Overview

A steady increase in reporting on environmental trends and performance during the past decade reflects a broad societal need for strengthening the evidence base for policy making. We also see a growth in systems for collecting and analysing data about the environment and human well-being at local, national, sub-regional, regional and global levels. Interest in fine tuning monitoring and data collection systems to reflect the real needs of society and decision-makers is now part of the mainstream.

At some point during the process of developing your integrated environmental assessment (IEA), you will need to collect, process and analyze data. As you begin, you will need to know essentials about data collection including selecting the most appropriate and reliable types and sources of data and how to collect, store and analyze your data. This module addresses these issues, with particular focus on statistics and spatial data collection, analysis and the use of tools such as the GEO Data Portal and regional data portals to support IEA.

With data in hand, the next step will be to convert the data into a meaningful form that can be used during decision making processes. Indicators and indices help us package data into a form that speaks to a relevant policy issue. You will learn the basic building blocks of indicators and indices, including frameworks, selection criteria, and elements of a participatory indicator selection process. The module outlines these elements, and includes examples of indicators, including the GEO core indicator set.

Once you have developed indicators, you will need to derive meaning from them. What trends, correlations, or spatial relationships are revealed through the data? To answer these questions, you will need familiarity with various non-spatial and spatial analysis techniques.

A common theme running through this module is the importance of participatory processes. Understanding which stakeholders and experts need to be involved in the process, and when and how is essential because what we choose to measure reflects our values. A participatory process also provides an opportunity for change, as society seeks to improve what gets measured.

A second theme is the importance of reliable data and well-chosen indicators. This is critical to the process, because poor information can lead to poor decisions. At the same time, information needs to speak to the intended audience in a relevant way; otherwise, the most of the well-developed indicators could have only limited impact.

Through a series of presentations, examples and exercises, this module will provide you with a number of tools and techniques necessary to complete the data collection and indicator development aspects for an IEA.

Course Materials

1. Introduction and learning objectives

Relevant and accessible information based on sound knowledge and facts is a cornerstone of integrated environmental assessment. Without a strong evidence base government, civil society and the public at large are not in a position to make informed decisions that take essential environmental and human well-being issues into account.

By the time you begin to develop data and indicators, you will likely have gone through the processes of planning the IEA, identifying lines of responsibility, clarifying key issues and identifying target audiences. Data development is an integral part of the implementation of integrated environmental assessment.

This training module is a practical guide to information tools, with emphasis on monitoring, data and indicators. Key concepts, techniques, benefits and constraints are explored in areas of monitoring, data collections, indicator and indices and analysis, through readings, exercises and examples. At the end of this course you will:

- understand the roles and uses of data, indicators and indices in integrated environ-mental assessment;
- know how to develop strategies for collecting and validating data;
- understand how indicators and indices are developed and used;
- be able to analyze indicators and indices based on outcomes; and
- be able to communicate and present statistical and map-based data visually.

2. Developing data for integrated environmental assessment

The flow of data in the IEA process as a means to influence decision making is shown in Figure 1. Given that data have an important role in decision making, it is critical that the data and indicators you use and develop are reliable and scientifically sound, relevant to your audiences and easily understood.

Understanding environmental issues, their causes and impacts on humans and ecosystems, and the effectiveness of current policy solutions is inherent to the scientifically sound reporting of information. Monitoring and observation will provide you with the information you need to begin the substantive part of the assessment process.

While “data” consists of detailed neutral facts, indicators and indices are selected and/or aggregated variables put in a policy context, connected to an issue identified in the IEA process and ideally also a policy target. A limited number of variables are selected from a wealth of observed or measured data sets, based on relevance of the variables to major issues and general trends. Indicators become signposts to inform policy actors and the public in a way that make thick volumes of detailed statistics and other data on the state and trends of the environment more accessible for decision making purposes.

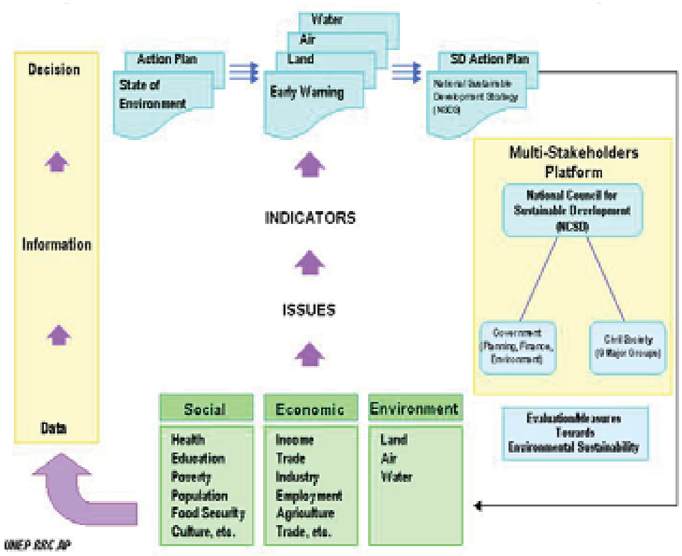


Figure 1: Framework of environmental data flows (UNEP Regional Resource Centre for Asia and the Pacific, 2000)

In order to use data and indicators for measuring performance, we need to identify reference points related to desired results. These reference points can be very generic and qualitative or, preferably, quantitative and time bound. The more specific the reference points, the easier it is to assess performance. For instance, we can monitor progress towards a target set for nitrate concentration in drinking water. Ideally, these targets or reference points are established through a science-policy dialogue, and become an organic part of policies adopted by government. The identification of climate change targets in the Kyoto Protocol underline both the necessity but also complexity and pitfalls of selecting targets and using them to implement programs and monitor progress.

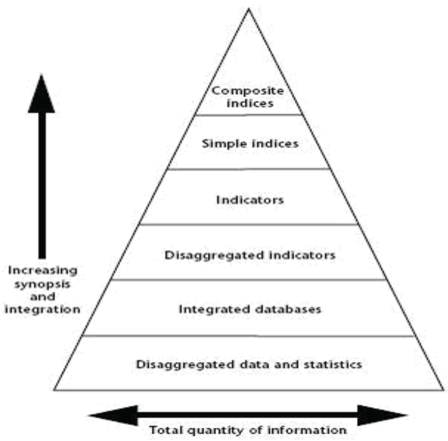


Figure 2: Relationship between Data, Indicators and Indices
Source: Australia Department of the Environment, Sport and Territories 1994

You can combine multiple indicators to form an index. Indices provide simple and high-level information about the environmental or social system or some parts of it. Indices may also be tied to a policy or society target. As shown in Figure 2, a gradient moves from data to indices resulting in increasingly aggregated data. At higher levels of aggregation, it is easier to see broader patterns, while indicators can pinpoint specific trends and performance. As an analogy, it is easier for us to see patterns when looking at the whole forest than when looking at a single tree. In real life indicators and indices are often used side by side and can form an integrated information system.

Box 1: Definitions: Environmental Monitoring, Data, Indicators, Indices and Information Systems

- Monitoring: Activity involving repeated observation, according to a predetermined schedule, of one or more elements of the environment to detect their characteristics (status and trends) (UNEP 2002).
- Data: Consists of facts, numerical observations and statistics that describe some aspect of the environment and society, such as water quality and demographics (Abdel-Kader 1997). A basic component of indicator work, data needs to be processed so that it can be used to interpret changes in the state of the environment, the economy or the social aspects of society (Segnestam 2002).
- Indicator: Observed value representative of a phenomenon to study. Indicators point to, provide information about, and describing the state of environment with significance extending beyond that directly associated with the observation itself. In general, indicators quantify information by aggregating and synthesizing different and multiple data, thus simplifying information that can help to reveal complex phenomena (EEA 2006).
- Indices: Combination of two or more indicators or several data. Indices are commonly used at national and regional levels to show higher levels of aggregation (Segnestam 2002).
- Information systems: Any coordinated assemblage of persons, devices and institutions used for communicating or exchanging knowledge or data, such as by simple verbal communication, or by completely computerized methods of storing, searching and retrieving information (GMET-MHD).

2.1 Importance of Process

While data, indicators and indices have value in and of themselves, this value can be significantly strengthened by the process you use to develop them. A participatory approach can be used when developing an IEA in general and its data and indicator components in particular. Involving experts and stakeholders in identifying, developing and interpreting data or indicators not only strengthens their relevance and understand ability, but also their actual use in decision making.

A larger number of issues may come up during a stakeholder IEA process .You might find it useful to use a set of criteria to narrow down the issues, using criteria such as the following:

- Urgency and immediate impact
- Irreversibility
- Effects on human health
- Effects on economic productivity
- Number of people affected
- Loss of aesthetic values
- Impacts on cultural and historical heritages

Similar to the process of identifying and selecting key issues, obtaining and analysing data, developing indicators and indices involves making decisions about what to measure and include. Due to constraints in resources, not everything that we want to measure or analyze can be included in the assessment process. A participatory approach may help you narrow down the list of indicators by ensuring that the ones selected are relevant, reliable and understandable. A participatory approach also engages people in the process, which can lead to shared responsibility for the state of our environment and society, leading to greater possibility for change. It is useful for us to consider who needs to be involved, and when and how to include them. Experts, stakeholders and policy-makers are general categories of critical actors in the process

Within the context of collecting data and developing indicators, you may find it useful to identify the following:

1. Who needs to be consulted when collecting data and developing indicators?
2. What are the most appropriate levels of participation for each group or individual?
3. What are the most relevant stages of the process for including stakeholders?
4. What are the most efficient and effective mechanisms to include various people in the process, given available resources?
5. How will input from those consulted be used and reported?

DISCUSSION QUESTIONS

1. In pairs, reflect on a participatory process that you led or were involved in that had successful elements. Use the following questions to help focus your discussion.
   - Why was using a participatory approach in the project important?
   - When in the project was a participatory approach used?
   - What were the main techniques?
   - What parts of the process worked well?
   - What were some of the challenges? How were these challenges overcome?
2. In plenary, ask people what they noticed or learned from their conversations. Then, ask them to describe features of the project that worked well.

3. Information Systems

Data, indicators and indices form an interlinked information system. While these elements are all related, developing them involves specific tasks that are different. The following section will provide you with an overview of some of the key conceptual issues and methods in developing data for use in indicators and indices.

3.1 Data

Data provide you with useful information that can be processed into a more readily accessible form for use by policy-makers and decision-makers. Data can be linked to important societal issues when the data are placed in the context of a relevant issue.

- Data on the increase in number of patients with the respiratory disease can mak you explore the information on where something is wrong with the quality of the air.
- Data on the increase in the number of cars in urban centres can provide estimations on the magnitude of air quality-related problems.
- Data on the changes in quantity of use of different kinds of fuel for indoor household use (e.g., cooking, heating) can help identify health-related problems.
- Change in the composition of solid waste in past 10 or 20 years can clearly indicate the trends of emerging issues (e.g., electronic waste in China and India).

3.1.1 Types of data

Environmental monitoring is typically involves "hard" science although there are also an increasing number of examples of non-expert (community, youth) involvement. Quantitative indicators and data, usually based on statistics or remote sensing and presented numerically in tables, graphs and maps, serve as the main foundation of environmental assessment and subsequent decision making by policy-makers, civil society and the public at large.

A. Qualitative Data

Besides the growing number of initiatives focused on quantitative measurement, there is also increasing interest in keeping track of qualitative ecological and socio-economic attributes that help provide a more holistic picture. Not everything can, or needs to be, quantitatively measured, so quantitative data could miss critical elements. Looking only at quantitative data and nothing else could lead to someone believing that the problem is understood in great detail, which may not always be true. There is a growing sense that environmental assessments could be strengthened by drawing on a wider range of information types and sources, and might be at their best when numerical, technical "hard" data are combined with socially-derived information that more relate to the practical "real-world" dimension of the environment.

Although socially-derived, experience-based information can be turned into quantitative, empirical data and scientifically scrutinized, it is usually gathered using qualitative methods and sources. This can be done, for example, through methods such as:

- field observations;
- interviews with people who live in and have direct experience with local environments; and
- narrative, descriptive, oral histories and interpretive sources on issues such as how much water each household uses in a day, how many cars there are per household and who gets to use them, how people cope with changing environmental conditions, as well as opinions on environmental policy priorities, disaggregated by race, gender, age or ethnicity.

Qualitative information can complement numerical data and physical indicators by:

- broadening of the scope of environmental inquiry to include people's experiences, perspectives and perceptions;
- making use of critical environmental information long before it shows up on the scientific or public radar;
- integration of certain indigenous or other groups into formal environmental discussions and decision making; and
- acknowledgement of the fact that human responses to environmental conditions are often based on perception rather than externally-validated facts.

Working with qualitative information poses many challenges in terms of validation, verification, reliability and comparability. For example, individual narratives or small-scale observational field notes can produce highly idiosyncratic and unreliable information. Local and subjective knowledge may not be comprehensive, reliable or correct. People's perceptions and memories can be distorted, and interviewers' interpretations of what is said can be skewed.

It is a challenging task to integrate qualitative and quantitative information into a holistic view of the state of the environment. Scale problems often mean that scientific assessments and experiential "bottom-up" information are not really examining the same environmental area or problem. Furthermore, it can be difficult to reach across the multiple variations in the form and presentation of information: scientific information often can be presented in a series of data tables, while qualitative information may require long narratives and nuanced interpretation.

Addressing these issues and figuring out how to integrate "hard" quantitative data and "soft" qualitative information in a science-based assessment is increasingly challenging when it is recognized that both approaches can complement each other and together enrich assessment results.

A growing number of case studies point to the successful combination of technical-scientific and social science approaches to environmental assessment. Several governmental and inter-governmental agencies are developing capacity for integrating these approaches. In the end, the goal may not be to "integrate" these apparently different forms of environmental information, but rather to make use of their complementarity. Side by side, these different kinds of environmental data and information can offer a broader field of vision than either does alone.

DISCUSSION QUESTION

The following discussion question is intended to identify potential sources of qualitative data, as well as explore other aspects of collecting this type of data.

Scenario: Part of your assessment includes a segment on water quality. In addition to using available water quality measurements from monitoring stations, you have decided to incorporate qualitative data into your research because you would like to have a better understanding of local perceptions and experiences related to water quality for the region in which you are working. What might you ask community members in order to understand their perceptions about water quality? Consider different segments of the community, such as local, indigenous community members, non-profit groups, local policy-makers, children, youth and the elderly.

Materials: Worksheet listing including blank spaces for adding others.

Alternative questions.

- What has been your experience with collecting and using qualitative data?
- What practices or approaches have worked well?
- How did you use this data in your assessment?
- What are some of the challenges in collecting, using and presenting qualitative data?

B. Quantitative Data

Quantitative data provide “raw material” for indicator and index development[1] . They are the primary, raw output of monitoring and observation systems, surveys and other forms of data collection, and normally require analysis to be meaningful to the wider audience.

Characteristics of quantitative data may include:

- generally have geographic locations (coordinates);
- are often large in volume (databases, reports, etc.);
- come from a variety of often heterogeneous sources ;
- have variability of resolution (details) and scales that sometimes hamper their compilation and integration;
- have a high degree of complexity;
- are needed at varying temporal frequency (e.g., hourly, daily, monthly, yearly), depending on the phenomena or subject under consideration;
- are available in varying forms and formats; and
- more and more available in digital or electronic versions.

Generically, data are categorized as bibliographical materials (including descriptive texts and reports), statistical tables, maps and remotely sensed data (World Bank, 1992) but they can come in many forms such as:

- maps;
- remotely sensed data such as satellite imagery, aerial photographs, or other forms of data;
- computer data files;
- reports and documents;
- bibliographies;
- videos and films;
- graphs and charts;
- tables;
- computer animated images; and
- drawings.

All assessment processes ultimately depend on data, but very few have the mandate, resources and capacity to collect primary data, so they rely on monitoring and data collection efforts by others. Therefore, compiling data for assessment usually requires that you obtain data from other sources, usually many different ones, both in terms of statistical (non-spatial) and spatial data.

[1] In general, for data is understood a representation of facts, concepts, or instructions in a formalized manner suitable for communication, interpretation and processing by human or automated means (Rosenberg, 1987).

Non-Spatial Data

Non-spatial data are collected for one particular point and result in a single number. Often, multiple data points for the same parameter are averaged so that a single value is obtained to represent a collection of spatial units. Non-spatial data can have temporal resolution if they are collected continuously over a period of time from a specific geographical point. You can obtain non-spatial data from statistical sources or isolated research. Statistical sources use the same methodology for multiple data, so that they can be statistically compared and averaged. Isolated research, while valuable, often does not provide the breadth you will need for analysis at broader levels.

Spatial Data

Spatial data, also referred to as geospatial data or geographic information, can most simply be defined as information that describes the distribution of phenomena and artifacts upon the surface of the earth. It is information that identifies the location and shape of, and relationships among, geographic features and boundaries, usually stored as coordinates and topology (i.e., the way in which geographical elements are related and linked to each other).

Spatial data are often displayed as layers of data one on top of the other, similar to a giant sandwich, where each layer is a related set of spatial data. Anything that has a geographic location on the Earth can be displayed as spatial data, including country statistics. Spatial data have become a major resource in environmental analysis and reporting, and present a very immediate and visual message regarding environmental issues and management.

Examples of "layers" you might use are:

- aerial photography
- satellite imagery
- country boundaries
- local administrative boundaries
- streets
- cities
- utilities
- protected natural areas
- habitat regions
- lakes and rivers
- elevation contours
- climate data
- soil layer data
- wildlife populations

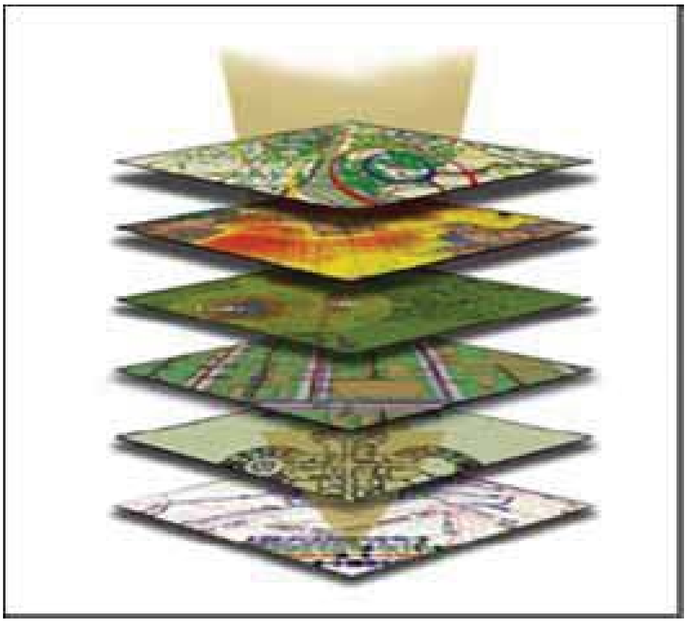
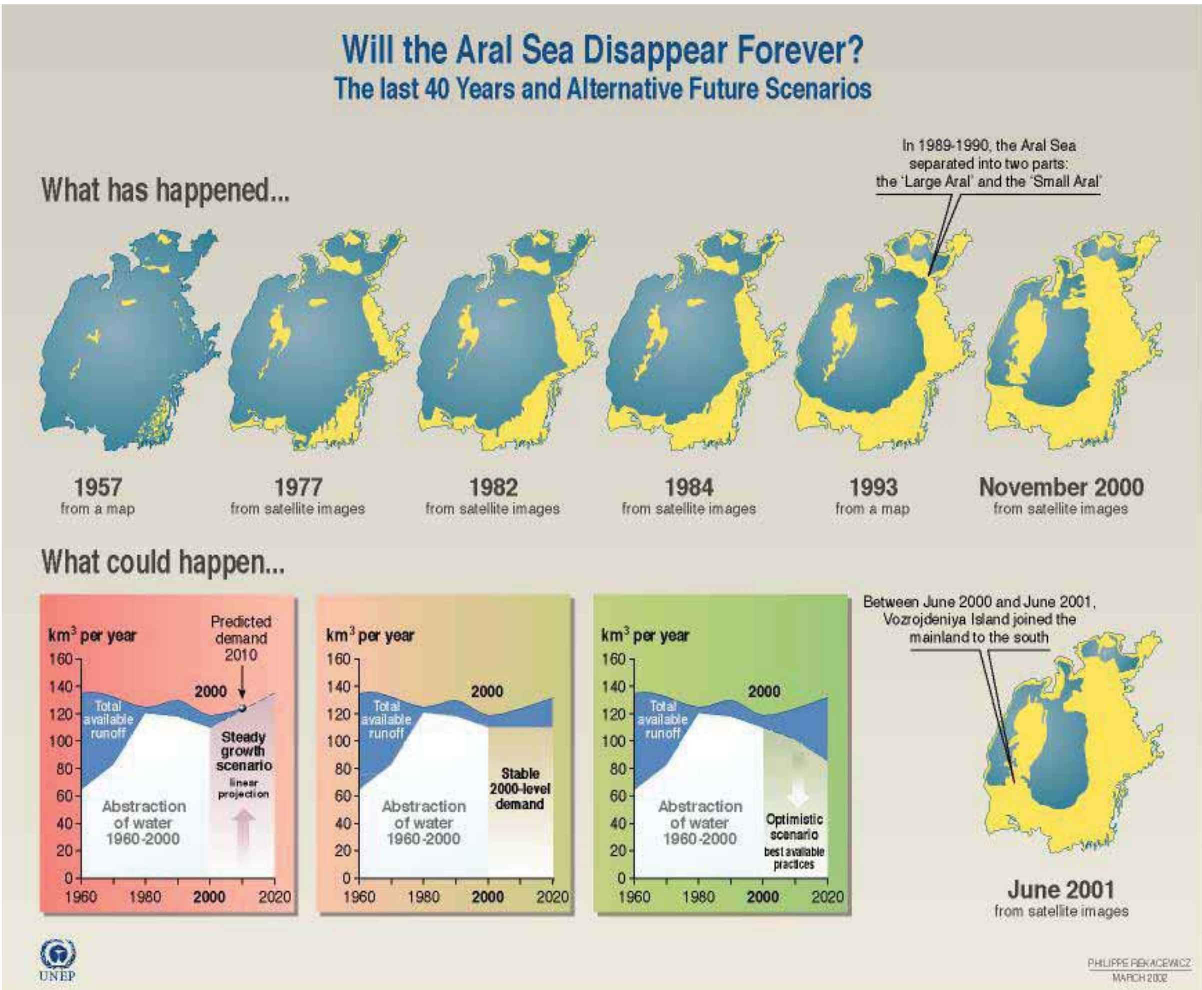


Figure 3: Layers of Spatial Data

You can also link additional non-spatial data, in the form of databases of information, to these spatial data layers by their common coordinates, and analyse and present them alongside spatial data layers. Climate data from different provinces or states in a country for example, could be linked to a provincial or state boundary layer, analysed and displayed in a spatial form, and produced as maps.

EXAMPLE: Case Study of Disappearing of Aral Sea from Central Asia

Figure 4 , shows that spatial information about the disappearing of the Aral Sea's water from 1957 to June 2001, in which water body and the dried portions are distinctly depicted in two colours. In this map the quantitative data is skillfully analysed and presented as three scenario of water availability in the graphs depicted below (Figure 4).



Sources: Nikolaï Denisov, GRID-Arendal, Norway; Scientific Information Center of International Coordination Water Commission (SIC ICWC); International Fund for Saving the Aral Sea (IFAS); The World Bank; National Astronautics ans Space Administration (NASA); United States Geological Survey (USGS), *Earthshots : Satellite images of environmental change*, States Department of the Interior, 2000.

Source: http://maps.grida.no/go/graphic/aral_sea_trends_and_scenarios

Figure 4: Disappearing of the Aral Sea in central Asia

The demise of the Aral Sea was caused primarily by the diversion of the inflowing Amu Darya and Syr Darya rivers to provide irrigation water for local croplands. Figure 4, graphics show the disappearance of the Aral Sea from 1957 to 2000 in which water body and the dried portions are distinctly depicted in two colour; three possible scenarios show the relationship between future demand (and thus water abstraction) and future available runoff in cubic kilometres per year. The scenarios cover the time period from 2000 to 2020. They explain as to what may happen if water abstraction and the demand for water continue to increase,