

CIAT/World Bank/UNEP Project

Rural Sustainability Indicators: Outlook for Central America

Technical Note

Conceptual Framework to Develop and Use Water Indicators

by

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1. Introduction

Sustainable development, and indicators to monitor it, implies a systemic approach. Nevertheless the management and policies for some resources are still organized at the sectoral level. For this reason, in the context of the CIAT/World Bank/UNEP rural sustainability indicators project – besides the development of environmental and sustainability indicators at different scales and levels – a goal is to develop *sectoral indicators*.

Water is one case where the management of a resource is still sectoral. Water resources play a vital role in the lives of all people and in the functions of ecosystems. At the same time, they may appear as one of the most endangered natural resources in the world. The present document is a technical note that introduces a framework that can be used in the development and use of water indicators. Two different indicator approaches are presented – a project-based approach and the Pressure-State-Impact-Response (P-S-I-R) approach.

2. First steps

The two first steps for any indicator developer are i) problem identification and ii) establishment of objectives. The phase of *problem identification* is necessary to focus the selection of indicators. Even if the choice to study water as a sector is a way to narrow down the selection, an identification of the specific issues – aspects of water quality or water quantity – is usually helpful. The problem identification can be achieved in two ways. One is public consultations. Key stakeholders that should be consulted include those who cause or are affected by environmental problems (industry, population in project area, etc.), those who have relevant information and expertise (the scientific community, international and local NGOs, the media, etc), and those who control implementation instruments (government). The other way is through literature reviews. Usually a combination of the two is the most efficient.

Both the problem identification and the *establishment of objectives* benefit from being as detailed as possible since that will enable the indicator selection and

policy formulation to be specific. Vague or overly broad objectives, such as "improving water quality", are of little use in selecting indicators (and may well indicate that the project or component itself is not very well thought out). The establishment of objectives is, however, only the first step – they are not of much use if the advances of the project are not measured against them. This implies a need to measure the environmental problem at three points in time:

In the case of a project base approach, before the project begins (to obtain baseline values), during project implementation (to enable changes in the project design if deviations from the objectives are noticeable), and after the project has ended (to compare baseline values to targets).

In the case of the P-S-I-R approach, first identifying the driving forces (to obtain a measure of pressure), monitoring the condition and the effects on the resource (to enable measure of state and impact) and defining targets and baseline values (to define responses that can be compare with baseline values and targets and design changes in policies and actions).

Hence, to identify and establish appropriate and reachable objectives, causal links must be clearly identified.

3. Selection criteria¹

There is no universal set of indicators that is equally applicable in all cases. However, the following criteria are appropriate to most indicator selections:

Direct relevance to project objectives or problems. The indicator selection must be closely linked to project objectives and the environmental problems being addressed. Where the environmental impact is not the primary objective, an Environmental Assessment (EA) process can outline the potential impacts and hence help select indicators.

¹ For a more detailed discussion about selection criteria, see World Bank, 1999, Environmental Performance Indicators. A Second Edition Note, The World Bank, Washington, D.C., USA.

Limitation in number. A small set of well-chosen indicators tends to be the most effective approach.

Clarity in design. It is important that the selected indicators are defined clearly in order to avoid confusion in their development or interpretation.

Realistic collection or development costs. Indicators must be practical and realistic, and their cost of collection and development therefore need to be considered. This may lead to trade-offs between the information content of various indicators and the cost of collecting them.

High quality and reliability. Indicators, and the information they provide, are only as good as the data from which they are derived. If the “ideal” indicator to measure a problem is based on unreliable data, it is common to depart from the “ideal” indicator and use proxies instead.

Appropriate spatial and temporal scale. Careful thought should be given to the appropriate spatial and temporal scale of indicators. Since the environmental impact of project activities seldom coincides with administrative boundaries, indicators often need to be measured on different scales. There might also be lags in time before project effects are felt.

4. Indicator approaches

4.1 A project based approach

One approach is depicted in Figure 1. In this, the focus is on a project – a water project has both overall *project objectives* it is designed to meet and *components* by which the implementation of the project proceeds. The implementation of these components, combined in complex ways, leads to the desired project outcomes and impacts. Even though it is common to distinguish between outcome indicators – which measure the immediate, or short-term, results of project implementation – and impact indicators – which monitor the longer term or more pervasive results of the project – the distinction is sometimes ambiguous. For this reason, the approach presented in this note bundles the two together.

Indicators are then developed for both the overall project objectives and the components: *impact indicators* relate to the stated objectives of the project; *output indicators* relate to the components. In the same way that the project components are closely linked to the overall objectives of the project, the output and impact indicators should be related. The framework also includes *baseline indicators*, which monitor aspects viewed as the context of the project. Table 1 presents examples of water indicators to be used in a project which is structured according to the framework.

Figure 1. A Project-Based Approach

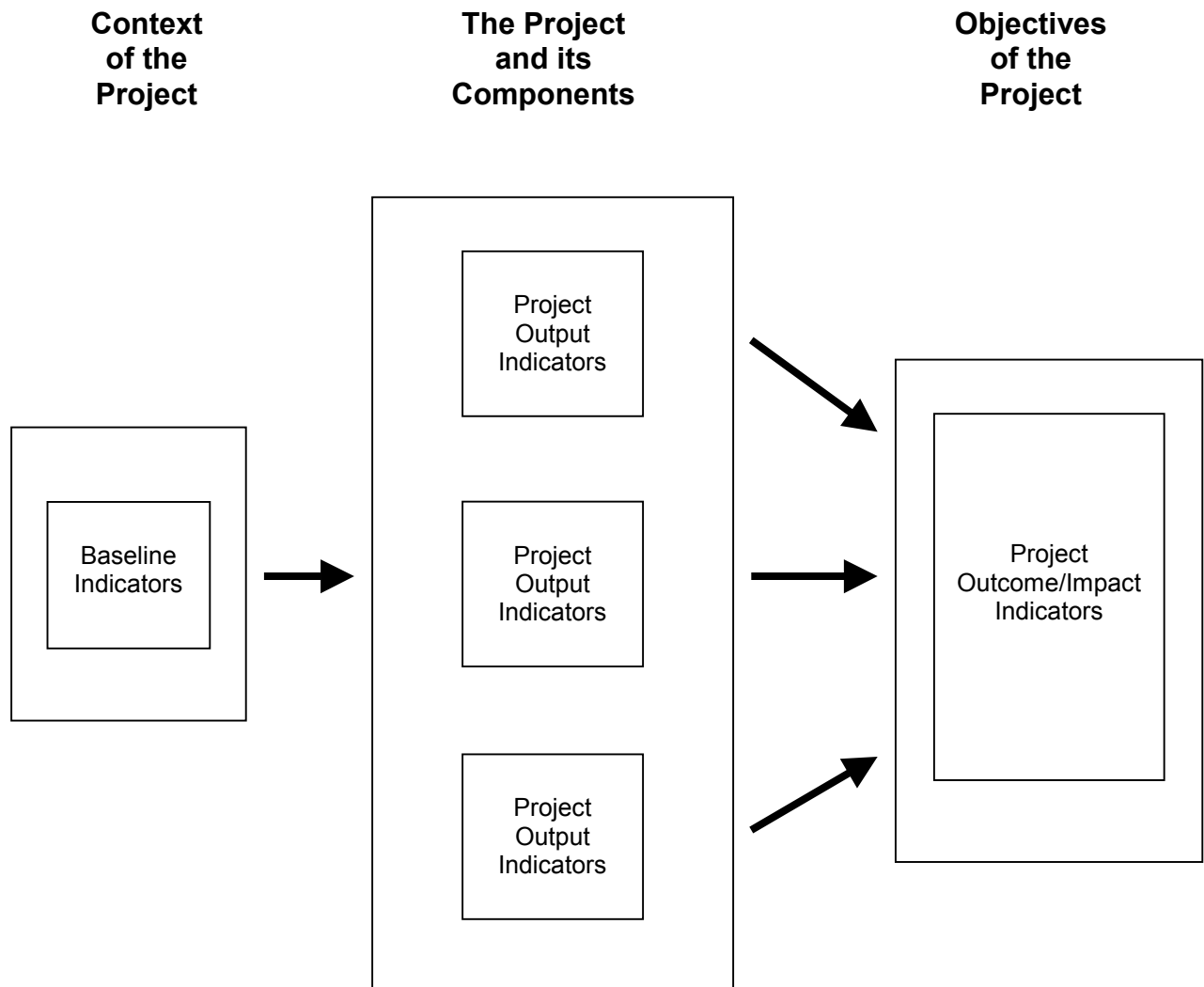


Table 1. Examples of Water Indicators for a Project-Based Approach

Baseline/Output Indicators

Outcome/Impact Indicators

Water Use/Demand

Water recycling potential (%)
 Water annual extraction per capita (m³)
 Water annual extraction by sector (%)
 Water total demand (m³)

Use efficiency (%)
 Population with access to potable water (%)
 Number of aqueducts (#)
 Water price (US/m³)

Hydroelectricity Generation

Dams (#, location)
 Hydroelectricity production (mw)

Kilowatts per hectare inundated (kW)

Water Emissions/Quality

N emissions (kg)
 Other emissions (kg)
 Eutrophication
 Acidification
 Toxicity/Heavy metal concentration
 Colibacilli (m L⁻¹)

Biological oxygen demand (mg L⁻¹)
 Chemical oxygen demand (mg L⁻¹)
 Treatment of used waters (%)
 Access to drains (%)
 People affected by diarrheic diseases (#)

Water Availability

Water reserves (m³)
 Rate of recharge (m³ yr⁻¹)
 Annual rainfall (mm)

Water annual extraction as % of total (%)

Population Risk

Population risking inundation (#)
 Capital risking inundation (\$)

Population affected by inundation (#)

Water Protection

Watershed land use (ha)

Watershed protected area (ha)

4.2 The P-S-I-R approach

Another possible approach to use in the structuring of indicators is the Pressure-State-Impact-Response approach. This approach is depicted in Figure 2, and differs a bit from the project based approach presented earlier in that it can, with advantage, be used for activities that focus on a relatively large area (e.g. a whole watershed). The difference would be that for a larger area, project-sized objectives and specific components may not be easily identified. Instead, this framework distinguishes between four different aspects of *environmental problems*:

The *pressure* variable describes the underlying cause of the problem. It can be an existing problem or it may be the result of a new project or investment.

The *state* variable usually describes some physical, measurable characteristic of the environment that results from the pressure.

The *impact* variable is the same as the impact indicators mentioned above – they monitor the long-term, or more pervasive, results of a project or investment.

The *response* variables are those policies, actions or investments that are introduced to solve the problem. As responses to environmental problems they can affect the state either directly or indirectly, by acting at the pressures at work.

When indicators are structured according to the Pressure-State-Impact-Response approach, they become sorted in a somewhat different way than in the project-based approach. Table 2 shows how indicators of use, demand, generation, and emissions are categorized as pressure indicators; indicators of availability and quality as state indicators; indicators of effects and risk as impact indicators; and indicators of protection and satisfaction as response indicators. Structured in this way, the indicators in each category can also be aggregated into four indices (see Table 2).

Figure 2. Pressure-State-Impact-Response Approach

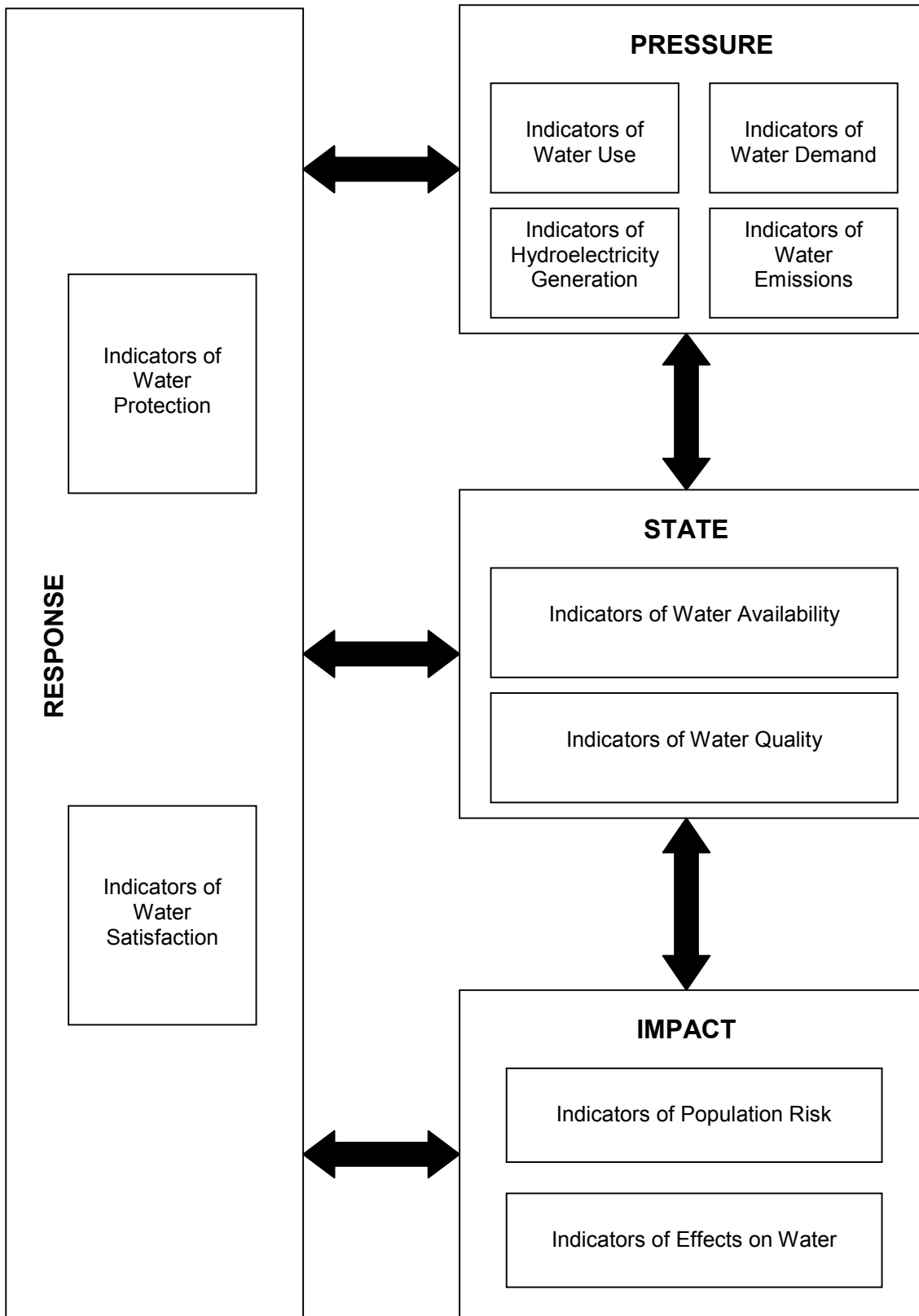


Table 2. Examples of Water Indicators for Pressure-State-Impact-Response Approach

		Detailed information	Aggregated information
PRESSURE	Indicators of Use	Annual extraction per capita (m ³) Annual extraction by sector (%)	Water Vulnerability Index
	Indicators of Demand	Total demand (m ³) Use efficiency (%) Recycling potential (%)	
	Indicators of Generation	Number of dams (no) Kilowatts per hectare inundated (kW) Hydroelectricity production (mW)	
	Indicators of Emissions	N emissions (kg) Other emissions (kg)	
STATE	Indicators of Availability	Reserves (m ³) Rate of recharge (m ³ yr ⁻¹) Annual rainfall (mm) Annual extraction as % of total (%)	Water Quality Index
	Indicators of Quality	Biological oxygen demand(mg L ⁻¹) Chemical oxygen demand (mg L ⁻¹) Eutrophication Acidification Colibacilli (m L ⁻¹)	
IMPACT	Indicators of Effects	People affected by diarrheic diseases (#) Population affected by inundation (#) Toxicity/ Heavy metal concentration	Climatic Risk Index
	Indicators of Risk	Population risking inundations (no) Capital risking inundations (\$)	
RESPONSES	Indicators of Protection	Watershed land use Watershed protected area	Safe Water Index
	Indicators of Satisfaction	Access to potable water (%) Access to drains (%) Aqueducts (#) Treatment of used waters (%) Water price (US/m ³)	

5. Conclusions

This note has presented a conceptual framework to the development and use of water indicators, as well as two different approaches to the structuring of the indicator work – the project-based approach, and the Pressure-State-Impact-Response approach. While there are several similarities to the two, such as the criteria to use in the selection of indicators, the need to identify problems as well as establish the appropriate objectives, and the importance of public consultation, there are clearly times and situations when one of the frameworks would be preferable to the other.

The first approach presented – *the project-based* – is most useful for a well-defined area, or project, where the specification of some project-level objectives and components is feasible. An example could be a water purification project – improved access to safe drinking water would be the project objective, and the installation of water monitoring stations one of the components. *The P-S-I-R approach*, on the other hand, is preferable in a situation that has taken a broader perspective, for example that of a nation, or region. The four categories forces the indicator developer and user to consider the various aspects of an environmental problem, which is usually important when several people from various stakeholder groups, are involved in the process.

Another similarity between the two approaches worth pointing out explicitly, is the need for interpretation of the indicators and for integration in the decision-making process. No indicator – irrespective of the approach used – is the end, but rather the means to an end. That is to say, the integration of the results from the monitoring into the decision-making processes, is what really makes the difference.

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