LECTURE 2:
EIA : WHAT IS EIA & WHY

EIA - FOCUS

- Why EIA? – remedy to a post industrial world.
- What is EIA? – thinking sustainability.
- What are impacts? – the consequences of developmental activities.
- How to identify impacts? – need to study.
- How to measure impacts? – importance of consistency.
- How to analyse and evaluate impacts?
- How to predict impacts?

EIA – A Priori Exercise

- EIA is carried out before a project rolls out.
- It is, therefore, predictive in nature.
- Impacts could be positive, negative, reversible, irreversible, short-term or long-term.
- Impacts could have land, air, water, biological, physical, social and economic dimensions - multidisciplinarity.

EIA – The Process

- Criticality of identifying impacts.
- Measurement of impacts to visualize the quantum of losses to environment.
- Can impacts be minimised and/or mitigated?
- Environment Management Plans.
- Dissemination of impact information to public/ administrators, etc.
- Statutory appraisals.
- Project clearance/rejection.

EIA - IMPERATIVES

- **Importance of forecasting environmental impacts arising out of small or large-scale development projects gave rise to the activity known as EIA.**
- **EIA is concerned with identifying and assessing the environmental consequences of development projects, plans, programmes.**
- **Carried out in order to formulate policies in an attempt to ensure that the best alternative for development is selected.**

EIA - IMPERATIVES

- The results of EIAs are presented in documents or reports known as Environment Impact Statements (EISs).
- Most EIA work in India has concentrated on development projects such as dams, highways, power projectsand harbors.
- Significantly, few EIAs have been carried out for land use plans, sectoral plans and especially the national policies which give rise to developmental activities – SEZ , a cause of conflict.

WHAT IS EIA?

- Identifying and assessing the environmental impacts of development are complex tasks because of the diversity of impacts which may be caused by human action or inaction.
- Identification and assessment of these impacts requires collection and manipulations of large amount of data, and most importantly, communicating the final results to decision-makers and members of public.

ACTIVITIES INVOLVED IN EIA?

- Impact identification
- Impact prediction and measurements
- Impact interpretation and evaluation
- Identification of monitoring requirements
- Identifying mitigation measures
- Communication of impact information to decision-makers and public

PROBLEMS IN EIA

- To overcome some of the difficulties involved in undertaking EIAs, considerable attention has been devoted to developing standard practices.
- These structured aids or approaches to assessment, are commonly called EIA methodologies or methods.
- The EIA methodologies have evolved over the last three decades, mostly in developed nations.
- The developing nations are either not carrying out EIAs or do a *wishy washy* job of EIAs.

EIA AND SEA

- EIA is carried out for individual developmental projects.
- Strategic environment assessment (SEA) is carried out for regional plans, programmes and policies on development.
- SEA includes cumulative environmental and social assessment of developmental profile.
- Carrying capacity is a tool to carry out SEA, which addresses supportive and assimilative capacity of environment of a region.

CARRYING CAPACITY

SUPPORTIVE

- Natural
- Limited
- Equilibrium state

ASSIMILATIVE

- Can be increased or decreased
- Limited but elastic
- Technology/administrative interventions

LECTURE 3:
Carrying Capacity – A tool to ensure Sustainability

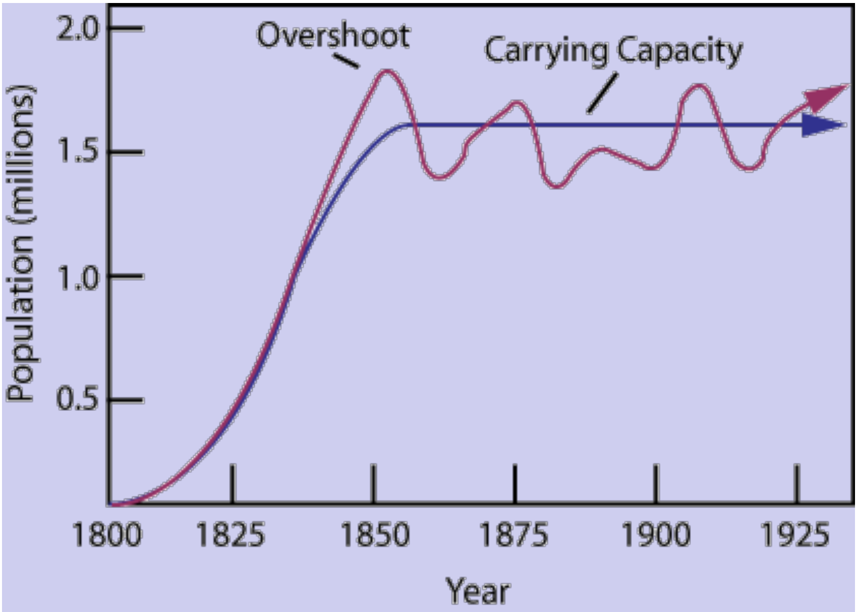
FOCUS

- What is carrying capacity?
- Tool to ensure sustainable development
- Environmental Impact Assessment [EIA] versus Strategic Environmental Assessment [SEA]
- Physical/Ecological/Cultural carrying capacity
- Have we reached ‘r’ selection pattern?
- New Paradigms in sustainability measurement
- Planetary boundaries
- Carbon Footprint

Normal

Abormal

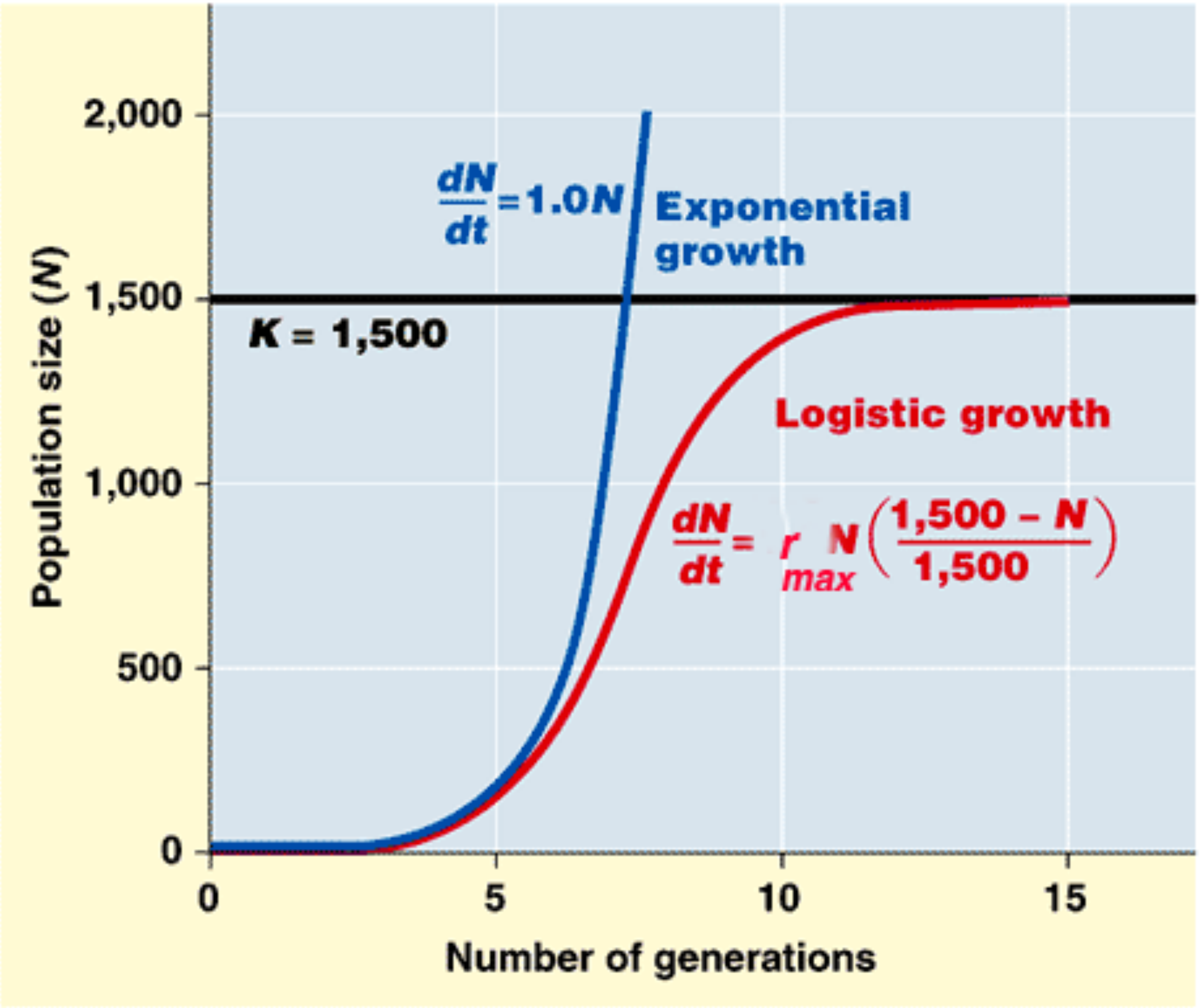
Carrying Capacity



The logistic growth curve

- A typical carrying capacity graph: The maximum population size a certain environment can support for an extended period of time, for a population. Under ideal conditions, a population naturally increases until it overshoots the carrying capacity beyond which the environment can no longer provide for it, due to a number of environmental limits, including food, crowding, competition, etc.
- The population, due to lack of resources, will begin to die out, allowing the environment to recover. As the environment recovers, the species population is able to flourish once more. This leads to a fluctuation between the prosperity of the species and the prosperity of the environment (hence the fluctuations in the graph).

Carrying Capacity: Logistic vs Exponential Growth



Carrying Capacity : A Tool

Sustainable Development

Pre-development

- EIA
- Carrying Capacity

Post-development

- Ecological footprint
- Planetary boundaries

Environmental Impact Assessment [EIA]

- Project specific
- A priori
- Predictive
- Based on available baseline data
- Scope determined by a specific developmental activity
- Public participation elicited

Carrying Capacity

- Region or development specific
- A priori
- Predictive
- Reconciliatory – development-oriented
- Scope determined by developmental planning
- Strong social & economic thrust
- Mostly government driven plans – SEZs
- Also referred to as strategic environment assessment [SEA]

EIA and SEA

- EIA is carried out for individual developmental projects.
- Strategic environment assessment (SEA) is carried out for regional plans, programmes and policies on development.
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- Carrying capacity is a tool to carry out SEA, which addresses supportive and assimilative capacity of environment of a region.

Carrying Capacity

Supportive

- Natural
- Limited
- Equilibrium state

Assimilative

- Can be increased or decreased
- Limited but elastic
- Technology/administrative interventions

Carrying Capacity

Geophysical

- Geological/Geomorphology
- Seismo-tectonic
- Geo-hydrological
- Air & weather phenomena
- Floods & extreme events
- GLOFs & Hazards

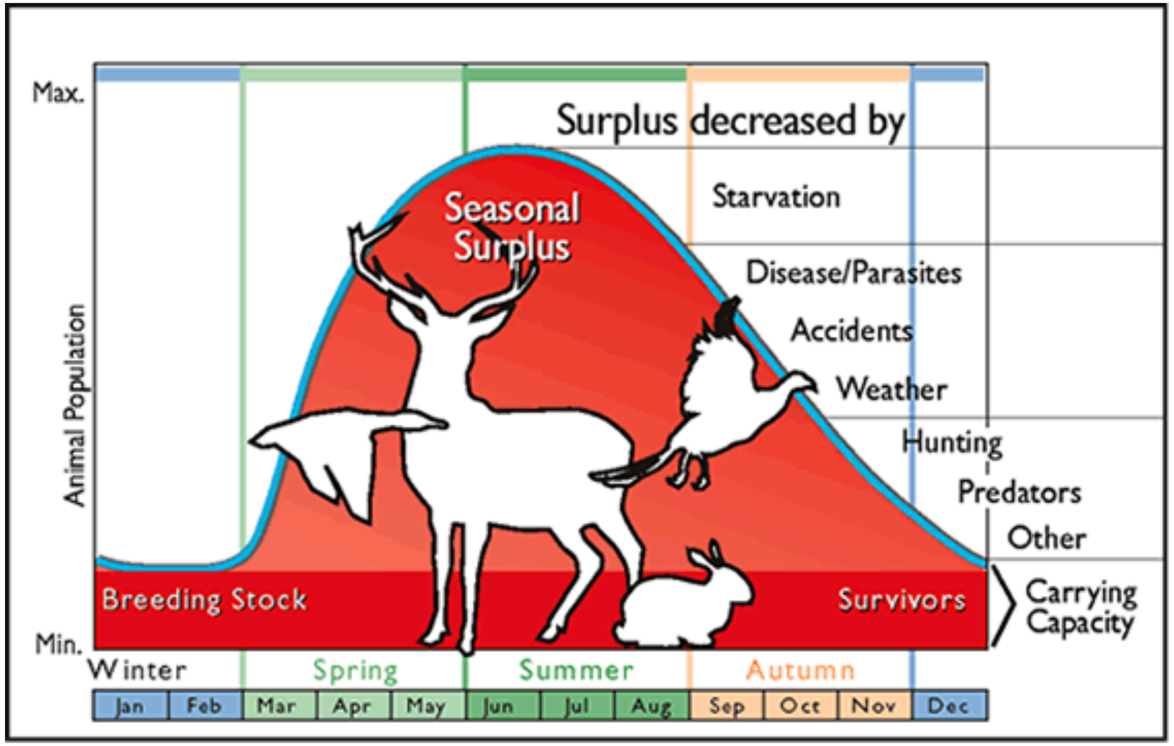
Ecological

- Population & resources
- Successional events
- Geo-hydrological
- Air quality
- Weather phenomena

Cultural

- Tradition
- Culture
- Belief systems
- Migration/immigration
- Changed economies
- Conflicts
- Diseases & health

Biological/Ecological Carrying Capacity



Some factors that limit the potential production of wildlife include:

Disease/parasites; Starvation; Predators; Pollution; Accidents Old age; Hunting.

Encroachment by development resulting in loss of habitat.

If the conditions are balanced, populations will produce a surplus, which can be harvested on an annual, sustainable basis.

Biological/Ecological Carrying Capacity

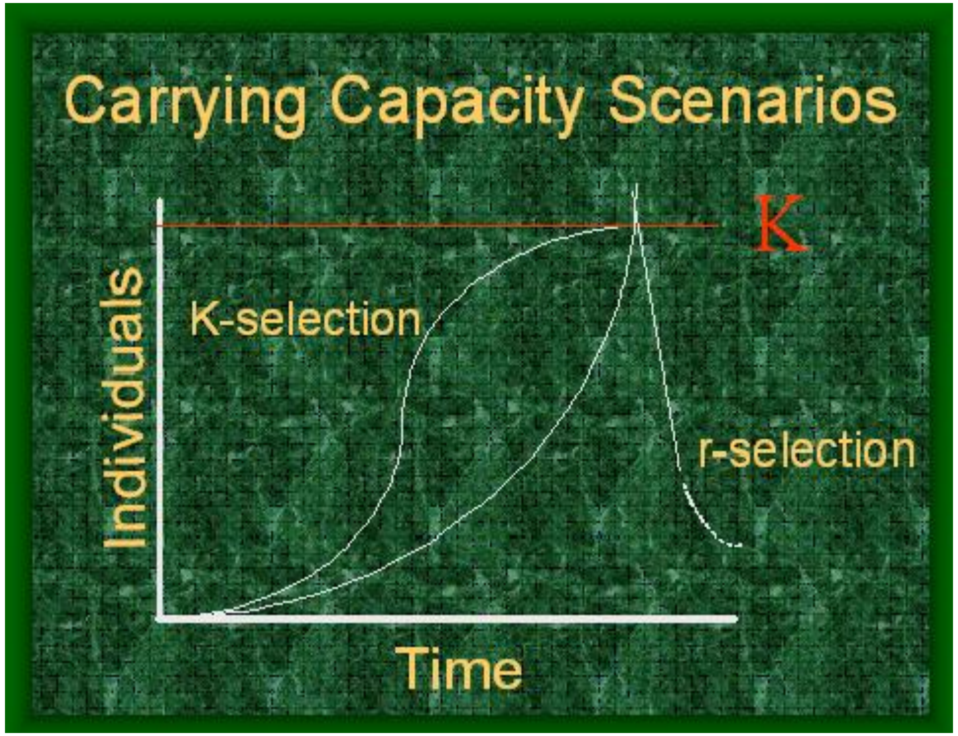
- Biologists define carrying capacity as the maximum population of a given species that can survive indefinitely in a given environment.
- Originally applied to relatively simple population-environments such as the number of sheep or cattle that could be maintained on grazing land without degrading the land so that it could no longer support the animals.
- Depends on conditions and resources available in an area, and consumption habits of the species considered. Because both what is available in the area, and the consumption habits of the species change over time, carrying capacity is always changing.
- Carrying capacity is a measure of sustainability within these changing conditions.

Growth Patterns & Resource Limits

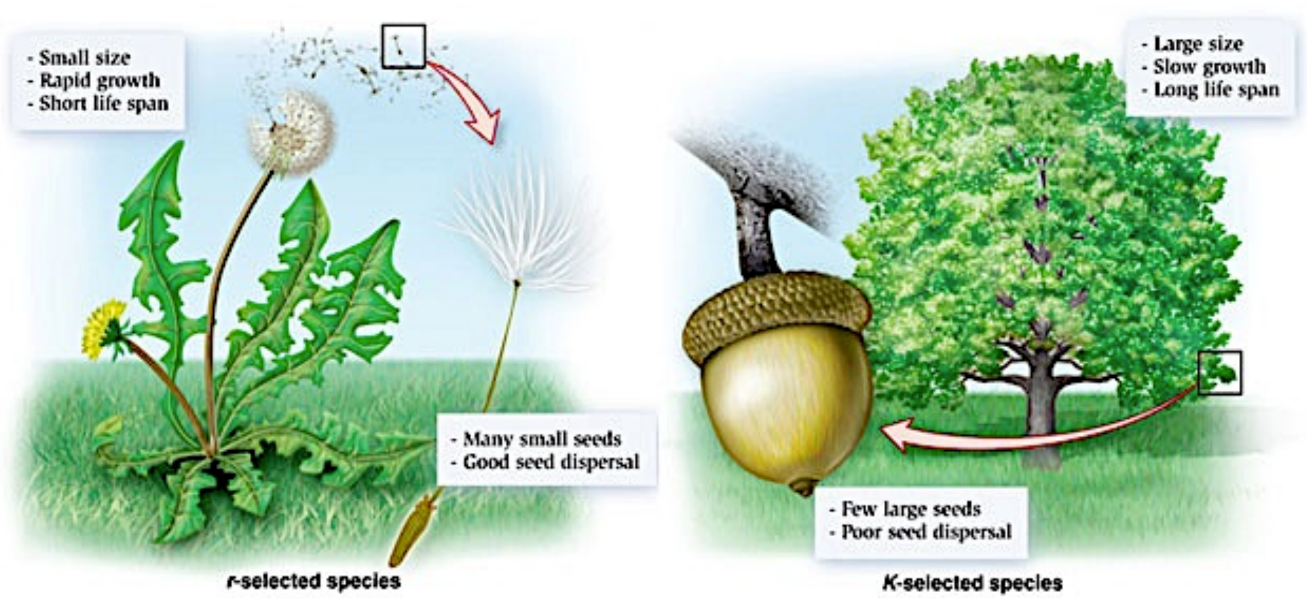
- **There are two quite different patterns which describe how various species reach carrying capacity, the sigmoid and peak phenomena.**
- **Populations which exhibit the sigmoid pattern increase rapidly while food and habitat are abundant, and then slow down as regulatory factors such as lower birth rate and reduced food availability come into play.**
- **As the rate of population growth slows down to zero, the population reaches a fairly stable level. This pattern is referred to as K (for constant) selected species.**

- The other pattern of reaching carrying capacity is similar in the early stages when the population is still small.
- But here the same regulatory factors do not come into play and the population increases rapidly to the point where it exhausts the resources upon which it depends.
- At this point, mortality becomes the primary regulatory factor, and the population collapses to a low level. When resources are replenished the population begins to rise again; this process is repeated in a boom and bust cycle. These are referred to as the "r-selected" species

Sustainability : 'K' & 'R' Selection



	r Unstable environment, density independent	*K* Stable environment, density dependent interactions
Organism size	Small	Large
Energy used to make each individual	Low	High
# Offspring produced	Many	Few
Timing of maturation	Early	Late (with much parental care)
Life expectancy	Short	Long



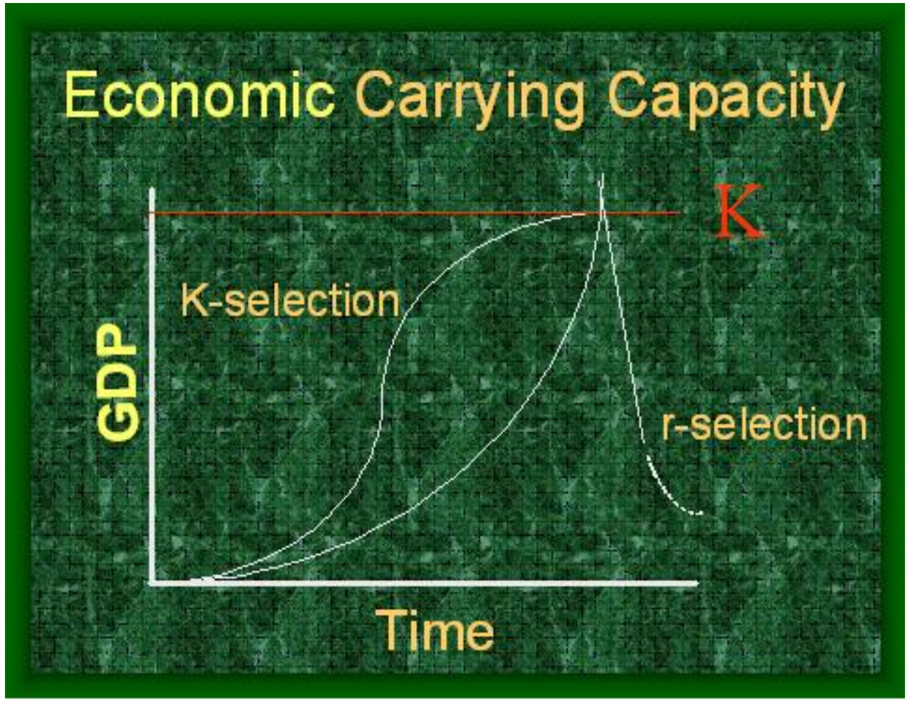
Comparative Growth Patterns

Human/Economic Applications

The concept of carrying capacity applied to human populations in the 1960's.

Consumption habits of humans are more variable than those of other animal species, making it considerably more difficult to predict the carrying capacity of the earth for human beings.

This realization gave rise to the IPAT Equation which pointed out that carrying capacity for humans was not only a function of population size, but also of varying levels of consumption, which in turn are affected by the technologies involved in production and consumption.



Impact [I] = Population [P] x Affluence [A] x Technology [T]

Humans : ‘r’ Selected Species?

- There are a large number of estimates for the human carrying capacity of the earth - a low of one half billion people to a sobering 800 billion.
- These estimates are more ideological than determined by scientific principles demonstrating the complexity of developing useful estimates of the human carrying capacity of the planet, and the limitations of using the methodology which has been successful with non-human species.
- Various estimates of HCC also demonstrate relationships among major factors involved. Clearly, if consumptions levels/capita are higher, then a smaller population can be supported. If technologies increase or decrease overall consumption, then also carrying capacity is affected.
- Because the idea and methodology of carrying capacity were developed in the natural science of biology, they incorporate the notion of limits imposed by the earth’s natural systems. Species can overshoot these limits (as with the r-selected species), and when they do, they collapse and risk extinction.

Big Question

- The big question for human civilization raised by this application of carrying capacity to the human population is whether we will be a K or r-selected species; whether we will reach a stable level that can be sustained for an indefinite period; or whether we will grow to a peak and collapse.

- Biological studies of various species provide us with some basic lessons to apply to the human condition, but new ideas and methodologies are needed to incorporate the added complexities of human technologies and culture.

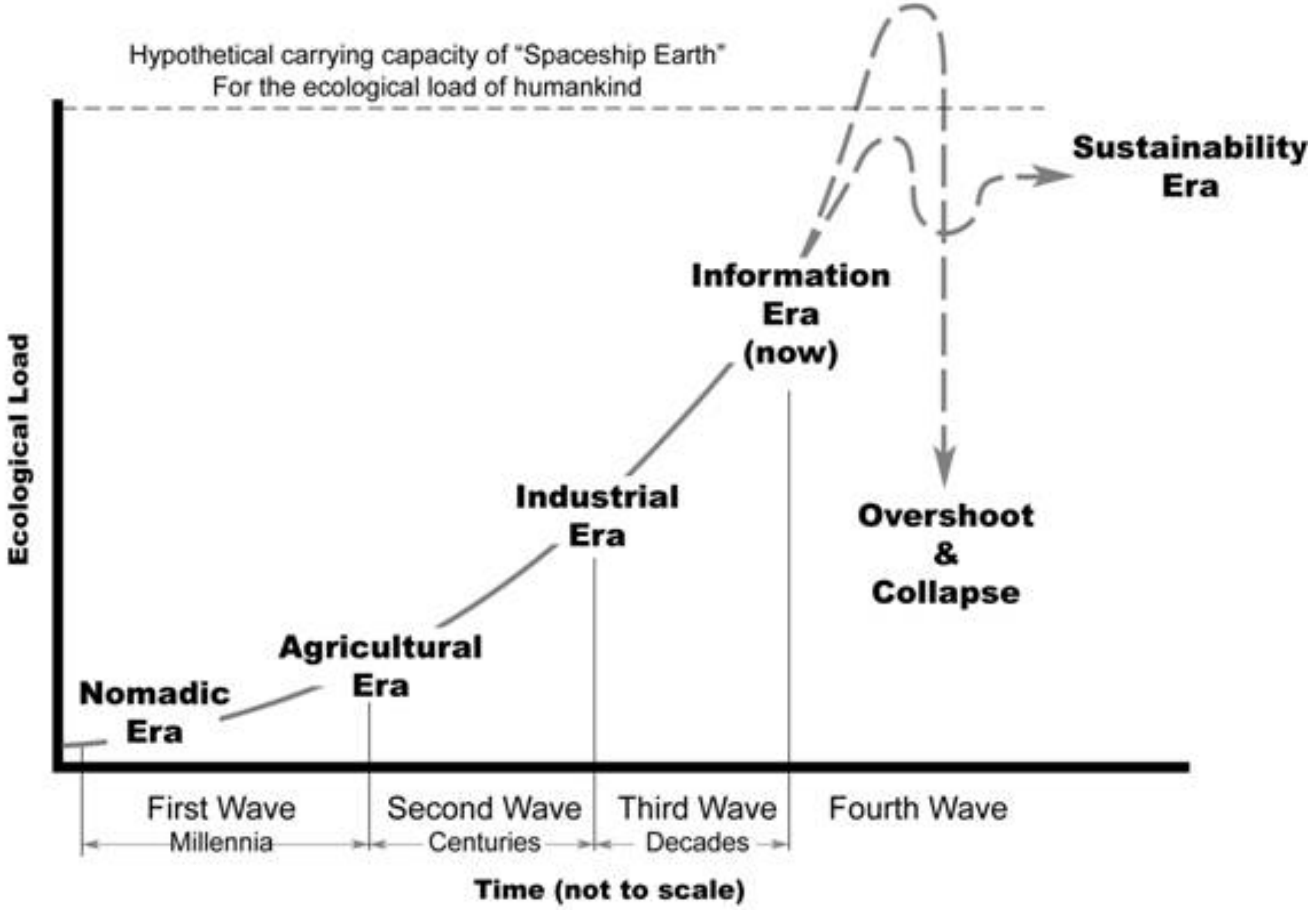
- But carrying capacity tells us that the biophysical limits of our environment are key in determining how many human can survive at what levels of consumption.

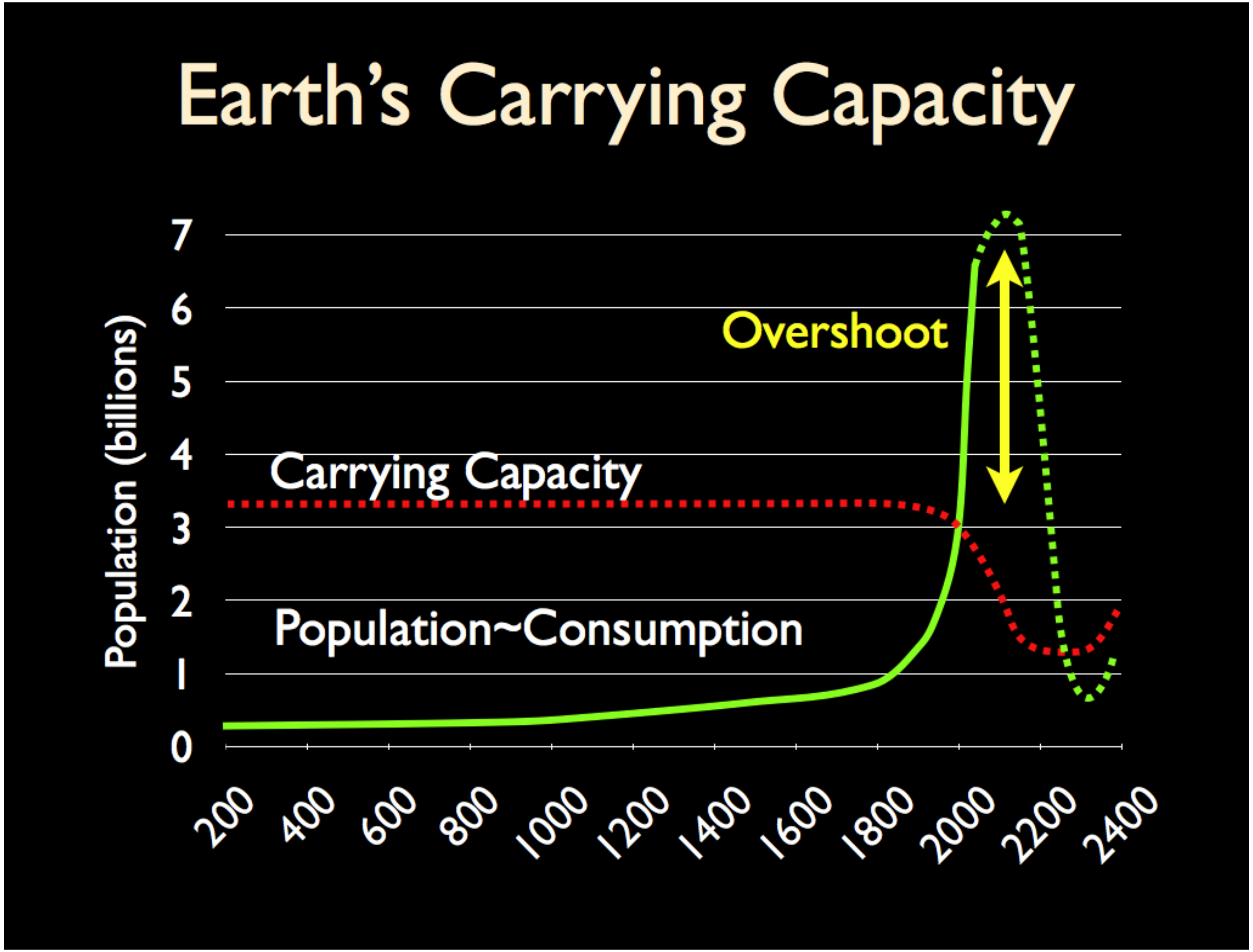
Relation to Sustainable Scale

- *The concept of carrying capacity is well rooted in biological science, and describes the rise and decline of plant and animal populations. It clarifies that there is a limit to the growth of any biological population, and identifies some of the parameters that determine the pattern of population rise and collapse. Additional layers of complexity occur for the human population in terms of the dynamics involved. Human choices are needed to ensure we imitate a K rather than an r-selected species.*

- *"…carrying capacity is determined jointly by human choices and natural constraints. Consequently, the question, how many people can the Earth support, does not have a single numerical answer, now or ever. Human choices about the Earth's human carrying capacity are constrained by facts of nature which we understand poorly. So any estimates of human carrying capacity are only conditional on future human choices and natural events." Joel Cohen*

Transforming from ‘K’ to ‘r’ ??




Earth's Carrying Capacity
Population (billions)
0
1
2
3
4
5
6
7
Overshoot
Carrying Capacity
Population~Consumption
200
400
600
800
1000
1200
1400
1600
1800
2000
2200
2400

LECTURE 4

ACTIVITIES INVOLVED IN EIA?

ACTIVITIES INVOLVED IN EIA?

- Impact identification
- Impact prediction and measurements
- Impact interpretation and evaluation
- Identification of monitoring requirements
- Identifying mitigation measures
- Communication of impact information to decision-makers and public

IMPACT IDENTIFICATION

- First task is to identify the likely impacts which need to be investigated in detail.
- Lack of knowledge concerning the nature and extent of impacts arises from variety of developments which are located in different environmental settings.
- The impacts of a particular development project in one location may be different from those at other location though activity may be same.
- Usefulness of identification of data is important to save time, finances and manpower.

- In order to avoid this loss we have to identify most likely important impacts - this activity is known as “scoping”.
- Scoping involves discussion in the form of meetings between user agencies and organizations implementing EIA and those responsible for design construction and operation of a project.
- The aim of scoping is to select from the total number of possible impacts those important ones that deserve further detailed study.
- Setting ToR…..

Nature & Location of Project

Geography
Environmental Setting

Nature of Project

- A cement factory in Madhya Pradesh & Uttarakhand
- A hydro-power project in Himalaya or in Assam Plains
- A coal mining project in a national park or a wasteland
- A fertilizer factory - river bank or….

IMPACT PREDICTION AND MEASUREMENT

- This involves an estimation of likely nature or characteristics of impacts in quantitative and qualitative terms.
- For example it might be essential to calculate changes in base level of noise due to installation of a project.
- Similarly concentration of air pollutants such as SO_2 may increase due to certain activities having harmful impacts on human health and lower plants such as lichens.

IMPACT PREDICTION AND MEASUREMENT

- The predictions can be carried out by means of various techniques such as analytical mathematical models which allow us to predict concentration of pollutants in air and water at varying distances from a source
- The measurement of change in the state of environmental features is an important first stage in estimating the nature of many impacts

IMPACT PREDICTION AND MEASUREMENT

- **The next stage is to determine the nature of the effects on human, animals or plants and compare these with dose-response curve studies**
- **Unfortunately, most of the time these data are not available which makes EIA as the most difficult and challenging task.**
- **The lack of baseline data makes predictions and projections difficult – both for environmental and response parameters.**

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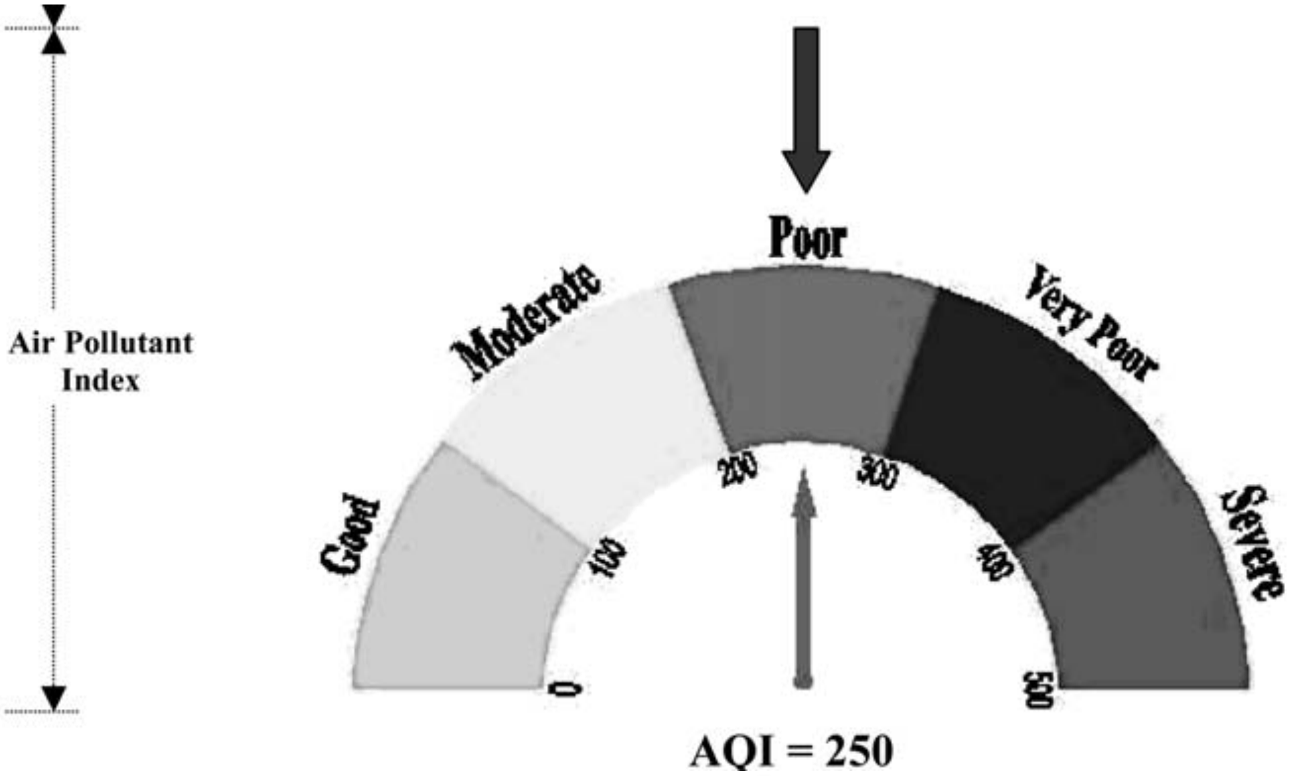


[redacted]

[redacted]

Table. 1. Short-term effects on health from 10-μg/m^3 increases in PM_{10} concentration

Health outcome	**Estimated percentage increase in risk per 10 μg/m^3 PM_{10} (95% confidence interval)**	**Estimates available for meta-analysis**
All-cause mortality	0.6 (0.4–0.8)	33
Mortality from respiratory diseases	1.3 (0.5–2.0)	18
Mortality from cardiovascular diseases	0.9 (0.5–1.3)	17
Hospital admissions for respiratory disease, people age 65 years and over	0.7 (0.2–1.3)	8

Source: Anderson HR et al. *Meta-analysis of time series studies and panel studies of particulate matter (PM) and ozone (O_3). Report of a WHO task group.* Copenhagen, WHO Regional Office for Europe, 2004 (http://www.euro.who.int/document/e82792.pdf, accessed 8 April 2005).

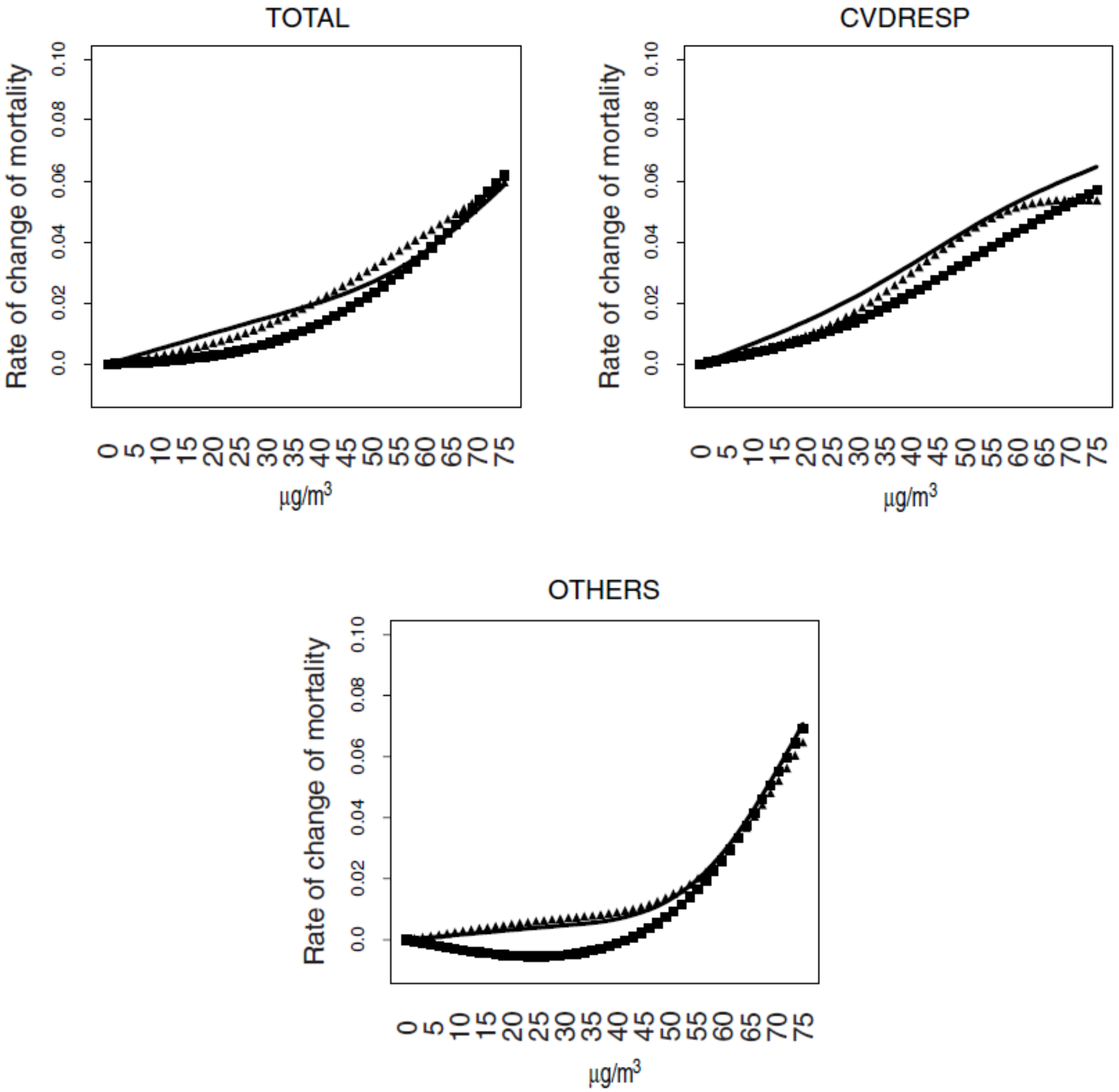


FIGURE 2. Mortality-particulate matter <10 μm in aerodynamic diameter (PM_{10}) dose-response curves for total (TOTAL) mortality, cardiovascular and respiratory (CVDRESP) mortality, and other causes (OTHERS) mortality, 20 largest US cities, 1987–1994. The dose-response curves for the mean lag, current day, and previous day PM_{10} are denoted by solid lines, squared points, and triangle points, respectively.

LECTURE 5
IMPACT INTERPRETATION
MONITORING &
EVALUATION

FOCUS

- Interpretation and Evaluation.
- Monitoring requirements and its importance.
- A stitch in time – lax monitoring.
- Communication of impact information.
- Public participation – myths & realities.
- Government & NGOs - rights & responsibilities.
- Case study – Hydropower in India.

IMPACT INTERPRETATION OR EVALUATION

- This activity can have two distinct operations:
- First, a need to determine importance of an impact.
- For example, in case of an industry it may be predicted that the inhabitants of a local community will be exposed to an increase in noise or pollution levels beyond the carrying capacity of humans/plants/other life forms.
- Such impacts become extremely important for consideration.

IMPACT INTERPRETATION OR EVALUATION

- **Second, relative importance of impacts, when compared with each other, is considered as part of impact interpretation.**
- **This exercise is known as "Evaluation".**
- **Not all impacts will be considered to be of equal importance by decision-makers therefore, judgments will be made on the relative importance of impacts.**

•The major problem faced while interpretation is the subjective interpretation and importance depending on the expert.

IDENTIFICATION OF MONITORING REQUIREMENTS AND MITIGATION MEASURES

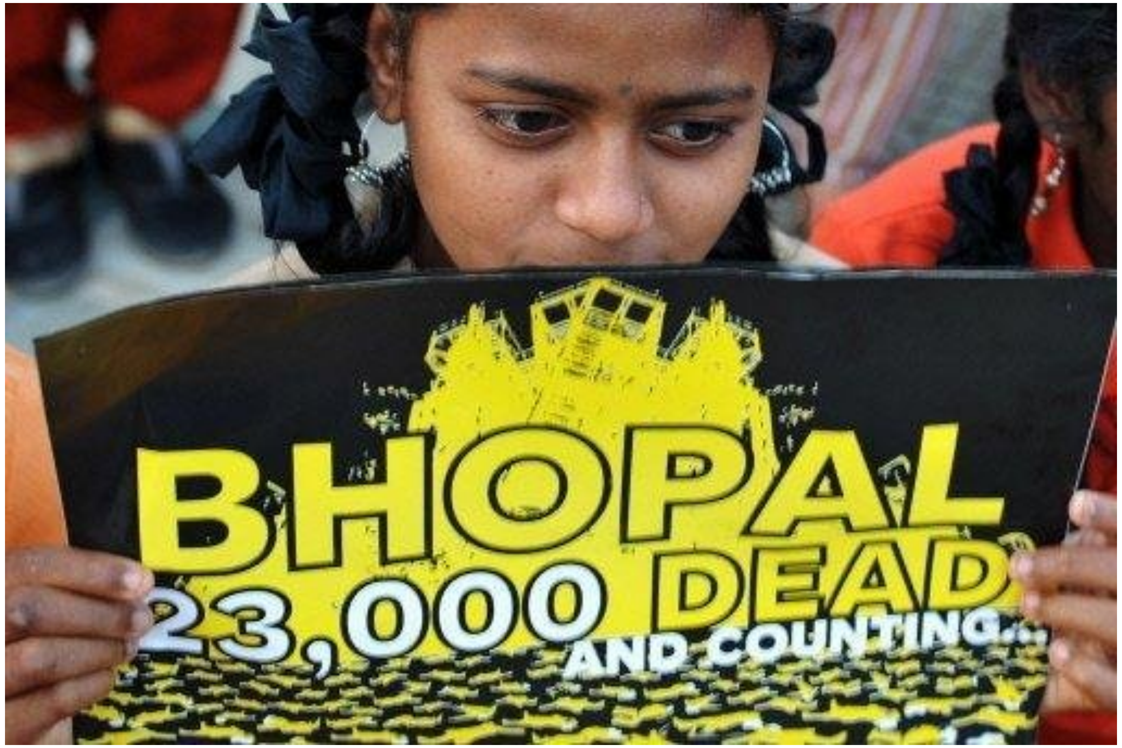
- The identification of mitigating actions to prevent harmful impacts or reduce their scale and intensity is an important feature of EIA.
- Once likely harmful impacts have been identified, possible mechanisms to mitigate them should be investigated and their ability to produce the desired objectives assessed.
- Monitoring can be instituted for three main reasons:
- First, to ensure that legal standards for pollutants are not exceeded.

IDENTIFICATION OF MONITORING REQUIREMENTS AND MITIGATION MEASURES

- Second, to check that mitigating measures are implemented in the manner described in EIS and the related documents.
- Finally, and most importantly, in the context of EIA, monitoring provides early warning system of environmental damage so that preventive action could be taken.
- In addition, the application of knowledge from impact monitoring can improve the accuracy of future EIAs by indicating the predictive techniques, which are most successful and those impacts actually to have occurred.

Absence or Lax Monitoring

- Bhopal gas tragedy – leaking MIC tanks
- Chernobyl nuclear disaster.



COMMUNICATION OF IMPACT INFORMATION

- **Once impacts have been interpreted, it is essential that quantitative data and qualitative information on impacts be presented in a form that enables non-experts to comprehend them.**
- **Unless interested members of the public and decision-makers can understand environmental impact information, they will be unable to form conclusions on the merits and demerits of a developmental proposal.**

India’s EIA & Public Participation

- **One way to ensure public participation in decision-making process in sustainable development, all major projects are required to carry out a public hearing of their proposed developmental activity/activities.**
- **This is done through properly advertised and legalized framework – public hearing of projects.**

•Any Indian citizen can participate and seek clarification from project authorities.

EIA, Public Participation & Indian Reality

- **Does public participation ensure sustainable development and/or people's participation in development?**
- **What are the problems with people's participation, in particular responsibility of NGOs?**
- **Elected representatives vs. unelected NGOs.**

Some Examples : Hydropower

- Does public participation ensure sustainable development and/or people's participation in development?
- What are the problems with people's participation, in particular responsibility of NGOs?
- Elected representatives vs. unelected NGOs – Fair or Unfair?.

LECTURE 6
EIA METHODOLOGIES
Date: 18.03.2020

EIA-METHODOLOGIES

A number of techniques have been developed for the presentation of environmental impact results to decision-makers and the general public. These techniques can be listed as follows :

- Ad hoc
- Checklists
- Matrices
- Overlays
- Networks
- Cost-benefit analysis (UNEP Test Model : natural system assessment)

AD HOC METHODOLOGIES

- This methodology gives broad idea of qualitative impacts & variables which are of value in comparing alternative development sites or schemes.

- This information is stated in simple terms readily understandable by a lay decision-maker or members of the public, and avoids outlining the actual impacts on the specific parameters which will be affected.

- It is not exactly "Delphic" in nature, nor based on expert opinion. It is only a reasonable statement of the *ad hoc* items of data for two or more alternatives, and can thus be prepared rapidly.

Illustration of the Ad hoc Technique

Items	Alternatives		
	A	B	C
Number of reservoirs on river system	4	1	0
Combined surface area (ha)	8,500	1,300	-
Total reservoir shoreline (km)	190	65	-
New irrigation areas (ha)	40,000	12,000	-
Reduced open space because of project & associated population increase (ha)	10,000	2,000	-
Inundated archaeological sites	11	3	-
Reduced soil erosion (relative magnitude)	4X	1X	Nil
Enhanced fisheries (relative magnitude)	4X	1X	Nil
Provision of flood control measures	Yes	Yes	No
New potential malarial areas (relative magnitude)	4X	1X	Nil
Additional employment potential (number of persons)	1,000	200	-

AD HOC METHODOLOGIES: Shortcomings

- This methodology has several drawbacks, such as:

  – No assurance of a comprehensive set of all relevant impacts.

  – The possibility of selection of different criteria from different groups, causing a lack of consistency in the analysis.

  – Its inefficiency because of the effort involved in identifying and assembling an appropriate panel for each impact assessment.

CHECKLISTS

- Checklists present a specific list of environmental parameters to be investigated for possible impacts
- They do not require establishing cause-effect links to project activities. They may or may not include guidelines about how parameter data are to be measured and interpreted
- The Checklists are of three types:
- *Simple checklist* - A list of parameters without any guidelines provided on how environmental parameters are to be measured and interpreted

CHECKLISTS

- *Descriptive checklist* - A list of identified environmental parameters and guidelines on how parameter data are to be measured
- *Scaling checklist* - Similar to the descriptive checklist, but with the addition of information basic to subjective scaling or parameter values
- *Scaling-weighing checklist* - Represents the scaling checklist with extra information (weightage) provided to the parameter

Checklist for A Road Project

Items	Adverse ST	Adverse LT	Adverse R	Adverse IR	Adverse L	Adverse W	Beneficial ST	Beneficial LT	Beneficial SI	Beneficial N
	Nature of likely impacts									
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								
Ground water	*	*	*	*	*	*	*	*	*	*
Soils		X				X				
Air quality	X				X					
Navigation		X			X					
Land transportation							X	X		
Agriculture								X		X
Socio-economic								X	X	
Aesthetic		X			X					

ST = Short-term LT = Long-term R = Reversible IR = Irreversible
L = Local W = Wide SI = Significant N = Normal
* = Negligible

ENVIRONMENTAL EVALUATION SYSTEM (EES)

- **Developed by the Battelle Columbus Laboratories in USA (Dee *et al.*,1979), is an example of the scaling-weighing checklist and was developed for water resources projects.**
- **It consists of a description of the environmental factors included in the checklist, as well as instructions for scaling the values of each parameters and assigning importance units.**
- **The EES is used by evaluating the expected future condition of environmental quality "without" the project and then "with" the project.**
- **A difference in environmental impact units (EIU) between these two conditions constitutes either an adverse (loss in EIU) or a beneficial (gain in EIU) impact.**

ENVIRONMENTAL EVALUATION SYSTEM (EES)

- Mathematically this process may be represented as follows (Dee *et al.*, 1972)

$$E_I = \sum_{i=1}^{m} (V_i)_1 W_i = \sum_{i=1}^{m} (V_i)_2 W_i$$

Where,

E_I = Environmental impact

$(V_i)_1$ = Value in environmental quality of parameter i with a project

$(V_i)_2$ = Value in environmental quality of parameter 1 without a project

W_i = Relative weight (importance) or parameter 1,

m = Total number of parameters

EES of a Multipurpose Project

S.No.	Parameter	Without project EIUs	With project EIUs	Net change in EIUs
1	Forest	533	476	-57
2	Wildlife	350	217	-133
3	Reservoir fisheries	0	243	243
4	Downstream fisheries	260	273	13
5	Eutrophication	139.4	110.5	-28.9
6	Aquatic weeds	84.9	95.1	10.2
7	Soil erosion	178.2		-64.9
8	Soil fertility	99.3	63	-36.3
9	Bank stability	85	50	-35
10	Sedimentation	156	142	-14
11	Flow variation	66	61	-5
12	Evaporation	70	70	0
13	Temperature stratification	88	80.4	-7.6
14	Dissolved oxygen	110	0	-110
15	Heavy metal	68.6	56	-12.6
16	pH	58.8	48	-10.8
17	Salinity intrusion	72	24	-48
18	Inorganic phosphorus	2.5	2.5	0
19	Water table	290	85	-205
20	Reservoir leakage	240.8	185.6	-55.2
21	Climatic changes	234.9	234.9	0
22	Air quality	170.7	120.4	-50.3
23	Nutrients	82	410	328
24	Water supply	90	285	195
25	Public sanitation	165.6	369	203.4
26	Power supply	90	285	195
27	Navigation	45	120	75
28	Irrigation	28	224	196
29	Flood control	12	235.2	223.2
30	Resettlement	441	387	-54
31	Highway relocated	100	50	-50
32	Archaeological treasure	190	133	-57
33	Transmission lines	126	106	-20
34	Landscape	107	136	29
35	Water quality	133	57	-76
36	Recreation	104.5	186.2	81.7

Environmental impacts : multipurpose project & environmental components

Category	Component	Without project EIUs	With project EIUs	Net change in EIUs
Ecological	Terrestrial	883	693	-190
	Aquatic	484.3	721.6	237.3
Physico-chemical	Land	518.5	368.3	150.2
	Surface water	535.9	341.9	194.0
	Ground water	530.8	270.6	-260.2
	Atmosphere	405.6	355.3	-50.3
Human Interest	Health	247.6	779	+531.4
	Socio-economic	806.0	1,586.2	+780.2
	Aesthetic & cultural	660.5	618.2	-42.3

Category	Without project EIUs	With project EIUs	Net change in EIUs
Ecological	1,367.3	1,414.6	47.3
Physico- chemical	1,990.8	1,336.1	-654.7
Human Interest	5,072.2	5,734.1	661.9

Major and Minor Red Flags Assigned to Various Environmental Parameters: Multipurpose Project

Habitat	Parameter
Terrestrial	Forest Species diversity Wildlife Rare & endangered species
Aquatic	Downstream fisheries Migratory fish Benthos Species diversity Rare & endangered species
Land	Soil erosion Soil fertility Bank stability Seismicity

Major and Minor Red Flags Environmental Parameters : Multipurpose Project

Environment	Parameter
Surface Water	Flow variation Temporary stratification Dissolved oxygen Heavy metal pH Salinity intrusion Inorganic nitrogen
Ground Water	Water table Reservoir leakage
Atmosphere	Air quality
Health	Parasitic diseases
Socio-economic	Crop production Resettlement Highway relocation
Aesthetic/Cultural	Archaeological value Transmission lines