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The Center for Environmental Policy

Sustainable Development Indicators in Israel

Summary Report Phase I

Editor: Eran Feitelson

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Abstract

Indicators are signposts that can point the way to sustainable development. Although there is no agreed and exact definition of sustainable development, indicators may show the direction toward which we are moving and even pave the road toward sustainable development. This report summarizes the first phase of a project designed to identify the indicators which should be monitored from the point of view of sustainable development.

The study was based on three primary efforts. The first effort focused on the assessment of existing knowledge in Israel and its adaptation to accepted indicator systems worldwide. For this purpose, a table was prepared which compiles Israel's existing environmental information by categories, level of availability, quality, continuity of the data, frequency of collection, and organizations which collect the information. Second, a survey of indicator systems accepted worldwide was carried out which assessed the applicability of the system proposed by the Mediterranean Action Plan. It was concluded that it is not desirable to merely implement a strategy developed by international bodies, but rather to create a system which would optimally respond to conditions in Israel.

The third effort identified indicators necessary in Israel, in two main ways: position papers were prepared on the indicators necessary to identify seven primary sectors from an environmental viewpoint in Israel. On the basis of each paper, an expert workshop on the specific area was held and the comments raised in the workshop were then integrated into the proposed indicators in this area. In addition, indicators which may facilitate follow-up of the implementation of the draft strategy for sustainable development, which was prepared in Israel, were identified. These included indicators designed to monitor the achievement of the strategy's targets and indicators designed to monitor the seven structural processes contradicting sustainable development, which were identified within the strategy.

On the basis of these three efforts, a preliminary system of sustainable development indicators is proposed for Israel. The indicators are classified according to six subjects: (I) monitoring economic growth; (II) monitoring the level of social and environmental equity in the present generation; (III) the capacity to cope with environmental subjects; (IV) the protection of the interests of future generations (especially their ability to shape their own future according to their

desires); (V) the efficiency of natural resource utilization; and (VI) indicators on the quality of life of the present generation.

The indicator system presented in this report is preliminary. It still requires completions in several areas as well as a review to assess its suitability to its goals. These tasks will be the focus of the study in the second phase.

Sustainable Development Indicators for Measuring Israel's Quality of Life:

Assessing the Relevance of Sustainable Indicator Research at the Local and National Levels

Clive Lipchin and Alon Tal

Introduction

Across the globe, sustainable community indicators are becoming an invaluable part of community and national planning.[1] Indicators are important tools for countries as they move toward implementation of sustainable development programs pursuant to the UN Commission for Sustainable Development's Agenda 21 program. Israel is a part of this trend.

According to most criteria, Israel has the leading economy in the Middle East. According to the UNDP 2001 Human Development Report, Israel ranks 22 out 162 countries and is considered a country with "high human development."[2] The attendant rise in standard of living brings costs as wells as benefits. Quantitative growth at the expense of qualitative development can be seen in many areas of the country; traffic congestion, air and water pollution and the loss of open space and urban sprawl. These and other environmental problems constitute symptoms of both the robust economy and high standard of living.

The environmental side effects of development raise questions about "quality of life." Quality of life, is to a certain extent a subjective dynamic and thus difficult to characterize, but invariably it involves choices that affect both the present and the future. Current demands by the population for private vehicles or single-family homes may hold immediate benefits for consumers, but the cost of such lifestyle choices will be felt by future generations in lower air quality, congestion and loss of open space. Sustainable development therefore, seeks to balance quantitative growth with qualitative development both in the present and in the future. As yet in Israel, there is no systematic, intergenerational process in place to prioritize and coordinate efforts to enhance the country's overall quality of life.

What are Sustainable Indicators?

Sustainable development is an endeavor to ensure that "progress" is balanced; that economic growth does not come at the expense of public health, environmental quality, or social equity. In working towards sustainability, aspects critical to the quality of life of a community such as health, economy, education, and environment can be measured and evaluated using indicators - numeric measures of community health and well being. Without indicators, we have no objective measures of our progress towards sustainability. As a society, we are overly reliant upon economic indicators like GNP and the stock market indices. These offer only a very limited understanding of our overall progress. We need broader indicators that recognize the linkages among economy, environment, health, and culture.

It is impossible to move forward without understanding the linkages among economic, social and environmental factors. The development of indicators helps to bring these linkages to the forefront allowing for policy makers to make policies in a broader and sounder framework. Traditional measures of quality of life looked at these activities in isolation. A sustainable development approach using indicators, allows for the linkages of these activities and integrates them into ultimate quality of life indexes (Figs. 1 and 2).

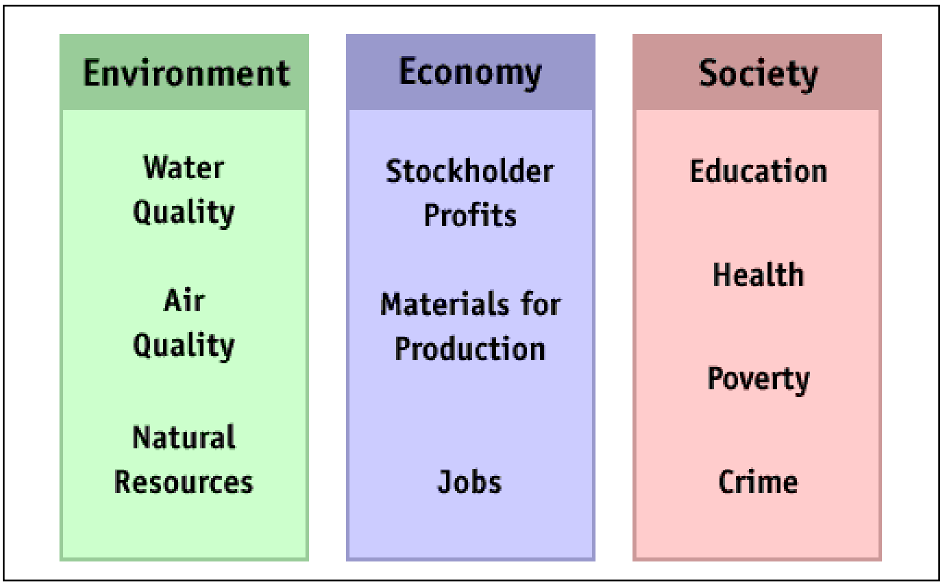


Figure 1: Traditional measures of quality of life
Source: www.sustainablemeasures.com

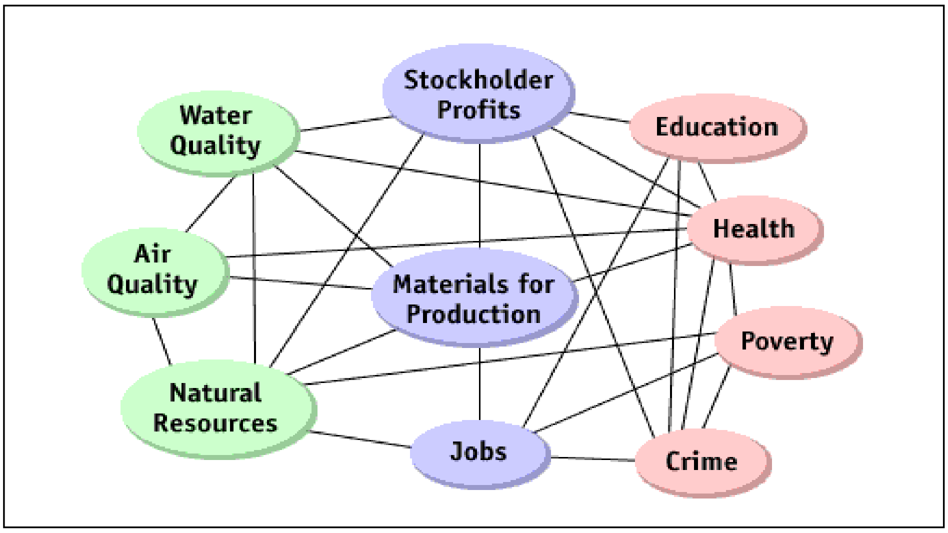


Figure 2: Sustainable development highlights linkages.
Source: www.sustainablemeasures.com

Not all quantifiable information constitutes a meaningful sustainable indicator. An indicator must be valid and understandable to a broad spectrum of users, detect problems and raise public awareness so the need for change, where necessary, is taken seriously. Valid indicators may vary across different communities, reflecting different cultures, values or geographical realities. Hence, the process by which stakeholders, representing diverse interests come together to develop a set of indicators, can create indicators that are cohesive and representative of the country as a whole. One of the purposes of this paper is to identify organizations that can make use of indicators. Because quality of life measures affect us all, organizations from business and industry, social and public services, government and non-government organizations and the environment need to be included in developing indicators. In cutting a swathe across all sectors of the country, we propose that indicators should[3]:

- Reflect something basic and fundamental to the long-term cultural, economic, environmental, or social health of the country over generations.
- Be accepted as a valid sign of sustainability or distress by experts and practicing professionals.

- Be meaningful and understandable to the public.
- Be attractive to the local media so that the press can publicize them and use them to monitor and analyze trends.
- Lend themselves to accurate measurment. Data and statistics must be relevant to the geographic area and, preferably, comparable to other countries with similar standards of living. If data are not readily available, a practical method of data collection or measurement should be developed.
- Be logically or scientifically defensible. Understandable rationales should exist for using the specific indicator and for drawing general conclusions from it.
- Clearly communicate trends over time and space. As tools for sustainable development, indicators should clearly tell us whether or not we are moving toward or away from sustainability or remaining stable.

Sustainable Indicators at Two Levels

Many organizations have promoted the development of indicators; among them are the OECD, UNCSD and the UK Department of Environment.[4] Like the Human Development Index, indicators like these can provide an accounting system that allows one to rank and compare countries. Such indicators has relevance for international level policy making, especially in the light of globalization. Many trade and environmental treaties and policies are incorporating sustainable development into their mandates. Indicators designed for the macro-level can help countries to close the gap between less and more sustainable countries. They can also be used by world bodies as pressure points to improve quality of life standards in less sustainable countries. A limiting factor of these measures is their relevance at the local level.

Yet, policy instituted at the national level should also reflect the interests of the local level. The development of indicators that are locally specific provides valuable feedback to policy makers at the national level. Consequently, indicators should be developed at two levels: national and local. These two systems must act in a coordinated way at both horizontal and vertical levels whereby transparent bottom-up and top-down processes exist.

Indicators for sustainability must be relevant both in the long term and in the short term. The challenge in developing long-term policies is clear. Within the turbulent political system of Israel, long term may be anything from five year to twenty years, a challenge, even where political systems are more stable. Technological transformation and new information about human and ecological health can also change projections and make certain criteria obsolete. If for example, recycling rates become extremely high, the sustainability implications of solid waste production might change.

Short-term policies, on the other hand, can some times miss the broader challenges and primarily serve a stop gap "finger in the dike" function in the here and now. The effectiveness of short-term policies can be enhanced by reflecting local concerns and needs. Indicators developed at the local level can ground the evaluation process in real-world concerns and aid in the development of longer-term indicators to be developed at the national level.

Indicators must be useful and understood at all levels. Indicators developed solely at the national level may not be relevant to those at the local level or vice versa. The publication, *Vital Signs 2000 Israel*, provides a good beginning for the development of indicators at both the local and national levels.[5] For example, in the chapter on groundwater, surface levels for the coastal and mountain aquifers are presented. These indicators measure the change in surface levels of the aquifers in meters over a period of six years. These indicators meet the requirement of presenting information over time and a clear downward trend is observed. The message of over pumping is clear from these indicators, with fairly evident ramifications regarding water management reform. Yet, the utility of this measure at the local level may be limited, with tap water quality serving as a more relevant reflection of local concerns. Indeed, as long as water continually flows from the tap, the issue of water scarcity so prevalent in the media today, may remain distant and theoretical.

In affecting a change at the local level, water use behaviors must be targeted. An indicator that focuses on local water use behaviors, such as the number of water wasting devices in people's homes (jacuzis, pools, etc.) or the rate of usage in the face of widely reported scarcity might better reflect the issue of general water use at the local level. The problem of simplistic monolithic indicators was highlighted recently when Israel's Minister of Infrastructure recommended allocating a set quota of water for individual households, regardless of family size, climate (evapotranspiration rates) etc.

Disaggregating this data along socioeconomic and sociodemographic lines will help to pinpoint where water use is high and where it is low. Scaling these indicators up to measures of decreasing water levels in the country's aquifers creates the necessary linkage to the operational decision at the national level. In addition, creating linkages among these indicators on water use with respect to their wider association with the economy (investments in alternative technologies), society (health effects as a consequence of water quality) and the environment (degraded ecosystems such as the Lake Kinneret and Dead Sea systems) increase the utility of indicators to both the public and policy-makers. The inclusivity that linkages provide allow for the development of policies that are not target-specific but rather solution-specific. In other words, policy development in remediating the water shortage must include both supply and demand side management where both suppliers and consumers are targeted together with the encompassing environmental attributes.

Public Awareness and Involvement

Indicators can potentially be powerful tools for involving the public in quality of life issues. Directly involving representatives or formally incorporated NGOs in the development of indicators will help ensure that the indicators represent the needs and priorities of the community. Community involvement is a key component of building trust among governmental and business institutions and the public. Indicator development that involves the public from the beginning stages of development educates and empowers the public, making them part of the decision making process. Indicators can also help in improving public knowledge about local infrastructure or environmental factors. For example, an understanding and awareness regarding the source and treatment of drinking water can help to allay fears when crises occur. Indicators can also act as public relations tools where communities can report on their progress with respect to sustainable development.

At the same time, the limitations of non-professionals and the general public should be considered when crafting a series of indicators. For example, air quality is an amorphous concept which can be defined in many ways, depending on the gasses or particulate matter which is being measured. If, for example, one wishes to define air pollution according to carbon monoxide levels, (today the only air emission standard in effect for private cars) then Israel's air is in good shape and growing cleaner. If, however, NOx, fine particulates or ambient ozone drive the indicator equation, then deterioration is alarming. The U.S. EPA pioneered a composite air quality indicator in order to help local authorities provide health advisories and warn the vulnerable sectors of the public about pollution episodes.[6] This single measure enable the public to immediately understand when the air is unfit for breathing, and saves them from deciphering different measurements and deciding which might affect their health and which are innocuous.

During a recent visit to Israel, the chairman of Germany's Green Party explained that none of the environmental positions which were advocated by his party, originated from the Green Party itself. Rather, the scientific community set the agenda and provided the relevant data for formulating policy positions.[7] This view constitutes an ideal in a country where salient data are unavailable or analysis and interpretation remain ambiguous. Along with the growing demands for public involvement in planning and policy decisions, comes a responsibility of making an informed and thoughtful contribution. Indicators should enhance the integrity of the public's participation, providing an empirical scientific basis for the positions which are ultimately advocated.

In sum, the information conveyed by a locally developed indicator should be self-explanatory. It should also provide temporal and spatial information in a clear and visible way, be accessible and of interest to the media, be scaled up and linked to a national indicator and be linked to other indicators across sectors. The development of indicators for solid waste can serve as an example. *Vital Signs 2000 Israel* has developed indicators on per capita waste production and waste composition.[8] These indicators have been developed at a national level and show trends of waste composition in percentage over time.

The indicator on per capita waste production measured in kilograms is a worthy attempt of a locally developed indicator. This indicator compares per capita waste production across selected cities in the country. It does not however, include the types of waste, nor the potential for recycling, waste-to-energy incineration potential, etc. It does, show, however, which communities are producing more or less waste. Linking this indicator to other indicators that measure social and economic factors such as per capita income and the specific waste recycling efforts of a given community (or nationally) will produce a clearer picture on waste production. The linkages will also help policy makers in drafting an integrated waste management strategy.

Assessing the Relevance of Sustainable Indicators for Environmental Organizations

In order to receive an initial indication of the value of research that would characterize sustainable indicators for Israel, we surveyed a broad range of environmental organizations on the relevance of sustainable indicators to their work. The assumption behind the survey was that it is important when developing indicators and publishing results that the endeavor does not remain academic. Because indicators are tools that help decision-makers and can galvanize the public, bringing them into the public policy discourse, it is imperative that they are understood by the public and perceived as relevant. We developed a survey questionnaire that sought to ascertain the most urgent environmental problems (which the public would presumably want monitored) and the way in which indicators might help to address these problems (appendix 1). We also asked questions on how indicators can be help organizations in their own work. The results are encouraging for sustainable indicator advocates and suggests that there is an appetite if not a hunger for the kinds of information which sustainable indicators are intended to provide.

According to the organizations surveyed, the most pressing environmental problems facing the country are air quality, water scarcity and water quality; the least pressing are noise and loss of biodiversity (table 1). As a first cut, this information can help in concentrating efforts on indicator development in those sectors with the highest relevance.

Table 1: Survey responses on environmental concerns facing Israel.

Respondents were representatives of local environmental organizations (n=15).
Responses are in percentages.

Environmental Concern	**Rank**			
	Most Urgent	**Urgent**	**Less Urgent**	**Least Urgent**
Air quality	80.00	13.33	6.67	0
Water Quality	93.33	6.67	0	0
Urban sprawl	20.00	53.33	26.67	0
Open space	66.67	20.00	13.33	0
Transportation (e.g.: road congestion, pollution etc.)	53.33	46.67	0	0
Noise	26.67	33.33	40.00	0
Energy shortage	13.33	46.67	33.33	0
Solid waste disposal	26.67	46.67	26.67	0
Pesticide Use	60.00	20.00	20.00	0
Hazardous waste treatment	60	20.00	20.00	0
Loss of biodiversity	6.67	46.67	46.67	0
Water scarcity	73.33	26.67	0	0

The ability of indicators to clearly produce and communicate trends was considered very important (53.33% of responses). Using indicators to clearly present information to the public was also considered very important (86.67% of responses). These results are encouraging for the need for indicators at this time (table 2).

Table 2: Survey responses on the temporal importance of indicators and their value to the public.

Respondents were representatives of local environmental organizations (n=15). Responses are percentages.

	Very Important	**Important**	**Neutral**	**Not Important**	**Don't Know**
A sustainable indicator is a measure of an environmental concern over time. For example, the number of days air pollutants exceeds health levels over the last 10 years. How important is information presented over time for your organization?	53.33	33.33	6.67	6.67	0
A well-designed sustainable indicator is one that clearly communicates information to the public. How important is information presented to the public for your organization?	86.67	13.33	0	0	0

The role of the media in helping to raise public awareness and to involve the public in quality of life issues cannot be ignored. Therefore, sustainable indicators should have the media in mind when they are developed. Already, the *HaAretz* newspaper's consistent publishing of Kinerret water levels or sulfur dioxide levels in urban centers suggests that the press is willing to provide coverage of environmental indicators if they believe their readers will see them as relevant and valid.

According to table 3, from the environmental organizations' perspective, the most effective media source for communicating indicator results to the public is television. Newspapers are considered next, with radio third. Forty percent of responses considered the Internet as being ineffective in communicating results to the public. It is advisable to involve the media at all stages of the indicator development process and not just at the dissemination of results. Public acceptance of the results is likely to be greater when the public has been informed from the beginning of the process.

Table 3: Survey responses on the effectiveness of various media sources in communicating sustainable indicator results to the public.

Respondents were representatives of local environmental organizations (n=15). Responses are percentages.

Public Medium	Most Effective	Effective	Not Effective	Least Effective
Newspapers	66.67	33.33	0.00	0.00
Television	93.33	6.67	0.00	0.00
Radio	46.67	46.67	6.67	0.00
Community meetings	20.00	53.33	26.67	0.00
The Internet	26.67	33.33	40.00	0.00
Public dialogue	13.33	46.67	26.67	13.33

As mentioned previously, involvement of NGOs in indicator development is essential, especially for indicators at the local level. The inclusion of NGOs active at the local level is an important resource for tapping into the concerns and priorities of the public. This should not prove to be a problem in Israel. The majority of the organizations surveyed were willing to help in indicator development (66.67% of responses, table 4).

Table 4: Survey responses on the willingness to help in the data gathering process for a sustainable indicators project.

Respondents were representatives of local environmental organizations (n=15). Responses are percentages.

Response	
Willing	66.67
Neutral	13.33
Not willing	13.33
Don’t know	6.67

Finally, we asked the organizations whether or not indicators would be beneficial to the work of the organizations themselves. Over two-thirds of the organizations surveyed indicated that indicators would be helpful in their work in communicating with the public. This attests to the importance of local indicators. Eighty percent of those surveyed indicated that indicators would be helpful in communicating with government agencies and ministries. This bears out the relevance for scaling up local indicators to national indicators and for the importance of linkages. In addition, over two-thirds of those surveyed indicated that indicators would assist them in seeking funding for their activities (table 5).

Table 5: Survey responses on whether or not a sustainable indicators project would be beneficial to environmental organizations.

Respondents were representatives of local environmental organizations (n=15). Responses are percentages.

Statement	Helpful	Neutral	Not helpful	Don't know
Would quality of life measures such as sustainable indicators be helpful in your work in communicating with the public?	66.67	13.33	13.33	6.67
Would quality of life measures such as sustainable indicators be helpful in your work in communicating with government agencies and ministries?	80.00	20.00	0	0
Would quality of life measures such as sustainable indicators be helpful in your work in seeking funding for your organization's activities?	66.67	20.00	13.33	0

A recent survey of environmental NGOs in Israel detected a striking growth in the number of formal organizations operating within Israel during the past decade.[9] It was estimated that well over a hundred environmental groups are active in a serious manner, most at the local level. Only 28% of the 51 organizations sampled had budgets below $5,000. This suggests a remarkable strengthening of environmental presence at the grass roots, who will increasingly provide a key clientele for the indicators results when they are measured and publicized.

Table 6 presents the names of the organizations surveyed and the number of years they have been active.

Table 6

Name	Number of Years Active
אגודת צער בעלי חיים בישראל	72
לינק לאיכות בסביבה	4
המועצה לישראל יפה	33
העמותה לקשרי התעשייה עם הקהל	13
אנונומוס	10
רשות הטבע והגנים	
האגוד הישראלי למים	6 months
פורום המשק והכלכלה למען איכות הסביבה בישראל	10
פורום ארגוני המתנדבים לאיכות הסביבה והחיים	7
מרכז השל	3
ויצו	80
נעמת - ארגון נשים עובדות ומתנדבות	80
ירושלים בת-קיימא	3 and half
המרכז הבינ״ל לחקר נדידת ציפורים בלטרון	
ההתאחדות הישראלית לכלבנות	30

A Proposed Methodology for Developing Indicators

It has been suggested by some that indicators can be used to develop an index for quality of life akin to a nation's GDP that measures economic performance. Such an index, produced on a monthly or annual basis, can communicate to the public their community's or country's progress with respect to sustainable development. An index based on a common methodology can also be used to compare sustainable development across countries. As accounting systems move toward internalizing externalities in analyzing market trends i.e.: including both man-made and natural capital, the need for sustainable development indexes will rise. The Institute for Innovation in Social Policy at Fordham University in the USA allows one to compute a single measure of the overall quality of life based on indicators.[10] By creating a longitudinal database for each indicator, changes in overall quality of life over the last twenty to thirty years, depending on available data, can be tracked.

The Institute for Innovation in Social Policy (IISP) has developed a creative process for aggregating disparate measures of quality of life into a single indicator. This provides a relatively objective overall score of quality of life for a given year. By tracking that overall measure over time, one can assess the overall direction and rate of change of quality of life. It is imperative that indicators present information over time. An indicator should not be a "snap shot" of how we are doing but rather a "serial" of where we are going. In other words, a valuable indicator is one that provides a trend.

Performance on each indicator is ranked on a scale of 0 to 100%. A rank of 0% represents the worst measured performance of that indicator for the studied time period. A rank of 100% represents the highest measured performance for that indicator. Indicator rankings are then averaged together for each year to produce an annual ranking. Separate rankings can also be produced for a variety of indicator subsets. For example there can be separate tallies for the subcategories economy, environment, health, and culture.

Data sources will most likely focus heavily upon existing governmental data such as the Central Bureau of Statistics in Jerusalem. A good source of locally disaggregated data is the publication of physical and socioeconomic data for local authorities in Israel by the Central Bureau of Statistics in Jerusalem. These data are for all communities in the country of 5,000 and over population. Currently, two publications exist, one presenting data for 1995 and the other for 1998.[11] A first priority nonetheless should be to seek data sources that provide annual data for as many years as possible. One cannot present a trend with two data points. Longitudinal data are essential for using the IISP methodology.

While there is clear benefits to utilizing available information, in no way should present monitoring and data collection drive the ultimate decision for characterizing sustainable indicators. To do so would be to cripple the initiative from the outset. Israel would find itself like the proverbial fool, looking for his lost coins under the street lamp, not because he thought it was there, but because the street there was already lit. A sustainable indicators research initiative should define what new street lights need to be posted and what areas of uncertainty need to be illuminated.

Conclusion

Today, sustainable development is an established component of Israel's ostensible public policy agenda. To reach this general objective, a higher level of resolution is required, sustainability, ultimately has to leave the level of general definition and be characterized in a measurable fashion. Indicators for sustainable development are tools that policy-makers can use to develop sustainable development programs for measuring quality of life.

Israel is about to embark on an indicator program. To maximize the effectiveness of indicators as tools for measuring quality of life we advocate that indicators be more than simple accounting measures. We suggest indicators should be developed at both a national and a local level, that the public be involved in the development process and be informed of the results, that clear linkages among the environment, economy and society are presented and that local indicators reflect national indicators and vice versa.

Appendix 1: Sustainable Development Indicators for Measuring Israel's Quality of Life

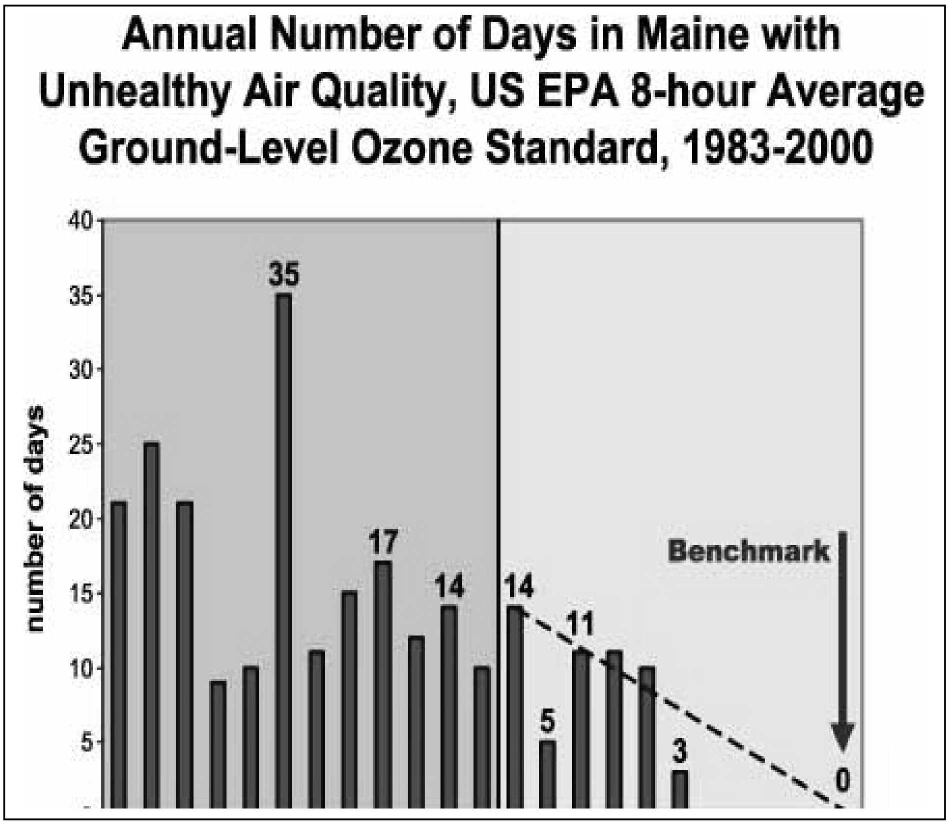
Survey Questionnaire for Environmental Organizations in Israel

Dear:

The Jerusalem Institute for Israel Studies and the Hebrew University are developing a project on sustainable development indicators as a means of measuring Israel's quality of life. A sustainable development indicator is a numeric measure of community health and well being. A sustainable development indicator is different from traditional indicators of a country's progress such as GNP in that it takes into account the linkages that exist among the economy, environment and society. Understanding how these three sectors interact with each other is critical in determining the quality of life of the citizens of Israel.

An example of an indicator is the following on air quality. This indicator, from the Maine Economic Growth Council's Measure of Growth 2001 report, clearly shows the number of days in Maine where air quality conditions were unhealthy. This indicator clearly shows an improving trend of air quality over time with an expected benchmark of zero poor air quality days in 2005. The information presented by this indicator can be clearly understood by the general public as a statement on the condition of the air they breathe.

Air quality is clearly linked to both society and economy. Poor air quality can mean increases in asthma rates in children; this can affect their attendance at school and can result in poor school performance. Because quality of life measures such as the one above affect us all, they must be valid and understandable to a broad spectrum of users, detect problems and raise public awareness so the need for change where necessary, is taken seriously. This survey therefore, seeks your input on the development of indicators for Israel.



Source: www.mdf.org/megc/

We are interested in your opinions and views to the questions below. There are no right or wrong answers to the questions. This questionnaire is confidential and the information collected is for research purposes only.

Thank you in advance for your participation.

Survey Questionnaire

1. Please rank between 1 and 4 the following environmental concerns. Use the ranking system below to indicate your preference for <u>each</u> environmental concern:

   1 being the most urgent, 2 being urgent, 3 being less urgent and 4 being the least urgent.

Environmental Concern	Rank
Air quality	
Water Quality	
Urban sprawl	
Open space	
Transportation (e.g.: road congestion, pollution etc.)	
Energy shortage	
Solid waste disposal	
Loss of biodiversity	
Water scarcity	

2. A sustainable indicator is a measure of an environmental concern over time. For example, the number of days air pollutants exceed healthful levels over the last 10 years.

   How important is information presented over time for your organization?

   Please circle the best possible answer:

   Important   Neutral   Not Important   Don't know

3. A well-designed sustainable indicator is one that clearly communicates information to the public.

   How important is information presented to the public for your organization?

   Please circle the best possible answer:

   Important Neutral Not Important Don't know

4. In order to effectively communicate with the public, sustainable indicators must be publicized in the media. Use the ranking system below to indicate your preference for <u>each</u> public medium:

   1 being the most effective, 2 being effective, 3 being not effective and 4 being the least effective.

Public Medium	**Rank**
Newspapers	
Television	
Radio	
Community meetings	
The Internet	

5. Gathering the relevant data for a sustainable indicator is an important part in developing indicators.

   How willing to help is your organization in the data gathering process?

   Please circle the best possible answer:

   Willing Neutral Not Willing Don't know

6. Would quality of life measures such as sustainable indicators be helpful in your work in communicating with the public?

   Please circle the best possible answer:

   Helpful　　Neutral　　Not Helpful　　Don't know

7. Would quality of life measures such as sustainable indicators be helpful in your work in communicating with government agencies and ministries?

   Please circle the best possible answer:

   Helpful　　Neutral　　Not Helpful　　Don't know

8. Would quality of life measures such as sustainable indicators be helpful in your work in seeking funding for your organization's activities?

   Please circle the best possible answer:

   Helpful　　Neutral　　Not Helpful　　Don't know

9. Could you please provide the following information about your organization:

   Briefly describe the main activity of your organization:

   ____

   ____

   ____

   Please indicate the number of years your organization has been in operation:

   ____

May we contact you again for further information?

Yes No

Would you be interested in receiving a copy of the final report on sustainable development indicators for Israel?

Yes No

You have now completed the questionnaire. Thank you for your cooperation.

Notes

[1] Carlin, S. and Weinstein R. (1998). *Sustainable Indicators: A Review of National Methods and Suggestions for Long Island.* Brookville, NY: Institute of Sustainable Development at Long Island University and
Institute for Sustainable Development at Long Island University, (2000) *Indicators of Community Sustainability: The City of Glen Cove, Long Island.* Brookville, NY: Institute for Sustainable Development at Long Island University.

[2] **www.undp.org/hdr2001**, The Human Development Index (HDI) is a composite index of a country's population life expectancy, education and GDP, Norway ranks first with the USA at sixth.

[3] Sustainable Seattle, 1995. *Indicators of a Sustainable Community: A status report on long-term cultural, economic, and environmental health*

[4] Refer to Chenoweth (2001) for more details on these and other indicator systems. Chenoweth, J. (2001) Indicators for Sustainable Development in Israel. Working Paper #1, The Jerusalem Institute for Israel Studies, The Israel Environment Policy Center

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[7] Reinhard Buetikofer, (2001)"Public Awareness in Germany — The Green Party," in *Increasing Environmental Awareness in Israel and Palestine,* (IPCRI-Jerusalem)..

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[9] Orr Karassin, (2001) "NonGovernment Organizations fot the Quality of the Environment and Life in Israel, A Survey," *National Environmental Priorities in Israel ,* Neeman Institute/Life and Environment, Haifa.

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A report on the social state of Connecticut in 1996 was developed based on this methodology. See the following URL for details:
http://info.med.yale.edu/chldstdy/CTvoices/kidslink/kidslink2/reports/socialstate/ssindex.html

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Indicators of Sustainable Development: A Review of the Existing State of Knowledge

Jonathan Chenoweth

Abstract

As part of the process of working towards sustainable development there is a need to measure the level of sustainability of society and development, as well as trends over time in a simplified format. Indicators serve the functions of simplification, quantification, and communication of complex information. One of the most widely known methodologies for the selection of indicators is the Pressure-State-Response (PSR) framework put forward by the OECD. This model is based upon the concept that pressures are exerted by human activities on the state of the environment and natural resources, with there being a response to these changes through a variety of environmental, economic, and sectoral policies. Due to the limitations of the PSR framework, such as it assumption of simple linear linkages between the different pressures, states, and response categories of the framework, or its inadequate attention towards economic and social aspects of sustainable development, this framework can only serve as a general indication of what sustainability indicators might encompass.

Variations on the PSR framework include the Driving force- state- response (DSR) framework adopted by the UN Commission on Sustainable Development (UNCSD). This framework recognizes that human activities can be positive or negative, and permits the inclusion of economic, social, and institutional aspects relating to sustainable development. Testing of the DSR framework developed by the UNCSD by individual countries has revealed that the many of the indicators selected do not reflect sustainable development, as it is generally conceived, specifically enough, and the lack of any integration of social, economic, and environmental issues within this framework was found to be a major shortcoming. Alternative frameworks to the PSR, DSR and other derived frameworks are under development by national bodies, such as the French Institute of the Environment, and seek to avoid the limitations of these frameworks.

Reference values are useful in assisting with the interpretation of indicators while the aggregation of indicators can be useful when trying to access overall progress towards sustainable development; both can be difficult to achieve in a way that is meaningful. Issues of scale make the selection of indicators difficult as what is appropriate at a national scale may be meaningless at a local scale, and practical considerations can limit the types of indicators that can be incorporated into an indicator framework. The development of a central indice of sustainable development for a national framework is not useful as the purpose at this level is not to compare countries but rather to identify the existing situation and internal trends within the country.

Introduction

The concept of sustainable development has gained prominence over the last two decades, with notions of sustainability being included in many government policies around the world. As part of this process of working towards sustainable development, there has been a growing need to find ways to measure the real level of sustainability of society and development. This has led to the search for methods of selecting sustainable development indicators, as well as indicators themselves.

Definitions

According to Lusigi (1995) sustainability is not a new concept but is tied in with the basic human desire to survive; the notion of sustainable yield, however, has been applied scientifically to resources management since the late 19th century. More recently, the concept of sustainability has served as a significant focus of renewed environmental attention (Simpson, 1996).

There is no universally accepted definition of sustainable development with there being more than 70 definitions of the term given in the literature (UNEP, 1995). There are two frequently cited and relatively widely accepted definitions of sustainable development. One of these is the definition given by the World Commission on Environment and Development (1987, p43) in *Our Common Future* (or the Brundtland report) stating that "Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs". The other major internationally accepted working definition of sustainable development is the whole of *Agenda 21*, the document resulting from the United Nations Conference on Environment and Development held in Rio de Janeiro in June 1992 (Dahl, 1997). It is a very wide ranging definition that covers issues ranging from housing provision, social structures, equal opportunity, and greater empowering of indigenous people, women, and young people in environmental decision making (Simpson, 1996).

In the context of the Mediterranean, the UNEP proposed that sustainable development could be considered as "Development which is respectful of the environment, technically appropriate, economically viable and socially acceptable to the meet the needs of present generations without endangering the possibility of future generations to satisfy theirs" (UNEP, 1995, p9).

The definition of sustainable development is further developed (and complicated) by some authors, such as Serafy (1996) and Noel and O'Connor (1998) who use terms strong and weak sustainability. Weak sustainability holds that sustainability can be maintained by substituting human and manufactured capital for natural capital, whereas the concept of strong sustainability holds that human capital is not a substitute for natural capital since the two are distinct and different (Noel & O'Connor, 1998). Depending upon which of these two definitions is chosen, there is a significant effect on how indicators of sustainability are chosen and used.

The above definitions of sustainability provide a clear indication of what is meant by the term sustainable development but they do not necessarily provide a simple definition that readily allows the degree of sustainability to be measured or to permit a development to be assessed as sustainable or unsustainable. Being able to do this is critical, however, if a meaningful set of indicators of sustainable development are to be compiled and used by policy makers. An alternative (and complementary) way of defining sustainability might be to form a negative definition and say that sustainable development is any development which is not unsustainable in the long term. This definition, advanced in the Israeli Sustainable Development Strategy, would have the advantage that it is easier to define what is unsustainable than agree upon what is sustainable.

Use of Sustainability Indicators

Concepts of sustainable development always involve timescales, but because most forms of development will involve the use of some resources which are renewable only on a geological time scale, sustainable development can really only be talked about in terms of increased degrees of sustainability (Simpson, 1996). Establishing sustainability indicators is a critical aspect to achieving sustainable development since indicators are needed to reveal progress towards development that is more sustainable (Luxem & Bryld, 1997). They are needed to reveal trends over time (Gallopin, 1997) and indeed Faucheux and O'Connor (1998) state that indicators by their very definition must refer to change over time.

Sustainability indicators are required to determine the direction of systems at the macro level and assist in formulating policy at this level while also providing information that is able to adequately support decision making at the micro level where action has greater impact (Rutherford, 1997). In short, they permit the evaluation of situations and trends compared with the foundations of sustainable development (UNEP, 1995) and are one of the tools necessary to achieve progress towards sustainable development (OECD, 1994).

According to the UK Department of Environment indicators serve three specific functions, namely simplification, quantification, and communication (UK DoE, 1996). Indicators serve to simplify and make complex phenomena communicatable. More specifically, they can also be used to link environmental impacts and socio-economic activity, while at the same time they may reduce the confusion potentially caused by large amounts of environmental and economic data (UK DoE, 1996). The degree to which indictors are able to fulfill these functions will depend upon whether or not indictor sets are appropriately constructed so that they will actually serve to simplify and convey information through a rational framework, rather than overwhelm policy makers with large quantities of information.

An indicator can be defined as "a parameter, or a value derived from parameters, which provides information about a phenomenon" (OECD, 1994, p8). Gallopin (1997) states that while indicators have been defined in many different ways by various scholars, including as parameters, measures, values, and as measuring instruments, indicators in their most general sense are signs, meaning that they are an image or abstraction which stands for something. Gallopin (1997) also notes that on a practical level indicators must be variables rather than values.

According to Bayliss and Walker (1996) the managerial approach to sustainability is the dominant approach and is based upon a positivist tradition. This approach conceives of the environment as objectively measurable, permitting the modelling of its processes, leading to the understanding of these processes that is required for their management. Indictor frameworks permit issues relating to environmental problems and their associated interconnections to be considered systematically (UK DoE, 1996).

Sustainability is often considered under the three broad headings of economic, social, and ecological sustainability, with these categories referring to both the system to be sustained as well as the types of units that may be used to measure the sustainability of the system (Faucheux & O'Connor, 1998). Faucheux et al (1998) argue, however, that methods which have received much popular attention, such as assessing sustainability through indicators which focus upon changes in capital stocks, both natural and manufactured, are empirically suspect in their approach.

Hodge et al (1995) examine the indicator needs of the different elements within a society, including individuals and households, communities, corporations, and the government. They note that all of these different groups within a society require indicators that allows them to assess how their activities impact upon the environment if they are to be aware of how their individual decisions impact upon the sustainability of development.

Sustainability indicators are related to but not the same as indicators used in state-of-the-environment reporting. State-of-the-environment reporting has gone from having a narrow focus on environmental and resource use in the 1970s to an examination of the relations between environmental and socio-economic processes within an overall focus upon sustainable development (Bosch, 2000).

Sustainable Development Indictor Frameworks

Adopting some sort of methodological framework for the selection and ordering of indicators is of fundamental importance if a meaningful set of indicators is to be selected which will permit effective assessment of progress towards sustainable development.

The Pressure-State-Response Framework

Just as there is no universally accepted definition of sustainable development, there is not yet a universally accepted framework that permits assessment of whether development is becoming more or less sustainable (UK DoE, 1996). One of the more widely known and discussed methodologies for the selection of indicators is the Pressure-State-Response (PSR) framework put forward by the Organisation for Economic Co-operation and Development (OECD). This model is based upon the concept that *pressures* are exerted by human activities on the *state* of the environment and natural resources, with there being a *response* to these changes through a variety of environmental, economic and sectoral policies (OECD, 1994). The PSR framework refers to three broad categories of sustainability indicators, indicators of environmental pressures, indicators of environmental conditions, and indicators of societal responses. Indicators of environmental pressures, (relating to the *pressure* category of the PSR framework), describe environmental pressures resulting from human activities (OECD, 1994). Indicators of environmental conditions, relating to the *state* category of the PSR framework, describe the quality of the environment and the quality and quantity of natural resources with such indicators intended to give an overview of the state of the environment and its development over time (OECD, 1994). Indictors of societal responses, relating to the *response* category of the PSR framework, measure the degree to which society, both through individual and collective actions, is responding to environmental concerns (OECD, 1994). The OECD (1994) notes that although the PSR framework is based on the concept of causality and tends to suggest linear relationships of human-environment interaction, this should not prevent more complex human-environmental interactions being observed.

A summary of the OECD indicators, showing how they relate to the PSR framework is given in Table 2.1.

Tables 2.1: Summary of the OECD indicators. (Source: OECD, 1994, p14).

Issue	**Pressure:** Indicators of environmental pressures	**State:** Indicators of environmental conditions	**Response:** Indicators of societal responses
Climate Change	-Index of greenhouse gas emissions -CO2 emissions	-Atmospheric concentration of greenhouse gases -Global mean temperature	-Energy efficiency -Energy intensity -Economic and fiscal instruments
Ozone layer depletion	-Index of apparent consumption of ozone deleting substances -Apparent consumption of CFCs and halons	-Atmospheric concentrations of ozone depleting substances -Ground level UV-B radiation	-CFC recovery rate
Eutrophication	-Emissions of N and P in water and soil -N from fertilizer use and from livestock -P from fertilizer use and from livestock	-BOD / DO, concentrations of N and P in inland water and in marine waters.	-% of population connected to biological and / or chemical sewage treatment plants -% of population connected to sewage treatment plants -User charges for waste water treatment -Market share of phosphate-free detergents
Acidification	-Index of acidifying substances -Emissions of NOx and SOx	-Exceedance of critical loads of pH in water and soil -Concentrations in acid precipitation	-% of car fleet equipped with catalytic converters -Capacity of SOx and NOx abatement equipment of stationary sources

Issue	**Pressure:** Indicators of environmental pressures	**State:** Indicators of environmental conditions	**Response:** Indicators of societal responses
Toxic contamination	-Emissions of heavy metals -Emissions of organic compounds -Consumptionof pesticides	-Concentration of heavy metals and organic compounds in environmental media and in living species -Concentration of heavy metals in rivers	-Changes of toxic contents in products production and processes -Market share of unleaded petrol
Urban environmental quality	-Urban air emissions: SOx, NOx, VOC -Traffic density (urban and national) -Degree of urbanization	-Population exposure to air pollution and noise -Ambient water conditions in urban areas	-Green space -Economic, fiscal, and regulatory instruments -Water treatment and noise abatement expenditures
Biodiversity / landscape	-Habitat alteration and land conversion from natural state	-Threatened or extinct species as a share of total species known	-Protected areas as a % of national territory and type of ecosystem
Waste	-Waste generation: municipal, industrial, nuclear, and hazardous	Not Applicable	-Waste minimization -Recycling rate -Economic and fiscal instruments, expenditures
Water resources	-Intensity of use of water resources	-Frequency, duration and extent of water shortages	-Water prices and user charges for sewage treatment
Forest resources	-Actual harvest / productive capacity	-Area, volume and structure of forests	-Forest area management and protection
Fish resources	-Fish catches	-Size of spawning stocks	-Forest area management and protection

Issue	**Pressure:** Indicators of environmental pressures	**State:** Indicators of environmental conditions	**Response:** Indicators of societal responses
Soil degradation (desertification and erosion)	-Erosion risks: potential and actual land use for agriculture -Changes in land use	-Degree of top soil losses	-Rehabilitated areas
General indicators not attributable to specific issues	-Population growth and density -Growth of GDP -Private final consumption expenditure -Industrial production -Structure of energy -Road traffic volumes -Stock of road vehicles -Agricultural production	Not Applicable	-Environmental expenditures -Pollution control and abatement expenditures -Public opinion

Problems with the PSR framework

The above framework outlined in Table 1.1 outlines a large number of potential indicators of changes in pressures, states, and responses relating to human interaction with the environment. Unfortunately for many of the indicators given, measurement in any meaningful way is either extremely complex or even impractical, and for other indicators careful and detailed definitions are needed first before they can be used. Examples include "Green space" appearing in the Response section of the Urban environmental quality category. Quantifiably measuring this in a meaningful way across time within a single country or city, or in a comparison of several countries is problematic since the value of green space to society does not depend so much upon its total area but the relative significance of the green spaces which are preserved. Green space in the central business district of a large city has much greater significance than green reservations appearing in a predominantly rural area. The value of any given piece of green space will also depend upon how it is managed or developed. Wasteland does not necessarily have the same value to a community as well managed parkland. Similarly, the preservation of small areas of habitat that support endangered species is more significant than the preservation of large areas of less critical land, and wildlife corridors can also have a significance beyond which can be measured in land area alone.

Other problematic variables appearing in the OECD list of indicators include "Population exposure to air pollution", which is again difficult to measure meaningfully. Similarly "Water treatment and noise abatement expenditures" is also problematic. A decrease in spending may be good since it might indicate that problems are decreasing, thus requiring reduced expenditure, or may indicate that sustainability is decreasing due to reduced attention being applied to a significant and continuing problem.

"Waste minimization" and "Recycling rate" are also extremely complicated. For some products, life cycle analysis may indicate that recycling is not the most environmentally sustainable option, and in some countries or regions, recycling generally may have a greater economic and environmental cost than benefit. This would frequently be the case, for example, in desert regions where population is sparse. In such regions, transport and processing costs (both economic and environmental) for recycling will be high while landfill sites may be plentiful. Similarly, in relation to water prices, rising prices may represent increased or decreased sustainability and will depend upon the conditions present in a country, both economic and environmental.

With the examples of problems outlined above, the pressure, state, response framework can only serve as a general indication of what sustainability indicators might encompass, rather than a definitive and practical set of indicators. Furthermore because significant further development on a country-by-country basis or region-by-region basis is still required, the different practical sets of indicators that are developed based on this framework will not necessarily be comparable between regions or countries.

There is a significant amount of discussion in the literature relating to the PSR framework of the OECD. Mortensen (1997) notes that the term "pressure" is not an exact description of human impacts in relation to sustainable development since such impacts may be both positive and negative. Rutherford (1997) also notes problems with the framework, pointing out that there are problems linking pressures, states, and responses within single countries (due to external environmental impacts) which have caused many analysts to conclude that it is best to focus only on pressure indicators. Others, like Gallopin (1997), note that users of the PSR framework are often tempted to use the simple linear linkages of the different pressures, states, and responses suggested by the framework mechanistically with this resulting in invalid inferences and wrong policy recommendations. The feedback loop between environmental and human interactions is missing from the PSR framework (UNEP, 1995). Certainly the linkages suggested by the pressure, state, response framework are rather simplistic and possibly not particularly useful in assisting policy makers. Another problem with the PSR framework of the OECD is that the indictors are essentially descriptive, and contain no threshold values or norms against which sustainability can be evaluated (Boisvert *et al.*, 1998).

The UK Department of the Environment (1996) in relation to the PSR framework and its own selection of sustainability indicators found that it was necessary to modify the framework in order to assess progress towards sustainable development as a whole rather than just the more limited environmental focus of the PSR framework. The indicators chosen by the Department of the Environment were chosen to also reflect the state of the economy as well as that of the environment (UK DoE, 1996). In a similar vein, Gallopin (1997) adds that even when considered as an environmental indicator framework only, the PSR framework is useful for ordering indicators but the task of establishing indicators with functional causality of human and environmental interactions remains. Doing this, however, is critical to forming an indicator framework that can effectively assist policy makers.

Variations to the PSR framework

The PSR framework of the OECD has formed the basis of other sustainable development indicator frameworks which have been developed subsequently or adopted by individual countries. Notable among these is the Driving force — State — Response (DSR) framework that was adopted by the United Nations Commission on Sustainable Development in 1995 (Mortensen, 1997). This framework is essentially an adaptation of PSR framework of the OECD. It recognizes that the impact of human activities can be both positive and negative, unlike the term "pressure" of the PSR framework (Mortensen, 1997). The term driving force also permits the inclusion of economic, social, and institutional aspects relating to sustainable development.

The different categories of sustainable development and every chapter of *Agenda 21* is reflected in the DSR framework in which there is a distinction between the different categories of sustainable development, namely social, economic, environmental, and institutional. A number of criteria for the selection of indicators for the framework by the United Nations Commission on Sustainable Development are outlined by Mortensen (1997). The indicators selected on the basis that they are:

primarily national in scale or scope

relevant for assessing progress towards sustainable development

readily understandable

within the general capacities of national governments

conceptually well-founded

limited in number but adaptable to future requirements

relevant to *Agenda 21*

largely reflective of international consensus

dependant upon accessible data.

Approximately 130 indicators were approved by the United Nations Commission on Sustainable Development at its third work session in April 1995 (United Nations Commission on Sustainable Development, 1996). The indicators of the DSR framework are not linked causally either horizontally or vertically by this framework. Mortensen (1997) states that this has the advantage that the framework does not make simplistic assumptions on the basis of difficult to establish causal links, and when the framework is used indicators can be selected on the basis of whether or not they fulfil the criteria outlined only rather than to fill out a specific cell in a framework.

Berger (1997) notes that there may be serious difficulties with the DSR framework if it assumes that rapid environmental change is always the result of human activity while natural change is gradual, benevolent and predictable. He argues that when assessing progress towards sustainable development, the effects of natural processes and change must also be acknowledged. Such considerations must certainly apply to processes such as climate change, where scientific evidence suggests huge natural variation in the past.

The UNCSD's set of sustainable development indicators was tested by a number of countries around the world between 1996-99, including eight European nations (Kristensen, 2001). Following reviews at UNCSD workshops and a joint EEA Eurostat workshop in 1998 it was found that many of the UNCSD's proposed indicators were already in regular use in Europe, and several of the proposed indicators were not relevant for evaluating sustainabile development in European countries, with there being a need to develop a set of indicators more relevant to monitoring sustainable development in EU states.

Institute Francais de l'Environment (IFEN) in their testing and review of the UNCSD's set of sustainable development indicators found that the greatest problem with the indicator set was that it did not reflect sustainable development as defined in the Bruntland report specifically enough (Institut Francais de l'Environment, 1998). Furthermore, the integration of the social, economic and environmental issues relating to sustainable development is crucial, with the absence of this placing a severe limitation on the framework as a means of monitoring progress towards more sustainable development (Institut Francais de l'Environment, 1998). Some of the indicators in the UNCSD's list were also found to be inappropriate for countries with high levels of social and economic development, such as France, and some of the indicators were specific to certain types of environments not found in a country such as France. It was for these reasons that the IFEN did not feel that it was appropriate to use the UNCSD's set of indicators for as the basis of France's sustainable development indicators.

The DSR indicator framework is more comprehensive in its coverage than that of the PSR framework, even if it completely lacks any linkages between the different indicators. While economic and social sustainability and many of the issues discussed in *Agenda 21* may be assessed through the use of this framework, other areas of sustainable development are still completely ignored. Dahl (1997) notes that there are other aspects of development equally critical to overall sustainable development which have largely escaped measurement and accountability. He gives the example of legal sustainability, noting that legal systems are built up over generations and are continually being adapted and changed; he asks whether or not it might be possible when assessing sustainable development to assess the degree to which a country's legal system is meeting its needs or whether it has become cumbersome and counter-productive. How this could be practically done, however, is another matter.

Other issues that indictors of sustainability could assess include social cohesion, and moral, ethical, and spiritual sustainability as these are all central to human interaction and must support development (Dahl, 1997). Dahl (1997) suggests that a society might appear to be materially successful while it is losing its moral core, and then later decline into anarchy. Spiritual and cultural sustainability must play an indirect but critical role in a society working towards development that is more sustainable since spiritual and cultural beliefs can have a major impact on daily patterns of life. Where such beliefs induce non-sustainable trends or practices, overall progress towards sustainability might be hindered. Examples of this might include beliefs and practices that promote unsustainable birth rates or the use of products derived from endangered plants and animals. Deriving indicators to measure spiritual and cultural sustainability is likely to be even more problematic than doing this for legal sustainability.

The first set of indicators of sustainable development produced by the UNCSD was revised during 1999 and 2000, with a new core set of 57 indicators then being proposed (Kristensen, 2001). This set is structured into 15 themes, such as health or atmosphere, and 38 sub-themes. Examples of sub-themes for the health theme include sanitation and drinking water, while sub-themes for atmosphere include climate change, ozone layer depletion and air quality (Kristensen, 2001).

Alternatives to the PSR (and variations) framework

The work of the French Institute of the Environment

At the French Institute of the Environment (IFEN) it is believed that there are four possible ways to deal with the development of sustainable development indicators (Lavoux *et al.*, *pers. comm.,* 2001). These are:

- Recycling of environmental indicators.
- Making use of international experiences at producing sustainable development indicators, including the work of the UNCSD, OECD, and others.
- Developing performance indicators that relate to sustainable development strategies.
- Starting from scratch to build a new system of sustainable development indicators.

The first option, recycling environmental indicators was thought by the IFEN to be too narrow since it doesn't permit the adequate consideration of the social and economic aspects of sustainable development, while the third option, developing performance indicators that relate to a sustainable development strategy is only possible in countries with an officially accepted (and detailed) strategy of sustainable development.

The second and fourth of the above options were adopted by IFEN in their development of sustainable development indicators (Lavoux *et al*., *pers. comm.,* 2001). The second option, making use of international experiences in the development of sustainable development indicators, in particular the PSR and its derived frameworks was not adopted for the basis of sustainable development indicators as such, but rather as the basis of environmental reporting due to the limitations of this framework noted in the previous section. Hence, a PSR type framework (and other international experiences) are used by the IFEN for environmental reporting simultaneously together with the IFEN's own framework that is specific to sustainable development indicators (Lavoux *et al*., *pers. comm.,* 2001).

The IFEN has produced a modular sustainable development indicator framework structure, consisting of ten modules (Rechatin *et al*., 1997). These are:

1. Assessing development
2. Linking flows and stocks
3. Status of heritage
4. Geographical distribution
5. Links with the external world
6. Social distribution of assets and nuisances
7. Access to heritage assets
8. Description of preference and grievances
9. Trust / mistrust in the future
10. Resilience and flexibility

These modules and how they interrelate is outlined in a schematic diagram / model in Figure 2.1. The object is to assess to what extent the dynamics and structure of a given type of development (module 1) are likely to meet the needs of present and future generations (modules 6 to 9) while also ensuring appropriate renewal of required capital and assets in their different forms (modules 2 to 5) (Rechatin *et al.*, 1997). In addition, module 10, attempts to introduce the notion of unforeseeable circumstances and assesses how the activity system described is able to respond to external events. Although the modules are inter-linked, they are assembled in such a way as to allow each one to be described and assessed independently of the others (Rechatin *et al.*, 1997).

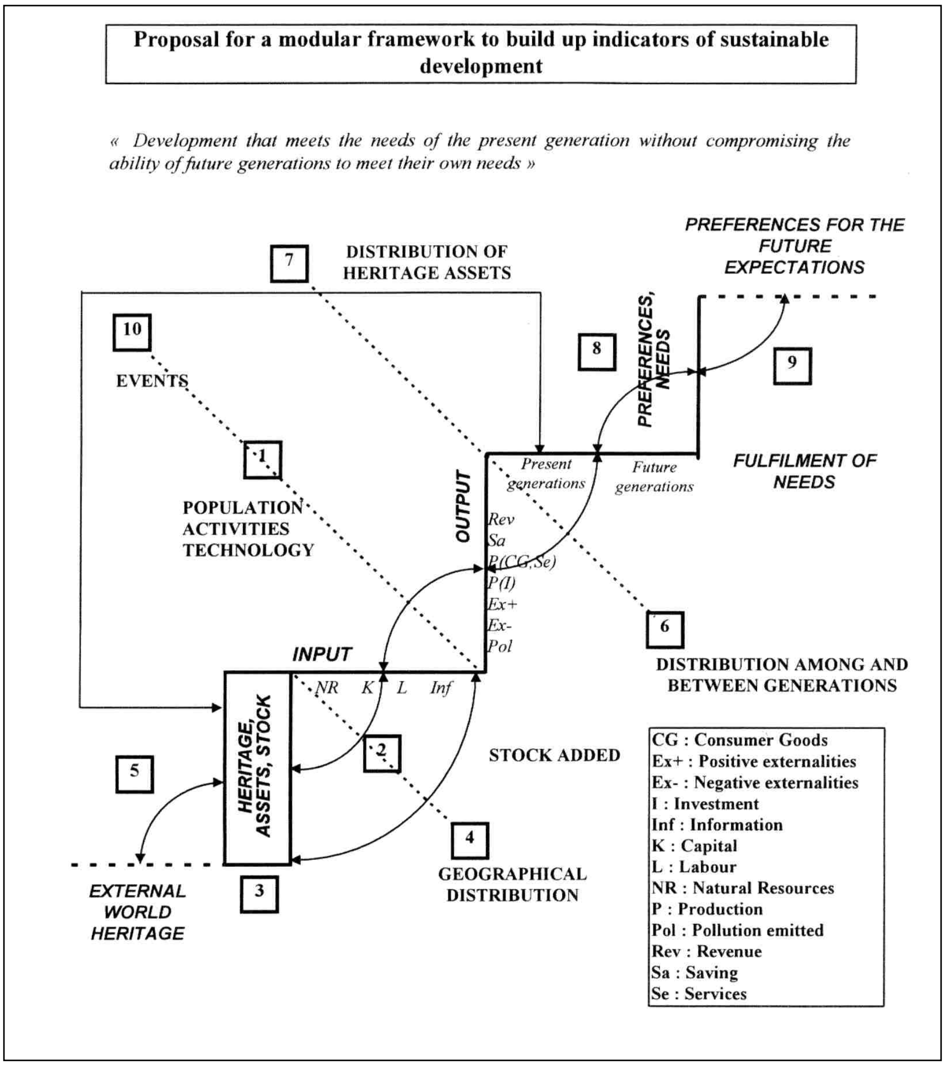

Figure 2.1: The IFEN modular framework for sustainable development indicators. (Source: Rechatin, C., Theys, J., Lavoux, T., & Piveteau, V., (1997) *Indicators of sustainable Development: A synopsis of work abroad and key points of Discussion*. IFEN. Orleans. France.

The core module, assessing development, focuses upon assessing the extent to which an increase in an activity is associated with an increase in resource use or pollution (Rechatin *et al*., 1997). This module also assesses the scale of activities, products, or services which are linked to the environment. A time element is included and thus a distinction is made between investment and consumer goods, durable and non-durable goods, in terms of pollution between persistent and non-persistent pollution, and for resource use whether nor not use is reversible or non reversible.

Modules 2 to 5 focus upon the quality of heritage and capital (Rechatin *et al*., 1997). Module 2, linking flows and stocks, links data on flows of natural resources, investment, pollution, etc. with data on stocks. This permits ratios, such as pollution flow / pollution stock, or resource use / stock increase, to be calculated. This module also allows assessments of rates of capital recharge, and the balance between labour demand and supply. Module 3 focuses upon the current state of heritage, linking up national and local approaches to construct indicators of wealth. Module 4, geographical distribution, permits the inclusion of indicators of density and indicators of carrying capacity, and permits inter-zone comparisons. Module 5 takes the geographical dimension a step further by linking national data with international and global data (Rechatin *et al*., 1997).

Modules 6 to 9 encompass indicators relating to the meeting of the needs of present and future generations (Rechatin *et al*., 1997). They focus upon questions of needs and their fulfillment rather than heritage and wealth issues. Module 6, social distribution of assets and nuisances, links output from productive systems to the fulfillment of present and future needs, while considering distribution mechanisms between both current and future generations. Module 7 looks at access to heritage assets, while module 8 describes the relationships between preferences and their fulfillment together with associated institutional regulatory mechanisms, building up a picture of preferences and mechanisms for handling dissatisfaction. Module 9, trust / mistrust in the future, adds a temporal dimension to the consideration of preferences by describing to what extent do preferences reflect a bias in favour of the present or of the future (Rechatin *et al*., 1997). This module contains indicators measuring things such as long-term interest rates, debt and savings ratios, etc.

Module 10, reliance and flexibility, differs from the other modules which are all based upon continuity in trends. This module assesses the ability of a society, an economy, or an ecosystem to adapt to unforeseeable event and major upheavals (Rechatin *et al*., 1997).

At this stage France is envisaging a maximum of 80 indicators of sustainable development. While it is recognized that a smaller number of indicators is good theoretically, this is very difficult to achieve in practice (Lavoux *et al.*, *pers. comm.,* 2001). These indicators are being selected by committees, beginning in 1998-99 with three committees (Lavoux *et al.*, *pers. comm.,* 2001). The three committees were economic, social, and geographical scales and the environment, with about 20 to 30 people in each committee. The committees tried to be multidisciplinary in their approach rather than just focus on their specific area. Initially they worked separately before a plenary session of the combined committees was held. As a result of this brainstorming session, a preliminary list of 20 headings was produced. In 2000-01 about ten people were involved in brainstorming exercises to produce a list of 300 indicators. This list has subsequently shortened to 80 indicators, with the modular structure outlined above being developed.

Interpretation and use of indicators

The OECD (1994) notes that different users of indicators will have different needs but that generally indicators are only one form of environmental evaluation and should be supplemented with qualitative and other information. The UNEP (1995) adds that indicators should be presented to users clearly in appropriate formats, such as maps for geographical data and graphics for statistical trends. Niessen et al (1995) make essentially the same point when they state that it is crucial to use appropriate visualization techniques. As larger numbers of indicators are included within an indicator framework this must become ever more important.

The IFEN in France expects that its sustainable development indicators will be used for the benefit of the public, decision makers, researchers, and so on (Lavoux *et al.*, *pers. comm.,* 2001). Being able to influence decision makers is seen as being important, with decision makers being particularly sensitive to public opinion. Therefore working with the media to reach the public and thus indirectly reach decision makers is necessary.

Targets for indicators

The UK Department of the Environment (1996) argues that the interpretation of indicators is facilitated by having targets or guideline levels against which indicators can be compared, with such targets ideally corresponding to paths that can be sustained in the long term. This same concept is also discussed by the Niessen et al (1995) who refer to the term reference values, the desired numerical or nominal value of indicators. They argue that without adequate reference values changes in indicator values do not necessarily have any meaning. Reference values also facilitate comparisons across environmental issues.

Alternatively to having target values against which indicators are measured, a more practical alternative may be to have values which indicate non-sustainability. This relates back to the alternative definition of sustainability proposed in the introduction whereby sustainable is defined as something which is not unsustainable. Such values of non-sustainability may need to be two tiered. The first tier would be the value for an indicator which if maintained in the long term is unsustainable but which if exceeded in the short term is of relatively minor concern. The second tier would be the value for an indicator beyond which essentially irreparable damage on society or the environment is inflicted. In terms of a nation's economic growth, slight negative growth is not un-sustainable in the short term but is unsustainable in the long term. Complete economic collapse, however, is completely unsustainable even in the short term. In terms of water resources use, water can be pumped at a level above the average annual rate of replenishment from a reservoir or aquifer during times of drought, thus passing the first tier of non-sustainability, but if such a rate of pumping continues indefinitely then permanent damage to the water resources will eventually be sustained.

Aggregation of indicators

According to Dahl (1997), building an overall perspective when assessing progress towards sustainable development requires the assembly of many specific dimensions and interrelationships, with this aggregation raising complex technical and methodogical issues. Despite the problems that doing this raises, Samuel-Johnson et al (2000) argue that there is a need for an environmental sustainability index, expressed as a single measure for each economy, which would function similarly to that of Gross Domestic Product, acting as a benchmark for judging progress towards sustainable development rather than economic growth.

Traditionally, economic approaches of aggregation have involved converting all measures into monetary values but this requires the generation of surrogate values for non-market goods (Dahl, 1997). Another issue raised by Dahl (1997) is that of the relative weight which is given to the different indicators in any aggregation, with this being heavily influenced by value judgments and cultural biases. Furthermore, because some pollutants are of no significance at low concentrations but their environmental effect will sharply increase at higher concentrations, each indicator component must be individually assessed and weighted, at times, on a non-linear scale (Dahl, 1997). The issue of choosing weighting schemes is further discussed by Jesinghaus (1997) who notes that weighting can be carried out through direct monetisation processes, expert assessments, public opinion polls, policy targets, through policy targets combined with the avoidance of costs, and implicit weighting.

Some attempts have been made to produce quantifiable indexes of sustainability. Munasinghe and McNeely (1995) propose a Biophysical Sustainability Index (BSI) which is composed of a Net Primary Productivity Factor (NPPF) that largely represents economic concerns, and a Biological Diversity Factor (BDF) which largely represents ecological aspects. According to this index, a figure for the level of biophysical sustainability can be found by multiplying the net primary productivity factor with the biological diversity factor. (ie BSI=NPPFxBDF.)

NPPF in turn is defined as the ratio of Annual Net Primary Production (ANPP) over the region for a given year less the ANPP of the region for the previous year. ANPP is equal to the Primary Production of Annuals (PPA), and the Primary Production of Perennials (PPP), less the Harvested Primary Capital of Perennials (HPCP). (ie ANPP=PPA+PPP-HPCP.) Munasinghe and McNeely (1995) state that the data needed to calculate ANPP is obtainable through the use of GIS. Other sources of some of the data might include the national or regional economic accounts available from a nation's national statistical office.

BDF is defined as the ratio of the Current Selected Biological Diversity (CSBD) of the region to the Natural Selected Biological Diversity (NSBD) of the same region. CSBD and NSBD refer respectively to the number of species of a set taxa which thrive in the region currently, and prior to human intervention.

Therefore:

$$BSI=\{(PPA+PPP-HPCP)_y / (PPA+PPP-HPCP)_{y-1}\}\{CSBD / NSBD\}$$

The problem with any attempt to aggregate sustainability indicators is that final result, when reduced to a single or small number of parameters is that the final value obtained is so dependent upon the weighting used to for its derivation. Small changes (or refinements) in the methodology used for the aggregation can produce significant variation in the final result obtained, with the effects of such changes not necessarily being apparent or transparent to policy makers or the wider community. This potentially provides a means to permit manipulation of the final result without there being any real change in level of sustainability.

A more comprehensive attempt at producing quantified sustainability index is that developed by Samuel-Johnson et al (2000). This is an unweighted index of five components, 21 factors, and 64 variables. The components which make up the index are environmental systems, environmental stresses and risks, human vulnerability to environmental impacts, social and institutional capacity, and global stewardship. Factors of the environmental systems component were urban air quality, water quantity, water quality, biodiversity, and land, with all factors each being given equal weight in the overall index. Examples of the variables that were incorporated within the factors of the environmental systems component included average annual urban NO2 concentration, surface water resources per capita, dissolved oxygen concentration, percentage of known plant species threatened, and severity of human induced soil degradation. For each variable a normalized range of values from 0 to 100 was created, with no threshold of sustainability being defined, and countries being assigned a score from 0 to 100 depending upon where along the continuum they fell. For a few variables a scientifically defensible cap was applied whereby all countries beyond that point received either 0 or 100 for that variable (Samuel-Johnson *et al*., 2000). The lack of weighting of the different factors was a de-facto equal weighting of all the factors included in the index, with the final ranking of countries in the index being significantly influenced by the structuring of the index and the individual variables measured. Nonetheless, the index is a significant attempt to produce a sustainability index comparable to the of Gross Domestic Product index widely used to indicate economic development.

Sources of data and limitations of sustainability indictors

Limitations of indicators

When an activity or form of development is defined as sustainable, such an evaluation is made upon the basis of existing knowledge only, thus meaning that there may be a significant degree of uncertainty about how sustainable something is (Lusigi, 1995). The UK Department of the Environment (1996) argues that indicators are simplifications which relate only to areas which can be readily quantified and aggregated, with this meaning that issues which are easily measured and quantified (like pollutant concentrations) will be focused upon. Difficult to measure issues (like the quality of land management) will be largely ignored in sustainability indicators. Conversely, however, when there are too many indicators there is a risk that trends will be obscured (UK DoE, 1996, Rutherford, 1997).

One of the major potential problems and limitations when compiling sustainability indicators is that monitoring data relating to appropriate parameters may be unavailable. Bayliss and Walker (1996) note that monitoring programmes of countries are developed over many years and at times parameters monitored may relate more to historic concerns rather than contemporary issues. Indicators which are chosen will be biased towards readily available information or information which can be obtained at a reasonable cost (Gallopin, 1997).

Data incompatibility

At the international level there are frequently problems of data incompatibility between different countries (Bayliss & Walker, 1996). The problem is compounded by the fact that monitoring methodologies used for collecting the data are often unavailable despite being essential for meaningful comparisons. In the report produced by the United Nations Commission on Sustainable Development (1996) for each indicator listed there is a brief discussion of data availability and data sources, indicating whether or not suitable data is available (and compatible) internationally and what the best sources of such data are. Without such information being presented in an indicator framework, the framework is of questionable practical application.

Issues of scale

The UNEP (1995) raises the question about whether the concept of sustainable development, something which must be applied as a global concept, has any real meaning at the local level. They argue that although it will only be viable if implemented globally, it is at the local level at which actions for its implementation must be carried out. Essentially, every country is interlinked economically and environmentally with the rest of the world to a greater or lesser extent, with sustainability thus also being inter-linked, but the implementation of sustainable development occur through local actions.

Gallopin (1997) argues that different kinds of indicators will be relevant to different scales, with some indicators that are useful at one scale being meaningless at others. This same point is taken up by the UK Department of the Environment (1996) when they state that the indicators they present in their listing are national indicators and are not necessarily suitable for indicating sustainable development trends within a particular geographic area. Some indictors in their listing, however, such as pollutants could be measured both nationally and locally, permitting local areas to see how they compare with the national average (UK DoE, 1996). The term "national" of course varies considerably in its meaning from country to country, with many small countries being smaller than the individual regions within large countries. This makes the development of a set of indicators specifically for national use in multiple countries and also for comparing between countries very problematic

The UK Department of the Environment (1996) argues that for indicators suitable for assessing progress towards sustainable development at the local level it is important that a national consensus about what should be monitored be established in order to permit comparisons between different areas, even though local areas are free to set their own assessment processes. This same principle must apply at the international level, where it is important that countries try to adopt compatible sustainability indicator frameworks and actual indicators so that sustainability can be assessed on a global scale. As Simpson (1996) remarks, what may be sustainable at the local level may not be at the global level, giving the example of carbon dioxide emissions. A similar principle must apply regionally with some forms of resources use, such as international water resources, where sustainable use on a national basis can be meaningless. Transboundary issues of sustainability can only meaningfully be assessed on a transboundary basis which for some issues and regions may be extremely difficult.

Indicator selection

A few writers give specific lists of criteria for the selection of indicators of sustainable development. Gallopin (1997) lists the universal requirements and desirable properties of indicators as:

- the values of each indicators must be measurable or observable.
- data must be either obtainable through measuring and monitoring or already available.
- the methodology of data management and indicator construction must be transparent and standardized.
- financial, human and technical means for monitoring the indicators should be available.
- the indicators must be cost effective.
- political acceptability of the indicators at their scale of use must be achieved if they are to be used by decision makers.
- public participation in the use of indicators is desirable.

Mortensen (1997) lists the criteria for selecting indictors as used by the United Nations Commission on Sustainable Development as:

- indicators should be primarily national in scale or scope.
- relevant to the objective of assessing progress towards sustainable development.
- understandable and unambiguous.
- within the capacities of national governments.
- conceptually well founded.
- limited in number but adaptable to future requirements.
- relevant to *Agenda 21* and covering all aspects of sustainable development.
- representative of international consensus as much as possible.
- use suitable data which are already readily available or can be obtained at reasonable cost.

The UK Department of the Environment (1996) also lists criteria for indicator selection, based upon the work of the OECD. In terms of policy relevance and utility for users an indicator should:

- provide provide a representative picture of environmental conditions, pressures, or responses.
- be understandable and show trends over time.
- be responsive to environmental change.
- provide a basis for international comparisons.
- be national in scope or applicable at this scale.
- have reference values for comparison.

In terms of analytical soundness, according to the UK Department of Environment (1996), indicators should:

- be theoretically sound technically and scientifically.
- be based on international standards and international consensus about its validity.
- be capable of being linked to economic models, forecasting and information systems.

In terms of measurability, according to the UK Department of Environment (1996), indicators should:

- be based upon readily available data or data available at reasonable cost.
- depend upon adequately documented data of known quality.
- use data updated at regular intervals according to reliable procedures.

Conclusion

The review of theory and existing sets of indicators of sustainable development suggests that the development of theoretical ideas relating to indicator frameworks is considerably more advanced than the development of actual frameworks. Essentially there is a significant gap between theory and practice and no framework exists which encompasses all of the ideas and concepts developed in the theory. The OECD framework, for example, really only relates to one aspect of sustainability, environmental issues, although this framework does attempt some causative linkages between environmental pressures, states, and responses, but only in a superficial way. Other indicator sets, like that of the UK Department of Environment, while being based off the OECD indicator set, are more encompassing than the original OECD set but are still far from comprehensive and have not developed linkages between the different types of indicators adequately. The United Nations Commission on Sustainable Development has produced a more comprehensive set of indicators but its framework is completely lacking any linkages between different types of indicators. All of the frameworks examined have problems of ill-defined indicators or indicators proposed for the national scale which are really more appropriate on the local scale. The only possible exception to this is the indicator framework of the IFEN, but this is still under development.

Developing a comprehensive set of indicators of sustainable development which takes into consideration the theoretical considerations outlined in this review may require large multi-disciplinary teams of experts if causative relationships between indicators are to be established and a framework with all the different interlinkages between driving force, state and response indictors is to be established. Linkages must also be developed between the indicators in the different broad areas of social, economic, and environmental sustainability. Multi-disciplinary expertise is needed to choose parameters which are appropriate on a national scale (assuming this remains the preferred scale for indicator frameworks) but still able to give an adequate picture of what is happening locally, since it is at the local scale where sustainable development must occur.

There is much less experience of sustainable development indicator frameworks at the national level relative to the international level. Furthermore, because international frameworks of sustainable development cannot necessarily be adequately adopted to the national level, it may be necessary to consider alternatives to the PSR framework and its variations. The development of a central indice of sustainable development for national frameworks is not useful as the purpose is not to compare countries but rather to identify the existing situation and internal trends.

Appendix 1: Lists of indicators

In addition to the list of OECD indicators some other lists of indicators are given below.

Table 2.2: Indicators of sustainable development for the United Kingdom, as presented in the UK Department of the Environment. (Source: UK DoE, 1996).

Broad Aims	**Sub category**	**Key indicators**
A healthy economy should be maintained to promote quality of life while at the same time protecting human health and the environment in the UK and overseas, with all participants in all sectors paying the full social and environmental costs of their decisions	The economy	-Gross Domestic Product -Structure of the economy -Expenditure components of GDP and personal savings -Consumer expenditure -Inflation -Employment -Government borrowing and debt -Pollution abatement expenditure -Infant mortality -Life expectancy
	Transport use	-Car use and total passenger travel -Short journeys -Real changes in the cost of transport -Freight traffic
	Leisure and tourism	-Leisure journeys -Air travel
	Overseas trade	UK imports and exports

Broad Aims	**Sub category**	**Key indicators**
Non-renewable resources should be used optimally	Energy	-Depletion of fossil fuels -Capacity of nuclear and renewable fuels -Primary and final energy consumption -Energy consumption and output -Industrial and commercial sector consumption -Road transport energy use -Residential energy use -Fuel prices in real terms
	Land use	-Land covered by urban development -Household numbers -Re-use of land in urban uses for development -Stock and reclamation of land -Road building -Out-of-town retail floor space -Regular journeys -Regeneration expenditure -Green spaces in urban areas
Renewable resources should be used sustainably	Water resources	-Licensed abstractions and effective rainfall -Low flow alleviation -Abstractions by use -Abstractions for public water supply -Demand and supply of public water -Abstractions for spray irrigation
	Forestry	-Forest cover -Timber production -Ancient semi-natural woodland -Tree health -Forest management

Broad Aims	**Sub category**	**Key indicators**
	Fish resources	-Fish stocks -Minimum Biological Acceptable Level (MBAL) -Fish catches
Damage to the carrying capacity of the environment and the risk to human health and biodiversity from the effects of human activity should be minimized.	Climate change	-Global greenhouse gas radiative forcing rate -Global temperature change -Emissions of greenhouse gases -Power station emissions of carbon dioxide
	Ozone layer depletion	-Calculated chlorine loading -Measured ozone depletion -Emissions of ozone depleting substances -CFCs consumption
	Acid deposition	-Exceedences of provisional critical loads for acidity -Power station emissions of sulphur dioxide and nitrogen oxides -Road transport emissions of nitrogen oxides
	Air	-Ozone concentrations -Nitrogen dioxide concentrations -Particulate matter concentrations -Volatile organic compound emissions -Carbon monoxide emissions -Black smoke emissions -Lead emissions -Expenditure on air pollution abatement

Broad Aims	Sub category	Key indicators
	Freshwater quality	-River quality — chemical and biological -Nitrates in rivers and groundwater -Phosphorus in rivers -Pesticides in rivers and groundwater -Pollution incidents -Pollution prevention and control -Expenditure on water abstraction, treatment and distribution Expenditure on sewage treatment
	Marine	-Estuarial water quality -Concentrations of key pollutants -Contaminants in fish -Bathing water quality -Inputs of contaminants -Oil spills and operational discharges
	Wildlife and habitats	-Native species at risk -Breeding birds -Plant diversity in semi-improved grassland -Area of chalk grassland -Plant diversity in hedgerows -Habitat fragmentation -Lakes and ponds -Plant diversity in streamsides -Mammal populations -Dragonfly distributions -Butterfly distributions

Broad Aims	**Sub category**	**Key indicators**
	Land cover and landscape	-Rural land cover -Designated and protected areas -Damage to designated and protected areas -Agricultural productivity -Nitrogen usage -Pesticide usage -Length of landscape linear features -Environmentally managed land
	Soil	-Soil quality -Heavy metals in topsoils
	Mineral extraction	-Aggregates output -Aggregates from wastes -Mineral workings on land -Land covered by restoration / aftercare conditions -Reclamation of mineral workings -Aggregates dredged from the sea
	Waste	-Household waste -Industrial and commercial waste -Special waste -Household waste recycling and composting -Materials recycling -Energy from waste -Waste going to landfill
	Radioactivity	-Radiation exposure -Discharges from nuclear installations and nuclear power generation -Radioactive waste arisings and disposal

Despite the length of the above list, a number of critical indicators have not been included. For example, the section specifying indicators of economic sustainability does not include any indicator for assessing the distribution of wealth nor the prerelevence of poverty in society, but this is critical to achieving sustainable economic development, and use of public transport is not assessed in a meaningful way. Other indicators in the list are too general in their present form to be of real use to policy making. For example, the indicator "Depletion of fossil fuels" would be a more useful indicator of progress towards sustainability if it were split up into each of the major fossil fuel types.

The greatest problem with the above list of indicators is that many of the indictors listed can only be meaningfully measured on a point specific or local / regional basis, meaning that any national figure that might be produced would be almost meaningless. Examples of such indictors, to name but a few are tree health, particulate matter concentrations, river quality, habitat fragmentation, and heavy metals in top soils. To measure many of these measures on a national basis would each require major studies that would not permit a meaningful national figure to be derived.

Table 2.3: Indicators of sustainable development as developed by the United Nations Commission on Sustainable Development. (Source: UNCSD, 1996).

Chapters of *Agenda 21*	**Driving force indicators**	**State indicators**	**Response indicators**
Category: Social			
Chapter 3: Combating poverty	-Unemployment rate	-Head count index of poverty -Squared poverty gap index -Gini index of income inequality -Ratio of average female wage to male wage	

Chapters of *Agenda 21*	**Driving force indicators**	**State indicators**	**Response indicators**
Chapter 5: Demographic dynamics and sustainability	-Population growth rate -Net migration rate -Total fertility	-Population density	
Chapter 36: Promoting education, public awareness and training	-Rate of change of school-age population -Primary school enrolment ratio (gross and net) -Secondary school enrolment ration (gross and net) -Adult literacy rate	-Children reaching grade 5 of primary education -School life expectancy -Differences between male and female school enrolment ratios -Women per hundred men in the labour force	-GDP spent on education
Chapter 6: Protecting and promoting human health		-Basic sanitation: percent of population with adequate excreta disposal facilities -Access to safe drinking water -Life expectancy at birth -Adequate birth weight -Infant mortality rate -Maternal mortality rate -Nutritional status of children	-Immunisation against infectious childhood diseases -Contraceptive prevalence -Proportion of potentially hazardous chemicals monitored in food -National health expenditure devoted to local health care -Total national health expenditure related to GNP

Chapters of *Agenda 21*	**Driving force indicators**	**State indicators**	**Response indicators**
Chapter 7: Promoting sustainable human settlement development	-Rate of growth of urban population -Per capita consumption of fossil fuel by motor vehicle transport -Human and economic loss due to natural disasters	-Percent of population in urban areas -Areas and population of urban formal and informal settlements -Floor areas per person -House price to income ratio	-Infrastructure expenditure per capita
Category: Economic			
Chapter 2: International co-operation to accelerate sustainable development in countries and related domestic policies	-GDP per capita -Net investment share in GDP -Sum of exports and imports as a percent of GDP	-Environmentally adjusted Net Domestic Product -Share of manufactured goods in total merchandise exports	
Chapter 4: Changing consumption patterns	-Annual energy consumption -Share of natural resource intensive industries in manufacturing value-added	-Proven mineral reserves -Proven fossil fuel energy reserves -Lifetime of proven energy reserves -Intensity of material use -Share of	

Chapters of *Agenda 21*	**Driving force indicators**	**State indicators**	**Response indicators**
		manufacturing value-added in GDP -Share of consumption of renewable energy resources	
Chapter 33: Financial resources and mechanisms	-Net resources transfer / GNP -Total ODA given or received as a percentage of GNP	-Debt / GNP -Debt service / export	-Environmental protection expenditures as a percent of GDP -Amount of new or additional funding for sustainable development
Chapter 34: Transfer of environmentally sound technology, co-operation and capacity building	-Capital goods imports -Foreign direct investments	-Share of environmentally sound capital goods imports	-Technical co-operation grants
Category: Environmental			
Chapter 18: Protection of the quality and supply of freshwater resources	-Annual withdrawals of ground and surface water -Domestic consumption of water per capita	-Groundwater reserves -Concentration of faecal coliform in freshwater -Biochemical oxygen demand in water bodies	-Waste-water treatment coverage -Density of hydrological networks

Chapters of *Agenda 21*	**Driving force indicators**	**State indicators**	**Response indicators**
Chapter 17: Protection of the oceans, all kinds of seas and coastal areas	-Population growth in coastal areas -Discharges of oil into coastal waters -Releases of nitrogen and phosphorus to coastal waters	-Maximum sustained yield for fisheries -Algae index	
Chapter 10: Integrated approach to the planning and management of land resources	-Land use change	-Changes in land condition	-Decentralised local-level natural resources management
Chapter 12: Managing fragile ecosystems: combating desertification and drought	-Population living below poverty line in dryland areas	-National monthly rainfall index -Satellite derived vegetation index -Land affected by desertification	
Chapter 13: Managing fragile ecosystems: sustainable mountain development	-Population change in mountain areas	-Sustainable use of natural resources in mountain areas -Welfare of mountain populations	
Chapter 14: Promoting sustainable agriculture and rural development	-Use of agricultural pesticides -Use of fertilizers -Irrigation percent of arable land -Energy use in agriculture	-Arable land per capita -Area affected by salinisation and water logging	-Agricultural education

Chapters of *Agenda 21*	**Driving force indicators**	**State indicators**	**Response indicators**
Chapter 11: Combating deforestation	-Wood harvesting intensity	-Forest area change	-Managed forest area ratio -Protected forest area as a percent of total forest area
Chapter 15: Conversation of biological diversity		-Threatened species as a percent of total native species	-Protected area as a percent of total area
Chapter 16: Environmentally sound management of biotechnology			-R&D expenditure for biotechnology -Existence of national biosafety regulations or guidelines
Chapter 9: Protection of the atmosphere	-Emissions of greenhouse gasses -Emissions of sulphur oxides -Emissions of nitrogen oxides -Consumption of ozone depleting substances	-Ambient concentrations of pollutants in urban areas	-Expenditure on air pollution abatement
Chapter 21: Environmentally sound management of solid wastes and sewage-related issues	-Generation of industrial and municipal solid waste -Household waste disposal per capita		-Expenditure on waste management -Waste recycling and reuse -Municipal waste disposal
Chapter 19: Environmentally sound management of toxic chemicals		-Chemically induced acute poisonings	-Number of chemicals banned or severely restricted

Chapters of *Agenda 21*	**Driving force indicators**	**State indicators**	**Response indicators**
Chapter 20: Environmentally sound management of hazardous wastes	-Generation of hazardous wastes -Imports and exports of hazardous wastes	-Area of land contaminated by hazardous wastes	-Expenditure on hazardous waste treatment
Chapter 22: Safe and environmentally sound management of radioactive wastes	-Generation of radioactive wastes		
Category: Institutional			
Chapter 8: Integrating environment and development in decision-making			-Sustainable development strategies -Programme of integrated environmental and economic accounting -Mandated Environmental Impact Assessment -National councils for sustainable development
Chapter 35: Science for sustainable development		-Potential scientists and engineers per million population	-Scientists and engineers engaged in R&D per million population -Expenditure on R&D as a percent of GDP

Chapters of *Agenda 21*	**Driving force indicators**	**State indicators**	**Response indicators**
Chapter 37: National mechanisms and international co-operation for capacity building in developing countries			
Chapter 38: International institutional arrangements			
Chapter 39: International legal instruments and mechanisms			-Ratification of global agreements -Implementation of ratified global agreements
Chapter 40: Information of decision-making		-Main telephone lines per 100 inhabitants	-Programmes for national environmental statistics
Chapter 23-32: Strengthening the role of major groups			-Representation of major groups in national councils for sustainable development -Representatives of ethnic minorities and indigenous people in national councils for sustainable development -Contribution of NGOs to sustainable development

Like the set of indicators produced by the UK Department of the Environment many of the indictors in the set produced by the United Nations Commission on Sustainable Development are more relevant and meaningful if assessed on a local basis. While the indictor set of the United Nations Commission on Sustainable Development is more encompassing than that of the UK Department of the Environment many of the indictors listed are very vague and of little use without further definition. Examples of such indictors include “Amount of new or additional funding for sustainable development”, “Share of environmentally sound capital goods imports”, or “Sustainable use of natural resources in mountain areas”. Defining and measuring these in a meaningful and useful way would be challenging. Some indicators listed, such as “Main telephone lines per 100 inhabitants” are becoming less relevant as use of cellar phone technologies around the world increases, and similarly indicators relating to access to technologies such as the internet are not included.

Table 2.4: Indicators of sustainable development as developed by the Mediterranean Commission on Sustainable Development.
(Source: Mediterranean Commission on Sustainable Development, 1999).

Indicator
Population growth rate
Total fertility rate
Women per hundred men in the labour force
Difference between male and female school enrolment ratios
Life expectancy at birth
Infant mortality rate
Main telephone lines per 100 inhabitants
Annual energy consumption per capita
Rate of growth of urban population
Urbanisation rate
Forest area change
External Debt / GDP
Arable land per capita
Irrigation percent of arable land
Energy intensity

The indicator set produced by the Mediterranean Commission on Sustainable Development has the advantage of being relatively concise and data is readily available in most countries. The indicator set, when compared to those of the UK Department of the Environment or the United Nations Commission on Sustainable Development is very limited in its scope and the potential to provide a real assessment of progress towards sustainable development in a country.

Air Quality Indicators for Israel

Mordechai Peleg

Introduction

The question of deteriorating air quality is not a new problem and has been around for centuries. Early documents from the first and second century in Israel show clearly that people reacted strongly against sources of air pollution . The Mishnah Law called for a minimal distance of 50 cubits (some 30 meters) from a polluting source to a neighbor's residence. In the case of tanneries the prevailing wind needs to be a considering factor. Not only health and nuisance affects were considered but also the effects of air pollutants on materials. For example, in Jerusalem, kilns and furnaces were not allowed, to avoid soiling of the walls and buildings. Shakespeare (c. 1600) also lamented the problem of bad air quality in his play on Hamlet (Act II, Scene 2). In 1661, a noted scientist and diarist by the name of John Evelyn wrote a small booklet in which he described the damaging effects in London of air pollution arising from the combustion of coal.

However, only in the 20th century, and especially the last few decades, have extensive experimental and epidemiological studies been carried out to verify these effects scientifically. In 1952, London was affected by a very serious smog (the word smog was coined to describe the "smoke-fog" of the famous so-called London pea-soupers) incident that caused almost 2000 excess deaths during a ten-day period. An epidemiological study showed for the first time a direct correlation between the excess mortality rate observed during the smog incident and the increased sulfur dioxide and smoke (soot) levels. This type of incident, which became known as the London type or "classical" smog, was identified as being due to industrial and household fuel (coal, petroleum) combustion emissions of sulfur dioxide and particulate. The time of occurrence of the worst episodes was during the winter months (increased pollution emission) and especially in the early morning when dispersion conditions were very bad. The health effects were lung and throat irritation and under extreme conditions, such as in London during winter of 1952, increased mortality.

While the London smog was known for hundreds of years it was only in 1943 that major smogs were first reported in Los Angeles. The smog incidents caused major eye irritation and reduced visibility. However, in contrast to the London type smog, this type of smog was observed to occur during summer and become more extreme around midday. Intensive experiments identified the main smog component as being ozone. Since ozone is a secondary pollutant and not emitted directly, extensive research was required to identify the causes of ozone production. The source of the ozone precursor emissions was attributed to motor vehicle fuel combustion that emits nitrogen oxides and hydrocarbons. The above compounds undergo photochemical reactions under the influence of sunlight to produce ozone. This type of smog became known as the Los Angeles or photochemical type smog.

Intensive efforts were made both in London and Los Angeles, and other places where these two smog types were observed, to reduce their affects. In London strict enforcement of a smokeless fuel law and other stringent limitations helped to effectively reduce the seriousness of smog incidents. Similarly in California, strict vehicle emission controls and transportation strategies were introduced which successfully reduced ozone production and hence the seriousness of the smog occurrences. The above shows in spite of the increased development that has occurred both in London and Los Angeles it has been possible to maintain or even improve the air quality with respect to specific pollutants. Thus development need not necessarily go hand in hand with decreasing air quality.

Although important steps have been made in attempting to maintain or even improve a reasonable air quality standard, it is still necessary to continue protecting the air we breathe. Further, as our scientific knowledge of atmospheric processes expands, evidence of possible new detrimental effects on air quality is being suggested.

Air Pollutants

The main air pollutants that affect the air quality in Israel are discussed in the following section. The pollutants can be collected into two classifications. Primary pollutants that are emitted directly into the atmosphere and secondary pollutants that are formed in the atmosphere from directly emitted precursors. The primary pollutants to be considered due to their detrimental effects are sulfur dioxide, carbon monoxide, lead, fine particulates and two volatile organic compounds, benzene and 1-3 butadiene. In addition two secondary pollutants, ozone and sulfate particulates will be evaluated. The sources of the different pollutant vary, ranging from large single sources (electricity power plants, oil refineries, industrial) to area sources (transportation, residential heating). Certain sources emit from elevated stacks (such as power plants) and affect areas large distance downwind of the source while other sources affect directly only regions adjacent to the emitting areas (such as transportation).

The review of the different pollutants will include information on the sources for each pollutant, the detrimental effects of the pollutant, their present ambient levels, future emission trends and other relevant information.

1. Carbon Monoxide

Carbon monoxide (CO) is a gas formed by the incomplete combustion of carbon containing fuels. In general, the more efficient the combustion process, the lower the carbon monoxide emission. The main outdoor source of carbon monoxide is currently road transport, in particular gasoline powered vehicles, which in 1997 accounted for 90% of carbon monoxide emissions in Israel. Thus it is expected that high levels of carbon monoxide will be found in the vicinity of main roads and in city centers and only limited amounts in rural areas.

The main threats to human health from exposure to carbon monoxide are the formation of carboxyhaemoglobin, which substantially reduces the capacity of the blood to carry oxygen and deliver it to the tissues, and blockage of important biochemical reactions in cells. People who have an existing disease that affects the delivery of oxygen to the heart or brain (e.g. coronary artery disease (angina)) are likely to be at particular risk if these delivery systems are further impaired by carbon monoxide.

Carbon monoxide levels reported by the Israeli Ministry of the Environment for the year 1999, showed a maximum half-hour values ranging between 2.4 and 8.2 mg/m^3 for urban sites and between 13.0 and 21.3 mg/m^3 for curbside sites on major traffic roads. The levels recorded for 8-hour exposure times were in the range 1.9 to 4.1 mg/m^3 and 7.8 and 11.7 mg/m^3 for urban and curbside sites, respectively. The Israeli ambient standard for half-hour exposure is 60 mg/m^3 and 11 $mg/m^3$for 8-hours. The maximum levels for urban sites which were measured in the center of downtown Jerusalem (Kikar Safra) were less than 15% for the half-hour standard and 38% with respect to the 8-hour requirement. For the curbside sites the maximum-recorded levels were adjacent to a main road in Tel-Aviv and reached 35% for the half-hourly standard and slightly above (106%) the 8-hour ambient standard. The annual carbon monoxide values for urban sites varied between 0.8 and 1.8 mg/m^3 and for the curbside sites between 1.5 and 3.1 mg/m^3, (no Israeli annual ambient standard exists for carbon monoxide).

The number of vehicles on the roads in Israel has doubled from one to two million between 1990 and 2001. However since 1994 the amount of carbon monoxide has been reduced by about 25%. This can be attributed to the introduction of catalytic converters in all gasoline driven vehicles introduced into Israel since 1994. The catalytic converter reduces the amount of carbon monoxide emitted by almost 80%. Since as stated above, the main source of carbon monoxide is from gasoline-powered vehicles it appears that introduction of the catalytic converters has been successful in enabling continued increase in vehicle use without causing increased carbon monoxide pollution levels.

2. Sulfur Dioxide

Sulfur dioxide is a gas at normal temperature and pressure. It dissolves in water to give an acidic solution, which is readily oxidized to sulfuric acid. The predominant source of sulfur dioxide is the combustion of sulfur-containing fossil fuels, principally coal and heavy oils. Most of the sulfur dioxide emissions in Israel (> 90%) are from major power plants and industries. These emissions are from elevated stacks and thus dispersion and dilution of this pollutant occurs before the plume reaches ground level. Depending on the height of the stacks, the pollution emitted affects areas tens or even hundreds of kilometers downwind of the plants. Most of the present measuring sites for sulfur dioxide in Israel are situated in the vicinity of the power plants in order to monitor the effects of these plants on the surroundings.

Sulfur dioxide causes constriction of the airways by stimulating nerves in the lining of the nose, throat and airways of the lung. The latter effect is particularly likely to occur in those suffering from asthma and chronic lung disease. The effects of sulfur dioxide on sensitive subjects appear almost immediately at the start of exposure.

Although declining emissions over recent years have reduced the importance of sulfur dioxide as a phytotoxic pollutant, it still plays a role in damage to ecosystems. This is particularly significant in combination with other stresses, such as cold. Potential effects include the degradation of chlorophyll, reduced photosynthesis, raised respiration rates and changes in protein metabolism. Sulfur dioxide also accelerates the natural weathering and corrosion of buildings and building materials. Various studies have shown that limestone has been degrading at the rate of 1mm/decade due to acid rainfall. Although levels of pollutants in air are falling, the levels being recorded currently, together with the accumulated pollution deposition of the last 200 years, mean that stonework has continued to deteriorate at this historic rate.

Sulfur dioxide levels reported by the Israeli Ministry of the Environment for the year 1999 varied greatly between the various sites. Maximum half-hour values ranged from less than 100 $\mu g/m^3$ at rural sites to above 500 $\mu g/m^3$ for sites adjacent to large power plants. The levels recorded for 24-hour exposure range from below 25 $\mu g/m^3$ to more than 100 $\mu g/m^3$. The annual averages varied from below 5 $\mu g/m^3$ for rural sites to around 30 $\mu g/m^3$ for urban sites. The higher values, such as recorded for Haifa and Ashdod could be attributed to the direct impact of power plant emission plumes. The lower values that were recorded at rural sites also showed the effects of power plant pollution. However due to greater distance traveled by the plume to the site substantial dilution has occurred and thus the pollution levels are greatly reduced.

The Israeli ambient standard for SO_2 is 500 $\mu g/m^3$ for half-hour exposure (it should be noted that 45 exceedances of the SO_2 standard of 1 hour periods are permitted annually if they do not exceed 1000 $\mu g/m^3$), 0.280 $\mu g/m^3$ for 24-hour period and 0.060 $\mu g/m^3$ for the annual average. Thus levels above the ambient standard were recorded only for the half hour periods. Since very little sulfur dioxide is emitted from vehicles there is no purpose in measuring curbside levels as for carbon monoxide.

The Ministry of the Environment reports that between 1980 and 1997 sulfur dioxide emissions have increased by only 14% in spite of more than a doubling in electricity production and increased industrial activity. This can be attributed to the increased use of low sulfur content fuels (1%) and the implementation of an intermittent control system (ICS) for the large power plants, especially for Haifa and Ashdod, which decrees the switch to very low sulfur (0.5%) fuel when meteorological conditions indicate bad dispersion conditions. Further, the newer coal fired power plants (80% of the power generated) do not pose a significant problem due to the tall stacks and the low sulfur content of the coal. These elevated stacks emit the pollution at heights hundreds of meters above ground level and therefore undergo large dispersion and dilution before hitting the ground. Further the new plant now in operation in Ashkelon includes scrubbers which effectively reduce the sulfur dioxide emitted out of the stacks.

In their 1995 report the UK EPAQS recommended an air quality standard of 100ppb (266µg/m^3) measured over a 15-minute averaging period. This recommendation is intended to reduce the exposure of the population, including individuals who may be particularly susceptible, to levels of sulfur dioxide at which harmful effects are unlikely to occur. The EPAQS acknowledged that an averaging time of just a few minutes might be desirable, but concluded that a 15 minute averaging time with a standard of 100ppb (266µg/m^3) represented an acceptable compromise between desirability and practicability. Thus in the future it is possible that also in Israel the ambient sulfur dioxide standard may become more stringent.

3. Nitrogen Oxides

All combustion processes in air produce oxides of nitrogen. This is due to the reaction at high temperatures, present in combustion processes, between the nitrogen and oxygen in the air to form primarily nitrogen oxide, which then undergoes rapid transformation to the nitrogen dioxide. Nitrogen dioxide (NO_2) and nitric oxide (NO) are both oxides of nitrogen and together are referred to as NO_x Road transport is thought to account for about 50% of total emissions of nitrogen oxides, the electricity supply industry for about 40% and the industrial and commercial sectors for about 10%. It should be emphasized that the nitrogen oxides emitted from coal fueled power plants and large industries is via high stacks, which assists dispersion and dilution of the pollutant before the plume touches the ground. Thus while about 40% of the NO_x emitted in Israel are from the power plants its affects at ground level are limited. Therefore in cities, road transport is thought to account for over 80% of emissions. While NO_x is important as a precursor of ozone formation, it is however only nitrogen dioxide that is associated with adverse effects upon human health.

At relatively high concentrations, nitrogen dioxide causes inflammation of the airways. There is evidence to show that long-term exposure to nitrogen dioxide may affect lung function and that exposure to nitrogen dioxide enhances the response to allergens in sensitized individuals. Both nitrogen dioxide and nitric oxide are absorbed by vegetation. Their effects on plants are additive and the scientific consensus is that they should be treated together. Nitrogen is an essential plant nutrient and low exposure to nitrogen oxides can promote growth. However, higher exposures can cause adverse effects including leaf or needle damage and reduced growth. The point at which damage begins depends on the species, on its nutritional state and on other environmental factors.

Nitrogen oxide levels reported by the Israeli Ministry of the Environment for the year 1999 varied greatly between the various sites. Maximum half-hour values ranged between 200 $\mu g/m^3$ to more than 2000 $\mu g/m^3$ for urban sites while all the curbside sites showed maximum values all above 2000 $\mu g/m^3$ and at one site almost 3000 $\mu g/m^3$. The levels recorded for 24-hour exposure for the urban sites varied widely, ranging from below 50 $\mu g/m^3$ to more than 800 $\mu g/m^3$ while the curbside stations were all around 1000 $\mu g/m^3$. The annual averages varied from below 10 $\mu g/m^3$ for rural sites to above 100 $\mu g/m^3$ for urban sites while the curbside sites varied between 150 to 500 $\mu g/m^3$. The very high nitrogen oxides values recorded for the curbside and central city sites are all due almost exclusively to vehicle pollution.

The Israeli ambient standard for NO_x is 940 $\mu g/m^3$ for half-hour exposure and 560 $\mu g/m^3$ for 24-hour period. No Israeli standard exists for nitrogen dioxide although the NO_x calculations are based on the assumption that all the oxides are present as only nitrogen oxide. The above measurements show that pollution levels for nitrogen oxides exceed both the 1/2 hour and 24-hour standards. No annual standard has been designated for the nitrogen oxides.

In the UK, objectives for nitrogen dioxide reflect evidence that it may have both acute (short-term) and chronic (long-term) effects on health, particularly in people with asthma. As a result, two provisional objectives have been set: 200$\mu g/m^3$ as a 1 hour mean, not to be exceeded more than 18 times per year; and 40$\mu g/m^3$ as an annual mean. An annual mean of 30$\mu g/m^3$ of nitrogen oxides has been suggested as a critical level at which the majority of species should be protected. These limits are much lower than the present Israeli standards.

Nitrogen oxides emissions have more than tripled in the last twenty years. This increase can be attributed to the rising consumption of gasoline and especially diesel fuels. This rise was however partially offset by the decreased use of heavy residential oil and the introduction of catalytic converters on private cars. While 40% of the nitrogen oxides emissions are from the large power plants situated along the Israeli coast only a limited affect is felt at ground levels due to the high stack emission heights. As seen above nitrogen oxides (NO_x) emissions are a major source of air pollution violations especially close to main traffic arteries. The problem is especially severe in the Dan metropolitan area where hundreds of violations of nitrogen oxide standards are recorded each year. Over 200,000 vehicles are registered in the Tel Aviv area alone, and another 400,000 vehicles enter city limits every day from peripheral areas. The pollution emitted by vehicles in this region also causes a secondary pollution cloud, especially ozone, which impacts inland areas such as Modi'in, Bet Shemesh, Jerusalem and even Beersheba.

The problem of elevated nitrogen oxides levels due to vehicular pollution is compounded in Israel by the composition of Israel's vehicle fleet that includes growing numbers of diesel vehicles, scooters and older cars. Most of the country's trucks, buses and commercial vehicles are diesel powered and a trend of growth in the number of private diesel cars has been noted in recent years. It should be emphasized that these vehicles emit significant quantities of nitrogen oxides — more than ten to twenty times those emitted by gasoline vehicles equipped with catalytic converters. Without serious intervention of governmental bodies the problem of nitrogen oxides pollution, and with that also the ozone problem, will continue to grow.

4. Particulates (PM_{10} and $PM_{2.5}$)

Unlike the individual gaseous pollutants, which are single, well-defined substances, particles (PM_{10} and $PM_{2.5}$, the 10 and 2,5 refer to particulate aerodynamic diameter of 10 and 2.5 microns respectively) in the atmosphere are composed of a wide range of materials arising from a variety of sources. The particles may be regarded as having three predominant source types; primary particles, arising from combustion sources (road traffic, production and industry); secondary particles, mainly sulfate and nitrate formed by chemical reactions in the atmosphere; and coarse particles, suspended soils and dusts, biological particles and particles from construction work. Analysis of concentrations of PM_{10} shows it is composed of each of the three source types. In general terms, the three source types each make up roughly one third of total long-term average PM_{10} concentrations at urban background locations. However, the relative contribution of each source type varies from day to day, depending on meteorological conditions and quantities of emissions from mobile and static sources. The fine particle fraction ($PM_{2.5}$) is composed predominantly of primary and secondary particles. Particles in the range from $PM_{2.5}$ — PM_{10} generally consist of coarse particles. It should be noted that during a number of days during the year, especially during spring, Israel is strongly affected by desert sand storm episodes that cause strongly elevated particulate levels.

Particulate air pollution is associated with a range of effects on health including effects on the respiratory and cardiovascular systems, asthma and mortality. A number of epidemiological studies have concluded that particulate air pollution episodes are responsible for causing excess deaths among those with pre-existing lung and heart disease, and that there is a relationship between concentrations of PM_{10} and health effects, such that the higher the concentration of particles, the greater the effect on health. There is emerging evidence to suggest that the health effects of particles are due principally to fine particles ($PM_{2.5}$). While most air quality standards refer to PM_{10} as providing an appropriate level of protection for public health. However, recently it is being recognized that $PM_{2.5}$ might better represent the toxic fraction of particulate air pollution, and that a $PM_{2.5}$ standard may be a desirable objective.

Particulate levels reported by the Israeli Ministry of the Environment for the year 1999 showed maximum daily averages of PM_{10} that ranged from 200 to 500 for all the measuring sites. The PM $_{2.5}$ values were lower and varied between 70 to 140 $\mu g/m^3$. The annual PM_{10} averages varied from 30 to 70 $\mu g/m^3$ while the $PM_{2.5}$ values remained in the limited range of 20 to 30 $\mu g/m^3$ for all sites.

The Israeli ambient standard for PM_{10} is 150 $\mu g/m^3$ for 24-hour period and 0.060 $\mu g/m^3$ for the annual average. There is at present no Israeli standard for $PM_{2.5}$. Levels above the 24-hour ambient standard were recorded for all 15 monitoring sites and a third of the sites recorded annual averages above the standard. Part, if not all, of the above standard levels measured, especially for the 24-hour periods can be attributed to natural sources and not anthropogenic causes. A question that still remains to be answered is the proportion between naturally emitted particulates and anthropogenic source particulates.

5. Ozone

Ozone is not emitted directly from any man-made source in any significant quantities. It arises from chemical reactions in the atmosphere caused by the influence of sunlight. In the stratosphere, where ozone plays a beneficial role by shielding the earth from harmful ultra-violet radiation, sunlight acting initially on oxygen molecules produces ozone. The balance between ozone and oxygen in the stratosphere is currently being disturbed by migration upwards of chemicals such as chlorofluorocarbons. They remove ozone and may therefore increase the amount of ultra-violet light reaching the earth's surface. Some ozone occasionally reaches the lower layers of the atmosphere from intrusions of air from the stratosphere. But it is primarily formed by a complicated series of chemical reactions initiated by sunlight. Oxides of nitrogen (NO_x) and VOCs (volatile organic carbons), derived mainly from man-made sources, react to form ozone. The VOCs are produced by combustion, various industrial processes, other activities such as solvent use, and gasoline distribution and handling. NO_X and VOCs are the most important precursors causing elevated levels of ozone. Production can also be stimulated by carbon monoxide, methane, or other VOCs that arise from plants, trees and natural sources. The ozone potential varies according to the specific organic compound. Ozone is also a greenhouse gas, so NO_x and VOCs can be considered indirect greenhouse gases. The photochemical reactions that cause ozone formation do not take place instantaneously, but over several hours or even days depending on the VOCs. Once ozone has been produced it may persist up to a limited number of days. In consequence, ozone measured at a particular location may have arisen from VOC and NO_x emissions hundreds of kilometers away, and may then travel further for similar distances. Maximum concentrations, therefore, generally occur downwind of the source areas of the precursor pollutant emissions. Indeed, in urban areas, where concentrations of traffic gases may be high, nitric oxide (NO) from exhaust emissions may react with ozone to form nitrogen dioxide (NO_2) thus reducing ozone concentrations. However, as the air movement carries the primary pollutants away, more ozone is generated and concentrations rise in the downwind areas. In urban areas with intensive traffic movement the ozone levels may be lower than in adjacent rural regions.

In terms of ozone measured at ground level, these photochemical episodes of high ozone concentrations are superimposed on a baseline that varies slightly throughout the year but averages for Israel around 60 — 80 $\mu g/m^3$. This is made up partly of ozone transported from the stratosphere, and some ozone produced in the troposphere (the region of the atmosphere, about 10 km deep, between the Earth's surface and the stratosphere) from naturally occurring and man-made precursors (in broadly equal proportions). There is evidence that this baseline has roughly doubled since the turn of the century, largely due to the increase in man-made NO_x emissions in the whole of the northern hemisphere. The baseline is close to levels at which effects have been observed on crops and plants.

Exposure to high concentrations of ozone may cause slight irritation to the eyes and nose. If very high levels of exposure (1,000-2,000$\mu g/m^3$) are experienced over several hours, damage to the airway lining followed by inflammatory reactions may occur. There is also evidence that minor changes in the airways may occur at lower concentrations, down to about 160µg/m^3).

Ozone levels reported by the Israeli Ministry of the Environment for the year 1999 showed limited variations between the various sites. Maximum half-hour values ranged between 150 µg/m^3 to 280 µg/m^3 while the eight-hour averages ranged between 115 µg/m^3 to almost 200 µg/m^3. The annual averages varied between about 40 to 80 µg/m^3. The lower levels were generally observed for the densely populated urban sites, such as Tel Aviv. The Israeli ambient standard for O_3 is 230 µg/m^3 for half-hour exposure period and 160 µg/m^3 for the 8-hourly average. Almost half of the monitoring sites (25 in number) reported ozone levels above the half hour ambient standard while only three sites exceeded the 8-hour standard.

Until recently very limited ozone monitoring has been performed in Israel outside of the coastal region. From measurements performed using an instrumented aircraft it has been shown that the ozone levels increase, as expected with increasing distance from the precursor emission areas close in the coastal regions. Further it appears that ozone levels are increasing with time and a serious effort is required to reduce precursor emissions and especially those of the nitrogen oxides.

6. Lead

Lead is the most widely used non-ferrous metal and has a large number of industrial applications, both in its elemental form and in alloys and compounds. The single largest use globally is in the manufacture of batteries. As the compound tetraethyl lead, it has been used as a petrol additive to enhance the octane rating. Most of airborne emissions of lead have arisen from gasoline powered engine vehicles. Industry, in particular secondary non-ferrous metal smelters, may contribute to emissions of lead in industrial areas. For Israel lead pollution from vehicles generally outweighed any other emissions. The reduction in the lead content in leaded petrol and the increasing use of unleaded gasoline has led to significant reductions in ambient urban lead levels.

Exposure to high levels of lead may result in toxic biochemical effects in humans which in turn cause problems in the synthesis of haemoglobin, effects on the kidneys, gastrointestinal tract, joints and reproductive system, and acute or chronic damage to the nervous system. The possible effect of lead on brain development in children, and hence their intellectual development, is the greatest cause for concern. Studies of populations of young children in the UK suggest that there may be a loss of up to about 2 IQ points for a rise in blood lead from 10 to 20 µg/dl (µg/dl = microgram's per deciliter (deciliter = 100 milliliters). The advice of the UK Department of Health's Committee on Toxicity was that it is not possible to identify a threshold for effects of lead on health.

No continuous monitoring of lead is performed in Israel. The Israeli ambient standards for lead are 5.0 $\mu g/m^3$ for 24-hour periods, 1.5 $\mu g/m^3$ monthly average and 0.5 $\mu g/m^3$ as annual mean. A recent study performed by scientists from the Hebrew University of Jerusalem measured lead levels along the main Jerusalem - Tel Aviv highway. The results, averaged over the entire trip during peak traffic loads, ranged between 0.2 to almost 1 $\mu g/m^3$. These levels are all well below the 24 hour standard and even the monthly standard. Since the above values were recorded inside the vehicle itself and during peak traffic loads it can safely be assumed that also the yearly average standard for lead will not be exceeded. The reduction of ambient lead in the atmosphere can be attributed to the introduction of lead-less fuel (a necessary requirement for all vehicles that have catalytic converters) and the reduction (from 0.42 to 0.25 and now to 0.15 gm/liter) in the amount of lead allowed in the normal gasoline. However it should be noted that the lead compound known, as tetra-alkyl lead, is still being added to Octane 96 fuel that is still used by the older model cars. This, today, is the main source of lead in the atmosphere in Israel. While plans were made to reduce and finally stop supplying the above fuel by the year 2003, this has not been implemented and Israel remains the only country in the west still producing gasoline containing lead. However even though the number of vehicles on the road has steeply increased the amount of lead emitted to the atmosphere has decreased.

7. Benzene

Benzene is a volatile organic compound. The main atmospheric source is the combustion and distribution of gasoline, of which it is a minor constituent. Benzene is also formed during the combustion process from aromatics in the gasoline. Diesel fuel is a relatively small source. The amount of benzene in gasoline is regulated in Israel since September 2001 to an upper limit of 1 % by volume by legislation. EU legislation requires that the amount of benzene in gasoline be below 1%. The main outdoor sources of benzene are from vehicle exhausts; gasoline refining and distribution; and uncontrolled emissions from fuel station forecourts without vapor recovery systems.

Benzene is a recognized genotoxic human carcinogen. Studies of industrial workers exposed in the past to high levels of benzene have demonstrated an excess risk of leukaemia that increased in relation to their working lifetime exposure. No Israeli ambient standard exists for benzene and no monitoring of this compound is at present taking place in Israel. Because it is a genotoxic carcinogen, no absolutely safe level can be specified for ambient air concentrations of benzene. In the UK a recommended an air quality standard for benzene has been suggested as 16.25µg/m^3 as a running annual mean, a level that was concluded to represent an exceedingly small risk to health. However a report of the UK Department of Health's Committee on Carcinogenicity suggested that exposure to benzene should be kept as low as practicable, and ecommended a target of 3.25µg/m^3, also as a running annual mean.

8. 1,3-Butadiene

1,3-Butadiene is a gas at normal temperatures and pressures and trace amounts are present in the atmosphere, deriving mainly from the combustion of gasoline and of other materials. Although 1,3-butadiene is used in industry, mainly in the production of synthetic rubber for tires, motor vehicles are its predominant source.

The health effect, which is of most concern in relation to 1,3-butadiene exposure, is the induction of cancers of the lymphoid system and blood-forming tissues, lymphomas and leukaemias. Like benzene, 1,3-butadiene is a genotoxic carcinogen, and so no absolutely safe level can be defined. The UK EPAQS nevertheless believed that a standard could be set at which any risks to the health of the population are exceedingly small. They recommended an air quality standard of 2.25 µg/m^3 as a running annual mean. No Israeli ambient standard exists for 1,3-Butadiene and no monitoring of this compound is at present taking place in Israel.

9. Sulfate

Sulfate is a secondary pollutant produced by photochemical transformation of sulfur dioxide. The process is relatively slow and takes the order of several hours and even days to covert the sulfur dioxide to the sulfate particulate. The deposition rate of this particulate is slow and thus once formed can remain in the atmosphere for several days. This means that the sulfate can be transported thousands of kilometers from the original emission region of the sulfur dioxide. Israel has been shown to be the recipient of relatively large quantities of sulfate caused by pollution emissions over Europe. In fact, measurements have shown that the eastern parts of the Mediterranean Basin have very high sulfate levels and as high as measured at even the most polluted sites in Europe or the USA.

Exposure to acidic aerosols such as sulfate particulates has been suggested by several investigators as posing a serious potential health threat. The possible association between fine particulates (those with aerodynamic diameter equal to or less than 2.5 µm – $PM_{2.5}$), sulfate particulates and health effects was clearly demonstrated in a study based on 15 years of air pollution and mortality data in six U.S. cities. The study indicated an increase of about 26% in mortality rate occurred in the more polluted of the cities ($PM_{2.5}$ and particulate sulfate long-term average concentration for the measuring period of about 30 µg m^{-3} and 13 µg m^{-3} respectively) as compared with the least polluted cities (12 µg m^{-3} $PM_{2.5}$ and 5 µg m^{-3} sulfate). A latter extended study on data from 151 U.S. metropolitan areas (covering more than half a million adults) indicated an adjusted relative mortality risk of 15% for the most polluted areas (about 25 µg m^{-3} $PM_{2.5}$ and 15 µg m^{-3} sulfate) as compared with the least polluted regions (~ 10 µg m^{-3} $PM_{2.5}$ and 5 µg m^{-3} sulfate). Analysis of epidemiological data has suggested that rises of 10 µg m^{-3} in particulate levels are accompanied by an increase in relative risk of mortality of about 1% in the exposed population, including elevated risks from both respiratory (around 3-4%) and cardiac (around 1-4%) causes. All the above, strongly indicates that fine particulates and especially sulfate particulates are a serious risk factor for respiratory and cardiovascular diseases. It should be pointed out that the same should apply for the acidic nitrate particulate but much less information is available at this stage to support or negate this proposition.

No continuous measurements are being performed at present for this pollutant although an Israeli ambient standard of 25 g m^{-3} for a 24 hours exposure time exists. A number of research studies have been performed at various sites in Central Israel that showed levels above the ambient standard are occasionally observed. Although inland sites show higher sulfate levels than observed at the Israeli coast, the main contribution to the sulfate in Israel is from long transported air masses originating over Israel.

Criteria for Air Quality Indicators

The purpose of the indicators, as the name suggests, is to follow trends in air quality in order to determine the state of air quality over Israel and based on that information to decide the strategies to be taken to maintain sustainable development.

Air Quality Ambient Level Indicator

As stated previously there are several different types of air pollutants that originate from various sources. Some pollutants affect areas adjacent to the emission sources while other pollutants affect regions kilometers downwind from the pollution origins (due to high stack heights). Certain pollutants are not directly emitted but are formed later after series of photochemical reactions. These secondary pollutants can pollute regions tens of kilometers downwind from the precursor origins (i.e. ozone) or even thousands of kilometers away (i.e. sulfate).

Further, meteorological conditions strongly affect the ambient pollution levels. Thus changing meteorological conditions need to be taken into consideration when formulating air quality indicators. This affects the question of the time period that needs to be considered for reporting. Dispersion conditions are at their worst during the winter months, thus higher ambient pollution levels are expected during the winter than for summer. Thus generally an annual average is taken as a good indicator since it comprises all the different seasons. However since the annual average is made up from the monthly averages it may be advantages to record on a permanent basis the monthly averages as well as the annual values.

Another possible method for air quality indicators is reporting the number of times a certain concentration level is exceeded. The ambient air quality standard for each specific pollutant is generally used as the cutoff level, although this need not necessarily be the case. Further, different time intervals can be chosen, such as half hourly or daily etc. It should however be pointed out that since the number of values exceeding the ambient standard levels are very limited, except for curbside NO_x measurements, this type of indicator may not necessarily reflect trends in air quality. A preferable approach would be to report the indicators both as 50% and also 95% percentile values with respect to the ambient standards. This method would better represent the trends in air quality since changing pollution levels might increase or decrease the 50% percentile value without necessarily affecting the 95% or 100% level values.

Air quality monitoring has been performed in Israel for more than twenty years. Most of the early monitoring has been performed in the proximity of the large electricity power plants, Haifa, Hadrera, Ashdod and Ashkelon. The main purpose of the above air quality measurements was to monitor the possible effects of the power plan emissions on the adjacent areas (range of some 10 - 15 kilometers). Consortiums of local town authorities operate these monitoring sites. The parameters monitored were essentially sulfur dioxide and nitrogen oxides. In addition the Israeli Electricity Corporation operated measuring equipment to monitor pollution levels caused by the power plants. In 1994 the Israeli Ministry of the Environment decided on the setting up of a national air quality network that would include 24 new stations in addition to the existing stations, which would be incorporated into the network. The new stations expanded the type of monitoring performed to include pollution from transportation (curbside), urban pollution, photochemical and background rural pollution levels. Today almost 100 monitoring sites exist in Israel. The parameters being monitored on a continuous level are; carbon monoxide, sulfur dioxide, nitrogen oxides, nitrogen dioxide, ozone, particulates (PM_{10} and $PM_{2.5}$) and benzene (only one site). A national control center has been setup in Ramla that accumulates all the air quality data for Israel. It should therefore be no problem to choose appropriate monitoring sites for which data should be available for the years ahead.

The choice of monitoring sites to be included as indicators is of great importance. Sites to be included need to be representative for the specific pollutant whether urban, rural or curbside. It is further suggested that where possible an average of a number of stations be taken to represent each pollutant. The monitoring equipment needs to provide continuous data for at least 80-90 % of the year and any missing data should not be for any continuous time period that would bias the annual average.

Efficiency Factor Indicator

A second approach, not based on continuous ongoing ambient level monitoring, would be an efficiency factor obtained by calculating values representing the pollution emitted per, for example, energy generated or kilometer traveled. This type of indicator would show whether the pollution emitted per unit energy generated was decreasing although the total pollution emitted might increase due to increasing anthropogenic activity.

However such values are not readily available and will require intensive data accumulation and calculations based on a number of assumptions. The simplest values to obtain would be the SO_2 and NO_x emitted per KW energy produced since both the pollution emitted and energy supplied are available from the Electricity Company. However since these pollutants are emitted from elevated stacks, their affects on ambient air quality is rather limited although it represents 50% of the total fuel consumed in the country.

An important indicator would be the amount of nitrogen oxides emitted per kilometer traveled or per traveler kilometer. The latter unit would also reflect the influence of public transport on the pollution load. This type of indicator requires data regarding, amount of fuel consumed, total vehicle kilometers traveled, vehicle type distribution (vehicle age, with or without catalytic converters etc), emission factors etc. The evaluation of a meaningful value is therefore not a simple matter and would require substantial manpower.

Likewise the evaluation of an efficiency factor for particulates such as PM_{10} or $PM_{2.5}$ is not a simple matter and would meet with similar problems as noted previously.

Further the above method is not applicable for evaluation with respect to ozone since it is a secondary pollutant.

While the use of an efficiency type factor is inviting it appears that it might be both difficult and time consuming to obtain meaning full values.

Pollutant Indicator Types

1. Carbon Monoxide

This pollutant does not appear to be a critical indicator for air quality. Since its main source is from gasoline powered vehicles, it will have only limited interest as an indicator for changes in emissions rates from mainly privately owned vehicles. It is suggested that only the curbside values be included as indicators.

2. Sulfur Dioxide

The main source of this pollutant is power plants and heavy industries and affects area kilometers away from the pollution source. It can therefore affect both urban and rural areas. Thus this pollutant should be included both for urban and rural sites.

3. Nitrogen Oxides

This is probably the major pollutant problem in Israel today, especially in urban areas. It is suggested that this pollutant be reported for two different types of sites, curbside and urban. The curbside sites will give a measure of the pollution due mainly to transportation along busy roads, while the urban value will reflect the pollution to which town dwellers are subjected. The curbside NO_x/NO value is a critical indicator for sustainable development with respect to transportation management. Since any increase or decrease in nitrogen oxides levels resulting from vehicular emission will be immediately reflected in the curbside values. The value for rural exposure reflects the precursor effects on ozone formation and it may also be worthwhile to record this value.

The question exists which species to include as indicators, NO_2 or NO_x or both. As stated above it is only the NO_2 species that has direct health effects, however the NO_x value is an indicator of the ozone formation potential. Further it should be noted that for the curbside station the main component to the NO_x is NO while for an urban site the NO_2 would be predominant. Since both parameters are available from the monitoring sites it seems appropriate to include them both in the air quality indicator list.

4. Particulate (PM_{10} and $PM_{2.5}$)

This pollutant could well be the pollutant with the most potential detrimental health effects, which should be included in the indicator list. However due to the large influence of particulates from natural sources it is difficult to extract the anthropogenic contribution to the particulate loading. However since the $PM_{2.5}$ represents the smaller particulates and especially the sulfate and nitrate, it may be less influenced by the larger sized natural dust and sand particles. Since both the PM_{10} and $PM_{2.5}$ are being monitored in Israel it appears appropriate to consider including both parameters in the indicator list.

5. Ozone

This is an important indicator both in itself and also due to the fact that it is an indirect indicator for precursor levels and especially for the nitrogen oxides. Care will be needed in deciding which measuring sites should be included in the averages. Only monitoring stations, which are outside of the main area of the precursor emissions, are of any value for inclusion in the indicator calculations.

6. Lead

For all practical purposes this is not an important indicator. Coupled with the fact that no continuous monitoring is at present being performed in Israel we see no reason to include this parameter in the air quality indicator list.

7. Benzene

This parameter has only recently started to be given serious attention and only one instrument is at present in continuous operation in Israel. However it probable that additional monitoring will become available in the future. The unit in operation in Israel is intended to measure aromatic compounds emit in the Haifa Bay which includes the oil refineries. Thus it is uncertain at the present if results from this site can be used as an indicator for benzene levels over Israel.

8. 1 3-Butadiene

This parameter has recently been given serious attention in Europe and especially in the UK. In Israel no measurements are at present being performed for this parameter. Thus at present this parameter cannot be included in the list.

8. Sulfate

Using the sulfate parameter as an indicator of particulates should be considered. Only recently have commercial monitors become available for this purpose. However only limited experience is at present available, which can allow an accurate evaluation of this monitor for continuous measurements. The advantage of monitoring this parameter is that it gives a direct measure of an anthropogenic particulate and has almost no contribution from natural sources. However, as mentioned previously, the main contribution to the sulfate levels is from Europe so this parameter will be an indicator of the impact of outside pollution sources on Israel. If data from monitoring of the sulfate becomes available in Israel it should be considered as a suitable candidate for inclusion as an indicator.

Recommendations

It is recommended that the main effort for air quality be based on data readily available from the Israeli air quality monitoring network operated by the Ministry of the Environment. This network operates more than twenty stations covering all of Israel (excluding the Negev) and provides accurate and continuous data. Further the network can be expected to continue to provide data in the future. It should also be possible to utilize the existing data base to calculate the index for previous years. If required it may be possible to include monitoring stations operated by other organizations. However this may only complicate the calculations and the national network provides sufficient information to calculate a meaningful air quality indicator.

It is recommended that the indicator be reported in the following manner:

The pollutants to be reported are those continuously reported by the national monitoring network and include: SO_2, NO_2, O_3, CO, PM_{10} and/or $PM_{2.5}$.

The values to report will be the 50% and 95% percentile value for each of the various pollutants. This method of reporting is preferred to the number of values above the 100% ambient standard, since it will give better trend indications.

The percentiles will be reported with respect to the relevant various time standard exposure periods (half-hourly, eight-hourly and daily).

The indicators will be reported as monthly and also yearly values.

The results will be reported for three different area types, urban, rural and curbside (traffic sites). The values for each of the three types will be averaged over a number of representative monitoring stations for each type.

The number of pollutants reported can be expanded as new monitoring equipment (such as benzene) becomes operational.

While an efficiency pollution factor indicator would also be attractive, in practice it is difficult to implement. As an alternative, it is recommended that trends in population growth, energy generation, fuel consumption, vehicle density etc. be provided in parallel to the air quality indicators. Comparison of the two sets of data will allow conclusions regarding increasing or decreasing pollution efficiency.