3

A Framework for Environment Statistics

The choice of a framework on which to base a program of environment statistics is a pivotal decision that will influence all subsequent phases of the work. This chapter begins with a discussion of the pressure-state-response (PSR) approach, which is the inspiration for several different frameworks. The UN-FDES is recommended as a starting point for countries that have recently embarked on a program of environment statistics. The various components of this framework are examined in some detail. At a later stage, countries may wish to adopt a more elaborate type of framework. The OECD's version of an environment statistics framework is also discussed in this chapter. Finally, statisticians must find ways to summarize the huge amounts of primary data that can be generated even at the early stages of the program. Environmental indicators are used for this purpose and a number of these measures are presented in this chapter.

Purpose of the Framework

No framework can adequately depict the intricate and constantly changing network of relationships that exists in the environment. Each version necessarily introduces simplifications, meaning that some aspects of reality are not accurately represented. The benefits, however, will usually outweigh the costs. Policy makers and analysts can still make rational decisions even though their information about any particular environmental problem or chain of events is incomplete. In fact, most of the decisions reached by government officials, whether dealing with the environment or other matters, must be made without complete information. In the case of the environment, the degree of uncertainty will vary, being greatest for broad issues such as global warming and climate change. Uncertainty will be less when attention turns to specific national issues and declines even further when the focus is on regional or local concerns.

A framework will be especially useful in the process of assigning priorities to various environmental issues. The severity of environmental problems varies widely from country to country and the adoption of a framework should help statisticians identify the issues of greatest importance for their country. Pollution, for example, is a concern everywhere, but it usually receives a higher priority in rich countries than in poor ones. In countries where the economy is dominated by agriculture or natural resources, issues relating to land conservation and resource depletion may loom large. In arid climates, water quality and availability are prominent issues. The significance of particular environmental problems also changes over time and this, too, must be reflected in the statistical program.

A framework can also be of help in reaching decisions on a number of organizational matters, such as

(i) agreement on the overall process of data collection, estimation, and interpretation;

(ii) determination of logical ways to organize the data around key issues and topics;

(iii) identification of important issues for which data is lacking;

(iv) clarification of the responsibilities for collection and reporting on specific topics, and agreement on the division of work between the NSO and other data suppliers.

When a program of environment statistics is first launched, statisticians usually choose a relatively simple type of framework as the basis for their program. However, the selection of any specific framework does not mean that all other versions are automatically excluded. Over time, the scope and detail of environment statistics expands and another framework may eventually be more suitable. Sometimes, a country may even use different versions simultaneously. Even within a particular publication, the framework can change from chapter to chapter.

The OECD Framework

The OECD has developed a framework based on the PSR approach, which was cited in Chapter 2. This approach is used in all OECD member countries, and parts of the framework are also being applied in other countries in East Europe and Central Asia. The OECD framework is based on two key assumptions. The first is that there is a direct line of causation, running from environmental pressure to state of the environment to societal response. Second, there is a one-to-one relationship linking each environmental pressure to a particular change in the state of the environment and to a response by society.

As with many other types of economic analysis, these assumptions oversimplify conditions in the real world. Simple, clear-cut, one-to-one relationships between cause and effect are rare. A new pressure on the environment may damage the quality of the air, water, or soil in numerous ways. Likewise, several distinctly different types of environmental pressures can have a concentrated effect on one environmental medium. Multiple relationships of this sort are also common among the responses of society. For example, a number of policies and/or regulations may be required to address a particular environmental problem, while in other cases a single policy will be an appropriate remedy for a multitude of pressures. The list of examples could be extended, but the underlying point is clear. Frequently, the cause-and-effect relationships that prevail in the real world are not one-to-one but many-to-many, and are sometimes too complicated to depict in any framework.

An overview of the OECD version is given in Figure 3.1. Human activities make use of environmental resources (air, water, land, and natural resources) and generate environmental pressures, which can be observed in various economic sectors such as energy, industry, or agriculture. Responses to environmental pressures come from "economic agents," which may include government (national, provincial, or local), households, and business enterprises. Links between the three stages depend on information flows. Economic agents receive information on the types of pressures being generated as well as on the state of the environment. The agents then formulate responses that may be directed at a particular economic sector or environmental medium.

A critical feature of the OECD framework is the information flows pictured in Figure 3.2. Different sets of environmental indicators have been developed to measure pressures, assess the state of the environment, and gauge society's responses. Other indicators are used to report on the state of the environment and to evaluate environmental performance. A core set of indicators has also been specified for regular data collection, together with environment-related indicators for each of several economic sectors (agriculture, transport, industry, and so on). Finally, the OECD has developed an extensive set of definitions and supporting examples for each type of indicator.[5]

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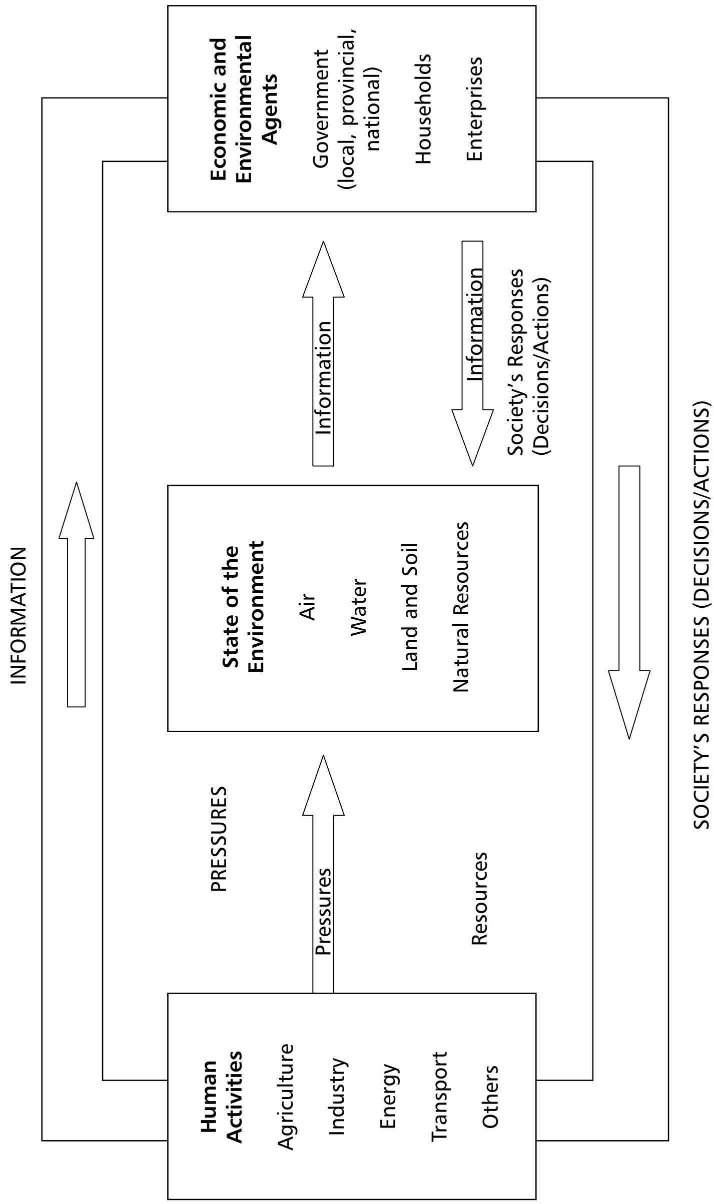
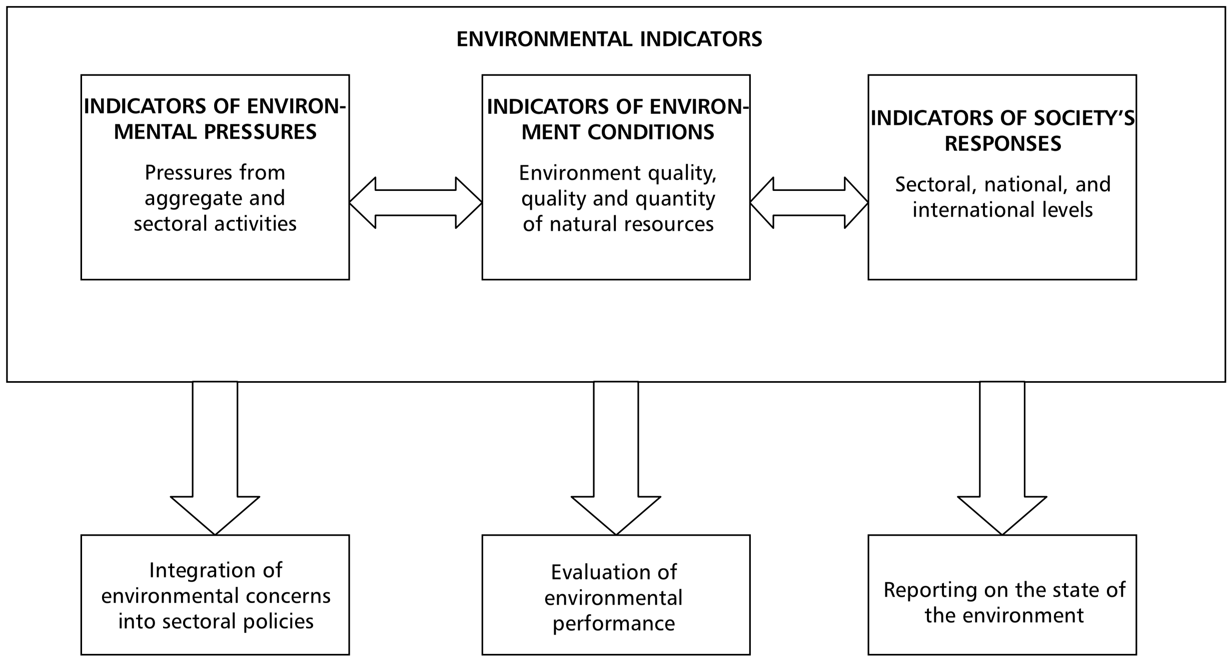
5 For more information on the PSR framework, see OECD (1993).

Figure 3.1: OECD's Pressure-State-Response Framework



Source: OECD (1993).

Figure 3.2: Environmental Indicators in the OECD Framework



Source: Adapted from OECD (1993).

Clearly, a great deal of thought has been given to the formulation and interpretation of all these environmental indicators. The OECD program has made much progress, but it also demands much in the way of data collection and manipulation (that is, construction of indicators, indices, and related measures). Because these requirements can be extremely challenging for a country just entering the field, a simpler alternative, the UN-FDES is recommended as a starting point.

The UN Framework for Development of Environment Statistics

The framework developed by the UN combines the PSR approach with a list of environmental concerns that closely correspond with the environmental media approach mentioned in Chapter 1. The UN-FDES does not require a specific set of statistical parameters or indicators. Nor does it depend on a specific classification scheme or a particular method of collecting data. Instead, the framework is designed to be sufficiently flexible to permit statisticians to monitor all unique features of their country's environment while still providing a basis for international comparison. However, this concession to flexibility is not without costs. There is, for example, a loss of precision in the specification of linkages between pressure, state, and response; in the ability to aggregate primary data; and in the underlying accounting relationships. Once countries reach an intermediate stage in the development of their program of environment statistics, they may require a more elaborate approach.

Structure of the FDES

The FDES follows a building-block approach that allows the user considerable leeway in selecting the topics and variables. Table 3.1 shows the overall structure of the framework. In this particular example, six environmental media or components (flora, fauna, atmosphere, water, land/soil, and human settlements) are singled out for attention. The table also identifies four information categories, which are associated with each component.

Environmental components. The six environmental components shown in Table 3.1 are only illustrations. Statisticians may expand, modify, or rearrange the list to better reflect conditions in their own country. Another option is to single out various submedia. For example, water can be broken down into freshwater, marine water, or groundwater, while environmental issues relating to land and soil can be distinguished as surface or subsurface.

Farming, animal husbandry, forestry, and mining are all activities that are likely to have a significant impact on both flora and fauna. They may affect certain animal species, reduce or improve the quality of land, contribute to erosion or have other consequences. Industry, human settlements, and transportation can have an indirect negative impact on these components as a result of emissions and discharges into the air and water.

In the case of the atmosphere, the statistician may choose to distinguish between pollution at the global level and urban air quality at local levels. If this breakdown is followed, urban air quality can be included as a component of human settlements because of its local impact, while general atmospheric or "background pollution" is a key element of air quality. Atmosphere as a component could also be broadened to include air quality and climate. Obviously, the way the statistician chooses to describe the component and the submedia will determine the activities, impacts, and responses that will be included in the FDES.

A major concern arising from atmospheric pollution is the impact of acid deposition on biota and their habitat, resulting in the acidification of lakes, soils, and forests. Eventually, atmospheric pollution will affect the quality of inland water, soils, biota, and ecosystems. These issues have local, national, or transnational consequences, while other atmospheric concerns are of international significance. The latter include emissions of chlorofluorocarbons (CFCs) and their effect on the ozone layer and the dispersion of human-caused radiation in the case of nuclear accidents and weapons testing.

Water quality is a more complex issue than air quality since much depends on its uses. For example, nutrient-rich water may be beneficial to certain kinds of biotic life, but unacceptable for recreational and drinking purposes. A distinction is usually made between fresh and marine water and the problems will vary accordingly. Seacoasts and shorelines of large lakes are favored locations for highly polluting industries because they offer an "easy" solution for waste disposal. Finally, the contaminants of major concern are toxins such as heavy metals and pesticides, organic matter, nutrient loadings such as fertilizer runoff, deposits from acid precipitation, and pathogens such as coliform. The list is still growing with each discovery of new contaminants and their associated stress effects on human health and aquatic ecosystems. Only a fraction of contaminants are monitored on a regular basis.

If land and soil are distinguished according to surface and subsurface problems, the relationships between each component and the related activities, events, and responses are often more easily identified. A wide range of activities may affect surface soil, while mining and energy extraction usually have the most impact on subsurface conditions. Waste and wastewater discharges may alter conditions for both these submedia and the responses will vary accordingly.

Human settlements can impact on the environment in a multitude of ways. Population concentrations will often contribute to the pollution of water and land resources. Lack of basic services such as water treatment plants, garbage collection, and other essential amenities may be a serious problem. Rapid population growth, migration, and urbanization can exacerbate all these problems. Local air pollution, often due to the concentration of motor vehicles, is yet another prominent aspect of this component. Finally, the FDES in some countries takes into account the quality of housing as measured in terms of the existence of slums and dependence on substandard housing.[6]

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6 For more information on the role of human settlements, see Chapter 6.

Table 3.1: Example of a Framework for Development of Environment Statistics

Environmental Component	Information Categories			
	Social and Economic Activities	Environmental Impact of Activity	Response to Impact	Inventories, Stocks, Background Conditions
1. Flora	Agricultural and livestock production[a]	Proliferation, depletion, extinction of species	Protection of endangered species	Inventory of species and genetic resources
	Forestry and logging	Depletion/growth of forests and woodlands	Forest management, including afforestation	Inventory of vegetation cover
	Emissions hazardous to flora	Impact of pollution on vegetation cover (e.g., acidic precipitation)	Pollution monitoring and control	Inventory of emissions hazardous to flora
2. Fauna	Competing land uses[b]	Change of habitats/ ecosystems	Protection of habitat[c]	Inventory of land uses and characteristics
	Emissions hazardous to fauna	Human health and welfare impact[d]	Pollution monitoring and control	Inventory of emissions hazardous to fauna
3. Atmosphere	Land use affecting climate[e]	Biological and ecological impacts[f]	Promotion of alternative land uses and production processes	Emission inventory (types, sources of air pollution)

Table 3.1: Example of a Framework for Development of Environment Statistics (continued)

Environmental Component	Information Categories			
	Social and Economic Activities	**Environmental Impact of Activity**	**Response to Impact**	**Inventories, Stocks, Background Conditions**
	Emission of air pollutants from stationary and mobile sources[g]	Impact on health and welfare[h]	Health protection, monitoring and control	Socioeconomic factors affecting air quality[i]
4. Water				
a. Freshwater	Water withdrawal[j]	Water quantity, water levels, flow and supply	Conservation, development of water resources	Inventory of water resources
	Water use for industrial, municipal, agricultural purposes	Water quality[k]	Water treatment (primary, secondary, tertiary)	Land use, types of vegetation cover, soil types, vulnerability
	Wastewater and discharges	Biological and ecological impacts[l]	Pollution monitoring and water quality control	Emission inventory (types, sources of discharges, pollutants)
b. Marine water	Water withdrawal and use (desalination, consumption)	Biological and ecological impacts[m]	Pollution monitoring and control, conservation	Inventory of ecosystems
	Emissions from coasts, rivers, seadumping, oil spills	Human health and welfare impacts[n]	Health protection	Coastal land use and characteristics

Table 3.1: Example of a Framework for Development of Environment Statistics (continued)

Environmental Component	Information Categories			
	Social and Economic Activities	**Environmental Impact of Activity**	**Response to Impact**	**Inventories, Stocks, Background Conditions**
5. Land/soil				
a. Surface	Land use for agriculture, forestry, mining, settlements	Soil gain or loss, loss of agricultural land, erosion	Land use regulation, zoning	Inventory of land use, tenure, characteristics, topography
	Waste and wastewater discharges	Health and welfare impacts[o]	Waste disposal, pollution monitoring and control	Emission inventory for solid and liquid wastes
b. Subsurface	Mining and treatment of minerals	Depletion of reserves, open pits, waste disposal	Reclamation and rehabilitation of land	Inventory of mineral resources
6. Human settlements	Construction (residential, non-residential) Emissions and waste discharges	Housing shortages, slum and squatter settlements Ambient concentration of waste and pollutants	Zoning, resettlement, community development Conservation of energy and water	Inventory of buildings, facilities Emission inventory (sources, types of pollutants)

[a] For example, land clearing, irrigation, grazing, use of fertilizers and pesticides.
[b] Agriculture, ranching, settlements, wildlife, recreation.
[c] Land-use regulations, zoning, national parks.
[d] Nutrition-related effects, changes in productivity and costs of livestock production, etc.
[e] Deforestation, desertification, drainage urban sprawl, infrastructure.
[f] Contamination, destruction of species, disruption of ecosystems by acidic precipitation, etc.
[g] For example, from industry, households, agriculture, transportation.
[h] Morbidity and mortality associated with air pollution, changes in productivity and costs.
[i] For example, population growth and density, urbanization, industrialization, patterns of production and consumption.
[j] Surface water, groundwater, other sources.
[k] Ambient concentrations of biological contaminants, chemical substances,and suspended solids.
[l] Eutrophication, contamination, destruction of biota.
[m] Depletion, extinction or contamination of marine biota, disruption of habitats/ecosystems.
[n] Waterborne diseases, impact on tourism and recreation, etc.
[o] Soilborne diseases, impact on productivity, and costs for agriculture, tourism, recreation.

Information categories. The four information categories in Table 3.1 imply some linkage between environmental problems and human activities or natural events. In general terms, the first three categories (columns 2, 3, and 4) represent a sequence of events involving action, impact, and reaction. The fourth category–inventories, stocks, and background conditions–gives supplementary background information.

Together, the four categories suggest–but do not assume–the existence of certain cause-and-effect relationships. The FDES does not insist on a one-to-one relationship between a pressure, the resultant stress, and the response of government or society. Its purpose is primarily organizational, rather than explanatory. The focus is on identifying and presenting data variables that should be useful in tracing and verifying interrelationships. In fact, several activities may be the cause of each impact. Agricultural activities, for example, may contribute to deforestation and soil erosion, but mining and forestry operations can also aggravate the impact on forests and soil. The implied sequence of pressure-state-response is not treated as an established fact, but rather as a challenge for statistical verification. A fundamental objective of the framework is to identify and organize various types of information that may be useful for tracing and verifying actual cause-and-effect relationships.

Socioeconomic activities represent the first of the four information categories in the framework. Human activities falling into this information category consist mostly of the production and consumption of goods and services, but can also include activities in pursuit of noneconomic goals. The environmental impact of all these activities results from the direct use or misuse of natural resources, or the generation of waste and emissions in production and consumption processes. Natural events may also be considered part of this category, although statisticians sometimes have chosen to treat such occurrences as a separate environmental component. In any case, natural events such as droughts, floods, earthquakes, and cyclones place a severe stress on the environment.

The environmental impact of economic activities or natural events includes the depletion or discovery of natural resources, changes in ambient concentrations of pollutants, and deteriorating or improving living standards in human settlements. These impacts can be harmful or beneficial. Responses to environmental impacts can be initiated by individuals, social groups, nongovernment organizations, and public authorities. The responses are meant to prevent or reverse negative impacts and to generate positive ones.

Finally, stocks, inventories, and background conditions provide benchmark data and illustrate links with other subject areas for possible analysis of these relationships. This information category includes stocks of natural resources and the capital assets of human settlements, as well as environmental inventories and economic, meteorological, or geographic background conditions.

Statistical topics and variables. Once the environmental components have been selected, attention turns to the statistical variables that appear in the body of the table. To ensure completeness and consistency, the selection of variables is a two-step process. The first step is to determine the aspects of general environmental concern that can–at least in theory–be subjected to statistical assessment. These items, which are referred to as statistical topics, should be identified for each environmental component and information category. Some examples of possible topics are already supplied in Table 3.1. Table 3.2 presents more examples referring to the natural environment. Topics are grouped together according to common characteristics (bold and italics). The reader should bear in mind that these examples are simply broad guidelines. Statisticians will need to make their own list of statistical topics that represent the specific environmental problems in their respective countries.

Once the list of statistical topics has been agreed upon, the statistician must prepare a corresponding list of statistical variables that will allow the quantitative assessment of each topic. One or more variables may be chosen for each topic. Some may be readily available from existing data collections. Others will not exist at present and their absence indicates a gap in collection procedures. The properties and related characteristics of these variables are likely to differ significantly from the more familiar types of data that statisticians usually work with.

The following are some of the distinguishing characteristics of the biophysical data that may be included in the framework:

(i) data variables based on scientific readings from instruments or laboratory analysis;

(ii) analytic or synthetic data produced from ground surveys and remote-sensing imagery, frequently recorded in mapped form;

(iii) sampling frameworks that are based on spatial rather than population distribution;

(iv) longer time intervals than are common in socioeconomic systems so as to detect significant environmental changes;

(v) natural spatial units, which are rarely as well-defined as administrative boundaries;

(vi) data based on physical measuring units (weight, volume, and area); and

(vii) lack of well-developed methods and techniques for aggregation of common denominators.

More generally, social, economic, and demographic statistics are collected using methods that are familiar to statisticians such as questionnaire surveys and administrative records. There is ample documentation on procedures of data collection and the information is readily available since all operations are conducted by the NSO itself. In contrast, the collection of environment statistics is still at an "immature" stage of development. Biophysical data may be obtained from monitoring programs, natural resource inventories, mapping and survey activities, or the interpretation of remote-sensing imagery. Procedures for collecting data from such sources are not always well-documented and can change over time.

Examples of completed framework tables are in Appendix 2. Neither the list of components nor the statistical variables in the appendix tables are meant to be exhaustive. Statisticians can use these examples as a

Table 3.2: Examples of Statistical Topics: Statistics of the Natural Environment

(A) Social and Economic Activities	(B) Environmental Impact of Activities	(C) Responses to Environmental Impacts	(D) Stocks and Inventories
1. Use of natural resources and related activities	**1. Resource depletion and increase**	**1. Resource management and rehabilitation**	**1. Biological resources**
Agriculture	Biological resources	Protection and conservation of nature	Agricultural stocks
Forestry	Cyclical and nonrenewable resources	Management and conservation of natural resources	Forestry stocks
Hunting and trapping	**2. Environmental quality**	Rehabilitation of degraded environments	Fishery stocks
Fisheries	Atmospheric pollution	**2. Pollution monitoring and control**	Fauna and flora inventories
Minerals, mining, and quarrying	Water quality	Pollution research and surveillance	**2. Cyclical and nonrenewable resources**

Table 3.2: Examples of Statistical Topics: Statistics of the Natural Environment (continued)

(A) Social and Economic Activities	(B) Environmental Impact of Activities	(C) Responses to Environmental Impacts	(D) Stocks and Inventories
Water use for human activities	Soil and land quality	Standards, control and enforcement	Hydrological systems
Land use and environmental restructuring	Quality of biota and ecosystems	Environmental cleanup and rehabilitation	Climate
2. Emissions, waste loadings and application of biochemicals		Pollution control facilities	Lithosphere
Emissions and waste loading in environmental media			Mineral resources
Application of bio-chemicals			

Source: United Nations (1991).

starting point and will probably have to introduce additional variables or otherwise modify the sample tables to ensure that the environmental concerns of their country are accurately depicted.

Environmental Indicators

An environmental indicator (EI) can be broadly defined as a parameter, or a value derived from a parameter, which provides information about a phenomenon.[7] The EI, however, has a significance that extends beyond its association with a specific parameter. First, the use of EIs should reduce the volume of information required to obtain an accurate picture of a situation. A huge amount of primary data can be generated even during the early stages of a program, and statisticians must have some way of summarizing the underlying trends. A decision on the appropriate number of indicators is itself a difficult one. Use of a great many indicators may only confuse the situation by introducing an unnecessary amount of detail. Conversely, reliance on one or a very few indicators may not be sufficient to convey all the information needed. Second, EIs are meant to facilitate the communication process between the statistician and the data user. To accomplish this goal, indicators are often simplified and tailored to meet users' needs. Because of these adaptations, EIs do not always meet strict scientific standards. Nevertheless, they can be regarded as an expression of the "best knowledge available."

OECD has carried out much of the methodological work on Els. The organization has developed indicators to serve various purposes, but the ones most relevant to the present discussion are those intended for application in a PSR framework.[8] The UN-FDES is not so rigorous in its

[7] This definition and the following discussion draw heavily on OECD (1993).

[8] Some OECD indicators refer to specific economic sectors such as energy, transport, industry, or agriculture. Others apply to particular issues or policy matters. For more information, the reader is referred to the OECD references in the bibliography. Other organizations that have also published material on environmental indicators include ADB and the United States Environmental Protection Agency. Their publications are noted in the bibliography.

specification of the relationships between pressure, state and response, but it does make use of ideas on which the PSR framework is based. Thus, the work of OECD can provide some useful insights for those using the UN approach.

The OECD framework relies on three types of EIs. Indicators of environmental pressure describe pressures on the environment resulting from human activities. These measures can be subdivided further into indicators of proximate pressure–that is, pressures exerted directly on the environment–and indicators of indirect pressure, which are known as "background indicators." Indicators of environmental conditions refer to the quality of the environment. They provide information on the state of the environment and its development over time. Finally, indicators of society's responses reflect the result of individual or collective actions to mitigate or prevent the negative impact of human actions on the environment, or efforts to halt or reverse damage already inflicted.

The distinctions between the three sets of indicators may seem clear-cut, but these boundaries can quickly become blurred when the ideas are put into practice. Some indicators of environmental conditions are sensitive to environmental pressures and this fact creates uncertainty about what is actually being measured. The development of a precise set of indicators to monitor environmental conditions can also be difficult and relatively expensive. As a result, statisticians frequently use measures of environmental pressures as a substitute for measures of environmental conditions.

The situation is even more ambiguous when attention turns to the indicators of societal response. The history of these Els is shorter than that of others used in the PSR framework. These Els are at an earlier stage of development, both conceptually and in terms of data availability. The "immature" status of societal indicators increases the likelihood of misinterpretation.

Indicators of societal response are also subject to conceptual weaknesses. First, the distinction between these measures and those designed to gauge environmental pressure is blurred when response indicators capture the results of society's efforts to mitigate pressures. For example, a reduction in greenhouse gas emissions or an improvement in energy efficiency can be regarded as either a change in environmental pressure or as a societal response. Second, all EIs are quantitative in nature, but some of society's responses can be judged only in qualitative terms. In other instances, society's responses are either too numerous or too specific to be measured without great difficulty. This problem arises frequently in the case of technology-related regulations and standards involving a comprehensive and detailed set of rules. The effects of such policies are usually too diffuse and detailed to be measured in any concise manner.

A few examples of indicators proposed by OECD, shown in Table 3.3, serve to illustrate some general characteristics.[9] They address two issues: eutrophication and acidification. Eutrophication is the enrichment of water by nutrients (especially nitrogen [N] and phosphorus [P] compounds). The result is an accelerated growth of algae and higher forms of plant life that upset the balance of organisms present in the water and jeopardize the quality of the water. The preferred indicator of environmental pressure from eutrophication takes into account the emissions of N and P compounds from manure, fertilizer, domestic and industrial wastewater, and various other sources. Because few OECD countries compile data on all these sources, proxies are commonly used. Examples of proxies include the apparent consumption of fertilizers and general information on wastewater discharges. Livestock density is regarded as a rough but measurable proxy for potential eutrophication from manure.

Similar compromises are necessary when choosing indicators of environmental conditions. Ideally, these indicators would take into account the amount of excess nutrients in both soil and water. Because the measurement of nutrients in soil is rather complicated, the preferred alternative focuses only on inland and marine waters. At present, data is available only for biological oxygen demand (BOD), phosphate, and nitrate concentrations for selected rivers in OECD countries.

9 OECD has developed a number of other indicators referring to various environmental issues. For more information, see OECD (1993).

Finally, indicators of societal responses should represent the country's efforts to reduce eutrophication and the amount of excess nutrients. The percentage of the population connected to sewage treatment with biological and/or chemical treatment is the preferred indicator, but few OECD countries have enough data to construct this measure. Nor do all countries collect information on waste charges. Instead, proxies such as the percentage of people connected to wastewater treatment are commonly used.

The situation is similar in the second example in Table 3.3. Sulfur (S) and N compounds are responsible for most acidification, and emissions of SO_x, NO_x, and NH_3 are useful indicators of environmental pressures. However, few countries are able to construct an index based on all three compounds since little information is available on emissions of NH_3. Emissions of the two other compounds are used instead. The most common indicator of environmental conditions is also a proxy–the concentration of acid precipitations (pH, SO_4, and NO_3). Data on depositions and measurements of pH values in surface waters and soil is available in some OECD countries and serves as another alternative. Finally, the preferred indicator of societal response is the capacity of SO_x and NO_x abatement equipment, but little information on this subject is being compiled at present. Most of the data refers to expenditures on pollution abatement equipment as a whole, including expenses for installing and running non-acidifying air emission equipment.

The examples given here are hardly exhaustive, but they serve to illustrate an important point. In addition to the conceptual difficulties and ambiguities in interpretation mentioned at the outset of this section, lack of data forces statisticians in developed countries to find proxies for many preferred indicators. For statisticians in developing countries–and particularly in those where the program of environment statistics is new–the scarcity of data will be even more acute. Although the FDES makes use of the pressure-state-response approach, its requirements are not so stringent as those outlined above. Statisticians will nevertheless encounter many data gaps. They will have to use their imagination and work closely with the suppliers of primary data in other agencies to devise meaningful proxies. At the same time, the collection effort must be gradually broadened to

Table 3.3: Examples of Indicators for Eutrophication and Acidification

Suggested Indicator	Preferred Indicator	Proxy Indicators
	Eutrophication	
1. Environmental pressure	Emissions of N and P into water and soil (L)	Apparent consumption of fertilizers, measured in N and P[a] (S) Wastewater discharges (M) Livestock density (S/M)
2. Environmental conditions	BOD/DO concentration of N and P in inland and marine waters (S/M)	None
3. Societal responses	% of population connected to sewage treatment with biological and/or chemical treatment (M/L)	% of population connected to wastewater treatment (S) User charges for waste-water treatment (M)
	Acidification	
1. Environmental pressures	Index of acidifying substances (M/L)	Emissions of SO_x and NO_x (S)
2. Environmental conditions	Exceedance of critical loads of potential acid in water and soil (S/M)	Concentration in acid precipitations - pH, SO_4, NO_3 (S) Total depositions of acidifying substances (M)
3. Societal responses	Capacity of SO_x and NO_x abatement equipment of stationary sources (M/L)	Equipment for abatement of air pollution (S)

S = Data is generally available in countries of the Organisation for Economic Co-operation and Development (OECD) or will be available in the short term; M = Additional empirical work and data collection efforts are necessary and the indicator will only be available in OECD countries in the medium term; L = Significant work on data development is needed and use of the indicator in OECD countries will only be possible in the long term; BOD = biochemical oxygen demand, DO = dissolved oxygen, N = nitrogen, NO_x = oxides of nitrogen, P = phosphorus, SO_x = oxides of sulfur.

[a] Apparent consumption is defined as production plus imports minus exports.

Source: OECD (1993), pp.23-25.

acquire the information that will enable them to produce more accurate proxies and, eventually, the preferred indicators themselves.

Some of the characteristics of EIs that should be kept in mind during the early stages of the environmental program are the following:[10]

(i) The values of an indicator should be measurable or at least observable.

(ii) An indicator must be empirically linked to the phenomenon under study. In other words, when the values of supporting data on which the EI is based move up and down, the indicator should behave similarly and in a proportional manner.

(iii) Data should be readily available or obtainable through special projects, surveys, or monitoring activities.

(iv) The methodology for gathering and processing data and for constructing indicators should be clear, transparent, and standardized.

(v) The resources necessary for building and monitoring the indicators should be in place. They include the financial, human, and technical requirements.

(vi) The process of collecting data, processing data, and developing the indicators should always be cost-effective.

(vii) The "political acceptability" of the indicators, whether at the local, national, or international level, is crucial. The most distinctive feature of indicators is their relevance to policy and decision making. Indicators that are not acceptable to policy makers are unlikely to influence decisions.

[10] The list of characteristics is based on Gallopin (1997) and the UN Statistical Division (1999).

Table 3.4: OECD/UNEP Matrix of Issue-Based Environmental Indicators

Issue	Pressure	State	Response
Climate change	Emissions (GHG)	Concentrations	Energy intensity, environmental measures
Ozone depletion	Emissions; production (halocarbon)	Concentrations (chlorine)	Protocol signed, CFC recovery, fund contribution
Eutrophication	Discharges (N, P, water, soil)	Concentrations (N, P, BOD)	Treatment connection, investments, costs
Acidification	Emissions (SO_x, NO_x, NH_3)	Deposition; concentrations	Recovery of hazardous waste, investments/cost
Toxic contamination	Emissions (POC, heavy metals)	Concentrations (POC, heavy metals)	Investments, signed agreements
Urban environmental quality	Emissions (VOC, NO_x, SO_x)	Concentrations (VOC, NO_x, SO_x)	Expenditures, transportation policy

continued next page

Close attention to these characteristics should help to simplify the statistician's job, but the task of specifying relevant EIs clearly remains more of an art than a science. Table 3.4 concludes this discussion with a listing of issue-based indicators developed jointly by OECD and the United Nations Environment Programme (UNEP).

Table 3.4: OECD/UNEP Matrix of Issue-Based Environmental Indicators (continued)

Issue	Pressure	State	Response
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 policies
Forest resources	Use intensity	Area of degraded forest, sustain-able growth ratio	Protected forest area, sustainable logging
Fish resources	Fish catches	Sustainable stocks	Quotas
Soil degradation	Land use changes	Topsoil loss	Rehabilitation/ protection
Oceans/coastal zones	Discharges, oil spills, depositions	Water quality	Coastal zone management, ocean protection

BOD= biological oxygen demand, CFC= chlorofluorocarbons, GHG= greenhouse gases, N= nitrogen, NH_3= ammonia, NO_x= oxides of nitrogen, P= phosphorus, POC= persistent organic compounds, SO_x= oxides of sulfur, VOC= volatile organic compounds.
Source: Adapted from ADB (1999), pp. 61-62.