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# PROBLEMS AND FUNDAMENTALS OF SUSTAINABLE DEVELOPMENT INDICATORS

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Measurement issues are of current concern to organizations faced with the task of promoting sustainability. Single figure aggregate indices of sustainable development (SD), primarily designed for use at the national scale, are not readily applicable locally and are a poor guide for decision-makers and citizens wishing to promote local sustainability. This has led to an abundance of sustainable development indicator (SDI) sets, each comprising a broad range of specific indicators. Existing indicator sets are not obviously compatible and there is a danger that, without the application of a clear method, indicators will be produced in an *ad hoc* fashion without full consideration of key SD principles or indicator characteristics. Such SDIs may be ineffective in promoting SD and possibly detrimental to the process. This paper examines the background to SDIs, including problems with their construction, and outlines fundamental steps that should be followed to produce any list of SDIs.

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## INTRODUCTION

Within the field of sustainable development (SD) the debate has largely moved on from the issue of definition to one of measurement. The Brundtland report (WCED, 1987) gave us the benchmark definition that has been supplemented by the widely accepted, but more precise, definition given in the second World Conservation Strategy report (IUCN–WWF–UNEP, 1991). However, no method of measuring SD has gained a similar widespread level of support and considerable effort is currently focused in this area by governments, public local authorities, non-governmental organizations (NGOs) and academics across a diverse range of disciplines.

Measurement of SD is an essential prerequisite to promoting a sustainable society and during the 1990s there has been a boom in programmes with the aim of devising sustainable development indicators (SDIs). At the international level the United Nations Environmental Assessment Programme (UNEAP) is reviewing work on indicators and is attempting to harmonize approaches and encourage greater user involvement (UNEAP, 1995). UNEAP is co-ordinating the SDIs work of a number of supra-national bodies, including the UN Development Programme, the UN Department of Policy Co-ordination and Sustainable Development, the UN Statistical Department, the Scientific Committee on Problems of the Environment, the World Resources Institute and the World Bank. The principal reason for this demand for indicators is the UN Conference on Environment and Development (the Rio Earth Summit), which stated that 'indicators of sustainable development need to be developed to provide solid bases for decision making at all levels and to contribute to self regulating sustainability of integrated environmental and development systems' (UNCED, 1992). The European Community's Fifth Environmental Action Programme 'Towards Sustainability' also notes that 'there is presently a serious lack of indicators and environmental assessment material' (CEC, 1993) and this has added to the demand for effective SDIs.

Nationally, there are some well developed SDI programmes (e.g. Sustainable Seattle, 1993) and some have been given a lead by existing State of the Environment (SOE) reporting programmes (e.g. SOE Canada, 1991). However, most countries are only beginning to address SDIs to meet their commitments made under the Rio declaration. At the regional and city scale Local Agenda 21 commitments are addressed by local authorities and NGOs. In the UK, for example, the Local Government Management Board advises local government on SDIs (LGMB, 1994a; 1995), whereas NGO initiatives include those of the Environmental Challenge group (NGOs and voluntary groups) (MacGillivray, 1995) and the current Environment City initiative (managed by the Royal Society for Nature Conservation with support from the Department of Environment).

Despite the considerable attention devoted to SDIs, no set has emerged with universal appeal, and new SDI sets experience difficulty in gaining wide acceptance. For example, the UK Department of the Environment is developing national SDIs and a preliminary set is due in January 1996 (HMSO, 1994: 220). If these indicators are to be useful in promoting SD, then they require widespread support, at least in the UK. But who are these indicators intended for, and who will act on the information they convey? Will the indicators include social and economic issues or will they only address the physical environment? What definition of SD is to be used and how will it be interpreted; will sustainable *development* be recognized or will the interpretation of the Brundtland definition be one of sustainable *growth*, as seems likely from the government White Paper? Will the social equity principle be recognized? This paper examines the difficulties with producing genuine SDIs and proposes fundamental steps in producing indicators that are strong measures of SD while retaining user appeal.

## MEASURING SUSTAINABLE DEVELOPMENT

### The need for indicators

One consequence of the information technology revolution is the rapid increase in the volume and availability of data on the social, economic and physical environments. Policy-makers must attempt to make sense of these data to make the best possible decisions. Unfortunately, the rate at which usable information is produced from these data is increasing only very slowly. There is a widening sea of data but, in comparison, a desert of information. A common way of avoiding being swamped by data is by using indicators as a tool to produce information. Ott (1978) describes indicators in this way : 'Ideally, an index or an indicator is a means devised to reduce a large quantity of data down to its simplest form, retaining essential meaning for the questions that are being asked of the data. In short, an index is designed to simplify. In the process of simplification, of course, some information is lost. Hopefully, if the index is designed properly, the lost information will not seriously distort the answer to the question'.

No indicator is perfect and the price to pay for extracting information from the available data is a probable distortion of that data. This is particularly relevant to SDIs, where the preferred data may not be available and so surrogate measures must be used. Clearly, if SDIs are to be a useful tool in promoting SD, then they must be designed with care so that they minimize information distortion and are best able to answer the questions that policy-makers and the public seek to answer.

### Approaches to measuring sustainable development

Indicators of SD can be conveniently divided into two groups: (i) the aggregated single index where just one variable is reported and (ii) the indicator set where many variables are reported. The former approach has been developed by economists, socio-economists and ecologists, and each has produced indicators that may be suitable for reporting alongside GNP or the share price index on the evening news, an attribute which Meadows (1990) advocates. Table 1 summarizes the characteristics of these indicators. Presently, no aggregated single index is widely used, although the 'index of sustainable economic welfare' (ISEW) (Daly and Cobb, 1989) is receiving considerable academic attention and has been applied to the USA, the UK and Scotland with similar results in each case. The most widely accepted move towards SD measurement is the development of methods for 'green accounting', which includes ecological and resource stock evaluation in the system of national accounts. However, some would argue that 'green' GNP, like all economic-based measures, can never be an adequate measure of SD due to the problems with evaluating common goods that exist outside the market place, such as clean air, scenic views and wildlife (Perrings, 1991), because economics fails to capture the complexities of ecosystem function (Jacobs, 1994) and due to problems in elucidating social equity.

A single aggregated index, such as the ISEW, may eventually gain the same level of support that the GNP currently enjoys, and so would prove a useful tool in promoting SD at the national scale. However, such indices are not likely to be adequate if used alone as they are difficult to apply at regional and local scales due to patchy data availability. Also, these indicators are not 'user friendly'; they are not readily understood by the layperson. Single aggregated indices may well communicate changes in SD, but are unlikely to be effective in identifying the changes that are required to promote SD at the local level. An analogy from medicine illustrates the point. If a doctor attempts a diagnosis and prescribes treatment knowing only that the patient is 'ill' or 'very ill', then the patient is unlikely to receive the correct treatment. However, in using many 'health indicators' such as location of pain, pulse rate, temperature and appearance, the doctor is more likely to prescribe the right treatment and cure the patient. So, at the local scale, a set of simpler indicators is required which local authorities and resource agencies can use to promote sustainability within their jurisdiction.

### Problems with sustainability indicator sets

Aggregated single indices are contentious in construction, are often poorly supported by the required data and are difficult to understand, doing little to communicate sustainability issues to most people. A set of simpler SDIs complements the use of the single aggregated index and is essential for promoting SD at the local level. However, indicators produced by one group are often found to be unsatisfactory by another and, to date, no common set of SDIs has been widely implemented. The reasons for this are that, firstly, the geographical diversity of cities, towns and countryside means that many groups seeking SDIs find existing indicator sets inappropriate to their locality. Secondly, needs vary between groups of people (both indicator developers and users), so some indicators must be selected that are good reflections of local concerns and cultural diversity. However, it should be possible to identify a core set of SDIs common to all localities that addresses global sustainability concerns. Thirdly, existing SDIs are occasionally found to be unsuitable due to 'technical' difficulties such as poor data availability. Finally, and perhaps most seriously, sustainability principles are not consistently applied within all indicator programmes. For example, the UK Government strategy on SD (HMSO, 1994) fails to address the principle of social equity and their SDIs are also likely to be deficient in this respect.

These factors are variously recognized by SDI developers and this adds to the demand for SDI programmes. However, rather than drawing on existing work many SDI programmes start anew each time, replicating work unnecessarily and often producing environmental, social or economic indicators with the appearance, but not the substance, of SDIs. Such indicators lack integrity, do not inspire confidence in the indicator users and may be ineffective, and possibly detrimental, in promoting action towards broadly agreed sustainability objectives.

Designing a good indicator is difficult enough when the subject matter is well understood, but is particularly difficult in the case of SDIs given the complex and multi-faceted nature of SD issues. Effective SDIs can best be identified by ensuring that personnel in organizations with the responsibility for their development are adequately briefed on sustainability issues and indicator characteristics. This process can be assisted, in part, by the application of a suitable SDI method able to guide developers through the process of indicator identification.

## FUNDAMENTALS OF INDICATOR DEVELOPMENT

Indicator development methods have until recently consisted simply of an agreed means of consulting a variety of groups with an interest in SD. The Sustainable Seattle programme consisted of an indicators' task team and a civic panel, collectively comprising several hundred people, who over a period of two years consulted widely to devise and research SDIs. With this degree of consultation the programme works well and is taken as a model throughout the world; however, it does require significant resources, perseverance and commitment. Even after the initial two year period the programme is only able to report on half of its desired 40 SDIs. Often resources are not available to allow such a prolonged and extensive consultation exercise. In these cases, a more theoretical approach, drawing on published indicator work, can be useful. One such method is PICABUE (Mitchell *et al.*, 1995), developed to produce indicators suitable for modelling urban SD. Although PICABUE was developed with a specific application in mind, it does have general applicability to a wide range of locations and user groups.

Table 1: Single aggregated indices of sustainable development

| Method (and units) | Description and example applications | Disadvantages |
|---|---|---|
| Economic | | |
| NRA: natural resource accounting (energy and various physical) | Monitoring of stocks and flows of physical resources (see Pearce and Warford, 1993). Supplementary to the system of national accounts (SNA). Norwegian system considers change in resource stocks over accounting period. Considers materials (e.g. minerals, fish, forestry), energy and environmental resources with non-market value (air, land and water quality). Similar French system covering economic, ecological and social function of environmental assets. The French system also specifies resource use. | Often considered a tool for measuring SD. However, cannot be used (and was not designed) as a measure of sustainable income, as there is no single unit and no method of aggregating different accounts. Omits non-market wildlife. Useful in forecasting resource consumption and its environmental impacts. |
| Percentage of GNP spent on environmental defence (monetary) | Correction of SNA to include environmental defence expenditure. Estimated for Germany at 1.5% of GNP (Liepert and Simonis, 1988) and for Japan at 2–10% GNP (Uno, 1989). | No agreement on which environmental losses to be included, or calculation method. Does not account for importing of resources and labour. |
| NDP: 'Green' GDP (monetary) | NRA incorporated into the monetized SNA. Net domestic product (NDP) calculated by subtracting value for depreciation of human made capital and environmental assets from GDP. Environmental depreciation assessed by placing monetary value on environmental loss (e.g. wildlife) and GNP foregone through environmental damage. Repetto *et al.* (1989) applied the method to Indonesia, examining environmental assets of oil, forests and timber. From 1979–1984 NDP rose 4% compared with GDP rise of 7.1%, showing that was Indonesia living off its capital, not income, so is not sustainable. Young (1990) found similar results when applying NDP to Australia. | Difficult to include resources with non-market value, such as wildlife, scenery and clean air, which are consequently often undervalued. Monetary valuation of the environment usually ignores functions crucial to the ecosystem. Few countries measure depreciation in human-made capital, making the method difficult to apply. |
| Weak sustainability (z) (monetary) | An economy is sustainable if its savings equal or exceed the depreciation of human-made and environmental capital, (Pearce *et al.* 1989). This is living off income, not capital and requires that losses in natural capital are replaced with at least an equal value of human-made capital. A strong *z* measure would require identification of critical natural capital, which, if lost, would demonstrate a move away from sustainability. | Difficulties of attaching monetary value to non-market environmental assets. Assumes perfect substitution of natural and human-made capital. Recognized by the authors as a crude method, but useful in providing an initial examination of sustainability. If countries fail the *z* test they are unlikely to pass more stringent tests. |
| AENP: approximate environmentally adjusted net national product (monetary) | A measure of sustainable income, similar to the *z* index, and also based on the inter-generational equity principle. AENP equals NNP less expenditure on pollution control, cost of dis-amenity due to environmental degradation (e.g. wildlife or scenery loss) and hotelling rents of all exploited natural resources. Hotelling rents are the price minus marginal cost of a resource which must be reinvested in human or natural capital to maintain a sustainable level of resource consumption (Hartwick, 1990; Solow, 1993). Applied to Scotland by Moffat *et al.* (1994) demonstrating sustainability, but same study shows that according to the z measure, Scotland is unsustainable. | Assumes that resource extraction programmes are economically optimum. A theoretically sound sustainable income measure, but hampered by severe lack of data and difficulties in placing a monetary value on non-market environmental assets. |
| Socio-economic | | |
| Quality of life index (composite index) | Many indices have been developed to measure quality of life (reviewed in Mitchell *et al.*, 1995), a key element of sustainability. These indices identify basic, physical and cultural needs, which are weighted and aggregated into a single index. This approach is used by the UN and OECD to predict social need and identify social inequalities. It has policy value as the index can be dissagregated to identify significant impact areas, and can be used to identify inequalities at a variety of spatial scales. | Indices are contentious in terms of items included in index, and present great difficulties of subjectivity in component weighting. Difficulties in quantifying intangible elements of quality of life that are important to an individuals perception of well being. Concentrates on human values and does not evaluate ecological elements that have no immediate human resource value. |

Table 1 (continued)

| Method (and units) | Description and example applications | Disadvantages |
|---|---|---|
| Socio-economic (continued) | | |
| EAW: economic aspects of welfare index (composite index) | Zolatos (1981) attempted to measure economic welfare in the USA using detailed questionnaire and census analysis. Index similar in construction to the ISEW. | Inadequate accounting for natural capital consumption or defensive expenditure. |
| ISEW: index of sustainable economic welfare (composite index) | A multivariate index that adjusts GNP with a variety of social and environmental factors (e.g. costs of long-term environmental damage, pollution control, commuting, plus value of household labour and health and education expenditure). Also includes an income distribution measure. First applied to the USA (Daly and Cobb, 1989) and later the UK (Jackson and Marks, 1994) and Scotland (Moffat and Wilson, 1994) with similar results. ISEW falling since 1980, while GNP continues to rise. | Data often unavailable in any form. Results vary depending on base year chosen. Controversial inclusion of value of unpaid work in the home. |
| Ecological | | |
| NPP: net primary productivity (kcal per capita) | Net primary productivity lost to human activity. NPP is the amount of solar energy converted to carbon and stored by terrestrial plants (i.e. it is the product of photosynthesis). NPP is limited and is lost through food consumption by people and livestock and from land used for human activity (roads, buildings). Applied on global scale by Vitousek *et al.* (1986). | Calculated from incomplete data sets with assumptions about ecosystem productivity. Inevitable inaccuracies in estimates of NPP and in human appropriation of NPP. |
| K/NPP: carrying capacity relative to human NPP consumption (kcal per capita) | K/NPP is the current population of a country, as a % of the population that could be supported (the carrying capacity, K) by NPP. The later population figure is calculated by dividing NPP (×0.25) with no human population (estimated from pre-agriculture studies) by per capita annual minimum required calorie intake. This method assumes that of all NPP produced. 25% at most is available for human consumption. Applied to the world by Vitousek *et al.* (1986) and to Scotland by Moffat *et al.* (1994). Scotland currently uses 93% of its NPP based carrying capacity. | Methodological assumptions made, including those about NPP consumption. Difficulties in accurately estimating NPP. |
| EF/ACC (ha per capita) | The ecological footprint (EF) appropriated carrying capacity (ACC) measure (Rees and Wackernagel, 1994). The land required to maintain current population and patterns of activity (e.g. food, energy and materials consumption, infrastructure requirements) is related to actual land area. Moffat *et al.* (1994) examining just food, energy and timber find that Scotland's population needs 20% more land than it has, indicating a net import of resources, threatening the sustainability of the exporting country. | Methodological assumptions and data estimation. |

Steps from the method that should be found in any SDI programme are outlined below.

(i) Clearly define the objectives of the indicators programme, specifying the purpose of the indicators and their user group.
(ii) State what is understood by SD, by specifying the definitions of SD that are referenced, and the sustainability principles to be applied.
(iii) Define the issues that are important both locally and globally.
(iv) Indicators have different properties depending on their construction. Indicator properties should be matched to the users of the indicators and the objectives of the programme.
(v) Evaluate the indicators against desirable indicator characteristics and programme objectives.

## Indicator objectives and users

Designers of SDIs should specify the objectives and intended users of the indicators. All indicators are used to promote action, but within this general aim lie more specific objectives. Cairns *et al.* (1993) reviewed environmental indicators and found that they are used to assess status, document trends, act as an early warning of change, diagnose cause and effect and identify linkages to make assessments more cost-effective. Indicators cannot be developed that effectively meet all these objectives and indicators developed to meet one objective may be different to those developed to met another. Similarly, indicators cannot communicate equally effectively to interested parties; local government officers, scientists or community groups. For example, an expert in a resource agency may find that SDIs developed for communicating sustainability progress to the public are of little use when evaluating sustainability progress in the areas of interest to the resource agency. Indicator properties and their relationship to objectives and users are discussed in more detail in the following.

**Sustainability definitions and principles**

The second step in indicator development should be a statement of the sustainability definitions and principles that the indicator developers wish to address. Even before the Rio Summit, Pearce *et al.* (1989) were able to identify over 60 definitions of SD, but it is likely that most SDI programmes would be based on the most widely accepted definitions (WCED, 1987; IUCN–WWF–UNEP, 1992). The statement of definition used is necessary as it makes a clear distinction between terms that are commonly confused. For example, the terms sustainable growth and sustainable economic growth have been used synonymously with the term sustainable development. Growth-based definitions are misleading as SD recognizes limits in natural systems (e.g. see Daly, 1991), implying that sustained (continuous) growth is not the development path that can deliver improvements in environmental integrity and quality of life.

Designers of SDIs should also specify the sustainability principles that they adopt. The principles detailed by Brundtland (WCED, 1987) are inter-generational equity (not stealing from our children and grandchildren), intra-generational equity (care for today's poor and disadvantaged) and maintenance of ecological integrity (environmental conservation and protection). These principles have wide support (e.g. Elkin *et al.*, 1991; UNCED, 1992; LGMB, 1993; 1994b), but are not necessarily universally applied to all indicator programmes. For example, MacGillivray (1995) proposes indicators that the UK Government may adopt as national UK SDIs. These indicators are suitable for assessing the state of, and pressure on, the UK environment and begin to address the ecological integrity and inter-generational equity principles, but give only cursory attention to questions of intra-generational equity. There is only passing reference to issues of public health and no consideration of issues such as housing, crime, unemployment, access to services, quality of education and leisure provision. This is not perhaps surprising, given that the study was supported by a group consisting of many wildlife-related NGOs that limit its terms of reference. The study is valuable in identifying environmental indicators but, as the author acknowledges, is limited in scope and cannot be recognized as a complete set of SDIs.

The UK's LGMB SDIs project (LGMB, 1994a) is more explicit in identifying the principles it adopts, but does not sufficiently address these principles in the selected indicators. This is due to the rather unsatisfactory method of selecting SDIs that began with a panel voting on a list of indicators drawn from published work on the social, economic and natural environments. This method is unsatisfactory as existing indicators, developed outside an SD framework, make no attempt to apply rate limits for resource renewal and pollution assimilation (Daly, 1991) that are a critical component of SD. Mitchell *et al.* (1995) demonstrate how sustainability principles and rate limits can be more rigorously applied to SDI construction. Taking water consumption as an example issue of concern, SDIs can be identified that address the three outlined principles. The SDIs are: (i) total annual water consumption as a percentage of the total existing developed water resource stock in a drought year with a 50 year return period (inter-generational equity); (ii) the percentage of households spending more than 10% of their household income on meeting water and sewerage needs (intra-generational equity); and (iii) the number of days per year that water flow in a public supply river drops below the level recommended for the maintenance of the hydrobiological community (ecological integrity).

**Selecting issues**

Achieving the best balance between local and global issues is a difficult task, but one that should be attempted. In an indicators' method that relies only on public consultation, there is a danger in placing undue emphasis on purely local issues. The importance of critical global issues, such as biodiversity protection and the emission of greenhouse gases, is not recognized by the average 'person in the street'. This is because of the 'tragedy of the commons' (Hardin, 1968) and because it is often difficult to perceive the link between local actions and global impacts. By drawing on published work it is possible to identify a core set of issues that are applicable to any community. This core set would address issues relevant to the global commons (e.g. greenhouse gases, biodiversity) and issues relevant to any community (e.g. local air and water quality, energy consumption, crime, housing provision). Some core issues would have indicators that are common to any area (e.g. carbon dioxide emission per capita). Other indicators would relate to a common core issue, but be expressed to address particular local circumstances. For example, protection of rare species might be a core issue, but the associated indicator would vary geographically depending on which species were locally important.

Conversely, in only identifying published issues, there is a danger that significant local issues will not be represented. A public consultation process allows local people to express concerns specific to them. These purely local issues might be rather mundane, relating to, say, litter, dog mess or vandalism, but are important as indicators of local issues will have a disproportionately large effect on communicating SD ideas to local people. They can therefore be effective in promoting action towards SD in other core issue areas. If resources allow a more extensive consultation process, then issues are likely to be identified that already exist in the core set of issues. This would enhance local progress towards SD as there would be a greater feeling of 'community ownership' of the complete set of SDIs.

### Indicator properties

Indicators have different properties and merits depending on the indicator approach taken and the specific characteristics of the indicator. These properties should be considered so that the indicators developed are appropriate to the user and the objectives of the indicators programme.

*Indicator properties and SDI programme objectives*

Cairns *et al.*(1993) list indicator properties and show how indicators designed to address different objectives can have subtle but important differences. For example, indicators used to document trends must be supported by data that has a higher degree of continuity than that needed for the assessment of status. Early warning indicators must be highly relevant to the potential change in conditions and preferably be supported by a data collection and analysis programme that is sufficiently rapid to allow pre-emptive management action. Such early warning indicators are usually very different from assessment or trend indicators. An assessment or trend indicator of river quality might be the population of fish found in the river. An early warning indicator of river quality might be biological oxygen demand, which could then be used to manage sewage input to the river so that fish populations are not exposed to unacceptable river water quality.

Indicators used to diagnose the cause of an effect cannot integrate many issues, as a composite indicator does (see Table 2), but must be highly specific. However, indicators that can be correlated with a high degree of confidence can be used to demonstrate linkages between system components. In these instances it may be appropriate to select just one of the correlated indicators as a key indicator, thus making the indicator programme more cost-effective and reinforcing the political will to make sound management decisions.

*Indicator properties and the indicator user*

There are three major approaches to indicator construction: the set of specific indicators, composite indicators and key indicators. The relative merits of these approaches (Table 2) should be matched to the indicator users. Different users (policy-makers, the public, scientists) have different opportunities to take actions in favour of SD, and a good user–indicator match maximizes the communication of relevant information, allowing the user to make the best possible pro-sustainable decision. Policy-makers in resource agencies or scientists working in specific narrow disciplines may prefer SDIs that can communicate significant amounts of highly technical information in a very precise way. In these instances many specific SDIs may be best suited to the objectives of the indicator users. For example, managers in NGOs such as the National Rivers Authority or Her Majesty's Inspectorate of Pollution may prefer SDIs that relate varied pollutants to a river's pollutant carrying capacity, as well as indicators of biological status. However, the public require fewer, simpler SDIs, and may be content with indicators that simply say if the river quality is 'high' or 'low'. SDIs for the public should be resonant – that is, clear, easy to understand and inspirational – so that action in favour of SD is promoted. Resonant indicators are mostly drawn from the key and simple composite index groups. Examples are the number of fish in a river and an air pollutant standards index.

However, in producing resonant indicators it is important to note that some indicator validity is usually sacrificed. The well-known Sustainable Seattle indicator of numbers of wild salmon returning to Kings County to spawn each year provides one such example. This is a key indicator and integrates many more specific indicators of river pollution, river bottom disturbance by waterside development and aquatic plant health. However, Seattle may take major steps towards SD by addressing all these specific issues, but still not see an increase in spawning salmon due to over-fishing

Table 2: Relative merits of different indicator approaches (adapted from Mitchell *et al.*, 1995).

| Indicator approach with pictorial representation | Advantages | Disadvantages | Main indicator uses and users |
|---|---|---|---|
| Many specific indicators<br>Data Data Data Data Data Data Data Data<br>↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓<br>Ind. Ind. Ind. Ind. Ind. Ind. Ind. Ind. | Comprehensive coverage of all the issues.<br>Few data gaps or omissions.<br>Selection difficulties are minimized.<br>Indicators are simple and closely reflect the data.<br>Results are non-controversial. | Burden of interpretation placed on user.<br>Communicates little sense of condition of the whole.<br>Limited potential for resonance. | Modelling.<br>Scientists. |
| A few composite indicators<br>[Data Data Data Data] [Data Data Data Data]<br>↓ ↓<br>Composite indicator Composite indicator | Communicates a sense of condition of the whole (or major parts of the whole). | Difficult to maintain consistently as old issues disappear, new issues arise.<br>Controversial. An index averages data and much important information can be lost.<br>Value judgements are required when weighting of components.<br>Limited resonance potential. | Communicating data to discipline experts.<br>Communicating data to policy-makers.<br>Modelling. |
| Key and simple composite indicators<br>Data [Data] Data Data [Data Data] Data Data<br>↓ ↓<br>Key indicator Simple composite indicator | Explicit.<br>Data gaps are clearly seen.<br>Unacceptable omissions corrected by selecting additional key indicator, rather than altering complex composites.<br>Long-term robustness.<br>High potential for resonance. | Subjective decision required in selecting key indicator.<br>Danger of oversimplification.<br>Danger of giving false impression of improvement by targeting resources at the key indicator and not the problem. | Communicating data to non-experts and the public. |

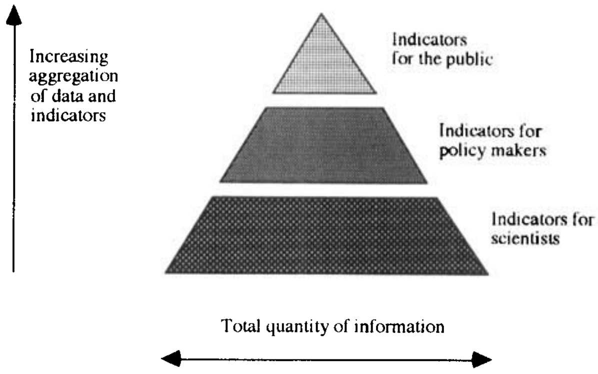


Figure 1. Relationships between data, indicators, information and indicator users. Reproduced with permission from Braat (1991)

in the northern Pacific where the salmon spend most of their adult lives. It is natural that in using key, resonant indicators some information distortion occurs as the total amount of information drawn upon is much reduced (Figure 1). However, by way of compensation, it is much harder to give a false impression of progress by targeting resources at an indicator, if key indicators, integrating many varied concerns, are chosen.

### Indicator evaluation

The final step in any programme to develop SDIs is to evaluate the indicators against a set of agreed criteria. These practical constraints are important, but should not be addressed before there is any conception of the ideal SDI. Mitchell *et al.* (1995) find eight criteria commonly used to assess SDIs. Indicator developers should determine if the indicators are: (i) relevant to the issues of concern and scientifically defensible; (ii) sensitive to change across space and across social groups; (iii) sensitive to change over time; (iv) supported by consistent data; (v) understandable and, if appropriate, resonant; (vi) measurable; and (vii) expressed in a way that makes sense (percentage, rate, per capita, absolute value). The importance of this last point can be illustrated by contrasting studies of the environmental performance of OECD countries. The New Economics Foundation found that Australia had one of the worst environmental records of all OECD countries when an environmental performance index (based on greenhouse gas emissions and resource consumption) was constructed and normalized on a per capita basis (MacGillivray, 1993). However, Brunton (1994), using the same OECD data but normalized on a land area, found that Australia had the best environmental performance record of any OECD country. A final criterion important to SDIs is (viii) the identification of targets and trends that allow progress towards or away from sustainability to be determined. Ideally, SDIs should be accompanied by a target value identifying desirable conditions and threshold values identifying problem, critical and irreversible levels. Irreversible levels could relate to, for example, loss of critical natural capital. These values should be identified, where possible, and their importance explained alongside the indicator. If targets cannot be identified with confidence, then it is preferable to specify desirable trend directions rather than mis-specify a target level. SDIs are unlikely to meet all eight indicator criteria perfectly, so deficiencies in the indicator should be recorded. For example, if there are practical problems with say, data availability, then a surrogate indicator may be chosen, but should be reported as the best currently practical indicator and not the best possible indicator.

## CONCLUSIONS

Indicators are useful in promoting sustainability if designed with care and used properly, but, like statistics, can be used to mislead and misinform. Many existing SDI sets have not been identified using an explicit methodology, making it difficult for other indicator developers to learn general lessons. Owing to geographical and cultural diversity and the varying needs of different user groups, there is likely to be a continued strong demand for SDIs. By now it should be possible to identify a core set of indicators common to all areas that would be supplemented by indicators of purely local issues. However, due to the uncertainty surrounding the development method of SDI sets it is difficult to identify this core set. An unequivocal method should be used when developing SDIs. The method should include the following steps: (i) define the purpose of the indicators and the user group; (ii) state what is understood by the term sustainable development and specify the SD principles that the SDIs are to address; (iii) define and distinguish the issues that are important locally and globally; (iv) match indicator types to the indicator purpose and user group; and (v) evaluate the indicators against a set of explicit criteria. Including these steps in an SDI development programme should ensure that SDIs recognize sustainability principles and limits and are focused on the objectives of the indicators and the user group.

Presently, there is a danger that SDI programmes will go awry as too much effort is devoted to developing 'instant' indicators without adequate thought being given to the terms of reference and long-term validity and robustness of the SDI set.

The lack of application of a clear and widely acceptable method may lead to SDIs that are arrived at by an unsatisfactory public consultation process or merely by selecting existing environmental, social or economic indicators. If SD really is a new paradigm, as seems likely following the Earth Summit and the commitments made to Agenda 21, then SDIs deserve to be constructed from a clean sheet and not simply developed in an *ad hoc* fashion. As well as monitoring progress towards SD, indicators will be used to judge the effectiveness of policy and ultimately will assist in setting policy. It is vital then, that SDIs, if they are to be useful in promoting SD, are designed with the care and attention their significance demands.

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