EIA Process and Role of Stakeholders

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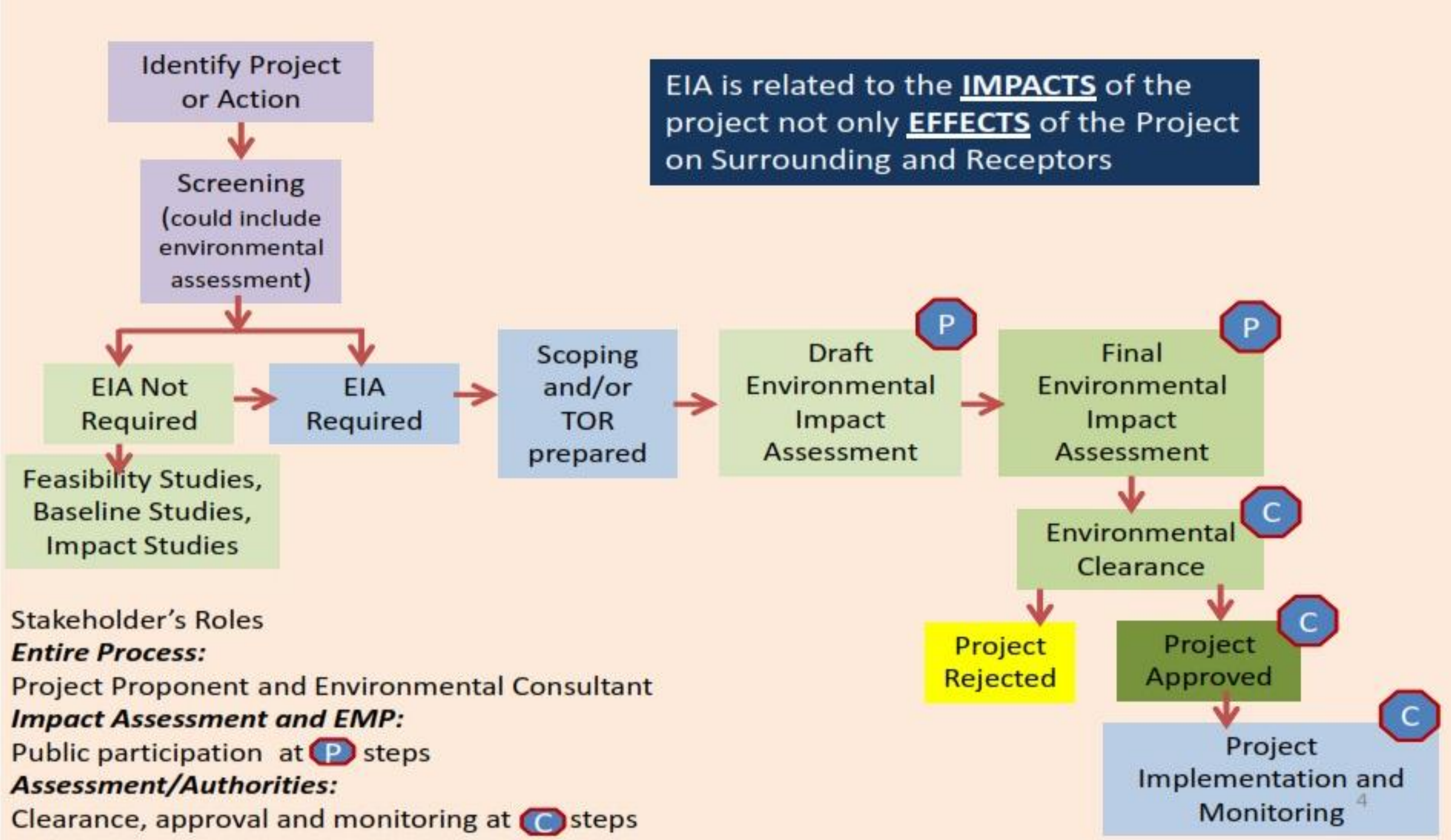

Phase 1

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Step 1. Screening

- to determine whether **EIA is required or not.**
- ***Outcome:*** no EIA, full EIA, limited EIA, initial environmental evaluation (IEE)
- ***Responsibility:*** project proponent + EIA consultant

  project proponent + EIA consultant+ competent authority
- ***Types of Screening***
    - ***Prescriptive:*** Follow the criteria given in the EIA framework

      List of Projects- Category A, B1, B2
  - ***Discretionary:*** Case by Case, no guideline, IEE
- ***Methods of Screening***
  1. Initial environmental evaluation
  2. Lists
  3. Thresholds
  4. Criteria
  5. Matrices

Methods of Screening

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1. **Initial environmental evaluation (IEE)**

- **preliminary environmental assessment.**
- initial examination of human health and safety, air and water quality, rare or endangered species, protected areas e. fragile or valued ecosystems, biological diversity, the lifestyle and livelihood of the local population, etc.

a. **EIA required**
b. **No EIA, only IEE required**
c. **Nothing required**

Impacts
(i) Insignificant
(ii) Significant but mitigable
(iii) Significant but may or may not be mitigable
(iv) Significant with significant public concern

Methods of Screening

2. List method: Standard approach

Based on type of projects	Based on degree of impacts
Experience of Project 1. Significant environmental impacts 2. Negligible or minimal impacts listed 3. Inclusive list of projects under legislation 4. Exclusive list (Exempt by law)	**a. Category- Red** - Serious, Irreversible, - Involuntary resettlement, affecting cultural heritage sites and ethnic minorities, <u>Area affected is more than site</u>, Unprecedented, Diverse - Eg: Power plants, factories, mining units, thermal plants, harbors, ports **b. Category- Orange** - Some irreversible impact, site-specific, and mitigation measures can be designed Eg: Natural dyes manufacturing industries) **c. Category- Green and white** - Do not require an EIA, Minimal or no adverse impacts.

Methods of Screening

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3. Threshold Method: Customised approach

- To increase flexibility, Reclassification of projects

A. Threshold under regulatory frame works	B. Vicinity of Project
• Project size, capital cost, output, area of land proposed • **EIA is required for projects exceeding thresholds limits** • *Mining of lease area > 5 hectares;* • *Thermal power projects > 5 MW;* • *Coke oven projects > 25000 metric ton per annum; Sugar industry > 5000 metric ton/ day;* • *Ports and harbors > 10000 metric ton per annum of fish;* • *Townships and area development > 50 hectares or 1,50,000 sq.m)* ***MOEFCC, 2006***	**(i) sensitive and valued ecosystems, heritage, or cultural resources** (ii) is proposed in a critically polluted area (MOEFCC 2006) (iii) has the potential of cumulative impacts (iv) displaces people who are particularly vulnerable and difficult to resettle

Methods of Screening

4. Criteria method: Characteristics of concerned projects

- **Types of project:**
  - Chemical, metallurgical, or automobile
  - Water consumption
  - Waste generation
  - Usage or production of hazardous substances.
- **Size:** micro, small, medium or large
- **Natural resources:** land, water-intensive, energy-intensive
- **Risk of accidents**
- **Degree of public interest**, e.g. scenic beauty, specific local features, or factors
- **Sensitive area:** distance from the nearby protected areas
- **Receiving environment: e**cologically sensitive or fragile
- **Location-** residential, commercial, industrial or mixed
- **Regenerative capacity** of natural resources

Methods of Screening

4. Matrice method

For major projects: Correlation of project activities with environmental consequences

Combination of two checklists:

a. **Environmental component on one axis**
b. **Project-related activities on another side**

Environmental components	Project Activities							
	Plant Construction	Pesticide and Fertilizer Use	Raw materials transport	Water Intake	Solid Waste	Effluent Discharge	Emissions	Employment
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								
Highways/Railways			X					
Water Supply						X		
Agriculture		X				X		X
Housing								
Health					X	X	X	
Socioeconomic								X

Questionnaire for screening (Shared as word-doc)

Categorisation based on pollution index

Pollution index	Category
PI≥80	Red
55≤PI<80	Orange
25≤PI<55	Green
PI<25	White category

Water	BOD, Type of pollutants, Qty. wastewater generated
Air	Type of pollutants, fugitive emissions, odour, quantity
Wastes	Hazardous/non-hazardous: waste treatment types, amount of wastes

$$PI = i_{max} + (100 - i_{max})\left(\frac{i_2 + i_3}{200}\right)$$

Where,

- i_{max}, is the maximum score among water (W), air (A), and Hazardous (H) pollution scores.
- i_2 and i_3 are the remaining pollution scores.

Scoring criteria for water polluting industries

Water Pollutant Group	Description	Score
Score W1: Score based on the oxygen demand of wastewater. (Maximum of the following scores to be considered)		
W11	BOD ≥ 5,000 mg/l or COD ≥ 10,000 mg/l	35
W12	1000 ≤ BOD < 5,000 mg/l or 5000 ≤ COD < 10,000 mg/l	30
W13	500 ≤ BOD < 1,000 mg/l or 1000 ≤ COD < 5,000 mg/l	25
W14	100 ≤ BOD < 500 mg/l or 250 ≤ COD < 1,000 mg/l	20
W15	BOD < 100 mg/l or COD < 250 mg/l	10
Score W2: Score based on presence of pollutants in the wastewater. (Maximum of the following scores to be considered)		
W21	Presence of pesticides, heavy metals and toxic compounds: Radioactive materials, etc.	30
W22	Nitrate Nitrogen, Nitrate, Amonical Nitrogen, Total Kjeldahl Nitrogen (TKN), Oil & grease, pH<5.5 or > 9	25
W23	Wastewater with high TDS generated from fresh-water RO rejects, boiler blow-downs and brine solution rejects	20
W24	Wastewater from cooling towers and cooling-re-circulation processes	15
Score W3: Score based on quantity of raw wastewater generation (Maximum of the following scores to be considered)		
W31	Wastewater ≥ 500 KLD	35
W32	100 KLD ≤ Wastewater < 500 KLD	30
W33	50 KLD ≤ Wastewater < 100 KLD	25
W34	10 KLD ≤ Wastewater < 50 KLD	20
W35	Wastewater < 10 KLD	15
Water Pollution Score (W) = W1+W2+W3		

Scoring criteria for air polluting industries

Air Pollutant Group	Description	Score
Score A1: Score based on presence of pollutants in the emissions. (Maximum of the following scores to be considered)		
A11	Presence of Hazardous Air Pollutants (HAPs), and heavy metals: HAPs (Phosgene, Benzene, Benzo[a]pyrene, Butadiene, Toluene Diisocyanate, Methylenediphenyl Diisocyanate, Ethylene Oxide, Ethylene Di Chloride, Acrylonitrile, Propylene Oxide), Dioxins & Furans, Asbestos, Polycyclic Aromatic Hydrocarbons (PAHs), HCN, Cd, Th, Hg, Sb, As, Pb, Co, Cr, Cu, Mn, Ni, V, etc.	35
A12	Presence of halogens, acids and pesticides based pollutants: H_2S, HF, HBr, P_2O_5 as H_3PO_4, NH_3, TOC, Cl, HCl, SO_3, CH_3Cl, Total Fluoride, PM having pesticide compounds/other organic compounds, Acid mist, etc.	30
A13	Presence of pollutants due to combustion of fuel: PM, CO_2, CO, NOx, SO_2, etc.	25
A14	Presence of Volatile Organic Compounds (VOCs): Ethyl benzene, Styrene, Toluene, Xylene, Aromatics, Propylene Glycol, Ethylene Glycol, etc.	20
Score A2: Score based on fugitive emissions and odour nuisance. (Maximum of the following scores to be considered)		
A21	Fugitive emissions of Particulate Matters (PM) due to process operations	30
A22	Fugitive emissions due to handling of materials, etc.	25
A23	Odour nuisance, including odour due to use of binding gums, cements, adhesives, enamels etc.	20
Score A3: Score based on the fuel quantity. (Maximum of the following scores to be considered)		
	Coal or liquid fuels	
A31	Fuel consumption ≥ 24 TPD	35
A32	12 TPD ≤ Fuel consumption < 24 TPD	30
A33	Fuel consumption < 12 TPD	25
	Biomass-based fuels	
A34	Fuel consumption ≥ 48 TPD	25
A35	24 TPD ≤ Fuel consumption < 48 TPD	20
A36	Fuel consumption < 24 TPD	15
	Cleaner/gaseous fuels, such as, PNG, CNG, LPG, Compressed Bio-gas (CBG), propane, butane etc.	
A37	Fuel consumption ≥ 120 TPD	20
A38	60 TPD ≤ Fuel consumption < 120 TPD	15
A39	Fuel consumption < 60 TPD	10
Air Pollution Score (A) =A1+A2+A3		

Scoring criteria for hazardous waste generating industries

Waste Pollutant Group	Description	Score
Score H1: Score based on the hazardous waste management/disposal method. (Maximum of the following scores to be considered)		
H11	Hazardous waste requiring disposal in secured landfill after stabilization	50
H12	Hazardous waste requiring disposal through incineration	40
H13	Hazardous waste requiring disposal in secured landfill without stabilization	30
H14	High volume and low effect hazardous wastes	20
Score H2: Score based on quantity of hazardous waste generation (Maximum of the following scores to be considered)		
H21	Hazardous Waste ≥ 5000 TPA	50
H22	1000 TPA ≤ Hazardous Waste < 5000 TPA	40
H23	200 TPA ≤ Hazardous Waste < 1000 TPA	30
H24	10 TPA ≤ Hazardous Waste < 200 TPA	20
H25	Hazardous Waste < 10 TPA	10
Hazardous Waste Generation Score (H) = H1+H2		

List of examples on categorisation

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Sector	W	A	H	PI	Category	Approval
Automobile manufac.	75	25	25	86.0	RED	Expert Appraisal Committee (EAC) by MOEFCC
Thermal power plants	70	95	70	98.5	RED	
Chemical	65	75	50	89.5	RED	
Natural dyes	70	50	0	77.5	ORANGE	State Expert Appraisal Committee SEIAA (State Environmental Impact Assessment authority)
Green crackers	0	25	0	25	GREEN	No approval
Flyash bricks biofertilizer industries	0	0	0	0	WHITE	No approval
Airports	80	50	50	90	RED	Expert Appraisal Committee (EAC) by MOEFCC
Hotels (above 3 star)	75	50	0	81.3	RED	
Nuclear Power, Hydroelectric plants					RED (Spl)	

Identify whether EIA is required or not?

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'Scrap waste-to-energy incinerator project at Kodungaiyur dumpyard'

Over 20 organisations and residents of north Chennai cite ecological concerns and health risks

Phase 1 Step 2. Scoping

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Tell us the breadth and depth of information needed. What should be included?

Objective

- **define the boundaries** of the EIA study.
- inform and identify **stakeholders**.
- find out the **concerns of EIA participants**.
- identify the **main issues and impacts to be studied.**
- consider feasible and **practical alternatives**.
- agree on means of **public involvement and methods of analysis.**
- establish the **Terms of Reference-→EIA Report: Outcome**

Who should be involved?

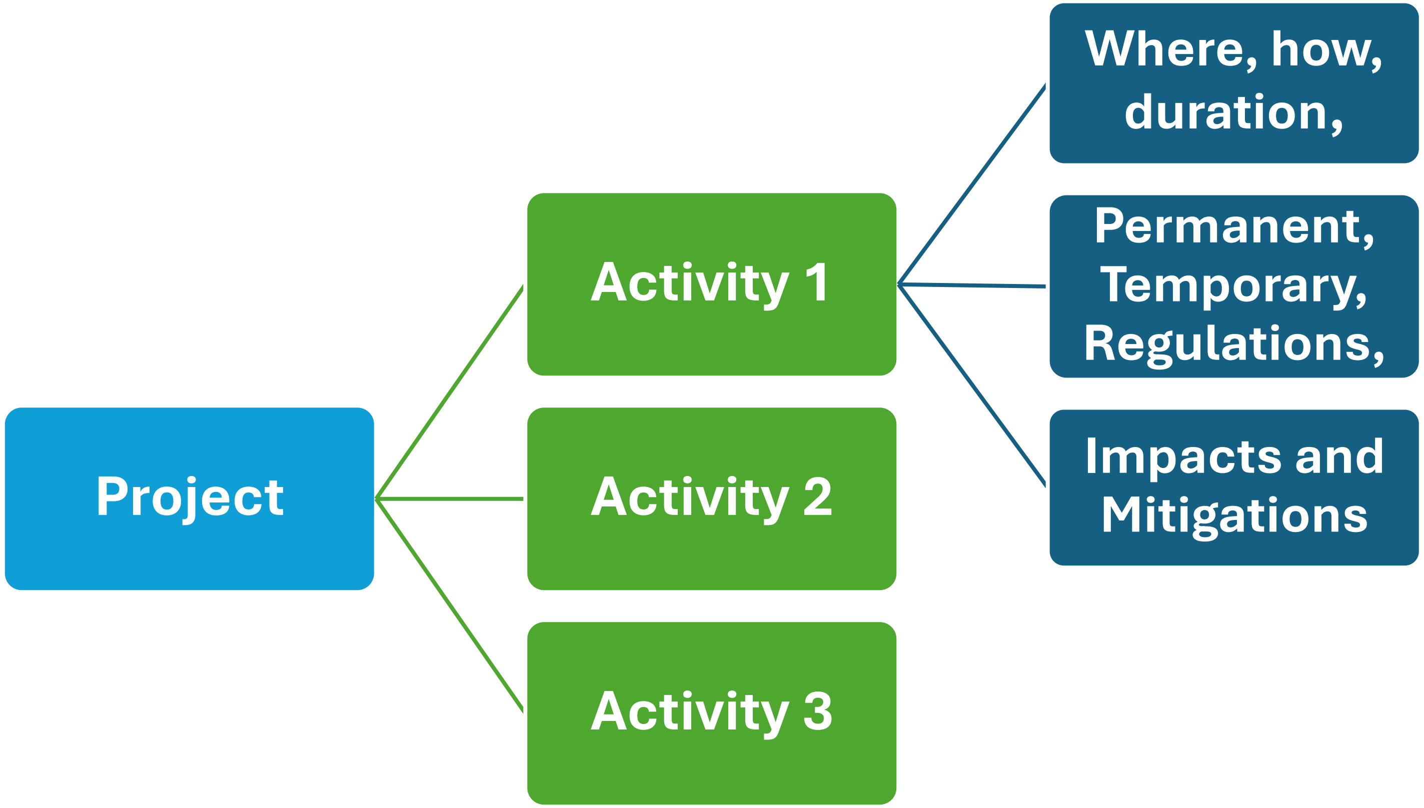
- the proponent, the EIA administering body
- other responsible agencies
- EIA practitioners and experts
- key stakeholders (Proponent, public, government bodies, decision council etc)

2. Scoping

Scoping is a process, not a one-time activity

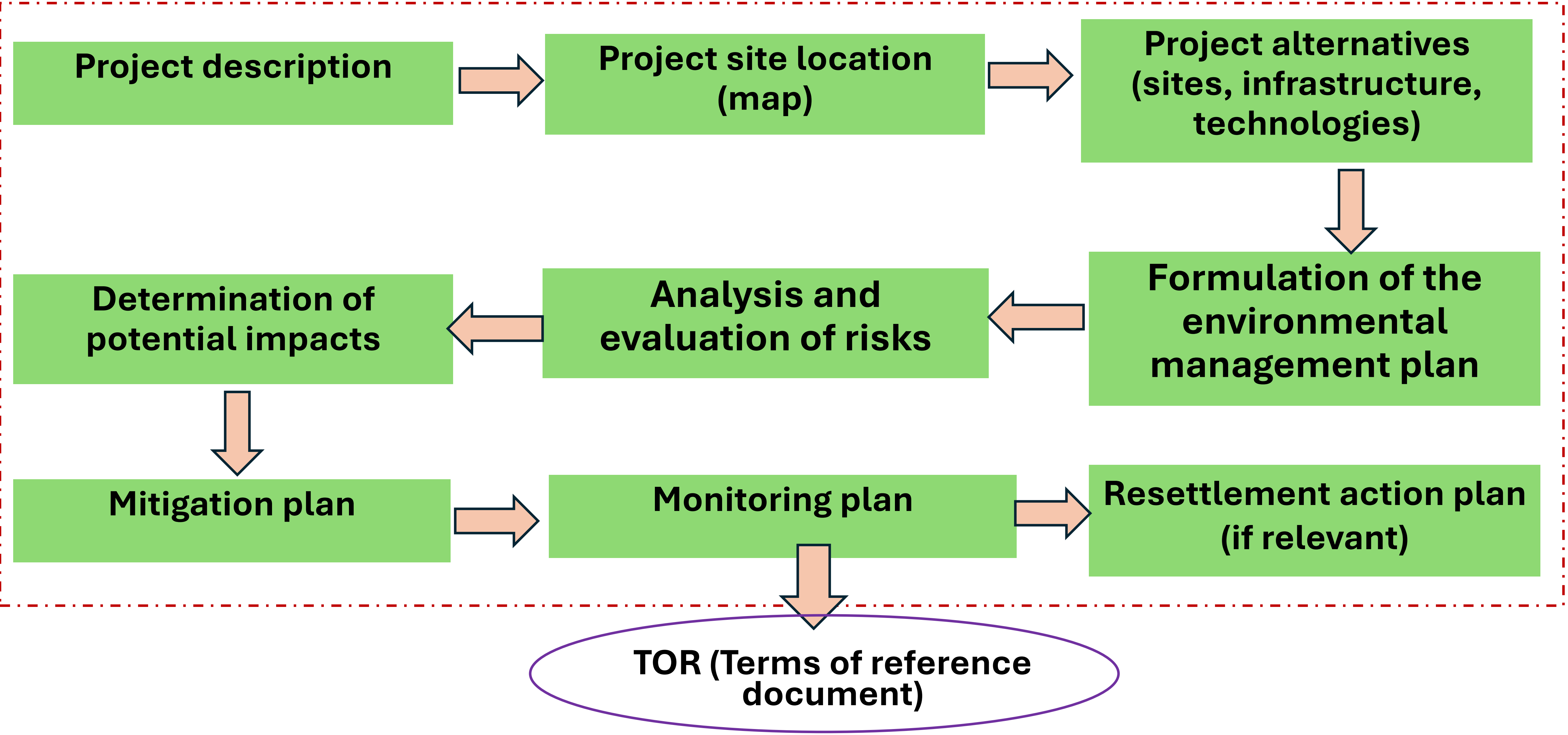
How to do?

1. Preparation of an exhaustive **list of a wide range of environmental issues and concerns.**
2. Evaluation of their relative importance and significance.
3. Preparation of a shortlist of key issues
4. Organization of the key issues for further evaluation
5. Establishing the TOR for the EIA, TOR is a road map for the EIA report



2. Scoping

(Process flow chart)



2. Scoping

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Information Needed for Scoping→ TOR

1. Contact Details of the Project Proponent: Name of the company, address & email

2. Characteristics of the project

- **Brief description** and **Reasons for proposing the project**.
- A plan showing the boundary of the development, including **any temporary sites.**
- The physical form of the development (**layout, buildings, other structures.)**
- Description of the activities/processes: size, capacity, throughput, input, and output.
- Any new access arrangements or **changes to the existing** road layout.
- A work program for **construction, operation, and commissioning** phases, and **restoration and after-use** where appropriate.
- **The relationship with other existing/planned projects.**
- Information about **mitigating measures** that are being considered.
- Other activities that may be required as a **consequence of the project** (e.g. new roads, provision of a new water supply, generation or transmission of power)
- Details of **any other permits** required for the project.

3. Location of the Project

(Maps and photographs showing the physical, natural, and man-made features)

- **Existing** **land uses** on and adjacent to the site.
- Protected areas or features Sensitive areas.
- Details of **any alternative locations** which have been considered.
- Characteristics of the potential Impact.

4. A brief description of the likely impacts of the project

- People, human health, fauna and flora, soils, land use, and material assets.
- **Water quality** and hydrology, air quality, climate, noise, and vibration
- **The landscape** and visual environment, historical and cultural heritage resources

➢ direct or indirect/secondary, short, medium or long-term, permanent or temporary, etc. discussed in previous slides

➢ **Mitigation plan** to be incorporated into the project design to reduce, avoid, or offset significant adverse impacts of the impact.

2. Scoping

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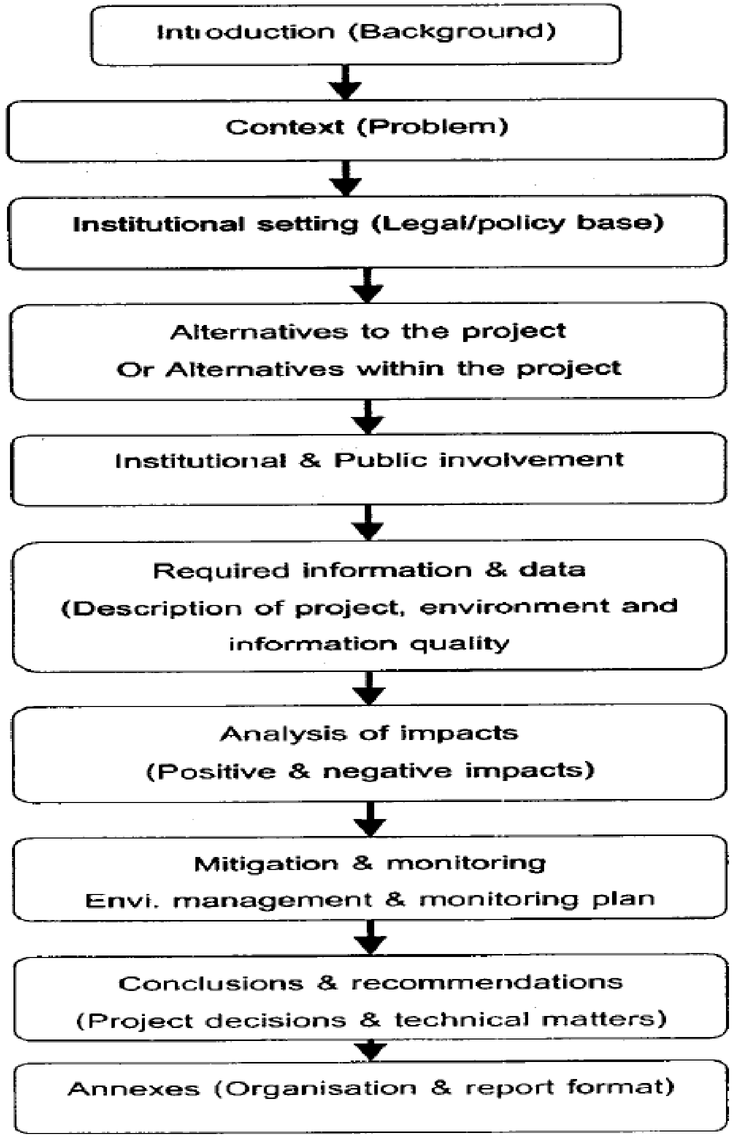
Terms of reference (TOR)

1. A description of the project.
2. A list of the agencies or ministries responsible for overseeing the EIA process and making decisions.
3. The geographic study area details (**Impact zone)**.
4. EIA requirements as per laws.
5. Impacts and issues to be studied .
6. Mitigation and monitoring systems designed.
7. Provisions for Public Involvement.
8. Key stakeholders.
   Timeframe for completing the EIA process.
   Expected work deliverables.
9. Budget for EIA.

Once TOR is approved by EAC/SEIAA, it should go for the EIA report



Step 2. Scoping

Scoping Methods

1. Checklists
2. Matrices
3. Component interaction technique
4. Networks
5. Overlay maps
6. Analogs

Scoping Methods

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1. Checklists

Listing of specific attributes in questionnaire form.

a. population
b. flora, fauna
c. air, water, soil
d. architectural and historic heritage
e. landscape and topography
f. designated sites and policies
g. risk of accident

Drawbacks: inherently too simple to identify; cannot help to identify all the significant impacts.

2. Matrices

* Combination of checklists
* Effect of activity vs impact

Drawback: indirect or secondary impacts cannot be shown

Matrices : Example-Thermal power plant

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Columns:

1. Air quality - PM
2. Air quality - Gaseous
3. Noise
4. Odor
5. Traffic
6. Water- resources
7. Water- quality Soil
8. Drainage pattern
9. LU in core zone
10. LU in buffer zone
11. Landscape/ asthetics
12. Agriculture
13. Pasture
14. Ecology - flora
15. Ecology - fauna, avifauna
16. Aquatic/ marine ecosystem
17. Wetlands
18. Socio-economic
19. Displacement
20. Livelihood
21. Health
22. Nuisance
23. Infrastructural development
24. Social development
25. Employment
26. Local economy
28. Cultural
29. Material assets
30. Risk
31. Occupational health

ACTIVITIES:	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
EFFECTS:																															
Preconstruction																															
Land acquisition																				✓	✓										
Construction materials sourcing (**offsite**)	✓		✓				✓	✓	✓			✓		✓	✓	✓	✓	✓					✓			✓	✓				✓
Construction																															
Site development	✓		✓				✓	✓	✓	✓		✓			✓	✓	✓	✓					✓			✓					
Transportation	✓	✓	✓		✓			✓															✓	✓		✓	✓	✓		✓	
Operation																															
Coal handling and storage	✓		✓		✓		✓	✓	✓	✓			✓	✓	✓		✓					✓	✓			✓	✓	✓		✓	
Coal pulverization	✓		✓										✓	✓	✓															✓	✓
Fuel combustion	✓	✓	✓	✓				✓					✓	✓	✓	✓	✓						✓						✓	✓	
Post-operation/ Decommissioning																															
Dismantling infrastructure	✓	✓	✓	✓			✓	✓	✓	✓		✓					✓				✓		✓			✓				✓	
Transportation	✓	✓	✓		✓																		✓			✓	✓			✓	
Site restoration	✓		✓				✓	✓	✓	✓		✓			✓	✓	✓	✓								✓					

3. Component interaction technique

- Developed to incorporate **secondary impacts.**
- The environment is modeled as a list of components, ranked in the order of ability to initiate secondary impacts based on linkages,
- Chains of dependence between different impacts.

Drawback: Requires a thorough understanding of the components of ecosystems and their interactions.

4. Networks

- Advancement of the component interaction method.
- Recognizes that the environment consists of a complex web of relationships
- Identification of the secondary impacts along with the estimation of:
    a. magnitude
    b. significance
    c. probability

Drawback: Time-consuming

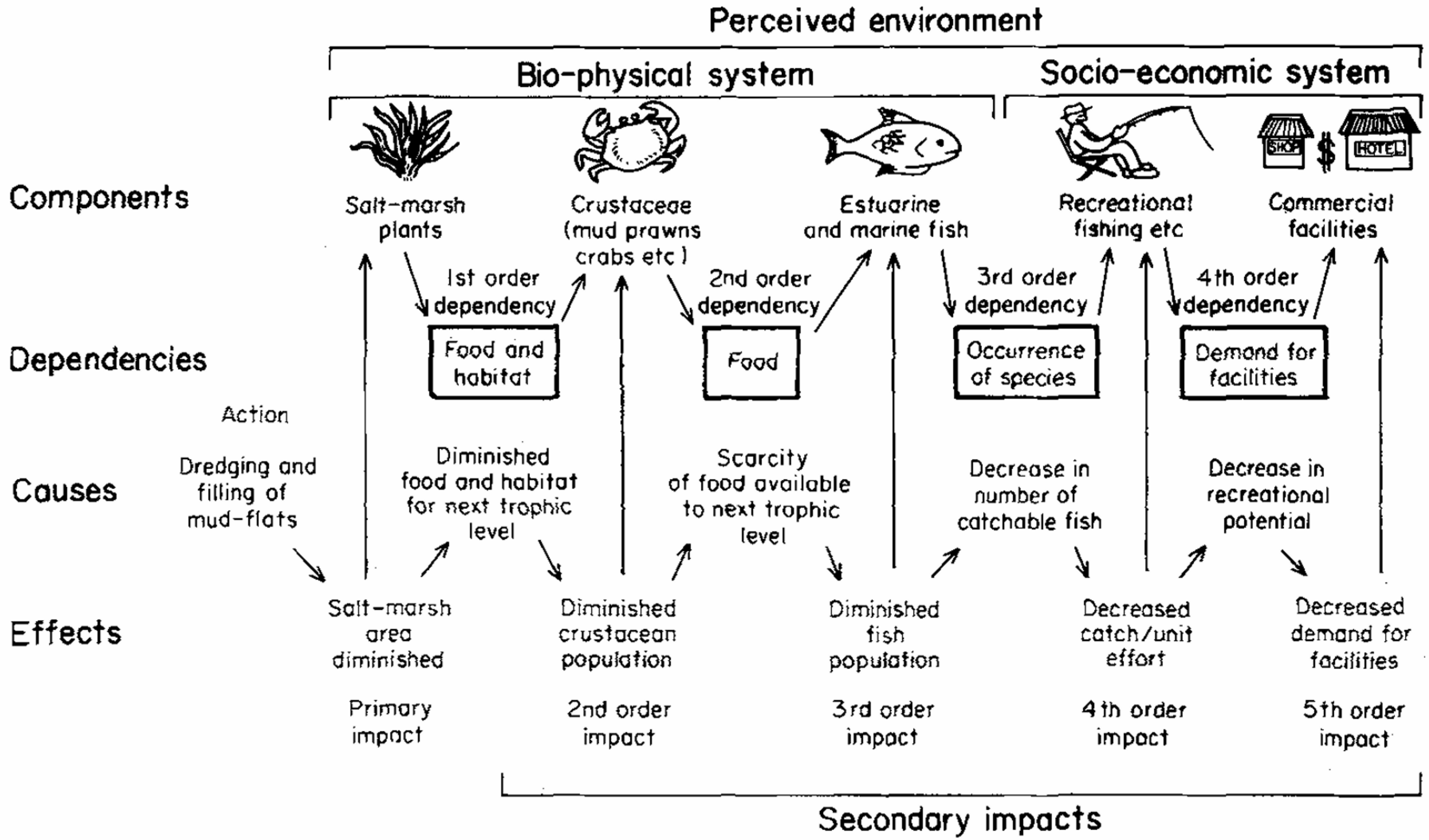
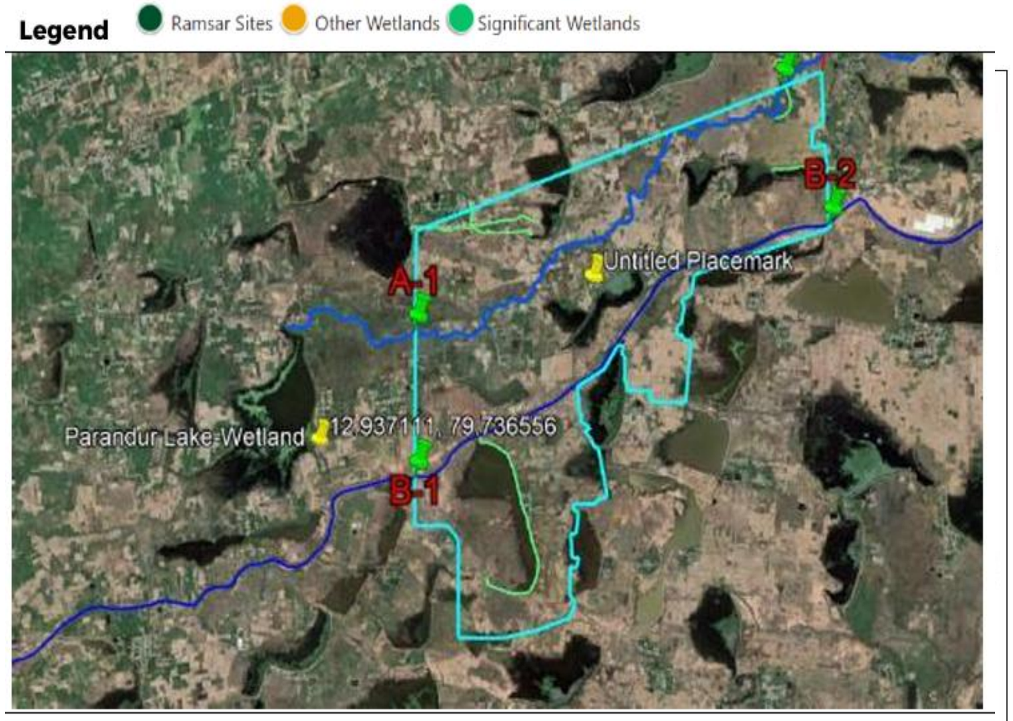


Figure 1. Symbolic representation of the secondary impacts which could arise from the dredging and filling of an estuarine mud-flat.

5. Overlay mapping

- superimposition of several thematic maps.
- widely used in environmental planning, especially for *large area developments and linear projects, e.g. townships, industrial areas, roads, railways, and cross-country pipelines,* and also for comparing alternatives.



Source: https://indianwetlands.in/wetlands-overview/interactive-wetland-map-of-india/

Location of proposed Greenfield international airport, Parandur, Chennai

6. Analogs

- used to draw on experiences of similar projects in other regions or countries with similar environmental settings.
- However, it needs to be ensured that a sound analogy gets drawn to the potential impacts.

Scoping Report Description

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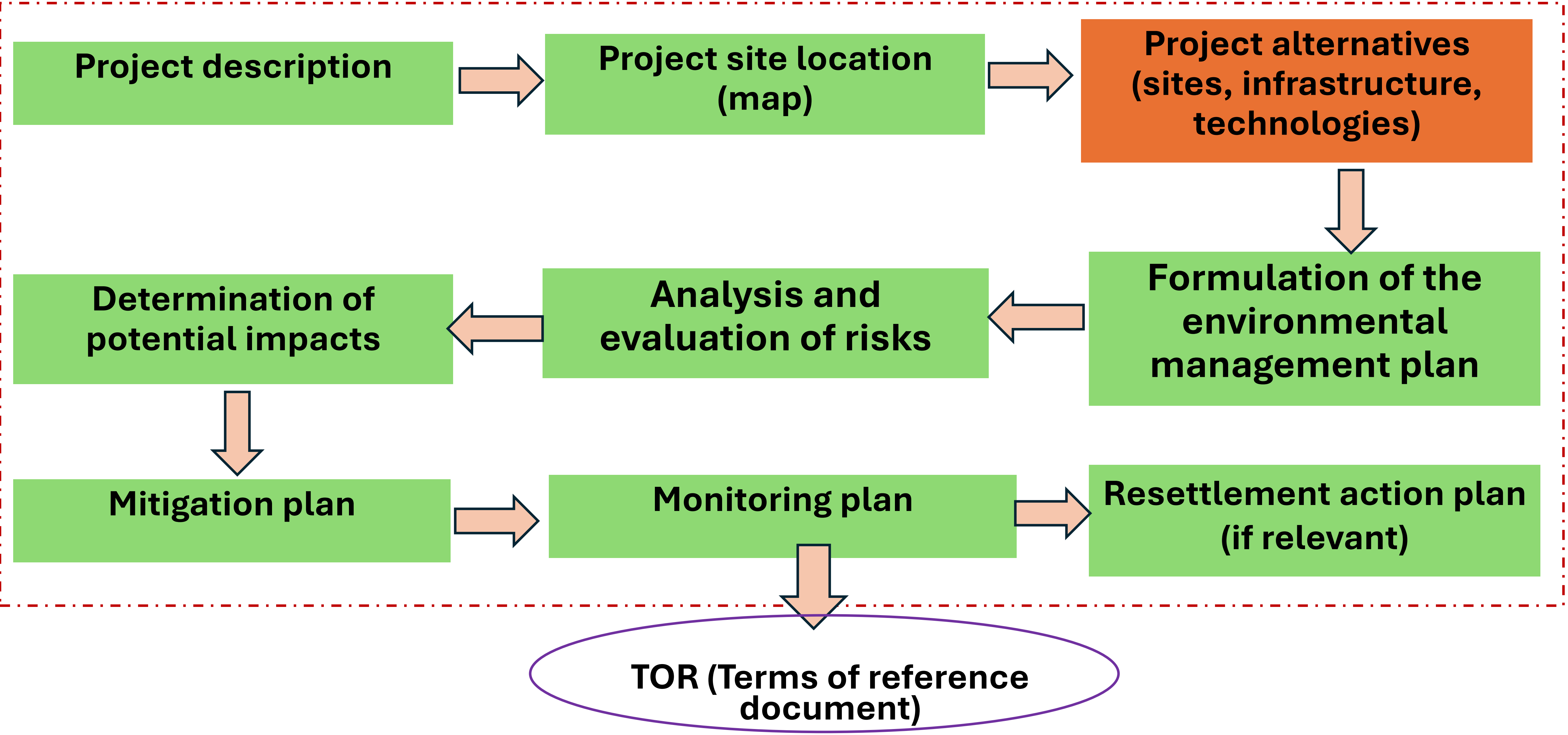
(Process flow chart)



Scoping stage: Consideration of Alternatives

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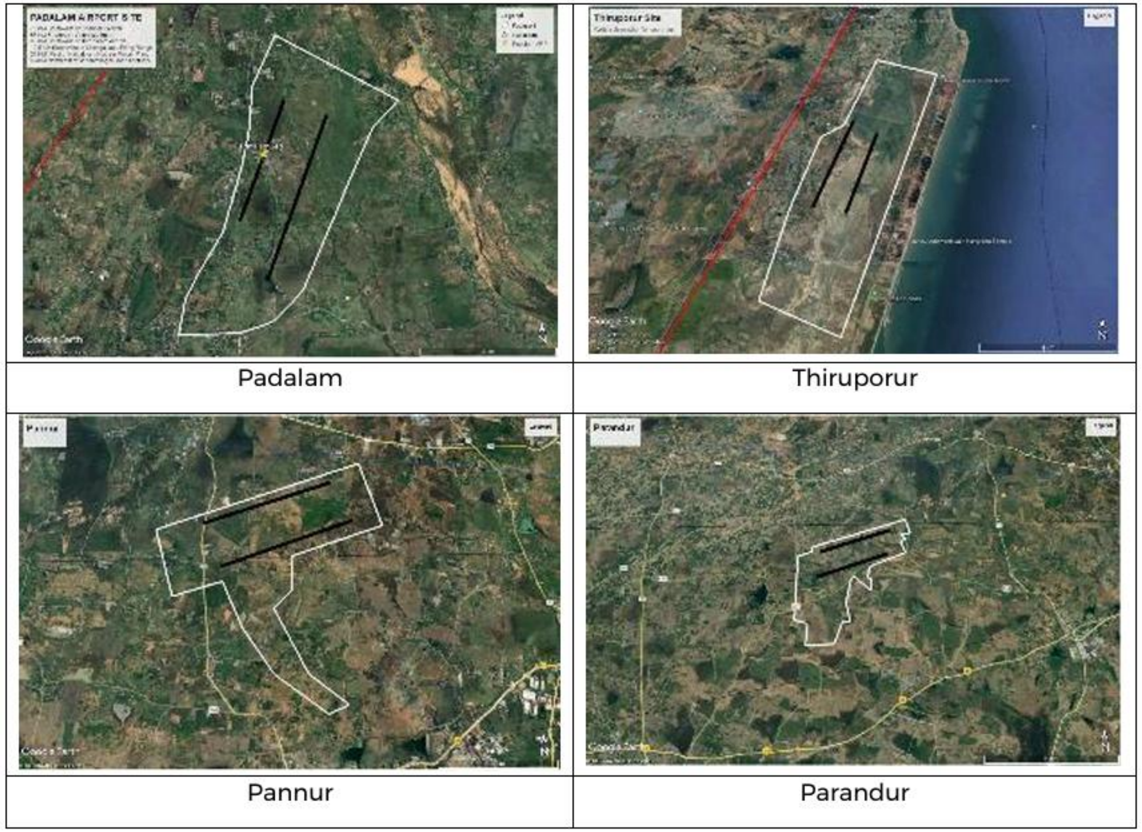
Heart of the environmental impact statement

- **the third key sub-stage; pre-feasibility stage of a project.**
- extremely important for sound decision-making,
- Identification and analysis of alternatives

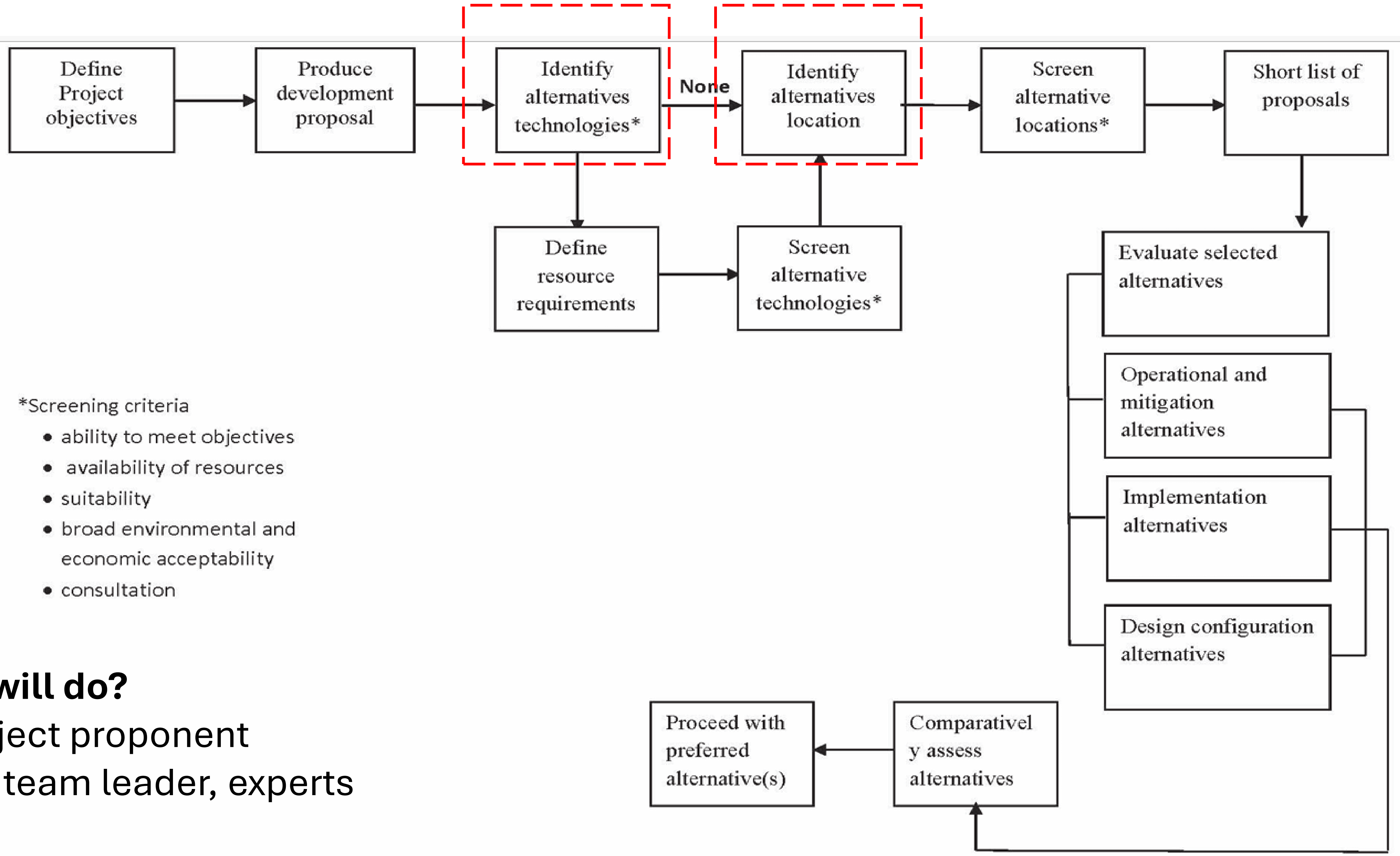
1. Project alternatives
2. Project size alternatives
3. Site-location alternatives
4. Design alternatives for the selected project
5. Construction and operation alternatives for a given design
6. Timing alternatives for project construction and operation
7. No project or no action alternative

,

Figure 3-23 Analysis of Alternatives- Location Map



Consideration of alternatives



*Screening criteria

- ability to meet objectives
- availability of resources
- suitability
- broad environmental and economic acceptability
- consultation

Who will do?

- Project proponent
- EIA team leader, experts

Steps in EIA process

- Screening
- Scoping
- Base line data
- Impact identification
- Prediction
- Evaluation
- Mitigation
- EIA preparation
- Public Consultation
- Review/Appraisal by EIA authority
- Environment audit

Draft EIA report preparation: PHASE 2

Phase 2: Impact Assessment

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Step 1: Baseline conditions of parameter → 2. Discharge conditions → 3. Permissible limit → 4. Predicted discharge conditions → 5. Mitigation/alternative/Management/ EMP

- **Baseline studies:**
- Refers to the collection of baseline information on biophysical, construction or operational stages of a project area.
- Gives a holistic picture of the overall environmental setting of the project location showing any potentially critical environmental changes and information about the site.
- **Parameters:**

physical-chemical environment, *viz*. air, noise, water and wastewater, soil, and risk

Baseline studies

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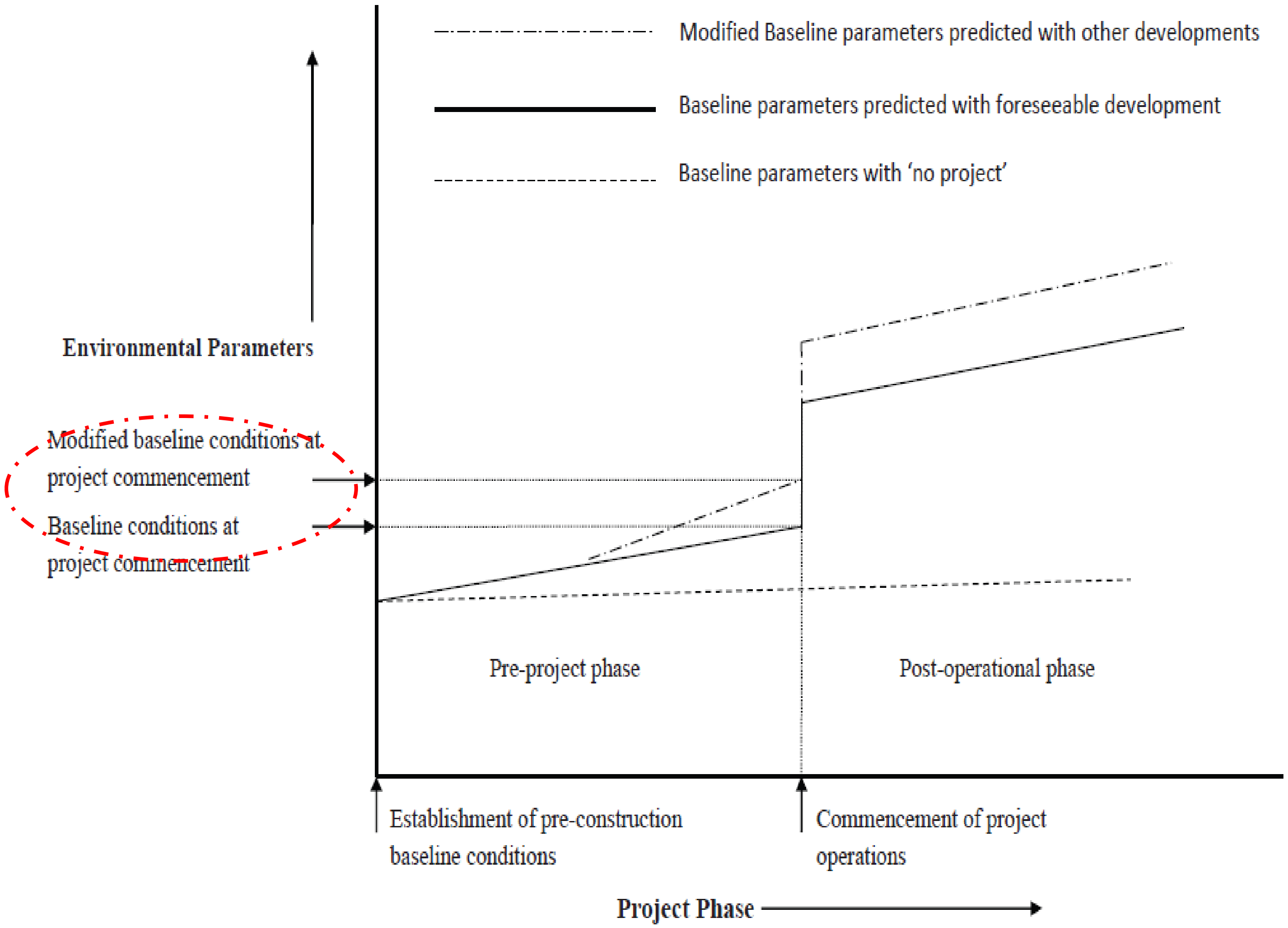
Two purposes:

- To provide a description of the **status and trends of environmental factors** (e.g., air pollutant concentrations) against which predicted changes can be compared and evaluated in terms of importance.
- To provide a means of **detecting actual change by monitoring** once a project has been initiated.



What is included in baseline data collection?

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(a) Site location and topography – Elevation levels

(b) Regional demography - population distribution; land-use and water-use pattern within 10 km radius .

(c) Regional landmarks like historical and cultural heritage in the area. For this archaeological or state register can be checked.

(d) Geology – Groundwater and surface water resources are quantified; water, quality, pollution sources etc are studied.

(e) Hydrology – Groundwater and surface water resources are quantified; water, quality, pollution sources etc are studied.

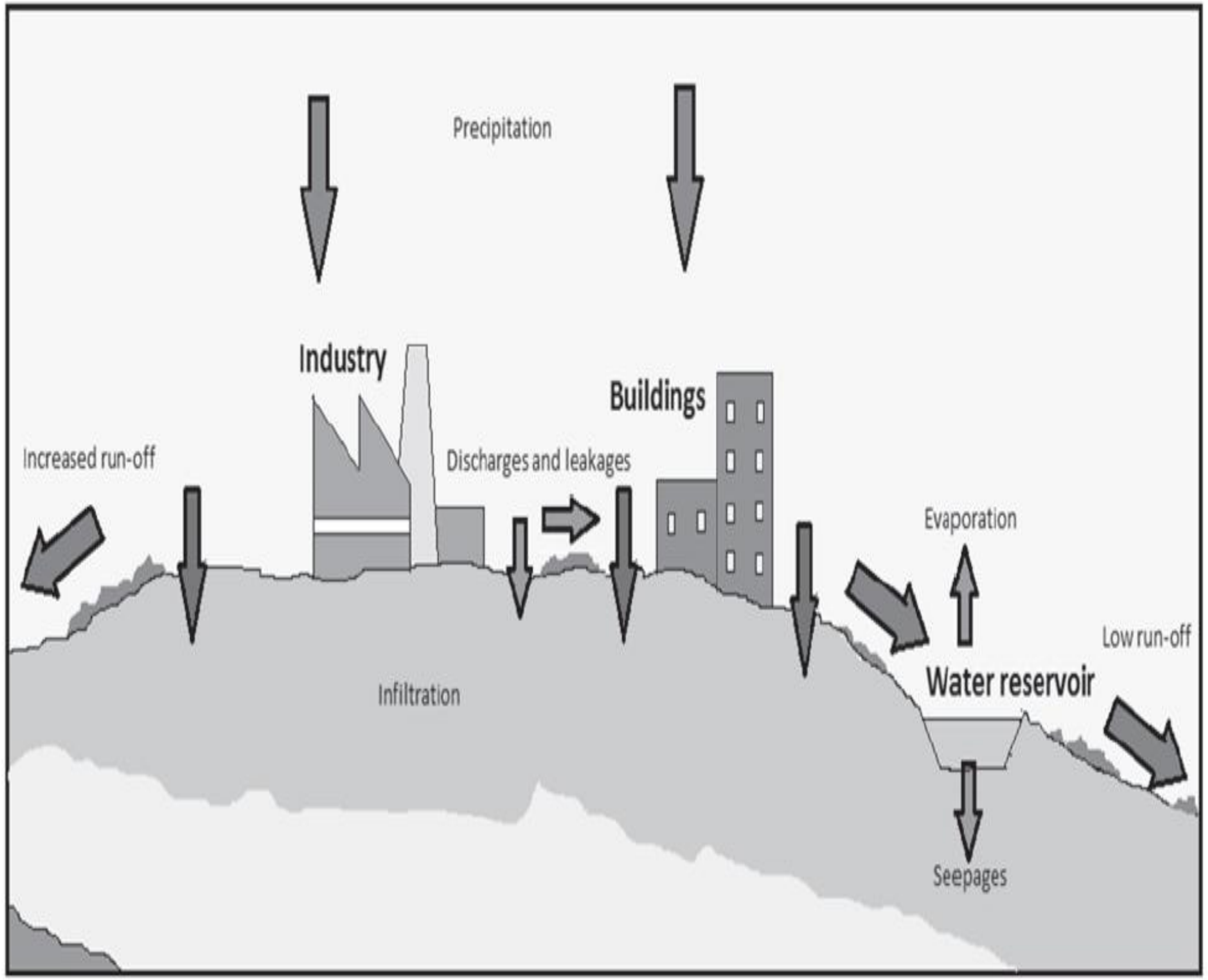
(f) Meteorology – Temperature extremes, wind speed and direction, dew point, atmospheric stability, rainfall, storms etc. are recorded.

(g) Ecology – The flora, fauna, endangered species, successional stage etc. are enlisted

Example Baseline data collection

Water

1. Source of water and water quality
2. Existing water runoff, groundwater quality, water table
3. Seasonal changes; Flooding
4. Users of water
5. Discharge in water bodies
6. Water bodies from where the proposed project will take water for its activities
7. Wastewater generation



Land/Soil

- Land use (residential, commercial, industrial)
- Land cover (agri, wetland, forestland)
- Drainage pattern
- Soil fertility
- Microorganisms

Air

i. Wind speed, wind direction, rainfall, solar radiation, temperature
ii. Major sources of air emissions
ii. their respective locations relative to the project location
iii. Existing ambient air quality
iv. local meteorological conditions (5-10 years)
v. sensitive receptors (Schools, hospitals, eco-sensitive zone/religious, historical)

Noise environment

- project location
- ambient noise levels
- sensitive receptors (Residential, schools, hospitals etc.)

Ecology

- National parks, Sanctuaries
- Ramsar sites, Biosphere reserves, Wetlands, Heritage sites

Social environment (*Detailed in socio-economic assessment)*

- communities at risk or beneficial by the project
- governmental agencies at the national and regional level
- NGOs , Level and sources of income
- In and out- migration profile

How to get baseline data ?

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1. Decide key impact areas
2. Collect Secondary data
3. Set up an appropriate monitoring system
4. Generate primary data
5. Data management, analysis and presentation

Baseline data sources

- **Primary sources:** Result of the field and laboratory data collected and analyzed directly
- **Secondary sources:** Data collected indirectly from published records or documents such as project documents, village profiles, maps, photos, internet sources, etc.

Methods of data collection:

- **General methods:** Literature review, map interpretation, checklists (e.g. scaling and questionnaire checklists, matrices etc.)
- **Resource-based methods:** Scientific instruments and techniques (inventory, species-area curve, sampling techniques, PRA, RRA)

How to get baseline data ?

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Step 1. Decide Key impact areas by studying

- Project background
- Resource requirements
- Technology and materials
- Emissions abatement
- Resource recovery
- Critical phases in project cycle
- Implementation schedule
- Interaction with other projects

- Key impact areas
  - Land
  - Surface water and groundwater
  - Atmosphere
  - Noise and vibration
  - Species and population (migration rate)
  - Habitats and communities
  - Health and safety
  - Socio-economic
  - Aesthetic/Cultural

Step 2. Potential Sources of Secondary Data

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State Government

- Department of Environment and Forest
- Pollution Control Board
- Planning Boards
- Department of Agriculture
- Department of Irrigation / Water Resources
- Groundwater Board
- Local NGOs in the state.
- District Collectorate
- Relevant State level Research Institutes
- Census Department
- Land use Planning
- State Remote Sensing Department
- Transport Department

Central Government

- Ministry of Environment and Forests
- Central Pollution Control Board
- India Meteorological Department
- Geological Survey of India
- Archaeological Survey of India
- Botanical Survey of India
- Zoological Survey of India
- National Informatics Centre
- National Land use and Soil Survey Offices

Step 3. Setting up an appropriate monitoring system for baseline studies

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3.1 Set monitoring objectives

3.2 Plan for quality assurance and quality control of data

3.3 Establish network design

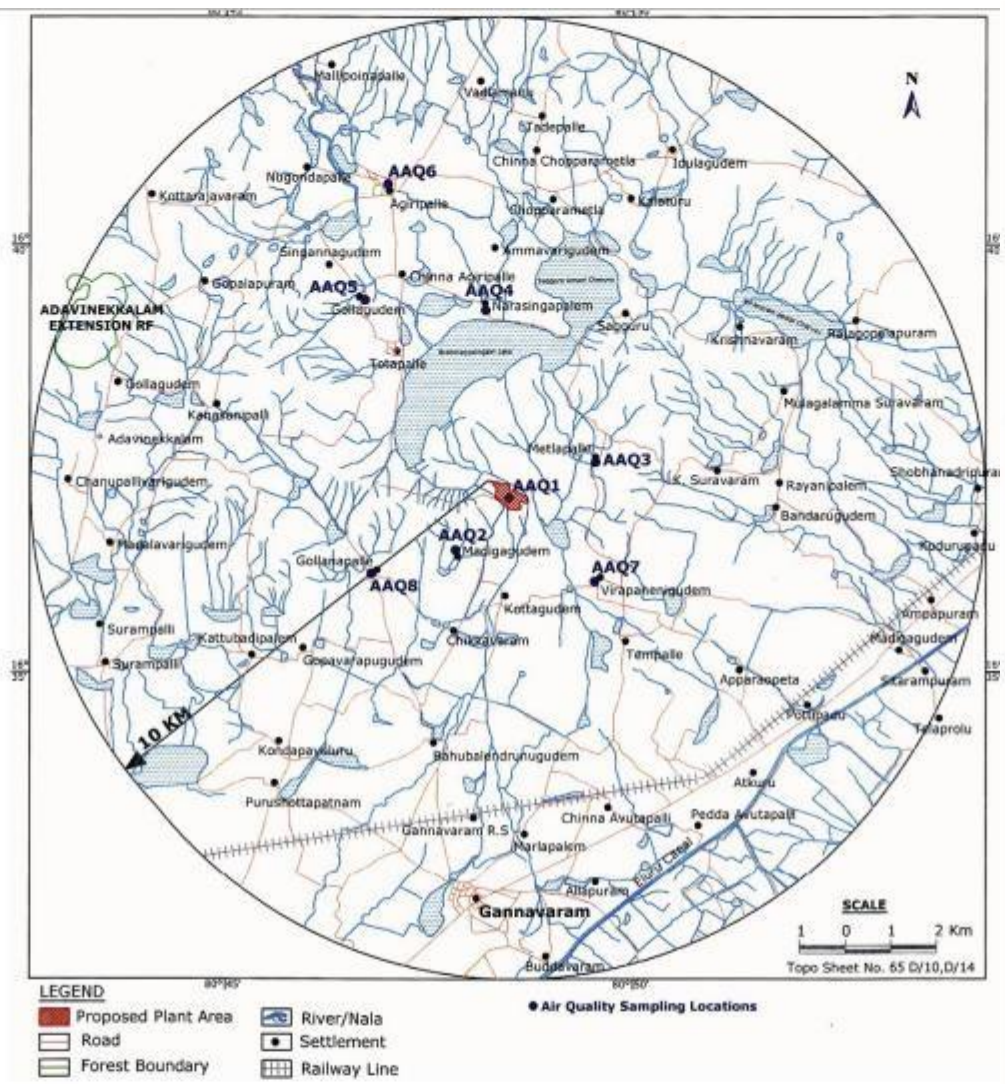
Step 3. Setting up an appropriate monitoring system for baseline studies

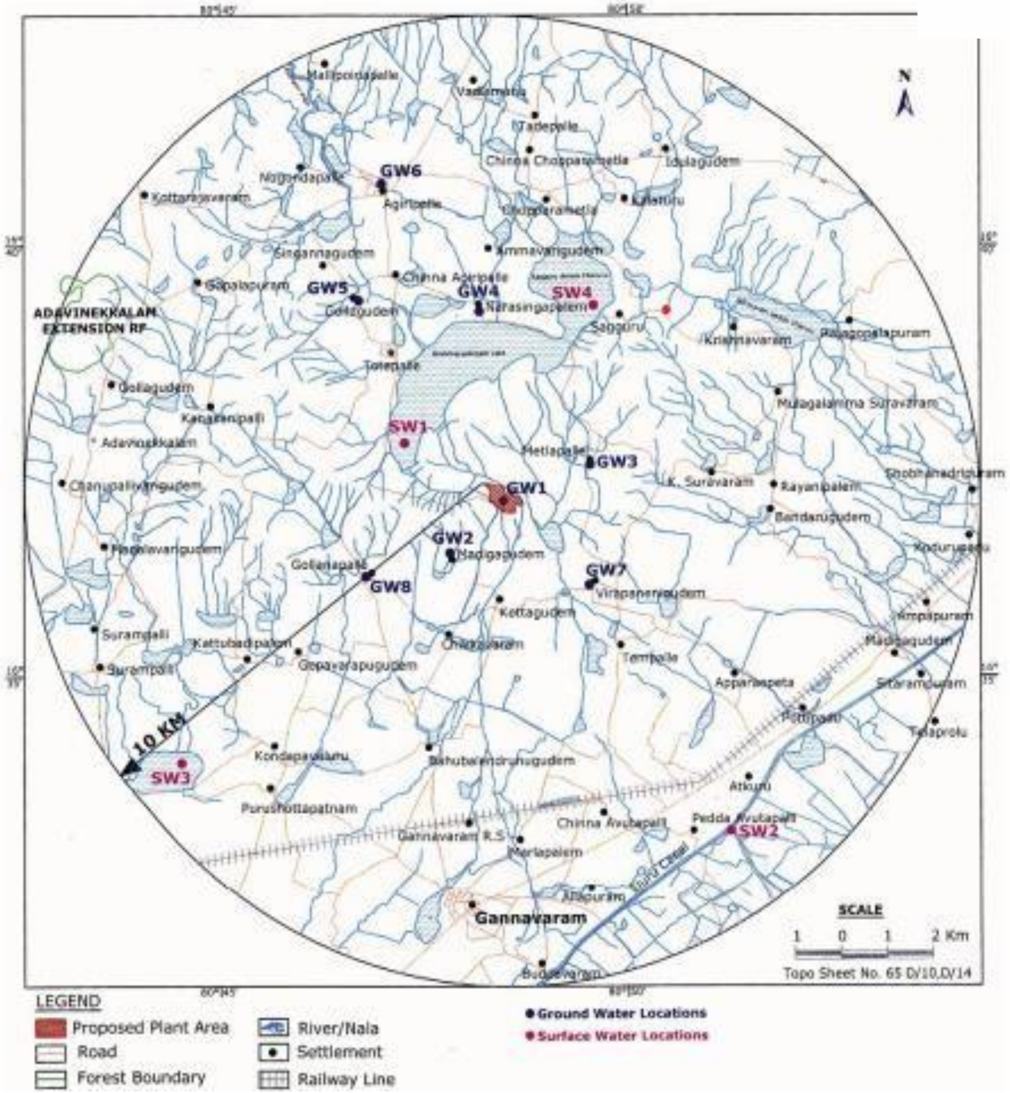
3.1 Monitoring Objective

Types of monitoring

- **Baseline monitoring** is the measurement of environmental parameters **during the pre-project period** for the purpose of determining the range of variation of the system and establishing reference points against which changes can be measured.
- **Effect monitoring** is the measurement of environmental parameters **during project construction and implementation** to detect changes that are attributable to the project and necessary information, to verify the accuracy of EIA predictions, and to determine the effectiveness of measures to mitigate adverse effects of projects on the environment.
- **Compliance monitoring** is the periodic sampling or continuous measurement of environmental parameters to ensure that regulatory requirements and standards are being met.
- Compliance and effect monitoring occur during the **project construction, operation, and abandonment stages.**

Examples of setting monitoring stations





Source: Mareddy, A. R., Shah, A., & Davergave, N. (2017). *Environmental impact assessment: theory and practice*. Butterworth-Heinemann.

Step 3. Setting up an appropriate monitoring system for baseline studies

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3.3 Network design

- To identify the sampling locations or monitoring stations to collect the parameters before and after the project's development, **a reconnaissance survey**- conducted with appropriate field experts, subject experts, and surveyors. The parameters are mainly **site-specific.**

- Factors deciding the monitoring station locations

1. Predominant wind direction;
2. Topography and location of surface water bodies;
3. Location of human habitations, villages, and towns;
4. Location of environmentally sensitive areas;
5. Identification of pollution pockets;
6. Accessibility, power availability, and security of monitoring equipment;
7. Representation features of baseline conditions; and
8. Nature- and site-specific baseline conditions.

Step 4. Generate primary data

- Seasonal and meteorological data: Temperature, Rainfall, Mean value of humidity, Inversion occurrence, Seasonal wind regime.
- Ambient air quality data: SPM, RPM SO2, NOx, CO
- Water quality: Physical parameters, inorganic, organic, nutrients, microbiological and hydrological conditons
- Soil quality: Physical, chemical and metallic properties
- Noise quality: Variation with time, Frequency, avg sound pressure levels,

Step 5. Data management, analysis and presentation

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- **Statistical methods** used to analyse data should be described in detail before data collection. This is important because repetitive observations are recorded in time and space.
- Besides, the statistical methods could also be chosen **to quantify uncertainty or error estimates** in the data.
- For example, statistical methods useful in an environmental monitoring program include (1) frequency distribution analysis, (2) analysis of variance, (3) analysis of covariance, (4) cluster analysis, (5) multiple regression analysis, (6) time series analysis, and (7) the application of statistical models.
- **Addressing temporal and/or spatial variations limited to a certain extent because of cost implications and time limitations. Therefore, analysis of all available information or data is essential to establish the regional profiles.**
- Baseline data management, analysis, and presentation. Software tools easily interpret and analyze data
- Presentation with the help of graphs, pie charts, isopleths facilitates understanding

Common baseline study problems

- Baseline studies in EIA may take a **long time**, **hence EIA is blamed for higher costs** and delays in project implementation.
- Unavailability of representative secondary data.
- Collected data often irrelevant to resolution of certain key issues.
- Not adequately tailored to needs of decision maker.
- Not many organizations equipped to carry out quality environmental monitoring – **NABL Accredited laboratories and NABET Accredited Organizations**

Phase 2: Impact Assessment

Steps :

3. Baseline conditions analysis
4. **Impact identification**
5. Impact prediction or estimation
6. Impact assessment for determining whether the impacts are significant
7. Mitigation plan/Environmental management plan

4. Impact Identification

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Methodologies for Impact Assessment

1. **Battelle Environmental Evaluation System**
2. Analogs
3. Case studies
4. **Checklists (simple, weighting, scaling)**
5. **Expert opinions**
6. **Expert systems (for impact identification, prediction, assessment, decision-making)**
7. Literature search
8. Mass balance
9. **Matrices and interaction diagrams (simple, stepped, weighting, scoring)**
10. **Networks (impact trees and chains)**
11. **Overlay mapping (GIS)**
12. Photographs and photomontages
13. **Qualitative modeling (conceptual)**
14. **Quantitative modelling (media, visual, archaeological, systems analysis)**
15. **Risk assessment**
16. Scenarios
17. Trend extrapolation
18. Environmental index using factor analysis
19. **Ad-hoc (expert opinion, opinion poll, Delphi)**

Criteria for Selection of Impact Identification Methods

1. General

- Simplicity
- Manpower, Time & Budget Constraints
- Flexibility

2. Impact Identification

- Comprehensive
- Specificity
- Isolation of project impacts
- Timing & duration

3. Impact Measurement

- Commensurate units
- Explicit indicators
- Magnitude
- Objective criteria

4. Impact Interpretation & Evaluation

- Significance
- Explicit criteria
- Uncertainty
- Risk
- Depth of analysis
- Alternative comparison
- Public involvement
- Portrayal of with and without situation

5. Impact Communication

- Affected parties
- Setting description
- Summary format
- Key issues
- Compliance

2. Checklists

- Checklists annotate the **environmental features or factors** that need to be addressed.
- Checklists provide a **systematized means of identifying impacts**
- **Sectoral checklists** are often useful when **proponents specialize in one particular area of order impacts or the interrelationships between impacts**.
- **Checklists** range from **simple listings** of environmental factors **to descriptive approaches.**
- Checklists may also involve the **scaling or rating** (or ranking) of the impacts of alternatives on each of the environmental factors under consideration.

Items	Nature of Likely Impacts									
	Adverse						Beneficial			
	ST	LT	R	IR	L	W	ST	LT	SI	N
Aquatic Ecosystems		x		x	x					
Fisheries		x		x	x					
Forests		x		x	x					
Terrestrial Wildlife		x		x		x				
Rare & Endangered Species		x		x		x				
Surface Water Hydrology		x		x		x				
Surface Water Quality		x								
Groundwater	*	*	*	*	*	*	*	*	*	*
Soils										
Air Quality	x				x					
Navigation		x			x					
Land Transportation								x	x	
Agriculture							x			x
Socioeconomic								x		x
Aesthetic		x			x					

Legend

x indicates potential for type of impact
R denotes Reversible
W denotes Wide
ST denotes Short Term
IR denotes Irreversible
SI denotes Significant
LT denotes Long Term
L denotes Local
N denotes Normal

Types of Checklists

Canter (1986) suggests that there are five broad categories of checklists.

1. **Simple checklists**
2. **Descriptive checklists**
3. **Threshold-of-concern checklists**
4. **Scaling checklists**
5. **Scaling-weighting checklists.**

- A simple checklist is a **straightforward list of relevant parameters** with no guidelines on how the environmental effects are to be measured or interpreted.
- **Short descriptive statements** used to outline the effects associated with a proposal.

Project	Phase	Activity	Environmental component
Coal-based power project	Planning and design phase	Speculation and acquisition of property	Land use

2. Descriptive Checklists

- Descriptive checklist – widely used in EIA
- It includes guidelines for the measurement of parameters.
- May include requests for data, sources of information and predictive techniques
- **No ranking**

3. Threshold of concern checklists

- In this case, a list of **environmental effects is again presented, and alongside each factor is a threshold** that indicates a level at which the assessor should become concerned about the impact.
- On the basis of the above analysis, air quality and recreation would be unacceptably impacted upon.

Environmental component	Criterion	Threshold of concern (TOC)	Impact (alternative 1)	Impact > TOC? (alternative 1)
Air quality	Emission standards	1	2C	Yes
Economics	Benefit-cost ratio	1:1	3:1	No
Endangered species	No. of pairs breeding spotted owls	35	50D	No
Water quality	Water quality standards	1	1C	No
Recreation	No. of camping sites	5000	2800C	Yes

- Impacts can also be rated for their durations.
- A indicates a duration of the impact of 1 year or less, B indicates 1–10 years, C is for 10–50 years, and D indicates an irreversible impact. Additional columns can be added to assess the effects of other alternatives.

4. Scaling checklists

- Similar to descriptive checklists, these include additional information that is basic to the scaling of parameter values.
- Example: a transport project, the environmental effects are given below.
- Scaling values - **range of -6 to +5** using **subjective evaluation**.

Environmental	Alternative A	Alternative B	Alternative C	Comments
Noise effect	−2	−1	0	Reduction of local traffic
Air pollution	−5	+2	+4	Improved traffic flow
Open space	+3	+1	−6	Some structures removed, etc.

The **drawbacks of the checklist method are**:

(i) one general, all-inclusive list of impact areas with applicability to all projects is likely to be very large, cumbersome to use, and may contain information too generalized.

(ii) innumerable checklists are available.

(iii) does not provide for the establishment for the direct cause–effect relationship.

5. Scaling-weighting checklists

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- **Overcome Battele Environmental Evaluation System (BEES).**
- The Battelle system is a **highly organized method**, and as such, it helps to ensure a systematic and comprehensive approach to identifying critical changes. **There is no passing or falling score, as the numerical evaluation has to be interpreted by the reader.**
- **These checklists are essentially *scaling checklists with information provided to enable the subjective evaluation*** of each parameter with respect to every other parameter.
- **Four Levels**

  I. Categories – 4 nos – *Ecology, Physical/Chemical (Pollution), Aesthetics & Human interest*

  II. Components/ factors – 18 nos

  III. Parameters – 78 nos

  IV. Measurements – 1000 nos

Level 1 Categories

Level 2 Components

Ecology	Pollution	Aesthetics	Human interest
a) species and populations b) habitats and communities c) ecosystems	a) water b) air c) land d) noise	a) land b) air c) water d) biota e) man-made objects f) composition	a) Education and scientific packages b) historical packages c) cultures, d) mood or atmosphere e) life patterns

Level 3: Parameters

Eg: species name, water pollution: BOD/COD, air pollution: AQI, etc

Level 3: Measurements

Measuring these parameters

Scaling-weighting checklists (1000)

ECOLOGY (240)	PHYSICAL/CHEMICAL (402)	AESTHETICS (153)	HUMAN INTEREST /SOCIAL (205)
Terrestrial Species & Populations	Water Quality	Land	Education/Scientific
-Browsers and grazers (14)	-Basin hydrologic loss (20)	-Geologic surface material (6)	-Archeological (13)
-Crops (14)	-Biochemical oxygen demand (25)	-Relief & topographic character (16)	-Ecological (13)
-Natural vegetation (14)	-Dissolved oxygen (31)	-Width and alignment (10)	-Geological (11)
-Pest species (14)	-Fecal coliforms (18)		-Hydrological (11)
-Upland game birds (14)	-Inorganic carbon (22)	Air	
-Inorganic nitrogen (25)	-Odour and visual (3)	Historical	
Aquatic Species & Populations	-Inorganic phosphate (28)	-Sounds (2)	-Architecture and styles (11)
-Commercia1 fisheries (14)	-Pesticides (16)		-Events (11)
-Natural vegetation (14)	-pH (18)	Water	-Persons (11)
-Pest species (14)	-Streamflow variation (28)	-Appearance of water (10)	-Religions and cultures (11)
-Sport fish (14)	-Temperature (28)	-Land & water interface (16)	-'Western Frontier' (11)
-Water fowl (14)	-Total dissolved solids (25)	-Odour and floating material (6)	
-Toxic substances (14)	-Water surface area (10)	Cultures	
Terrestrial Habitats & Communities	-Turbidity (20)	-Wooded and geologic shoreline (10)	-Indians (14)
-Food web index (12)			-Other ethnic groups (7)
-Land use (12)	Air Quality	Biota	-Religious groups (7)
-Rare & endangered species (12)	-Carbon monoxide (5)	-Animals -domestic (5)	
-Species diversity (14)	-Hydrocarbons (5)	-Animals -wild (5)	Mood/ Atmosphere
-Nitrogen oxides (10)	-Diversity of vegetation types (9)	-Awe/inspiration (11)	
Aquatic Habitats & Communities	-Particulate matter (12)	-Variety within vegetation types (5)	-Isolation/solitude (11)
-Food web index (12)	-Photochemical oxidants (5)		- Mystery (4)
-Rare & endangered species (12)	-Sulphur oxides (10)	Man-Made Objects	-'Oneness' with nature (11)
-River characteristics (12)	-Other (5)	-Man made objects (10)	
-Species diversity (14)			Life Patterns
Land Pollution	Composition	-Employment opportunities (13)	
Ecosystems	-Land use (14)	-Composite effect (15)	-Housing (13)
-Soil erosion (14)	-Unique composition (15)	-Social interactions (11)	
Noise Pollution			
-Noise (4)			

How to carry out scaling-weighting checklists?

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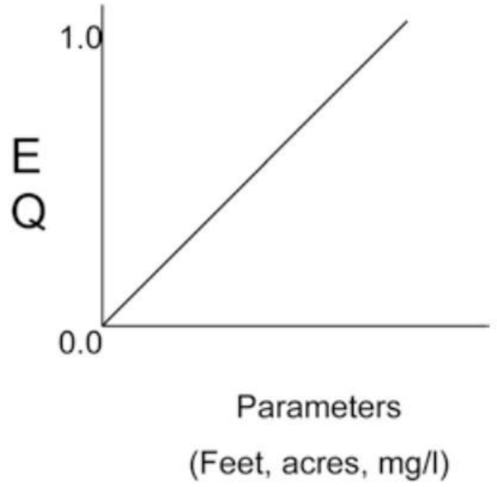
Step-1: Obtain existing condition data for each of the **78 environmental factors**. **Each environmental parameters are converted into Environmental Quality (EQ)** value using value function curve

- It relates the various levels of environmental parameter estimates (X-axis) of functions like DO, % of the total acreage of natural vegetation, community health etc. to the appropriate levels of environmental quality (EQ, Y-axis).
- Objective measurements are transformed into a subjective interpretation of EQ on a scale of 0–1, where 0 stands for poor EQ and 1 stands for excellent EQ.

Step-2: Environmental impact units' (EIU) is obtained by multiplying the EQ values with respective PIU.

A total of 1000 weight units are distributed amongst 78 different parameters as per importance assigned by an expert team. These units are known as 'parameter importance units' or PIUs.



$$\mathrm{EIU}_1 = \sum_{i=1}^{n} (V_i)_1 * W_i$$

where $(V_i)_1$ = value of environmental quality of parameter i with project.
W_i = relative weight of parameter $i(\mathrm{PIU}_i)$
n = total no. of parameters

- **Step-3:** The EIU for each parameter is added to obtain two EIU scores for 'with' and 'without' the proposed projects
- **Step - 4:** The difference between the two scores is a measure of the environmental impact (EI)

$$\mathrm{EI} = \mathrm{EIU}_1 - \mathrm{EIU}_2$$

For EI > 0, the situation 'with' the project is better than 'without' the project, indicating that the project has positive environmental benefits. Conversely, for EI < 0, the situation 'with' the project is worse than 'without' the project, indicating that the project has certain negative impacts. A large negative value of EI indicates the existence of substantial negative impacts.

Drawbacks of scaling-weighting checklists

- As in the case with other methods, **very little emphasis is given to socioeconomic facts.**
- The method is **inflexible** in terms of application to different types of projects.
- Although the method appears to be scientific in its development of **quantitative measures** of environmental quality and the weighting factors, in reality, Impacts that **cannot be readily quantified are likely to be distorted** or masked in such an analysis.
- There is **no effective mechanism for estimating or displaying interactions** between the environmental effects.
- The method is **not strictly mutually exclusive**. While effects are not counted twice, the same effect may appear in different parts of the method; for example, water quality appears in the physical/chemical section and may come into the section on esthetics (if the water is turbid).

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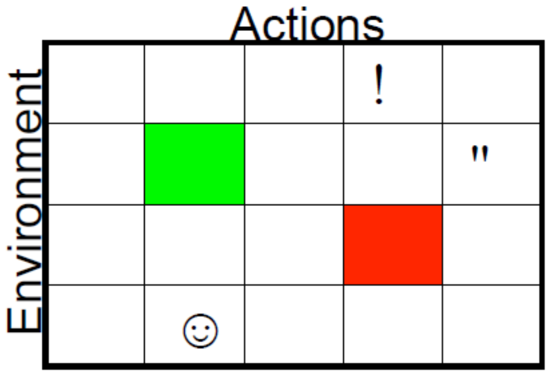
Methodologies of impact assessment

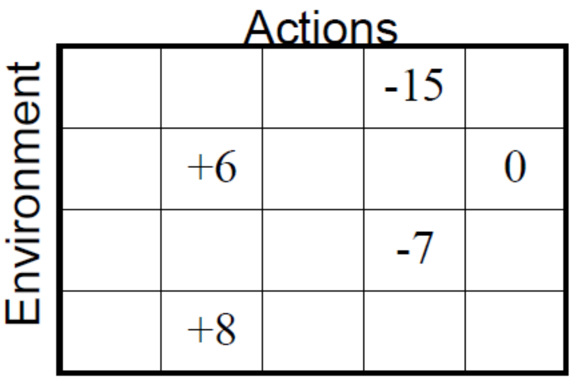
3. Matrices and interaction diagrams

- project are listed along one axis, and environmental components on the other axis.
- (The simplest matrices- Impact occurrence without any magnitude/significance.
- Importance-rated matrices- with Significance and magnitude.
- combined with a weighting scheme to obtain an overall impact score.

Qualitative



Quantitative



Advantages

a. visual relationship of project vs environmental component

b. impact identification in each lifecycle phase of the project

Interaction matrix for Effluent treatment plant

Proposed wastewater collection, treatment, and disposal project

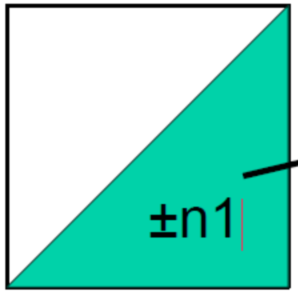
Environmental attributes	Baseline quality	Construction phase: Collection system	Construction phase: Treatment plant	Construction phase: Outfall line	Construction phase: Resultant quality	Operation phase: Collection system	Operation phase: Treatment plant	Operation phase: Outfall line	Operation phase: Resultant quality
Air quality	In compliance with air quality standards	A/M	A/M	a	Dusts, CO	a (odor at lift station sites)	A/m	O	Localized odor
Noise	Typical of urban residential areas	A/M	A/M	a	Increase in local noise	a (pumps)	a	a (pumps)	Small increase in noise
Groundwater	Satisfactory for area	O	O	O	Same as existing	b	b	b	Better quality due to less sheet water discharge
Beach erosion, coral reef, and coastal water quality	Erosion of 0.1–0.3 m/yr. deteriorating coral reef and coastal water quality	NA	NA	a (Water quality)	Turbidity increase	b	SB	NA	Improve quality
Traffic	No problem as it is inside the industry	SA/M	a	a	Increase in congestion	a	a	a	Continued problem due to the movement of vehicles

A, adverse impact;
M, mitigation measure planned for adverse impact;
a, small adverse impact;
O, no anticipated impact;
NA, environmental factor not applicable;
SA, significant adverse impact;
b, small beneficial impact;
B, beneficial impact;
SB, significant beneficial impact.

Leopold Matrix

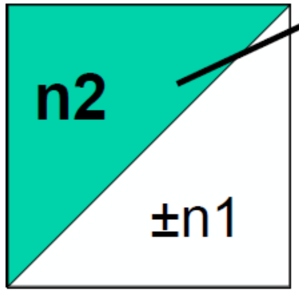
Each impact is described by two factors:

1. *significance*: indicates the theoretical importance of the impact
2. magnitude (size or importance): how much case the impact is present in this varies



Varies between -10 and 10

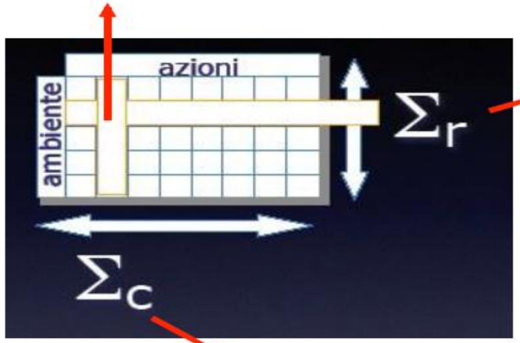
Importance



varies from 1 to 10

(Magnitude)

10 → greatest magnitude of impact
1 → least (no zeros should be assigned)



Total impact on the environmental component

The impact of a single action

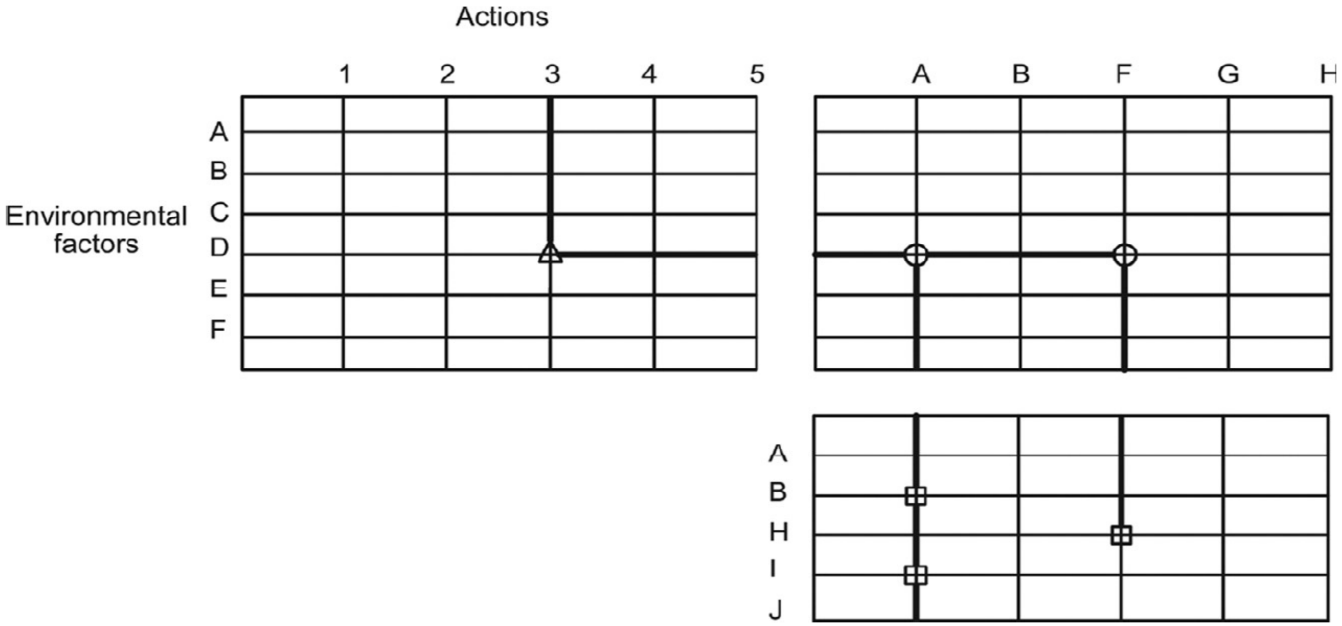
- Leopold matrix is a comprehensive matrix – with 88 environmental characteristics along the top axis and 100 project actions in the left-hand column.
- One of the attractive features of the Leopold matrix is that it can be **expanded or contracted**—that is, the *number of actions and environmental factors* can be increased or decreased
- The **primary advantages** of using the Leopold matrix are that it is very useful **as a gross screening tool for impact identification purposes** and it can provide a valuable means for impact communication by providing a visual display of the impacted items and of the major actions causing impacts.
- Summation of the number of rows and columns designated as having interactions can offer insight into impact assessment.
- For example, assume that a matrix incorporates the impacts of 8 actions on 20 environmental factors. Further, assume that the average action would cause 10 factors to be impacted and the average number of impacts per factor is 6. The impacts could be grouped and discussed in items of those actions exhibiting a greater-than-average, near-average, and fewer-than- average number of impacts.

Example of Simple Leopold Matrices

Priority Value	Proposed Action / Resources	Immigration of Labour	Dam Construction	Transmission Line	Reservoir Filling	Heavy Metal Discharge	Growth of Aquatic Weeds	Relocation of Inhabitants	Total: Leopold Method	Total: Lohani & Thanh
10	Health	5/8	4/6		5/8	4/7	6/6		24/35	1,680
8	Spawning of Fish		3/4		3/6	3/7	5/5		14/22	608
7	Archaeological Artifacts	4/6			8/8				12/14	616
6	Tourism			7/6	7/6				14/12	504
5	Downstream Water Pollution		7/7		7/8	2/4			16/19	565
4	Social and Economic Aspects							8/7	8/7	224
3	Forestry		4/2						4/2	24
9	Fishery		2/5			2/5			4/10	180
1	Navigation				6/5				6/5	30
2	Aquatic Plants				6/6				6/6	30
	Leopold Method	9/14	20/24	7/6	42/47	11/23	11/11	8/7		
	Lohani & Thanh	64	103	42	286	67	61	56		

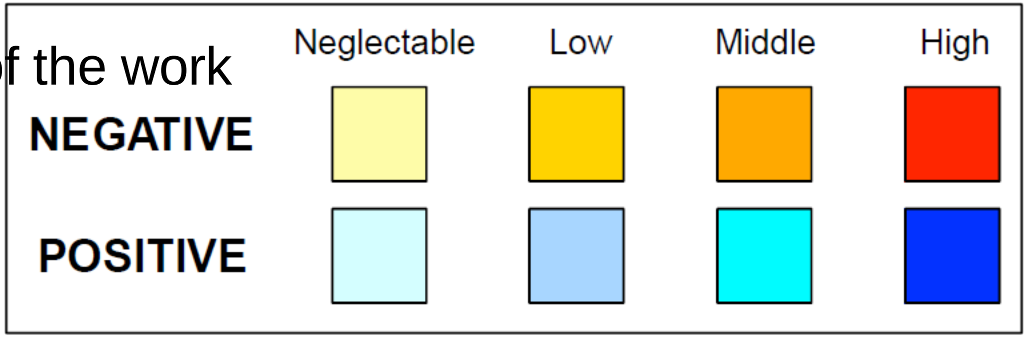
Stepped Matrices

- **A stepped matrix, also called as cross impact matrix**, can be used to **address secondary and tertiary impacts of initiating actions.** A stepped matrix is one in which environmental factors are displayed against other environmental factors. The consequences and of initial changes in some factors on other factors can be displayed.
- In the figure, action 3 impacts factor D; changes in factor then cause changes in factors A and F. Finally, changes in factor A cause changes in factors B and I, while changes in factor F cause changes in factor H.



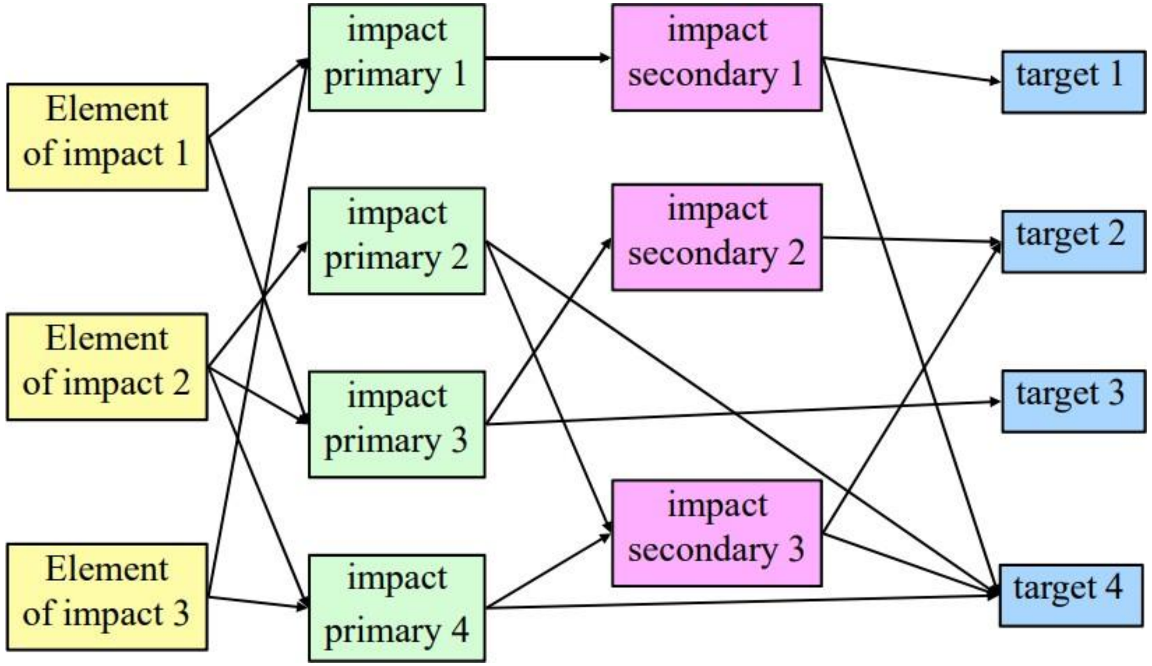
Chromatic matrices

- A series of 4 matrices: analyze the impacts of different "aspects" of the project.
- **Matrix A: Cause-effect interrelation**s with respect to potential impacts
  - ❖ Correlates impact elements and causal factors that generate them
  - ❖ Useful in identifying the weak points of a project
- **Matrix B: Interrelations impact-environmental components**
  - ❖ Correlates the elements of the impact of the work with environmental categories
  - ❖ Allows to identify the impacts of the work on the surroundings
- **Matrix C: Effect on potential impacts of the foreseen containment criteria**
  - ❖ Correlates the impact of the work with the containment measures (negative impacts of B)
- **Matrix D: Assessment of residual impacts (Matrix D)**
  - ❖ Expresses a judgment on the environmental compatibility of the work



Networks

- **Networks** method is mainly based on the integration of impact causes, consequences, and interrelationships between them.
- Networks illustrate the **cause-effect relationship** of project activities and environmental characteristics.
- Useful in identifying and depicting **secondary impacts (indirect, cumulative, etc.).**



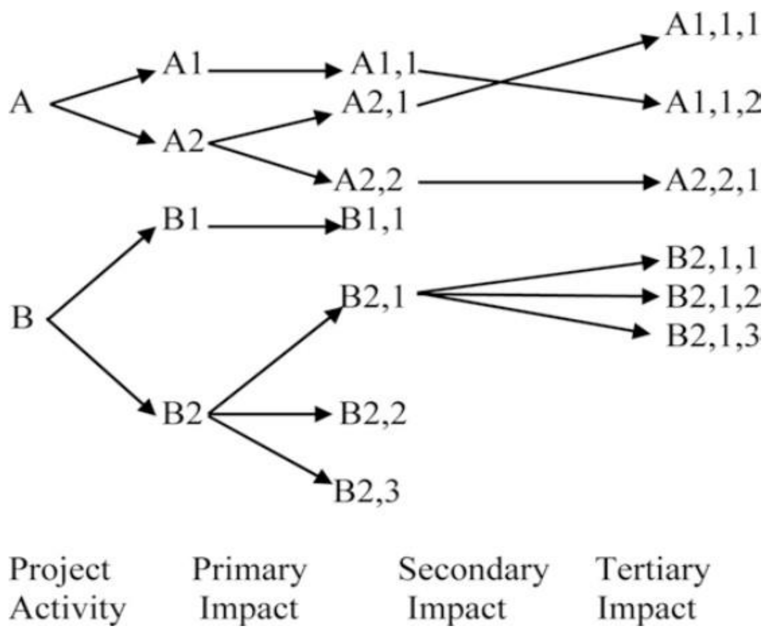
There are four steps in this method. They are:

- **Step 1:** Creation of impact tree
- **Step 2**: Branch resolution
- **Step 3**: Assignment of probability (P_i), magnitude (M_x, +ve or –ve) and importance (I_x) for each activity or impact of these chains.
- **Step 4:** Sum up for total environmental impact score (EIS), where

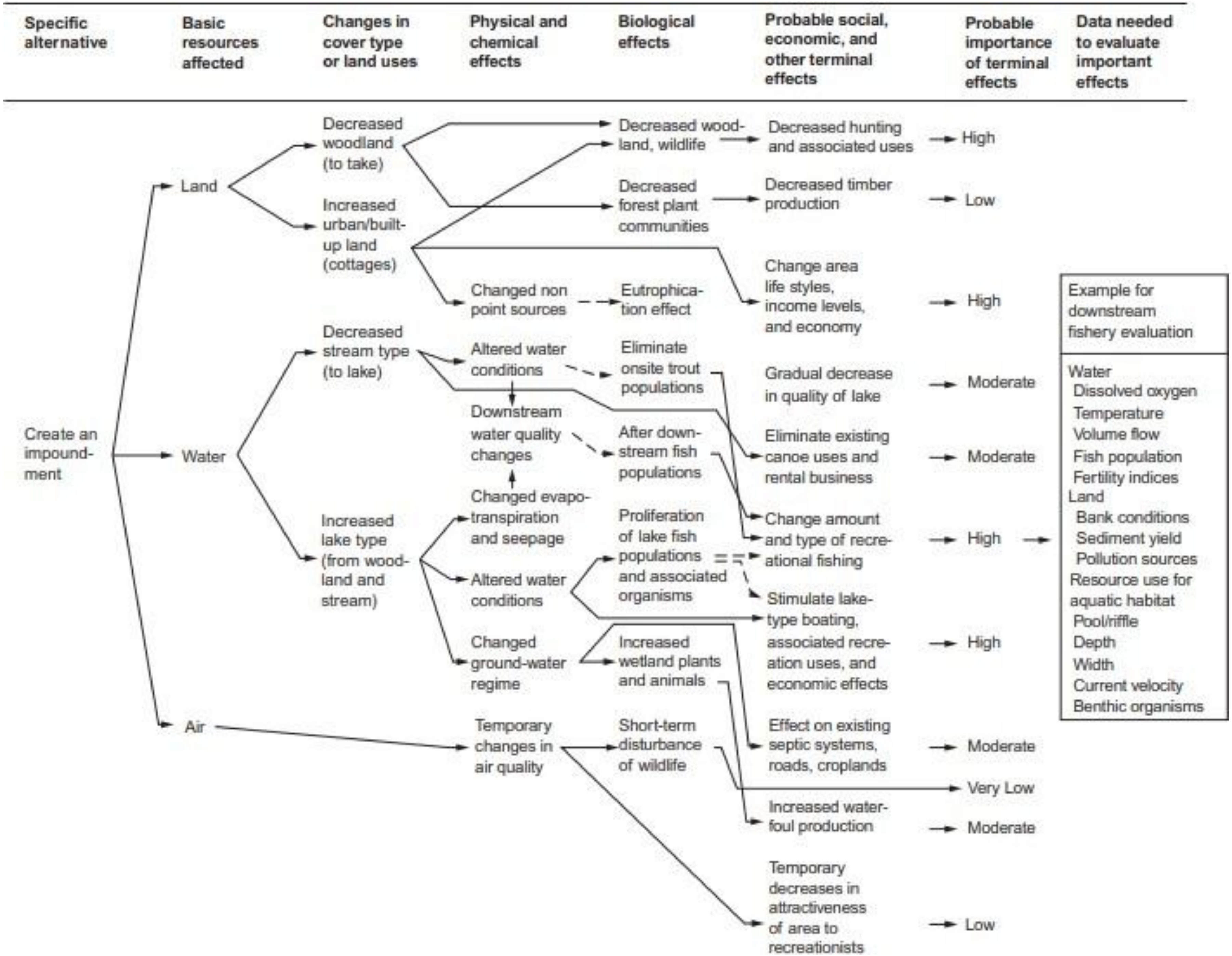
$$EIS = \sum_{i=1}^{n} P_i \sum_{x=1}^{k} M_x I_x$$

where k = no. of events of branch I

n = no. of branches



BRANCH 1	A1	→	A1, 1	→	A1, 1, 1
BRANCH 2	A1	→	A1, 1	→	A1, 1, 2
BRANCH 3	A2	→	A2, 1		
BRANCH 4	A2	→	A2, 2	→	A2, 2, 1
BRANCH 5	B1	→	B1, 1		
BRANCH 6	B2	→	B2, 1	→	B2, 1, 1
BRANCH 7	B2	→	B2, 1	→	B2, 1, 2
BRANCH 8	B2	→	B2, 1	→	B2, 1, 3
BRANCH 9	B2	→	B2, 2		
BRANCH 10	B2	→	B2, 3		



Specific alternative
Basic resources affected
Changes in cover type or land uses
Physical and chemical effects
Biological effects
Probable social, economic, and other terminal effects
Probable importance of terminal effects
Data needed to evaluate important effects
Create an impound-ment
Land
Water
Air
Decreased woodland (to take)
Increased urban/built-up land (cottages)
Decreased stream type (to lake)
Increased lake type (from wood-land and stream)
Changed non point sources
Altered water conditions
Downstream water quality changes
Changed evapo-transpiration and seepage
Altered water conditions
Changed ground-water regime
Temporary changes in air quality
Decreased wood-land, wildlife
Decreased forest plant communities
Eutrophica-tion effect
Eliminate onsite trout populations
After down-stream fish populations
Proliferation of lake fish populations and associated organisms
Increased wetland plants and animals
Short-term disturbance of wildlife
Decreased hunting and associated uses
Decreased timber production
Change area life styles, income levels, and economy
Gradual decrease in quality of lake
Eliminate existing canoe uses and rental business
Change amount and type of recre-ational fishing
Stimulate lake-type boating, associated recre-ation uses, and economic effects
Effect on existing septic systems, roads, croplands
Increased water-foul production
Temporary decreases in attractiveness of area to recreationists
High
Low
High
Moderate
Moderate
High
High
Moderate
Very Low
Moderate
Low
Example for downstream fishery evaluation
Water
Dissolved oxygen
Temperature
Volume flow
Fish population
Fertility indices
Land
Bank conditions
Sediment yield
Pollution sources
Resource use for aquatic habitat
Pool/riffle
Depth
Width
Current velocity
Benthic organisms

4. Overlays

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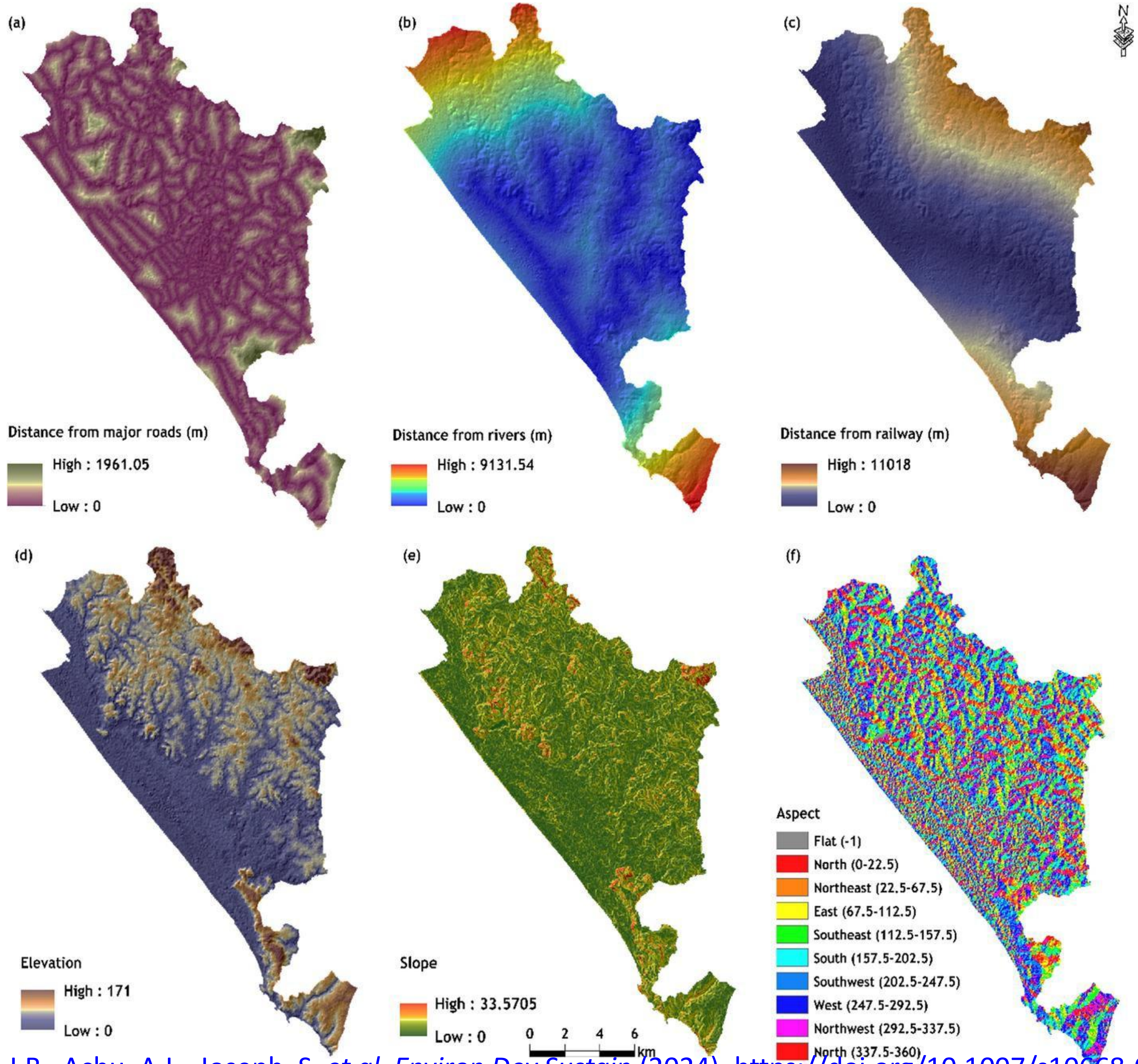
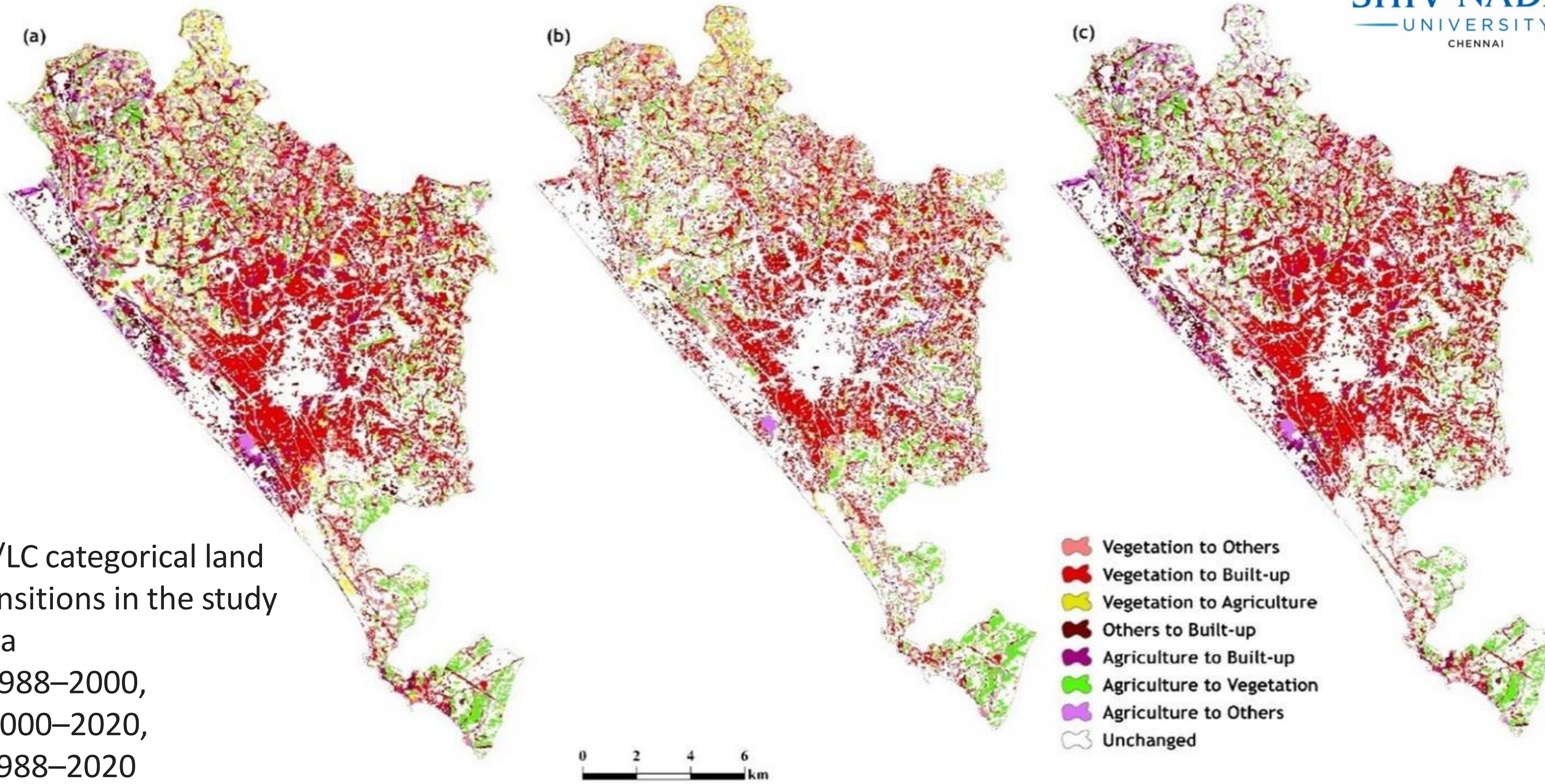
- Overlays can be used **to map impacts spatially and display them pictorially**.
- This approach is **useful for comparing site, planning alternatives** and for routing linear developments to avoid environmentally sensitive areas and landscape and habitat zoning at the regional level.
- **GIS** ***stores, retrieves, manipulates, and displays environmental data in a spatial format*****.** A set of maps or overlays of given area provide different types of information and scales of resolution.
- **The main drawbacks are**
  - **Lack of appropriate data and the expense** of creating a usable system.
  - **Lack of precision in differentiating the likelihood and magnitude of impacts** and relating them to project actions.
  - **Objectivity is low**; except with respect to the spatial positioning of effects and impacts (e.g., flooded land), interactions are not displayed.
  - **Extreme impacts** with small probabilities of occurrence are not considered.
  - Each alternative would require a separate set of overlays to be produced, and **less than gross differences between alternatives** may be difficult for the decision-maker to detect.



Jibitha, J.B., Achu, A.L., Joseph, S. *et al. Environ Dev Sustain* (2024). https://doi.org/10.1007/s10668-024-04494-9

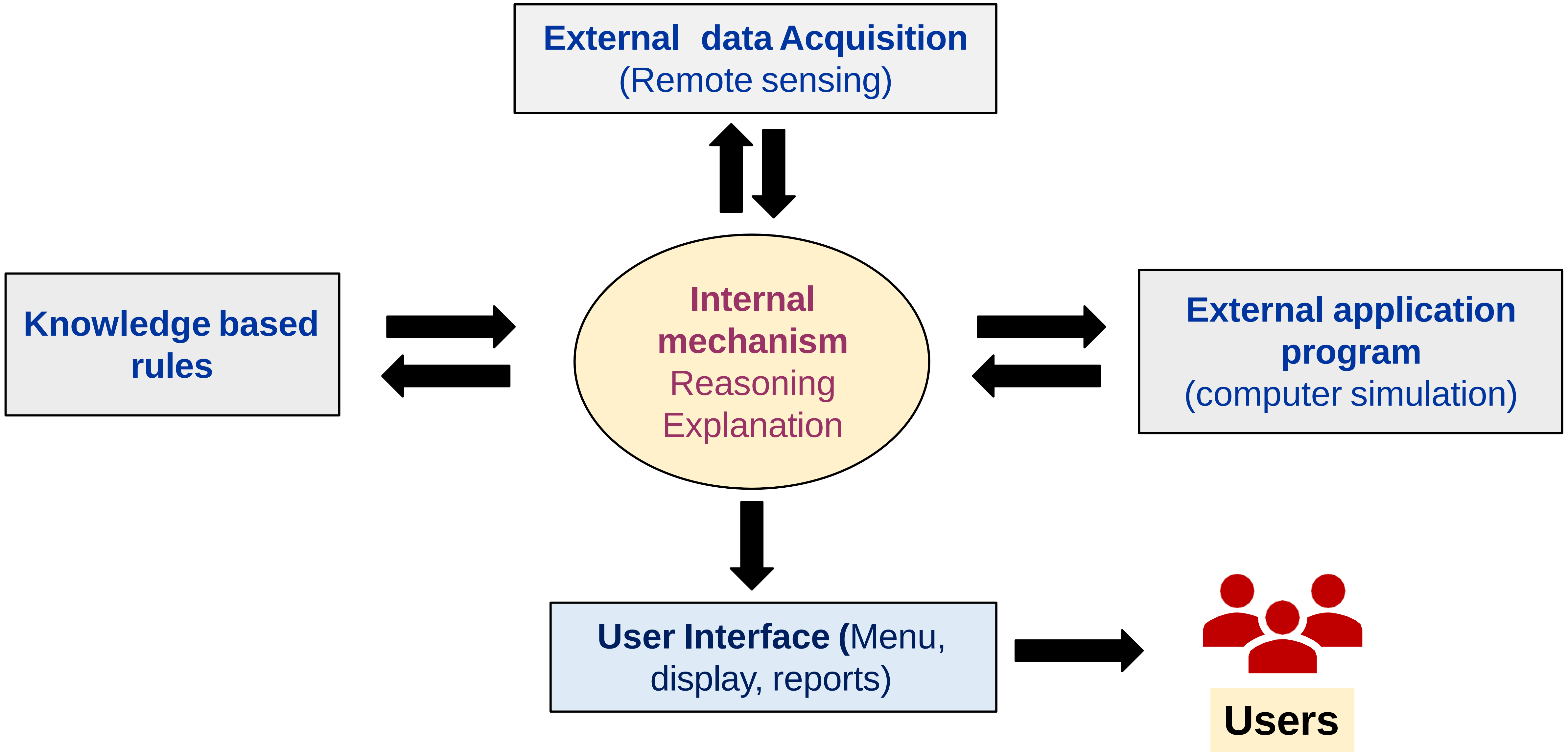


LU/LC categorical land transitions in the study area
a 1988–2000,
b 2000–2020,
c 1988–2020

Jibitha, J.B., Achu, A.L., Joseph, S. *et al. Environ Dev Sustain* (2024). https://doi.org/10.1007/s10668-024-04494-9

5. Expert System

- Expert or knowledge-based systems are used to assist diagnosis, problem solving, and decision-making.
- The user has to **answer a series of questions** that have been systematically developed to identify impacts and determine their “mitigability” and significance.
- Software available in market: IMPACT; ORBI; ESSA; SCREENER; CALYX
- As such, they are **limited in their current use** and application, especially by many developing countries.
- Computer programs can be written **to perform the task of aggregating the predicted impacts**. This is done by coding the geographic area in terms of small zones, assigning a numerical weighting to each zone to represent the impact for each environmental effect, and summing all the numbers allocated to each particular zone.
- Such systems are **efficient at performing multiple map overlays**, allowing a number of different scenarios to be investigated quickly, by varying the parameters for successive analysis runs.


External data Acquisition
(Remote sensing)
Knowledge based rules
Internal mechanism
Reasoning
Explanation
External application program
(computer simulation)
User Interface (Menu, display, reports)
Users

6. Cost – Benefit Analysis (CBA)

- Cost- benefit analysis is a **systematic process for identifying, valuing, and comparing costs and benefits of a project.**
- It is used to determine options that provide the **best approach to achieve benefits while preserving savings.**
- **CBA is a standard tool for evaluating the economic analysis** or trade of analysis, investment of development projects.
- **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

- 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.

Example of CBA– Highway project

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 landscaping.
- Construction of noise barriers.

Highway Cost Components

- **Agency Cost**: This includes the expenses incurred by the government or private agency for construction and maintenance of highway roads.
- **Construction cost** : surveying, planning and designing, Installation of electrical poles, traffic control equipment, Administrative cost involved in supervising the traffic,
- **Maintenance cost** includes periodic repair of the damaged roads.
- **User Cost:** Registration charges ,insurance expenses, road tax and road permit tax etc

Benefit components of highway road: efficient and safe transportation, saving in travel time, improvement in health, education, agriculture, industry trade and various other fields.

7. Qualitative modeling

The qualitative models to understand the effects of project.

8. Quantitative modelling

- These are mathematical models used specifically for predicting the expected changes in environmental media or resources over a period.
- Extensive data input is often required
- Eg: LCA, Risk analysis

9. Analogs

- Prior experiences of similar projects in other regions/countries
- Using the already monitored data and estimate probable impacts

10. Expert opinions

- seeking opinions of the recognized experts in relevant fields on the impacts of the proposed project, Opinions may be sought from individuals or by holding meetings or workshops with experts for developing alternatives.

11. Mass balances

- analysis of existing situations and conditions with those expected to result from the proposed project activities.

Eg: Case study: Windfarm near the mountainous area, an ecologically sensitive area

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Table 1. Matrix of <u>magnitude of the impact</u> of factors on environmental components for WF, "Kladovo"

		PROJECT ACTIVITIES										
	Envisaged impact factors	Placement of wind turbines	Foundation of columns	The use of building materials	Substation construction	Transmission line construction	Construction of internal roads	Operation of construction equipment	Waste material Treatment	Project exploitation	Sum of IF values by types and bio. comp..	Average values
PHYSICAL COMPONENTS	Water	0	0	0	0	0	0	0	0	0	0	0.00
	Microclimate	0	0	0	0	0	0	0	0	0	0	0.00
	Land	1	2	1	1	1	1	2	2	1	12	1.33
	Erosion	0	0	0	0	0	0	0	0	0	0	0.00
	Air	0	0	0	1	0	2	3	1	0	7	0.77
	Noise	1	1	1	2	1	2	3	0	2	14	1.55
BIOLOGICAL COMPONENTS	Diversity of flora	0	1	0	0	1	0	1	1	0	4	0.44
	Diversity of fauna	2	1	1	1	1	0	2	2	2	12	1.33
	Ornithofauna	2	1	1	1	1	0	2	2	2	12	1.33
	Chiropteran fauna	2	1	1	1	1	0	2	2	2	12	1.33
	Barriers/corridors	2	1	1	1	1	0	1	1	2	10	1.11
SOCIO-CULTURAL COMPONENTS	Landscape	2	2	1	2	1	1	1	3	2	15	1.66
	Land use	1	2	1	1	1	1	1	2	1	11	1.22
	Economy	0	0	0	0	0	0	0	0	0	0	0.00
	Cultural heritage	0	2	0	0	0	0	0	0	0	2	0.22
	Accidents	2	0	0	1	0	0	0	2	2	7	0.77
Cumulative values of IF according to environmental factors		15	14	8	12	9	8	18	18	16		
Average		0.93	0.87	0.50	0.75	0.56	0.50	1.12	1.12	1.00	IF = 0.82	

0 – no observable effect
1 – low effect
2 – tolerable effect
3 – medium high effect
4 – high effect
5 – very high effect (devastation)

Table 2. Matrix of significance of the impact of factors on environmental components for WF, "Kladovo"

	Envisaged impact factors	PROJECT ACTIVITIES: Placement of wind turbines	Foundation of columns	The use of building materials	Substation construction	Transmission line construction	Construction of internal roads	Operation of construction equipment	Waste material Treatment	Project exploitation
PHYSICAL COMPONENTS	Water									
	Microclimate									
	Land	L	L	L	L	O	L	L	L	L
	Erosion									
	Air				L		L	L	L	
	Noise	L	L	L	L	L	L	L		L
BIOLOGICAL COMPONENTS	Diversity of flora		L			L		L	L	
	Diversity of fauna	L	L	L	L	L		L	L	M
	Ornithofauna	L	L	L	L	L		L	L	M
	Chiropteran fauna	L	L	L	L	L		L	L	M
	Barriers/corridors	L	L	L	L	L		L	L	L
SOCIO-CULTURAL COMPONENTS	Landscape	L	L	L	L	L	L	L	L	L
	Land use	L	L	L	L	L	L	L	L	L
	Economy									
	Cultural heritage		L							
	Accidents	L			L				L	L

L – limited impact on location
O – impact of importance for municipality
R – impact of regional character
N – impact of national character
M – impact of cross-border character.

3. Matrix of probability of the impact of factors on environmental components for WF, “Kladovo”

		PROJECT ACTIVITIES								
	Envisaged impact factors	Placement of wind turbines	Foundation of columns	The use of building materials	Substation construction	Transmission line construction	Construction of internal roads	Operation of construction equipment	Waste material Treatment	Project exploitation
PHYSICAL COMPONENTS	Water									
	Microclimate									
	Land	M	I	M	I	V	V	M	M	M
	Erosion									
	Air				V		M	I	M	
	Noise	V	V	M	V	V	V	I		V
BIOLOGICAL COMPONENTS	Diversity of flora		M			M		M	M	
	Diversity of fauna	M	M	M	M	M		M	M	M
	Ornithofauna	M	M	M	M	M		M	M	M
	Chiropteran fauna	M	M	M	M	M		M	M	M
	Barriers/corridors	M	M	M	M	M		M	M	M
SOCIO-CULTURAL COMPONENTS	Landscape	I	M	M	I	I	V	V	M	I
	Land use	I	I	V	I	I	I	I	M	I
	Economy									
	Cultural heritage		M							
	Accidents	M			M				M	M

M – impact is possible (probability of less than 50%);V – impact is probable (probability of over 50%); I – impact is certain (100% probability).

ble 4. Matrix of <u>duration of the impact</u> of factors on environmental components for WF, “Kladovo”

		PROJECT ACTIVITIES								
	Envisaged impact factors	Placement of wind turbines	Foundation of columns	The use of building materials	Substation construction	Transmission line construction	Construction of internal roads	Operation of construction equipment	Waste material Treatment	Project exploitation
PHYSICAL COMPONENTS	Water									
	Microclimate									
	Land	P	D	P	D	P	P	P	P	D
	Erosion									
	Air				P		P	P	P	
	Noise	P	P	P	P	P	P	P		D
BIOLOGICAL COMPONENTS	Diversity of flora		D			P		P	P	
	Diversity of fauna	D	P	P	D	M		P	P	D
	Ornithofauna	D	P	P	D	M		P	P	D
	Chiropteran fauna	D	P	P	D	M		P	P	D
	Barriers/corridors	D	P	P	D	M		P	P	D
SOCIO-CULTURAL COMPONENTS	Landscape	D	D	P	D	D	D	P	P	D
	Land use	D	D	P	D	P	D	P	P	D
	Economy									
	Cultural heritage		D							
	Accidents	P			P				P	P

P - (occasional/temporary) D (long-term/permanent)

Phase 2: Impact Assessment

Steps :

3. Baseline conditions analysis
4. Impact identification
5. **Impact prediction or estimation**
6. Impact assessment for determining whether the impacts are significant
7. Mitigation plan/Environmental management plan

Impact Prediction

The objective of prediction is to **estimate the magnitude, extent, and duration of the impact in comparison with the situation without that project/action.** An environmental **impact prediction should, at minimum**, perform the following:

- Determine the initial reference or baseline state (i.e. conditions/levels prior to project);
- Forecast the future state/conditions with and without the project; and,
- Compare with environmental standards and guidelines where appropriate.

- Impact Magnitude
- Impact Duration
- Impact Extent

Impact Prediction Methods

Impact Prediction Methods:

- Mathematical Models
- Statistical Models
- Geographic Models
- Task Specific Computer Models
- Laboratory Experimental Methods
- Biological Methods
- Socio-Economic Method
- Expert Judgment
- Public Perception Model

Mathematical Models

- Cause-effect relationships, simple input-output models or complex dynamic type
- Different types:
  - ❖ Empirical or internally descriptive
  - ❖ Generalized or site-specific
  - ❖ Stationary or dynamic
  - ❖ Homogenous or non-homogenous
  - ❖ Deterministic
  - ❖ Stochastic/ Probabilistic

2. Statistical Models

- If methods are used to test hypothesis, statistical methods are useful.
- Cause and Effect relationships can be established by correlation and regression analysis.
- Flood frequencies are usually predicted by such methods.

3. Geographical Models

- Are used to predict impacts over the space and time
- Satellite images, physical maps or aerial photos and GIS are used

4. Laboratory Experiments

- The field study provides information on the availability, nature and conditions of the environmental resources, possible impacts on such resources can also be predicted, but the level of impacts are difficult to predict.
- Laboratory experiments provide information on possible biological magnification, and concentration of agro-chemicals on species of prime importance

6. Biological Methods

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- Habitat indices or biological diversity indices
- Population, nutrients, chemical cycling, energy system diagrams
- Biological impact (Habitat Evaluation System (HES), Wetland Evaluation Technique (WET),
- Ecological and health-based risk assessment

7. Socio-Economic Methods

Based on the following data trend (growth or decline)

- Birth
- Death
- Migration

Population change = (Birth rate + Immigration) – (Death rate + emigration)

Phase 2: Impact Assessment

Steps :

3. Baseline conditions analysis
4. Impact identification
5. Impact prediction or estimation
6. **Impact assessment for determining whether the impacts are significant**
7. Mitigation plan/Environmental management plan

Impact Assessment depends on:

- regulatory framework
- environmental baseline information
- type and nature of the predicted impacts
- level of confidence in predictions
- details of project-related activities under implementation and those approved
- carrying capacity of the region

Impact Evaluation

- Evaluating the significance of residual impacts after predicting the nature and magnitude of impacts based **on before-versus-after-project comparisons** and identifying measures to mitigate these effects in a systematic way.

Step 1: Are the environmental effects adverse?

Criteria for determining if effects are **"adverse"** include the following:

- Effects on biota health, Effects on rare or endangered species
- Reductions in species diversity, Habitat loss
- Transformation of natural landscapes
- Effects on human health
- Effects on current use of lands and resources for traditional purposes
- Foreclosure of future resource use or production

Step 2: Are the adverse environmental effects significant?

Criteria for determining "**significance**" are to judge that the impacts:

- Are extensive over space or time.
- Are intensive in concentration or proportion to assimilative capacity.
- Exceed environmental standards or thresholds.
- Do not comply with environmental policies, land use plans, and sustainability strategy
- Adversely and seriously affect ecologically sensitive areas.

There are a number of ways to answer this question:

1. Scoping results may be used as a guide;
2. Relevant national laws, regulations or policies.
3. Expert judgment (scientists); and
4. Reconvening the scoping sessions

Significance of Impacts to make decision

- **Environmental Evaluation System (EES)**
- **Nominal Group Process Technique (NGP)**

NGP is an interactive group technique developed in 1968.

NGPs divide respondents into small groups and ask each which option they prefer in a series. From this collective judgment, it’s possible to work out which option is most preferred before individual opinions are known.

- **Delphi Technique (DM)**

Subjective method that involves the participation of stakeholders. This is a good method to bring consensus among stakeholders regarding aspects of evaluation. The Delphi technique comprises **two or more rounds of structured questionnaires, each followed by an aggregation of responses and anonymous feedback to the participants (usually experts).**

E.g., Is the decline in the fishery of equal importance to the noise level increase, or is it same important?

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Step 3: Are the significant adverse environmental effects likely?

- Criteria for determining **"Likelihood"** include the following:
- Probability of occurrence
- Scientific uncertainty