

(h) ***Public involvement:*** *The methodology should suggest a mechanism for public* involvement in the interpretation of the impacts and their significance.

4.2.5 Impact Communication/himu

(a) ***Affected parties*** *: The methodology should provide a mechanism for linking* impacts to specific effected geographical or social groups.

(b) ***Setting description****: It should provide a description of the project setting to aid the* users in developing an adequately comprehensive overall perspective.

(c) ***Summary format:*** *It should provide the results of the impact analysis summarized* in a format that will give the users, who range from the lay public to the decision makers, sufficient details to understand it and have confidence in its assessment.

(d) ***Key issues :*** *It should provide a format for highlighting the key issues and impacts* identified in the analysis.

(e) ***Compliance:*** *One of the most important factors in choosing a methodology is* whether it is able to comply with the terms of reference established by the controlling agency.

4.3 EIA METHODS

There is a range of methods from the simplest to complex approaches that developers, consultants and academics who aim to further "best practice" may wish to investigate further.

4.3.1 List of Environment EIA Methods

The following are the important methodologies of utility for assessing the impacts of developmental activities on the environment.

I. Adhoc methods/
2. Checklists methods 3. Delphi
4. Matrices methods
5. Networks methods or impact trees
6. Overlays methods
7. Environmental index using factor analysis
8. Cost/benefit analysis
9. Predictive or Simulation methods

4.3.2 Ad hoc Methods

- Basically ad hoc methods indicate broad areas of possible impacts by listing composite environmental parameters (for example flora and fauna) likely to be affected by any development.
- Ad hoc methods involve assembling a team of specialists to identify impacts in their area of expertise.
- In this method, each environmental area, such as, air, and water, is taken separately and the nature of the impacts, such as, short-term or long term, reversible or irreversible are considered.
- Ad hoc methods are for rough assessment of total impact giving the broad areas of possible impacts and the general nature of these possible impacts. For example, the impacts on animal and plant life may be stated as significant but beneficial.

In the ad hoc methods, the assessor relies on intuitive approach and makes a broad-based qualitative assessment. This method serves as a preliminary assessment which helps in identifying more important areas like :

I. Wildlife
2. Endangered species
3. Natural vegetation
4. Exotic vegetation
5. Grazing
6. Social characteristics
7. Natural drainage
8. Groundwater
9. Noise
10. Air Quality
11. Recreation
12. Health and safety
13. Economic values
14. Visual description and services
15.Open space
16.Public facilities

- The ad hoc methods, while being very simple can be performed without any training, merely present the pertinent information of a project's effects on the environment without any sort of relative weighting or any cause-effect relationship.
- It provides minimal guidance for impact analysis while suggesting broad areas of possible impacts.
- It does not even state the actual impacts on specific parameters that will be affected.
- Ad hoc method is a simple approach to identify the total impacts of a project and would ***consider each environmental area.***
- The ad hoc method involves assembling a team of specialist to identify impacts in their area expertise i.e. expert opinion.
- The advantage of expert opinion data gathering techniques is ***its speed and inexpensiveness***.

- The ad hoc method has the following drawbacks:

(a) It gives no assurance that it encompasses a comprehensive set of all relevant impacts;

(b) It lacks consistency in analysis as it may select different criteria to evaluate different groups of factors;

(c) It is inherently inefficient- as it requires a considerable effort to identify and assemble an appropriate panel for each assessment and

(d) It is inherent subjectivity and biasness.

4.3.3 **Checklist Methodologies**

- Checklists are an advance on ad hoc methods in that they list biophysical, social and economic components, which are likely to be affected by a development, in more detail.
- Checklist methodologies range from listings of environmental factors in highly structured approaches involving importance weightings for factors and application of scaling techniques for the impacts of each alternative on each factor.
- Checklists in general are strong in impact identification and are capable of bringing them to the attention and awareness of their audiences.
- Impact identification is the most fundamental function of an EIA and in this respect, all types of checklists, namely simple, descriptive, scaling and weighting checklists do equally well.

Checklists are of four broad categories and represent one of the basic methodologies used in EIA. They are:

(a) ***Simple Checklists****: that are a list of parameters without guidelines provided on* how to interpret and measure an environmental parameter.

(b) ***Descriptive Checklists****: that includes an identification of environmental parameters* and guidelines on how parameter data are to be measured.

(c) ***Scaling Checklists****: that are similar to descriptive checklist with the addition of* information basis to subjective scaling or parameter values.

(d) ***Scaling Weighting Check Lists****: are capable of quantifying impacts.*

Advantage

- **Check lists are mainly useful for**

a) It promotes thinking about the array of impacts in a systematic way and allows concise summarization of effects.
b) It is the simplest assessment methodologies
c) Summarizing information to make it accessible to experts in different fields or decision makers who have little technical knowledge.
d) Preliminary analysis will be available in scaling check lists.
e) Information on eco system functions can be clearly understood from weighing methods.

- **Some of the draw backs/*Limitations* of check lists are**

1) Checklists do not usually include direct cause-effect links to project activities.
2) Checklist may be too general or incomplete
3) They do not illustrate interactions between effects
4) The same effect may be registered in several places under heading that overlap in content (double counting)
5) The number of categories to be reviewed can be immense thus destructing attention from the more significant impacts.
6) Involves the identification of effects which are qualitative and subjective

4.3.*4* Delphi

Delphi is a method of collecting opinions, from different expertise by building different methods to minimize the various negative attribute of other opinion gathering methods (mentioned earlier). This method can:

1. side step halo, decibel and vanity effects
2. handle large number of opinion givers than panels or brainstorming session can.
3. also enables collecting opinions and using the information in developing dynamic models

Special characteristic

1. Anonymity among participants
2. Scope for statistical treatment of responses
3. Interactive feedback

Procedure

1) A structured, formal and detailed questionnaire is given to the participants by mail or in person.
2) The organizer of the Delphi then collects, analyses, combines and averages the responses and represents them medians.
3) Questionnaire for second round are given with modification if necessary.
4) The averaged response of 1st questionnaire is provided to the participants (where the participants may be asked to respond to scaled objective item.)
5) After scrutinizing 2nd round, respondents may be asked to justify the response
6) Further interactions are continued, if necessary
7) Convergence of opinion emerges (NOT BY FORCE)

Limitations

- There is pressure towards convergence and this may suppress other valid perspectives.
- The role of the Delphi coordinator is crucial and subjective biases may be introduced through this route.
- Lack of item clarity or the common interpretation of scales and feedback may lead to invalid results.
- Delphi is time consuming and if the questionnaires are long, one may tend to fill them in a casual manner.

4.3.5 Matrix Methods

•Matrices are grid like tables used to identify the interaction between project activities and environmental characteristics.

• While checklists are “one dimensional” lists of potential impacts which tell whether an impact will occur or not, matrices are ‘two dimensional’ lists which also give an indication of the ‘magnitude’ of likely impacts. Matrices are thus checklists of a higher dimension and contain more information than the latter.

•Matrices are the most commonly used method of impact identification in EIA.

• Simple matrices are merely two-dimensional charts showing environmental components on project (e.g. construction, operation, decommissioning, buildings, access road etc.) have different impacts.

• Three-dimensional matrices have also been developed in which the third dimension refers to economic and social institutions: such an approach identifies the institutions from which data are needed for the EIA process, and highlights areas in which knowledge is lacking.

- In matrix methods interactions between various activities and environmental parameters will be identified and evaluated. Matrix methods are basically generalized checklists where one dimension of a matrix is a list of environmental social and economic factors likely to be affected by a project activity. The other dimension is a list of actions associated with development
- Matrices provide cause-effect relationships between the various project activities and their impacts on the numerous environmentally important sectors or components. Matrices provide a graphic tool for display impacts to their audience in a manner that can be easily comprehended.
- Simple matrices, though able to identify first order effects, cannot show higher interactive effects between impacts. Simple, interaction matrices largely overcome this limitation. But such matrices are generally useful for depicting ecological interactions only for the sake of documentation.

Salient Features of Matrices Methods

1. It is necessary to define the spatial boundaries of environmental factors. The temporal phases and specific actions associated with the proposed project: and the impact rating or summarization scales used in the matrix.
2. A matrix should be considered a tool for purposes of analysis, with the key need being to clearly state the rationale utilized for the impact ratings assigned to a given temporal phase and project action, and a given spatial boundary and environmental factor.
3. The development of one or more preliminary matrices can be a useful technique in discussing a proposed action and its potential environmental impacts. This can be helpful in the early stages of a study to assist each team member in understanding the implications of the project and developing detailed plans for more extensive studies on particular factors and impacts.

4. The interpretation of impact ratings should be carefully and critically considered, particularly when realizing that there may be large differences in spatial boundaries as well as temporal phases for a proposed project.
5. Interaction matrices can be useful for delineating the impacts of the first and second or multiple phases of a two-phase or multi phase project; the cumulative impacts of a project when considered relative to the other past, present; and reasonably foreseeable future actions in the area; and the potential positive effects of mitigation measures.

6. If interaction matrices are used to display comparisons between different alternatives, it is necessary to use the same basic matrix in terms of spatial boundaries and environmental factors, and temporal phases and project actions for each alternative being analyzed. Completion of such matrices can provide a basis for trade off analysis.
7. Impact qualification and comparisons to relevant standards can provide a valuable basis for the assignment of impact ratings to different project actions and environmental factors.
8. Color codes can be used to display and communicate information on anticipated impacts. For example, beneficial impacts could be shown by using green or shades of green; whereas, adverse effects could be depicted with red or shades of red.

9. One of the concerns relative to interaction matrices is that project actions and/ or environmental factors are artificially separated, when they should be considered together. It is possible to use footnotes in matrix to identify groups of actions, factors, and/or impacts which should be considered together. This would allow the delineation of primary and secondary effects of projects.
10. The development of a preliminary interaction matrix does not mean that it would have to be included in a subsequent EA or EIS. The preliminary matrix could be used as an internal working tool in study, planning and development.

11. It is possible to utilize importance weighting for environmental factors and project actions in a simple interaction matrix. If this approach is chosen, it is necessary to carefully delineate the rationale upon which differential importance weights have been assigned. Composite indices could be developed for various alternatives by summing up the products of the importance weights and the impact ratings.

12. Usage of an interaction matrix forces the consideration of actions and impacts related to a proposed project within the context of other related actions and impacts.

In other words, the matrix will prevent overriding attention being given to one particular action of environmental factors.

Table 3: part of a simple matrix

Environmental component	Project activities				
	Clearing	Excavation	Construction	Operation	Transportation
Soil and geology	x	x			
Flora	x	x			
Fauna	x	x			
Air quality				x	
Water quality	x	x	x		
Population density			x	x	
Employment		x		x	
Traffic	x	x	x	x	
Housing			x		
Community structure,etc.		x	x		

4.3.6 Network Methods

- Networks are capable of identifying direct and indirect impacts, higher order effects and interactions between impacts, and hence are able to identify and incorporate mitigation and management measures into the planning stages of a project. They are suitable for expressing ecological impacts but of lesser utility in considering social, human and aesthetic aspects.
- This is because weightings and ratings of impacts are not features of network analysis.
- Development of network diagrams Fig. 2.3 present the potential impact pathways as casual chains will be very usefull for displaying first ,secondary, tertiary and higher order impacts.

Network Methods cont…

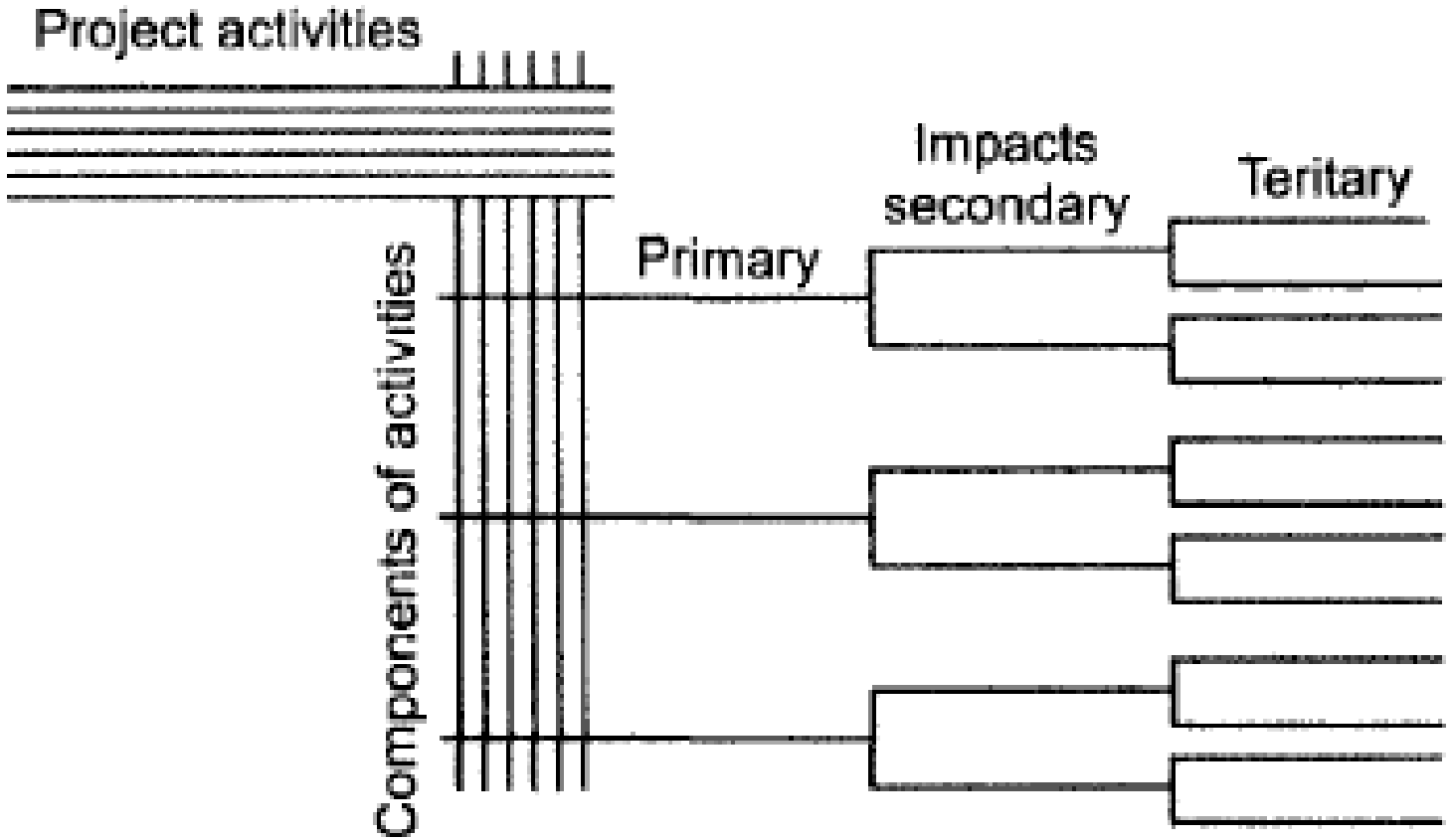

Fig. 2.3 Conceptual model of impact networks.

The limitation of the network approach :-

- minimal information provided on the technical aspects of impact prediction and the means for comparatively evaluating the impacts of alternatives.
- networks can become very visually complicated.
- Networks generally consider only adverse impacts on the environment and hence decision - making' in terms of the cost and benefit of a development project to a region is not feasible by network analysis.

Temporal considerations are not properly accounted for and short term and long term impacts are not differentiated to the extent required for an easy understanding.

- the display becomes very large and hence unwieldy when large regional plans are being considered.
- provide no avenue for public participation.

2.3.7 Map overlay/GIS techniques

Overlay maps have been used in environmental planning since the 1960s, before the NEPA was enacted. A series of transparencies is used to identify, predict, assign relative significance to and communicate impacts. In this technique a base map is prepared, showing the general area within which the project may be located. Successive transparent overlay maps are then prepared for the environmental components that, in the opinion of experts, are likely to be affected by the project.

Overlay Methods cont…

- Overlay methods involve preparation of a set of transparent maps, which represent the spatial distribution of an environmental characteristic (e.g., Extent of dense forest area).
- Information on wide range of variables will be collected for standard geographical units within the study area which will be recorded on series of maps typically one for each variable.

These maps will be overlaid to produce a composite Fig 2.8.

The resulting composite maps characterize the area's physical, social ecological, land use and other relevant characteristics relative to the location of the proposed development.

Overlay Methods cont...

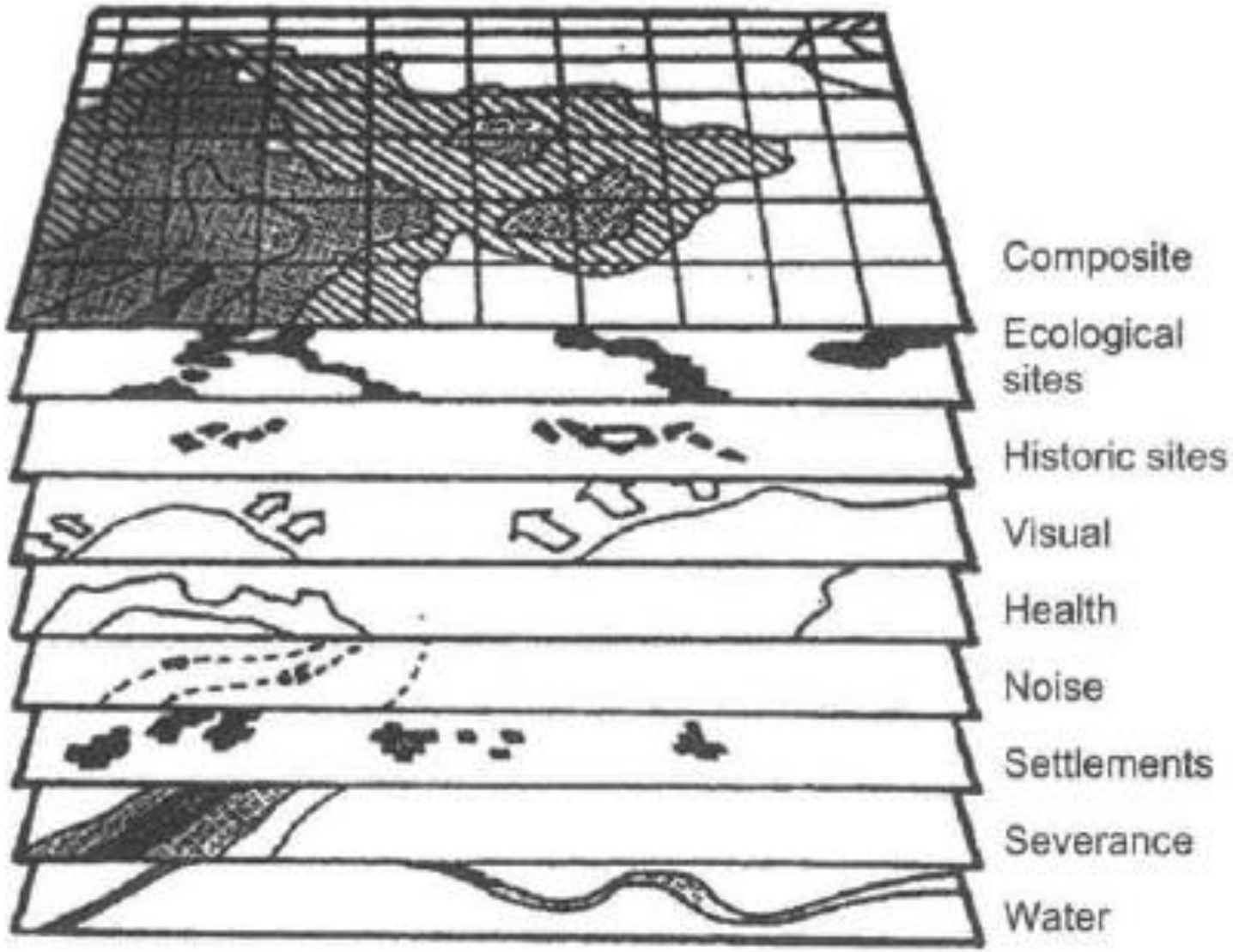

Fig. 2.8 Presentation of array of variables in overlay method.

Source: Wathern 1988

Overlay Methods cont...

- Overlays are very subjective in that they rely on the judgment of the analyst to evaluate and assess questions on compatibility relating to the existing land use patterns and the prospects of the development activity.
- In practice, overlays are self-limiting because there is a practical limit on the number of transparencies that can be overlaid.

Overlays are useful when addressing questions of site and route selection.

They provide a suitable and effective mode of presentation and display to their audiences.

- But overlay analysis cannot be the sole criterion for environmental impact assessment.

Overlay Methods cont...

- The considerations in overlay analysis are purely spatial,
- temporal considerations being outside its scope.
- Social, human and economic aspects are not accorded any consideration.
- Further, higher order impacts cannot be identified.
- The methodologies rely on a set of maps of environmental characteristics (physical, social, ecological, aesthetic) for a project area. These maps are overlaid to produce a composite characterization of the regional environment.
- The approach seems most useful as a method of screening alternative project sites or routes, before detailed impact analysis. The overlay approach is generally effective for selecting alternatives and identifying certain types of impacts;
- however, it cannot be used to quantify impacts to identify secondary and tertiary interrelationships.

Overlay Methods cont…

- A significant application of GIS is the construction of real world models based on digital data.
- Modeling can analyze trends identify factors that are causing them reveal alternate paths to solve the given problem and indicate the implications or consequences of decisions. GIS can show how a natural resource will be effected by a decision.
- GIS is a powerful management tool for resource managers and planners. Its applications are limited only by the quality, quantity and coverage of data that are fed into the system.
- Some of the standard GIS applications are integrating maps made at different scales.
- Overlaying different types of maps, which show different attributes and identifying, required areas within a given distance from roads or rivers.

The overlay maps method is particularly useful for identifying optimum corridors for developments such as electricity lines, roads, and grazing land, for comparisons between alternatives, and for assessing large regional developments.

Limitations

- It does not consider factors such as the likelihood of an impact, secondary impacts or the difference between reversible and irreversible impacts.
- It requires the clear classification of often indeterminate boundaries (such as between forest and field), and so is not a true representation of conditions on the ground.
- It relies on the user to identify likely impacts before it can be used.

2.3.8 Cost/Benefit Analysis

- Cost/benefit analysis provides the nature of expense and benefit accruable from a project in monetary terms as a common practice in traditional feasibility studies and thus enables easy understanding and aids decision-making.
- The principal methods available for placing monetary values (costs and benefits) on environmental impacts, a taxonomy of valuation methods, and steps involved in economic evaluation of environmental impacts are discussed under this category.

The role of environmental economics in an EIA can be divided into three categories, namely:

I. The use of economics for "benefit-cost analysis" as an integral part of project selection;

2. The use of economics in the assessment of activities suggested by the EIA and

3. The economic assessment of the environmental impacts of the

Methods cont…

- Environmental economics can aid in the selection of projects in that benefit-cost analysis can be used in the prescreening stage of the project, and the environmental components can be brought into the process of presenting various options and selecting among them.
- Doing so eventually leads to a project selection process, which takes the environment into consideration.
- In the second role, the economic assessment is focused on the cost assessment of environmental mitigation measures and management plans suggested in the EIA.
- The economic analysis in the EIA may include a summary of the project costs and how such cost estimates would change due to the activities proposed under the EIA. This component can be considered as an accounting of the environmental investment of a project.

- The third role, which is the economic assessment of the environmental impacts of a project, is geared towards seeking the economic values (of both costs and benefits) of the environmental impacts. These impacts are neither mitigated, nor taken into account in traditional economic analysis of projects. They should be identified by the EIA and sufficient quantitative and qualitative explanations should be given in EIA documents.

The difficulty encountered in the use of these techniques will be that impacts have to be transformed and stated in explicit monetary terms, and this is not always possible, especially for intangibles like the monetary value of health-related impacts of industrial development.

Steps in Economic Valuation of Environmental Impacts

- Economic analysis of environmental impacts is important in project preparation to determine whether the net benefits of undertaking the project are greater than the alternatives, including the non-project scenario.
- Project alternatives often vary in their economic contribution and environmental impacts.

Economic assessment of different alternatives in the early stages of project planning should provide important inputs to improve the quality of decision-making.

- The economic analysis of the environmental impacts of the selected projects also allows for amore complete assessment of the project‘s costs and benefits.

METHODS CONT…

At a minimum, the following six tasks need to be completed in the economic analysis of environmental impacts

1. determine the spatial and conceptual boundaries of the analysis;
2. identify environmental impacts and their relationships to the project;
3. quantify environmental impacts and organize them according to importance – the impacts described qualitatively, if they cannot be expressed in quantitative terms;
4. choose a technique for economic valuation;
5. economic valuation (place monetary values) of environmental impacts identified; and
6. set an appropriate time frame and perform the extended benefit cost analysis.

2.9 Simulation Modeling

- System analysts have developed an approach to environmental impact assessment and management commonly referred to as Adaptive Environmental Assessment and Management (AEAM), which combines various simulation models to predict impacts.
- This approach broadens the potential of simulation models to evaluate the impacts of alternatives and is beneficial for project planning.

Simulation cont…

- overcomes the short-comings of most other methods in that other methods assume unchanging conditions or project impacts in a single time frame on statistically described environmental conditions
- The technique can be time-consuming and may impose a severe burden on the monetary resources available for the purpose of environmental assessment.

Simulation models especially of ecosystems, are still in an embryonic stage of development and their accuracy and predictive capacity is yet to be proved.

The use of this technique requires the input of people trained in its use and functions.

- This may lead to the need for expatriate expertise in proportions greater than required for other techniques and this may be the limiting constraint

Summary

Impact assessment methodologies range from simple to complex and are also progressively changing from a static, piecemeal approach to the one that reflects the dynamism of nature and the environment. Consequently, the trend is away from mere listing of potential impacts towards more complex modes whereby the methodology can identify feedback paths, higher order impacts than merely those apparent, first order ones, and uncertainties.

In short, the methodological trend is approaching an overall management perspective requiring different kinds of data different in formats and varying levels of expertise and technological inputs for correct interpretation. It is important to understand their drawbacks in order to determine which of the methods are most appropriate.

An evaluation of various methodologies is presented in Table 2.1.

Table 2.1 Summary of current EIA methodology evaluation.

Criteria	Check lists	Over-lay	Net-work	Matrix	Environ-mental index	Cost/ benefit analysis	Simulation modeling workshop
1. Comprehensiveness	S	N	L	S	S	S	L
2. Communicability	L	L	S	L	S	L	L
3. Flexibility	L	S	L	L	S	S	L
4. Objectivity	N	S	S	L	L	L	S
5. Aggregation	N	S	N	N	S	S	N
6. Replicability	S	L	S	S	S	S	S
7. Multi-function	N	S	S	S	S	S	S
8. Uncertainty	N	N	N	N	N	N	S
9. Space-dimension	N	L	N	N	S	N	S
10. Time-dimension	S	N	N	N	S	S	L
11. Data requirement	L	N	S	S	S	S	N
12. Summary format	L	S	S	L	S	L	L
13. Alternative comparison	S	L	L	L	L	L	L
14. Time requirement	L	N	S	S	S	S	N
15. Manpower requirement	L	S	S	S	S	S	N
16. Economy	L	L	L	L	L	L	N

Legend : L = Completely fulfilled, or low resource need.
S = Partially fulfilled, or moderate resource need.
N = Negligibly fulfilled, or high resource need.

Source: *Environmental Impact Assessment: Guidelines for Planners and Decision Marker, UN Publication S1/1 SCAP/351/ESCAP, 1985 (1)*