Available online at www.sciencedirect.com
SCIENCE DIRECT
ELSEVIER
Ocean & Coastal Management
Ocean & Coastal Management 46 (2003) 299–312
www.elsevier.com/locate/ocecoaman

Socio-economic indicators and integrated coastal management

Robert E. Bowen*, Cory Riley

Environmental, Coastal and Ocean Sciences (ECOS), University of Massachusetts, Boston, MA 02125, USA

Abstract

The need to better understand the linkages and interdependencies of socio-economic and coastal environmental dynamics has taken on a more deliberate role in the development and assessment of Integrated Coastal Management world-wide. The analysis and establishment of indicator-driven programs to assess change in coastal and watershed systems have increasingly moved to stress socio-economic forcings and impacts. This article serves to review the need for and provide an assessment of important frameworks designed to foster such integration. It argues that the evolution of the Driver–Pressure–State–Impact–Response (DPSIR) framework, now in broad use, provides an essential contribution.

One of the more significant challenges faced by those interested in and responsible for Integrated Coastal Management is to better refine our understanding of the linkages between coastal system dynamics and the social benefits associated with them. While both the coastal management and marine science communities have developed indicator systems to better assess change, the degree to which such efforts have been linked has been surprisingly limited. For the most part, the management community has focused on institutional measures of program performance while the marine science community has worked to build indicators of the scope and scale of change in natural systems. The degree of interaction between social systems and environmental variability has held relatively less focus. That humans and the environment are linked has been long asserted. Measuring the degree and importance of those interactions has been less of a core activity.

*Corresponding author. Tel.: +1-617-287-7443.
E-mail address: bob.bowen@umb.edu (R.E. Bowen).

0964-5691/03/$ - see front matter
doi:10.1016/S0964-5691(03)00008-5

However, the past decade has witnessed a more refined effort to expand an understanding those interdependencies. This has been the result of several related endeavors. First, pressure has been building by national governments and the international donor community to better evaluate the success of coastal management programs. Part of that evaluation pressure has been to link management with the mitigation coastal environmental degradation. Second, the design of international monitoring and assessment protocols, such as the Global Ocean Observing System (GOOS), the Global International Waters Assessment (GIWA), and, more recently, the Global Terrestrial Observing System (GTOS) and the Millennium Ecosystem Assessment (MA) has provided an opportunity for more systematic reflection. And, third, emerging models for indicator development have begun to provide appropriate frameworks for the articulation effective data strategies. Taken as a whole these efforts provide an opportunity to engage in more strategic planning for the design of coastal-based socio-economic indicators. Several nations (or more appropriately regional programs under national sponsorship) have provided for or begun efforts to better quantify these relationships. However, these have been limited in scale, scope and temporal dimensionality. The recent meeting "The Role of Indicators in Integrated Coastal Management" co-organized by the Department of Fisheries and Oceans of Canada and the Intergovernmental Oceanographic Commission established an opportunity for strategic consideration at the international level.

For these efforts to achieve their hoped for success they should embrace a consistent and internationally compatible approach. It should be fully recognized that local and regional ICM programs must respond to and provide benefit to their own stakeholders. Integrated Coastal Management is an approach driven by local conditions. However, a larger context should not be ignored. Our understanding of social/environmental linkages can only be effectively understood through an assessment across biomes, social conditions and management approaches. Critical lessons are established through multiple and cross-cutting case analyses. The choice of effective and efficient coastal management should draw upon the successes articulated from both similar and dissimilar regulatory environments. The purpose of this paper is to describe a set of indicator models that most directly contribute to this process of strategic planning. It will also report limited and preliminary results of a set of dialogs (primarily conducted through the recent DFO/IOC meeting and through various panel meetings of GOOS) establishing a general framework for the identification of coastal socio-economic indicators.

1. The articulation of indicators

Environmental concerns that have surfaced in the United States and around the world in the past 30 years have added a new variable into the scientific search for knowledge of the natural world; human influence. The inclusion of humans into the natural web of interactions calls for new protocols for studying natural systems and for solving economic and health problems. Acknowledgment that people are a part of biogeochemical cycles and physical processes has necessitated a more integrated approach to natural resource management and research [1–3]. Economic, political, and social structures are intertwined with resource use patterns. Changes in the condition of natural systems have a direct impact on the ecosystemic functions that humans depend on for health, services, and economic growth. Here, we face a dual challenge. First, understanding the complexity of those linkages is difficult. Natural variability, the impact of episodic events (such as major storms) and anthropogenic forcing all play a substantial role in the flux of natural systems. Isolating the relative contribution of each is, at best, difficult. Second, the complexities of public health risk or economic sustainability are difficult to understand and predict. Determining the role of environmental conditions is even more challenging. These difficulties have contributed the relative paucity of indicator-based approaches to management. The recognized conundrum is that without an integrated and sustained indicator-based system it is unlikely that critical linkages can be established, generally accepted and acted upon.

The first step to using indicators to advance our knowledge of coastal systems and the effectiveness of management programs is to establish an appropriate definition for the term indicator. Measure, variable, parameter, analyte, metric, and index are all terms that can be found in the literature and in the glossaries of current programs designed to develop and use indicator frameworks [4–6,24]. Each has been used to describe (sometimes inappropriately and occasionally to the point of confusion) efforts to build an empirical approach to understanding coastal system dynamics. In an effort to mitigate that confusion we suggest that a focus on the function of an indicator as an appropriate starting point. The OECD [4] has argued that a successful indicator should:

- Reduce the number of measures which normally would be required for an exact presentation of a situation; and
- Simplify the process of communication to managers, stakeholders and communities.

In short, indicators should represent dynamic parts of an overall portrait that is understandable and compelling to its intended user community. They should be part of a process to minimize the number of individual variables and data points while maintaining a sufficient level of critical understanding to those responsible for or interested in coastal systems.

For this process to succeed purpose and context must initially be established. What questions serve as motivation for the effort? Some indicator frameworks are designed to determine program performance, some are created to establish links between anthropogenic activity and ecosystemic health, and some attempt to track trends and conditions in ecosystem dynamics or resource use. While this initiating step appears obvious it is often challenged—particularly, in situations in which available information takes precedent over appropriate information. The design of new data-driven programs are often broadly influenced by the availability of existing data files. While it is essential to fully utilize existing data it is equally essential to understand the value and voracity of data when the present context is substantively and substantially different. That data exists does not de facto mean it should be used.

When the purpose of data collection is established, a blueprint for the design and use of indicators should be put into place from the inception of the project, to ensure that the time, effort and money invested are not wasted. Five general steps seem to summarize the considerations that should be incorporated into the indicator system:

- *Articulate an indicator framework driving the selection of specific measures*. With an agreement on a context and question alternative frameworks should be assessed to determine their applicability in selecting an indicator set of greatest value. The needs of and value to the user community should sit at the core of these deliberations.
- *Determine an efficient and effective data acquisition strategy*. Cost, compatibility and sustainability of effort should be considered as should the value of existing data sources.
- *Create and maintain a sustained data management system*. Making data broadly and openly available through an established quality assurance/quality control system is essential.
- *Agree to protocols for data analysis*. One of the historic difficulties in system monitoring as been too strong a focus on data acquisition and too little a focus on data analysis.
- *Develop reporting products to ensure information reaches and is understood by the broader user community*. The number and nature of coastal area stakeholders reaches well beyond the scientific or regulatory communities. Traditional forms of reporting (i.e., limited runs of printed reports with data tables) are increasingly limited in terms of their ability to inform those whose interests are at stake. New graphic display and information management technologies need to be more fully embraced.

A substantial focus of this paper resides in the first of these steps: that is, the description of frameworks driving the selection of specific measures. However, it is important to recognize that the selection of measures and acquisition of data should be viewed as part of system in which data acquisition, management, analysis and product production are viewed as part of a synthetic whole which should be addressed concurrently in the early stages of program initiation.

2. Models for the selection of socio-economic indicators

The indicator models are herein described within a specific context; that is, the linkages between socio-economic conditions (including management and regulatory approaches) and changes in coastal environmental dynamics. As such, they serve as performance measures of success in those aspects of an overall ICM effort for which those linkages are a part. We acknowledge that these linkages are viewed as an important part of an ICM framework—but, only a part. The process of developing a broadly integrated management effort will need to incorporate a richer set of performance measures. Institutional evaluation, an understanding community dynamics, and policy assessment all play a central role. However, the synergies of social/environmental interaction are also important. Most ICM efforts articulate goals relating to coastal environmental improvement yet often lack specific performance measures dedicated to understanding how well those goals are being met.

Ideal performance measures provide a clear indication of how well a program is achieving its objectives. Thoughtful design, use, and adaptation are critical to their usefulness as a management tool. Industry, international aid organizations, and government agencies all have unique processes to implement performance measures that are compatible with the specific aims of the organization. Most models use indicators to determine if the performance measures are being met. Considerable theoretical work has been done discussing the framework and design of evaluation techniques [4,7–9]. Several themes repeat themselves in the academic and applied discussions of indicators that may be helpful to keep in mind as we explore the potential use of performance measures in ICM efforts.

An ideal combination of indicators could be fed into a conceptual or technical model that efficiently identifies what, where, how, and why change is occurring within the system. Performance-based management frameworks should organize indicators into sets that are responsive to and driven by the needs of the user community. The Organization for Economic Cooperation and Development (OECD) created the "Pressure–State–Response" model in 1993 to help model the cause and effect relationship between humans and the environment [10,11]. This model has been expanded since 1993 by the United Nations and the European Commission (among others) to include the root causes of environmental change and the impacts this change has on ecosystems and on humans. Input, output, outcome and impact measures are classified according to the programmatic goals of the management action.

Developing a performance-based evaluation begins with clearly defined strategic goals and a detailed set of intermediate targets [12]. The intended results of the program and the specific type of change that is desired need to be understood and articulated within the context of measurable increments. Differences in the situation, condition, level of knowledge, or attitudes and behavior of a population need to be assessed with appropriate units [12]. The more precise the vision of the program, the easier it will be for the organization to develop measures that yield useful information.

3. Pressure–State–Response model

The Pressure–State–Response (PSR) model, popularized by the OECD [11], is an example of a common framework for environmental evaluation. Environmental problems and solutions are simplified into variables that stress the cause and effect relationships between human activities that exert pressures on the environment, the condition of the environment, and society's response to the condition (see Fig. 1).

Water quality is a typical environmental concern that can be used as an example to display the three types of indicators. Tons of fertilizers used by waterfront property owners is an indicator that measures the "pressure" that the environment is

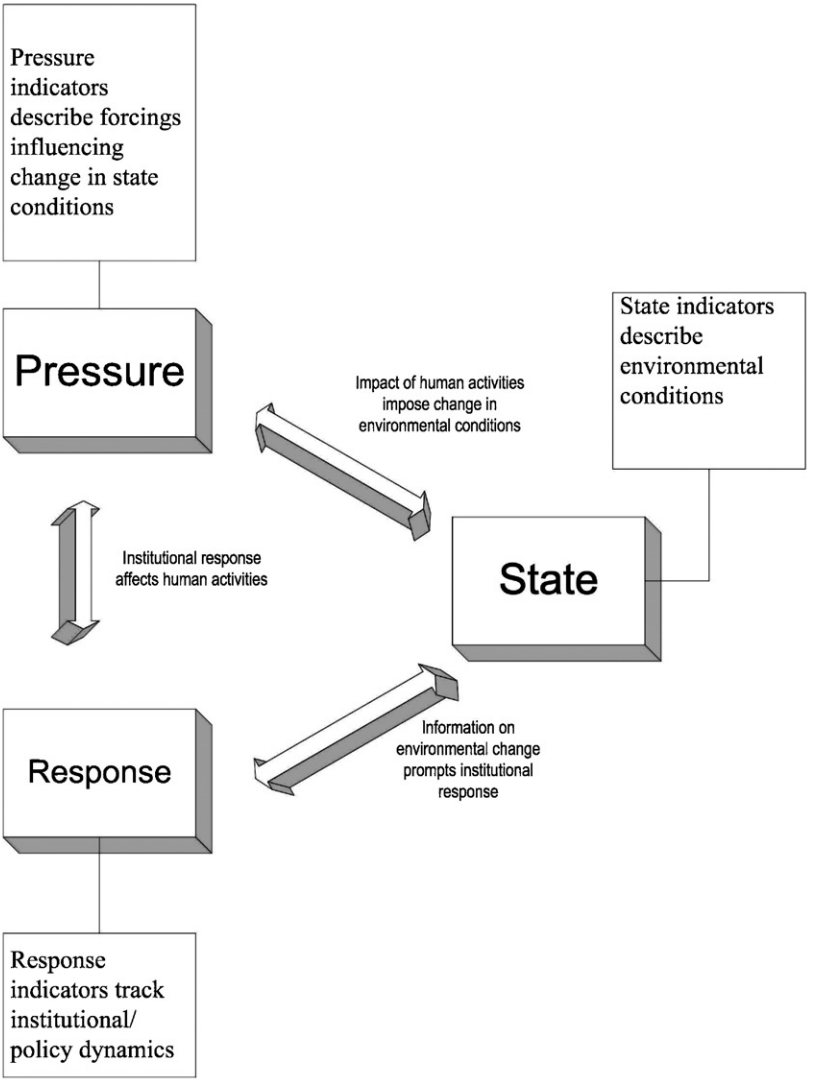

Fig. 1. Pressure–State–Response model for indicator development. Adapted from: OECD [11] and LEAD [20].

experiencing. "state" variables monitor the condition of the environment. In this example, the actual nutrient dynamics of the water body would serve as the state indicator. The "response" indicator measures the actions taken to reduce pressures or improve the state of the resource in question. The number of workshops held or amount of protective legislation passed in a certain timeframe to protect water quality are quantitative examples of response indicators.

The P–S–R approach was a useful addition to the literature in that is made explicit the need to focus on those factors influencing environmental systems and associated consequences (both in terms of environmental conditions and regulatory change). However, its conceptual limitations are significant. It describes a system overly simple in its view and overly narrow in its scope.

4. Driving force, pressure, state, impact, response model

The original P–S–R descriptions focused on anthropogenic pressures and responses. One of several problems was that the original definitions did not effectively factor natural causes into the pressure category. Therefore, natural variability and episodic events had no real place in the model. While anthropogenic forcing is often an important, if not dominant, factor in environmental change, efforts that ignore other influences may lead to the imposition of unwarranted regulatory constraints that hold little, if any, promise to improve environmental quality.

In part, this challenge led some, most notably the United Nations Commission on Sustainable Development to describe a Driving Force–State–Response model. A primary modification here was to expand the concept of "pressure" to incorporate, social, economic, institutional and natural system pressures [22]. However, even when "driving force" replaces "pressure", the model does not explicate a category to account for the underlying reasons for the pressures. To analyze policy options and resource allocation in environmental management, it is essential to have a grasp of the root causes of the problems being addressed [13]. A model that measures pollutants but gives no information about the social conditions surrounding driving pollutant introduction (e.g., changes in the organization of watershed agriculture or coastal industrial production) is not providing the data needed to inspire meaningful change.

Another element missing from the P–S–R model is an examination of human motivation responding to the state of environmental conditions. While social stewardship of the environment should be an essential component of environmental policy, it is not the sole motivation. Social resources are not infinite. Expenditures of time, energy and effort are prioritized according to a rich and often conflicting suite of factors. Certainly, one of those factors should be the social costs imposed or benefits gained through changes in the quality of supporting environments. The social impact of environmental change is an essential factor in influencing policy. An indicator system that records the state but not the impact essentially assumes that every change in the pressure, state, or response should be given the same amount of attention or resources. Realistically, all ICM efforts are a careful balancing of priorities. Including indicators that measure impacts to humans and the ecosystem makes the model a more useful management tool.

Thus, challenges to the initial P–S–R model have contributed to the refined and expanded approach described as the Driver–Pressure–State–Impact–Response Model by, among others, the European Commission [9]. Within this model:

- *Drivers* describe large scale socio-economic conditions and sectoral trends such as patterns in coastal land use and land cover, and growth and development in coastal industry sectors,

- *Pressures* such as patterns of coastal wetland alteration, the introduction of industrial POPs/metals and fertilizer use in the coastal watershed hold the ability to directly affect the quality of coastal environments;
- *State* indicators describe observable changes in coastal environmental dynamics and in functions describing sustainable development;
- *Impacts* are the discrete measured changes in social benefit values linked to environmental condition such as the cost of marine-vectored disease, loss of recreational bathing beach value, or losses to commercial fishing value due contaminant burdens; and,
- *Response* indicators are described as the institutional response to changes in the system (primarily driven by changes in state and impact indicators).

Fig. 2 represents the D–P–S–I–R approach and is designed to emphasize the fact that any indicator framework should focus not only on the articulation of

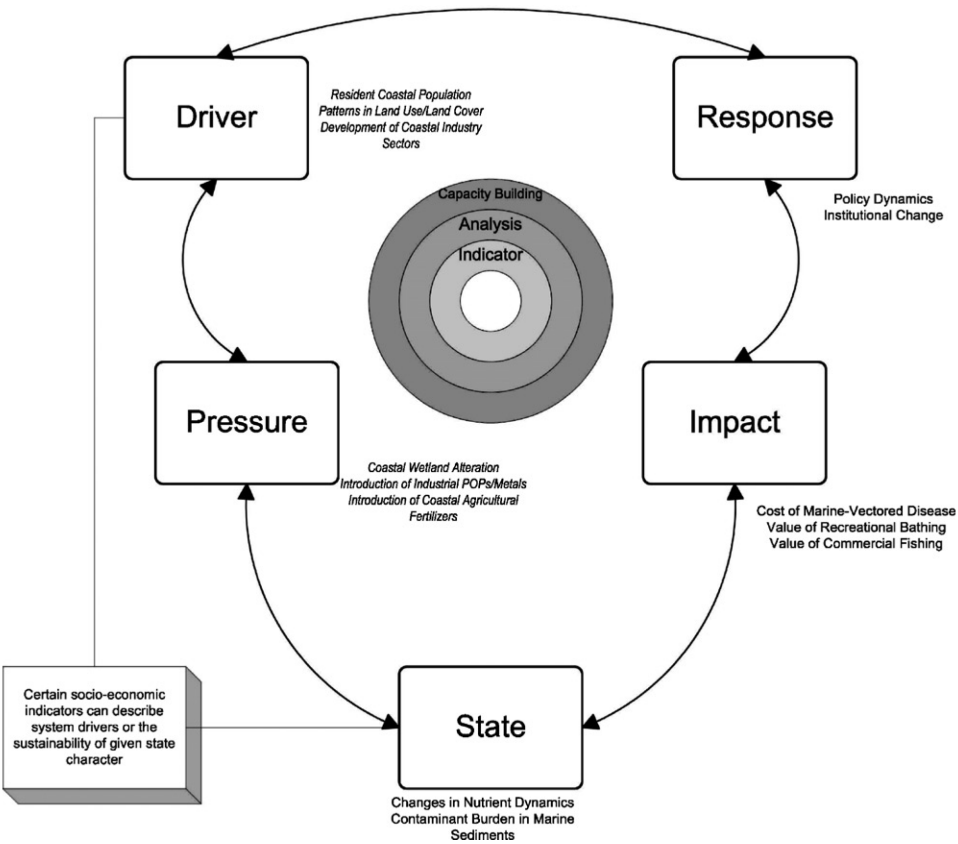

Fig. 2. Driver–Pressure–State–Impact–Response model for indicator development. Adapted from: IUCN [21] and European Commission [9].

Table 1
Illustration of socio-economic indicators within a driver–pressure–state–impact–response framework

	Driver/state	Pressure	Impact
Population dynamics	Resident coastal population Coastal land-use/land cover Coastal zoning patterns		
Economic conditions	Annual GDP growth Environmentally adjusted net domestic product Economic value/ employment in coastal industry		
Social conditions and cultural traditions	% population with potable water Cultural stability/ integrity		Change in user conflict
Development pressure/ capital construction		% of altered coastal land	Cost of coastal flooding/ hazards and savings provided by coastal habitat
		% of impermeable surface in CZ Coastal fill acres/year	Dredging costs driven by sediment contamination
Habitat change/ ecological value		Service value of coastal habitat Value of habitat driven manufactured products	Social costs of invasive species Service value changes from habitat alteration Changes to non-use values of coastal habitat
Contaminant introduction		% of population with wastewater treatment	% of coastal harvesting areas under environmental restrictions
		Fertilizer use in coastal watershed Industrial inputs of POPs/metals	
Resource extraction activities		Oil spills from extraction/transportation	Seafood value changes from seafood risk/ habitat alteration
		Commercial fishery landings Seafood consumption patterns	
Human uses/activities		Coastal aquaculture Beach attendance	Marine-vectored disease Beach closing costs

appropriate indicators and on the development of data acquisition systems (indicators), but should also embrace the need for analysis and capacity building through the construction of reporting products responsive to user needs.

As already noted, the present effort is a focus on using conceptual models in the building of socio-economic indicators viewed to be of greatest value in understanding the dynamics of social/environmental integration. Table 1 provides an illustration of that effort. Here, indicators are classed according to whether they best meet the description of Driver, State, Pressure or Impact indicators. They are also classed into the substantive themes of:

- Population dynamics
- Economics conditions
- Social conditions and cultural traditions
- Development pressure/capital construction
- Habitat change/ecological value
- Contaminant introduction
- Resource extraction activities
- Human uses/activities

These substantive themes are used to stress the complexity of the coastal social system. When developing an indicator system data should be drawn from a broadest range of human activities influencing, and influenced by, coastal environments. In any given situation it may be that the range of influence is more narrow than those characterized in these thematic categories. However, a systemic review of the possible relationships should be an early part of the design of any indicator-based effort. Table 1 is provided as an illustration of specific indicators representing these classes. It draws from a more complete list of indicators developed for the recent meeting in Ottawa(1). This set can be viewed as a fuller palette against which the discrete informational needs of individual programs could be judged. Table 1 also attempts a reflection of more recent discussions on the application of the model to various questions facing coastal and environmental managers. In linking the model categories of driver and state the table attempts to emphasize the value of context in indicator development. In certain instances indictors may best assess the relationship between drivers and pressures. In other instances the same indicators are best viewed as contributing toward an understanding of the influence of Pressures on the State of social sustainability functions [23]. This illustration is meant to further stress the need for flexibility in the development and use of indicators. Models hold their greatest value when they provide insight and inspiration into a broad range of complex questions and hold less value when viewed as a constraint on creative application. The D–P–S–I–R approach more effectively represents the complexities of social/environmental interaction and highlights the need to understand and measure the nature and scale of that dynamic.

5. Process and outcome indicators

The indicator approaches described above can, and should, be incorporated into more traditional program evaluation efforts. They can make important contributions to emerging and evolving efforts to assess the success of Integrated Coastal Management. However, again, certain caveats need to be recognized. Integrated Coastal Management represents a complex set of activities that include, but is by no means limited to, efforts to improve environmental quality. Assessments of the success of ICM (particularly at the local level) need to incorporate a broad range of cultural and institutional measures. However, the degree to which evaluation measure can expand to more effectively incorporate social/environmental dynamics the stronger the argument will be that these programs hold broad and general value.

Evaluation efforts can usually be divided into those that measure process, those that measure outcomes, and those that measure both [14,15]. In the context of coastal program evaluation, process evaluation measures the policies, the laws passed, money spent, permits issued/denied, and the management programs implemented. Outcome indicators document the changes in social or physical conditions brought about by the activities of the public program [16]. Acres of land protected, number of public access sites established, an improvement in water quality, or measures of organizational learning or progress are all considered outcome indicators. Historically, much of the coastal management evaluations conducted in the United States, for example, have concentrated on measuring process indicators [16]. Managing for results has recently become a trend in US governmental agencies, sparked by the Government Performance and Results Act of 1993. Focusing on outcomes rather than solely on process indicators intends to shift the government away from overemphasizing inputs and hopes to introduce accountability for desired agency results [7]. Performance measurement also promotes communication within an organization about what the exact goals are, how they are to be achieved, and who is responsible for each aspect of project implementation [7]. Strengths and weaknesses of the project and of the organization are more easily identified and addressed early in the process if outcomes are being measured for each objective [7]. Within coastal management, it is more difficult to find and collect outcome data than process data. Contributing outcomes directly to a specific program is also a challenge compounded by the fact that criteria for success are not often clear from coastal legislation or program plans [17]. Creating an indicator framework that has a place for both process and outcome indicators can help trace management efforts more directly to environmental and social conditions.

6. Input, output, outcome, impact indicators

Program assessment indicators can also be theoretically categorized into input, output, outcome, and impact variables [5]. The World Bank categorizes indicators to correspond with project components following an implementation scheme that flows from project design to implementation of sub-projects interacting toward desired impacts. Tracking the performance of a project begins with input measures to keep track of procurement of material of equipment, funds, material and labor. Output and outcome indicators relate back to the stated goals of sub-projects and impact indicators measure progress towards the goals stated at the highest level of the project/organization. The World Bank uses this model to evaluate development projects of all kinds, but the framework is applicable to coastal program evaluation as well [18].

To demonstrate some examples of these types of measures, indicators from the D–P–S–I–R model can be viewed as contributory to each of these categories. Input variables measure the amount of time, personnel, or resources invested in a project or task (response indicator). Output indicators measure specific actions taken by the program, such as a decrease in point pollution (pressure). The outcome indicator measures larger goals of the program such as improved water quality as measured through nutrient dynamics (state). Impact indicators take this thinking one step further, measuring the improved quality of resources or human health (impact). Any organization attempting to design a performance-measuring system must recognize that each action could be measured using input, output, outcome, and impact indicators and design goals with this spectrum of results in mind. Accepting such an assessment approach provides an effective mechanism to link specific program performance measures with a broader environmental and social sustainability perspective. It also more effectively structures the opportunity to link coastal environmental monitoring programs with local ICM program actions and goals.

7. Broadening the concept of program performance

As already noted most ICM program efforts incorporate the improvement of local environmental conditions in either the rationale for the program or in the statement of program goals. Therefore, indicators of environmental variability and the socio-economic relationships to them should be built into a comprehensive system of program performance. And, while it is readily acknowledged that environmental improvement and social change are not typically reflected within the duration of a specific ICM program effort this should not preclude their inclusion as indicators of longer-term program success or as contributors to development of broader-scale policy development. These broader indicators of change cannot be used alone to judge program implementation at individual sites, however, this information is critical to understand local, state, and national trends. Indicators of coastal environmental change can be used to prioritize projects at the site level and should feed into state, national, and potentially international efforts to relate coastal and human health to management efforts. Ecological indicators should be one category of performance measures crafted from the mission statements of coastal management programs to reflect pressures to the environment from natural sources (such as weather) and the environmental state of coastal systems.

The pressures imposed by human action are also important in forming strategic goals program priority actions. Land use patterns may contribute to an understanding of water quality data, and demographic trends in the surrounding towns may help managers redesign education programs.

Tracking anthropogenic influences will provide a better long-term picture of program effectiveness in changing behaviors and attitudes as well as documenting health and economic consequences (impacts) of environmental services and degradation. Any practical environmental program must incorporate social realities into its plan of action. Selecting indicators for socio-economic factors enriches the body of measures used to improve programming and evaluate progress on a broader scope than using institutional performance measures alone.

To adapt to the most pressing local issues and assess the long term impacts of program action monitoring information outside the direct control of the site management should also be assessed, organized, and used to shape local plans. Recently, agencies, nations and even small towns have been publishing "sustainability indicator" lists that track economic, ecological, cultural, and social indicators to alert decision makers to trends [18,19]. Through these data, the state of the environment can be assessed along with the pressures that result from human social and economic activity. Models can be drawn, plans made, and actions prioritized based on monitoring indicators. Program implementation should address the findings of a monitoring program or data collection that reflects current conditions and patterns. Achieving the goals of Integrated Coastal Management requires a clear picture of programmatic progress, environmental conditions and influencing anthropogenic factors.

This view admits to significant challenges. Attempting to tease out the relative contributions of natural cycles, episodic events, and anthropogenic influence requires sophisticated statistical analysis and the occasional heroic assumption. Programs may contribute to improvements in the state of the natural environment and relieve certain pressures on the estuary, but it is clearly difficult to measure the proportion of change attributable to a specific action. The long-term use of socio-economic and ecological indicators can indicate how well the programmatic approach contributes to broader goals of Integrated Coastal Management over the period of years to decades (which, admittedly, is beyond the budgetary cycle of most local programs). In the short term, these indicators can aid local managers in moving toward more informed decisions on prioritizing projects and revising strategic plans.

Socio-economic, ecological, and management indicators all fit into a linked approach to program performance. Understanding coastal processes, and therefore evaluating program success in addressing coastal issues, requires a broad and rich set of integrated indicators. Comprehensive program assessment should incorporate appropriate components revealed through consideration of a D–P–S–I–R modeling effort as well as more traditional institutional performance measures. The more effective integration of social condition, environmental dynamics and institutional response can only enrich the process of informed decision-making on sustainable resource use and development practices.

References

[1] Crabtree B, Bayfield N. Developing sustainability indicators for mountain ecosystems: a study of the Cairngorms Scotland. Journal of Environmental Management 1998;52:1–14.

[2] Gottret MA, White D. Assessing the impact of integrated natural resource management: challenges and experiences. Conservation Ecology 2001;5(2):17.

[3] v.Bodugen B, Turner RK. Science and integrated coastal management. Berlin: Dalhem University Press, 2001.

[4] Organization for Economic Cooperation and Development (OECD). Towards sustainable development: environmental indicators. Paris, 1998.

[5] World Bank. Environmental performance indicators, 2002. http://worldbank.org/html/opr/pmi/envindi2.htm, 2002.

[6] United Nations Development Programme. Development watch: monitoring progress on sustainable development, sustainable development indicators. Retrieved February 20, 2002 from www.undp.org/devwatch/indicatr.htm, 2002

[7] Hakes JE. Can measuring results produce results: one manager's view. Evaluation and Program Planning 2001;24:319–27.

[8] United Nations (UN). Department of economic and social affairs from theory to practice: indicators of sustainable development. Retrieved February 22, 2002 from. http://un.org/esa/sustdev/indi6.htm.

[9] European Commission. Towards Environmental Performance Indicators for the European Union (EU). A European system of environmental indicators, First Publication. Retrieved February 22, 2002 from http://www.e-m-a-i-l.nu/tepi/firstpub.htm.

[10] International Institute for Environment and Development (IIED). National strategies for sustainable development: the pressure state response framework. Retrieved February 15, 2002 from www.nssd.net/References/SDInd/PSR.html.

[11] Organization for Economic Cooperation and Development (OECD). OECD core set of indicators for environmental performance reviews, Paris, 1993.

[12] United States Agency for International Development (USAID). Performance monitoring and evaluation tips, No. 6, 1996. http://www.usaid.gov/pubs/sourcebook/usgov/mfr.html.

[13] Global International Waters Assessment (GIWA). GIWA in brief. Retrieved April 24, 2002 from www.giwa.net.

[14] Niedowski N. The role of impact assessment in the valuation of integrated coastal management. Masters project,. Boston: University of Massachusetts, 1997.

[15] Belfiore S, Miriam B, Jordi G, Bernice M, Meredith B, Danielle T. Background Paper for The International Workshop on the Role of Indicators in Integrated Coastal Management. Ottawa, 2002.

[16] Hershman MJ, James G, Tina BC, Robert G, Virginia L, Pamela P. The effectiveness of coastal zone management in the United States. Coastal Management 1999;27:113–38.

[17] Knecht RW, Biliana C-S, Gregory WF. Perceptions of the performance of state coastal management programs in the United States. Coastal Management 1996;24:141–63.

[18] World Bank. Indicator frameworks. Retrieved March 14, 2002, from http://lnweb18.worldbank.org/ESSD/essdext.nsf.

[19] United States Environmental Protection Agency. National coastal assessment, 2002. Retrieved April 15, 2002 from www.epa.gov/emap/nca/html.

[20] Livestock Environment and Development Initiative (LEAD). Livestock and environmental toolbox; pressure state response framework and environmental indicators. Retrieved February 13, 2002 from www.Virtualcentre.org/en/dec/toolbox/Refer/EnvIndi.htm.

[21] http://www.iucn.org/webfiles/doc/archive/2001/IUCN769.pdf, 2001.

[22] UNEP, 2000. Global Change of Infoterra to UNEP-Infoterra: Enabling Countries to Build an Integrated Environmental Information Service. UNEP/INF2000/WP/3, 11 September, 2000.

[23] OECD, 2000. Towards Sustainable Development: Indicators to Measure Progress, Proceedings of the OECD Rome Conference, Rome.

[24] IOC/GOOS, Intergovernmental Oceanographic Commission/Global Ocean Observing System, Implementation Plan for the Health of the Oceans Panel of the Global Ocean Observing System (GOOS), January 2002, 75 pp.