Chapter 3

Framework for the Development of Environment Statistics

Introduction

This chapter discusses frameworks for compiling environment statistics. The discussion is based on a review of the work done by various international organizations in developing environmental information systems, and environmental indicators and indices. The chapter argues that because of the large volume of environmental data or data needs that are likely to be encountered, the information system should be systematically structured in such a way that it facilitates data aggregation, information organization (or grouping under a logical framework), analysis, and communication.

This chapter is not written specifically for environment specialists or resources managers. Rather, it is intended mainly for statisticians who may not yet be fully apprised of environmental management issues. Therefore, issues as well as the mechanics of environmental data collection and processing themselves are presented together. The aim is to ensure a strong link among efforts at data collection and their usefulness for actually solving environmental problems.

Framework for Environment Statistics

A framework is important to systematically sort out environmental data (particularly on air, water, and soil conditions), which are often very large in volume. The framework provides a suggested approach to organizing environmental data into types, levels of aggregation, issue relevance, uses, and potential users.

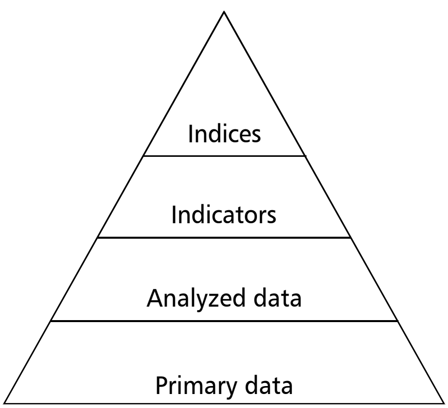
The preliminary framework presented here represents a collection of various subframeworks. For instance, one subframework presents levels of data aggregation and uses or users. Another presents ways of grouping the data according to whether they pertain to states of the environment, the pressures or stresses creating such states, and the responses (policy and program interventions) of the concerned authority. These data groupings are further organized according to related key issues. Finally, a third subframework is presented for analyzing linkages among issues and, in general, the link between the environment and socioeconomic development.

The Information Pyramid

As used here, the term environment statistics refers to a collection of data and information organized into layers, as in a pyramid with a wide base and an apex, to indicate increasing levels of data aggregation. The layers are not independent categories. Rather, the lower layers are used for building the upper layers – a pattern that results in increasing information content (as well as degree of consolidation and simplification) as one moves toward the top of the pyramid. In itself, the pyramid is the model of the information system (Figure 3.1).

At the base of the pyramid are primary data. Primary data for water, for example, may refer to daily measured concentrations of various key pollutants in a river sampling station. Other primary data

Figure 3.1
The Information Pyramid



for the river might include the volume rate of flow, water temperature, dissolved oxygen, suspended solids, and so on. On top of this primary layer is a second level of aggregation, representing the analysis and initial consolidation of primary data. The analyzed data may include annual averages, variabilities, and totals for each of the water parameters. Usually, the analysis is reported as time series information (showing changes in the parameter measurements over time at a given location). Also at this second level, the primary data would be combined so as to, say, generate information on the pollution load in the river (this is obtained by combining data on pollutant concentration with volume rate of flow). Thus, the two aspects of analysis involved here are those of data aggregation (e.g., obtaining averages of measurements or depicting patterns in time and space) and data combination (putting together two or more parameters to derive new information).

For the most part, the two base layers of the environmental information pyramid–the primary data and the analyzed data–are the familiar ones. The methodologies for primary data collection and analysis are well known, especially for physical parameters (soil, water, and air). The main concerns have had to do with whether the data themselves are actually being collected and, if so, whether they are being collected adequately, and analyzed and reported in standard, comparable fashion. Ultimately, the test is whether the information actually influences decision making.

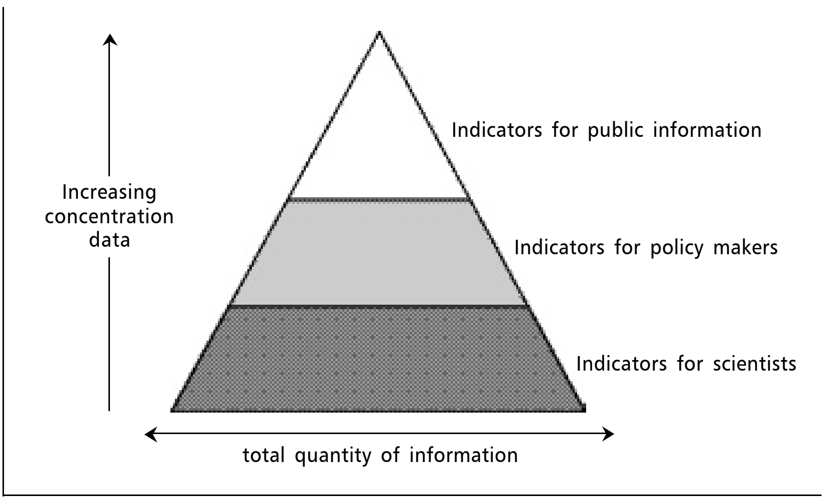
In recent years, environmental advocates have realized that to capture the attention of both policy makers and the public, what is needed is a compact core set of environmental indicators (derived from the huge amount of primary, multisectoral data) that are capable of conveying key information in a simple and integrated manner. The inspiration for environmental indicators derives from experience with economic indicators. In any country, for instance, the key economic indicator reported is GNP (gross national product), which commands literally everyone's attention. Such an indicator demonstrates what a single number can do when its significance is widely understood.

The task is how to develop similar indicators for the environment so that they are analytically sound, comprehensive, easily grasped, and derived from a disciplined methodology of data aggregation and combination. What complicates the task is the fact that the building blocks for deriving indicators are disproportionately large in comparison with the small number of key indicators and even smaller number of indices desired.

In such a case, it is more realistic to view the conventional information pyramid as an inverted funnel with a disproportionately large base and a very narrow tip. Add to this the characteristic that the base itself is very heterogeneous -–a characterization used here to indicate that there are many actors or data producers involved at the base. In most countries, it is unclear who or which agency is in charge of consolidating the mountains of separately collected and analyzed data to come up with aggregate indicators. More fundamentally, of course, there remains the question of how to derive the indicators themselves. Various approaches to deriving environmental indicators are described in the references listed in the bibliography.

Parallel to the information pyramid is a model of information use. This model shows relationships among the quantity of information, the degree of data consolidation, and the types of users (Figure 3.2). One sees that as the type of users changes from technical

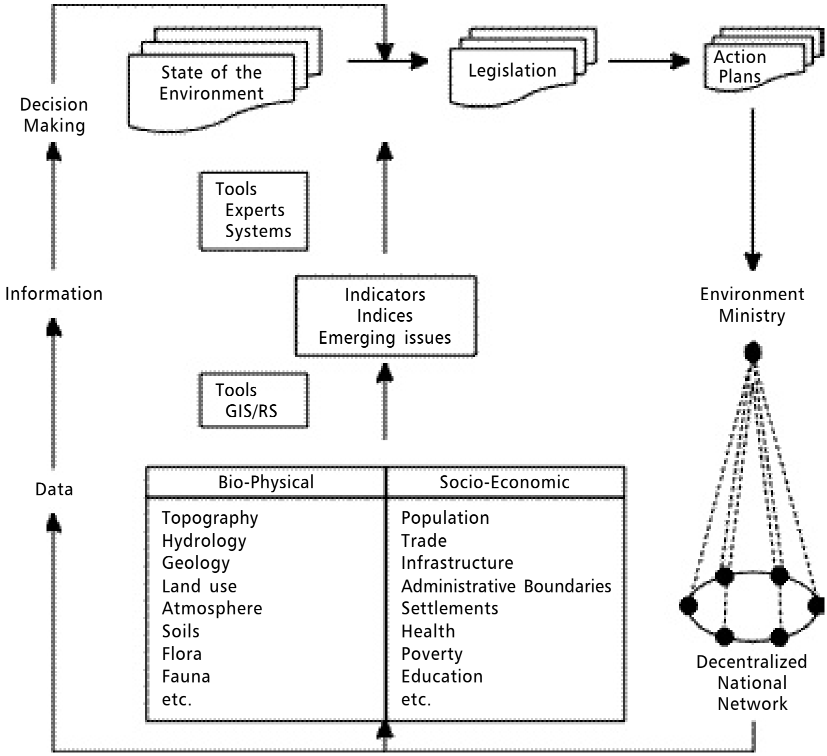
Figure 3.2
Relationship Between Data, Indicators, and Information to Meet Users' Needs



Source: UNEP Environmental Assessment Program for Asia-Pacific (1995) users (e.g., researchers and scientists) to regulators to policy makers and, finally, to the general public, the degree of information consolidation and simplification increases. That may seem obvious. However, what is important to note is that although the information becomes increasingly simplified to improve communication, the measures remain quantitative. Quantification throughout all levels of the pyramid is important because it instills systematic data consolidation and facilitates comparison. By itself, quantitative information helps in rapidly assessing trends and patterns contained in the data.

An expansion of the user model is shown in Figure 3.3. This model is adapted from an information systems framework developed

Figure 3.3
Environmental Information Systems Model



Source: UNEP Environmental Assessment Program for Asia-Pacific (1995) by the UNEP Environmental Assessment Programme for Asia-Pacific. It superimposes three elements: (i) the activities (data collection, information generation, and decision making); (ii) the nature of the data and information produced and the level of aggregation; and (iii) the method of data collection and aggregation. A notable aspect is that the information collected, analyzed, interpreted, and aggregated is oriented to the users' needs. In short, it is utility that drives information collection and aggregation, rather than the other way around.

The Pressure-State-Response Model

While the information pyramid provides a basic model for environment statistics in terms of levels of data aggregation, a logical framework is needed to organize the contents of the information system to make it relevant to policy making and environmental problem solving at the national level and, increasingly, at the global level. The information base is often overwhelming in terms of the variety of data related in one way or another to the environment. It is important to sort out the information base to make explicit the connections among the data elements – for instance, in terms of cause-and-effect linkages, or in terms of interactions (i.e., the interaction between man and the biophysical environment).

A framework that is gaining increasing acceptance is the pressure-state-response (PSR) model, which was developed by the Organization for Economic Co-operation and Development (OECD). The framework uses a cause-effect-response structure in which parameters or indicators are grouped according to whether they pertain to cause, effect, or response (Figure 3.4). Essentially, the framework addresses the following fundamental questions:

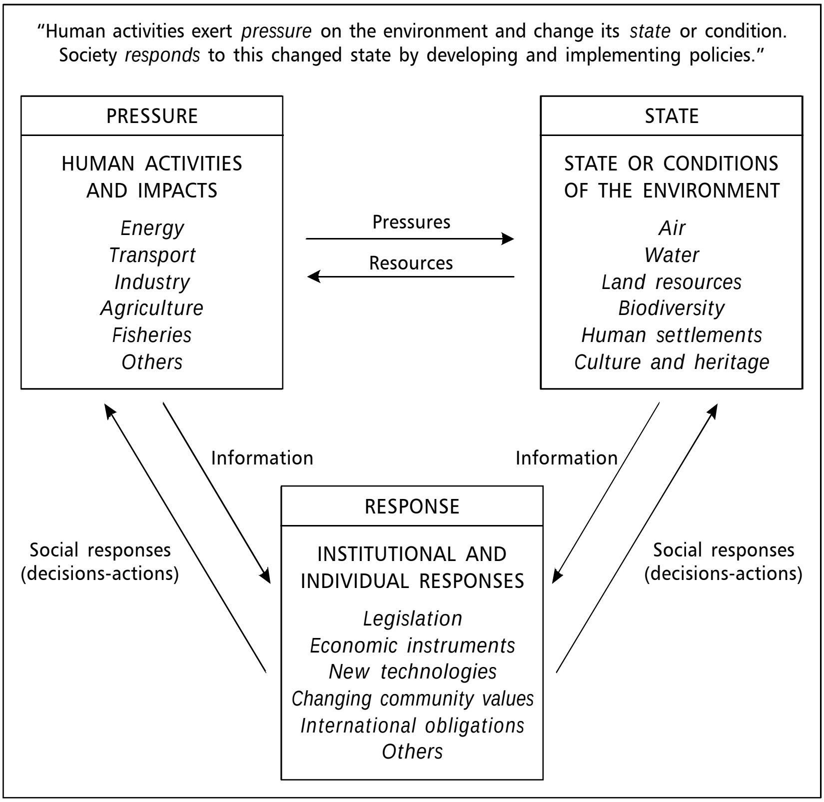
(i) What is happening to the state of the environment, and how is this state measured in terms of key indicators of conditions or trends?

(ii) What are the causes responsible for this state of the environment; in particular, what pressures do human activities bring to bear on the environment?

(iii) What is being done to manage both the state of the environment and the human pressures that it is subjected to?

Figure 3.4

OECD Pressure State Response Model



Source: UNEP Environmental Assessment Program for Asia-Pacific (1995)

Environmental parameters may thus be categorized as state indicators, pressure indicators, or response indicators. These categories provide a logical framework for environment indicators. However, the framework need not apply exclusively to aggregated indicators. It is also applicable to organizing primary and secondary data (secondary, meaning data that have been subjected to analysis) before these are aggregated or combined to form indicators. The PSR model supplements the information pyramid model. In the following discussion, the term "parameter" is used to refer generally to either data or aggregated measures, depending on the level of the information pyramid that is pertinent.

State parameters measure changes or trends in the physical or biological state of the natural environment. *State* in this sense refers to the condition of a particular environmental aspect (e.g., water quality in a river stretch as measured by average dissolved oxygen concentration) or to whole ecosystems (e.g., wetlands, whose state may be characterized in terms of remaining areal extent). A state parameter could be either quantitative or qualitative. To fully appreciate the state of a particular environmental element, however, one has to consider both qualitative and quantitative parameters.

Pressure parameters show the causes of the existing state of the environment, as well as probable future states that can be discerned from past trends and current states of the environment. For example, the poor quality of a particular water environment may be traced to discharges of industrial wastes, the reduction in wetland area may be traced to the expansion of fishpond operations or to conversion for urban settlements, and the reduction in fish stocks may be traced to excessive fishing efforts or to the degradation of the fishing area. In all three examples, the pressure comes from human activity. Pressure parameters generally refer to human activities affecting the environment. However, it is not always easy to relate pressure parameters to state parameters in a one-to-one correspondence. A given state may be the effect of multiple pressures whose separate contributions are difficult to isolate. The pressures themselves might be linked to one another. For example in tracing the cause of deforestation, the principal causes frequently pointed to are industrial logging and shifting cultivation, yet it is not possible to ascertain exactly how much each contributes to deforestation. Logging by itself does not cause deforestation. On the other hand, logging activities provide access (through roads) for farmers to enter the forests, such that while shifting cultivation may be an immediate factor in forestland degradation, logging plays an initiating role.

This example suggests that the PSR model needs to be supplemented by submodels that capture the nature of the cause-and-effect linkage. Such linkage models must be developed around specific environmental issues. In fact, most PSR formulations are organized around key environmental issues or problems (Tables 3.1 and 3.2). Here, in addition to grouping data according to pressure, state, or response categories, they are also organized according to issues. In the example of deforestation, a submodel of the linkage connecting human activities to loss of forests may be formulated to understand the forces or factors driving deforestation.

Table 3.1

OECD/UNEP Matrix of Issue-Based Environmental Indicators

Issue	Pressure	State	Response
Climate change	(GHG) emissions	Concentrations	Energy intensity, environmental measures
Ozone depletion	(Halocarbon) emissions; production	(Chlorine) concentrations; O_3 column	Protocol signed, CFC recovery, fund contribution
Eutrophication	(N,P, water, soil) emissions	(N, P, BOD) concentrations	Treatment connection, investments/costs
Acidification	(SO_x, NO_x, NH_3) emissions	Deposition; concentrations	Investments, signed agreements
Toxic contamination	(POC, heavy metal) emissions	(POC, heavy metal) concentrations	Recovery of hazardous waste, investments/cost
Urban environmental quality	VOC, NO_x, Sox) emissions	(VOC, NO_x, SO_x) concentrations	Expenditures, transportation policy
Biodiversity	Land conversion; land fragmentation	Species abundance compared with that in a virgin area	Protected areas
Waste	Waste generation municipal, industrial, agricultural	Soil/groundwater quality	Collection rate, recycling investments/cost
Water resources	Demand/use intensity in residences industry agriculture	Demand/supply ratio, quality	Expenditures, water pricing, savings policy
Forest resources	Use intensity	Area of degraded forest, use/sustainable growth ratio	Protected area forest, sustainable logging
Fish resources	Fish catches	Sustainable stocks	Quotas

Table 3.1 *(continued)*
OECD/UNEP Matrix of Issue-Based Environmental Indicators

Issue	Pressure	State	Response
Soil degradation	Land use changes	Topsoil loss	Rehabilitation/ protection
Oceans/coastal zones	Emissions, oil spills, depositions	Water quality	Coastal zone management, ocean protection
Environmental Index	Pressure index	State index	Response index

BOD= biological oxygen demand, CFC= chlorofluoro carbons, GHG= greenhouse gases, N= nitrogen, NH_3= ammonia, NO_x= oxides of nitrogen , OECD= Organization for Economic Cooperation and Development, P= phosphorus, POC= persistent organic compounds, SO_x= oxides of sulphur, UNEP= United Nations Environment Programme, VOC= volatile organic compounds.

Source: Hammond et al. 1995.

Table 3.2
World Bank Matrix of Issue-Based Environmental Indicators

Issue Pressure	State	Response	
A. Source indicators			
1. Agriculture a. Land quality b. Others	Value added/gross output human-induced soil degradation	Cropland as percent of wealth, climatic classes and soil constraints	Rural/urban terms of trade
2. Forest	Land use changes	Area, volumes, distribution; value of forest	Input/output ratio, main users; recycling rates
3. Marine resources	Contaminants, demand for fish as food	Stock of marine species	Percent coverage of international protocols/conventions
4. Water	Intensity of use	Accessibility to population (weighted percent of total)	Water efficiency measures

Table 3.2 *(continued)*

World Bank Matrix of Issue-Based Environmental Indicators

Issue	Pressure	State	Response
5. Subsoil assets	Extraction rates	Subsoil assets, % wealth	Material balances/ NNP
a. Fossil fuels	Extraction rates	Proven reserves	Reverse energy subsidies
b. Metals and minerals	Extraction rates	Proven reserves	Input/output ratio, main users; recycling rates
B. Sink or pollution indicators			
1. Climate change			
a. Greenhouse	Emissions of CO_2	Atmospheric concentration of greenhouse gases	Energy efficiency of NNP
b. Stratospheric ozone	Apparent consumption of CFCs	Atmospheric concentration of CFCs	Percent coverage of international protocols/conventions
2. Acidification	Emissions of SO_x, NO_x	Concentration of pH, SOx, NOx in precipitation	Expenditures on pollution abatement
3. Eutrophication	Use of phosphates (P), nitrates (N)	Biological oxygen demand; P, N in rivers	Percent population with waste treatment
4. Toxification	Generation of hazardous waste/ load	Concentration of lead, cadmium, etc. in rivers	Percent petrol unleaded
C. Life support indicators			
1. Biodiversity	Land use changes		Protected areas as percent threatened
2. Oceans	Threatened, extinct species percent total		
3. Special Lands (e.g., wetland)			

Table 3.2 *(continued)*
World Bank Matrix of Issue-Based Environmental Indicators

Issue	Pressure	State	Response
D. Human impact indicators			
1. Health	Burden of disease (DALYs/person)	Life expectancy at birth	Percent NNP spent on health, vaccination
a. Water quality		Dissolved oxygen, fecal coliform	Access to safe water
b. Air quality	Energy demand	Concentration of particulates, SO_2, etc.	Access to safe water
c. Occupational exposures, etc.			
2. Food security and quality			
3. Housing/Urban	Population density (persons/km^2)		Percent NNP spent on housing
4. Waste	Generation of industrial, municipal waste	Accumulation to date	Expenditure on collection and treatment, recyling rates
5. Natural disaster			

CFC_S= chlorofluorocarbons, $DALY_S$= disability adjusted life years, NNP= net national product, NR= natural resources

Source: Hammond et al. 1995.

Response parameters identify and assess efforts to mitigate undesirable environmental states or to curb pressures that create these states. They may include a wide array of actions involving policies, regulatory efforts, budgetary commitments, management plans, economic incentives, research and development, imposition of quotas, ratification of conventions, and so on. Activities of a more direct nature and which aim to improve the state of the environment, such as reforestation of denuded areas, establishment of artificial reefs, or rehabilitation of rivers, also fall under this category. Like pressure and state parameters, response parameters are grouped according to the set of issues being addressed.

Conceptual Model for Compiling Environment Statistics

This section presents a conceptual model for preparing an FDES. The conceptual model sees each environmental component as a resource that has use or value to human society. Based on this resource perspective, the environment is categorized into two types of resources: natural or environmental and human resources. Natural/ environmental resources include land/soil, atmosphere, water, flora and fauna, and ecosystems. Human resources refer to populations, human settlements, and the economy. The model recognizes interactions among various environmental resources and these interactions should be reflected in any FDES.

Two principles form the basis of a conceptual model:

(i) There should be a purpose for compiling environment statistics.

(ii) The characteristics (which determine the nature of variations) of an environmental resource should be taken into account in compiling statistics relevant to the resource.

The purpose for compiling environment statistics can be gleaned from the concerns or themes associated with individual environmental domains, as statistics will eventually be required to address these concerns or themes. The conceptual model systematically identifies the characteristics of environmental resources so as to develop a logical framework for identifying appropriate statistics to represent each environmental resource as well as the interactions of this resource with other components of the environment.

The main purpose of a framework for environment statistics is to provide a reliable and easily accessible information system to facilitate the incorporation of environmental factors in public decision making. A public decision invariably involves making a choice—or selecting an alternative—to achieve an objective or a set of objectives in the interest of the public. These objectives are broadly aimed at arresting the deterioration of, or enhancing the quality of life.

Typically, any public action uses resources to achieve social objectives or benefits. However, the use of a resource deprives society of deriving other benefits from the same resource, which is generally scarce. The benefits so forgone are the costs of the resource used to achieve the objectives of the public action. Thus, any public action is associated with both costs and benefits. A rational choice would then involve selecting that action or alternative that maximizes the net benefit to society. To make this choice, costs and benefits associated with the resource use should be quantifiable.

Costs and benefits associated with a resource use, which converts the resource into marketable goods or services, can easily be quantified since the market allows the costs of resources and benefits from goods and services to be measured in monetary values through pricing mechanisms. However, a resource use cannot always be translated into a marketable commodity. Two such examples are the use of air and a visit to a scenic spot for recreational purposes. Resource use could also cause the degradation of the social or natural environment or both, which would result in the forgoing of benefits that the society would have derived had the degradation not taken place. For example, the deterioration of land and water quality due to a mining activity could deprive local people of the use of their agricultural lands and also adversely affect their health. These social costs are not captured by traditional market mechanisms. In the same way, a public action may result in incidental benefits to society, which are not marketable. Traditional market mechanisms are also blind to time dimensions in the sense that they fail to consider the value of a resource to future generations, or the desire of the present generation to sustain the resource for future generations.

One way of internalizing social and environmental costs and benefits (which are external to the market mechanism) in the decision-making process is to find surrogate ways of giving values to these costs and benefits in monetary terms. An action, which results in higher net benefit after internalizing social/environmental benefits and costs, would then be the rational choice of a decision maker. The objective or objectives of an action would then be treated as a benefit to society. Expressing costs and benefits in monetary terms allows the comparison of net benefits associated with various alternatives, and thus facilitates decision making. However, widely acceptable surrogate methods for putting a monetary value on each resource use or on the resulting degradation of a resource are not yet well-established.

Another method to incorporate social/environmental costs and benefits in decision making involves defining a set of "norms" or "ideal states" for each resource or environmental component. In this case, two decision-making options are available:

(i) to select a least-cost alternative that does not violate any environmental norm; or

(ii) to select an alternative that causes minimum adverse environmental impacts (measured with respect to the norms) while meeting the cost constraint.

There are problems associated with this method. It may not be possible to define "norms" or "ideal states" for an environmental component due to lack of complete understanding of the exact implications that the component's various states will have for human society. For example, as of now, we do not have an ideal level of greenhouse gases in the atmosphere. This type of difficulty is, however, temporarily circumvented by specifying targets (e.g., a target may be set to reduce carbon dioxide emission levels by 25 percent of the baseline level in the next five years) and selecting a public action that will meet the targets.

Even if norms could be established, it may be difficult to find a course of action that satisfies all the norms. In fact, one alternative may satisfy one set of norms and not others, whereas another option may have the opposite effect. As a result, it is difficult to compare the impacts of different alternatives. Attempts are made to develop environmental indexes that provide a single value to reflect the overall state of the environment, and thereby allow the comparison of potential environmental impacts due to various alternatives.

The underlying premise for both methods of incorporating social/environmental factors in decision making–the method based on cost-benefit analysis and the one using social/environmental objectives explicitly–is that we should be able to identify and measure those parameters or variables of a resource or environmental component that determine its use to human society. Valuating resource uses in monetary terms or establishing targets for achieving environmental and social goals is the next step.

As a first step toward facilitating the decision-making process, an environment statistics system should provide data with respect to the current and potential uses of a resource or environmental component. This system should identify the variables or parameters as well as the appropriate statistics for each variable or parameter selected, so that the data become useful in deciding the particular use of that resource.

It would also be desirable for the environment statistics framework to add to the quality of decision making by providing a structure to the data so that it can be used to identify data gaps; define norms, targets, and indexes with respect to the various uses of a resource; and relate these statistics to social or environmental concerns and themes.

Implementation of an Environment Statistics Program

One of the objectives of the Bank's technical assistance is to establish a sound foundation for an environment statistics system so that environment statistics are compiled on a continuing basis by the participating countries. The successful implementation of the environment statistics program can be ensured by the following factors:

(i) adaptability of the FDES to the existing institutional framework and mechanisms of the participating countries;
(ii) organization of information to facilitate the flow of data from the statistics-compiling agencies to the statistics-user agencies;
(iii) provisions in the FDES to preserve the linkages among statistics compiled for different environmental domains; and
(iv) provision in the FDES for a logical framework for identifying relevant agencies that will compile nontraditional statistics, the need for which has arisen because the interactions among various environmental components have become critical.

Organization and Flow of Information

Information or statistics for individual resources or domains are usually compiled by departments or agencies that use the information. Therefore, the data collected and processed meet the specifications of the agency that collects them. For example, an agriculture department is likely to compile soil information useful for agriculture only. Different departments may collect similar information for their respective uses. Information on hydrology may be compiled by both irrigation and power departments. The FDES will play an important role by identifying statistics compiled by one agency but also useful to other departments or agencies, so that duplication of efforts is avoided. Then, whether a single agency or multiple agencies are given the responsibility of compiling statistics could depend on the existing institutional framework of the participating country.

As shown in the information pyramid in Figure 3.2, different resolutions and levels of information may be required at various user levels. The resolution of information is very high at the base level and decreases as one moves up the pyramid. At the same time, the information content of statistics or data compiled at base level is low. This lower level information is processed and becomes useful for decision making at the middle and higher levels. Thus, whereas carbon dioxide emissions from each major individual source may be monitored or estimated at a local level, sectorwise carbon dioxide emissions per unit gross domestic product (GDP) may be relevant to the formulation of a national policy on global warming. Therefore, it is desirable that the FDES explicitly show the flow of information between and across various levels.

Two types of systems – centralized and decentralized – can be envisaged for organizing information flow. Each has advantages and disadvantages. In both systems, the traditional user agencies would continue to collect or compile data at the base level. In the centralized system, all data from the data collection agencies would be transmitted to an apex agency, where the information would be processed. Various user agencies could then access this centralized database to retrieve the information they require for decision making. The advantages of the centralized system are that (i) all information will be available at one nodal point, and (ii) coordination between data collection agencies and the apex agency is going to be simple. The disadvantages of the system are that (i) processing and maintaining all information will put on the apex agency a heavy burden that the agency may not be able to handle; (ii) most of the information will be used at the regional and local levels and, thus, processed information will have to be transmitted back to the regional and local user agencies; and (iii) the noninvolvement of user agencies in compiling and processing statistics may make them averse to the use of centrally prepared statistics in their decision making.

In a decentralized system, a statistics/data collection agency at the local level would transmit data/statistics to its regional head offices, where the information would be processed for the agency's own use. The regional office would disseminate the relevant information to other user agencies. All regional user departments or agencies would transmit relevant information to the apex agency. In this model, information would be processed at all levels and only relevant information would be transmitted between the levels and across a level. In this model, information will flow from the bottom to the top and decisions will be transmitted from the top to the lower levels. The advantages of the decentralized system are that (i) user agencies would be involved in the system and, therefore, would tend to favor the use of statistics, (ii) user agencies would have expertise in processing information for their own use, and (iii) information at each level would be more manageable. The main disadvantage of the system is that coordination between all the concerned agencies could be complex.

Preservation of Linkages Among Statistics

As discussed earlier, environmental resources interact with each other in a number of ways. A development activity could have adverse impacts on a number of environment components, which, in turn, may trigger a series of higher order impacts. The particular state of an environmental resource may further exacerbate an impact on that environmental resource. Therefore, in selecting a development alternative or a response action for environmental protection, decisions will have to be based on relevant statistics from all interacting environmental resources. Since the required statistics could belong to different environmental domains, these statistics are likely to be compiled by different agencies. An FDES should provide a means to show the interlinkages among statistics maintained by different institutions so that the statistics will be useful for decision making.

The significance of preserving the association among statistics for better planning or decision making is demonstrated by the following example. Suppose a city planning office is preparing a plan to reduce air pollution in the city. To develop various alternatives and finally select the most cost-effective option, the office should have statistics or information from different domains. Pollutant emissions from different industries, locations and types of individual industries, and the cost of reducing the unit level of a pollutant from each industry type are required to relate industrial emissions to ambient air quality. The cost of industrial pollution control should also be considered. Statistics on vehicle density on various roads, vehicle types, and emission factors for each vehicle type are required to account for air pollution from vehicular sources. The distribution of ambient air pollution levels in the city and the incidence of air pollution-related diseases in different areas of the city must be known before pollution control strategies can be assessed.

The city planning office will have to rely on secondary sources to obtain this information. It is logical to expect industry-related information to come from the department of industry or an equivalent agency, ambient pollution statistics from the local or regional pollution control agency, and health information from the department of health. However, this information will be meaningful only if it could be spatially related. The information should show the relationship between air pollutant emissions and ambient air pollutant concentrations at different locations, and air pollution exposure of the population and the incidence of respiratory diseases to justify the cost of, say, setting up a railway transit system or relocating some industries.

One way of providing or preserving spatial relationships among statistics is to lay a grid over the region under consideration. The statistics for which spatial dimensions are important are assigned a grid identification number corresponding to the location on the grid to which the statistics belong. Statistics belonging to the same grid but compiled and maintained by different agencies could then be related through this grid identification number. Any proposed FDES should provide a mechanism for determining information needs to be shown in a grid format.

Logical Framework for Delineating Responsibility for Compiling Statistics

Four types of variables represent environmental resources and interactions: stock variables, rate variables, state variables, and activity or event variables. Stock, rate, and state variables pertain to an environmental resource; therefore, statistics on them should be compiled by the agencies designated for compiling statistics on that particular environmental resource. Since activities and events give rise to interactions among environmental resources, the responsibility for compiling statistics on these variables needs to be delineated. Any proposed FDES should organize information on an activity or event under the resource in which an activity or event originates.

Summary

The basic elements of a framework have been presented: (i) the information pyramid model for showing hierarchical levels of data aggregation and use; (ii) the pressure-state-response model for providing a logical approach to organizing data and grouping them by issues; and (iii) an environment-development linkage model, which provides a framework for analysis of how key issues interact with one another.

One characteristic of the environmental information pyramid is that its base is very wide; that is, there is a great magnitude of data to contend with, often to the point of overwhelming the users. A key concern is to ensure that the mass of information on numerous environmental parameters is actually used to influence policies and programs and, on the whole, governments' environmental management capabilities. To promote this, work is under way on developing a core set of environmental indicators that can be used to focus attention on key issues and, at the same time, be more manageable. Those responsible for compiling environment statistics should perhaps focus on the upper layers of the information pyramid, that is, on data consolidation and the formulation of core indicators.

An added feature of the large environment database is that, invariably, data are collected and analyzed by different sets of people, or by different agencies of government. Going back to the example on water, quantity data (river flows, groundwater supplies) are often collected by an agency different from the agency in charge of monitoring water quality. The problem itself is not in the diffuse manner in which data are being collected — since, for practical reasons, such a decentralized system is the de facto arrangement in many countries, and is probably not going to change — but in the lack of systematic consolidation of the mass of data on numerous aspects of the environment. Work on environment statistics needs to start with an effective arrangement for managing and consolidating information generated from a largely decentralized information network. National statistics agencies working closely with counterpart national planning agencies are the key places to perform consolidation. They can ensure that the information compiled on, say, key indicators are tied in with national issues of concern to the government, particularly socioeconomic development issues.

In the end, only the users know what information they need, and how such information will be put to use. While this itself is a basic principle in designing information systems, it is not always followed and cannot be taken for granted. The implication is that a key step is the identification of the target users of environment statistics. As discussed earlier, the projected use of the data should drive the development of the information system.

Incorporating an issue dimension into a framework for environment statistics helps ensure that information made available is attuned to the needs of those who will use the system. The issues are not defined after the environmental data are collected and indicators developed. Rather, the parameters (indicators and various other categories of data aggregating) are formulated after the key issues have been identified. This makes the information system issue-based. Data generation and combination to come up with indicators may then be done around specific environmental issues.