Module 7 – Assessing the State of the Environment

Overview

This module is designed to introduce you to assessing the state of the environment as a first step in IEA and reporting.

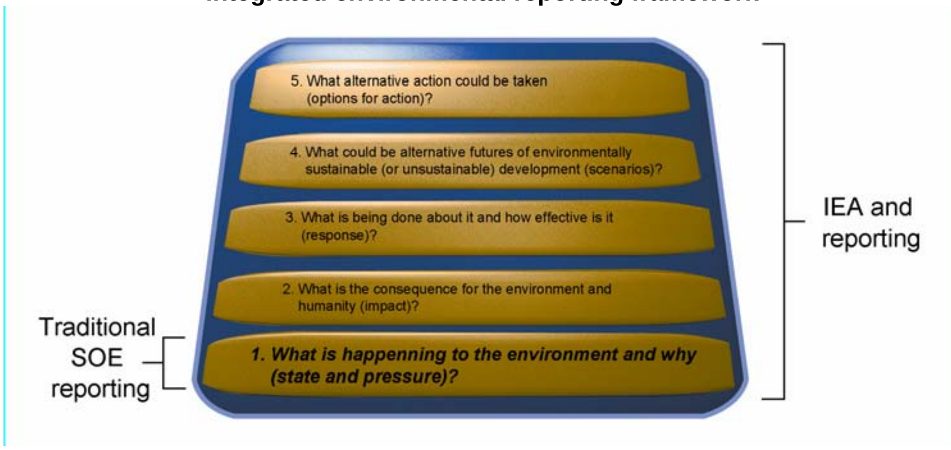
By the end of the module you will:

- Know the importance of reporting on environmental trends and conditions within an integrated system of environmental analysis.
- Learn a strategy for selecting the most important points in assessing the state of the environment.
- Learn about data and indicators and their importance in assessing the state of the environment and linking this assessment to environmental policy formulation.
- Learn about the value of unconventional sources of data such as remote sensing and the internet, and unconventional techniques of spatial data organization such as geographic information systems (GIS), in SOE analysis.

7.1 Introduction:

Reporting on the state of the environment is the first step in integrated environmental assessment. Traditional SOE reporting only answered the question "What is happening to the environment" (see Figure 7.1). While the reports were useful in informing about the state of the environment, they were not sufficient to ask questions required for influencing policy to do something about its state.

Figure 7.1: The place of SOE analysis in the integrated environmental reporting framework



Source: Pinter and others 1999

7.2 Important points in assessing "What is happening to the environment?"

In answering the first of the five questions in Figure 7.1, we get the basic environmental conditions and the pressures that are responsible for these conditions. An accurate understanding of the answer to the question lays a good foundation for IEA and reporting. Strategy for compiling information for the assessment may differ but the following points will be important:

- *What is the extent of the area to be covered by the assessment?*
  The area to be covered must be determined as the starting point. Data requirements vary with scale; what may be perfectly acceptable for decision making at one scale may be insufficient at another. Global data is good enough to compare regions of the world. On the other hand, there may not be sufficient capacity for data analysis if very detailed data is collected at the global level. At some level, too much detail blurs environmental trends and makes it difficult to link policy to the environment in the later stages of the analysis. At the other extreme, policy formulation may be difficult where data lacks sufficient detail. It is therefore important to determine the extent of the area to be covered before any plans for environmental assessment are made.

  How the area is demarcated may be important as well. The boundaries may be:

  - an ecosystem: a more natural division of an area to be assessed with more meaningful ecosystem averages. The functioning of the ecosystem are much more easily understood. The Zambezi Basin State of environment report (Chenje 2000) is a good example of this area demarcation for assessment.

- o political boundaries: more common at all levels of assessment (global to sub-national) because they already exist in all countries and have been used for data collection. Many policies are also based on political jurisdictions with administrative structures that can be used for environmental assessment.

- *What are the most important environmental trends and conditions?*
  Identifying the most important environmental trends and conditions at this stage helps us to see what the direction of deterioration or improvement of the environment is. If these are identified properly at the stage of assessing the state of the environment, linking environment to human activity will be easier in later analysis. The number of issues of general concern on which the report might be based is likely to be high. The most important of these for a specific interest must be put together as a set for further analysis. Each set of issues is unique and depends on the theme of interest and the area where the assessment of the state of environment is carried out.

- *What are the forces for environmental change?*
  Pressures that influence environmental trends and conditions (e.g. demographics, production and consumption, etc.) must be identified to understand the state of the environment. Some of these may be indirect (e.g. trade) but powerful in influencing environmental change. Identifying the wrong pressures may be very damaging to further analysis and linking policy and the environment because they would tend to misdirect policy formulation.

There may be many other important points to note depending on either the area of analysis, the themes of interest, or data organization.

7.3 Data and indicators

All environmental assessments need to be supported with appropriate, good quality data and indicators. Data for SOE reporting comes from many sources and in various forms, and some of it (e.g. satellite data) may require special techniques and skills to process. Each type of appropriate data, however, may add a new aspect to the SOE analysis. An environmental indicator is a sign or symptom that may be used to assist in identifying environmental change. For example, agricultural data showing tins of sorghum obtained from a given acreage may be processed to detect deterioration in agricultural yields over time by calculating the number of tins of sorghum per hectare, an indicator of land productivity. A comparison of this indicator over time will show (i.e. indicate) whether there is an increase or decrease in land productivity. Processing data to obtain indicators is useful to improving environmental assessment and communication among scientists, the public and decision-makers.

The emphasis of indicators may, in general, be influenced by the framework used in environmental assessment. When using the Opportunities Framework, indicators may be designed to reveal what opportunities are available in the environment and how they can be used to achieve sustainable development. For example, a deteriorating ecological system will need a given level of effort to reach a stage where it will become self-sustaining. Instead of focusing on an indicator that will assess how much deterioration of the ecosystem is occurring over time we can be more positive and look for a threshold beyond which it will start “healing” itself. We should then be able to use it as a basis for deciding the appropriate action to take to prevent or reduce unwanted environmental change. Alternatively, it should be useful as an early warning sign to reduce the impact of the change on activities or livelihoods that might be affected. When using the DPSIR framework, indicators may be more focused on assessing changes in pressure, state, or response on any environmental issue. For all frameworks, however, indicators are useful in formulating policy and monitoring progress towards sustainable development.

Data and indicators also (Pinter and others 1999):

- provide feedback on system behaviour and policy performance;
- improve chances of successful adaptation;
- ensure movement toward common goals;
- improve implementation; and
- increase accountability.

7.4 Data quality

Data quality and data availability are two of the most important problems for SOE reporting in Africa. Inconclusive debates based on poor quality data complicate the decision making process. However, using poor quality data may probably be more dangerous than having no data at all since it can build false confidence in environmental analysts and decision-makers that they are making appropriate responses when in fact they are not. While poor data collection techniques are responsible for much of the poor data, the worst problems in data quality relate to underestimates of the magnitude of various problems with political undertones, real or imagined, commonly as a result of ignorance of the potential dangers of intentional under-reporting (e.g. the rate at which HIV/AIDS is spreading) the problem. Table 7.1 gives some examples of the potential damage poor quality data may bring to decision making.

Table 7.1: Examples of potential damage to decision making by poor quality data

Variable	Potential error with poor quality data
Underestimate of the rate of land degradation	Insufficient attention to potential reductions in land productivity and desertification with a wide range of consequences for the economy and (on a large scale) climate. Reduction of biodiversity.
Underestimates of population growth	Errors in estimates of natural resources consumption. Poor planning for sustainable development.
Overestimates of crop yields	Insufficient attention to food security problems.
Mapping at inappropriate scales	(Scale too large) Excess and unsustainable expenditure on mapping at the expense of other problems deserving attention. (Scale too small) Insufficient information for all spatial planning.

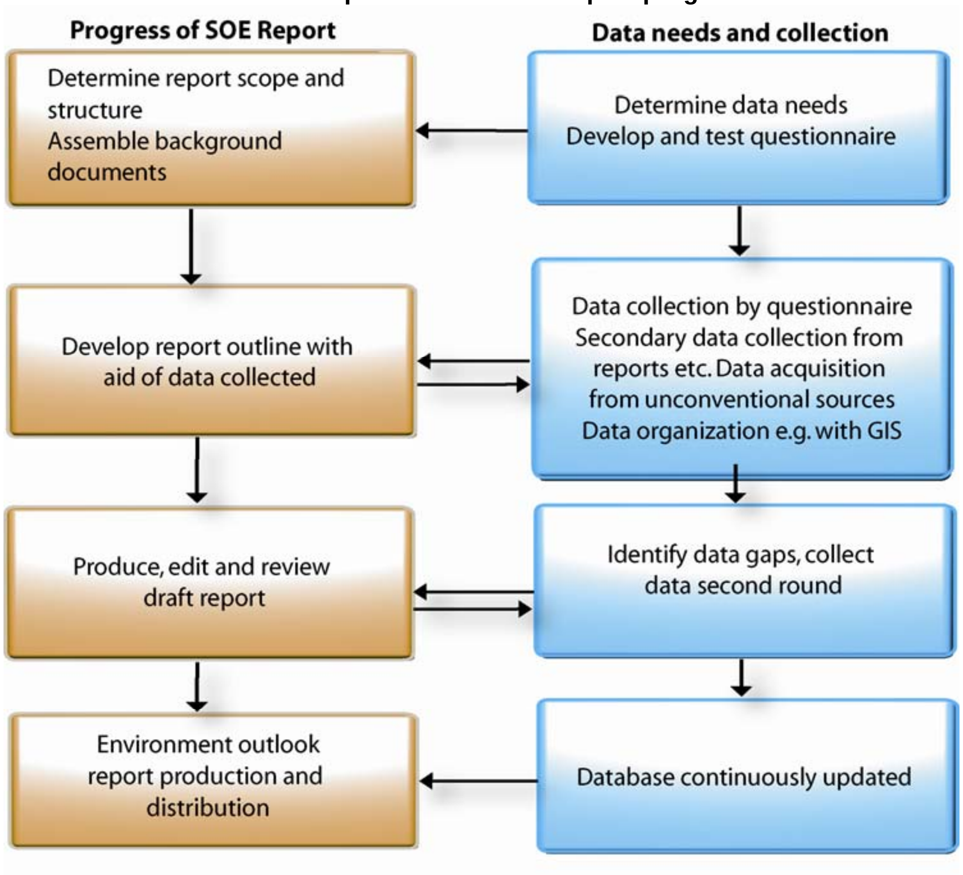
For example, data on rates of land degradation may show erroneously that degradation is progressing at a slower rate than is actually the case. Quality control should therefore be in-built in the data collection process.

7.5 Collection of data for an SOE Report

The range of data and the variables on which data is collected will be determined by the issues in the SOE report reflecting priorities of the area for the report (e.g. regional, sub-regional, national, etc.). SOE reporting may use data that might be discarded in scientific research, but even with this relaxation, availability of data may limit the issues on which analysis may be. A listing of the priorities may reveal gaps where new data has to be collected. It is advisable to first list the issues of interest regardless of whether data is available on some of them or not. The effort for data collection may then be directed at variables where gaps exist and various bodies may be identified to collect data to fill the gaps identified. For IEA and reporting, the range of issues will necessarily be wide requiring getting data from many government departments, NGOs and the private sector. Not all of these will have a keen interest in SOE reporting and maintaining data updates from their sources may be difficult.

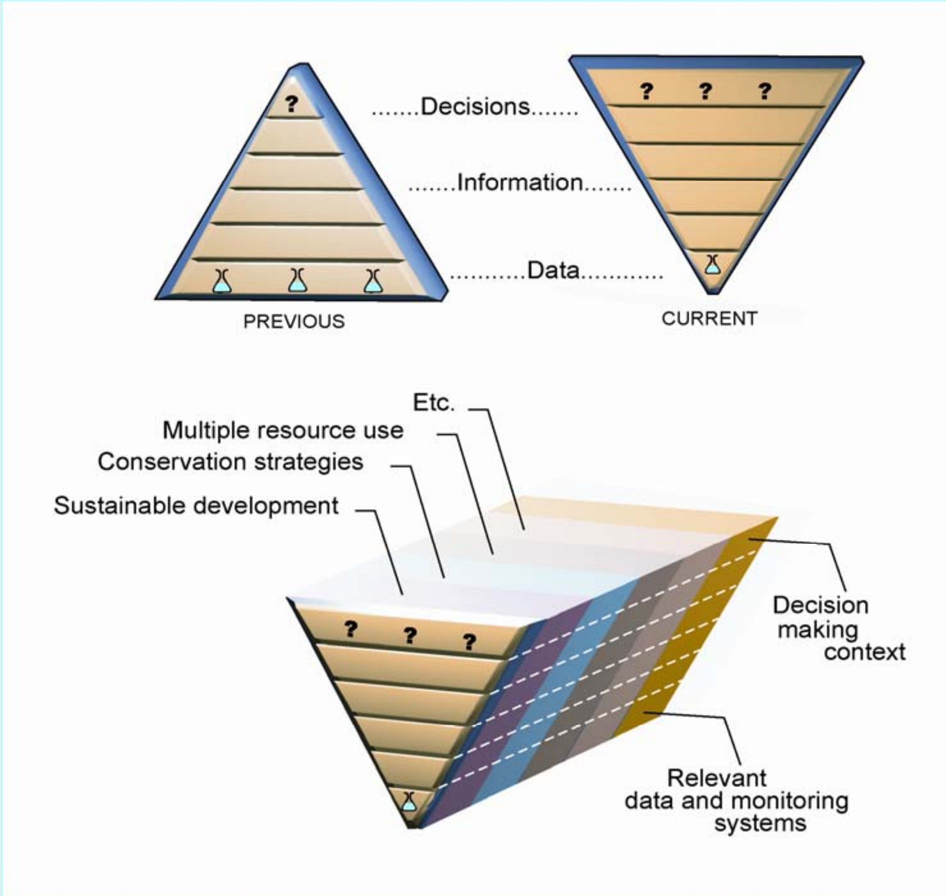
Managing the data for the SOE report is carried out in step with report development throughout the process. The arrangement of the stages may differ depending on what data relevant to the issues is already available. One illustrative development is given in Figure 7.2. Data should be collected and processed with a clear decision making process in mind rather than as an end in itself (see Figure 7.3).

Figure 7.2: An illustrative continuous data collection and acquisition effort as the development of the SOE report progresses



Source: modified from Rump 1996

Figure 7.3: Reversing situation of baseline data and decision making trends



7.6 Study/Discussion questions

Q1: Think of one example where an inappropriate indicator may be erroneously used and creates problems in assessing the state of the environment.

A1: ____
____
____
____

Q2: How can you justify collecting and acquiring data being in step with the development of the SOE report? Why not decide on all the data you need and collect it all at the beginning of the process?

A2: ____
____
____
____

7.7 Other unconventional sources of data

Many sources of data for SOE reporting are available on a global scale or from public domains. Many sources offer restricted access to their data. For the last of these categories, the AEIN is trying to negotiate wider accessibility for African scientists and decision-makers. For more on AEIN, see the AEIN implementation guidelines (www.unep.org/dewa/Africa/docs/en/AEIN_Implementation_Guide_en.pdf).

7.7.1 Remotely sensed data

Remote sensing is a technique which can be used to acquire data on features on the face of the earth without the observer being in direct contact with the object of observation. Data for many areas of Africa is difficult to acquire because they are difficult to access or lie across various types of boundaries. In other cases, the cost of acquiring data for extensive areas for which SOE reports are required is beyond the means of many governments. For these, 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 advantages.

- Remotely sensed images provide good “pictures” for convincing the public and decision-makers to participate in discussions on issues of importance but which may not be part of their daily life (see Box 7.1).

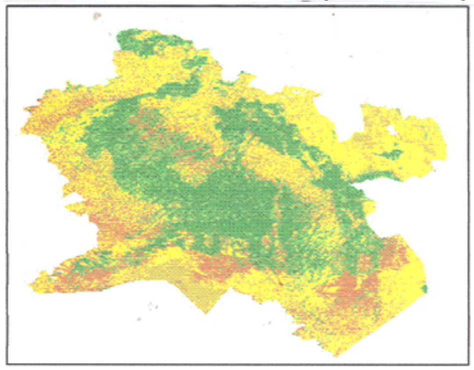
- Remote sensing provides data with a standardized format. Standardization of spatial data has received a lot of attention in almost all the countries of Africa. However, problems of formats still exist over large areas and across national boundaries. Satellite systems (e.g. LANDSAT) take images over large areas with the same format over many years with no regard for political boundaries. Integrating this data with socioeconomic data for IEAbecomes easier.

- Remote sensing may also be used to monitor the progress of projects resulting from policy decisions designed to improve the state of the environment. Proof of progress towards success may be essential for further investment (See Box 7.2)

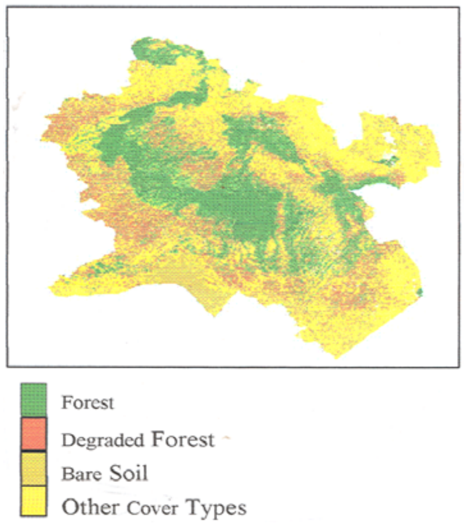
- Remotely sensed data is available on a cyclical basis and has been used for providing data for monitoring the environment over long periods. This is particularly important for SOE reporting in very rapidly changing environments. For example, available data for the spatial expansion of urban areas in many African countries is commonly grossly outdated and makes it difficult to assess the pressures spatial urban growth is putting on available resources (See Boxes 7.3 and 7.4).

Box 7.1: Vegetation degradation in the Mau Forest on the Mau Escarpment, Kenya

Conservation of forest vegetation on the mountains of Kenya is critical to the water supply and daily life of many people in the Kenya highlands. However, without data it was difficult to prove that this was an important issue in the state of the environment of the country and a strong illustration of its importance was essential.



Vegetation cover of Mau Forest, 1986 (*above*)
Vegetation cover of Mau Forest 2000 (*below*)



In February 2001, the Government of Kenya announced its intention to accept requests for licences for logging over a 353.01 km^2 area in the Eastern Mau Forest on the Mau Escarpment (UNEP 2003). The images in this box show forest degradation in the Mau Forest between 1983 (top) and 2000 (bottom). Conservationists used data acquired from remotely sensed images to argue the case against the Government's intention, pointing out that half the dense forest in Lake Nakuru's catchment area had disappeared between 1973 and 2001. Further destruction of the forest in the upper reaches of the basin would mean that the main rivers that feed Lake Nakuru would disappear. Using remote sensing, both UNEP and the Regional Centre for Mapping of Resources for Development (RCMRD) in Nairobi buttressed this argument with analyses of the importance, recent human activities in, and the potential fate of mountain forests in Kenya. Hardly a public in any African country can claim to be as charged about any natural resource as the Kenyan public is about its mountain forest resources now.

Source: RCMRD 2004

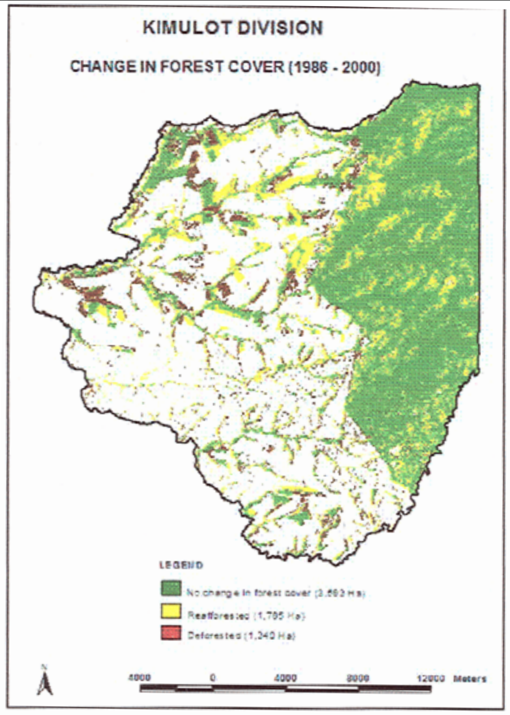
Comment [M1]: Reference is missing THIS REFERENCE IS FOR THE MAPS, CHRIS WILL CONFIRM. Musisi suggested that UNEP 2003 was the source, but it is only the source for some of the data.

Box 7.2. Acquiring data to prove the success of the "Response" to deforestation in the Kimulot Division of Mau Forest

The decreasing forest cover on East Africa's mountains and the interest the East African communities have taken in its recovery has attracted attention from various organizations and donors. Forest recovery projects exist in many districts, sub-districts and localities.

In the Mau Forest in Kenya, forest recovery projects in Divisions have been in progress since 1986. Progress is slow and the acquisition of more funds from various sources has been largely dependent on proving that the forest recovery project is getting some success.

Data from the progress of the project from Kimulot Division in the Mau Forest of Kenya shows how remotely sensed satellite images were used to provide this data. As may be seen from the statistics, between 1986 and 2000, the reforested area was more than 91 per cent of the deforested area.



Area Statistics
Forest – 9,427 Ha (94.27 Km^2)
Deforested – 2,036 Ha (20.36 Km^2)
Reforested – 3,894 Ha (38.94 Km^2)

Source: RCMRD 2004

Comment [M2]: Reference? CHRIS WILL CONFIRM. Musisi suggested UNEP 2003 but it is not the source.

Box 7.3: Remotely sensed data to analyse Midrand's state of environment

Remotely sensed data for Midrand suggest that effective environmental management strategies are required now to avoid deterioration in environmental quality.

Midrand is strategically located halfway between the major urban centres of Johannesburg and Pretoria. It is 240 km^2 and had a population of 240 000 in 2001. The satellite images in this Box show the area in 1985 (top) and 2001 (bottom). Within this period, data acquired using remotely sensed images showed that 65 per cent of Midrand was transformed for human settlement, crops and industry. There are 232 ha of wetlands and river areas. The dominant ecosystem is a transition of grasslands that contains species that exist in both grasslands and in the bushveld ecosystems.

The rapid growth of Midrand's economy is expected to continue with associated impacts on the environment. Current development trends indicate that if effective environment strategies are not adopted soon, we can expect significant deterioration of the environment.

Source: UNEP 2003

Box 7.4: Acquiring data from remote sensing for monitoring urban growth and its impact in changing the state of the environment: Banjul, the Gambia

Rapid urban growth is one of the greatest influences in changing the state of the local environment in many African countries. The potential growth of many African cities was grossly underestimated at a time when population densities were low and extensive land tracts could have been set aside for their growth. Recent growth of many cities has been very rapid due to immigration from poverty stricken rural areas. Getting data to assess the impact of this growth on the state of the environment both within and around the growing cities using conventional means would be very time consuming and costly. Remotely sensed data has been useful for acquiring this data.

Banjul, the capital city of Gambia, is one such city located at the end of a peninsula with land grossly insufficient for its growth. The satellite images in this Box show the extent of the city in 1973 (above) and 2001 (below) during which time the Greater Banjul city tripled in population size. It now has sprawled to include several outlying districts such as Serekunde and Kanifing. Technology to drain the mangrove swamps has so far not been introduced and the swamps that lie to the north-east border of Banjul have not been destroyed but this may not be for long unless an urban growth policy protects them in the future.

Source: UNEP 2003

Box 7.5: Acquiring data for the protection of important tourist spots: Lake Nakuru, Kenya

Without time series data, the deterioration of the environment is sometimes difficult to detect if it is very slow. This is particularly the case with "protected areas" where the pressures on the land may overcome the protection. The satellite images in this Box show the deteriorating state of the environment for the "protected" area around Lake Nakuru between 1973 and 2001. Lake Nakuru, located southwest of the city of Nakuru in the Rift Valley, Kenya, is one of the most beautiful tourist destinations in Africa. It hosts the world's greatest concentration of flamingos, and has many of the more important animals that have made Kenya an important tourist destination.

In spite of its protected status, the Lake Nakuru area has a high degree of vegetation deterioration. The satellite images show the state of the vegetation in 1973 (above) and 2001 (below). The deterioration is having major impacts on the fluctuations of water flow and on water quality. The satellite images provide data to assess the changing state of the environment of the Lake Nakuru region.

Source: UNEP 2003

7.7.2 World Wide Web sources

The internet has become a major source of data for SOE reporting. Internet mapping has been used very effectively by UNEP to communicate images, maps and other types of datasets to potential users. The most comprehensive is probably the family of GEO Data Portals which provide city, national, sub-regional, regional and global environmental data and information to all who may want to use it. The exercise below is a simple introduction to accessing this Africa-focused source.

7.8 Exercise: Introduction to GEO Africa Data Portal

This exercise is included in this module to give you an introduction to one of the most versatile sources of environmental information and data on the World Wide Web: GEO Africa Data Portal. The GEO Africa Data Portal is the web interface of the AEO - Environment Information System (AEO-EIS) designed to improve access to harmonized national, sub-regional and regional statistics and geospatial datasets for IEA and reporting in Africa. It covers thematic areas such as freshwater, land, socioeconomics, forests and woodlands, atmosphere, energy, coastal and marine environments, human settlements, biodiversity, health and the environment, and wetlands. The portal can generate output in the form of graphs (*bar graphs, line graphs, pie charts*), maps, data tables and one can also download data in various formats.

Step 1 – Open the webpage http://www.unep.org/geo/data/africa

Figure 7.4: GEO Africa Data Portal Homepage

The Homepage

The homepage (Figure 7.4) offers access to a wealth of information. In principle, it has three main areas of interest:

- The simple "free text search" which is simple and straightforward: type in a free (thematic, indicator or data variable) keyword(s) such as "emission", "waste", "forest", click on "Search" and follow the instructions.

- Use the "Advanced Search" for more specific search options. Limit your search to an AEO/GEO Theme, a geographic region (AEO/GEO) or a scale/resolution (city, sub-national, national, sub-regional, regional, geospatial).

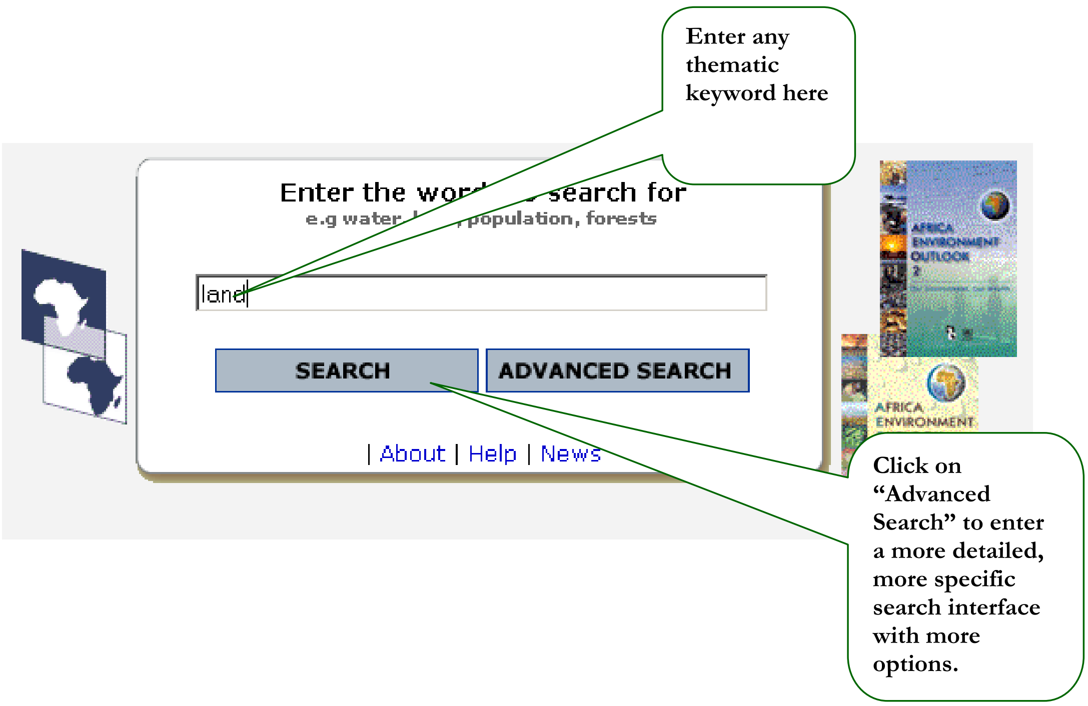
- In the section "links" one will find links to, the AEO-1 report, AEO-2 indicators and AEO-2 data compendium.

In addition, for French-speaking users, most of the Portal has been translated into French. Just click on the link "**Français**" above "links".

Step 2 – Search for some data and indicators, graphics and maps that are contained in the database.

Free text Search
The primary function of the basic search is to provide users with an easy way of searching for an indicator or data variable based on a word or words related to the what they are searching for. The search is an easy to use interface, which will query different fields for the entered keyword(s). All words contained in the theme, data variable, or indicator name fields will be searched. Just enter any thematic keyword such as "water", "forest", "population", "emission", "trade", etc.

Figure 7.5: GEO Africa Data Portal Search Box

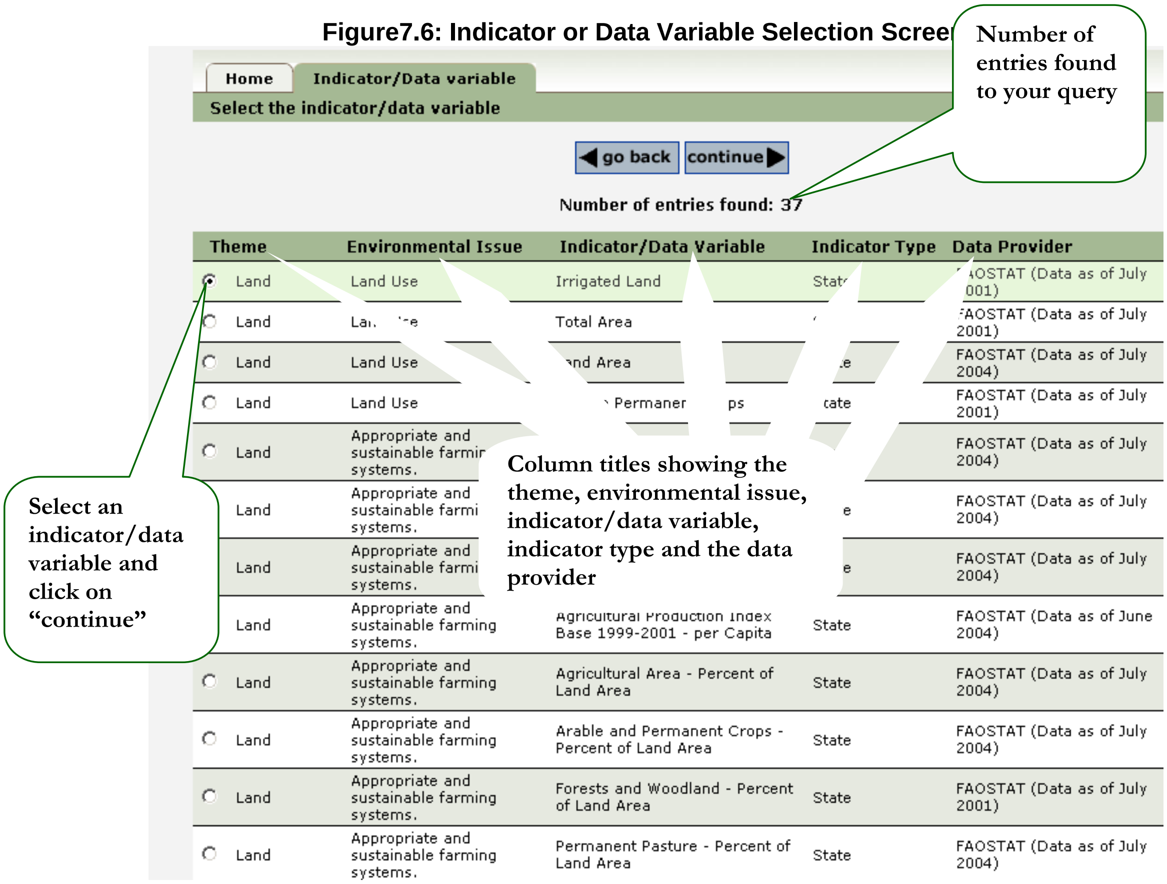


Step 3 – Indicator or Data Variable Selection

The keyword(s) entered on the homepage is searched through several fields of the theme, data variable, or indicator name. The number of entries found for the search, are displayed in the first line. One can try to limit the number by specifying several or more precise keyword(s), in order to avoid long lists of variables.

A variable can be selected by clicking on a circle in front of each data set name and then clicking on the "continue"-button at the top or bottom of the page (see Figure 7.6).

Figure7.6: Indicator or Data Variable Selection Screen



The different columns of the search result screen (Figure 7.6) give the following information about the dataset:

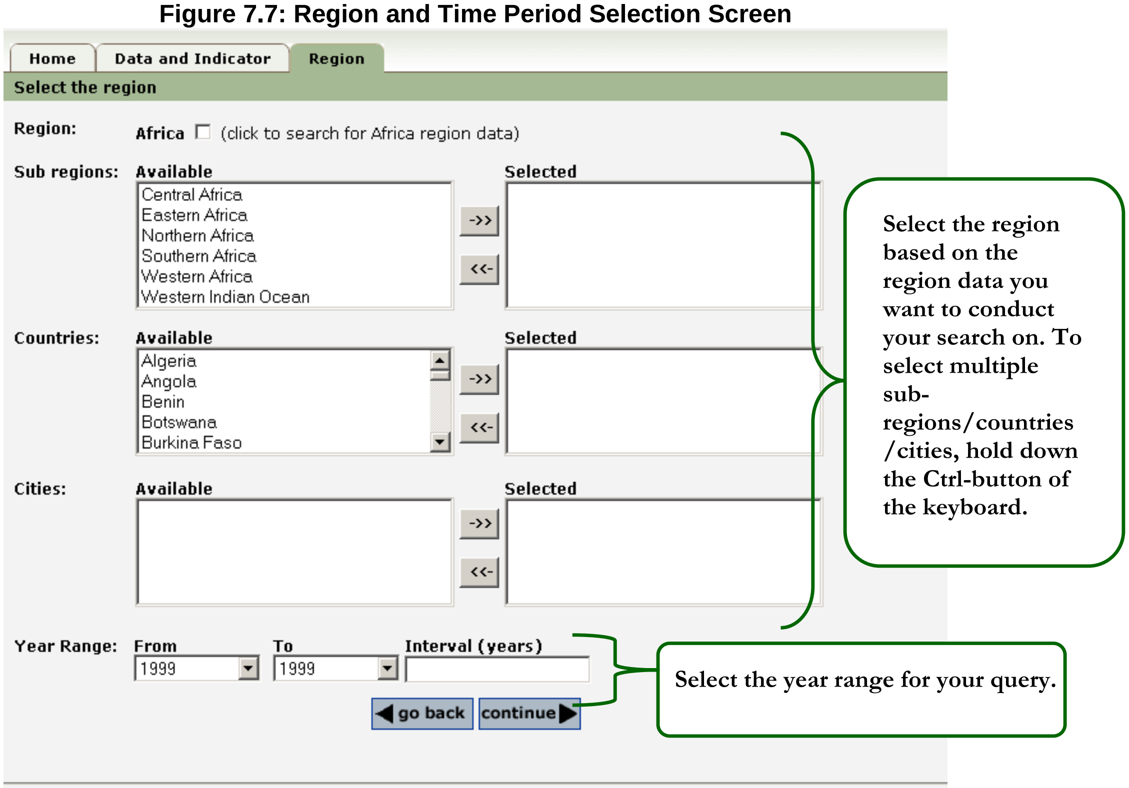
- The theme name of the indicator/ data variable,
- The environmental issue of the indicator/data variable,
- The indicator/data variable name,
- The indicator type(either driving force, state, pressure, response, or impact)

- The name of the data provider.

Step 4 **– Region and Time Period Selection**

After having selected a specific indicator/data variable, one has to choose the desired region and time period (See Figure 7.7).

Figure 7.7: Region and Time Period Selection Screen



The regions are categorized as follows:

- Africa region,
- the AEO sub-regions,
- countries, and
- cities.

The years are displayed in the "From" and "To" boxes, and are always ordered descending, so that one has the most recent year at the top of the list. The interval box gives one the option to indicate the interval in years of the expected output.

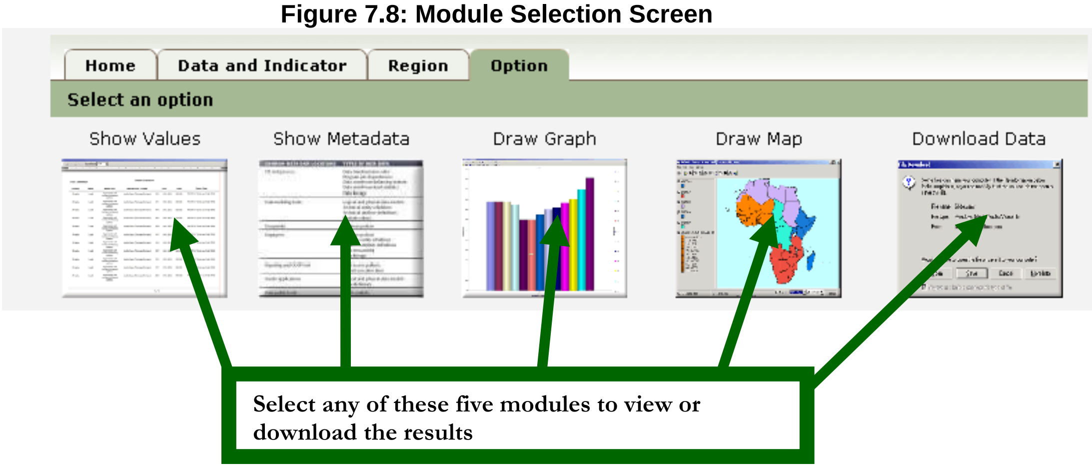
The availability of years for different data sets varies considerably. Where possible, data are available for a period of 30 or more years, but sometimes there are only a few years available.

Even though years are displayed in this box, it does not mean that the data are really available for all cities/countries/sub-regions/region. Missing values may occur occasionally.

Step 5 - Module Selection

The "Option" page is the "hub" for all further actions. It offers one access to different display and analysis modules, as well as to the download and metadata modules.

Figure 7.8: Module Selection Screen



- *Dynamic mapping (draw map):* This module is still being developed.
- *Customized graphing (draw graph):* The Portal also enables one to produce graphs for the selected data set. This helps to explore trends and analyze changes over time. The values of several countries or sub-regions can be compared to each other, and one can also show the value for Africa as a whole.
- *Generating data tables (show values):* One can display the selected variable in a data sheet.
- *Data download:* The Portal offers two different formats for the download of statistical data sets. The formats are Microsoft® Excel and comma delimited/separated values (CSV).
- *Displaying metadata:* This module offers detailed background information for the selected data set, such as data provider, source, publisher, date etc.

If one wants to switch from one module to another, then there are two possibilities to do this:

- By clicking on the "Back" button of one's browser until the "Option" page appears again.

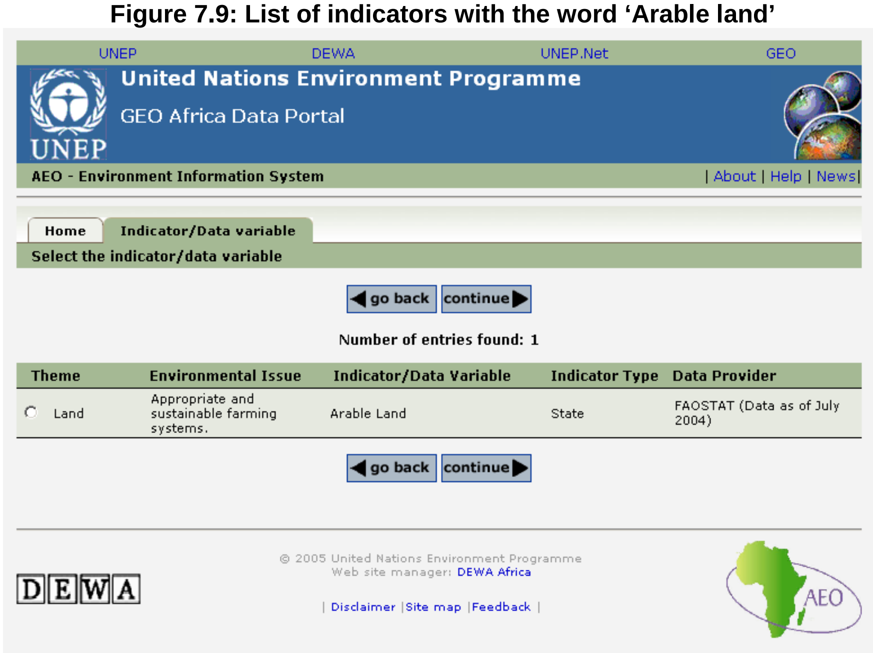
- By clicking on the “option tab” at the top of the selected module. The module one is using at the moment is highlighted in a green colour.

Step 6 **– Example of state of arable land in Ghana**

To extract data for the indicator (arable land), which is part of the land theme, for Ghana, a country in Western Africa, follow these steps:

- Enter the words ‘arable land’ and click on ‘Search’ button. The following screen appears (Figure 7.9).

Figure 7.9: List of indicators with the word ‘Arable land’

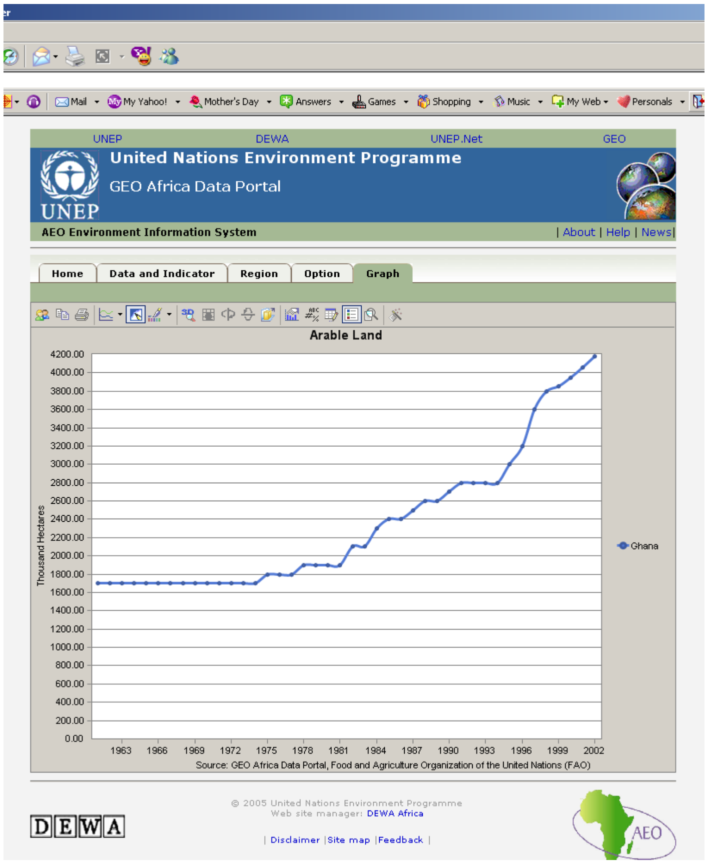


- Click on the “circle” to the left of the column with the indicator "Arable land" then click on the "Continue" button to proceed. The screen showing the different geographic regions appears.

- In the "Available sub-regions" list box click on "Western Africa". In the "Available countries" all the countries in western Africa will be listed. Select "Ghana" and click on the ">>" button to add it to the "Selected countries" list box. Select the "Year from" and "Year to" and click on the "continue" button to proceed.

- On the “Option” page listing the different modules, click on the image below ‘Draw Graph’ , the graph will be generated as shown below (Figure 7.10).

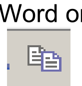
Figure 7.10: Graph illustrating indicator values for Ghana



Step 7 – using search results of GEO Africa Data Portal to support narrative in report

Let us put the three illustrations together to assist us in writing an SOE report on arable land in Ghana.

Note that you can click the  button to print the graph or copy the graph onto a Microsoft® Word or Excel file by:

- Clicking . Select "Bitmap" or "Metafile" to copy the image or "Text" to copy the figures.
- Opening a Word or Excel file.
- Opening the "Edit Menu", and clicking on "Paste".

Note: You can change the type of graph by clicking on the  button. (For more details about the features and functionality of the portal, please consult the GEO Africa Data Portal User/Training manual)

Discuss the results using the following sub-headings, illustrating your discussion with data from different countries in Western Africa.

1. Pressures on arable land in Ghana
2. State of arable land in Ghana
3. How does the situation compare with other countries in the Western Africa sub-region?
4. How does it compare with countries in other sub-regions in Africa?

Do the same for any other geographical selection (one country; several countries; one sub-region or several sub-regions) and analyse using the DPSIR framework.

7.9 Developing Indicators

There are many points to observe when developing indicators. Among these are the following:

a. Indicators express information in ways that are directly relevant to the decision making process. They are developed:

- within the limitations of available data. Where relevant data is available and is of high quality, very good indicators can be developed
- to be directly within the information needs of decision-makers
- to answer questions on key policy priorities

b. Indicators are powerful tools for assessing environmental change because:

- they are directly linked to assessment and evaluation
- they strengthen environmental accountability

c. There should be a criterion within which indicators are collected so that their selection is not haphazard. An example of a criterion for developing a set of indicators is given Box 7.6. No Criteria set is ever complete; criteria should always be improved with participation of those who are using it. Quality control should be in-built in the discussions for the entire set.

Box 7.6: An example set of a criterion for developing indicators

Indicators should:

- Be developed within an accepted framework
- Be clearly defined and easy to understand

- 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 is available or data that can be collected at low cost and within the ability of the country's statistical agencies)
- Be relevant to users
- Be limited in number
- Reflect causes, processes or results (i.e. reflect pressure, state and response).

Source: World Bank 1997

d. Caution should be taken in developing indicators to make sure that they reflect aspects of a system that you want to measure. Indicators are central to how you perceive system performance. Developing the wrong set of indicators will encourage recommending the wrong policies and eventually to changing system performance. If, for example, the issue for which a new policy is required is ecological sustainability, and the indicators selected measure economic sustainability, the new policy, if approved, will change the environmental system in the direction for which it was not intended.

Table 7.2 below lists some indicators that have been suggested for AEO-2.

Table 7.2: Some Environmental Indicators suggested for AEO-2

Issue	**Indicators**		
	Pressure	**State/Condition**	**Response**
Climate change	- Fossil fuel - Greenhouse gas emissions	- Mean global temperature - Ambient levels of CO_2 or other greenhouse	- Change in energy use
Water quality/ eutrophication	- Nitrogen and phosphorus emissions - Wastewater discharges - Livestock density	- Biological oxygen demand; dissolved oxygen; nitrogen and phosphorus levels in water	- Population served by treated water supply - User charges for waste water treatment
Urban environmental quality	- Air pollutant emissions - Traffic density - Rural-urban migration	- Urban air quality - Ground-level ozone concentrations	- Pollution abatement charges

7.10 Participatory indicator development

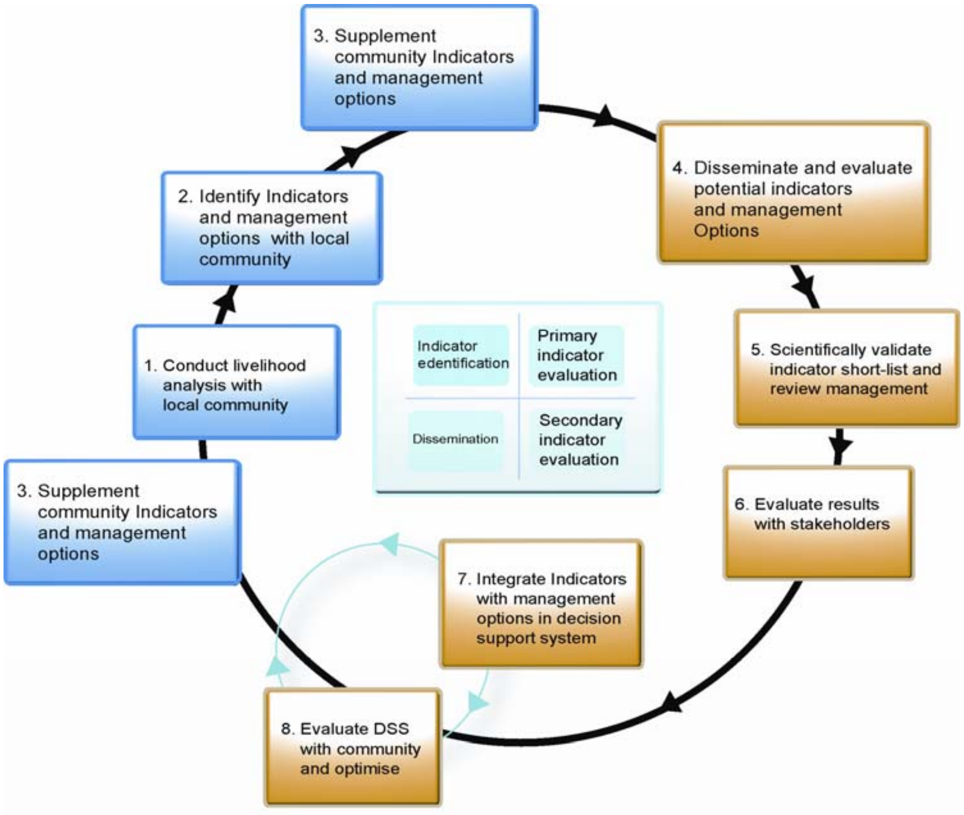
Indicators arise from the values of the people who use them. Different people living and working in different environments have different values and these must be reflected in the development of indicators. Many indicators exist that are developed by scientists for other scientists to use in environmental assessment. Many such indicators, for example, exist in rangeland management to detect whether rangelands are degrading or are sustainable. These tend to be too expensive and complicated for farmers and cannot be used by them to monitor and respond to environmental change. The aim of participatory indicator development is to replace such indicators with sets that local people can use effectively. For participatory indicator development to be effective, professionals and researchers should learn to solve environmental problems together from multiple perspectives. This is the true participatory approach to IEA and reporting. It ensures that local skills and knowledge are considered in the development of environmental indicators that the local communities can use and maintain. Figure 7.3 gives one example of a possible framework for participatory indicator development

When indicators are developed for indigenous people, their value system may be very different from that of the scientists. However, comparisons of scientific-based and indigenous knowledge-based indicators (see Box 7.7) have shown that:

- there are many elements in both indicator sets that may be useful as a link in developing a combined set of indicators which will be more
- the indigenous knowledge-based indicators are easier to use and better locally understood descriptions of indicators; and
- not all scientific indicators considered relevant by scientists are accepted under local indigenous knowledge scrutiny; some are rejected as irrelevant.

These points emphasize the importance of integrating indigenous knowledge in indicator development wherever it is appropriate.

Figure 7.11: An example of a framework for participatory indicator development



Source: modified from Reed and Dougill 2003

Box 7.7: Integrating indigenous knowledge and scientific enquiry in participatory Indicator development for sustainable development in the Kgalahadi, Northern Botswana

Research work to integrate indigenous knowledge and scientific enquiry in participatory development of potential indicators of rangeland degradation in the Kgalahadi region of Botswana demonstrated a number of advantages associated with this approach:

- Each of the indicators developed by this approach was confirmed by the communities to be easily used
- There was a considerable overlap between scientific and local knowledge, suggesting that the majority of indicators cited by the communities have an empirical basis in scientific literature
- Communities provided non-technical, locally more meaningful interpretations of some indicators found in the scientific literature, e.g. “dirtiness” of sand as a surrogate for soil organic matter which would require laboratory facilities to

measure.

- Many indicators from the scientific literature were not cited, while others were rejected as irrelevant to their localities (e.g. abundance of earthworms)

- Communities cited a large number and range of indicators. The range elicited was far broader than any published scientific list encompassing vegetation, soil, livestock, wild animal, and socioeconomic indicators. Some of the indicators were new to science and require investigation. Examples:

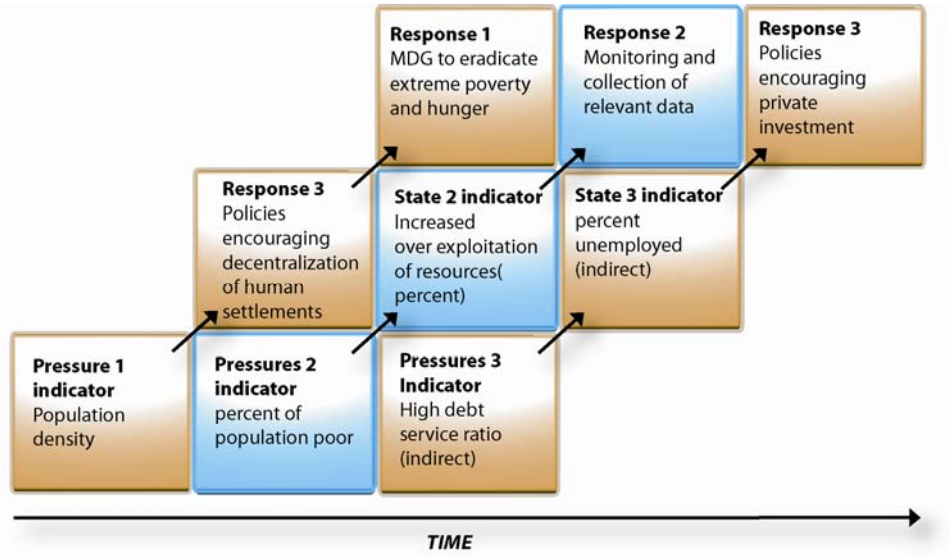
  - Soil — Decreased incidence of cattle tracks
  - Vegetation — Increased abundance of grasses with hollow tillers; Tree growth increasingly stunted
  - Livestock — Increased abundance of livestock disease

Source: Reed and Dougill 2003

7.11 Using indicators for environmental assessment

For any environmental issue for which time series data is available, indicators may be used to assess environmental change in pressures and state, and to assess whether the responses put in place are making any impact over time. This combined and holistic use of indicators is very powerful in environmental assessment and is useful in policy formulation and adjustments. Figure 7.12 is an illustration of how indicators for the pressures on the environment and the state of the environment may be linked to the society's responses over time. The Figure simplifies the links by introducing the pressures one at a time. In real life, multiple pressures would be impacting on the environment at the same time and those that are introduced as new are part of the set with the old ones.

Figure 7.12: An illustration of how to link Pressure/State indicators with Response

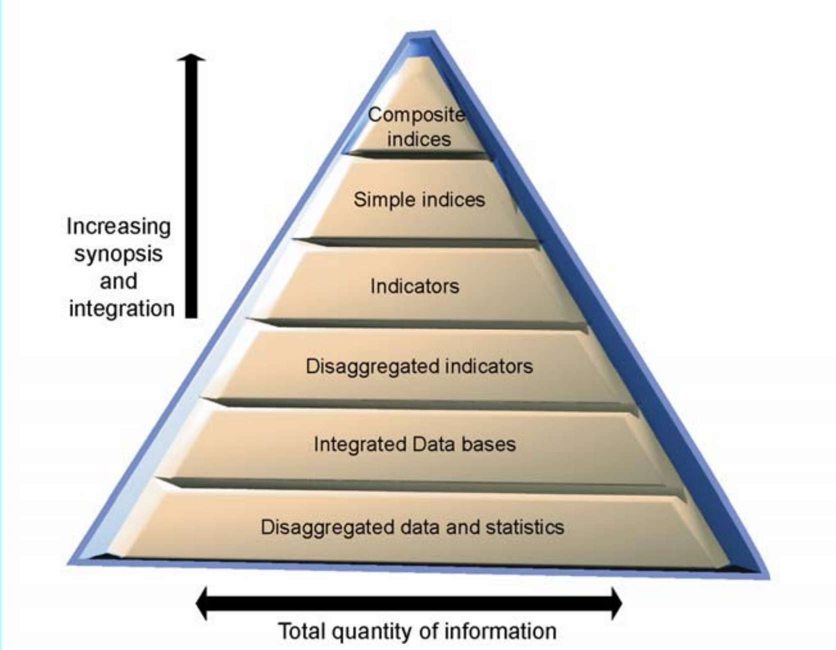


Source: Reed and Dougill 2003

7.12 Data, indicators and indices

Data may be seen as being at the bottom of a hierarchy the peak of which are indices (see Figure 7.13). Data are collected from the field in a disaggregated format but are aggregated to build a database. From the database, variables are used to build indicators unique for each application, socioeconomic circumstances and geographic area. Indicators are used to communicate the performance of the system to all stakeholders and decision-makers. Simple indices may be built from indicators and composite indices from simple indices. The aggregation is necessary because scientists working at different scales will need different levels of aggregation to formulate policy for that level. Indices, such as the Human Development Index (HDI), and the Gross National Product (GNP) are attractive for scientists working at the national level because of their simplicity in use. However, highly aggregated indices may not give sufficient detail to decision-makers to see a realistic performance of a system.

Figure 7.13: Relationship between data, indicators and indices



Source: After Braat, in Kuik & Verbruggen 1991

7.13 Presentation of spatial data and indicators with GIS

The techniques of GIS have provided the ability to organize spatial data for many scientific investigations. GIS helps us to turn environmental data into spatial information and to use environmental indicators to reveal anomalies, for the purposes of decision making. The information obtained may also be used to influence the formulation or modification of policy. GIS helps the scientist to communicate spatial information with the public and with decision-makers.

Spatial environmental data has many characteristics. Some (e.g. rainfall, temperature, pollution levels) are continuous, others (e.g. water bodies, land parcels) are relatively discrete by comparison. Most current GIS software has the ability to map either of these categories and to work with both to reveal spatial patterns, anomalies and relationships in environmental data or environmental indicators that might otherwise not be obvious. The relationships are not uniform throughout any geographical area. The finer the scale at which you map the data, the more you are able to understand the real relationships on the ground. They may differ by tribal or ethnic areas, ecological zones, administrative districts, etc.. GIS provides the ability to map these relationships quickly and relatively cheaply. When using integrated environmental assessment, a wide range of data from different sources and using different formats must be used to link the environment to socioeconomic activities. The most important advantage GIS provides is probably that a spatial database with environmental and socioeconomic data (in addition to other data considered useful and relevant) are forced into a standardised format which makes it easy to observe spatial variations on many themes. Not all the data relevant for IEA and reporting is mappable, but that which is mappable provides a good basis for understanding spatial variations in pressures on the environment, differences in its state, and the effectiveness of responses in different parts of the area of interest (sub-national, national, sub-regional or regional). Once a database has been developed, many operations may be performed to obtain spatial information to influence policy. The following are good examples:

- *Queries on spatial environmental data*
  This is the simplest of GIS operations that may be used to obtain information from raw environmental data in a GIS database. The interrogation of the database may be on any aspect of its contents, but two types of queries are common. The database may be queried to reveal the location of all features that meet a certain criteria. For example, it may be interrogated to show all areas whose rainfall is less than 25 mm. Further decisions may be based on this information. The areas identified may have populations that are most vulnerable to environmental change and the Government may formulate special policies to give more attention to them. The second type of query identifies specific features at given locations: reveal what is located at this point. These (and other categories of queries) are very powerful in providing information for decision making and policy formulation. With a lot of GIS software, answers to these queries can be obtained by pointing to certain locations. The returns to the queries may be in tabular or map view.

  When the datasets queried in the database are indicators, the information returned may be more useful for assessing the environment and formulating policy. If the indicator selected has a normative yardstick (e.g. the required level of water quality) we will be able to identify the spatial variation of areas that are below the required level and how far they are below that level.

  One of the most important aspects in IEA and reporting is the participation of a wide range of people in decision making. Multiple map views of different aspects of what is in the data and in the indicators are very useful for convincing people about the meaning of the data and indicators. Map *views* of answers to queries provide good visual impressions that are useful in soliciting for participation in environmental policy formulation.

- *Transformations*
  In transformation operations on datasets, simple (adding, dividing, etc.) or complex operations are performed on the datasets in the database to provide new perspectives of the data. Indicators may in fact be obtained in this way. Population density, for example, may be a pressure indicator and may be obtained by dividing the column “area” by the column “population”. We could compare the result with a threshold value or the carrying capacity yet in another column in the database. Other important transformations include:

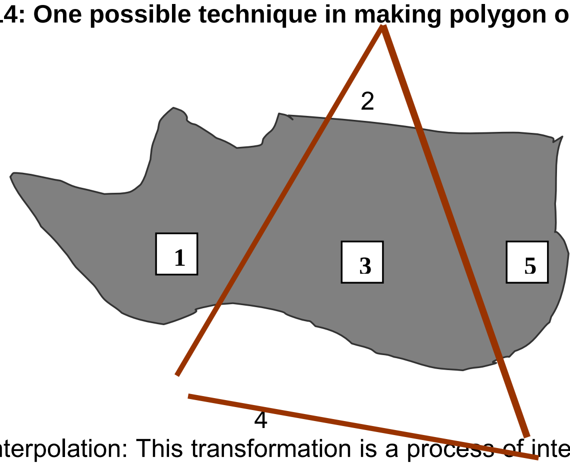
  - Buffering: This is a popular operation in the environmental protection of delicate areas. From a set of objects, which may include points, lines or areas, new objects are built by identifying all areas that are within a given specified distance of the original objects. For example, policy may be formulated to ban all land clearance, grazing, and logging within a given distance of reservoirs in a country, the distance depending on the size of the water reservoir. It is not common to involve the public in the development of buffer zones for protecting objects in Africa. There are, however, many cases when the interaction of scientists, decision-makers and civil society is useful before policy is formulated.

Subsequent enforcement of the policy becomes easier. In the Okavango Delta in Botswana, the government demarcated consecutive zones of buffer zones around the Moremi Game Reserve, the most attractive focus for tourists, the innermost zone is reserved for viewing and photography only. Activity increases in the outer buffer zones to the outermost zones where grazing and arable agriculture are allowed (Modise 2001). Enforcing the regulations for this policy has been difficult because of challenges from local communities who were not consulted when the policy was formulated (Mbaiwa 2005).

- Polygon overlay: This operation is used in GIS to determine an area of overlap of two or more objects viewed in map form. In Figure 7.14, two polygons have been selected from two view maps: one showing an indicator of the state of the environment (*underground water polluted*) (grey polygon) (say, 4 times the average for the area where the polygon comes from). The polygon with thick lines shows a pressure indicator: population density. It has the highest population density, which is 4 times the average for the area. The overlay of the two polygons gives us 5 polygons with three combinations of state and pressure:
  - Polygons 1 and 5 have the highest levels of pollution but fall below the highest population density
  - Polygons 2 and 4 are included in the area with the highest population density but not in the area with the highest underground water pollution
  - Polygon 3 seems to be the worst: it is included in the area with the highest population density and the area with the highest underground water pollution.

  The GIS analysis in this case gives us the area which needs the greatest attention judging form the combination of the existing state and pressure. Probably in formulating policy, responses most suitable to polygon 3 will be given priority

Figure 7.14: One possible technique in making polygon overlays



- Spatial interpolation: This transformation is a process of intelligent guesswork in which the GIS attempts to make a reasonable estimate to obtain values for points where no values have been measured based on the measured values in a field. Spatial interpolation has been used for centuries in drawing isolines (e.g. contours, isohyets, etc.). GIS adds speed and constant algorithms being used in the estimates. The tourniquet is particularly useful in areas where there are limited environmental data recording stations (temperature, rainfall, etc.) as is the case in many African countries.

7.14 Key Internet resources on indicators

The following organizations offer key resources and data on indicators:

- UN Commission on Sustainable Development (UNCSD) (http://www.un.org/esa/sustdev/isd.htm)
- World Bank (http://www-esd.worldbank.org/eei/)
- IISD (http://iisd.ca/measure/compindex.asp)
- FAO (http://apps.fao.org)
- World Resources Institute (WRI) (http://www.wri.org/data/)
- UN System-wide Earthwatch (http://www.unep.ch/earthw.html)
- Center for International Earth Science Information Network (CIESIN) – World Data Centre (http://www.gateway.ciesin.org/wdc)

7.15 Exercise 7.2: Monitoring systems, indicators and indices

1. Working together as a group, please provide other examples of data, indicators, indices and the underlying monitoring system from your profession.

Monitoring system	Index	Indicator	Data
Water quality sampling sites, personnel and Equipment	Water quality index	Rate of compliance with nitrate standards for drinking water	nitrate levels in water

2. Give two examples where polygon overlay can be used in integrated environmental assessment. Clearly state what your overlay achieves in each case.

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