Module 4: Monitoring, Data and Indicators

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.

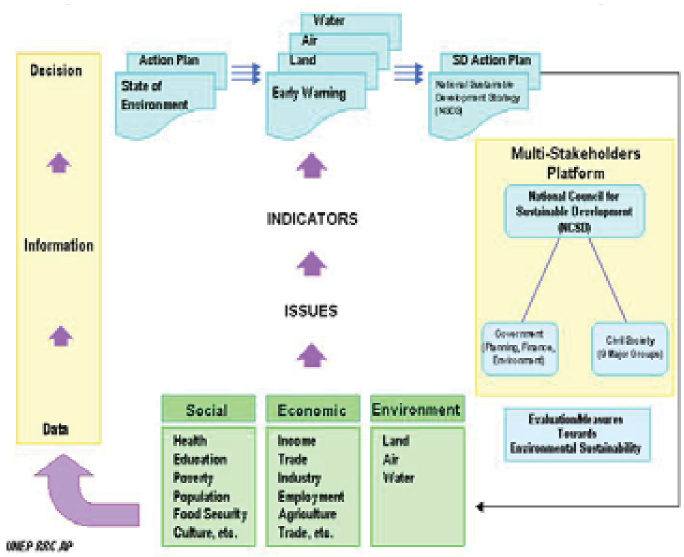


Figure 1: Framework of environmental data flows (UNEP Regional Resource Centre for Asia and the Pacific, 2000)

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.

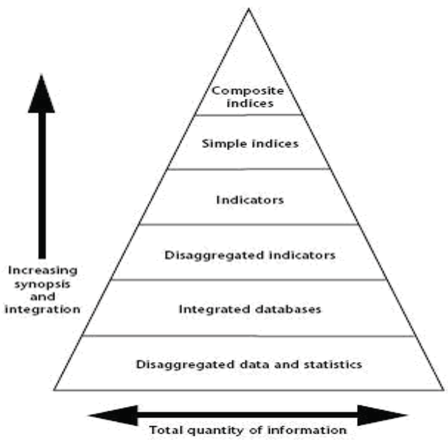


Figure 2: Relationship between Data, Indicators and Indices
Source: Australia Department of the Environment, Sport and Territories 1994

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

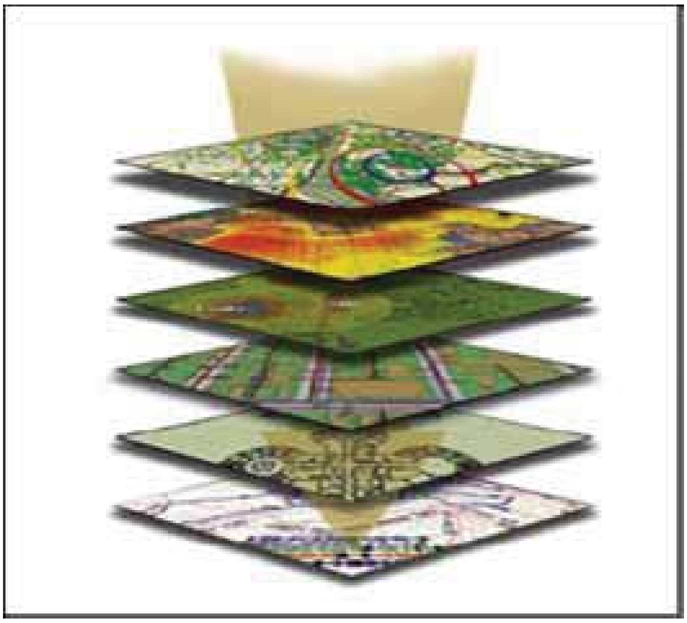
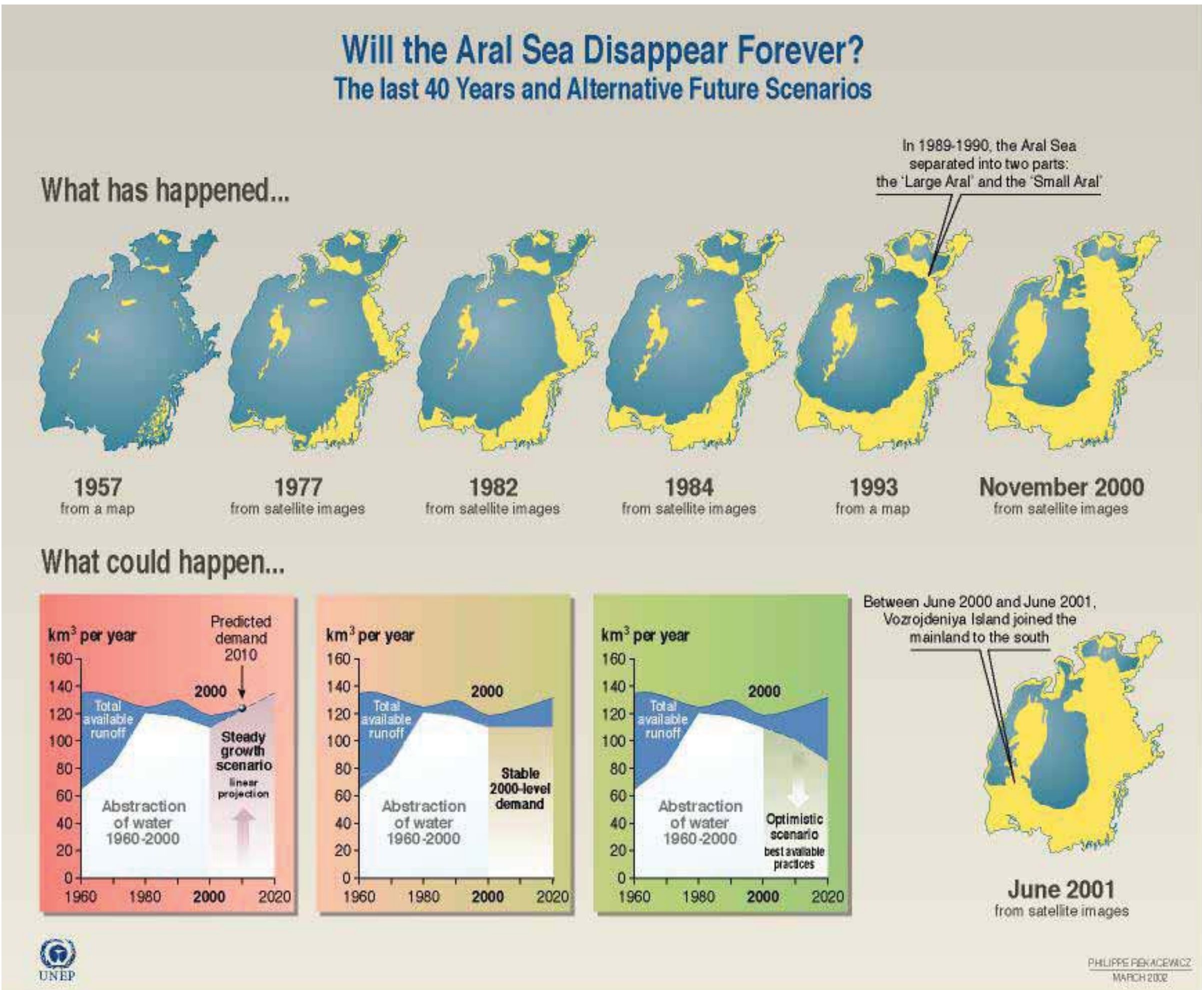


Figure 3: Layers of Spatial Data

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, what may happen if they remain the same as they were in the year 2000, and what may happen if they decrease. In this map the quantitative data has been presented through three plausible scenarios of water availability in the region (UNEP/GRID Arendal, 2002).

Remotely Sensed Data

Remotely sensed data are useful when ground level data are difficult to acquire, such as when the area is difficult to access, or the areas of interest cross country boundaries. In other cases, it is useful when the cost of acquiring ground-based data for extensive areas, for which SoE reports are often required, is beyond the means of many governments and organizations. For these cases, remote sensing provides a partial solution for data acquisition for SoE reporting. But even for areas where conventional methods have been used to acquire data, remote sensing provides many added advantages.

Box 3: Remotely Sensed Data

- Provide a unique perspective from which to observe large regions.
- Sensors can measure energy at wavelengths which are beyond the range of human vision (ultraviolet, infrared, microwave).
- Monitoring is possible from nearly anywhere on earth.
- Remotely sensed images provide good "pictures" for convincing the public and decision makers to participate in discussions on issues of importance that may not be part of their daily life.
- Used to monitor long-term changes.
- Readily integrated into GIS.

How is remote sensing useful for IEA?

Remote sensing is particularly useful for environmental monitoring and reporting because it provides a unique overhead or "bird's-eye" perspective from which to observe large areas or regions. Because of this, it can be used for management and planning in large local areas, and for monitoring the progress of ongoing projects. In many cases, these data collection can offer proof of progress towards success of projects that are a result of policy decisions designed to improve the state of the environment. Such data may be essential for further investments.

Another merit of remotely sensed data is that they are often available on a repetitive basis. This type of time series data is extensively used to monitor changes in the environment over long periods (examples in Box 4). This is particularly important for SoE reporting in very rapidly changing environments.

Types of Remotely Sensed Data

Satellite Imagery

Satellite imagery is digital information obtained from sensors carried in satellites, and includes data both in the visible and non-visible portions of the electromagnetic spectrum (i.e., optical, thermal, radar). Satellite imagery is available from several sources from around the world (i.e., Landsat, SPOT, Quickbird, Envisat, ERS, IRS, Radarsat, NOAA, ASTER), and from numerous companies that process and distribute satellite data products. One of the benefits of satellite imagery is the ability to capture multispectral images (i.e., images in two or more spectral bands, such as visible and infrared). These images provide a unique resource for people who work in agriculture, geology, hydrology,forestry, regional planning, education, mapping and global change research.

The multi-date satellite imagery shown in the Figure 5 provides the pattern of drying up of the Aral sea between 1977 and 2006.

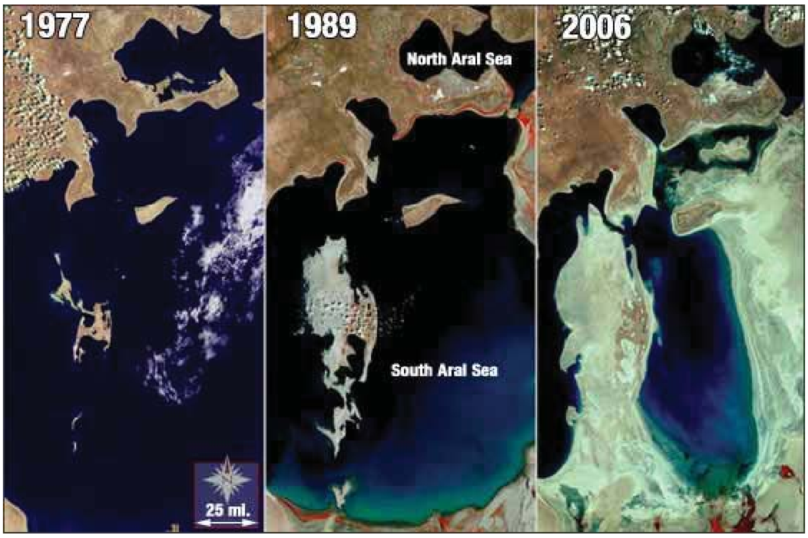


Figure 5: Temporal imagery of Aral Sea taken 1977, 1989 and 2006

Source: http://epod.usra.edu/archive/epodviewer.php3?oid=352352

Aerial Photography

Aerial photography consists of images taken of the Earth's surface from a camera on an airplane flying at a relatively low altitude. Depending on their purpose, aerial photographs are taken in black and white, colour, and/or infrared. For example, simple planning or navigation may only require black and white photography, while vegetation studies require infrared in order to distinguish among landforms based on infrared heat signals. Similar to remote sensing, aerial photography provides a unique overhead view of an area, and can be used to acquire data on local areas without the observer being in direct contact.

Aerial photography has several benefits over satellite imagery; one is that it provides a much higher resolution of an area, allowing you to get a very close-up and detailed picture of a fairly small feature on the Earth's surface. With the necessary corrections for distortion and processing, aerial photographs are powerful tools for studying the earth's environment. Acquiring aerial photography for an area is much more expensive than obtaining satellite imagery.

DISCUSSION QUESTIONS: Spatial Data in Environmental Reporting

Option 1. - Discussion

Working in small groups, discuss how you have personally used spatial data, as well as data combinations including spatial data, in your profession, or how you have seen it used.

For Example: You may have at some point used a satellite image of your country as a base layer with an overlay showing regional boundaries. You may have then linked data, such as a climate database, to the map to show average precipitation for each region across the country.

Provide examples of any environmental monitoring or reporting you may have done, and whether or not spatial data were used for this reporting.

Choose someone in your group to record aspects of the stories collected, including what worked and what could be different.

Option 2. - Questions to discuss:

What are the benefits of spatial data?

Identify an environmental problem or concern. What kind of spatial data could you use to help understand and communicate the issues involved?

What are some of the challenges you might encounter when using spatial data?

Spatial Data and the Internet

The Internet has become a major source of data used for assessment and reporting. There is an unprecedented amount of free environmental and socio-economic data on the Internet, and more and more websites also allow the exploration of the data through online mapping and/or statistical analysis (see Box 4 for some current examples of available sources). In addition, there are many online national, subregional, regional and global data and map services available that are fairly simple to use with most Internet browser programs, and this has become a very effective way to communicate images, maps and other types of datasets to potential users without the need to acquire and run specialized computer software. UNEP Geo Data portal, ekh (environment Knowledge Hub for Asia-Pacific) and M-eKH portal(Mountain environment Knowledge) are some of the authoritative international sources of data available to the assessment community, while offering at the same time various possibilities to look at the data online by means of maps, graphs and tables.

Box 4: Examples of Monitoring Systems

National-regional data sources

- UNEP Environment Knowledge Hub (eKH) (http://ekh.unep.org/)
- ICIMOD: Mountain Environment Knowledge Hub (http://menris.icimod.net/)
- Regional 3R Knowledge hub on Waste management (http://www.3rkh.net/)

International data collecting sources

- OECD has developed solid environmental data collection systems. OECD Environmental Data Compendium and Environmental Indicators reports are published in book format every two years.
- UN Regional Commissions are collecting environmental data from countries at the regional level, sometimes in cooperation with UNEP.
- UN Statistical Division collects country data in cooperation with UNEP and coordinates with similar surveying by OECD and Eurostat, into account data collection activities by other organizations such as FAO, UNFCCC and GEMS-Water. (http://unstats.un.org/unsd/default.htm)

Some major multilateral environmental agreements that have prompted data reporting:

- Ozone depleting substances (Vienna Convention and Montreal Protocol, http://ozone.unep.org/)
- Greenhouse gas emissions (UNFCCC, http://unfccc.int)
- Hazardous waste movements (Basel Convention, http://www.basel.int/)
- Long-range transboundary air pollution (CLTRAP, http://www.unece.org/env/lrtap)

Global Environmental Observation coordination – in-situ and satellite remote sensing

- Global Observation Systems include land, oceans and climate (GTOS, GOOS, GCOS, together labelled G3OS, see http://www.gosic.org/), guided through an Integrated Global Observing Strategy (IGOS) and supported by the IGOS Partnership (http://www.igospartners.org/).

Global Earth Observation initiatives

- Committee on Earth Observation Satellites (CEOS, http://www.ceos.org/)
- United Nations Office of Outer Space Affairs (UNOOSA, http://www.unoosa.org/)
- Global Earth Observation System of Systems (GEOSS, http://www.epa.gov/geoss/)

3.2 Monitoring and Data Collection of Environmental Trends and Conditions

Monitoring provides you with tangible information on a regular basis over an extended period of time about past and present conditions of the environment. In addition to environmental information, monitoring systems also collect social and economic information that is relevant for understanding environmental issues. A monitoring system may be developed for a number of objectives, such as (ADB 2002):

- assess the quality of the environmental situation, and enhance public awareness;
- determine compliance with national or international standards;
- assess population exposure to pollution, and the impact on human health;
- identify threats to natural ecosystems, and develop early warning systems;
- identify sources of pollution and estimate pollutant loads;
- evaluate the effectiveness of pollution control measures;
- provide inputs for environmental management, traffic management and land-use planning;
- support the development of policies, determination of environmental priorities, and other managerial decisions; and
- support the development and validation of managerial tools (e.g., database models, expert systems and geographic information systems).

In addition to the above, monitoring can be used to evaluate the performance and effectiveness of policies implemented and actions taken. Monitoring data should not be used alone, however, as differences in national priorities and environmental circumstances influence various aspects of a monitoring system. These factors might include financial resources and human resource skills.

Monitoring and observation takes place at various levels, including community, regional, national, global and outer space. As it is usually not feasible to set up a dedicated monitoring system, particularly in the context of a GEO-type assessment, it is important that monitoring systems have an institutional base that builds on data using multiple methods from multiple sources.

At the national level, data are usually collected by the central bureau of statistics or equivalent office, and/or by certain ministries (e.g., environment, land, water, agriculture) who run networks of measurement stations and undertake statistical surveys.

International, national and regional monitoring system data are often used in compilations and databases. National monitoring systems are sometimes able to draw on data from both the regional or ecosystem level and international sources, such as statistical compilations of data from UN or other international agencies. International satellite observation systems often provide valuable information as well. At the same time, international organizations often use data collected at national - and sometimes regional - levels to compile global databases. Thus, in practice the data collection and dissemination flows can be quite complicated. Over the years, several global observation programmes have been initiated to harmonize, support and improve basic data collection efforts, and make them useful and available for the users, including scientists, governments, civil society and the public at large. (See Box 4.)

While a number of monitoring and data systems are available, there still remains a shortage of comprehensive, harmonized, high quality data that are readily available for analysis of environmental issues. This holds true for issues such as renewable energy, waste disposal and processing, land and coastal degradation, water consumption or deforestation. When limited to those environmental indicators for which there are sound, regular, country statistics available, one arrives at a small set of broad indicators, such as those contained in the Millennium Development Goals under Goal 7: Ensure environmental sustainability (http://www.un.org/millenniumgoals/).

Thus, coordination among international monitoring and data systems still presents challenges and opportunities in the IEA context. From the IEA side, a contribution to the improvement of data availability can be made by identifying the most important data gaps, and providing feedback to monitoring and observation programmes.

When selecting the type of monitoring system to use, you will also need to consider cost implications. For example, differences in cost between on the ground and remote monitoring can be significant. On–the-ground monitoring is more costly, as it involves measuring stations, questionnaires and other forms of collecting data.

3.3 Data Collection/Data Compilation

Though challenging, collection of high-quality data is an essential part of the IEA. You can approach initial decisions about what data to collect and how to collect it in a couple of different ways. You may begin by conducting a survey of available data prior to scoping thematic issues for the assessment. Availability of data then becomes a criterion for selecting data and developing indicators. Alternatively, you may use a more targeted approach, where priority areas are identified first, followed by data collection. In this case, if data are not already available, you may need to collect them, although you may be constrained by cost and time availability.

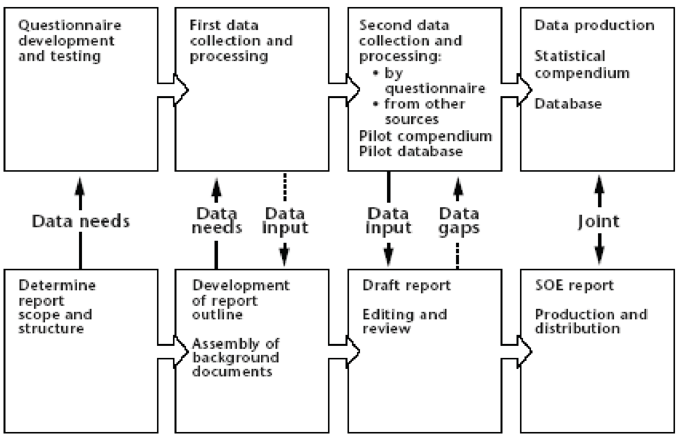


Figure 6: Links between Database and Report Development in OECD Countries (as quoted in UNEP/DEIA 1996)

Once you have decided on the approach you will use for data collection, you will need to further develop a plan that includes elements of developing research methods, defining the type of data needed, and prioritizing which data must be collected. You will also need to specify data sources, and have a clear sense of the quality of the data. The steps involved in obtaining data and building a database go hand in hand with developing an assessment report (Figure6).

Quality of data and precision of measurement are important considerations during data collection. “Perfect” data are not always necessary, but data quality must be sufficient to satisfy the objectives. Imperfect approximations (proxies) might be used in case no direct data can be obtained. Well-known examples of this are the use of CO2 emissions to show climate change, or of protected areas to indicate biodiversity. Although different opinions exist as to whether it is better to have poor data rather than no data at all, the general notion is that environmental assessment is to be based on the best available, scientifically sound data from widely recognized sources.

Once the basic data are selected and collected, usually you will need to compile and store them in a dedicated database, which might be also made available on the Internet. A database is an organized collection of data that is used to bring together all information about the state and trends in the environment, and may also include information about environmental policy, references to other data sources and to current research. It is important to ensure the database has continuity, and is kept up to date by linking it to monitoring systems, so that data generated through monitoring are regularly fed into the database. The environmental database can also be used to regularly publish printed documents, such as environmental data compendia and indicator reports, to inform policy-makers and the public, and to provide a snapshot overview of the state of the environment. In many countries, building such a database is, or can be, a collaborative effort of various agencies, such as a central bureau of statistics, environmental and related ministries (e.g., agriculture, water), as well as research organizations and non-governmental organizations.

Data Harmonization

Generation of individual Environmental parameter data depends on various aspects which contributes towards easier comparability with the similar parameter collected in another location. During the GEO process, experts were encountered with the data problem. The interpretation of the definitions of the various categories of data may vary from country to country and region to region. Aggregating such data for the purpose of IEA reporting may amount to adding apples and oranges. For example, the definition of open or closed forests may from country to country in terms of the crown cover percentage. While some countries use FAO definition, others may be using their own definition. Similar is the case while defining poverty and total fish catch. Thus, aggregating that information at sub-regional or regional level may cause a problem. Harmonizing efforts at the national level will improve the international comparability of environmental information as well as facilitate easier comparative analysis and aggregation. Consistent national, sub-regional, and regional wide information are needed on critical indicators of air, soil, and water quality, and natural resources degradation processes as several environmental issues are or transboundary in nature. The data harmonisation aspect has to be taken due consideration also in IEA reporting at national level while undertaking comparison of data of several geographical locations with definition, collection methods.

GEO Data Portal

In order to filter relevant national data from authoritative, primary international data sources and harmonized databases, as well as to provide aggregated data at sub-regional, regional and global levels, UNEP has developed a dedicated reference database for GEO and similar reporting: the GEO Data Portal.

The GEO Data Portal has by now matured into a reference data system, and has become the authoritative source of data used by UNEP and its partners in the GEO reporting process and other integrated environment assessments. The Data Portal gives access to a broad collection of harmonized environmental and socio-economic data sets from authoritative sources at global, regional, sub-regional and national levels, and allows basic data analysis and creation of maps and graphics. Its online database currently holds more than 450 variables that can be analysed and displayed as maps, graphs or tables. The data sets can also be downloaded in a variety of formats, supporting further analysis and processing by the user.

The contents of the GEO Data Portal cover a broad range of environmental themes such as climate, disasters, forests and freshwater, as well as categories in the socio-economic domain, including education, health, economy, population and environmental policies. Although primarily targeting the GEO user community (UNEP offices, GEO Collaborating Centres and contributors), extensive use of the portal is also made by other (UN) agencies, universities, schools, civil society and the general public. To the extent possible, the data cover the period since 1970, and are constantly being kept up-to-date. Apart from statistical data sets, a good selection of geo-spatial data (maps) is also available, usually at global and regional scales. The data providers include many primary data collection agencies among the UN system and other key partners, including FAO, UNEP, UNESCO, UN Statistical Division, WHO, World Bank and OECD.

The global GEO Data Portal is now being supplemented by regional versions, starting in Latin America and Africa, and to follow in Asia and Pacific and West Asian regions. The Global GEO Data Portal is available on the Internet at http://geodata.grid.unep.ch/. It gives information on updates, new items, etc. A CD-ROM version has also been produced, as well as an e-Learning set of tools and a User Guide (http://www.grid.unep.ch/wsis/).

Although the GEO Data Portal is open to everyone and provides data for all countries of the world, for national-level environmental reporting authoritative data sources are more likely found within the country itself from the government (environmental and other ministries, bureau of statistics), research organizations, NGOs and other sources.

Environment Knowledge Hub (eKH) for Asia-Pacific

The Environmental Knowledge Hub (eKH) aims to build a virtual storehouse of information about the environment in the Asia and Pacific region. Data acquisition is a continuing process. Hence, compiling datasets catalogue is also a continuing activity and service of UNEP RRC.AP under eKH. This catalogue is updated every six months to include new data acquisitions as well as new datasaets. Every effort has been made to ensure the accuracy of the information stored, and to fully acknowledge all sources of information, graphics and photographs used.

A Mountain Knowledge Hub (MKH) or Mountain Geo Portal:

A Mountain Knowledge Hub or Mountain Geo Portal is the initiative for promoting Geoprahical Information and Earth observation Application for the Sustainable Development of the Hindu Kush-Himalayan (HKH) region . This site provides the in spatial data and information and its analysis in the HKH mountain ranges expanding from Afghanistan to Myanmar. http://menris.icimod.net/

3R Knowledge Hub on Waste Management :

The Asian Development Bank (ADB), AIT, UNEP, and UNESCAP are jointly establishing a knowledge hub on “Reduce, Reuse, and Recycle” (3R). The knowledge hub will function as a think tank on technology, good practices, policy strategy and management, and issues related to 3R, which promotes sustainable production and consumption of limited natural resources, and improved economic and environmental efficiency. This site will be ideal place for the national data and information on state, trend, policy and initiatives on waste management

EXERCISE 1: GEO Data Portal

The following exercise is intended to give you practice using the GEO Data Portal. There are two themes for this exercise, Population Indicators and Making Globalization Visible. For the first part of the exercise, choose a theme and work with a partner on the exercise. For the second part, do the exercise on your own. Use the handouts provided with this activity to follow the steps.

1. Population Indicators: A Global View

Geodemography is one of the most commonly used themes for mapping in geography, mainly because population data are often readily available and lend themselves quite well to mapping, particularly at the global level. Mapping geodemography allows us to go beyond basic population numbers to the population indicators that give us a more complex picture of the population dynamics of a place, such as birth rate, death rate, total fertility rate, and infant mortality rate. This exercise gets you started comparing population indicators at a global scale.

Step 1 At your computer, launch your browser and go to the GEO Data Portal at http://geodata.grid.unep.ch/.

First, let’s focus on the fertility rate data. The fertility rate is a relatively useful indicator of forthcoming changes in population density for a country.

Step 2 Under “search the GEO Database,” enter the word “fertility,” and click “Search.” You should now see a set of available database options relevant to “fertility.”

Step 3 In this list, choose the top data option, fertility at the national level, by clicking on the radio button and then clicking “continue.”

Step 4 From the year selections, check the box labelled "Select All" next to the list of available years, and then click "continue."

You should now be looking at a list of available output options for the data, as shown on the right. The GEO Data Portal offers data to view in a map, chart or table, as well as to download for use in statistical or mapping packages.

First, let's find out what type of data we have by looking at the metadata, which are the background information about a data set itself. They include facts, such as the source of the data, the scale at which they were collected, the year they were collected, the projection if there is one, and any other information that you need to know before you can interpret the meaning of the data and use them in your analysis or report.

Step 5 Under "Show Metadata," click "display as...Metadata."

Question 1: Read the "Abstract" and "Purpose" sections of the metadata. How is fertility rate defined for this data set?

Question 2: How were the data for fertility rate collected and measured?

Question 3: Why is fertility rate considered a more useful population indicator than birth rate?

Step 6 When you're finished browsing the metadata, click the orange "go back" link on the right to return to the display options page.

Step 7 Under "Draw Map," click on the image of the map. This will open up a separate window with a world map showing estimated fertility rate for the years 2045–50.

The fertility rate map shows a century of estimated data for each country. How are regional patterns of fertility estimated to change over this period of time?

Step 8 Explore the different estimates by clicking on the "General" tab in the red Theme box below the map, selecting another time period from the "Selected Year" drop-down menu, and clicking "update map."

Question 4: Choose four different time periods from the drop-down menu, and analyse what you see. What regional patterns do you find for fertility rate?

Question 5: Based on these patterns, which countries or regions might you predict to have a decreasing population density?

Hint: By selecting the "Identify" tool icon to the left of the map, and then clicking the map with your cursor, you can get data for individual countries.

Step 9 Next, go back and explore the global data for Infant Mortality Rate. Click on the orange "new search" link to the right of the map. This should take you back to GEO Data Portal home page. In the box, type "infant mortality" and click "Search."

Step 10 From "select a dataset," choose "Infant Mortality Rate -- National," click "continue," again choose all years of the data, and click "continue."

Step 11 Draw your map as in Step 7.

Question 6: Using the options in the "General" tab again, browse the estimated infant mortality data between 1950 and 2050. What regional patterns do you see?

Question 7: Reflect on what you have learned in class about infant mortality rate as a population indicator. If you could look at these two data sets, infant mortality and fertility rate, simultaneously, how would you expect them to correlate? In other words, for a country with a high fertility rate, would you expect infant mortality to be high or low? Explain your reasoning.

2. Making Globalization Visible

Globalization is a complex concept to grasp, much less measure or monitor. Most people agree that it is a combination of specific process-like and structural shifts in economics, culture and governance at the global level. These patterns include a shift from industrial to service economies, and from national to global markets, an increasing spread of popular culture, rising consumerism and often a widening gap between the rich and poor.

Question 1: What other kinds of economic and cultural patterns are indicators of globalization?

Question 2: What kinds of activities are indicative of political and cultural resistance to globalizing forces?

Based on these patterns of globalizing forces and resistance to those forces, do you think it is possible to make a "map of globalization"? What would it look like?

It is one thing to consider globalization as a series of case studies, with separate issues, indicators and effects. But, it is far more difficult to achieve an integrated awareness of globalization, a whole picture of globalization in our head. If we cannot look at it as a whole, how can we monitor it as a whole?

In this exercise, we will experiment with online mapping to see if the kinds of datasets available to us are useful for illustrating the complex idea of globalization. We will use the GEO Data Portal and try to explore its capabilities to grasp of the notion of globalization.

Step 1 Launch your browser and go to the "GEO Data Portal" at http://geodata.grid.unep.ch/.

Step 2 For the search term, type in "trade" and click "search."

Step 3 In the resulting list, select "Trade - Percent of GDP" for the national level, and click "continue."

Step 4 Select "1970" for the year, and click "continue."

Question 3: Based on what you know about regional globalization patterns, what type of data display for "Trade - Percent of GDP" do you expect to see?

Step 5 Test your hypothesis by clicking on "Draw Map" from your list of options.

Question 4: Which countries or regions show the highest proportion of GDP in trade for 1970? Which countries show lower proportions?

Step 6 Now click the "Trend Analysis" tab in the red "Theme" box, and check the "Calculate difference" option. Choose to look at the difference between 1970 and 1980, and display the difference "in percent." Click "update map" to see your results.

Question 5: Is GDP in trade increasing or decreasing? For which regions or countries?

Question 6: Redraw the trend analysis map for 1980 to 1999, and compare the results. Does the visual pattern fit your hypothesis from Question 3? Why or why not?

Question 7: How does the "No data" category affect the different views of the choropleth map? (A choropleth map uses shading, colouring or a symbol to show the geographical distribution of the information.) How does it affect your perception of the global balance of trade?

Question 8: Explore and evaluate the generalization, scale and projection, and data classification of this interactive map. In what ways does each factor limit your interpretation of globalization trends?

Step 7 Print a copy of the map that you made, and copy and paste it into a Word document.

Using the Histogram

A histogram shows the distribution of data values for one continuous variable. Rather than showing each individual variable along a single axis, as you saw with line graphs in Exercise 1, a histogram divides the data into data classes, and then plots the frequency of occurrences of those data classes relative to the variable as a whole.

Step 8 Click the "Table" tab above the map. This should take you to a table showing the 1970 GDP trade values by country.

Step 9 Click "Histogram" to get a pop-up window showing a histogram display of the tabular data. Print the histogram pop-up using the print options on your computer, then close the pop-up.

Step 10 Click the "redefine years" option to the right of the table, set the year to 1980, choose "Draw Map," choose "Table" again, select "Histogram," and print a new histogram for the 1980 data.

Step 11 Finally, repeat step 10 to make a histogram for the most recent year available. You should now have three histograms showing change in "Trade – Percent in GDP" over time.

Question 9: Compare your three histograms. How is the proportion of GDP in trade changing? Does this support the concept of globalization? Explain why you think the histograms do, or do not, reflect globalization trends.

Question 10: Do the histograms assist with your visual picture of GDP in trade? Why or why not?

Guide to GEO Data Portal – CD-ROM and e-learning.

Run the e-Learning for Sustainable Development CD-ROM, using the GEO Data Portal. For the video demonstration and exercises, see also http://www.grid.unep.ch/wsis/

<CD-ROM to be provided with Training Manual>

4. Indicators and Indices

You have become familiar with considerations and processes involved in collecting and developing data for use as indicators and indices. The next step in the process is to package the data into a form that can be more easily interpreted from a policy relevance perspective. The following section will provide you with an overview of conceptual and methodological considerations associated with developing and using indicators and indices. The section reviews the process of selecting indicators, including criteria for good indicators, participatory processes and indicator frameworks.

4.1 Indicators

Indicators are what make data relevant for society and for policy making. They help us make decisions or plans because they help us understand what is happening in the world around us. Indicators have an important role in both informing and assessing policy (UNEP 1994). The World Bank (1997) stated that, "The development of useful environmental indicators requires not only an understanding of concepts and definitions, but also a thorough knowledge of policy needs. In fact, the key determinant of a good indicator is the link from measurement of environmental conditions to practical policy options." Practical policy options imply a relationship between environmental and societal affairs. As any decision has a price, whether it is environmental or social, a policy's impact ultimately depends on the priority of the decision-maker as influenced by the perceived priorities of that person's constituents. Thus, the integration of policy areas must provide a solid platform for supporting the path toward sustainable development (Gutierrez-Espeleta 1998).

The value of indicators in policy making can be summarized as:

- providing feedback on system behaviour and policy performance;
- improving chances of successful adaptation;
- ensuring movement toward common goals;
- improving implementation; and
- increasing accountability.

Selecting Good Indicators

One of the challenges of selecting good indicators is that it may be easier to choose indicators based on ease of measurement or data availability, rather than what needs to be measured. As mentioned previously, filling data gaps can be a resource intensive process, which means that options in terms of indicator selection may be limited. Notwithstanding, it is still valuable for you to select indicators that have the best possible fit with the IEA process.

Part of the process of selecting good indicators is weighing them against a set of indicator criteria. Selecting indicators can be a balancing act, with trade-offs among such factors as ensuring they are relevant to society and policy-makers, scientifically sound and accurate, and easy to interpret with a reasonable degree of accuracy and precision.

The following criteria, drawn from the World Bank (1997) and OECD (1993) are commonly cited as useful in the indicator selection process.

Indicators should:

- be developed within an accepted conceptual framework ;
- be clearly defined, easy to understand and interpret, and able to show trends over time;
- be scientifically credible and based on high-quality data;
- be policy relevant;
- be relevant to users, politically acceptable and a basis for action;
- be responsive to changes in the environment and related human activities;
- provide a basis for international comparison by providing a threshold or reference value;
- be subject to aggregation (from household to community, from community to nation);
- be objective (be independent of the data collector);
- have reasonable data requirements (either data that are available or data that can be collected periodically at low cost); and
- be limited in number.

An important consideration is selecting the appropriate number of indicators. Too many indicators may create "noise" that is difficult to interpret, while too few indicators limit the scope of understanding. Selecting indicators based on a select set of priority issues is an increasingly common way of limiting the number of indicators.

Participatory Process

Because indicators are intended to help inform decisions that affect society, indicators better serve society when they reflect the diverse perspectives held by multiple stakeholders, such as citizens and citizen groups, private and public sectors, and policy-makers. As shown in the following figure, participatory processes occur across the spectrum of indicator development, from an initial identification of broadly-held values and issues that inform indicator selection, to more focused tasks of setting indicator targets and criteria for performance.

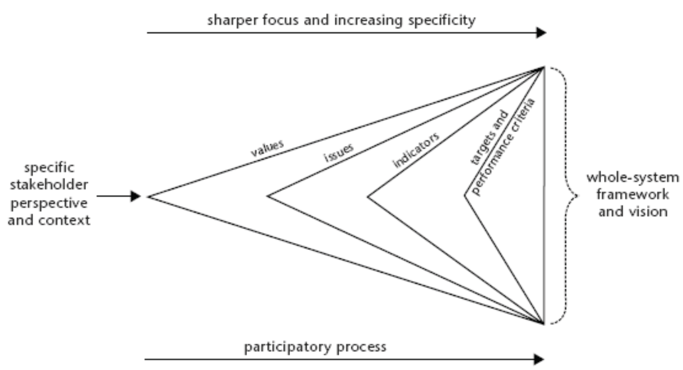


Figure 7: Linking Values, Issues, Indicators and Performance Criteria in a Participatory Process

An additional step not shown in Figure 7 is the process of communicating indicator results with stakeholders, and understanding how they interpret the results in relation to values and their world-views. Developing an effective participatory approach requires careful planning so that the people who need to be involved are involved in an appropriate way, taking into account available resources (See Section 2).

Indicator Frameworks

Indicators are developed based on priority issues. The orientation of indicators to issues as well as relationships among indicators (such as cause and effect relationships) is often structured using conceptual frameworks as shown in Figure 8. In an IEA and in GEO, the conceptual framework is the Drivers – Pressure – State – Impacts – Responses (DPSIR) framework, which shows relationships between human activity and ecosystem well-being. The DPSIR framework used in GEO-4 is shown in Figure 8. Variations on the DPSIR framework include Driving-State-Response (DSR), which was originally used by the UN Division for Sustainable Development (UN-DSD), and the Pressure-State-Response framework used by the OECD. This framework has been discussed detail in other module.

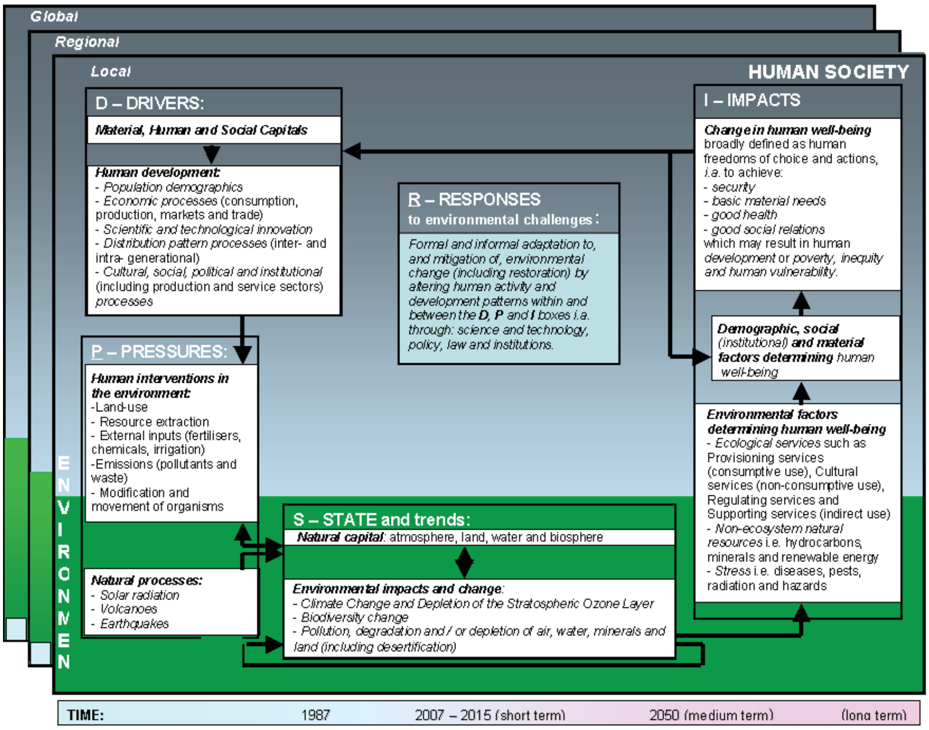


Figure 8: DPSIR Framework for GEO-4 (Source: DEWA 2006)

Another type of framework is the capital stock model. This framework focuses on the maintenance or growth of capital stock in the areas of physical capital stock, natural capital, human capital and social capital. Each form of capital is converted into a monetary equivalent. The goal of this model, which is in use by the World Bank, is to ensure that "future generations receive as much or more capital per capita than the current generation" (World Bank 1997).

Types of capital include:

- physical capital - buildings, structures, machinery and equipment, and urban land;
- natural capital – renewable and non-renewable natural resources;
- human capital – return on investment in education; and
- social capital – norms and social relations, social cohesion.

The capital stock model enables trade-offs to be identified among different forms of capital, and also enables aggregation of all the measures. A limitation of the model is that it excludes aspects of natural and human/social resources that do not have assigned monetary values (Hardi 2000) or with which monetary values cannot reasonably be associated.

Flow of indicator development

Figure 9 provides an example of the process used for indicator development in South Africa as part of a SoE report. The main steps are further described below.

Step 1 involved identifying a framework to guide the selection of indicators. The framework was based on a review of environmental and local government legislation, and consultation with stakeholders. It was built around core environmental mandates for local government, and if a core mandate was not present, then around the role of provincial and national government.

Step 2 involved drafting a set of indicators based on a set of criteria for indicator selection. The draft set of indicators was reviewed by local, provincial and national government, to ensure that the new indicators would have as consistent a format and language as pre-existing indicators. A workshop was then held to obtain feedback from stakeholders.

Step 3 involved further categorizing the indicators. Because municipalities and provinces across South Africa manage areas with different characteristics, and with different levels of resources, capacities, knowledge and available data, further categories were needed to reflect these differences. The indicator categories were then placed within the indicator framework.

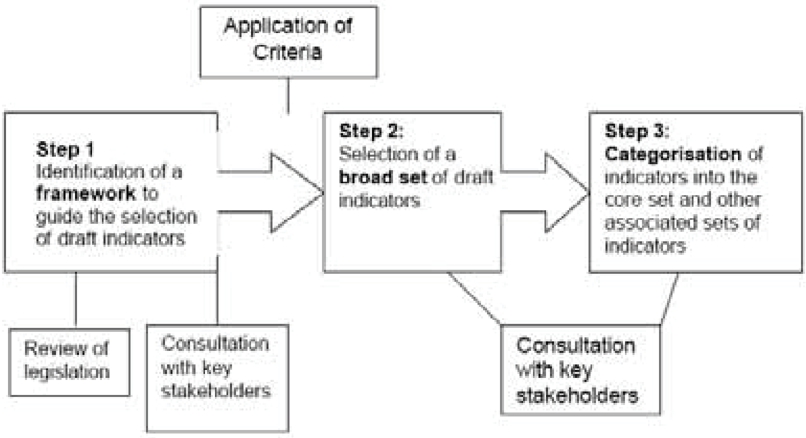


Figure 9: Example of an Indicator Development Process from South Africa

Source: Palmer Development Group 2004

Towards the end of the project, a workshop was held with stakeholders for three purposes: to finalize the draft set of indicators, to categorize the indicators into proposed sets, and to discuss issues related to the use of indicators by government. The workshop resulted in a draft set of categorized indicators and a number of recommendations from stakeholders directed towards the government department responsible for indicator reporting.

Core Indicator Sets

Once indicators have been identified, you can further reduce them into core and peripheral sets of indicators. Core indicators provide clear and straightforward information to decision-makers and civil society on trends and progress for specific issues. Few in number (10-15), core indicators are sometimes clustered around themes, parameters or dimensions to assist with understanding more complex situations. They do not, however, provide a comprehensive picture of the situation, including relationships among different aspects being measured. More detailed, supporting indicators may be included in a peripheral set to provide a higher level of detail.

Several "core data/indicator" sets have been developed, mainly differing by geographic scope (i.e., country, region, global). Examples are the OECD Key Indicator Set, the EEA Core Data Set, the EU Structural Indicators, the GEO Core Data Matrix and the UN CSD Theme Indicator Framework.

EXAMPLE: GEO Core Indicator Set

As shown in the GEO Core Indicator Data Matrix, the GEO Core Indicator Set is based on a series of theme areas that reflect global issues and trends for selected environmental issues. These theme areas include:

- land;
- forests;
- biodiversity;
- fresh water;
- atmosphere;
- coastal and marine areas;
- disasters;
- urban areas;
- socio-economic; and
- geography.

Each year, the list is updated with new indicators, based on the rise and fall of the importance of global issues. Amidst efforts to ensure data are collected using environmental monitoring, surveying and remote sensing, there remain a number of data gaps, particularly in areas concerning waste disposal and its management, land degradation and urban air pollution (UNEP 2006). Table 1 describes broad themes, issues and provides detailed information about data variables, lead indicators and lead sources for the data. The first section of the framework is shown in the text below, and the remainder of the framework is provided in Appendix A.

Table 1: GEO Core Indicator Data Matrix

THEME	ISSUE	POTENTIAL DATA VARIABLE	PROPOSED KEY AND LEAD INDICATOR	UNITS	Current Primary (Led) data Source(s), use in in GEO Data portal
Land	Soil erosion	♦ Water erosion (000 tonne/ha) ♦ Wind erosion (000 tonne/ha)	♦ Average annual soil erosion rate	000 tonne/ha	♦ UNEP/FAO/ISRIC: GLASOD
	Desertification	♦ Area affected by desertification (000 ha and %) of rain-fed croplands, irrigated land, forest and woodlands ♦ Livestock levels per km2 in dryland area ♦ Population living below poverty line in dryland areas	♦ Total land affected by desertification ♦ Population living below poverty line in dryland areas	000 ha, % million, %	♦ UNEP/FAO/ISRIC: GLASOD
	Land salinization	♦ Areas affected by salinization and waterlogging (000 ha and change)	♦ Total area affected by salinization	000 ha, % p/y	♦ UNEP/FAO/ ISRIC: GLASOD

THEME	ISSUE	POTENTIAL DATA VARIABLE	PROPOSED KEY AND LEAD INDICATOR	UNITS	Current Primary (Led) data Source(s), use in in GEO Data portal
Forests	Forest loss, Forest resources management	♦ Forest management fractions (% protected) ♦ Forest change/ domestication by sector (to agric., urban) ♦ Forest area change (open, closed, natural forests) ♦ Deforestation rate (open, closed, natural forests) ♦ Reforestation, natural and total, % success ♦ Production and trade of forestry products (wood, paper)	♦ Intensity of forest use (harvest/growth) ♦ Area of forest and woodland ♦ Proportion of land area covered by forest (%) ♦ Exports of forestry products (%) ♦ Protected forest area ♦ Regeneration/ afforestation area	% p/y total, per capita, %, p/y % p/y % p/y 000 ha, % p/y	♦ FAO: FRA/SOFO ♦ FAO: FAOSTAT ♦ UNSD: UN COMTRADE database
	Degradation of forest quality	♦ Volume distribution by major tree species group within each biome (ha per biome) ♦ Share of disturbed/ deteriorated forests in total forest area	♦ Share of affected forests	% of total forest area	♦ FAO: FRA/SOFO
Biodiversity	Loss of species	♦ No. of species known (number) and threatened species (%) for vascular plants, mammals, birds, amphibians, reptiles, freshwater fishes	♦ Number of threatened species, animals and plants ♦ Threatened animal and plant species as % of described species ♦ Red List Index for birds	No. %	♦ IUCN: Red List of Threatened Species
	Loss of habitat	♦ Recorded wildlife habitat by ecosystem, for forests (dry, moist, all forest), wetlands, mangroves, grassland/ savannah, deserts/ scrubland	♦ Total areas of wetlands/marshes ♦ Total mangrove area ♦ Change in arable land area	000 ha 000 ha 000 ha	♦ Ramsar list ♦ WWF: Lakes and Wetlands database, Global ecoregions ♦ IUCN/WCMC: Protected Areas Database ♦ USGS/EDC: Olson World Ecosys. ♦ FAO: FAOSTAT

5. Data Analysis

This section will review aspects of non-spatial and spatial analysis of data which is used in the IEA report. Module 7 provides the further information about physical product outcomes as it considers in a more in-depth presentation and communication of the IEA report in reader friendly way. In this section non-spatial analysis includes performance evaluation, along with trend, correlation and graphical analysis. Also included is the presentation of indicators using symbols. This is followed by a review of spatial analysis using GIS.

5.1 Non-Spatial Analysis

Performance evaluation

Indicators become especially useful when they can be interpreted in the context of performance. Distance to a specified target is a common way of measuring performance. These measures also promote accountability to policy-makers, particularly when policies are linked to environmental performance.

Baselines, thresholds and targets are ways of measuring changes in the system compared with previous states or future desired states. Baselines allow us to monitor either positive or negative changes in a system, based on the initial state of the system. It is important that baseline information is present at the beginning of a project to monitor changes over time. Thresholds allow us to monitor activities that may result in negative activities; the Air quality Indicator (AQI) discussed above has a threshold of 151, beyond which most people will experience health impacts. Thresholds can act as our "alarm systems," enabling us to take preventative action. Targets indicate goals for performance, and enable us to monitor positive progress towards the goal. Targets are often used for projects when sustainable development or improving the system is a goal (Segnestam 2002).

Globally, performance indicators are used to assist countries or regions in monitoring their compliance with globally agreed-upon goals and targets. A well-known example is the Millennium Development Goals, defined by the UN General Assembly in 2000.

Trend Analysis

Trend analysis is instrumental in understanding how the data are functioning over time, sometimes against targets, baselines and/or thresholds. Various possibilities exist to present the trends, which can easily lead to different interpretations and conclusions. For example, the presentation of an indicator as absolute value, percentage or index can make an important difference. If we look at the global supply of renewable energy when displaying the trend in terms of totals (kilotons of oil equivalents, Figure 10) or shares (%, Figure 11), then we see little change: the supply of total biofuels goes up a little bit, but most others are more or less stable. In fact, the shares hardly change at all. The message from these graphs simply be "renewable energy has not shown significant changes since 1990," which from an environmental point of view is rather disappointing.

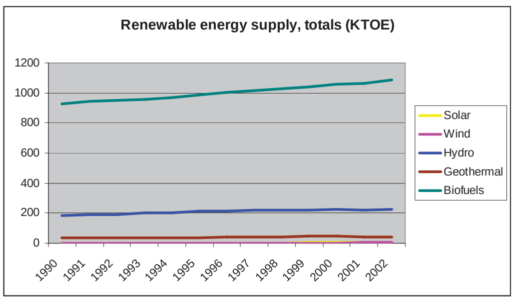


Figure 10: Renewable Energy Supply, Total

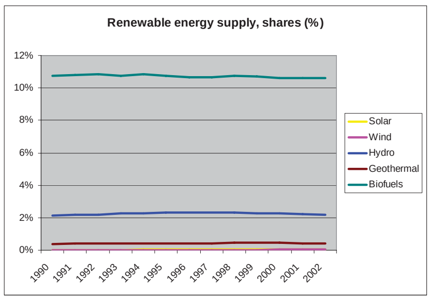


Figure 11: Renewable Energy Supply, %

However, when we show an indexed change with 1990 set at 100 (Figure 12), we can clearly depict the increase in the supply of wind and solar energy. Thus, the message now could be "renewable energy has shown a substantial increase since 1990, in particular for the supply of wind and solar energy." – which is much more positive message from an environmental perspective.

Another example is the use of appropriate scales on the X and Y-axis. For example, the two graphs below (Figures 13 and 14) can give quite different impressions. At a glance, one could easily say that Figure 13 does not show a trend at all, while Figure 14 presents a stable situation. However, they are derived form the very same data and only differ in the Y-axis scale.

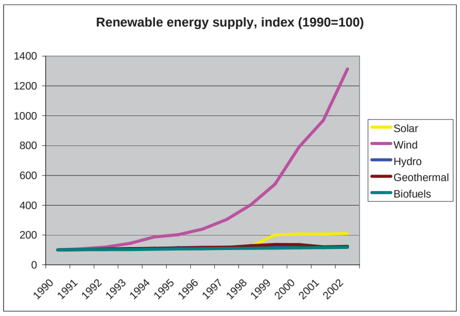


Figure 12: Renewable Energy Supply, Index

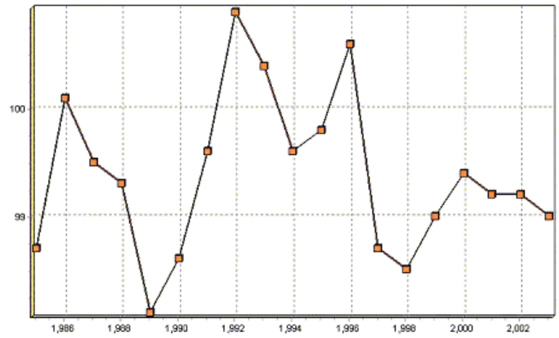


Figure 13: Graph Showing Erratic Pattern

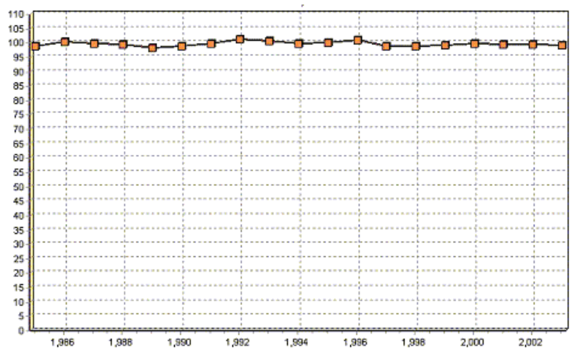


Figure 14: Graph Showing Erratic Pattern

Correlation Analysis

Correlation analysis assists us in understanding the degree to which variables is related to one another, but does not show cause and effect. Correlated data are presented on a graph, with one variable on the Y-axis and the other on the X-axis. A positive correlation is shown when the scatterplot moves in an upward direction, from lower left to upper right. When variables are negatively correlated, the scatterplot line will run from the upper left to the lower right. The closer the correlation coefficient is to +1 or -1, the stronger the relationship between the two variables, and the straighter the line on the graph.

Presenting indicators using symbols

In addition to presenting indicators in graphical form, you can also use symbols to depict the status of indicators. Symbols communicate complex information in ways that are easily and quickly understood. Changes in the value of the indicator may be shown using up and down arrows, and an indication of whether the change is favourable or unfavourable may be shown using, for example, a happy/frown face or green and red colours.

DISCUSSION QUESTION

- Consider the pros and cons of different approaches to presenting indicators to different audiences.
- Who are the different audiences that would see the indicators?
- What information needs does each audience have?
- What are some ways you can provide the technical information needed while at the same time making the indicators visually captivating?

5.2 Spatial Analysis

Using Geographic Information Systems (GIS) for IEA

Spatial analysis is the process of modelling, examining and interpreting spatial data and any associated databases. Spatial analysis is a powerful and useful tool for interpreting and understanding geographic areas, evaluating suitability and capability of natural areas, or for estimating and predicting impacts of human development. An example of a spatial analysis you might perform is to overlay several layers of data to show the proximity of different features, such as human encroachment into natural wetland or forest areas, and to identify changes in the boundaries of natural areas over time.

Applications of GIS in IEA

- View and analyse data from global perspective.
- Overlay data layers for analysis and mapping.
- Provide framework for studying complex systems.
- Powerful tool for analysing changes in landscapes and human impacts.
- Create simulations and models to predict possible future conditions and effects.
- Have a a powerful visual and universal language.

Spatial analysis is typically done using various types of computer software, one of which is a GIS.

Geographic Information Systems are database management systems for handling geographic data. Not only can you use a GIS to store data, but it is also a useful tool for manipulating and analysing data, particularly to examine spatial relationships among landscape features, and in monitoring long-term changes. GIS is not only a storage and analysis tool, but it is a very powerful visual and universal language. For example, using GIS you can easily calculate the area of forested lands within 100 m of a particular road, and identify with point locations where critical or protected areas may be. You could also utilize maps for change detection analysis (determining loss of natural habitats from one time period to the next) that can be used to influence government policies and programmes (Boxes 7 to 10 – missing ???).

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Attachment :

Appendix A: Continuation of GEO Core Indicator Matrix

THEME	ISSUE	POTENTIAL DATA VARIABLE	PROPOSED KEY AND LEAD INDICATOR	UNITS	Current Primary (Led) data Source(s), use in in GEO Data portal
1	2	3	4	5	6
	Wildlife Trade	♦ Trade in flora and fauna (birds, reptiles, plants, mammals, butterflies, ornamental fish)	♦ Net trade in wildlife and captive-bred species	Million US$	♦ CITES Trade Database ♦ UNSD: UN COMTRADE database
	Overfishing	♦ Total inland, fresh water and marine fish catch, production, consumption and trade	♦ Total and per capita marine fish catch ♦ Total fish catch in inland waters (incl. aquaculture)	000 tonnes/ year 000 tonnes/ year	♦ FAO: FishStat, State of World Fisheries and Aquaculture ♦ UBC Fisheries Centre
	Protected areas	♦ National, international and local parks and protected areas: Biosphere reserves (terr. and marine), Wetlands of international importance, World heritage sites	♦ Total protected areas (number, size) and % of total land ♦ Marine protected areas in LMEs	No. Km2, %	♦ IUCN/WCMC: Protected Areas Database ♦ UNESCO World Heritage List
Freshwater	Freshwater resources	♦ Annual internal renewable water resources ♦ Annual river flows from/to other countries, by basin ♦ Annual freshwater use by sector (domestic, industry, agric., following ISIC classes) ♦ Annual groundwater recharge ♦ Annual groundwater withdrawals by sector	♦ Annual internal renewable water resources per capita ♦ Annual freshwater use per capita ♦ Population with water stress	Km3/year, m3/capita/ year Km3/year, m3/capita/ year	♦ FAO: AquaStat ♦ UNSD: Envstats database ♦ UNESCO: World Water Resources ♦ WRI: World Resource Database/Earth Trends ♦ UNH/GRDC: Runoff Fields ♦ Univ. of Kassel: WaterGap ♦ IGRAC (Int Groundwater Resources Ass. Centre) GGIS

THEME	ISSUE	POTENTIAL DATA VARIABLE	PROPOSED KEY AND LEAD INDICATOR	UNITS	Current Primary (Led) data Source(s), use in in GEO Data portal
	Water quality	♦ River pH, concentrations of oxygen (DO, BOD), coliforms, particulates (TSS, TDS), nitrates (NO3, NH4, NP), phosphor (PO4), metals (HMs), pesticides ♦ Fish biodiversity (reserves, specie no.) ♦ Groundwater pH, concentrations of nitrates, TDS (salinity), iron, chlorides, sulphates ♦ Waste Water Treatment: % served, public expenditures	♦ BOD level of most important rivers ♦ Nitrates level of most important rivers ♦ Coliform count per 100 ml) ♦ Pesticides concentrations in most important rivers	mg/l mg/l no/100 ml, µg/l, US$/capita	♦ GEMS/Water: Atlas of Global Water Quality, GEMStat ♦ WRI: World Resource Database/Earth Trends
Atmosphere	Climate change	♦ Anthropogenic emission of GHG (CO2, CH4, N2O, also HFCs, PFCs, SF6), total and by sector (transport, industry, agric., livestock, fossil fuels) ♦ Emissions of precursors (NOx, CO, NMVOC, CH4), total and by sector ♦ Emissions of acidifying gases (NH3, NOx, SO2), total and by sector ♦ Atmospheric concentration of GHG, CO, SO2, NOx, NH3, PM, Pb, VOC, O3 ♦ Glacier retreat ♦ Annual change of temp., precip. ♦ Fossil fuel supply (% and intensity) ♦ Rainwater pH for selected areas ♦ Expenditures on air pollution abatement and control	♦ GHG, NOx, SO2 emissions total and per capita ♦ GHG, NOx, SO2 emissions per USUS ♦ Global mean temperature rise ♦ Global mean concentration of CO2, SO2, NOx, PM10 ♦ Fossil fuel consumption share ♦ Renewable energy supply index	tonne/ capita, tonne/US$ oC ppm %	♦ CDIAC: Trends Online ♦ UNFCCC: National Communications ♦ UNSD: MDG and Envstats database ♦ IGBP/GEIA/RIVM: EDGAR Database ♦ IPCC/CRU: mean monthly climatologies ♦ WMO: climate anomalies ♦ IEA: Energy Statistics and Balances

THEME	ISSUE	POTENTIAL DATA VARIABLE	PROPOSED KEY AND LEAD INDICATOR	UNITS	Current Primary (Led) data Source(s), use in in GEO Data portal
	Stratospheric Ozone Depletion	♦ Production, consumption, import and export of CFCs, Halons, HCFCs, Methyls, CCl4, MeBr ♦ Atmospheric ODS concentration over selected cities (parts per trillion) ♦ Ozone levels/total ozone column over selected cities (Dobson units) ♦ Ground level UV-B radiation over selected cities	♦ Total ODS production by compound ♦ Total CFC, HCFC and MeBr consumption	ODP tonnes, kg/capita	♦ UNEP Ozone Secretariat ♦ World Ozone and Ultrav. Rad. Data Centre ♦ AFEAS production, sales and emissions
Coastal and Marine areas	Coastal and Marine pollution	♦ Average annual sediment load ♦ Average annual untreated waste disposal by sector (dom. ind. and agric. – fertilizers, pesticides/ insecticides) ♦ Discharge of oil into coastal waters (000 tonne) ♦ Concentrations of HMs (Hg, Pb, Cd, Cu, Fe, Mn, Ni, Co) ♦ Concentration of PCBs ♦ Industrial activities in coastal region ♦ Share of pollution caused by sector (domestic, industrial, urban, coastal, transport, refineries) ♦ Coastal population (growth, urban share) ♦ Tourist arrival in coastal marine areas (million/ year) ♦ Number of hotels/resorts in coastal areas (000)	♦ Average annual sediment load ♦ Average annual untreated waste disposal by sector (dom./ ind./agric., fertilizers, pesticides/ insecticides.) ♦ % of urban population living in coastal areas ♦ Area of Exclusive Economic Zone (EEZ)	tonne/year tonne/year, % % km2	♦ UNEP Regional Seas Programme and Global Programme of Action (GPA) ♦ WCMC: Protected Areas Database ♦ IMO: Global Waste Survey ♦ UNSD: UN Common Database, WRI/ Earth Trends. GEO Data Portal ♦ ICLARM: ReefBase, FishBase ♦ WRI: Reefs at Risk ♦ G3OS (GOOS, GTOS, GCOS)

THEME	ISSUE	POTENTIAL DATA VARIABLE	PROPOSED KEY AND LEAD INDICATOR	UNITS	Current Primary (Led) data Source(s), use in in GEO Data portal
Disasters	Natural disasters	♦ Occurrences, financial damage and casualties (people affected, homeless, injured, killed) related to floods, droughts, cyclones, earthquakes, landslides, volcanic eruptions, forest fires	♦ Total number of natural disasters p/y ♦ Number of people killed by natural disasters, per mln ♦ Economic loss due to natural disasters	Number, per million, million US$	♦ OFDA/CRED: EM-DAT ♦ Munich Re: Annual review of nat. dis. ♦ UN-OCHA: ReliefWeb ♦ UN-ISDR
	Human-induced disasters	♦ Occurrences, financial damage and casualties (people affected, homeless, injured, killed) related to transport and industrial accidents	♦ Total number of techn. accidents p/y ♦ Total number of people affected by technological accidents ♦ Economic loss due to techn. Accidents	000, million US$	♦ OFDA/CRED: EM-DAT ♦ UN-ISDR
Urban Areas	Urbanization	♦ Urban population, total, growth rate ♦ Number of cities with over 750 000 population	♦ Average annual urban population growth rate	%	♦ UNPopDiv: World Urbanization Prospects
	Urban air pollution	♦ Concentration of pollutants in cities	♦ Concentration of lead, PM, SO2, NOx in major cities of the world	ug/m3	♦ OECD Environmental Data Compendium and Indicators
	Waste management	♦ Waste generation and disposal methods by sector: municipal, industrial, agricultural, hazardous	♦ Municipal waste production per capita (solids) ♦ Industrial waste generated per US$ ♦ Hazardous waste production per US$ ♦ Movement of hazardous wastes ♦ Waste management fractions ♦ Exposure to HMs, toxic chemicals ♦ Share of recycled waste	kg/capita kg/000 US$ kg/000 US$ %	♦ OECD Environmental Data Compendium ♦ UNSD: Envstats database ♦ WRI :World Resources Database ♦ UNEP Chemicals, Basel Conv. Secr.

THEME	ISSUE	POTENTIAL DATA VARIABLE	PROPOSED KEY AND LEAD INDICATOR	UNITS	Current Primary (Led) data Source(s), use in in GEO Data portal
Socio-Economic (incl. health)	Population and social	♦ Population, total and growth rate ♦ Total fertility rate ♦ Adult literacy (%) by sex ♦ Education enrolment, net and gross (primary, secondary, tertiary), by sex ♦ Education expenditures (prim., sec., tert.) ♦ Labour force total (% population), by sector (agric., ind., serv. and by sex ♦ Telephones (main lines and cellular per 100 people) ♦ Daily newspapers (copies per 100 people) ♦ Radios (number per 100 people) ♦ Televisions (number per 100 people) ♦ Computers (number per 100 people) ♦ Internet connections (number per 10 000 people)	♦ Average annual population growth rate ♦ Population density change	%, inh/ km2	♦ UNPopDiv: World Population Prospects ♦ UNESCO: World Education Statistics ♦ UNDP: Human Development Indicators ♦ UNSD: UN Common Database ♦ ILO: Laborstat Database, KILM indicators ♦ World Bank: World Development Indicators
	Economy	♦ Real GDP, total and per capita, annual ♦ Power Purchasing Parity (PPP) ♦ Number of people in absolute poverty, rural and urban ♦ Merchandise exports (value), total and by sector: manufacturing, fuels/ minerals/metals, services ♦ Merchandise imports (value), total, food, fuels ♦ Trade (% of GDP) ♦ Terms of trade (1995=100) ♦ Inflation, consumer prices (annual %) ♦ Unemployment rate (%) ♦ Total external debt total and % of GNP ♦ Total debt service (as % of exports of goods and services) ♦ Foreign direct investment, net inflows (% of GDP) ♦ Official Development Assistance and Aid (ODA)	♦ GDP per capita ♦ PPP per capita ♦ Value added as % of GDP by sector: agriculture, industry, services	Constant 1995 US$ Intern. $ %	♦ World Bank: World Development Indicators ♦ UNSD: UN COMTRADE database ♦ Univ. of Purdue: GTAP ♦ UNSD: UN Common Database ♦ UNSD: National Accounts Main Aggregates database

THEME	ISSUE	POTENTIAL DATA VARIABLE	PROPOSED KEY AND LEAD INDICATOR	UNITS	Current Primary (Led) data Source(s), use in in GEO Data portal
	Consumption and Production	♦ Total commercial energy production, by sector: fossil fuels, hydro, nuclear, geothermal, biomass, solar, wind ♦ Total commercial energy use, total and per capita ♦ Energy efficiency and intensity ♦ Traditional fuel use (% of total energy consumption) ♦ Energy imports, net (% of energy consumption) ♦ Renewable energy use (%) ♦ Total electricity generation by sector: thermal, hydro, nuclear, non-hydro, renewables ♦ Total electricity consumption ♦ % population with access to electricity ♦ Value added by sector: agric., ind., manuf., services ♦ Distribution of GDP by demand sector: government consumption, private consumption, gross domestic investment, gross domestic saving ♦ Defence expenditures (% of GDP)	♦ Total commercial energy production ♦ Commercial energy consumption per capita ♦ Energy use per unit GDP	Tonnes of oil equivalent	♦ IEA: Energy Statistics and Balances ♦ UNSD: Energy Statistics Database ♦ World Bank: World Development Indicators
	Transport	♦ Motor vehicles in use (per 000 people), by type of engine ♦ Total length of motor ways (000 km) ♦ Density of motor ways (km/10 000 km2) ♦ Road traffic intensity per unit of GDP (vehicle km/ US$) ♦ Number of departures and arrivals (airports) ♦ Energy consumption by road transport (% share of total consumption)	♦ Road traffic intensity per unit of GDP	vehicle km/000 US$	♦ World Bank: World Development Indicators ♦ UNSD: UN Common Database

THEME	ISSUE	POTENTIAL DATA VARIABLE	PROPOSED KEY AND LEAD INDICATOR	UNITS	Current Primary (Led) data Source(s), use in in GEO Data portal
	Agriculture and Livestock	♦ Agricultural production index ♦ Food production index ♦ Pesticide consumption (tonnes) ♦ Fertilizer use (000 kg) ♦ Livestock units (000 head)	♦ Use of nitrogen on agric. land ♦ Use of phosphate on agric. land ♦ Use of pesticides on agric. land ♦ Agricultural production value added	tonnes/ km2 tonnes/ km2 active kg/km2 % of GDP	♦ FAO: FAOSTAT ♦ IFA: Fertilizers and their use