Impact Assessment Methods

Tomás B. Ramos
Professor of Sustainability Assessment and Planning

Department of Environmental Sciences and Engineering
NOVA School of Science and Technology
NOVA University Lisbon
&
CENSE, Center for Environmental and Sustainability Research

E-mail : tabr@fct.unl.pt

1

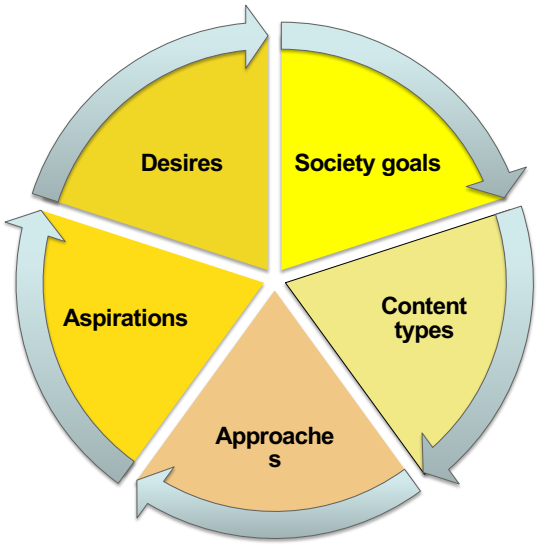
Contents

2

I. Introduction and background

3

The concept of sustainable development is charged with complexities as it involves and balances several different aspects:



CENSE center for environmental and sustainability research

NOVA SCHOOL OF SCIENCE & TECHNOLOGY

4

I. Introduction and background

Sustainability assessment:

concept and aim

Despite the existence of several non-consensual definitions, interpretations, and methods, the term 'sustainability assessment' (SA) is often used to refer to a systematic and comprehensive approach:

to characterize the sustainability "state"

covering the environmental, social-cultural, economic, and institutional/governance dimensions, integrated across generational time

5

I. Introduction and background

Sustainability assessment:

approaches

(i) ex ante ***(before the event)*** **– forward-looking predict the potential effects of an activity prior to its implementation**

and

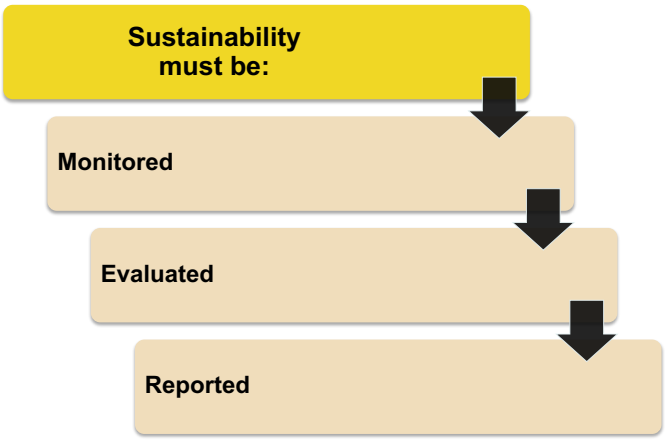
(ii) ex post ***(after the event)*** **– current implemented situation**

(Pope et al., 2004; 2017)

6

I. Introduction and background

Assuming that sustainability is to be used to support decision-making and policy/planning processes



7

I. Introduction and background

In the monitoring of national, regional and local sustainability issues one of the main goals is to

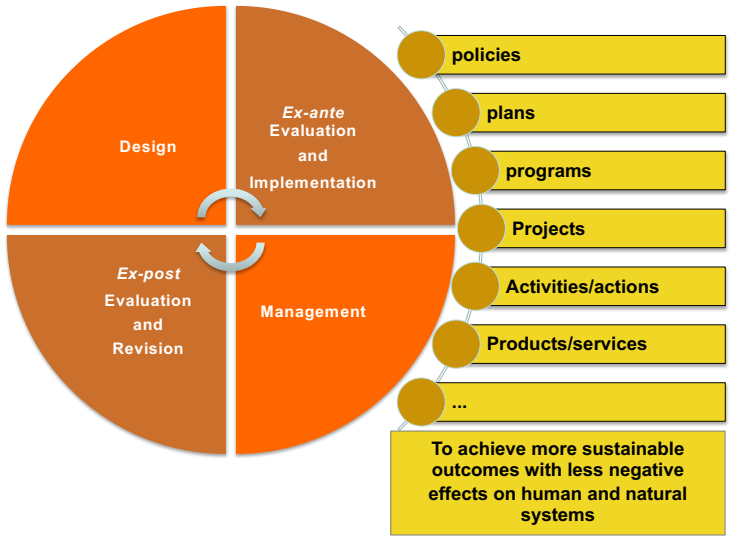
- Support decision-making

and

- Policy and planning processes

improving management, assessment and communication.

8



9

A Sustainability Impact Assessment Process...

- Must be managed and monitored on a regular basis
- Provides an opportunity to involve civil society (participation)
- Needs to be communicated
- Helps to take better decisions in a more transparent manner (democracy)

Adapted from Spangenberg (2007)

10

II. Overview of Impact assessment methods

11

Impact assessment methods

Most common methods (1/2)

identification, prediction and assessment

1. **Checklists**
2. Flowcharts and networks of impacts
3. Overlay of thematic maps | Geographical Information Systems
4. Matrices and interaction diagrams

CENSE center for environmental and sustainability research

NOVA SCHOOL OF SCIENCE & TECHNOLOGY

12

Impact assessment methods

Checklists

A checklist is designed to help users identify the likely significant environmental effects of proposed projects (mainly for screening and scoping phases)

QUESTIONNAIRE CHECKLIST OF POTENTIAL HEALTH IMPACT OF WATER RESOURCE DEVELOPMENTS AND IRRIGATION PROJECTS

A. DIRECT IMPACTS ON PEOPLE IN THE PROJECT AREA:

- Will new diseases or new strains of the disease be introduced by immigration of construction workers or new settlers? Will these affect new settlers or residents or both?
- Will relocated communities be exposed to diseases to which they have little or no immunity?
- Will new settlers be exposed to locally endemic diseases to which they have little or no immunity?
- Will food, waste or water cycles aggravate sanitation and disease problems?
- Will housing and sanitary facilities become overburdened, misused or not used at all, leading to conditions conducive to increases in water washed diseases and spread of communicable diseases by the faecal-oral route?
- Will soil and water be contaminated by excreta, facilitating spread of communicable disease?
- Will introduction of migrant workers cause increases in venereal disease among workers and subsequently residents?
- Will new settlers and relocated communities be exposed to physical, social and cultural changes leading to psychological strains and traumas? These may include changes in lifestyles and employment.
- Will changes in food supplies lead to possibilities of malnutrition, nutritional deficiencies or toxic effects? These effects may occur because of:
  - introduction of Western-style convenience foods;
  - changes in staple foods—possibly using unfamiliar toxic plants as substitutes for usual foods;
  - contamination of soil or agricultural water supplies with toxic substances;
  - reduced productivity of soils caused by hydrological changes (waterlogging, etc.), mineralisation or pollution of ground and surface waters;
  - reduced productivity of fisheries caused by hydrological changes or water pollution;
  - change in availability of trace metals in soils caused by hydrological changes (lowering or raising of water table etc.).
- Will effluents and emissions, or substances released intentionally into the environment (e.g. pesticides) pollute air or water or soil presenting a threat to human health?
- Will irrigation of fields increase opportunities for human contact with water borne, water based and water related disease?
- Will traffic in the area, and therefore road accidents, increase as a result of the development?
- Will new industries and similar activities attracted to the area by growth, result in pollution of air, soil or water or noise, with subsequent impacts on human health?

B. INDIRECT IMPACTS THROUGH EFFECTS ON DISEASE VECTORS:

- Will new vectors be introduced into the area from upstream as a result of hydrological changes?
- Will new vectors be introduced into the area on vehicles, animals, transplanted plants, soil, etc.?
- Will existing vectors be infected or reinfected by contact with infected humans coming into the area?
- Will the prevalence and distribution of existing infected vectors be changed by changes in the availability of suitable habitats for breeding and survival? These changes may result from hydrological changes (water velocities, temperature, depth, standing water, etc.), morphological changes (bank slopes, cover, etc.), climate changes (rainfall, humidity) and biological changes (vegetation, predators, etc.). They may affect presently infected or uninfected areas.

C. DIRECT IMPACTS ON WORKERS:

- Will migrant workers be exposed to locally endemic diseases to which they have little or no immunity?
- Will migrant workers be exposed to psychological strains and traumas from changes in living and working conditions?
- Will workers be exposed to physical threats to their safety (injuries, deaths) or chemical and physical hazards to health (toxic substances, noise, vibration, radiation, high pressures, etc.)?
- Will workmen be particularly exposed to contact with water and thus with water associated disease during their work?
- Will workmen be exposed to dangerous animals during their work (snakes, scorpions, etc.)?
- Will adequate supplies of food be provided to prevent malnutrition and minimise spread of disease (e.g. by use of itinerant food vendors)?

D. IMPACT ON HEALTH SERVICES:

- Will health and other social services be overburdened with consequent effects on health of residents and workers?

No.	Questions to be considered in Scoping	Yes/No?	Which Characteristics of the Project Environment could be affected and how?	Is the effect likely to be significant? Why?
1. Will construction, operation or decommissioning of the Project involve actions which will cause physical changes in the locality (topography, land use, changes in waterbodies, etc)?				
1.1	Permanent or temporary change in land use, landcover or topography including increases in intensity of land use?			
1.2	Clearance of existing land, vegetation and buildings?			
1.3	Creation of new land uses?			
1.4	Pre-construction investigations eg boreholes, soil testing?			
1.5	Construction works?			
1.6	Demolition works?			
1.7	Temporary sites used for construction works or housing of construction workers?			
1.8	Above ground buildings, structures or earthworks including linear structures, cut and fill or excavations?			
1.9	Underground works including mining or tunnelling?			
1.10	Reclamation works?			
1.11	Dredging?			
1.12	Coastal structures eg seawalls, piers?			
1.13	Offshore structures?			
1.14	Production and manufacturing processes?			
1.15	Facilities for storage of goods or materials?			
1.16	Facilities for treatment or disposal of solid wastes or liquid effluents?			
1.17	Facilities for long term housing of operational workers?			

13

Impact assessment methods

Most common methods

identification, prediction and assessment

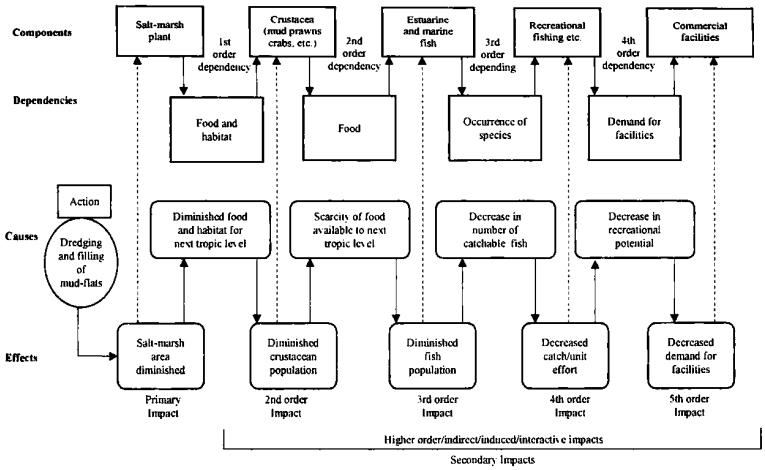
1. Checklists
2. Flowcharts and networks of impacts
3. Overlay of thematic maps | Geographical Information Systems
4. Matrices and interaction diagrams

14

Impact assessment methods

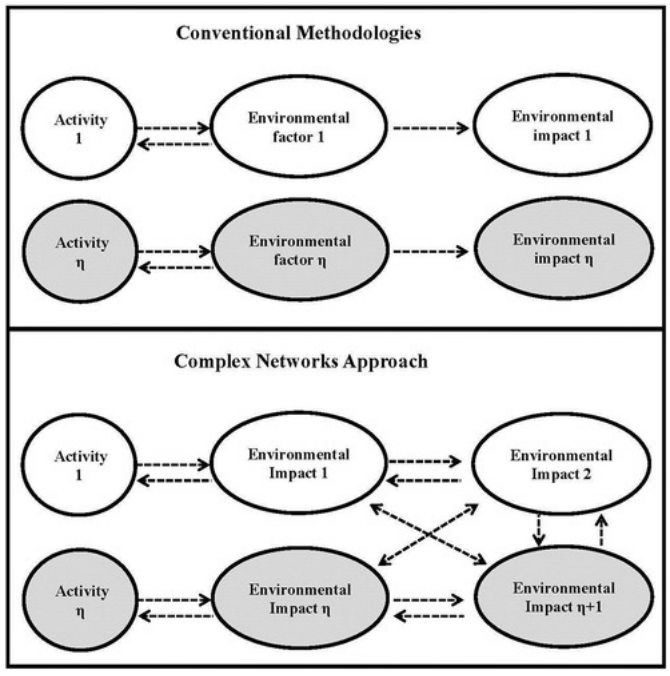
Flowcharts | Networks

Identify the linkages between different environmental impacts (primary, secondary, tertiary ,…, n, impacts) and project activities



15

Impact assessment methods



Source: Martínez et al. (2018)

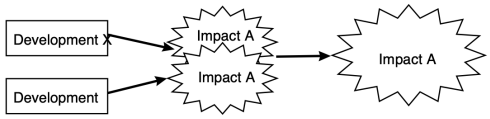
16

Impact assessment methods

Indirect Impacts: Impacts on the environment, which are not a direct result of the project, often produced away from or as a result of a complex pathway. Sometimes referred to as second or third level impacts, or secondary impacts.

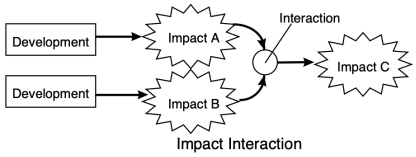
Indirect Impact

Cumulative Impacts: Impacts that result from incremental changes caused by other past, present or reasonably foreseeable actions together with the project.



Cumulative Impact

Impact Interactions: The reactions between impacts whether between the impacts of just one project or between the impacts of other projects in the areas.



Impact Interaction

17

Impact assessment methods

Most common methods

identification, prediction and assessment

1. Checklists
2. Flowcharts and networks of impacts
3. **Overlay of thematic maps | Geographical Information Systems**
4. Matrices and interaction diagrams

CENSE center for environmental and sustainability research

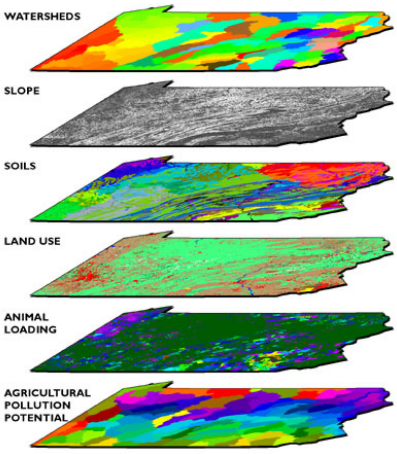
NOVA SCHOOL OF SCIENCE & TECHNOLOGY

18

Impact assessment methods

Overlay of thematic maps | Geographical Information Systems

The overlay approach to impact assessment involves the use of a series of thematic maps to identify and assign relative significance to, and communicate impacts in a geographical reference frame



CENSE center for environmental and sustainability research
NOVA SCHOOL OF SCIENCE & TECHNOLOGY

19

Impact assessment methods

Most common methods

identification, prediction and assessment

1. Checklists
2. Flowcharts and networks of impacts
3. Overlay of thematic maps | Geographical Information Systems
4. **Matrices and interaction diagrams**

CENSE center for environmental and sustainability research
NOVA SCHOOL OF SCIENCE & TECHNOLOGY

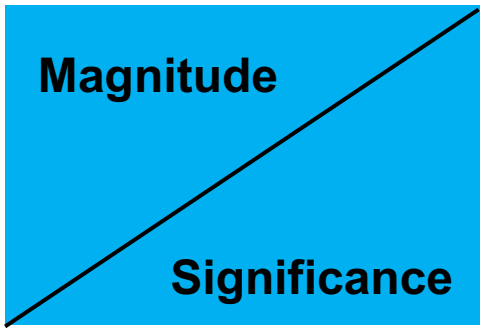
20

Impact assessment methods

Matrices

Based on the Leopold matrix: a qualitative environmental impact assessment method developed in 1971 Leopold et al. for the USGS. It is used to identify and evaluate potential environmental impacts of proposed projects on the environment —

environmental impacts *versus* project activities



CENSE center for environmental and sustainability research

NOVA SCHOOL OF SCIENCE & TECHNO

21

Impact assessment methods

Impact assessment matrix (example)

Figure 4 : Example of matrix for the pulp and paper industry (Leopold method).

Evaluation method: Magnitude / Importance				ACTION												
				RAW MATERIAL PRODUCTION	BUILDING OPERATIONS	WATER SUPPLY	ENERGY SUPPLY	RAW MATERIAL PREPARATION	INDUSTRIAL PROCESSES	GASEOUS EMISSIONS	LIQUID EFFLUENTS	COOLING WATER DISCHARGES	SOLID WASTES TREATMENT	TRANSPORTATIONS	TOTAL
ENVIRONMENTAL / SOCIAL CONDITIONS	PHYSICAL	SOIL	SOIL QUALITY												
			EROSION												
			GEOMORPHOLOGY												
		WATER	RIVERS												
			COASTAL ZONE												
			SUBSURFACE WATER												
			SEA QUALITY												
		AIR	AIR QUALITY												
			ODOURS												
			NOISE												
	BIOLOGICAL	FLORA	FORESTS												
			CROPS												
			WETLANDS												
			SEA-GRASSES												
			RIVER FLORA												
		FAUNA	MAMMALS												
			BIRDS												
			FISH												
			OTHERS VERTEBRATES												
			INVERTEBRATES												
		ECOSYSTEMS	ECOSYSTEMS QUALITY												
			ECOSYSTEMS DESTRUCTION												
	SOCIAL	LAND USES	RURAL												
			FISHERIES												
			URBAN												
			INDUSTRIAL												
			RECREATIONAL USES												
		PATRIMONY	LANDSCAPE												
			HISTORICAL/CULTURAL												
			HERITAGE												
			WILDERNESS QUALITY												
		SOCIAL	POPULATION DENSITY												
			EMPLOYMENT												
			HAZARDS												
	TOTAL														

Source: FAO

CENSE center for environmental and sustainability research

NOVA SCHOOL OF SCIENCE & TECHNOLOGY

22

Impact assessment matrix (example)

Environmental Factors	Project Actions: Excavation	Construction	Waste Disposal	Transportation
Air Quality	3, -2	4, -3	5, -4	3, -2
Water Resources	2, -1	3, -2	4, -3	2, -1
Soil Quality	4, -3	5, -4	3, -2	2, -1
Wildlife	2, -1	3, -2	4, -3	2, -1

(*numbers represent examples magnitude and significance of impact e.g., "5, -4" means high magnitude and significant negative impact.*)

Part of a more detailed impact prediction matrix: UK National Forest

Environmental effect	*Policy importance of issue*	*Extent of effect*	*Scale of effect*	*Probability of effect occurring (at any scale/extent)*	*Scope for further mitigation or enhance-ment*
Positive					
Employment creation	Regional	Extensive, beyond forest	++	Certain	Good
Employment effect on timber support industries	District	Extensive, beyond forest	+	Likely	None
Negative					
Employment effect of pest increases	District	Localized effects, but across the whole forest	0	Remote	None

Source: Land Use Consultants (1994)

Impact assessment methods

Most common methods (2/2)

identification, prediction and assessment

- Expert judgment
- Similar cases
- Models: quantitative physical, visual, and mathematical models
- Laboratory and *in situ testing*, e.g. ecotoxicology tests
- Indicators and Indices, e.g. Battelle Environmental Evaluation System
- Cost benefit analysis
- …

CENSE center for environmental and sustainability research

NOVA SCHOOL OF SCIENCE & TECHNOLOGY

25

III. Final remarks

26

III. Final Remarks

- The selection of appropriate impact assessment methods is **crucial**
- Each method has **its strengths and limitations**, making it essential to combine multiple approaches for a **more integrated assessments**
  - Qualitative methods (e.g., expert judgment, checklists, flowcharts)

    provide structured yet flexible ways to identify potential impacts but may introduce subjectivity.
  - Quantitative approaches (e.g., mathematical models, GIS overlays, cost-benefit analysis)
    - enhance precision and comparability, though they require reliable data and technical expertise.
  - Hybrid techniques (e.g., matrices, indicators, and indices)

    help bridge the gap between descriptive assessments and numerical evaluation, offering a balanced perspective on environmental effects.

27

III. Final Remarks

Ultimately, selecting the right **combination** of methods depends on project, plan or programme

- Relevancy

  Including scientific/technical robustness and reliability
- Feasibility
  - complexity
  - data availability
  - cost and resource efficiency
  - …
- Communicability/understandability
- Stakeholder Involvement

  (the extent to which different actors can participate and provide input into the assessment process)
- Regulatory requirements

  (it is not very common)
- …

Ensure a scientifically sound and decision-supportive impact assessment process.

28