Frameworks for Compiling and Presenting Environmental Indicators for the Transport Sector.

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Abstract:

This paper describes developmental work currently underway to use existing ABS and other source data to describe the linkage between transport economic activity and its impact on the environment. It is expected that this work will result in the preparation of an ABS publication which has the current working title of *Australian Transport and the Environment* (ABS Cat No 4605.0)

The starting point for this exercise is the OECD 'pressure-state-response' framework. The paper describes how this framework is used for the transport sector, including discussion of the indicators that are used to identify the linkage between the activities of various transportation modes ('pressure'), the resultant 'state' of various environmental media, and the 'response' by governments, businesses and individuals in terms of policies, and economic and other activities to improve the environmental media's state. Some data will be provided to illustrate the framework.

An alternative approach is also discussed which further elaborates on the economic-environment linkages. This discussion encompasses the concept of "sustainability indicators" as opposed to indicators that simply show "environmental state".

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1 INTRODUCTION

"Transport systems play a major role in the economic life of industrialised countries and in the daily lives of their citizens. The transport sector (production, maintenance, and use of transport infrastructure and mobile equipment) accounts for 4 to 8 per cent of GDP in the economies of industrialised countries, and for 2 to 4 per cent of employment. It also has a substantial importance in international trade, in business operating and household consumption expenditure, and in public expenditure. Negative effects of transport activities include air pollution and noise, consumption of energy, of land and of other natural resources, and congestion and accidents which are also part of environmental concerns. The non-internalised social costs of road transport are estimated to amount to around 5 per cent of GDP for industrialised countries." (OECD, 1993a)

In order to address any statistical description of a complex and broad issue, such as the relationship between transportation and the environment, it is necessary to have an organisational approach or a conceptual framework to provide an order to the boundaries of the task and to present information within accepted concepts and standards.

This paper discusses the approach that the ABS is using in the preparation of the publication *Australian Transport and the Environment* (ABS Cat No. 4605.0) which is expected to be released shortly. Then the paper goes on to describe another approach that could be tested and discuss where some of the relevant information would fit in that approach. Finally the paper explores the concept of "sustainability indicators", suggesting the future direction of indicator development.

The general reader may consider the frameworks under consideration to be rather detailed and complex. Nevertheless, the summary indicators frequently referred to in public debate need to be firmly based. The ABS sees the provision of comprehensive statistical frameworks as a necessary tool for ensuring the provision of relevant and relatable information.

The basic framework being used for the transport and environment publication is called the **Pressure - State - Response** (PSR) approach. The Organisation for Economic Co-operation and Development (OECD) has published several issues of a report on Transport and the Environment using this framework. The second section of this paper reviews another framework - the **Population - Environment Process** (PEP) framework which has been devised by Statistics Canada. The ABS is considering the use of this framework as the basis for its next general compendium of environment statistics.

Frameworks are necessary to bring order to a considerable volume of information. From the statistician's viewpoint, they assist in the application of standard definitions, classifications and methods; help to identify gaps in the data and so set priorities for data gathering; and guide the organisation of the information to draw out the relevant interactions between entities in the subject matter. These efforts to make frameworks more systematic led a number of countries, during the 1970's, to consider the relationship between stressors and responses. Probably the most developed formulation was the Statistics Canada Stress-Response framework, developed from the biological and medical literature. "The basic premise was that a given action (or stress or "dose") will bring about a certain level of response in an organism. Assuming that environmental systems should behave somewhat like individual organisms, it should be possible to quantify the "doses" (pressures and management responses) and relate those to changes in environmental state. ..... in practice it proved impossible to relate specific environmental changes back directly to specific pressures with any degree of certainty. The level of scientific knowledge and data available did not allow it." (Mitchell, 1994)

The stress-response approach was adapted by the United Nations in its Framework for the Development of Environment Statistics (FDES) and by the OECD in the Pressure - State - Response model. The ABS used the FDES as the organising framework for its compendium publication *Australia's Environment: Issues and Facts* (ABS Cat No. 4140.0), released in June 1992. These frameworks bring together the elements of environmental media, issues and sectoral approaches showing some of the flows taking place.

Statistics Canada introduced the Population - Environment Process (PEP) framework in its 1991 report *Human Activity and the Environment*. "In developing this approach, Statistics Canada tried to address some of the shortcomings of the UN and OECD frameworks for statistical office needs. The major concern was the limitations the existing frameworks imposed for the examination of impacts on the population and the socio-economic system from the environment. Both the availability and quality of environmental resources have a major impact on society and how it operates. It was felt that the then existing frameworks needed to be expanded to include these interactions, especially in the light of demands from policy makers regarding the assessment of sustainable development." (Mitchell, 1994)

The ABS is using the PEP framework to organise information about agriculture in the publication *Sustainable Agriculture - Issues and Facts* (ABS Cat No. 4606.0), expected to be released by the end of 1994. That effort draws on the work associated with the ecologically sustainable development initiative and undertaken under the broad direction of the Standing Committee on Agriculture and Resource Management (SCARM). The report *Sustainable agriculture: tracking the indicators for Australia and New Zealand* (SCARM, 1993) provides a good description of "a set of practical indicators which can be used unambiguously by decision makers to evaluate the sustainability of agricultural systems at regional and national scales". The processes, selection criteria and framework would be a useful starting point for any sector attempting to identify indicators related to sustainable development.

2 OECD "PRESSURE - STATE - RESPONSE" (PSR) FRAMEWORK

There are three parts to the PSR model and these form the basis for the Parts of the forthcoming ABS publication. Part 1 addresses the **pressures** on the environment resulting from transportation activities. The chapters in this part are organised according to mode of transport, for example road, rail and air.

Part 2 examines the impact of transportation activity on the **state** of environmental media, and other related issues. The chapters in this part cover the environmental media of air, water and land; and some related issues such as noise, wastes and human health (namely accidents and injuries).

Part 3 of the publication deals with the **responses** of society, in terms of policies, programs and actions, to the state of the environmental media. In this exercise, the responses are focused on aspects related to transportation.

Figure 1 provides a schematic description of the OECD Pressure - State - Response framework. The PSR framework is based on a concept of causality: human activities exert pressures on the environment and change its quality and the quantity of natural resources (the state box). Society responds to these changes through environmental, general economic and sectoral policies (the societal response). The latter forms a feedback loop to human activities. It is acknowledged that the PSR framework tends to suggest a linear relationship in the human activity-environment interaction. The OECD view is that the more complex relationships in ecosystems and in environment - economy interactions, need not be obscured by this presentation. Some data published by the OECD, comparing Australia with other countries is presented in Attachment 1.

Pressures

The pressures on environmental media that result from transport activities include restructuring of the environment, for example the development of new roads and airports; the generation of pollution and nuisances, such as air pollution and noise; and detrimental effects on the quality of life and health due to these and other outcomes such as congestion and accidents. The environment provides the source of natural resources, such as land, materials and energy, that are consumed by the activities of transport.

In OECD terms, indicators of environmental pressures derived from the detailed statistics in this part are termed indicators of indirect pressures, that is human activities which lead to direct environmental pressures. Some examples are the road traffic volumes, tonnes of freight transported and the number of vehicles. [Direct pressures, that is pressures directly exerted on the environment, are such things as emissions and consumption of natural resources.]

To investigate these pressures, chapters in the publication cover the following transport modes: Road, Rail, Shipping, Air and Pipelines. Within each chapter, information is presented, where available, to cover changes over time and geographic distribution of:

* infrastructure (for example, the kilometres of roads)

* stock (for example, number of vehicles)

* volume of activity through use of the infrastructure and stock (for example, number of passengers carried, total kilometres travelled, freight carried)

* consumption of resources (for example, quantity of fuel used)

* economic significance of the sector (for example, percentage of GDP contributed by the transport sector, number of people employed).

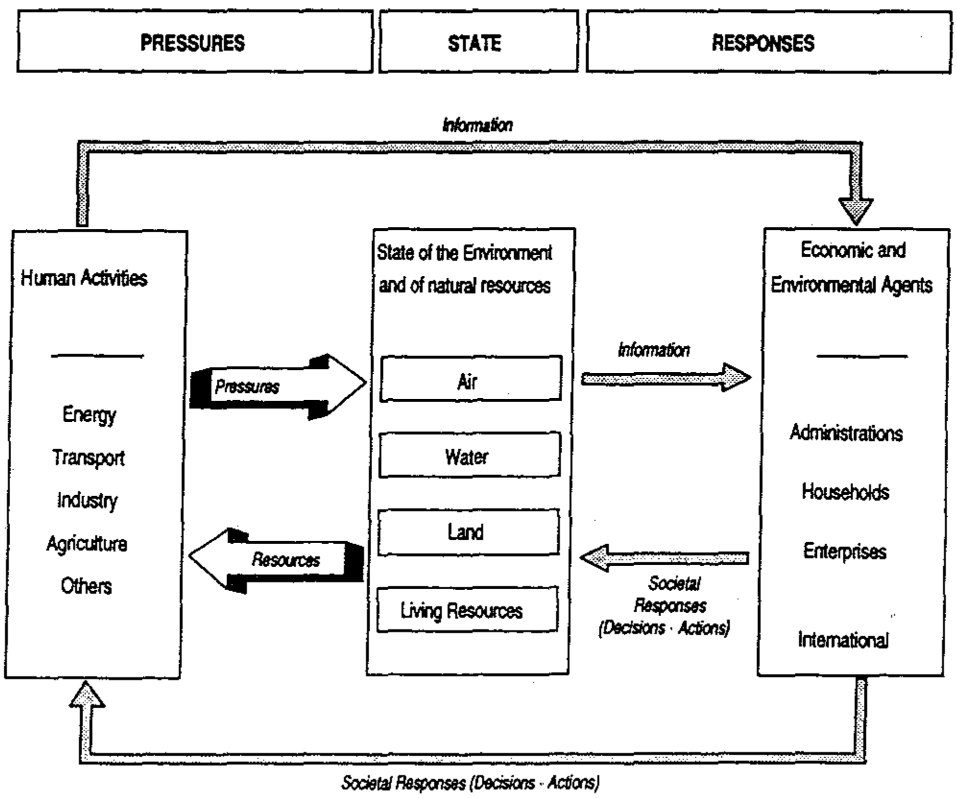

Figure 1: Pressure - State - Response Approach

Source: OECD Environmental Data, 1993

Through the statistics presented about "pressures" on the environment, the reader should be able to identify trends over time and possibly line up this information with known events and policy changes, as presented in the "response" part of the framework. The information on the significance of the mode of transport to the overall socio-economic system is provided in the final section of each chapter so that the reader can consider the balance between the contribution to society and the impact of those activities in terms of consumption of natural resources and degradation of environmental media. This is a slight departure for the basic approach.

State

This part of the framework is concerned with the impact of transport activity on environmental media, and some other related issues. To describe the state of the medium, air, for example, would require a description of the ambient concentration of various gases, such as carbon dioxide and nitrogen oxides. In the case of the gases mentioned, transportation is a large contributor, but other sectors such as industry and power generation also contribute.

The chapter on air concentrates on estimating the impact of transportation on environmental media by calculating the emissions of certain gases from the various modes of transport. With respect to other media the causality may sometimes be even more obvious, for example the impact of oil spills from ships in terms of the state of the water quality. However, there are a number of other impacts of transportation that are not clearly linked to environmental media, including noise and human health aspects (for example deaths, injuries and cost of vehicle accidents). These are included in this part but in the process provide an example of the difficulty experienced with placing some data within the framework.

Responses

This part includes information on the response of economic and environmental agents to the state of the environment, and other issues related to usage of natural resources. In the OECD framework, these agents can be governments, households and businesses, and any international flow-ons would also be included. Indicators of responses refer to actions to mitigate, adapt to or prevent human induced negative impacts on the environment; to halt or reverse environmental damage already inflicted; and to preserve the environment and to conserve natural resources.

Relevant information would cover noise and emission standards and vehicle design rules, new vehicle systems and alternative fuels, agreements about hazardous waste transportation and transport management, and usage of public transport. Information in the response category is frequently unavailable in quantitative terms, so a more qualitative and descriptive presentation may be required. This means that it is not a simple matter to select key indicators.

In summary, the PSR framework is a useful way of exploring the individual components of transport activity that impact upon the environmental media. However the focus does not appear to be strongly oriented toward the interactions between these components, although some of the flows are explored in the presentation of the information. Similarly, the pressures on the environment imposed by the nature of the population and its expectations for consumption can only be explored through the demands for the goods and services of the relevant economic sector. The following section of this paper therefore introduces another approach, namely, the Population - Environment Process framework , for researching the information requirements and presentation of that data.

3. AN ALTERNATIVE FRAMEWORK

An advance on the earlier approaches is to focus on the interactions between component parts of the system. This was identified as the way forward in terms of developing indicators and the environment statistics system, from a statistical agency viewpoint. The PEP framework focuses attention on the activities that society can control and for which it has responsibility, for example the activities of industry sectors, consumption by households and activities of governments, as well as the quality of publicly available resources of the environment such as water and air for which no one can be held directly accountable.

The PEP Framework

The Population-Environment Process (PEP) approach originated in the Environment and Natural Resources Section of Statistics Canada. Their work brings a systematic approach to bear on the organisation of environmental information. Problems with the earlier descriptive methods (based on the stress - response concept) were the implication that individual stresses could be associated with individual responses, and that at higher levels of aggregation the interrelationships are not clear. In reality, changes in environmental state are a complex reaction to a wide array of inputs resulting from human and natural activities.

A fundamental concept in the model is that of restructuring, a term used to summarise the range of impacts humans have on the environment. There are three basic expressions of these impacts: physical restructuring which results from construction activity and other changes to the natural landscape; chemical restructuring resulting from the release of pollutants and wastes; and biological restructuring as the result of harvesting, introduction of exotic species, and loss of species.

The PEP approach divides the world into three major components: the **population**, the **socio-economic system** and the **natural environment**, and incorporates the following principles:

* The socio-economic system is embedded in the natural environment.

* The managed processes within the socio-economic system that have environmental impacts are of two types: (a) extraction, harvest and use of the natural environment as processes providing necessary resources for the socio-economic system; (b) restructuring as a byproduct of production and consumption.

* The natural environment is affected by the outputs from the socio-economic system and the inputs required by the socio-economic system. The state of the environment changes as a result.

The framework is shown in Figure 2. The population appears as a stock endowed with a set of population processes (birth, death, and migration). This population draws services and non-durable goods from a set of socio-economic processes (largely consisting of production and operation) based on a capital stock of durable human made items. The population also interacts with stocks of natural assets in the environment through the processes of breathing air, drinking water, engaging in activities such as fishing, camping and hiking, and enjoying the aesthetics and amenities provided by the natural world. Direct use of the environment by the population leads to some restructuring, both through the use and degradation of natural assets and through release of wastes.

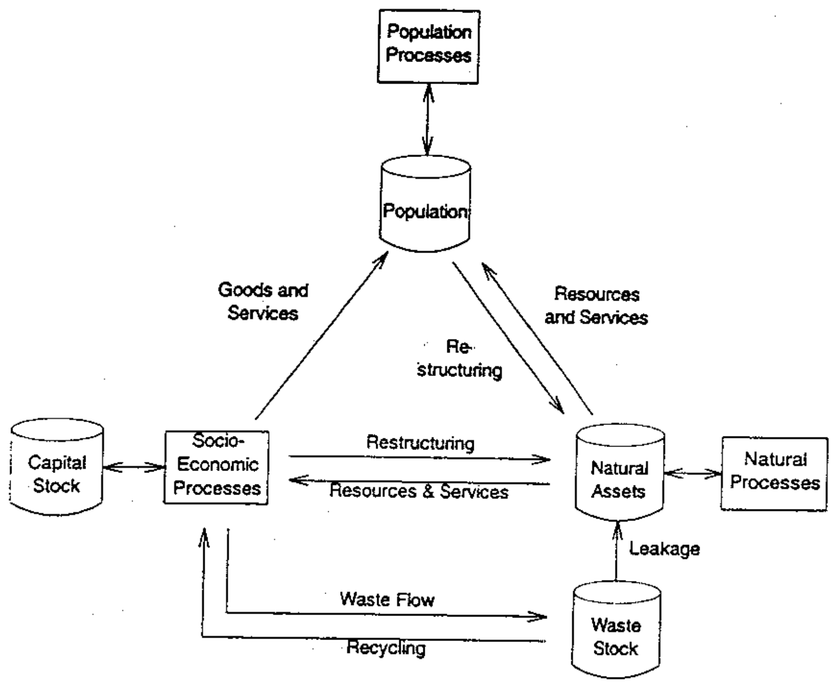

Figure 2: Population-Environment Process Framework

Source: Statistics Canada, 1991

Wastes are treated as a separate output of socio-economic processes as their generation does not necessarily have a direct environmental impact. These byproducts of production may be treated, stored or recycled to minimise their impact.

The specific purpose of the model is to show how traditional environmental data (emissions, loadings in media and biota, measures of physical and biotic state) can integrate with socio-economic data to provide a more complete picture of: (i) how environmental quality may be related to socio-economic activities; and (ii) how socio-economic activities may be influenced by changing environmental quality.

This approach can be used to organise research at a range of levels, from detailed regional and specific issue to a broadly based, indicative and national perspective. Many of the existing statistical classifications and data definitions can be used in the detail of parts of the framework. For example, the Australian System of National Accounts which describes the market economy would be almost entirely encompassed by the 'socio-economic processes' component and 'capital stock' component. Extension of the national accounts system, that is the integration of economic and environmental accounting would encompass the flows between the socio-economic, natural assets and waste components. With further development, econometric models could be incorporated, making it possible to investigate different regulatory mechanisms, for example pricing structures, taxes and tradeable rights.

The natural assets component would cover not only the national level in spatial terms, but also connections with the global dimension. Thus this approach could be extended to encompass global environmental issues, such as emissions of greenhouse gases and depletion of the ozone layer. In a similar fashion, the impact of Australian decisions and policies beyond our national boundaries could be described. This would be particularly true where international trade was an important feature of an issue, for example the import or export of wastes, endangered species or hazardous materials or, on a more positive note, trade in products associated with protection of the environment or to substitute for declining natural resources.

Information requirements of the PEP Framework

In this discussion the order of components is not significant. For presentation here, I have worked through the stocks, followed by the processes and then the flows. In a publication using this approach, careful consideration must be given to the selection and ordering of the components so that the message in the information is as clear as possible. Information to be included in a statistical report would be based on the level of geographic detail and the scope of the sectors or issues to be covered.

Population

A considerable number of data items are needed to provide background about the demand for personal transportation and transportation of goods and services. These are based on consumption patterns and location. Some of the relevant data are: number of residents, age distribution, location, number owning vehicles, number of households, distances to services, availability of public means of transport.

Capital Stock

Under this heading are placed all the variables describing the human made assets. For the transportation theme, information relating to infrastructure would be of particular relevance, such as: length of roads, type of roads, railways, ports;

number of vehicles, ships, locomotives.

Natural Assets

This section covers the state of the natural environment. The main focus in this component would be on land-use by transportation facilities and related impacts on the natural habitat, air and water; stocks of non-renewable natural resources (such as oil and gas); and the availability of renewable natural resources (such as alcohol fuels based on plant production). Data would be required on land use and land cover change, change in the stocks of natural resources, quality of the environmental media and the state of flora and fauna in the environment. [A boundary problem needs to be resolved, namely whether to include or exclude the natural resources consumed by the construction and manufacturing sectors in the production of the infrastructure and stock, and also the wastes generated by such activity.]

Waste Stock

This set of data items describes the amount of wastes that have to be dealt with before they impact on the natural assets and refers to quantities at a point in time. Some items would include the quantity of waste oil, used tyres, batteries and vehicle bodies.

Population Processes

This element deals with activities which change the human population and therefore impact on the demand for transport activity. Data items of interest could include: changes in population and their location bought about by migration, changes (trends) in the age structure and degree of urbanisation which could indicate demand for modes of transport and travel requirements, changes in income and employment distribution.

Socio-Economic Processes

The data items in this section would be associated with the activity of transporting people and goods and could include tonnes of freight transported by mode, type and location; numbers of passengers conveyed; distances travelled by motor vehicles; employment and financial information associated with these activities; overseas trade data; energy consumption.

Natural Processes

The information here would describe various natural cycles impacting on the natural environment. With respect to the transportation issue, the following could be considered: storms causing shipping accidents, meteorological conditions causing ozone smog, actions of extreme weather conditions causing degeneration of the transport infrastructure, air and water circulation systems which affect dispersion of pollutants, for example inversion layers and wind strength for air;

size, currents and flows of water bodies.

Goods and Services (flow to Population from Socio-economic processes)

This interaction between the socio-economic and population components could be described by information about availability of transport services; health issues such as lead concentrations in air, noise levels and exposure, road and other transport accidents; degree of public transport provision; reliance on motor vehicles.

Resources and Services (flow to Population from Natural Assets)

The stock of natural assets provides resources and services to the population. It could be argued that the impact of transport activity on air quality leads to an interaction with the population because of poorer quality air in particular regions.

Restructuring (flow to Natural Assets from Population)

The restructuring caused by the population interacting with the natural assets is covered by this part of the PEP approach. The interest here would relate to the more readily available access provided by transport modes to natural habitats for recreation where adverse use could occur, and to shortened travel times, particularly for international travel, which could give rise to quarantine issues.

Resources and Services (flow to Socio-economic processes from natural assets)

This flow identifies relevant items about the resources consumed by the socio-economic process from the natural assets. These include for the transport issue the use of land for infrastructure and the quantity of non-renewable resources consumed, such as oil.

Restructuring (flow to Natural Assets from Socio-economic processes)

The main impact of the socio-economic process in restructuring the natural assets is in the release of polluting material to air and water. This flow would cover a detailed examination of the emission of gases, emission of lead from petrol, ballast water discharge from ships.

Waste Flow (flow to Waste Stock from Socio-economic processes)

The final three flows between the Waste stock and the other components in the model could be described for this issue by information on the quantities of waste generated by type in the reference time period, details about recycling and information about leakages through breakdowns and release of wastes.

In summary, the PEP approach provides a systematic platform for investigation of various topics, whether sector or issues based; at differing levels of geographic detail, such as regional, ecozone, state or national; and focussing on the linkages between the major components of the whole system: people and their activities, the demands and outputs of the economy and the environment. Availability of data at the level of detail selected could be a limiting factor, however the approach has then assisted in identifying gaps.

4. SUSTAINABILITY INDICATORS

When considering the issue of sustainable development there is a requirement to take a broad view that includes the social and economic components, as well as the environment, and the interactions between all three components. All three components are interdependent and policy decisions and programs aimed at providing sustainable development have to be concerned about the viability of all three.

Definition

Most readers would be familiar with environmental indicators that reflect the condition of the environment. State of Environment reporting mainly uses this type of indicator which describes the quality or condition of environmental media. An example would be annual mean concentrations of dissolved oxygen and biological oxygen demand; concentrations of nitrate, phosphorus and ammonium; concentrations of lead, cadmium and copper in water; all measured over time. These indicators would describe the trend in the quality of water in particular locations.

Opschoor and Reijnders (Kuik, 1991) describe environmental indicators as "quantitative descriptors of changes in either environmental pressure or in the state of the environment. The ..... environmental pressure indicators express changes in the amount/levels of emissions, discharges, depositions etc in a predetermined region." These pressures can be by way of pollution, over-exploitation of natural resources such that future supply is at risk, and modification of ecosystems and landscapes so that the integrity of the system is in jeopardy.

Environmental effect indicators express the consequences of environmental quality changes in terms of their effects on people, populations of plants and animals, resources, ecosystems etc. For example, effect indicators concerning people would include indicators of public health, and for animal or plant species, the indicators could be monitoring qualities and size of populations.

Sustainability indicators are more than 'state' descriptors. They are concerned with the distance between the current state of an environmental resource and the desirable condition or goal, and the description of the interactions (or linkages) between social, economic and environmental sectors. The economy and society must interact with the natural environment and the condition of one is important to the other. Economic activity is based on the continued availability of material and energy resources and an environment that is sufficiently clean to support life. However by discharging pollution and by other features associated with human activity, society is having an impact on environmental processes and systems. To integrate the economy and environment, the indicators need elements from both parts, for example the carbon dioxide emitted per kilometre travelled.

Sustainability indicators should assist decision-makers to answer questions, such as: is there scope for further economic development in a region? Is the pattern of use of a resource sustainable or unsustainable? What is the urgency for taking measures to alleviate a particular pressure on the environment? The time horizon for the decision-maker becomes very important in terms of the focus for sustainable development, that is between a socio-economic focus and an environmental one. In "sustained economic growth", the emphasis is on the economy expanding within some (often rather relaxed) side conditions related to environmental quality and resource utilisation. Alternatively the "environmental sustainability" of development emphasises the preservation of the natural resource base plus environmental quality (referred to as the environmental capital), to be passed on intact to future generations.

Sustainable development has been a catch-cry since the Brundtland Report in 1987 and was given even greater prominence with the UNCED conference in Brazil in 1992. The Australian version is described in the documents related to the National Strategy on Ecologically Sustainable Development, endorsed by heads of government at the end of 1992. UNCED's Agenda 21 has strategies for sustainable development that Australia is committed to follow. The favoured definitions of sustainable development are clearly people-centred - "a pattern of development that meets the needs of the present generations without jeopardising the ability of future generations to meet their own needs" (WCED, 1987).

Opschoor and Reijnders identify a number of issues related to sustainability. These include the weight given to the 'integrity' of natural elements and the 'diversity' of species and systems. A further issue relates to 'substitution' possibilities. It is conceivable that one natural resource might replace another, eg sugar cane as a substitute for fossil energy, and when resources can be replaced then the unsustained use of a particular resource may not pose a problem in terms of economic survival of the activities using that resource. Technological development or innovation may lead to an expanded range of options for substitution of one resource for another from an economic viewpoint, but the implications from the environment viewpoint may be substantial.

An operational definition of sustainability requires that it be decided over what span of time we wish to ensure sustainability, and how to deal with the possible substitution of man-made assets for environmental resources. The time issue has been partly answered by reference to succeeding generations. This means that the physical stocks and condition of the environment are handed over such that economic and social development, at their current levels, are possible in that future time period. (This condition assumes that the current levels are themselves sustainable and where they are not then some repair work would be needed.) Examples of relevant practices might be harvesting trees at or below the maximum sustainable yield, and not emitting more gases from motor vehicles than can be handled by natural processes.

Selecting sustainability indicators and their characteristics

Lists of criteria for selecting environmental indicators and desirable characteristics of these indicators abound (CEPA, 1993). To these characteristics it is necessary to add that 'sustainability indicators' should:

* be derived from a coherent system of statistics, to assist with analysis of causes and consequences, and comparison with international activities;

* include the target or goal that is considered to be the sustainable level so that the trend toward or away from the target can be identified. Because the scientific knowledge is not complete, the goal may initially be a political compromise, but, as with the experience of the Netherlands, a pragmatic approach is a good starting point and there then exists an indicator for assessing the performance of environmental policy and programs;

* be consistent with underlying principles, classifications and the maintenance of traditional balances relating to production, income, consumption, savings, investment, etc;

* be developed in such a way as to allow formal modelling. For example, the Netherlands statistical agency has developed the National Accounting Matrix including Environmental Accounts (NAMEA) module which includes feedback from non-monetary to monetary variables and allows the simulation of trade-offs between different environmental objectives and most other objectives of macro-economic policy.

Indicator Development

A process for deriving indicators has been suggested by Opschoor and Reijnders and includes the following stages.

1. Identification of the main natural elements of environmental capital and their interactions, the relevant biophysical cycles, ecosystems, biological diversity.

2. Identification of the economically relevant features within these elements and their relationships to specific economic activities, such as whether they are inputs into the activity (eg a resource such as oil) or whether they receive the outputs from the activity (eg a waste to air such as carbon dioxide).

3. Selection of those elements that are quantitatively and/or qualitatively at risk, and a further analysis of these elements in terms of their significance in regenerative and resource support systems, and substitution options for these resources in economic activities.

4. Set standards/targets/critical levels with respect to the elements selected, in relation to the knowledge of sustainability and the minimum biological diversity to

be maintained.

5. Construction of indicators reflecting the development of environmental capital for step 3 above, either by building aggregate variables or by picking specific items from the set of elements. These indicators might be expressed as rates or flows; rates to stocks; and rates to goals or stocks to goals (if the targets have been set). This method emphasises the integrating principle of these indicators.

Adriaanse (1993) provides a very useful description of the development of environmental policy performance indicators which are underpinned by the Dutch policy to reach a sustainable development situation in one generation. The work is based on identifying relevant 'themes', for example change in climate, acidification of the environment, disposal of solid wastes, squandering of resources, and disturbance of local environments; and 'target groups', for example agriculture, traffic and transport, energy sector and consumers.

Indicators are selected for each 'theme': for example for change in climate the indicators are carbon dioxide, nitrous oxide, methane and CFC emission; for acidification the indicators are sulphur dioxide, nitrogen oxide and ammonia deposition; and for disturbance the indicators are the percentage of people adversely affected by odour or noise. Measures for the economic activity of the 'target group' are selected. For example the indicator chosen for traffic and transport is the time series of total kilometres travelled by all vehicles (called road traffic performance). It is often necessary to have a "weighting" method to produce a single indicator for a 'theme', and in their first attempt compromises were made in terms of limiting the possible contributing substances. Targets have been established for each 'theme'.

For each 'target group' it is necessary to relate the economic activity to a measure of the environmental pollution caused. The Dutch process identifies all the contributions of target groups to each of the themes, rearranges these in order to select the three main themes contributed to by each target group. For transport, these themes are change of climate, acidification and disturbance of local environment. Using the main contributing components (substances or agents) for each theme and a weighting process , an "environmental pressure" is computed. In addition to the measures of economic activity and environmental pressure, an "emission factor" (obtained by dividing the annual environmental pressure by the annual economic activity) is computed to show the trend. The trend is then in terms of "pollution per unit of economic activity", and is an indication of the effort put into emission reduction.

From the above analysis the Dutch environmental policy has set goals for each 'target group' so that the overall target for a 'theme' is achieved. For example, a policy targets have been set for the year 2010 for road traffic performance such that there should be a maximum growth of 35 per cent compared with the 1986 level; that the maximum emission of carbon dioxide be 21.6 million tonnes; and that the maximum emission of nitrous oxide be 65,000 tonnes. This approach relies on a good data source for both economic activity and the emissions from all sources to the environment.

Natural Resource Accounting and sustainability indicators

Natural Resource Accounting (NRA) offers a system for gathering and presenting information about resources in a way that is more comprehensive than deriving indicators. NRA is based on physical units of measure and describes the state and changes in the stocks and flows of natural resources which provide the economy with goods and services. The Norwegian implementation is generally regarded as well advanced. In that country they have two main categories of natural resources - material resources and environmental resources. Material resources are consumed by the production process (the quantity changes) whereas environmental resources are changed by the production process (the quality changes). Material resources include mineral resources (non-renewable), biological resources such as fish, forests (conditionally renewable) and inflowing resources, such as solar radiation (renewable). Environmental resources cover air, water, and soil, and are regarded as conditionally renewable. Most work to date has been on material resources but some countries have commenced development work on environmental resources. The ABS is currently preparing an energy resource account. Some work on valuing sub-soil assets, livestock, forests and land has been undertaken as part of the work on a national balance sheet. The previously mentioned NAMEA system from the Netherlands is an example of resource accounting to integrate environmental stocks and flows with economic activity.

The useful parts of a NRA from a sustainability indicator viewpoint are the reserves data at the beginning and the end of the reference period, the total extraction through the period and the adjustment to the reserves or resource base (through new discoveries, reappraisal, new technology etc). This information can be used to produce a ratio of use to stock available, often expressed as the number of years of availability before exhaustion of the stock, at economic extraction rates.

From a transport perspective the natural resource account on energy would be the most valuable as it would show the energy consumed by the various modes over time and allow calculation of various ratios such as energy intensity. The account covering possible substitution sources for petroleum and gas would be useful in policy analysis related to future availability of supply. The residual account (which deals with environmental impacts) would provide the data sources for indicators about load on the environment and also efficiency of cleaner vehicle technology measures.

5. CONCLUSION

Although ABS work in the field of environment statistics is relatively new and limited, the work on presentation of available information has led to a number of conclusions. First, the conceptual framework underpinning our statistical activities has to recognise the linkages between people, the economy and the environment, and provide information about those interrelationships. Experience has shown the need for a systematic approach showing how the activities of people influence and change the state of the environmental media.

Second, it has become obvious that the isolated indicators of the state of the environmental media, or the size of economic activity or changes in population do not separately provide adequate guidance to decision-makers in terms of sustainable development. The concept of *indicators of sustainability,* is needed to measure overall progress towards the ideal of sustainable development. These indicators require a target or threshold against which to observe the trend, and so become performance indicators for the range of programs and policies designed to achieve the target.

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ATTACHMENT 1

Comparison of Data from Selected Countries

The OECD has compiled indicators related to transportation and the environment which provide some indication of international relativities. They have been organised here to demonstrate the information associated with the different components of the PSR approach.

Table 1: OECD Transport - Environment Indicators

Indicator		Australia	Canada	USA	UK	Netherlands
Pressure						
Road Traffic Volume (billion veh-km)						
	1981	118.8	201.8	2,425.4	245.2	69.9
	1991	161.6	236.3	3,574.5	402.8	91.3
% change		36%	17.1%	47.4%	64.3%	30.6%
per capita ('000 veh-km per person)						
	1981	8	8.3	10.5	4.3	4.9
	1991	9.3	8.7	14.1	7	6.1
% change		16.3%	4.8%	34.3%	62.8%	24.5%
Road Network Length ('000km)						
	1981	792	928	6,235	342	93
	1991	853	930	6,243	358	118
% change		7.7%	0.2%	0.1%	4.7%	26.9%
Density (100km/sq km)	1991	11	9	67	146	317
Final Energy Consumption by Transport Sector (% of total)						
	1980	25.2%	22.4%	23.2%	16.9%	13.4%
	1990	25.5%	19.6%	25.3%	22.0%	15.9%
% change		0.8%	-12.5%	9.1%	30.2%	18.7%

Indicator		Australia	Canada	USA	UK	Netherlands
Tonnes of Oil equivalent per capita - 1990		1.32	1.55	1.93	0.81	0.71
State						
Atmospheric emissions of pollutants						
Carbon dioxide (million tonnes)						
	1971	40	88	1,080	99	48
	1991	67	118	1,489	142	67
% change		67.5%	34.1%	37.9%	43.4%	39.6%
% of total emissions - 1991		23.6%	27.1%	29.6%	23.3%	34.7%
Per capita (tonnes)		3.9	4.4	5.9	2.5	4.4
Response						
Fuel Price ($US per litre at current purchasing power parities)						
	1982	$0.36	$0.35	$0.34	$0.70	$0.67
	1992	$0.51	$0.43	$0.30	$0.77	$0.91
% change		41.7%	22.9%	-11.8%	10.0%	35.8%
Taxation (%)						
Gasoline	1992	46.2%	46.1%	33.9%	69.3%	73.1%
Diesel	1992	47.7%	39.0%	35.7%	59.0%	50.2%

Source: OECD (1993a), OECD (1993b)