CHAPTER – 2

EIA METHODOLOGIES

2.1 Criteria for selection of EIA Methods

I. 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.

c) Flexibility:

The methodology should be flexible enough to allow for necessary modifications and changes through the course of the study.

II. 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.

III. Impact measurement

a) Commensurate units:

It should have a commensurate set of units so that comparison can be made between alternatives and criteria.

b) Explicit indicators:

It should suggest specific and measurable indicators to be used to qualify impacts on the relevant environmental parameters.

c) Magnitude:

It 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 weighing 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.

IV. 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 Criteria:

The criteria and assumptions employed to determine impact significance should be explicitly stated.

c) Portrayal of "with" and "with out" situation:

The methodology should be able to aggregate the vast amounts of information and raw input data.

d) Uncertainty:

Uncertainty of possible impacts is a very real problem in environmental impact assessment. The methodology should be able to take this aspect into account.

e) Risk:

The methodology should identify impacts that have low probability of occurrence but a high potential for damage and loss.

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.

f) Public involvement:

The methodology should suggest a mechanism for public involvement in the interpretation of impacts and their significance.

V. Impact Communication

a) Affected parties:

The methodology should provide a mechanism for linking impacts to specific effected geographical or social groups.

b) Setting description:

It should be 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 user, 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.

2.2 Objectives of Methodologies

- Understand the nature and location of the project and possible alternatives
- Identify factors of analysis and assessment objectives
- Preliminary identification of impacts and scoping
- Baseline studies and evolution in the absence of projects
- Prediction and assessment of impacts and alternatives comparison
- Mitigation of impacts management.

2.3 Requirements of EIA Methodologies

The EIA Practitioner faces vast varieties of raw and unorganized information that must be collected and analyzed in preparation of an EIA report.

The best methods should be able to

- Organize a large mass of heterogeneous data
- Allow summarization of data
- Aggregate the data into smaller sets with least loss of information
- Display the raw data and the derived information in a direct and relevant fashion
- Target audience should also be considered (if not educated use color codes, size etc.)

2.3.1 EIA Methodology Evaluation

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.

2.4 Major Methodologies for EIA

The methodologies can be broadly divided into five types on the basis of impact identification strength.

1. Adhoc methods
2. Matrices methods
3. Network methods
4. Overlays methods
5. Environmental index using factor analysis
6. Cost/benefit analysis

2.4.1. Adhoc Method

Ad hoc methods indicate broad areas of possible impacts by listing composite environmental parameters (Ex: flora and fauna) likely to be affected by the proposed activity. These methods involve assembling a team of specialists who identify impacts in their area of expertise. Here, each parameter is considered separately and the natures of impacts (long term or short term, reversible or irreversible) are considered. These methods give a rough assessment of total impact while giving the broad areas and the general nature of possible impacts. In this method, the assessor relies on an intuitive approach and makes a broad-based qualitative assessment. This method serves as a preliminary assessment and helps in identification of important areas like:

1. 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. Visual description and services
12. Open space
13. Recreation
14. Health and safety
15. Economic values and
16. Public facilities

Types of Ad hoc method are:

a) Opinion poll
b) Expert opinion and
c) Delphi methods

This method is very simple and can be performed without any training. It does not involve any relative weighting or any cause-effect relationship. It provides minimal guidance for impact analysis while suggesting broad areas for possible impacts. Moreover, it does not even state the actual impacts on specific parameters that will be affected.

The drawbacks of this method are listed below:

1. It gives no assurance that a comprehensive set of all relevant impacts have been studied.
2. Analysis using this method lacks consistency as it different criteria are selectively evaluated by different groups.
3. It is blatantly inefficient as it requires a considerable effort to identify and assemble a panel for each assessment.

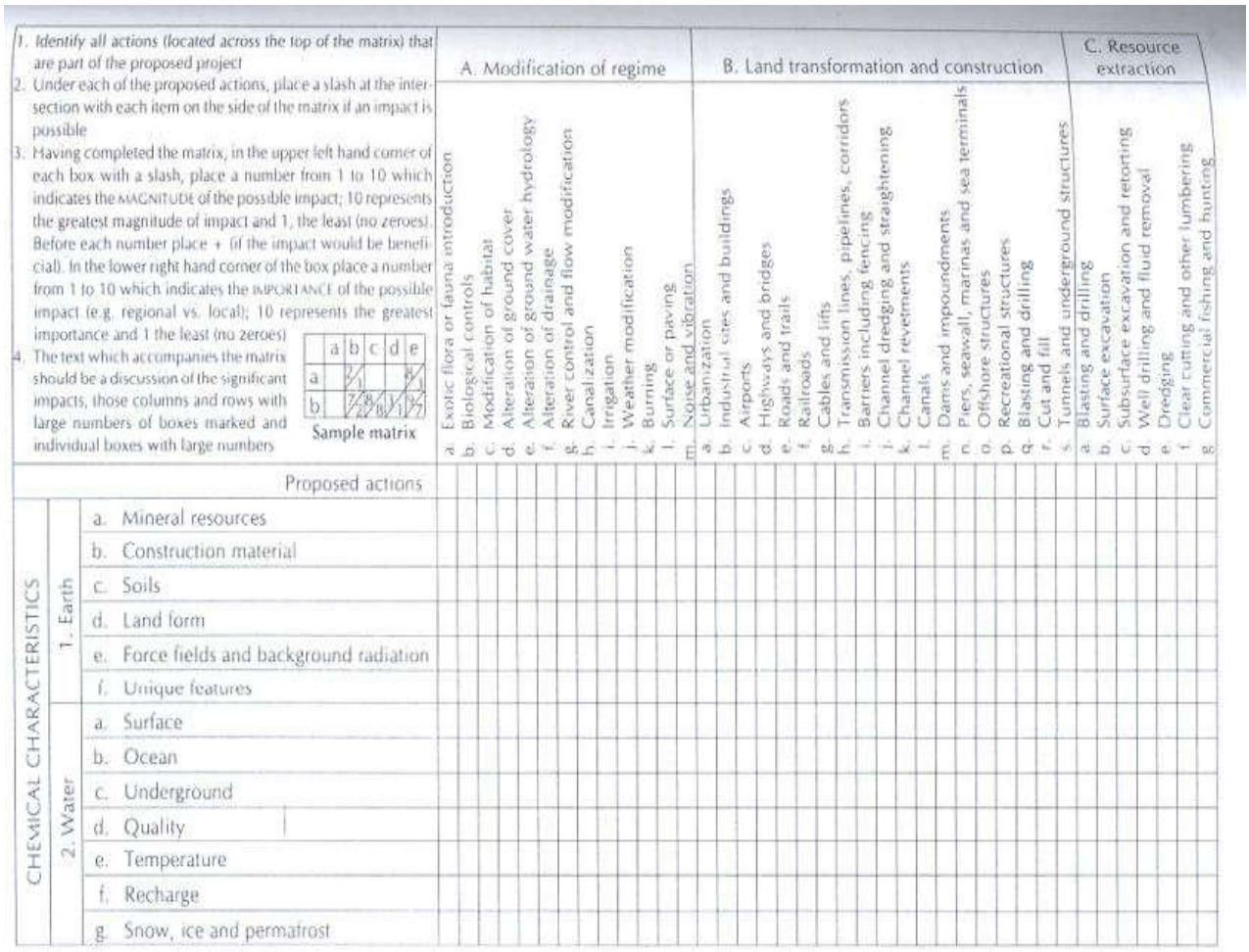
Example

EIA Study for High way Construction Project

Impact Area	Positive Effect	Negative Effect	Adverse	Beneficial	Problematic	Short Term	Long Term	Reversible	Irreversible
Wildlife		*					*	*	
Endangered species		*					*	*	
Natural vegetation						*		*	
Exotic vegetation			*		*		*		*
Grazing									
Social characteristics									
Natural drainage									
Groundwater									
Noise			*		*				
Air quality		*							
Visual description and services		*				*		*	
Open space									
Recreation									
Health and safety									
Paved Surface	*								
Public facilities	*								
Public amenities	*								
Employment Opportunities	*								

2.4.2. Matrices Method

This methodology provides a framework of interaction of different activities of a project with potential environmental impacts caused by them. A simple interaction matrix is formed when project actions are listed on one axis (usually vertical) and environmental impacts are listed along the other axis. This technique was pioneered by Leopold et al in 1971. It lists about 100 project actions and about 88 environmental characteristics and conditions. An example of this matrix is shown below:



1. Identify all actions (located across the top of the matrix) that are part of the proposed project
2. Under each of the proposed actions, place a slash at the intersection with each item on the side of the matrix if an impact is possible
3. Having completed the matrix, in the upper left hand corner of each box with a slash, place a number from 1 to 10 which indicates the MAGNITUDE of the possible impact; 10 represents the greatest magnitude of impact and 1, the least (no zeroes). Before each number place + (if the impact would be beneficial). In the lower right hand corner of the box place a number from 1 to 10 which indicates the IMPORTANCE of the possible impact (e.g. regional vs. local); 10 represents the greatest importance and 1 the least (no zeroes)
4. The text which accompanies the matrix should be a discussion of the significant impacts, those columns and rows with large numbers of boxes marked and individual boxes with large numbers

Sample matrix

A. Modification of regime

a. Exotic flora or fauna introduction
b. Biological controls
c. Modification of habitat
d. Alteration of ground cover
e. Alteration of ground water hydrology
f. Alteration of drainage
g. River control and flow modification
h. Canalization
i. Irrigation
j. Weather modification
k. Burning
l. Surface or paving
m. Noise and vibration

B. Land transformation and construction

a. Urbanization
b. Industrial sites and buildings
c. Airports
d. Highways and bridges
e. Roads and trails
f. Railroads
g. Cables and lifts
h. Transmission lines, pipelines, corridors
i. Barriers including fencing
j. Channel dredging and straightening
k. Channel revetments
l. Canals
m. Dams and impoundments
n. Piers, seawall, marinas and sea terminals
o. Offshore structures
p. Recreational structures
q. Blasting and drilling
r. Cut and fill
s. Tunnels and underground structures

C. Resource extraction

a. Blasting and drilling
b. Surface excavation
c. Subsurface excavation and retorting
d. Well drilling and fluid removal
e. Dredging
f. Clear cutting and other lumbering
g. Commercial fishing and hunting

Proposed actions

CHEMICAL CHARACTERISTICS

1. Earth
a. Mineral resources
b. Construction material
c. Soils
d. Land form
e. Force fields and background radiation
f. Unique features

2. Water
a. Surface
b. Ocean
c. Underground
d. Quality
e. Temperature
f. Recharge
g. Snow, ice and permafrost

Importance of Matrices

- Matrices are two dimensional tables.
- These facilitate the identification of impacts arising from the interaction between project activities and specific environmental components.
- The entries of the cell of the matrix can be either qualitative or quantitative estimates of impact.

i) Simple Matrix

Simple environmental impact matrix for the Phoenix Pulp Mill (*source:* Lohani and Halim, 1983).

Environmental Components	Project Activities								
	Plant Construction	Farming of Kenaf	Use of Pesticide Fertilizer	Transport of Raw Materials	Water Intake	Solid Waste	Effluent Discharge	Emissions	Employ-ment
Surface Water Quality			x			x	x		x
Surface Water Hydrology					x				
Air Quality				x				x	
Fisheries			x				x		
Terrestrial Wildlife Habitat	x								
Terrestrial Wildlife	x								
Land Use Pattern		x							
Highways/Railways				x					
Water Supply			x				x		
Agriculture		x							
Housing									x
Health						x	x	x	
Socioeconomic									x

ii) Leopold Matrices

- Identify all actions that are part of the proposed project
- Under the each of the proposed actions, place a slash at the inter-section with each item on the side of the matrix if an impact is possible.

	a	b	c	d
a				
a				
c				

- In the upper left hand corner of each box with a slash, place a number from 1 to 10 which indicates the MAGNITUDE of the possible impact.

- 10 represent the greatest magnitude of impact.
- 1 is the least magnitude of impact (no zeroes).
- Before each number place + (if the impact would be beneficial).
- In the lower right hand corner of the box place a number from 1 to 10 which indicates the IMPORT ANCE of the possible impact (Eg. Regional vs. Local).
- 10 represents the greatest importance and 1 the least (no zeroes).

	a	b	c	d
a	-1 / 3	+5 / 8		
b				
c				

Methodology - Leopold matrix definitions

NUMBER	MAGNITUDE	DEFINITION
5	Great	The impact is predicted to have a long term positive effect on the environment on a global scale
4	Major	The impact is predicted to provide a leading advantage to the environment and the community
3	Moderate	The impact is predicted to have a positive impact on the ecosystem
2	Slight	The impact is defined to have a mild but positive impact on the changes to the environment
1	Negligible	The impact is defined to have a minor positive impact
-1	Negligible	The impact is identified as modest, almost non-existent
-2	Slight	The impact is minor with a short-term effect on the local environment without changes to the distribution or status of the species.
-3	Moderate	The impact is identified as mild, short-term and reversible without changing overall integrity of the natural habitat and the community
-4	Major	The identified impacts are predicted to result in a primary change to the environment with a long term effect
-5	Catastrophic	The impact is predicted to results in an adverse and irreversible effect on a global scale

NUMBER	SIGNIFICANCE	DEFINITION
5	Great	Impact of cross-border character
4	Major	Impact of national character
3	Moderate	Impact of regional character
2	Slight	Impact of importance for municipality
1	Negligible	Limited impact on location

NUMBER	PROBABILITY	DEFINITION
3	Impact is certain (100% probability)	
2	Impact is probable (probability of over 50%)	
1	Impact is possible (probability of less than 50%)	

NUMBER	DURATION	DEFINITION
2	Long-term/Permanent	
1	Occasional/temporary	

Advantages:

1. The matrix method is that it links action to impact
2. This is a very good method for displaying EIA result.

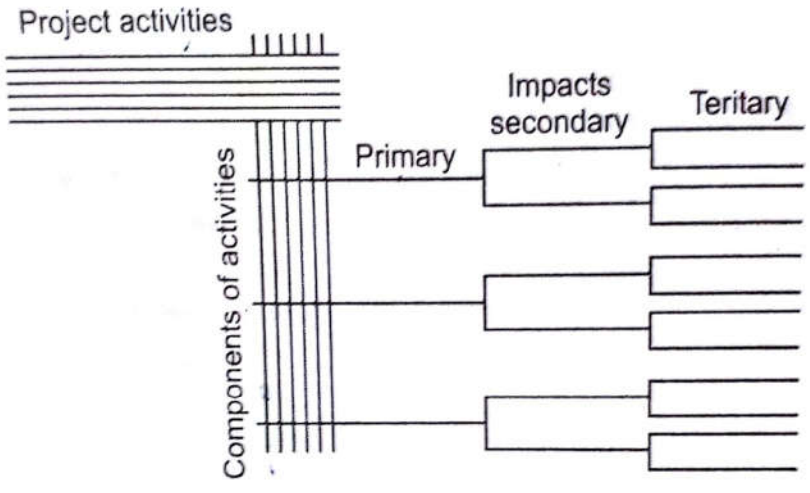
Disadvantages:

- It is difficult to distinguish between direct and indirect impacts using this method.
- There is potential for double-counting of impacts.
- It is qualitative in nature and does not refer to quantity of impact.

2.4.3. Network Method

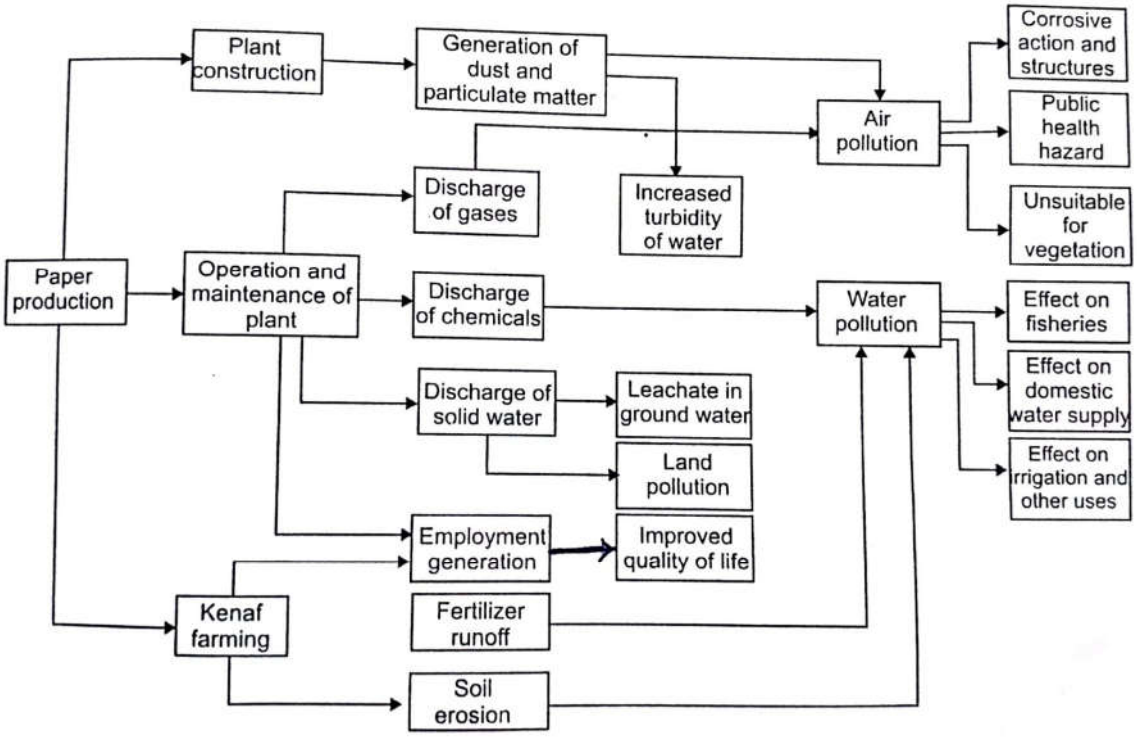
- This method uses the matrix approach and extends it to include both the primary as well as the secondary impacts.
- It is shown in the form of a tree called impact tree. This diagram is also called as reference or sequence diagram.
- Identification of direct, indirect along with short, long term impact is a crucial and basic step of making an impact tree.
- The impact tree is used to identify cause-effect linkages.
- The impact tree is a visual description of linkages.

Network Model



Conceptual model of impact networks.

Example



Network of pulpmill impacts.

Advantages:

- It links action to impact.
- It is useful to check second order impacts in a simplified form.
- It handles direct and indirect impacts.

Disadvantages:

- It becomes overly complex if used beyond simplified version.
- It is completely qualitative in nature.

2.4.4. Overlays Method

1. Overlay methods involve preparation of a set of transparent maps, which represent the spatial distribution of environmental characteristics (e.g., Extent of dense forest area).
2. 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.
3. These maps will be overlaid to produce a composite.
4. 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.
5. To evaluate the degree of associated impacts many project alternatives can be located on the final map and validity of the assessment will be related to the type and number of parameters chosen.

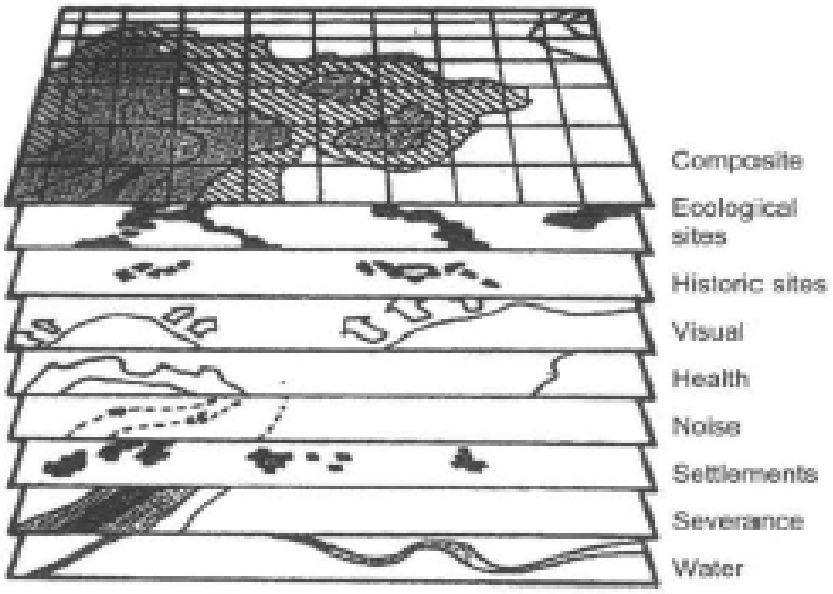


Fig. 2.8 Presentation of array of variables in overlay method.
Source: Wathern 1988

6. Normally to have some clarity the number of parameters that can be over layed in a transparency map is limited to 10.
7. These methods are widely used for assessing visually the changes in the landscape before and after the activity.
8. Secondly it can be used for preparing combined mapping with an analysis of sensitive areas or ecological carrying capacity.

9. As these methods are spatially oriented they can very clearly show the spatial aspects of cumulative impacts.
10. These maps are overlaid to produce a composite characterization of the regional environment.
11. Impacts are identified by noting the impacted environmental characteristics lying within the project boundaries.
12. The approach seems most useful as a method of screening alternative project sites or routes, before detailed impact analysis.
13. Overlays can be useful for industrial EIA of any project for comparing land capabilities existing and projected land uses, road route alternatives and other under parameters, and alternative levels of air quality conditions along with pollution control.

Advantages:

- It is easy to understand and use
- It has a good display
- It is good for setting site selection

Disadvantages

- The overlay method can accommodate both qualitative and quantitative data.
- The weakness of the overlay method is that it is only moderate comprehensive, because there is no mechanism that requires consideration of all potential impacts.
- There is no provision for quantification and measurement of the impacts nor is it assured that all impacts will be covered.
- 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.

2.4.5. Cost – Benefit Analysis (CBA)

1. Cost benefit analysis is a systematic process for identifying, valuing and comparing costs and benefits of a project.
2. It is a systematic approach to estimate the strengths and weakness of alternatives (for ex. In transactions, activities, functional business requirements or project investments)
3. It is used to determine options that provide the best approach to achieve benefits while preserving savings.
4. CBA is a standard tool for evaluating the economic analysis or trade of analysis, investment of development projects.
5. Economic analysis takes into account the opportunity costs of resources employed and attempts to measure in monetary terms the private and social costs and benefits of a project to the community or economy.

CBA Purposes

Broadly CBA has two main purposes

1. To determine if an investment/decision is sound (justification or feasibility) verifying whether its benefits outweigh the costs, and by how much.

2. To provide a basis for comparing projects which involves comparing the total expected cost of each option against its total expected benefits.

CBA Process:

- Define the goals and objectives of the activities.
- List alternate projects /programs.
- List stakeholders.
- Select measurement and measure all cost/benefit elements.
- Predict outcome of cost and benefits over relevant time period.
- Convert all costs and benefits into a common currency.
- Apply discount rate.
- Calculate net present value of project options.

- Perform sensitivity analysis to identifying the key variables that are major influence in the cost and benefits of the project.
- Adopt recommended choice.

**Cost Benefit analysis is carried out for the selected EIA report

- The cost-benefit analysis of the highway road project enables to make a comparison of the individual-projects and give priority to the competing projects on a monetary basis.
- The Road Authority and Transport Department must use the available resources efficiently, keeping in mind the welfare of the environment and its inhabitants.
- Provision for service roads/alternate road connectivity, two-laning/ four-laning/ six-laning, riding quality, bypasses and over-bridges, bridges amenities. Based on these factors, the investment needs can be calculated.

Example:

Highway Road Authority

The road authority costs include

- Expenditure involved in the construction and maintenance of roads.
- Acquiring the land from the land owners and providing appropriate compensation, expenses incurred in setting up fences and land scaping .
- Construction of noise barriers to reduce the sound entering the residential locality by absorbing, transmitting or reflecting the sound.

Highway Cost Components

1. **Agency Cost**

   This includes the expenses incurred by the government or private agency for construction and maintenance of highway roads.

   a) Construction cost includes
      - Expenses incurred in surveying, planning and designing.
      - Purchasing land from the land owners to lay road.
      - Construction of road.
      - Installation of electrical poles, traffic control equipment.
      - Administrative cost involved in supervising the traffic.

   b) Maintenance cost includes
      - Periodic repair of the damaged roads.

- Relocation and rehabilitation of the displaced people .
- Expenses incurred in maintaining and operating the traffic related equipment.

2. **User Cost**
   This includes the cost incurred in vehicle operation and cost due to the unavoidable accidents, cost incurred in vehicle operation, fuel, spare parts, wear out of the tires ,lubricants, registration charges ,insurance expenses, road tax and road permit tax etc.

Benefit components of highway road

- A well maintained highway road provides efficient and safe transportation to the road users.
- The benefits include saving in travel time.
- Improvement in health, education, agriculture, industry trade and various other fields.