MODELS AND METHODS OF MEASURING SUSTAINABLE DEVELOPMENT PERFORMANCE

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1. Introduction

The objective of this report is to identify operative models presenting measurable dimensions of social, economic as well as biophysical conditions on the level of state / provincial governments and large municipalities. Also provided are methodological suggestions that apply to the *process* of identifying and using sustainable development indicators. Given the above objectives, at this stage of IISD's work the report is limited to providing the following:

- a summary of outstanding community based and provincial / state level projects using or developing indicators that cover most sustainable development issue areas, as well as a short analysis of their strengths and weaknesses;

- a reference to initiatives of international organizations providing globally relevant sustainable development indicators and a discussion of their applicability in a provincial level project; and,

- a discussion of a coherent framework and methodology to develop indicators for provincial level sustainable development reporting and suggestions for the application of indicators.

On the level of states or provinces the benchmarking process of the State of Oregon as well as Alberta's and Colorado's indicator project are mentioned. British Columbia's reporting is in the earlier planning stages [1]. Some municipal initiatives can also provide help to the provincial indicator development process. The examples mentioned include the projects of Jacksonville, FL and Seattle, WA. There is also a considerable number of projects in Canada collecting data on and publishing indicators with relevance to sustainable development [2]. Perhaps most developed is the institutional background of state of the environment (SOE) reporting on the national, provincial or local level. In most cases, SOE reports attempt to present indicators with long data series that may permit the identification of significant trends. SOE reports in the past did not routinely contain indicators on economic and social dimensions. Environment Canada's State of the Environment Directorate (SOED) is broadening the focus of their national indicator reporting activities with more emphasis on linkages between environmental and socio-economic factors. Other Canadian projects, like community health initiatives that also extend to economic and social dimensions are usually less institutionalized, and rarely publish standardized and regular reports with a focus on measurable indicators.

An important point to make is that the methodology of measuring 'sustainability' or 'sustainable development performance' is not standardized, there is no textbook version available, one that is generally accepted and applicable across regions and sectors of the economy. Indicator categories and individual indicators are usually identified and validated through a focused exercise either using a public hearing / public consultation process or working with representatives of major stakeholders from government, NGOs, the private sector, academia and the general public.

As local socio-economic/biophysical conditions and value systems are diverse, also different are the goals and necessarily the indicators of sustainable development. These differences seem to

support the concept of sustainable development being a "story line", requiring contextual interpretation [3]. How can, given this complexity, an initiative learn from the experience and potentially improve the usefulness of other measurement projects that have gone through indicator selection, data collection, and are in the process of incorporating extended indicator sets into decision processes?

There seem to be similarities between projects under different conditions on two accounts. First, although indicator sets are never completely overlapping, there are strong scientific arguments for a category of compulsory biophysical indicators as *minimum* requirements of sustainability [4,5]. The argument is that approaching sustainability in the social or economic sense is strictly conditional upon a number of critical factors, for instance the maintenance of soil fertility. It is subject to discussion, whether or to what extent should an expert-derived minimum indicator set come under stakeholder scrutiny. Secondly, there are similarities between the way indicator selection procedures are structured. There is also an emerging consensus on a framework for the identification, use and organization of indicators, which is conducive to the recognition of cause-and-effect relationships and trade-offs between human activities and environmental as well as social conditions. None of the operative models on the national, regional or community level known to us have been explicitly using this emerging pressure-state-response (PSR) framework in the past. This option should be considered in a provincial initiative. *While providing an opportunity to establish causal relationships between indicators and policy decisions, a PSR-framework may also improve the comparability of data between different jurisdictions.*

The concept of indicator measurability and the transparency of the measurement process is critically important. Measurability means using quantitative versus qualitative indicators where possible. In a transparent process the tools, responsibilities and step-by-step procedures of measurement are accurately documented, publicly available and endorsed by stakeholders involved in the indicator selection process. Meeting the above criteria is a condition of indicators significantly contributing to the accountability of decision-makers and those implementing decisions.

2. Model Initiatives on the Provincial / State Level

The inclusion of the following models in this report for illustrative purposes is justified, because we believe some of their components had or are expected to have trendsetting value. They have been selected for review because they meet one or more criteria that are in our opinion important for the success of an indicator initiative. Some of these criteria are the following:

- definition of indicator sets through a public participation or public or stakeholder consultation exercise; public participation in the identification of indicator sets can be effectively linked to the task of setting measurable targets;

- provision of indicator profiles that cover both ecological as well as socio-economic dimensions;

- institutionalization of the indicator initiative in terms of effective laws and regulations, assignment of data collection, monitoring and report preparation responsibilities, and regular reporting; and,

- integration of indicators into decision processes.

As noted earlier, it is not feasible, or even possible to entirely copy the structure of a measurement project from one jurisdiction to another. It is possible, however, to learn from their particular strengths, and take useful modules from their structure as pieces of a mosaic to create a project that is best suited to the circumstances of Manitoba.

2.1. Alberta's Sustainable Development Indicators

The province's indicator project was initiated by the Alberta Round Table on Environment and Economy (ARTEE) in 1992, after the Roundtable identified nine basic vision elements for Alberta's sustainability in the future [6,7]. Under the guidance of the Roundtable's Indicator Working Group an Indicator Project Team coordinated a one year long exercise focusing on indicator identification as laid out in a Project Plan (Fig. 2). Among other steps the Project Plan contained provisions about a review of indicator literature, development of a screening model and indicator criteria, design of a management system as well as consultations with Roundtable members, specialists and other stakeholders.

A preliminary database of more than 850 indicators was compiled based on polls and interviews with Roundtable members as well as different stakeholder groups, and this list was later reduced in two steps to a final number of 59 on the basis of selection criteria, expert advice and literature data (Appendix 1). Each indicator is presented with a short description, a rationale and source of data. There are no explicit categories for organizing indicators. In principle, the project realized a difference and causal linkage between driving forces of change and results of change, and assigned each vision element into one of these categories. Although the direction of linkages in terms of what is a cause and what is more a result may be subject to discussion, the realisation of connections and trade-offs between various vision elements is important. Unfortunately, there is little discussion in the project of the methodological challenges that arise when decision-makers attempt to address causal linkages between heterogeneous indicators in decision making. As of this date, quantitative indicators have not yet been reported.

Responsibility for the coordination of data collection and regular indicator publication was assigned to the Alberta Bureau of Statistics, but the Working Group has considered several other options as well. Soon after indicator identification was completed, however, the Bureau of Statistics have been dissolved as part of the government's budget cutting efforts. This fact highlights the importance of finding the right institutional framework with *long term* security in terms of human and financial resources and technical capabilities. This point is even more important considering that without reporting indicators over extended periods of time no trends can be established. Without significant trends it is not possible to link policy measures to changes in indicator values, thus any meaningful application of indicators for planning purposes may become unfeasible.

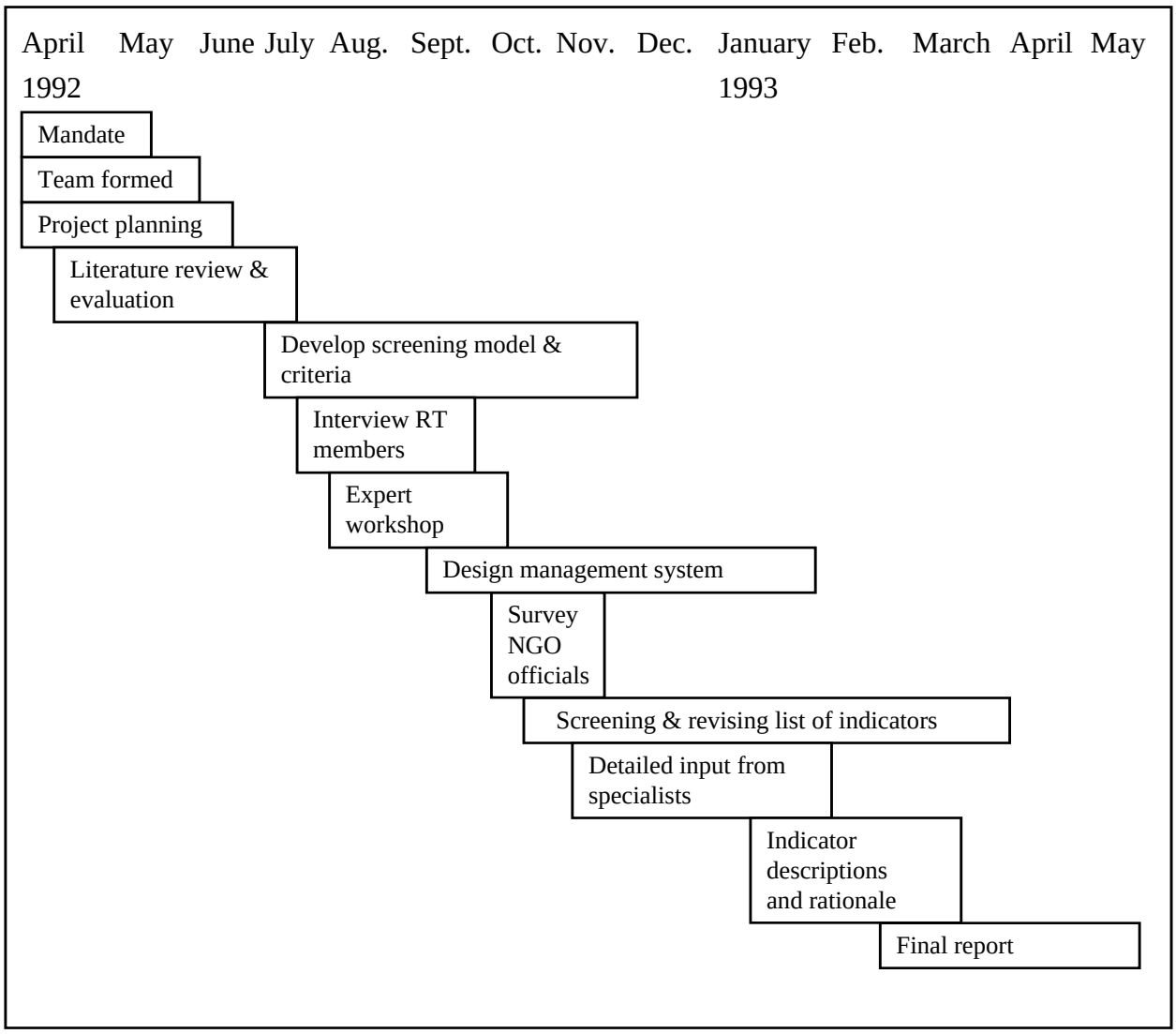

Figure 1: Project plan time line for Alberta's indicator initiative [6].

Alberta's project has been effective in using the resources of the provincial Roundtable in a well structured indicator selection process. The project could be further improved by placing indicators into a causal framework, systematically addressing the aspects of insitutionalization and discussing the detailed methodology of using indicators in decision making.

2.2. Oregon Benchmarks

The benchmarking process of the State of Oregon was initiated in the late 1980s, and by now has become a model for a number of state level programs elsewhere in the United States (Minnesota, Montana, Kansas) [8]. Although Oregon Benchmarks is not referred to explicitly as a sustainable development or sustainability measurement exercise, several of its components are compatible with sustainable development principles. Comparing the project to SOE report methodologies

seems to be appropriate. The Benchmark project goes beyond currently used SOE reporting in five key ways:

a. indicators are identified by major stakeholders through a public consultation exercise instead of only experts and government officials;

b. besides biophysical environmental indicators normally accounted for in State of the Environment reports the Benchmarks process also considers social and economic indicators;

c. Oregon Benchmark not only provides historical and current values for a given indicator, but also reports future targets quantitatively;

d. actual application of indicators is ensured by legal provisions approved by the State Assembly; specific measures include appointing an accountable senior government official to be responsible for each lead benchmark;

e. benchmarks are incorporated into the state budgeting process as important criteria in allocating resources.

A key feature of the benchmarking process in Oregon is that besides the continuous process of data collection on individual indicators, benchmarks are revisited every second year. Thus, the project ensures that the changing perceptions and values of the public, affected by most recent developments are also reflected in benchmarks for the future. In fact, it may be more accurate to consider Oregon Benchmarks as an institution instead of a project that will be completed in the foreseeable future. A long term view is also necessary because in many instances long time series data are required to obtain statistically valid trends that are convincing enough to promote policy action. As a sign of official commitment, primary responsibility for the Benchmarks rests with Oregon Progress Board, headed by the State Governor. In its multi-stakeholder structure, the Board may bear certain similarity to provincial Roundtables but with a mandate oriented specifically towards coordinating the benchmarking process, including the institutionalization of benchmarks.

Indicator categories selected in the Oregon Benchmark program are shown in Appendix 2. There are altogether 159 measurable indicators, for which - in principle - there are 4 data points available so far: from 1970, 1980, 1990, and 1992. Benchmark projections are identified for 1995, 2000, and 2010. Among the 159 indicators used most critical ones are identified as 'urgent benchmarks', and ones that are considered important for the longer term sustainability are designated as core benchmarks.

2.3. Choices for Colorado's Future

The Choices for Colorado's Future, or C-Future project was initiated in 1990, and it is managed by Colorado Trust, a multilateral organization with representatives of stakeholders from all regions of the State [9]. The C-Future project is different from Oregon Benchmarks in several ways, the most important for the present purposes being that the emphasis is not on measurable indicators. Even though there is a significant amount of data presented about key issues relevant

to sustainable development, the project is not set up to obtain and publish indicators at regular intervals.

The component of the C-Future project whose integration into a provincial indicator project should be considered is the creation and application of future scenarios. Scenario construction was extended to three alternatives -- a most likely, a pessimistic and an optimistic scenario. Scenarios have been constructed around four issue areas:

a. social driving trends;
b. political driving trends;
c. economic driving trends, and
d. technological driving trends.

In the case of C-Future, scenarios are developed by stakeholder working groups, and given in a narrative style. Scenario construction places the planning process in a proper perspective by drafting a spectrum of alternative future outcomes instead of simply identifying a single target and may make the uncertainties associated with policy planning explicit. In case an indicator system is in place, like Oregon Benchmarks, it is possible to describe scenarios narratively as well as by expressing optimistic, most likely and pessimistic outcomes by quantitative indicators. For planning purposes decision makers can still consult the most likely scenario and its accompanying indicators, however, the provision of less likely, but possible outcomes for each indicator can help making precautionary provisions. It also helps stakeholders to visualize the nature of uncertainties associated with decision-making on a given issue.

2.4. The Sustainable Seattle

This initiative is a community based project that was started in 1991 by the Task Team of Sustainable Seattle, a multi-stakeholder volunteer organization [10]. The project is comparable Oregon Benchmarks in the sense that emphasis is put on measurable dimensions of social life, economy and biophysical environment, and in its approach to identify indicators in a participatory process.

One of the project's major strengths is a well-structured indicator selection process. The following have been the major steps of the process:

a. establish Task Team;
b. Task Team develops draft set of indicators through four iterations;
c. Civic Panel of 150 established with representatives of key stakeholder groups;
d. Civic Panel reviews draft set of indicators, narrows the list and categorizes indicators into issue areas;
e. Task Team conducts technical review of individual indicators;
f. indicator sets are further narrowed and focused based on data availability;
g. data are organized in a format appropriate for public distribution.

The other merit of the Seattle project is its concise presentation of indicators developed through a community participation process. An original set of 99 indicators in 10 topic areas were

narrowed down to 39 measurable indicators in 4 categories (Appendix 3). Each indicator is presented with a description, definition, interpretation, evolution and linkages. The indicators are grouped into two categories, the first twenty being well researched parameters, while the rest is still under research and development. While the structure of Seattle's indicator selection process is comparable to Oregon's, there are differences between indicator sets. The differences are necessary to reflect unique local conditions, although they also make cross-regional comparison more difficult.

There is some emphasis on institutionalizing indicator use, although it is less specific than in the case of Oregon Benchmarks. Indicators are to be operationalized through the following four channels:

a. local media publications and broadcasting;
b. informing decision makers in business and development planning;
c. influencing decisions to manage growth in the region; and,
d. influencing individual citizens in their personal decisions.

2.5. Life in Jacksonville: Quality Indicators for Progress

The Life in Jacksonville project has been one of the first and original community-based indicator initiatives in the United States, one that has been looked at by many other regions and communities in the country and abroad as an example [11]. Started in 1985 by Jacksonville Community Council, Inc., the project now reports 77 indicators in 9 categories (Appendix 4). The initiative is referred to as a quality of life project, and although there is no reference to sustainable development, there is an excellent coverage of major sustainable development issues on the local level.

The strengths of the project are the clarity and simplicity of data presentation: data are given in numerical as well as graphic format, the methods of obtaining primary data are described, and there are short, straightforward explanations that highlight the meaning of the indicator as well as point out some of the uncertainties associated with its measurement or interpretation (Figure 2). These issues become extremely important for indicators to be effectively communicated to a broad audience. Jacksonville's report is published annually in a simple, cost-effective but highly informative format.

Life in Jacksonville presents time series data for several years on many indicators. Depending on the scatter of the data points for individual years and the frequency of sampling, it may take several years or even decades, before a trend can be clearly identified. This point highlights the need for establishing a clear responsibility for the gathering of data and preparation of reports. It depends on actual circumstances, whether data collection and indicator reporting should be assigned to an existing organization, or there is a need for setting up an entirely new organization. In the case of Manitoba, as well as in other Canadian provinces building on the SOE reporting experience and provincial Roundtables should be considered.

2.6. Common Weaknesses of the Presented Models

Both the models presented in this document, and other measurement approaches not listed here struggle with shortcomings that are expected to raise some difficult questions during the use of indicators especially for sustainable development related planning. Most of these shortcomings are realized by various national and international institutions, but there is little sign yet of an emerging solution. These are some of the problems that we consider significant yet insufficiently addressed by current approaches:

- although running an indicator selection process with public involvement in a given jurisdiction is advantageous for the reasons mentioned in section 2.1., the resulting heterogeneity of indicator sets and - to some extent - methods make cross-jurisdictional comparison and data aggregation difficult;

- having an excessively *ad hoc* selection process the indicator set may not provide a true and balanced view of key sustainability issues, and may tie indicators to short term and insignificant, (very) local goals; unrepresentative indicator sets are likely to lead to a skewed decision process that may not recognize key sustainability issues;

- indicators with heterogeneous dimensions are not readily applicable in decision-making; two major problems are that their dimensions are not comparable, and even if they are, their weighting based on stakeholder priorities requires careful consideration;

- indicators themselves do not necessarily point out important multivariate, synergistic and cumulative effects that are the source of uncertainties and surprises;

- the unwillingness of the target audience with using multidimensional indicators instead of simple, usually budgetary measures as decision aids; institutions may be structured to rely on decision processes using a single or a small very set of indicators, and implementing extended sets may necessitate substantial structural adjustment.

Notwithstanding the difficulties, indicator selection should ultimately depend on the political process in the form of public participation and consultation. Through setting the structure and framework of this process, public education and proper representation of expert opinion, however, it is possible and desirable to define indicators with a sufficiently broad coverage that help make appropriate choices for sustainable development.

3. Suggestions for Indicator Selection Methodology and Application

Measurement and indicators might be applied for policy development and policy control. Our objective is to elaborate on four of their functions that serve both of these processes:

1. *Analytical function:* Provide a framework for measurement and indicators with a supporting matrix. Both the framework and the matrix will be based on the availability of data and analytical methods and will focus on the policy assessments of decision-makers.

2. *Communication function:* Make decision-makers familiar with the concepts and methods of sustainable development evaluation and help planning future developments, set up coordinating mechanisms both for evaluation and feedback analysis. In principle, indicators help to assess trade-offs associated with a given decision, supposing that there is appropriate communication between the parties affected by the trade-offs.

3. *Warning & mobilization function:* Help administrators to put in place a mechanism for major periodical (multi-year) assessments, time series analysis and indicator updates. This mechanism should include the annual publication of a simple report card with key indicators.

4. *Coordination function:* Create a measuring/reporting system which easily integrates data from different issue areas, collected by dispersed agencies; which can be handled cost-effectively both in budgetary and human resources terms; and which is open for public participation and control.

In the first stage of our work, we focus on the policy development support function of measurement and indicators (i.e. on points 1. and 2.).

In general, there are three emerging approaches to indicator selection that could be followed in a provincial level project:

- to establish a comprehensive indicator profile without the guidance of key issue areas;
- to use selectively chosen individual indicators around key issue areas; or,
- to use a causal model as a framework and chose indicators that satisfy the cause and effect algorithms required by the model.

In principle, the province could rely on certain innovative components of the described model initiatives as modules. Emphasizing that to some extent all procedures may require adjustment to local circumstances, a provincial indicator initiative could build on the following strengths of the reviewed reports:

- Alberta's Sustainable Development Indicators: use of provincial Roundtable and State of the Environment reporting mechanism; well structured indicator selection process; identification of vision elements;
- Oregon Benchmarks: public consultation; institutionalization of indicator project; account-ability in applying indicators;
- Choices for Colorado's Future: drafting most likely, optimistic and pessimistic future scenarios (may be coupled with target-setting for individual indicators);

Figure 2: Example of indicator representation in the Life in Jacksonville project [11].

- Sustainable Seattle: organization of public involvement and marketing of measurement results both within and outside of the jurisdiction;

- Life in Jacksonville: simple and well explained presentation of indicators in annual report.

In terms of public consultation and stakeholder involvement Canada's internationally recognized provincial roundtable system provides a logical opportunity on which to build the indicator identification, target setting and regular revision processes. In terms of core indicators, data analysis and publication of indicators, the experience of provincial and federal organizations involved in State of the Environment reporting provides a solid foundation.

3.1. A General Framework for Sustainable Development Related Indicators

While using modules of operative models where appropriate is feasible, there are some questions that none of the current projects answer adequately. In particular, there is scarce reference in the literature to the application of indicators in subsequent decision processes as decision aids or planning tools. Unless this issue is explicitly addressed, one can reasonably assume that the use of indicators will be excessively *ad hoc* or discretionary. We argue that in order to make indicators operationally useful, the methodology of both indicator selection and use should address causal linkages between issue areas and their respective indicators in the context of given decision alternatives.

In order to establish causal linkages, connection has to be found between (***a***.) actions of society as source of impact (pressure), (***b***.) the condition of the environment influenced partly by human action (state of the economy, the environment or society), and (***c***.) the efforts and resources we as a society devote to offsetting or preventing undesirable combined effects of our actions and intrinsic environmental change (response).

In other words, measurement of sustainable development should be based on indicators which signal:

(***a***) the *pressure* that society puts on the environment (in the form of pollution and resource depletion);
(***b***) the resulting *state* of the environment (especially the incurred changes) compared to desirable (sustainable) states; and
(***c***) the *response* by human activity, mainly in the form of political and societal decisions, measures and policies.

Preliminary agreement has been reached by the UN Commission on Sustainable Development (CSD), the UN Department for Policy Coordination and Sustainable Development (DPCSD), UNSTAT and the Scientific Committee on Problems of the Environment (SCOPE) from ICSU to use a pressure - state - response framework for the presentation of indicators [12]. A similar framework is being considered by OECD and the World Bank [12,13].

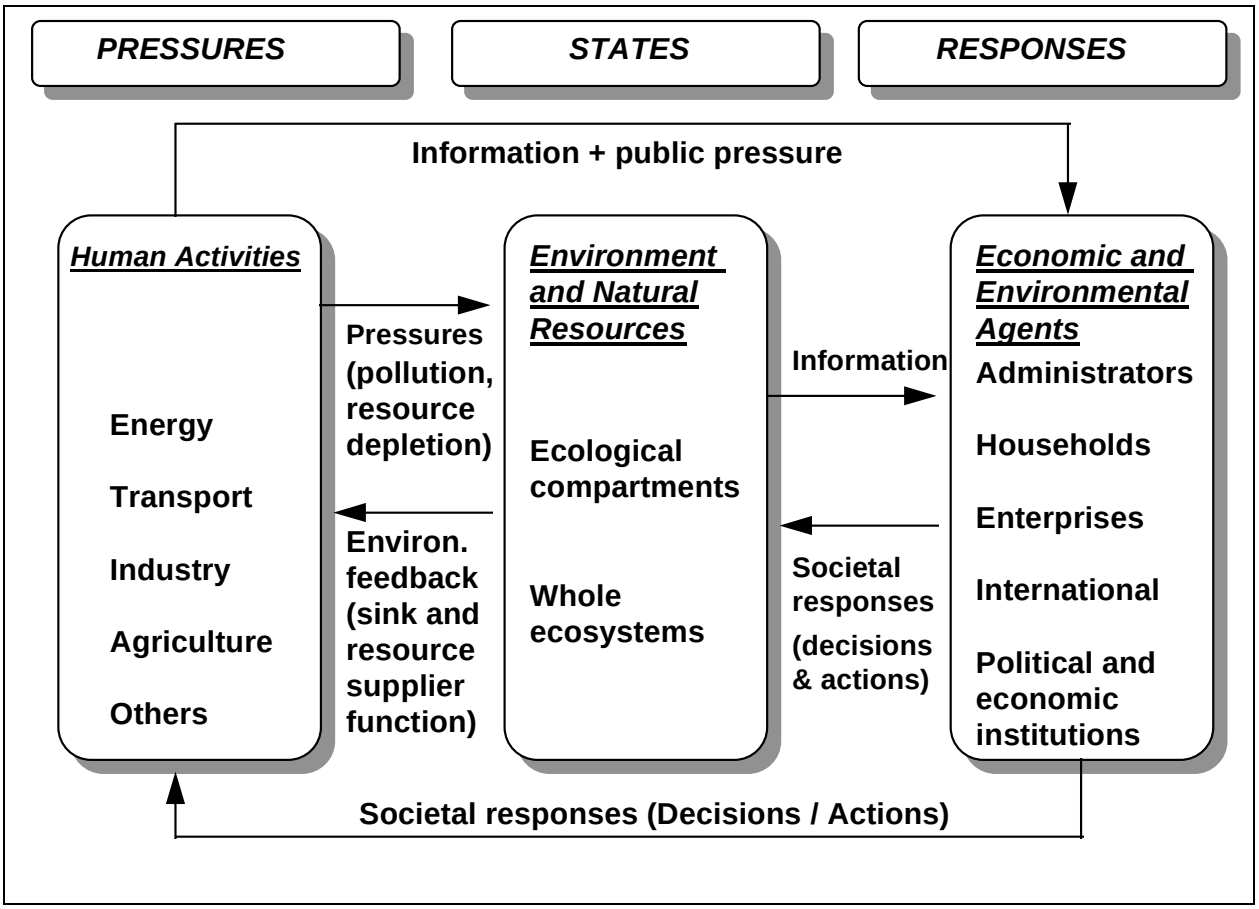

Figure 3: General framework of a Pressure-State-Response model [10 (modified)].

Initially, the PSR model has been developed for environmental indicators by Statistics Canada, and currently there is no operational version that is extended to include other factors. However, the extension of the model to include social and economic dimensions is possible, although the integration of social and equity issues is still inadequately developed; one example for an extended model is shown on Figure 3.

The model categorizes environmental, economic as well as social indicators according to their position in a causal chain. Causality refers to a recognition that a/ human activity creates ecological problems, i.e. *pressures* on the environment; b/ society evaluates the biophysical phenomena i.e. the *state* of the environment that are resulted by the pressures; and c/ as a result of the evaluation process, decision-makers at various levels initiate actions i.e. *responses* to ease/eliminate the pressures. Accordingly, different indicators should be applied for monitoring the pressures, the state of the environment, and social responses. In the PSR model, the first group of indicators provide information about the causes of ecological problems (such as activities depleting natural resources or discharging pollutants and wastes) and the extent of pressure exerting activities. The second group of indicators provides information about the resulting quality or state of the environment, ideally the changes in quality that can be attributed to human activities (such as the accumulation of greenhouse gases or the depletion of the ozone layer). The third group of indicators provides information about actions started or measures

taken by social institutions, organizations or individuals to improve the state of the environment or reinstate its previous balance (such as the introduction of regulations, the use of market instruments, increased enforcement, etc.). These measures may either target the improvement of environmental conditions, or may target pressure activities fundamentally affecting the condition of the environment.

Pressure related activities, besides clearly generating social or private benefits, often generate risks that are not realized directly and immediately by decision makers. Institutional response may be thus delayed, and may not target directly the source of risk, only the consequences or symptoms of risk. Indicators of pressure link to institutional response through the mediation of changing environmental or socio-economic conditions. By systematically connecting pressure or risk generating activities to social response, decision makers can improve their adaptive capacities, anticipate and prevent risk by clearly identifying and targeting the source. The PSR framework can be applied at various levels, both nationally and locally (i.e. for a community), sectorally (i.e. for agriculture) or individually (i.e. for a single factory).

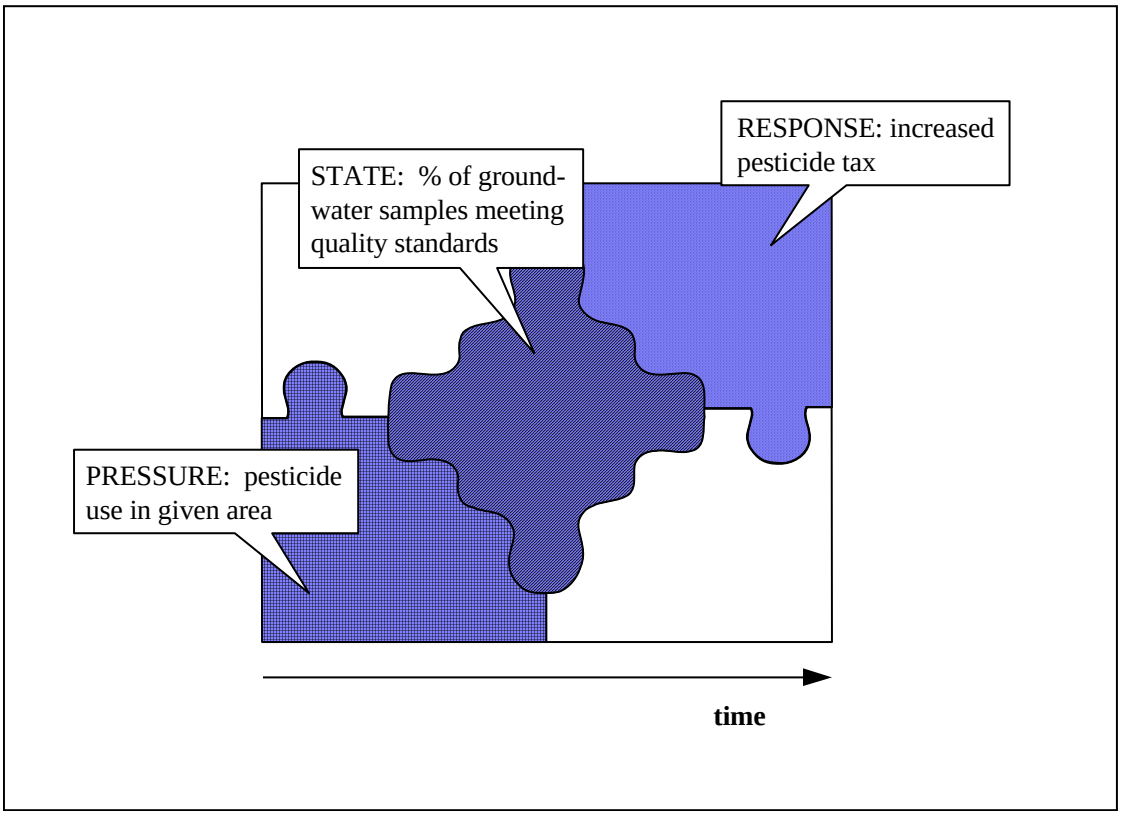

Figure 4: *Example* of linked pressure, state and response indicators.

Development is a complex and comprehensive process which reflects all amenities, both economic and non-economic ones. As a policy goal, it is a multi-objective process with an overall purpose to improve all dimensions of the quality of human life. Measurement of performance or success in sustainable development has to take into consideration ecological, social and economic variables. As a consequence, within the PSR framework indicators should

fall into one of three categories: environmental (biophysical), economic, and social indicators. Social indicators should include equity measures. An example matrix for organizing indicators along pressures - states - responses horizontally, and along economy - environment - society issues vertically is shown in Appendix 5.

On Figure 4 we provide an *example* for illustrating pressure, state and response indicators and the logic of their causal linkages. As noted in the example, the quantity of a given pesticide used is a pressure indicator, but in isolation it does not provide sufficient information on the overall utility or disutility of pesticide application. Pesticide use becomes an important indicator through the recognition that it transfers considerable *risk* and associated costs to society. The increased risk is mediated to decision makers in society through changes in the state of the environment, economy or social fabric. In the quoted example appropriate indicators can show the increase of contamination risk through monitoring the contamination of runoff, groundwater or food products by the given pesticide. Presuming that correlation is found between pesticide application rates and increase of this risk, the correlation between *pressure* and *state* indicators is established.

The linkage of increased risk to the *response* of social institutions - in the example using an economic instrument, pesticide tax - establishes a connection with the pressure indicator. It is clear that the need for taxing pesticides does not directly arise from using a particular pesticide; this need arises from the fact that water from local sources is contaminated. Although in this particular example the linkage seems to be obvious, policy decisions often ignore linkages and risk transfers, especially if there is no price attached to some of the factors; consequently, ignoring external risks may potentially lead to unsustainable outcomes. In the following sections indicator selection and application will be explored using the logic of the pressure-state-response (PSR) framework.

3.2. Indicator Selection

The logic of connecting PSR factors can be helpful during the indicator selection process on the one hand, and later in the application of indicators on the other.

Indicator selection should proceed in three main stages (Figure 5). In the *preparatory stage* participants include experts and decision support staff focusing on the following issues:

- preparation of expert report on project structure and strategies;
- assignment of project management responsibilities;
- preparation of project plan;
- identification of indicator selection criteria
- selection of issue areas and preliminary list of indicators.

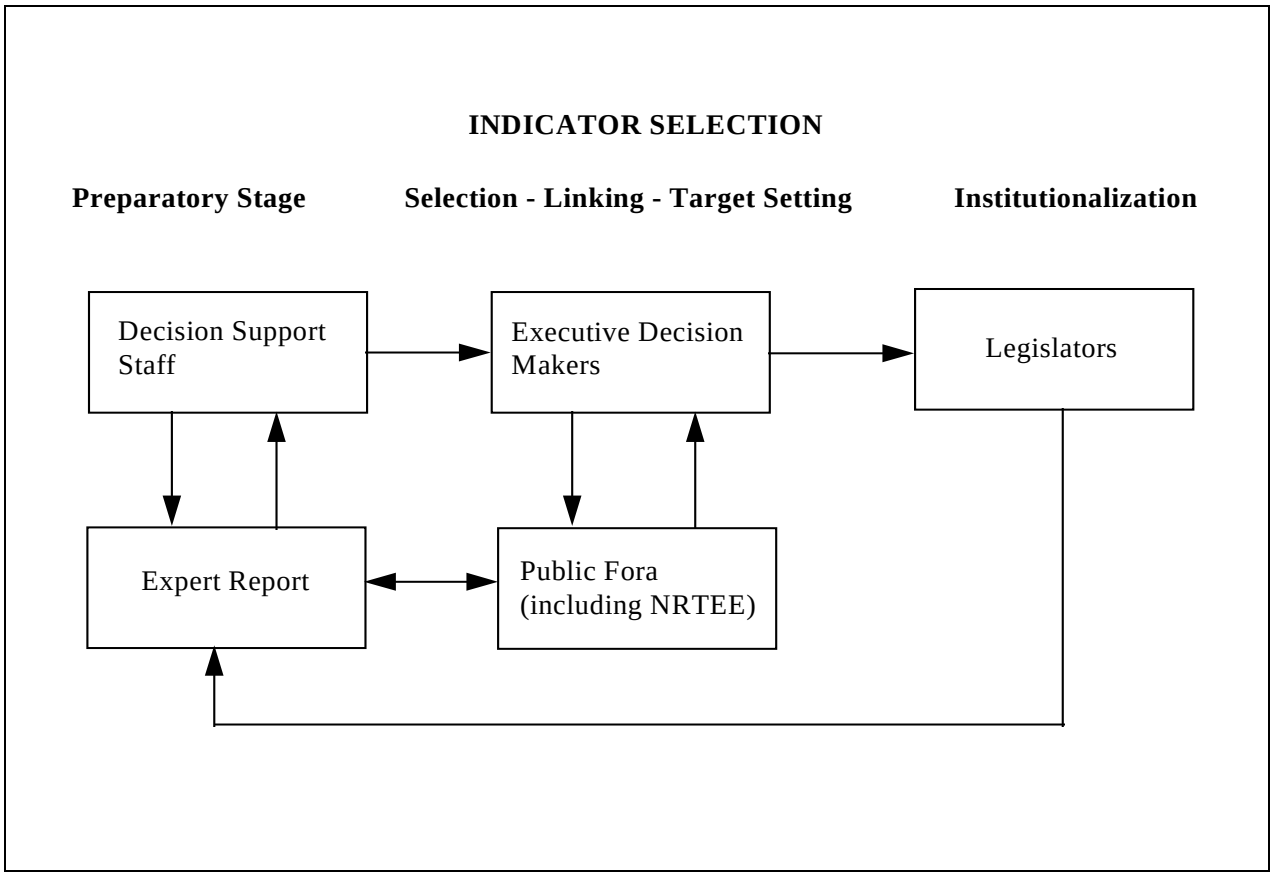

Figure 5: Indicator selection process structure.

The preparatory stage of indicator selection is primarily expert driven. Although public participation and stakeholder involvement in the later stages will have the power to modify the list, experts should have considerable impact by recommending issue areas and core indicators as well as methodology for using indicators.

The following are the tasks that executive decision makers, stakeholder and public representatives as well as experts and decision support people have to address in the *selection - linking - target setting stage:*

- public / stakeholder education on the objectives and mechanisms of the indicator selection exercise;
- review, amend and focus the initial indicator set around issue areas to arrive at a core set of reportable indicators;
- place core indicators in a PSR framework, identify and document *key* linkages, and finalize core indicators;
- first, in consultation with experts, draft a future vision for issue areas, then assign indicators to them with acceptable target values and time lines.

Indicator lists completed in the preparatory stage of the selection process may contain redundancies or may lack indicators that are essential in the particular context. Stakeholder

representatives in the *selection - linking - target setting stage* should be consulted to determine if a given indicator signals a pressure, state or response. Once stakeholders determine the classification of the indicator in terms of pressure, state or response, they should examine what other indicators would complete the pressure-state-response relationship. For instance, if they have initially identified groundwater quality as important and classified it as a state-type indicator, they should ask a question about what kinds of major pressure and response indicators would make the causal linkage complete. It is important to emphasize not only major indicators but also *major* linkages, because the final indicator set will have to be focused on a limited number of highest priority issues. It is up to stakeholder decision, whether they wish to include all pressure, state and response indicators for a given issue area, or want to use only one or two from the three classes. In terms of the previous example this may mean that although pesticide use, groundwater contamination, and pesticide taxes are in a pressure-state-response relationship, in the actual circumstances a groundwater contamination indicator may be judged to sufficiently represent this issue area.

Target values may be set according to broad social preferences or they can be based on expert advice. Theoretically, an indicator directly related to essential natural resources should rely on information about the carrying capacity associated with a given resource, if dependable information about this factor is available. The pressure-state relationship is a process based on flows of energy and materials between society and the natural environment. In an optimal case, sustainable flows should be determined by science; due to inherent uncertainties of natural systems insistence on "beyond doubt" proof, however, is in most cases impractical. Therefore, the definition of base lines and reference points to which indicators are related, are determined by the policy process. Thus targets and indicators themselves are the products of a compromise between scientific accuracy and the pressure of decision-making. This limitation becomes quite clear in the social dimension where many of the variables, like political stability, cultural aspirations, several dimensions of equity are hardly quantifiable or even valuable in physical terms. A limited goal might be to measure these variables also in cause-effect relationship, in comparable and possibly integrative manner in order to provide *trends of change* in the environment and its links to human activities.

The third stage of the indicator selection process is *institutionalization* when the indicator set, the mechanism for its periodic review, the associated target values are endorsed and necessary human and capital resources are allocated and approved endorsed by legislative authorities. Provisions should be made to assign the responsibility of data collection and monitoring to specific agencies and the task of central information gathering, indicator reporting as well as overall project coordination to a single organization.

3.3. Indicator Application

As noted earlier, most of the SD indicator initiatives are relatively recent, and guidance concerning the coherent application of indicators is scarce. There is little empirical evidence connecting the influence of indicators on decision making to sustainable outcomes (as a result of an improved decision). This situation is nonetheless not surprising considering the time required

to obtain meaningful trends and build institutional capacities to effectively use heterogeneous indicator sets.

SD indicators can be applied either as *performance measurement* or as *planning* tools. The performance measurement application is a component of using SD indicators as planning tools. In their performance measurement capacity actually measured values of indicators have to be compared to either an applicable target value (progress determined in absolute terms) or to previously recorded values of the same indicator (progress determined in relative terms or differentials). For the purpose of performance measurement a monitoring, data analysis and reporting system must be in place. This is the first phase of indicator implementation, as noted on Figure 6. The second phase requires that institutions have the capacity to consider actual and target values of indicators with an appropriate weight when making choices between decision alternatives.

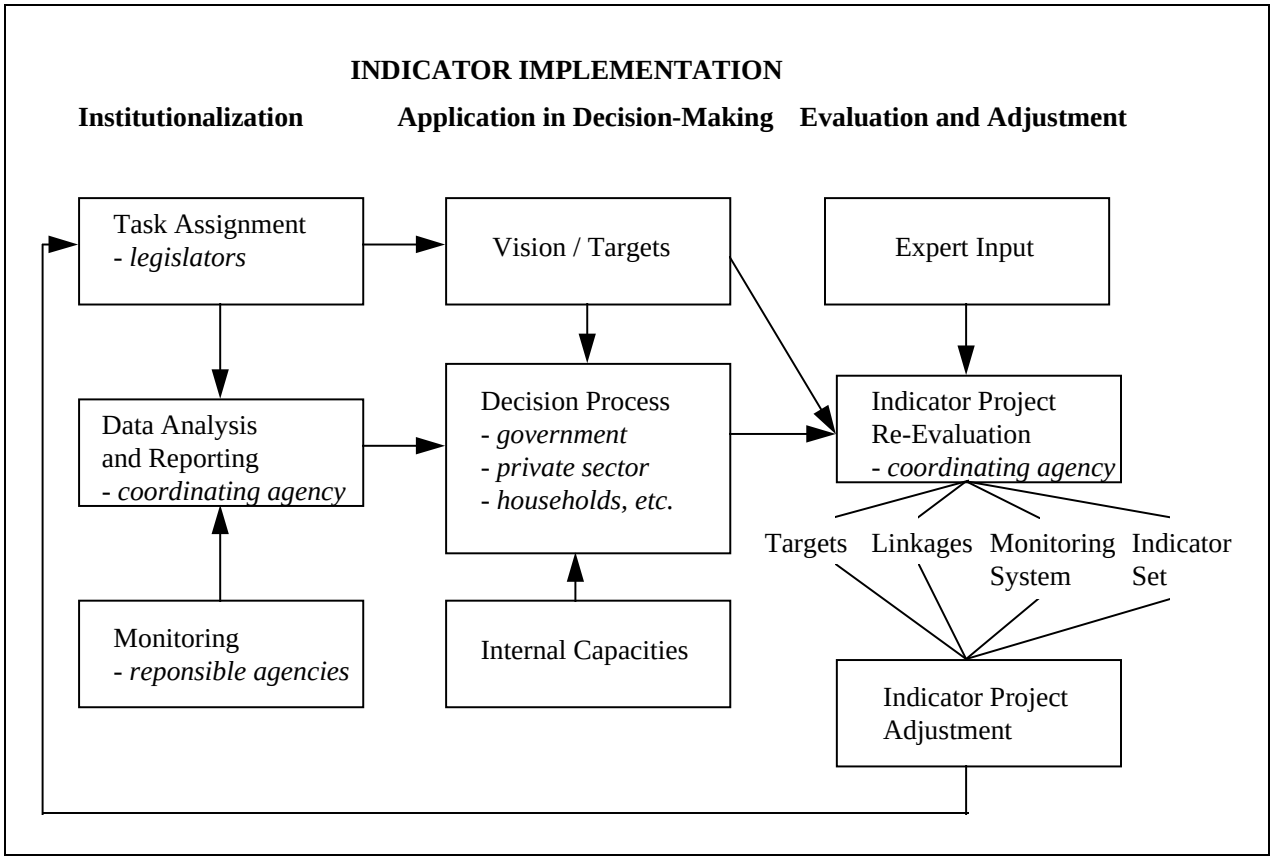

Figure 6: Processes and participants of indicator implementation.

Individual indicators by themselves do not have predictive capacity, they *become* predictive if they are properly linked to causes or impacts in spatial or temporal terms. Staying with our former example, the link between pesticide use and the need for taxing pesticides renders the indicator of pesticide use predictive of groundwater quality problems and associated social and economic costs. Stakeholders may decide to identify a threshold value e.g. for the pesticide use

indicator. In order to prevent acute water quality problems, when pesticide use reaches the threshold, it triggers an anticipatory planning process that aims at finding acceptable alternatives to further increasing pesticide use. In a sense, indicator use thus becomes a tool for an institutional adaptive learning process to prevent unsustainable scenarios.

Periodic reviews are to be undertaken by the coordinating agency upon the advice of indicator users, independent experts, and by considering the actual progress measured by each indicator. Revision should be extended to targets, major linkages between indicators, the actual indicator set (redundancies or additions) and required adaptations of the monitoring process.

3.4. Additional Criteria

The following are important criteria that should be considered during initial indicator selection and also later during the periodic revision process.

- Aggregation

  Concern about the use of currently available, highly aggregated, indicators in a sustainable development framework by some organizations. At the same time, however, new versions of complex indicators are also developed and tested in pilot studies in North America and Europe [14,15,16,17]. The idea of using highly aggregated indicators is also considered by SCOPE [12]. Until the policy relevance, scientific as well as statistical soundness and applicability of these indicators in decision processes are clarified, the provincial project should focus on less aggregated indicators.

- Cost-efficiency

  In order to optimize the costs associated with the gathering and interpretation of primary data for indicators, wherever possible, the use of existing monitoring, data processing and reporting infrastructure should be considered. In practical terms it means to study the feasibility of amending the capacities of provincial statistical or state of the environment reporting offices. Building on existing capacities, however, does not exempt the government from making appropriate new institutional arrangements explicitly for the purposes of reporting on sustainable development indicators.

- Time requirement

  The time requirement of the measurement process and reporting is an important dimension. As sustainable development indicators report on changes and trends, the adequate time interval is crucial to generate appropriate responses. The purpose of SD indicators is primarily to assist the design of long term adaptive strategies rather than help coping with short term crises or temporary though severe deterioration. A longer term trend can be identified only through continuous measurement for several years; a four-year period to review performance and adjust the political decision-making process accordingly might be sufficient in some cases depending on the actual process being monitored. At the same time,

shorter term estimates are indispensable to prevent irrreversible changes in several dimensions of highly sensitive areas where reports on threshold values are critical. There is a danger of losing sight of critical issues when the general trend seems to be satisfactory. To avoid such situation, beyond focusing on general cross-cutting or horizontal trends, vertical studies should be commissioned to watch thresholds of unsustainability.

- Public awareness

  Prior to embarking upon a public participation or consultation exercise, a public education campaign should be initiated to focus indicator selection on issues of highest importance. The public participation exercise should have a very clear, well-planned and result-oriented agenda to avoid excessively spending time and resources on irrelevant or insignificant indicator issues.

- Institutional participation

  Institutions that will be expected to use indicators and participate in data gathering as well as processing should participate in indicator definition from the beginning. Their input early on is essential to include indicators that will have relevance for decision makers.

- Ecosystem concern

  The geographic boundaries of the province where a sustainable development initiative is undertaken do not coincide with natural ecosystem boundaries. Thus, there is likely to be a number of issues that are relevant to neighbouring jurisdictions and beyond. In fact, an indicator set may contain parameters that are of purely local, regional, national or global relevance. Indicators that are clearly above the level of local relevance (e.g., CFCs, CO_2 emissions) should be harmonized with national or international level reports.

- Issue ranking

  Environmental quality, social or economic goals, can be identified by assigning numerical values to specific indicators. Goals could be identified in relation to existing standards (e.g. for environmental quality parameters) taking public preferences into consideration.

Throughout the report, public participation has been referred to as a method recommended for the identification of sustainable development indicator sets. Besides being a method, however, public participation is also an indicator by itself, measured and reported by various projects **[11,12]**. Under an optimistic scenario the average voting citizen should have easy access to, and should be interested in, the current status, main tendencies and proposed directions of sustainable development indicators. Although the target audience of sustainable development indicators includes government, business, the non-governmental community and others, it is probably the level of the individual citizen, where the information provided by indicators could have the most important impact.

4. Further Contribution Recommended

The following are further possible contributions IISD's SD Indicators project could provide to the Sustainable Development Coordination Unit's work on developing Manitoba's SD indicators:

- definition of issues and relevant indicators (minimal set). Outline of the suggested indicator matrix;
- elaboration on the criteria of evaluation, weighting and ranking. Draft format presentation of report cards;
- recommendation for the working process to institutionalize SD reporting.

Appendices

Appendix 1: Alberta's Sustainable Development Indicators [6].

1.	Air quality index
2.	Exposure to substandard ambient air quality
3.	Production of acid-forming emissions
4.	Purchase of ozone-depleting substances
5.	Emission of carbon dioxide and other greenhouse gases
6.	Area of land affected by soil erosion and salinity
7.	Total area of contaminated sites
8.	Area of lands under formal agreement for wildlife habitat
9.	Number of commercial crop varieties
10.	Number of biogeographical regions with adequate protected areas
11.	Number and size of recreational, cultural and spiritual sites
12.	Per cent of urban areas in parks and playgrounds
13.	Total area in significant land use categories
14.	Per cent of harvested forest that is successfully restocked
15.	Waste per capita going to landfills
16.	Size and distribution of significant wetlands
17.	Groundwater quality index
18.	Lake water quality index
19.	Condition of major rivers
20	Length of heritage rivers
21.	Per cent of runoff treated at primary, secondary and tertiary levels
22.	Per capita water consumption
23.	Water resource depletion rates
24.	Number of species at risk
25.	Proportion of species approaching target population size
26.	Population of species for which Alberta has a key custodian role
27.	Efficiency of non-renewable resource recovery and use
28.	Proportion of energy from fossil and non-fossil fuel sources
29.	Per capita energy consumption
30.	Employment index
31.	Average education level attained
32.	Per cent of post-secondary graduates finding employment in their field
33.	Job satisfaction index
34.	Percent of Albertans on welfare
35.	Volunteer rate
36.	Percent of population taking each mode of transportation to work

37.	Average commuting distance to work
38.	Population growth
39.	Urban and rural crime rates
40.	Percent of GDP spent on research and development
41.	GDP per capita
42.	GDP per capita adjusted for natural resource depreciation
43.	Percent of GDP from secondary production and business services
44.	Number of environmental services, products and technologies exported
45.	Per capita debt
46.	Accumulated depreciation of antural resources
47.	Degree of non-compliance with environmental regulations
48.	Percent of performance based regulations
49.	Percent of sustainable development compatible legislation
50.	Public perception of information accessibility
51.	Percent of organizations that have adopted sustainable development
52.	Percent of management job descriptions including sustainable development
53.	Sustainable development literacy of the public
54.	Amount of foreign aid contributed
55.	Frequency of sustainable development in K-12 curricula
56.	Market value of permits traded or sold
57.	Percent of products and servies where price reflects life-cycle cost
58.	Percent of recyclable products actually recycled
59.	Number of people involved in recycling initiatives

Appendix 2: Oregon Benchmarks indicators [9].

Classification of Indicators	Sub-Classes of Indicators	Indicators
Children and Families	Early Childhood Development	percentage of children that kindergarten teachers feel are ready to succeed in school
	Teen Pregnancy	pregnancy rate per 1,000 females ages 10-17
	Drug-Free Babies	mothers not using alcohol during pregnancy
		mothers not using tobacco during pregnancy
		mothers not using illicit drugs during pregnancy
	Drug-Free Teens	free from involvement with alcohol in the previous month
		free from involvement with illicit drugs in the previous month
		free from involvement with tobacco in the previous month
	Safe Child Care	child care facilities which meet established basic standards
Education and Work Force Preparation Reforms	Educational Skill Levels	composite reading and math skills (students achieving established skill levels)
		composite writing skills (students achieving established skill levels)
Work Force Training	Job Skill Preparation	high school students with significant involvement in professional-technical education and entrepreneurial programs
	Disabled Students	disabled high school graduates moving to competitive or supported employment
	Workforce Adaptability	displaced workers re-employed within 24 months and earning at least 90% of previous income
Value-Added Products, Global Business	Value Added Natural Resource Products	value added manufacturing as a percentage of total industry employment
	International Trade	manufactured goods sold outside of the U.S.
Health and Health Care	Health Care Access	percentage of Oregonians with economic access to basic health care
	Rural Health Care	Oregonians with geographic access to basic health care
	Health Care Costs	costs relative to 1980 costs
	Human Immuno-deficiency Virus	annual percentage of HIV cases with an early diagnosis
		total number of HIV cases with an early diagnosis

Physically Livable Communities	Air Quality	Oregonians living where the air meets government air quality standards
	Affordable Housing	Oregon households below median income spending less than 30 percent of their household income on housing
	Mobility	vehicle miles travelled per capita in Oregon metropolitan areas
	Public Safety	number of communities involved in a community-based strategic plan for law enforcement
		average rate of reincarceration of paroled offenders within three years of initial release
Socially Livable Communities	Arts and Culture Funding	rank in per capita funding
	Hate Crimes	reported crimes against people or property motivated by prejudice per 100,000 Oregonians
Clean Natural Environment	Stream Flow	key rivers and streams with in-stream water rights meeting in-stream flow needs 9 or more months out of the year
	Stream Quality	miles of assessed Oregon rivers and streams not meeting state and federal government in-stream water quality standards
	Salmon	key sub-basins in which wild salmon and steelhead populations are increasing or at target levels
Government Efficiency: Revenue Reform	Taxes	Oregon ranking in state and local taxes per capita
	Public Infrastructure Investment	real per capita outlays for facilities
	Public Agency Performance	agencies the employ results oriented performance measures
		Oregonians who think the government is doing a good job providing government services
Education	Student Skills	11th grade students who achieve skill proficiency: composite reading and math skills
		11th grade students who achieve skill proficiency: composite writing skills
	Comparative Math Skills	ranking of 12th grade students on international math assessments
	Adult Education Attainment	adults who have completed high school or equivalent program
		adults who have completed baccalaureate degree

	Adult Literacy	adults with intermediate proficiency at prose literacy
		adults with intermediate proficiency at document literacy
		adults with intermediate proficiency at quantitative literacy
Individual and Family Health	Adult Health	adults with good health practices
	Family Stability	children ages 0-17 living 100% above the poverty level
		number of children abused or neglected per 1,000 persons under 18
Clean Environment	Air Quality	Oregonians living where the air meets government air quality standards
	Natural Resource Lands	1970 agricultural land still preserved for agricultural use
		1970 forest land still preserved for forest use
		1990 wetlands still preserved for wetlands
	Groundwater	quantity of Oregon groundwater
Livable Communities	Affordable and Available Housing	Oregon households that can afford the median-priced Oregon home for sale
	Transportation	Oregonians who commute (one-way) within 30 minutes where they live and where they work
		Oregonians living in communities with daily scheduled inter-city passenger bus, van, or rail services
	Sense of Community	index crimes per 1,000 Oregonians
		Oregonians who volunteer at least 50 hours of their time per year to civic, community, or non-profit activities
		eligible Oregonians who vote
		Oregonians with positive view of the state
Personal Income, Economic Diversity and International Trade	Personal Income	Oregon's real per capita income as a percentage of the U.S. real per capita income
		level of real per capita income
		income per capita as a percentage of the Oregon overall per capita income
		Oregonians in the middle income range

		average annual payroll per covered worker (all industries, 1990 dollars)
	Economic Diversity	manufacturing employees outside of state's five largest manufacturing industries
		percentage of Oregonians employed outside the Portland tri-county area
	Manufacturing Exports	manufactured goods sold outside of the U.S.

Appendix 3: Sustainable Seattle indicator sets **10**.

Classification of Indicators	**Indicators**
Environment	* wild salmon runs through local streams
	biodiversity in the region
	* number of good air quality days per year, as reported by the pollution standards index
	amount of topsoil lost in King County
	acres of wetlands remaining in King County
	* percentage of Seattle streets meeting "Pedestrian-Friendly" criteria
Population and Resources	* total population of King County (with annual growth rate)
	* gallons of water consumed per capita
	* tons of solid waste generated and recycled per capita per year
	* vehicle miles travelled per capita and gasoline consumption per capita
	* renewable and non-renewable energy consumed per capita
	acres of land per capita for a range of land uses (residential, commercial, open space, transportation, wilderness)
	amount of food grown in Washington, food exports and food imports
	emergency room use for non-emergency purposes
Economy	* percentage of employment concentrated in the top ten employers
	* hours of paid employment at the average wage required to support basic needs
	real unemployment, including discouraged workers, with differentiation by ethnicity and gender
	average savings rate per household
	reliance on renewable or local resources in the economy
	* percentage of children living in poverty
	* housing affordability gap
	* health care expenditures per capita
Culture and Society	* percentage of infants born with low birthweight
	ethnic diversity of teaching staff in elementary and secondary schools
	number of hours per week devoted to instruction in the arts for elementary and secondary schools
	percent of parent / guardian population involved in school activities
	* juvenile crime rate
	* percent of youth participating in some form of community service
	percent of enrolled 9th graders who graduate from high school
	* percent of population voting in odd-year (local) primary elections
	* adult literacy rate

	average number of neighbours the average citizen reports knowing by name
	equitable treatment in the justice system
	ratio of money spent on drug and alcohol prevention and treatment to money spent on incarceration for drug and alcohol related crimes
	percentage of population that gardens
	* usage rates for libraries and community centres
	* public participation in the arts
	percent of adult population donating time to community service
	individual sense of well-being

* Indicators researched until the 1993 report.

Appendix 4: Life in Jacksonville indicators [11].

Classification of Indicators	Indicators
Education	Public High School Graduation Rate
	Average Achievement-Test Percentile Scores
	Public School Expenditures per Student
	Average Public School Teacher Salary
	Teachers Holding Advanced Degrees
	Students Attending Desegregated Schools
	Faculty Holding Terminal Degrees
	Higher Education Degrees Awarded
	Student Participation in Higher Education Programs
The Economy	Net Job Growth
	Total/Black Unemployment Gap
	Effective Buying Income per Capita
	Retail Sales per Capita
	Taxable Real Estate Value
	New Housing Starts
	Affordability of Single-Family Home
	Students in Free/Reduced Lunch Program
	Tourism/Bed- Tax Revenues
	Cost of 1,000 kwh of electricity
Public Safety	People Feeling Safe Walking Alone at Night
	Violent Index Crimes per 100,000 Population
	Nonviolent Index Crimes per 100,000 Population
	People Reporting Being Victims of Crime
	Average Rescue Call Response Time
	Average Fire Call Response Time
	Average Priority One Police Call Response Time
	Motor Vehicle Accident Deaths per 100,000 pop.
	Other Accidental Deaths per 100,000 pop.
	Motor Vehicle Accidents per 100,000 population
Natural Environment	Days With Air Quality Index in Good Range
	River Compliance with Metal Water Standards
	Streams Compliance with Dissolved Oxygen Standards
	Water Level in Floridan-Aquifer Wells
	New Septic-Tank Permits Issued
	Sign Permits Issued
	Tons Per Capita of Solid Waste
Health	Infant Deaths per 1,000 Live Births
	Age Adjusted Death Rate per 100,000 Population

	Deaths from Heart Disease per 100,000 Population
	Deaths from Lung Cancer per 100,000 Population
	Packs of Cigarette Sold per Capita
	New AIDS Cases per 100,000 Population
	Student Fitness Test Scores, 50th Percentile
	Alcohol Use Reported by Youth
	People Rating Health-Care System Good/Excellent
	People Reporting Having No Health Insurance
Social Environment	People Believing Racism Is A Local Problem
	Substance-Exposed New-borns per 1,000 Live Births
	Substantiated Child Abuse /Neglect Reports per 1,000 Children under 18
	Births to Females under 18 per 1,000 Live Births
	Employment-Discrimination Complaints Field with JEOC
	People Reporting Having Volunteered in the Past Year
	City Human-Services Expenditures per Capita
	Contributions Per Capita to United Way and Agencies
Government/ Politics	People Who Rate Local Government Leadership Good/ Excellent
	Percent 18 and Older Registered to Vote
	Percent Registered to Vote
	Percent of City Council Members Non-White
	Percent of City Council Members Female
	People Accurately Naming Two City Council Members
	People Keeping Up With Local Government News Frequently
	People Feeling Local Public Services are Frequently Effective
Culture / Recreation	City Financial Support Per Capita of Arts Organizations
	City Parks and Recreation Expenditures Per Capita
	Public Park Acreage Per 1,000 Population
	Public Library Materials Per Capita
	Public Library Book Circulation Per Capita
	Event/Days of Bookings at Major City Facilities
	Museum of Science & History Attendance Per 1,000 Population
	Symphony Attendance Per 1,000 Population
	Zoo Attendance Per 1,000 Population
Mobility	People Reporting Commuting Time 25 Minutes or Less
	Weekday Commercial Flights In and Out of JIA
	Destinations with Direct Flights In and Out of JIA
	Average Weekday JTA Bus Ridership Per 1,000 Pop.
	Average Weekday Miles of JTA Bus Service
	JTA Bus Headways within 30 min. peak/60 min. nonpeak

Appendix 5: The World Bank's initial indicators for a matrix on environmentally sustainable development [10].

ISSUE	PRESSURE	STATE	RESPONSE
I. ECONOMIC			
Production	Intermediate Inputs as % GNP	Value added per capita (NNP)	Efficiency of produced assets (NNP/Cap.St.)
Expenditure	Inflation	Gross National Expenditure (GNP)	saving (adjusted) GNP
Income	Population (growth rate)	Distributional inequality	Safety nets
Labour	Wages, etc. (share in GNP)	Human capital (educational attainment)	%EDP spent on education
II. SOCIAL			
Urbanization	...	Population in urban areas (% total)	...
- *Housing*	Population Density (persons/km sq)	...	%EDP spent on housing
- *Water Quality*	...	Dissolved oxygen	...
- *Air Quality*	energy Demand	Concentration of particulates, SO_2 etc.	...
Health	Burden of Disease (DALYs/1000 persons)	Life expectancy at birth	%EDP spent on health, vaccination
Nutrition	Prevalence of underweight children	Dietary energy supply	...
Transport	...	% of total produced assets	...
Women's Status, Caring Capacity	Maternal mortality rate	Total fertility rate	Females/100 males in secondary school
III. ECOLOGICAL			
Global Commons			
- *Climate Change*	Emissions of CO_2	Atmospheric concentration of greenhouse gases	Energy efficiency of EDP

Over...

III. ECOLOGICAL (continued)			
Global Commons			
- *Stratospheric Ozone*	Apparent Consumption of CFCs	Atmospheric concentration of CFCs	% coverage of international protocols and conventions
- *Oceans*	...	...	...
- *Marine Resources*	Contaminants, demand for fish as food	Stock of marine species	...
National Trusts			
- *Biodiversity*	Land use changes	Threatened, extinct species % total	Protected areas as % threatened
- *Water*	Intensity of use	Accessibility to population (weighted % total)	Water efficiency measures
Marketable Assets			
- *Gas, Oil and Coal*	Extraction rate(s)	Proven reserves	Reverse energy subsidies
- *Metals and Minerals*	Extraction rate(s)	Proven reserves	Input/output ratio, main users; recycling rates
- *Forest Resources*	Land use changes, inputs for EDP	Area, volumes, distribution, value of forests	Input/output ratio, main users, recycling rates
- *Land (Soil Quality)*	Human-induced soil-degradation	Climatic classes and soil constraints	...
Carrying Capacity			
- *Eutrophication*	Use of phosphates and nitrates	Biological oxygen demand, P, N in rivers	% population with waste water treatment
- *Acidification*	Emissions of SO_X and NO_X	Concentration of SO_X, NO_X in precipitation, pH	Expenditure on pollution abatement
- *Toxic Contaminants*	Generation of hazardous waste	Concentration of lead, cadmium, etc. in rivers	% of gas unleaded
- *Waste*	Generation of industrial, municipal waste	Accumulation to date	Expenditure on collection and treatment, recycling rates
General Indicators	...	Opinion polls on environment	Expenditure on pollution control, abatement

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