URP 4141: Environmental Planning and Management

EIA Methods and Techniques (Impact Identification)

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EIA

- EIA is a systematic process to identify, predict and evaluate the environmental effects of proposed actions in order to aid decision making regarding the significant environmental consequences of projects, developments and programmes.

Origin of EIA

- The USA decided to respond to environmental issues and established a National Environmental Policy Act in 1970 to consider its goal in terms of environmental protection. The USA became the first country to enact legislation on EIA. This was the first time that EIA became the official tool to be used to protect the environment. The United Nations Conference on the Environment in Stockholm in 1972 and subsequent conventions formalized EIA. At present, all developed countries have environmental laws whereas most of the developing countries are still adopting it (Lee, 1995). Multilateral and bilateral lenders included EIA requirements in their project eligibility criteria (OECD, 1996).

EIA Methodologies

EIA Methodologies developed to **identify, predict** and **value** changes of an action.

The development of methodologies to assess impacts depend on:

- The relationship between territorial elements (or Characteristics) and the actions
- The specific **measurements** and the necessary information to estimate the impacts.
- The mitigation measures, compensation and follow-up.

Choice of EIA method depends on

- To ensure compliance with regulations.
- To provide a comprehensive coverage of a full range of impacts, including social, economic and physical.
- To distinguish between positive and negative, large and small, long term and short term, reversible and irreversible impacts.
- To identify secondary, indirect and cumulative impacts as well as direct impacts
- To distinguish between significant and insignificant impacts

Choice of EIA method depends on

- **To allow comparison of alternative development proposal.**
- **To consider impacts within the constraints of an area’s carrying capacity**
- **To incorporate qualitative as well as quantitative information**
- **To be easy and economical to use.**
- **To be unbiased and to give consistent result.**
- **To be of use in summarizing and presenting impacts in the EIS.**

Objectives of Methodologies

1. Understand the nature and location of the project and possible alternatives
2. Identify factors of analysis and assessment objectives
3. Preliminary identification of impacts and scoping
4. Baseline studies and evolution in the absence of projects
5. Prediction and assessment of impacts and alternatives comparison
6. Mitigation
7. Monitoring and Impacts management.

Methods of Impact Identification

There are five main classes of quantitative impact identification techniques exist:

- Checklist
- Matrices
- Networks
- Map Overlay
- Ad hoc method

Checklist

Checklists are comprehensive lists of environmental effects and impact indicators designed to stimulate the analyst to think broadly about possible consequences of contemplated actions.

Checklist: Types

There are four types of cheklist:

1. Simple
2. Descriptivee
3. Questionnaire
4. Threshold concern
5. Scaling Checklist

Simple Checklist

A list of environmental parameters with no guidelines on how they are to be measured and interpreted.

Proposed Activities	
clearing	X
cut/fill	X
dredging	X
blasting	-
Environmental components:	
Physical	
air quality	X
water quality	X
water flow	X
Biological	
spawning habitat	X
rearing habitat	X
Socio-economic	
fishing	X

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	ST	denotes Short Term	LT	denotes Long Term
R	denotes Reversible	IR	denotes Irreversible	L	denotes Local
W	denotes Wide	SI	denotes Significant	N	denotes Normal

Descriptive Checklist

Includes an identification of environmental parameters and guidelines on how to measure data on particular parameters.

Table 4.3 Part of a descriptive checklist.

Data required	Information sources, predictive techniques
Nuisance	
Change in occurrence of odour, smoke, haze, etc., and number of people affected.	Expected industrial processes and traffic volumes, citizen surveys.
Water quality	
For each body of water, changes in water uses, and number of people affected.	Current water quality, current and expected effluent.
Noise	
Change in noise levels, frequency of occurrence, and number of people bothered.	Current noise levels, changes in traffic or other noise sources, changes in noise mitigation measures, noise propagation model, citizen surveys.

Questionnaire Checklist

- Are based on a set of questions to be answered. Some of the questions may concern indirect impacts and possible mitigation measures. They may also provide a scale for classifying estimated impacts from highly adverse to highly beneficial.

Questionnaire Checklist

Disease vectors

a) Are there known disease problems in the project area transmitted through vector species such as mosquitoes, flies, snails, etc. ?	yes	no	not known
b) Are these vector species associated with:			
– aquatic habitats?	yes	no	not known
– forest habitats?	yes	no	not known
– agricultural habitats?	yes	no	not known
. . .			
f) Will the project provide opportunities for vector control through improved standards of living?	yes	no	not known

Estimated impact on disease vectors?

high adverse ◄------------- insignificant -------------► high benefit

Questionnaire Checklist

Aspects of EIA	Checklist Questions Will the project:	Yes	No	Additional Data needs
Sources of Impacts	1. Require the acquisition or conversion of significant areas of land for reservoir/treatment works etc. (e.g. > 50 ha rural, > 5 ha urban)?	☐	☐	☐
	2. Result in significant quantities of eroded material, effluent or solid wastes?	☐	☐	☐
	3. Require significant accommodation or service amenities to support the workforce during construction (eg > 100 manual workers)?	☐	☐	☐
Receptors of Impacts	4. Flood or otherwise affect areas which support conservation worthy terrestrial or aquatic ecosystems, flora or fauna (eg protected areas, wilderness areas, forest reserves, critical habitats, endangered species); or that contain sites of historical or cultural importance?	☐	☐	☐
	5. Flood or otherwise affect areas which will affect the livelihoods of local people (eg require population resettlement; affect local industry, agriculture, livestock or fish stocks; reduce the availability of natural resource goods and services)?	☐	☐	☐
	6. Involve siting sanitation treatment facilities close to human settlements (particularly where locations are susceptible to flooding)?	☐	☐	☐
	7. Affect sources of water extraction?	☐	☐	☐
Environmental Impacts	8. Cause a noticeable permanent or seasonal reduction in the volume of ground or surface water supply?	☐	☐	☐
	9. Present a significant pollution risk through liquid or solid wastes to humans, sources of water extraction, conservation worthy aquatic ecosystems and species, or commercial fish stocks?	☐	☐	☐
	10. Change the local hydrology of surface water-bodies (eg streams, rivers, lakes) such that conservation-worthy or commercially significant fish stocks are affected?	☐	☐	☐
	11. Increase the risk of diseases in areas of high population density (eg onchocerciasis, filariasis, malaria, hepatitis, gastrointestinal diseases)?	☐	☐	☐
	12. Induce secondary development, eg along access roads, or in the form of entrepreneurial services for construction and operational activities?	☐	☐	☐
Mitigation Measures	13. Be likely to require mitigation measures that may result in the project being financially or socially unacceptable?	☐	☐	☐
Comments				
	I recommend that the programme be assigned to Category Signature: Delegation.......................................Desk.................................	☐		

Threshold Checklist

Consist of a list of environmnetal components and , for each component, a threshold at which those assessing a proposal should become concerned with an impact. The implication of alternative proposals can be seen by examining the number of times that an alternative exceeds the threshold of concern.

Threshold Checklist

Environmental component	Criterion	TOC	Alt X		Alt Y		Alt Z	
			Imp	Imp > TOC?	Imp	Imp > TOC?	Imp	Imp > TOC?
Air quality	emission standards	1	2C	yes	1C	no	2C	yes
Economics	benefit: cost ratio	1:1	3:1	no	4:1	no	2:1	no
Endangered species	no. pairs of spotted owls	35	50D	no	35D	no	20D	yes
Water quality	water quality standards	1	1C	no	2C	yes	2C	yes
Recreation	no. camping sites	5000	2800C	yes	5000C	no	3500C	yes

Scaling Checklist

- similar to a descriptive checklist, but with additional information on subjective scaling of the parameters.

Advantages of Checklist

There are several major reasons for using checklists:

- They are useful in summarizing information to make it accessible to specialists from other fields, or to decision makers who may have a limited amount of technical knowledge;
- scaling checklists provide a preliminary level of analysis; and
- weighting is a mechanism for incorporating information about ecosystem functions.

Disadvantages of Checklist

Westman (1985) listed some of the problems with checklists when used as an impact assessment method:

1. They are too general or incomplete;

2. They do not illustrate interactions between effects;

3. The number of categories to be reviewed can be immense, thus distracting from the most significant impacts; and

4. The identification of effects is qualitative and subjective.

Matrix

- Matrix are two-dimensional tables which facilitate the identification of impacts arising from the interaction between project activities and specific environmental components.
- They are essentially expansions of checklists that acknowldge the fact that different component of development project (e.g. Construction, operation,decommissioning, buildings, access road)
- The entries in the cell of the matrix can be either qualitative or quantitative estimates of impact.

Types of Matrix

- Simple Matrix
- Time dependent matrix
- Magnitude Matrix
- Quantified Matrix (Leopold Matrix)
- Weighted Matrix

Simple Matrix

Environmental component	Project action				
	Construction		Operation		
	Utilities	Residential and commercial buildings	Residential buildings	Commercial buildings	Parks and open spaces
Soil and geology	X	X			
Flora	X	X			X
Fauna	X	X			X
Air quality		—		X	
Water quality	X	X	X		
Population density			X	X	
Employment		X		X	
Traffic	X	X	X	X	
Housing			X		
Community structure		X	X		X

Time Dependent Matrices

- Includes a number sequence to represent the time scale (e.g one figure per year) of the impacts

Environmental component	Project action: Construction (3 years): Utilities	Project action: Construction (3 years): Residential and commercial buildings	Project action: Operation (25 years, evens out after 4 years): Residential buildings	Project action: Operation (25 years, evens out after 4 years): Commercial buildings	Project action: Operation (25 years, evens out after 4 years): Parks and open spaces
Soil and geology	211	321	0000	0000	0001
Flora	221	422	1223	1111	1123
Fauna	221	311	1100	.1100	1122
Air quality	000	000	0123	0034	0011
Water quality	010	022	1223	0111	0000
Population density	011	112	2344	0222	0011
Employment	120	342	1111	1334	1111
Traffic	220	332	2333	2333	1111
Housing	010	121	2344	0000	0000
Community structure	010	232	2344	1111	1233

Magnitude Matrices

Go beyond the mere identification of impacts according to their magnitude, importance and or time frame (e.g short, medium or long term)

Environmental component	Project action: Construction		Project action: Operation		
	Utilities	Residential and commercial buildings	Residential buildings	Commercial buildings	Parks and open spaces
Soil and geology	•	•			
Flora	•	●			◯
Fauna	•	•			○
Air quality				•	
Water quality	◯	•	•		
Population density			○	○	
Employment		◯		◯	
Traffic	•	•	•	●	
Housing			◯		
Community structure		•	◯		○

• = small negative impact ○ = small positive impact
● = large negative impact ◯ = large positive impact

Quantified Matrix

- The best known type of quantified matrix is the Leopold Matrix, which was developed for the US geological survey by Leopold et al. This matrix is based on a horizontal list of 100 project action and a vertical list of 88 environemntal components.

Example of Leopold Matrix

Table 6 Leopold Matrix Explaining the Impact of Mining on Environmental Parameters Presented in Terms of Weightings

Project Actions / Environmental Characteristics	Blasting Drilling	Surface Excavations	Mineral Processing	River Transport	Surface Transport	Ocean Transport	River Dumping/ Loading	Pumping of Mine Pit Water	Ocean Dumping	Solid Waste Disposal	Total
Soils	2 / 3.5	8.5 / 9	2 / 2.5		3 / 2			1.5 / 2		7.5 / 8	24.5 / 23
Land Forms	3 / 4	8 / 10			1 / 1.5					7.5 / 10	19.5 / 25.5
Surface Water			6.5 / 6	4.5 / 6			3.5 / 4	3 / 4		4.5 / 4	18 / 24
Ground Water		7.5 / 7						4.5 / 6		1.5 / 2	13.5 / 15
Ocean Water						1.5 / 3			1 / 1		2.5 / 4
Air	3 / 4	3 / 4	1.5 / 2		4.5 / 6						12 / 16
Erosion	1.5 / 2	5.5 / 7	1 / 2					1 / 1.5			9 / 12.5
Deposition/ Sedimentation			3 / 3	3.5 / 4			3 / 4	2 / 2		4.5 / 5.5	16 / 18.5
Flora	2 / 3	7 / 8.5	1.5 / 3	2 / 3	2.5 / 3	1.5 / 1.5	1.5 / 2		2 / 1	5 / 6	25 / 31
Fauna	2.5 / 2.5	5 / 6	1 / 1	1.5 / 2		1.5 / 1	1.5 / 2		1 / 1	1 / 1.5	15 / 17
Agriculture			4 / 6		1.5 / 2.5			3 / 4		4.5 / 6.5	13 / 19
Noise	3.5 / 4	2.5 / 4	2 / 2	1.5 / 2.5	3 / 4		1.5 / 1.5	1.5 / 1.5			15.5 / 20.5
Asthetics		7.5 / 9.5			4 / 5.5		1 / 1	1.5 / 1.5		9.5 / 9	23.5 / 26.5
Social Health & Safety	4.5 / 4.5	3 / 3			5 / 6						12.5 / 13.5
Total	18.5 / 27	57 / 64	22.5 / 27.5	13 / 17.5	21.5 / 40.5	4.5 / 5.5	12 / 14.5	17 / 22.5	4 / 3	45.5 / 52.5	

How to Use Quantified Matrix

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

	a	b	c	d
a				
a				
c				

How to Use Quantified Matrix

- In the upper left hand corner of each box with a slash, place a number from 1 to 10 which indicate the Magnitude of the possible impact; 10 represents- the greatest magnitude of impact and 1, the least (no zeroes). Before each number place + (id the impact would be beneficial)
- In the lower right hand corner of the box place a number 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 (non zeroes)

How to Use Quantified Matrix

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

Leopold Matrix

- The leopold matrix is easily understood, can be applied to a wide range of developments, and is resonably comprehensive for first order, direct impact
- It can't reveal indirect effects of development.
- The inclusion of magnitude/significance scores has additional drawbacks: It gives no indication whether that on which these values are based are qualitative or quantitative.
- It doesn't specify the probabilty of impact occuring
- It excludes detail of techniques used to predict impacts.
- The scoring system is inherently subjective and open to bias.

Weighted Matrix

- Weighted matrics were developed in an attempt to respond to some of the above problems.
- Importance weightinings are assigned to environmental components, and sometimes to project components.
- The impact of the project (component) on the environmental component then assessed and multiplied by the appropriate weightings.

Weighted Matrix

Environmental component	(a)	Alternative sites					
		Site A		Site B		Site C	
		(c)	(axc)	(c)	(axc)	(c)	(axc)
Air quality	21	3	63	5	105	3	63
Water quality	42	6	252	2	84	5	210
Noise	9	5	45	7	63	9	81
Ecosystem	28	5	140	4	112	3	84
Total	100		500		364		438

(a) = relative weighting of environmental component (total 100)

(c) = impact of project at particular site on environmental component (0–10)

Weighted Matrix

	Importance weighting (a)	Treatment plant	Pumping station	Interceptor	Outfall	Total
Air quality	21	10(b)	0	50	40	15,750
		8(c)	–	7	8	
Water quality	42	100	0	0	0	37,800
		9	–	–	–	
Noise	9	0	100	0	0	2700
		–	3	–	–	
Ecosystem	28	10	20	40	30	19,320
		5	4	8	8	
Total	100					75,570

(a) – relative weighting of environmental component (total 100)

(b) = relative weighting of project component (total 100)

(c) = impact of project on environmental component (0–10)

Calculations: 21*10*8+21*0+21*50*7+21*40*8 = 15750

Advantages

- This method has the advantage of allowing various alternatives to be compared numerically.
- The method also doesn’t consider indirect impact.

Network

- Network is an alternative for illustrating the **secondry and subsequent effects** of action on environmental elements is to construct a network tracing such effects.
- The advantage of a network approach is that it permits clear tracing of high-order effects of initial actions; indeed mitigation and control measures can also be illustrated.
- One problem encountered in applying the network is that many higher-order effects can be postulated that are actually unlikely to occur.

Network

Possible Adverse Impacts		
Initial Condition	Consequent Condition	Effects
Increased surface runoff **(E)**	Flooding **(H)**	Gullying and Erosion **(K)**
Pollution of Ground Water **(F)**	Degradation of Water Supply **(I)**	Health Hazard **(L)**
Removal of Topsoil **(G)**	Decreased Fertility **(J)**	Death of Flora **(M)**

Corrective Action
Place intermittent flower beds
Plant Shrubs

Control Mechanisms
Building Code
Plant Shrubs

Network

Action	Impacts			Branches
A	(F)	(I)	(L)	1
B	(E)	(H)	(K)	2
C				
D	(G)	(J)	(M)	3

	Impact Score (1-10 interval Scale)					
Impacts	Magnitude	Importance	Probability of Occurance			
E	5	3	B →	E(0.8)	D →	E(0.7)
F	2	5	A →	F (.5)		
G	3	4	C →	G(.3)	D →	G(.4)
H	4	5	E →	H(.7)		
I	2	9	F →	I(.6)		
J	2	5	G →	J(.8)		
K	3	7	H →	K (.7)		
L	2	10	I →	L (.9)		
M	1	6	J →	M (.8)		

Branch 1 (2)(5)(.5)+(2)(9)(.6)+(2)(10)(.9)=33.8

Branch 2 (5)(3)(.8)+(5)(3)(.7)+(4)(5)(.7)+(3)(7)(.7)=51.20

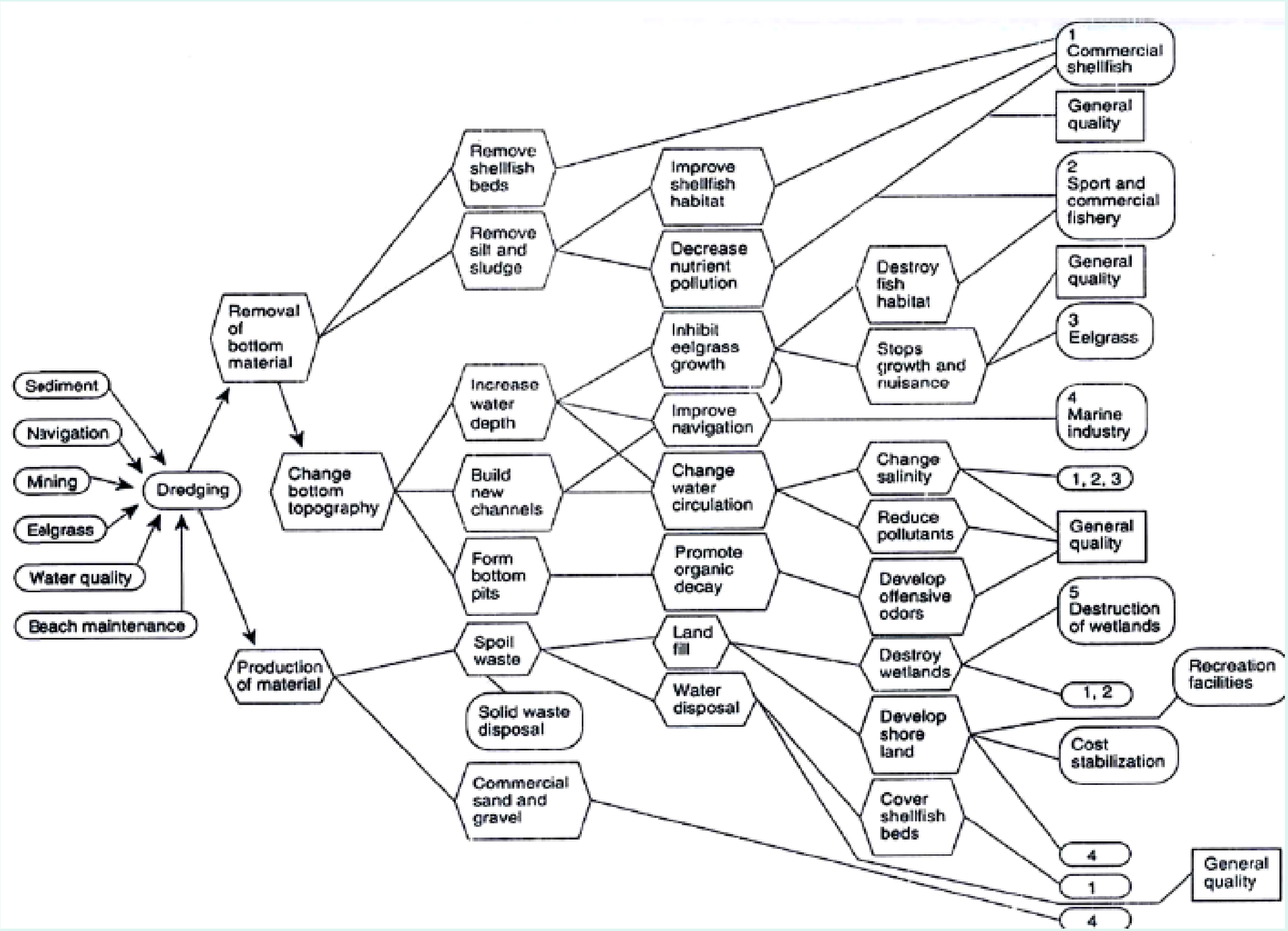
Brach 3 (3)(4)(.3)+(3)(4)(.4)+(2)(5)(.8)+(1)(6)(.8)=21.2

Grand Network Index 33.8+51.2+21.2= 106.2

Sorenson Network

- Sorenson network is probably the best known approach for investigating higher order impacts.
- It identifies feasible mitigation measures. Structure/content of the network must be predefined for a particular EIA.
- Its application is limited by adequate data availability and reference networks relevant to the local environment.

Sorenson Network



EES (Quantitative Method)

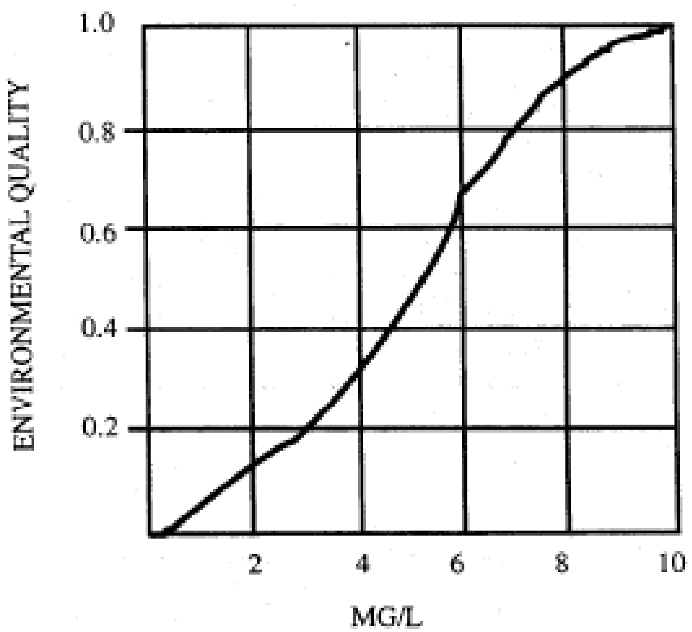
- Battelle Environmental Evaluation system was designed to assess the impacts of water resource developments, water quality management plans, highways, nuclear power plants and other projects.
- This system is sopisticated checklist

EES

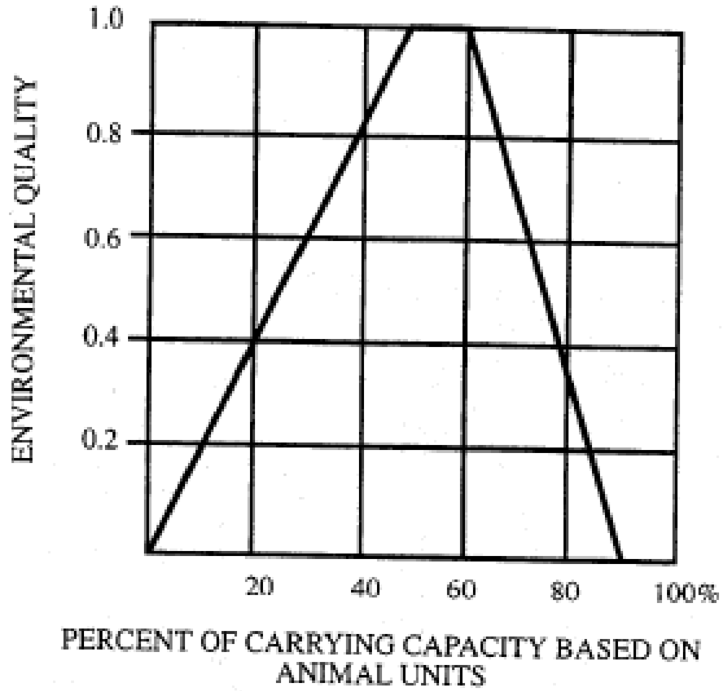
- Major concerns are seperated into four categories:
- Ecology, Physical/chemical, Aesthetics and Human Interst and Social
- Each Category is broken down into number of environmental components
- For each component an index of environmental quality, normalized to a scale ranging from 1 to 10 is developed.
- Environmental Indicator defined as difference in environemntal quality between before and after impacts states.
- Each environmental components has weighting factor (relative importance)

https://ponce.sdsu.edu/the_battelle_ees.html

- Weights are fixed and overall impact of project alternative is calculated by summing the weighted impacts indicators.



(b) Dissolved oxygen.



Advantages of EES

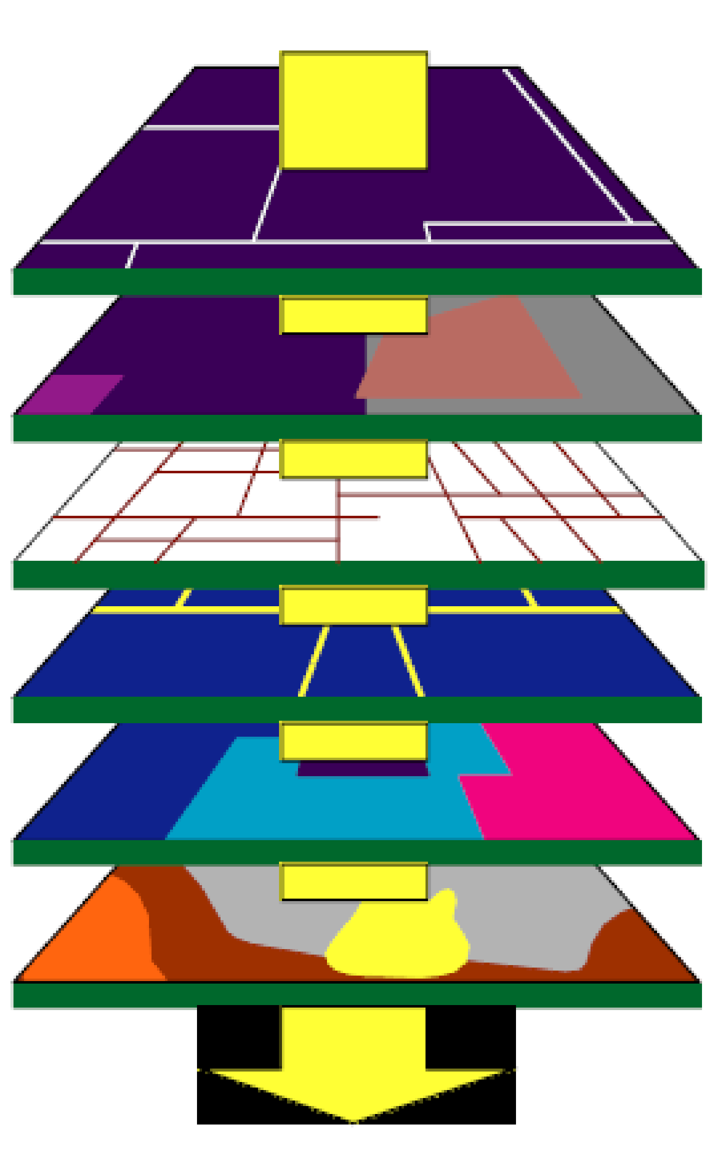
- Has high capability for identification and prediction of impacts and good replicability of results
- Provides high level of detail for assessment and documentation purposes.
- Basis for the development of environmental indicators and associated weights in fully docemented.

Limitation of EES

- System is applicable only to projects for which was designed, development additional indicators is demanding.
- System has no mechanism for estimating or displaying interactions between environmental components.
- System doesnt link impacts to affceted parties or dominant issues.
- The system has very high resource requirements (money, time, manpower, skills)

Overlay and GIS

- An effective visual aid
- Useful as documentation of environmental conditions existing before project implementation
- May describe both biophysical and social aspects of area under study.



Overlay

- The overlay method is effective in considering:
  - Sensetive lands, requiring protection human activity (e.g Shorelines, wetlands etc)
  - Hazard land, requiring protection from the environment (e.g flood plains, unstable slopes, volcanic slopes, etc)
  - Renewable resource areas, where the environment needs to be protected from human activities (e.g aquifer recharge zones, fish and wildlife habitat, etc)
  - Cultural heritage (area of scientific/)

	ADVANTAGES	DISADVANTAGES
Checklists **–simple** **–ranking and weighting**	• simple to understand and use • good for site selection and priority setting	• do not distinguish between direct and indirect impacts • do not link action and impact • the process of incorporating values can be controversial
Matrices	• link action to impact • good method for displaying EIA results	• difficult to distinguish direct and indirect impacts • significant potential for double-counting of impacts
Networks	• link action to impact • useful in simplified form for checking for second order impacts • handles direct and indirect impacts	• can become very complex if used beyond simplified version
Overlays	• easy to understand • good display method • good siting tool	• address only direct impacts • do not address impact duration or probability
GIS and computer expert systems	• excellent for impact identification and analysis • good for 'experimenting'	• heavy reliance on knowledge and data • often complex and expensive

Thanking YOU

Sample Questions

- Write down the advantages and disadvantages of checklist, matrices and networks methods of impact identification.
- What are the limitations of quantified matrix? How can weighted matrix be used to eliminate the limitations of quantified matrix? Explain your answer with an example.
- In which method of impact identification the probability of occurrence is considered? Give an example of that method.
- Explain the concept of Environmental Evaluation system and Threshold checklist for impact identification.
- What are the limitations of quantified matrix? How can weighted matrix be used to eliminate the limitations of quantified matrix? Explain your answer with an example.

Sample Questions

- In which method of impact identification the probability of occurrence is considered? Give an example of that method.
- Explain the concept of Environmental Evaluation system and Threshold checklist for impact identification.
- What are the limitations of quantified matrix? How can weighted matrix be used to eliminate the limitations of quantified matrix? Explain your answer with an example.

Sample Questions

- In an EIA project, primary, secondary and subsequent impacts (initial condition, consequent condition and their effects) are identified. Total Impacts are classified into three categories viz. Branch 1, 2 and 3. Actions and Impacts of three Branches along with their magnitude and importance with probability of occurrence are also shown. Using Network methods of impact identification, Calculate the network index for each branch along with grand index and provide your insights on the results.

Possible Adverse Impacts		
Initial Condition	**Consequent Condition**	**Effects**
Increased surface runoff (E)	Flooding (H)	Gullying and Erosion (K)
Pollution of Ground Water (F)	Degradation of Water Supply (I)	Health Hazard (L)
Removal of Topsoil (G)	Decreased Fertility (J)	Death of Flora (M)

Sample Questions

Relation Between Action and Impacts of three Branches				
Action	Impacts			Branches
A →	(F) →	(I) →	(L)	1
B →	(E) →	(H) →	(K)	2
C				
D →	(G) →	(J) →	(M)	3

Relation among different type of impacts, their magnitude and importance with probability of occurrence						
Impacts	Impact Score (1-10 interval Scale)		Probability of Occurrence			
	Magnitude	Importance				
E	5	3	B →	E(0.8)	D →	E(0.7)
F	2	5	A →	F (.5)		
G	3	4	C →	G(.3)	D →	G(.4)
H	4	5	E →	H(.7)		
I	2	9	F →	I(.6)		
J	2	5	G →	J(.8)		
K	3	7	H →	K (.7)		
L	2	10	I →	L (.9)		
M	1	6	J →	M (.8)		