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Sustainability and indicators in Amazonia

Conceptual framework for use in Amazonia

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Report number: W-99/37

September 1999

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1. Sustainable development and indicators

Sustainable development has become an important conception in the international policy debate, especially when referred to issues of environmental quality and the global distribution of resource use. However, what the concept exactly implies has never been clear and a considerable debate has evolved over the last decade that discussed the definition, operationalisation, implications and measurability of sustainable development. This discussion is due to the fact that sustainable development is a multi-dimensional concept by definition. The dimensions do not only include the two elements ‘sustainability’ and ‘development’, but also many aspects that are considered as being important for a ‘sustainable development’, among them welfare, environment and an equal distribution of resources over space and time.

This report outlines issues of sustainable development and its measurement which can be relevant for use in the PanAmazonian Countries (PAC). It reviews concepts of sustainability that have been formulated both in the political and scientific worlds and attempts to apply them to specific issues that can be relevant for assessing sustainable development in the PAC. The order of this report is as follows: Chapter 2 discusses the political evolution of the concept of sustainable development in the international policy field. Chapter 3 investigates the more recent developments of concepts of sustainable development in the scientific world. Five different conceptions of sustainable development will be introduced. Then, Chapter 4 discusses general aspects relevant for constructing indicator sets that can be important if sustainable development is to be used as an operational concept. Finally, Chapter 5 discusses issues of measurability of sustainable development in the PAC countries by illustrating indicators and management rules for specific case studies that can be important for the region.

2. Sustainable development in the international policy debate

For a long time, development was considered to be equivalent to promoting economic growth. Economic growth was supposed to be the single mechanism through which long-run increases in living standards could be achieved. Besides, economic growth would leave room for redistributive policies, which have been perceived as an important mechanism for solving social conflicts in modern welfare states (Thurow, 1980). For these reasons, promoting economic growth has been (and probably still is) the main determinant of development policies, as can be seen with reference to the structural adjustment programs (SAPs) of the World Bank and IMF (see Reed, 1992, 1996).

However, since the mid 1960s, economic growth as a goal society should attain was increasingly criticised. Within a couple of years Boulding (1966), Mishan (1967) and Georgescu-Roegen (1971) questioned the desirability of continuous income growth. In 1972, the famous report to the Club of Rome appeared (Meadows *et al*., 1972) that emphasised the costs of economic growth in terms of increased resource scarcity and environmental damage due to rising production and population growth. The alarming message of the model calculations presented in the report was that the limits would be reached within two generations: a collapse of human civilisation would be the result. Technological change would not escape the limits but would result only in higher levels of population and industrial production before the collapse. The limits are reached inevitably unless growth in both population and per capita income would be halted.

These publications may have altered the way development was perceived. In 1972, the United Nations Conference on the Human Environment was held in Stockholm. It attempted to find a compromise between economic prerogatives and ecological imperatives. One of the conclusions of this conference was that economic growth was desirable only if it was environmentally sustainable and equitable in terms of human benefits. As an aftermath of this conference, the United Nations Environment Programme (UNEP) was formed. During the 1980s, the world became increasingly aware of global environmental problems such as global warming and the ozone layer depletion. Recognition was growing that many environmental and social problems were not only local or regional, but global. In 1983, the Brundtland commission was formed to study problems of economic development integrated with environmental concerns and equity considerations. Their report, “Our Common Future”, published in 1987, stressed the need for development strategies in all countries that recognised the limits of the ecosystem’s ability to regenerate itself and absorb waste products. It recognised poverty as one of the main threats for an ecologically sound economic development. The notion of *sustainable development*, as an alternative to more traditional models of development, was presented in this report. Sustainable development is development that “meets the needs of the present without compromising the ability of future generations to meet their own needs” (WCED 1987, p. 8; see also Box 1). An alternative, and more illustrative, description of sustainable development was also given in the report: “a process of change in which the exploitation of resources, the direction of investments, the orientation of technological development, and institutional change are all in harmony and enhance both current and future potential to meet human needs and aspiration" (WCED 1987, p. 46).

Box 1. The Need for Sustainable Development

The Brundtland report explicitly attempted to combine aspects of economic development, environmental quality and equity considerations in one overarching concept: sustainable development. It does not only imply equity between generations, it also implies equity for the current generation. It was recognised that sustainability is an issue for all communities, from small rural towns that are losing the natural environment upon which their jobs depend, to large metropolitan areas. In a sustainable community, solutions to problems take into account the links between economy, environment and society. In fact, the very questions asked about problems in a 'sustainable' community include references to these links. Many communities which have been linked to their natural environment in a sustainable way, break this link once they are connected to the world market, as export-led growth includes the growing of crops for exports and withdrawn from natural assets within the community in exchange for some small amount of money.

The unequal global division of resource use also emphasises the need for sustainable development. The 26% of world's population living in the North nowadays consumes 80% of the resources (WCED, 1987). When the remaining population, living in the 'South', wants to achieve a similar lifestyle of the North, total resource withdrawn can be expected to raise by more than 300%. As humans consume nowadays already 40% of global terrestrial net primary production (Vitousek, 1994), 54% of total water resources that are available (Postel *et al*., 1996) and about 66% of marine fishery resources (Food and Agriculture Organisation, 1994), it is clear that a three times fold increase cannot be supported by the carrying capacity of this earth. Hence the current division of resource use can be characterised as unsustainable in the long-run.

The concept of sustainable development was subsequently embraced by several national governments. The government of the Netherlands, for example, has adopted the principle in their national environmental policy plans (VROM, 1989). However, it was recognised that a world-wide approach was favourable due to the global nature of the problems at stake. For that reason, the United Nations was considered as the most effective supranational organisation to co-ordinate, initiate and stimulate discussion on and implementation of sustainable development. At the United Nations Conference on Environment and Development (UNCED) in Rio de Janeiro in 1992, the global issue of sustainable development was addressed. This conference resulted in the formal acceptance by 182 governments of the 27 principles enshrined in the Rio Declaration on Environment and Development (see Box 2), and adopting the global agenda for action on sustainable development represented by the forty-chapter Agenda 21 (see Chapter 3.2.5 and Annex I). Out of this conference, too, came the Statement of Principles on the Management, Conservation and Sustainable Development of all Types of Forests, the United Nations Framework Convention on Climate Change, the United Nations Convention on Biological Diversity, and a recommendation for an international convention on desertification. Each of these conventions on specific environmental problems are still operating and in force. Hence, the concept of sustainable development was applied and spread out to a number of specific and urgent environmental problems.

Box 2: Rio Declaration on Environment and Development

Recognising the integral and interdependent nature of the earth, the nations meeting at the Earth Summit in Rio de Janeiro adopted a set of principles to guide future development. These principles define the rights of people to development, and their responsibilities to safeguard the common global environment. The Rio Declaration states that the only way to achieve long-term economic progress is to link it with environmental protection. This will only happen if nations establish a new and equitable global partnership involving governments, their people, and key sectors of societies. They must build international agreements that protect the integrity of the global environment and the development system. The Rio Declaration includes the following principles:

- People are entitled to a healthy and productive life in harmony with nature.
- Development today must not undermine the development and environment needs of present and future generations.
- Nations have the sovereign right to exploit their own resources, but without causing environmental damage beyond their borders.
- Nations shall develop international laws to provide compensation for damage that activities under their control cause to areas beyond their borders.
- Nations shall use the precautionary approach to protect the environment.
- In order to achieve sustainable development, environmental protection shall constitute an integral part of the development process, and cannot be considered in isolation from it.
- Eradicating poverty and reducing disparities in living standards in different parts of the world are essential to achieve sustainable development and meet the needs of the majority of people.
- Nations shall co-operate to conserve, protect, and restore the health and integrity of the Earth's ecosystem. The developed countries acknowledge the responsibility that they bear in the international pursuit of sustainable development in view of the pressures their societies place on the global environment and of the technologies and financial resources they command.
- Nations should reduce and eliminate unsustainable patterns of production and consumption, and promote appropriate demographic policies.
- Environmental issues are best handled with the participation of all concerned citizens. Nations shall facilitate and encourage public awareness and participation by making environmental information widely available.
- Nations shall enact effective environmental laws, and develop national law regarding liability for the victims of pollution and other environmental impact of proposed activities that are likely to have a significant adverse impact.
- Nations should co-operate to promote an open international economic system that will lead to economic growth and sustainable development in all countries. Environmental policies should not be used as an unjustifiable means of restricting international trade.
- The polluter should, in principle, bear the cost of pollution.
- Nations shall warn one another of natural disasters or activities that may have harmful transboundary impacts.
- Sustainable development requires better scientific understanding of the shared global problems. Nations should exchange knowledge and innovative technologies to achieve sustainability.
- The full participation of women is essential to achieve sustainable development. The creativity, ideals, and courage of youth and the knowledge of indigenous peoples are needed, too. Nations should recognise and support the identity, culture, and interests of indigenous peoples.
- Warfare is inherently destructive of sustainable development, and nations shall respect international laws protecting the environment in times of armed conflict, and shall co-operate in their further establishment.
- Peace, development, and environmental protection are interdependent and indivisible.

Source: UN (1992). *Rio Declaration on Environment and Development*, United Nations.

The member states of the UN, pledged to reflect the UNCED agenda in their institutions, policies and international relationships, have ensured that the environmental and global impact of their decisions are considered. It was perceived that sustainable development can only be realised through national adherence to the principles of Rio and the recommendations of Agenda 21. Non-governmental organisations, as well as business, scientific and civil communities should also participate in the implementation of sustainable development. To co-ordinate and supervise implementation of the Rio Agreements and to monitor progress, the United Nations Commission on Sustainable Development was set up. Within this commission many efforts have been undertaken to set up a system of sustainable development indicators, building upon initial work of Peter Bartelmus at the UNEP (Bartelmus, 1994). The United Nations, in 1953 responsible for the nowadays widely used system of national income accounts (cf. Myrdal, 1974), hope now again to introduce a new system of sustainable development accounts, where indicators are formulated that monitor progress on several important chapters of Agenda 21 (see Section 5.1).

3. The sustainable development debate in science

Sustainable development is in particular a political concept, introduced in a political environment (i.e. the UN) and elaborated through conferences which can be perceived at best as 'negotiations at the supranational level'. One of the members of the WCED-commission, Timberlake, has argued that the concept is not so much scientifically based, but the outcome of a political compromise between North and South (Timberlake, 1989). The North wanted environmental protection, the South poverty alleviation and combined they form sustainable development. This compromise does, however, not guarantee that sustainable development is feasible. Moreover, it does not specify how the concept can be co-operationalised.

However, although the origins of sustainable development, are political, many older formulations of the concept have been found in the scientific literature, especially in the political, economic and philosophical sciences. For example, the issue of non-declining utility over generations has originally been at the hart of economic theory and early economic writers like John Stuart Mill investigated issues of sustainable development *avant la lettre*.

Especially after the concept of sustainable development was reinforced by the Brundtland report, there has been a substantial scientific literature aiming to provide sustainable development with a scientific basis. Whereas the scientific literature in the late 1980s basically was dealing with questions how the concept of sustainable development could be extracted from existing philosophical theories (cf. Hilhorst, 1987), in later years more efforts were devoted towards the measurability of the concept of sustainable development. The remainder of this section deals with the question of what sustainable development exactly implies; the measurement of the concept will be addressed in subsequent sections.

3.1 What is sustainable development?

3.1.1 A meteoric shower of definitions

What is sustainable development? The Brundtland-report stated that sustainable development "meets the needs of the present without compromising the ability of future generations to meet their own needs" (WCED 1987, p. 8). The concept of sustainable development was formulated as a right in Principle 3 of the 1992 UNCED Rio Declaration: "The right to development must be fulfilled so as to equitably meet developmental and environmental needs of present and future generations". Alternatively it has been suggested that sustainable development is development based on patterns of production and consumption that can be pursued into the distant future without degrading the human or natural environment (Ekins and Jacobs, 1995). Tietenberg (1984) has remarked that the sustainability criterion suggest that, at a minimum, future generations should be left no worse off than current generations. The European Union, speaks in its Fifth Action Programme, that "sustainable is intended to reflect a policy and strategy for continued economic and social development without detriment to the environment and the natural resources on the quality of which continued human activity and further development depend". And O'Riordan, an environmental scientist has argued that sustainability implies "embracing ethical norms pertaining to the survival of living matter, to the rights of future generations and to institutions responsible for ensuring that such rights are fully taken into account in policies and actions."[1]

3.1.2 Central elements in definitions

Morati *et al.* (1993), who have reviewed over 40 definitions of sustainable development found in the scientific literature or in the political discourse, have suggested that the central elements in most of the definitions of sustainable development are:

(i) a notion of environmental decay that has to come to a halt;
(ii) a notion of intergenerational equity so that future generations will not be worse off than present generations;
(iii) a notion of intra-generational equity, which has mostly been applied in the North-South context.

The various definitions found in the literature differ, however, with respect how these three aspects have been assimilated in the definitions. Environmental aspects, for example, have been differently defined in terms of biodiversity, carrying capacities, conservationists arguments or economists arguments (i.e. internalising externalities). It is likely that in science, the way the concept of sustainable development is defined is influenced by the metaphysical orientation of the researcher (or research group) and the disciplinary background of the researchers. In the absence of a uniform definition of the concept of sustainable development, the exact implications of a development that is sustainable remain unclear and subject to much discussion.

3.1.3 Distinguishing development from sustainability

Hansen (1996, cited from Smith and McDonald, 1998) has made a useful distinction between sustainability concepts as an ideology or sustainability concepts as a property of a system. The former describes sustainable development as a *goal* society should attain; the latter defines sustainable development as a *property of a system*, i.e. the ability of a system to fulfil a set of goals over time. This useful distinction can be found also elsewhere in the literature. Pearce *et al.* (1990), for example, have suggested to divide sustainable development into development and sustainability. Development refers then to a set of desirable (social) objectives, such as increases in income, a more equitable distribution of income, improvements in education, housing, environment, health and so forth. Let us call this set of objectives *D*. Sustainability is then the property of the system that ensures that the calculated value of this set of desirable objectives does not decrease over time (or is not lower than a certain defined minimum level). Let us call this non-decreasing condition, the sustainability constraint *C*. The essential points are then (i) *what* is included in *D*, and (ii) *how* do we determine *C*. The first is clearly an ethical question and deals with objectives society considers as valuable. The second question,

[1] O'Riordan 1988 (p. 30), cited from Pezzey (1989, p. 64). Many more definitions of sustainable development can be found in the literature (Morati *et al.*, 1993).

however, can, in principle at least, be determined more scientifically (see also the discussion in Box 3).

Box 3: Sustainability constraints in economics

Sustainability constraints in economics have been heavily debated. What are the exact implication of the sustainability constraint *C*? Two possibilities have been emphasised: (i) maximising the net present value of *D*, which implies that the vector *D* is discounted over time; (ii) maintaining a minimum level of *D*, which implies that discounting of *D* is not allowed. Economists have argued that the positive rate of time preference or diminishing marginal utility provide an argument for positive discount rates (cf. Pearce *et al*. 1990, Ch.2). But Ramsey (1928), an early economic modeller, emphasised that discounting utility between generations was 'ethically indefensible'. Solow (1986, p. 143) states that economists probably have been less concerned with ethics in this case due to the mathematical convenience of discounting in economic modelling. However, discounting is a highly sensitive parameter in intergenerational models (see Dasgupta and Heal 1979, p. 310) and should be determined by other arguments than 'mathematical convenience'. Pezzey (1989) made in this respect a useful distinction between sustainable and optimal development. Optimal development implies maximising the net present value of future *D*. This contrasts with 'sustainable development' in which a minimum level of *D* is preserved. Sustainable development can then be seen as a constraint to the optimisation problem (i.e. a minimum level of non-discounted *D* which should be conserved) and discounting of other variables in the model can be performed within the bounds set by the sustainability constraint (Pearce *et al*. 1990, p. 57).

The sustainability constraint can essentially be translated to the question: can it be sustained? A system, or a process, cannot be sustained if it is not able to repeat and regenerate itself infinitely (see also the treatment of the work of Bossel (1996) in Chapter 3.2.4). Clearly, unlimited growth in the extraction of exhaustible resources can not be sustained indefinitely as the earth is limited in a physical sense. However, improving the efficiency of the use of materials in the economy, can make the strive for greater welfare compatible with a reduced dependence on natural resources, if technology would permit us to follow such a strategy. In a similar reasoning can the logging of timber forests called unsustainable, as long as no efforts are undertaken for reforestation and measures for maintaining biodiversity.

3.2 Operationalising sustainable development: five different approaches

The scientific literature dealing with sustainable development has obviously not concentrated very long on establishing the exact definitions of sustainable development. Operationalising sustainable development, whatever it may be precisely, has become the central cornerstone of the scientific literature dealing with the concept. This literature essentially deals with the question how the set of desirable (social) objectives can be identified. It deals with the question how *D* can be defined in the framework outlined in Section 3.1.2. On this operationalisation of sustainable development, five different approaches were found in the literature:

1. the wealth-approach;
2. the mosaic-systems approach;

3. the mosaic-principles approach;
4. the systematic-principles approach;
5. the political approach.

Each of these approaches will be elaborated below. The question how these approaches are translated into indicators, so that sustainable development can be *measured*, will be discussed in Chapter 4.

3.2.1 The wealth approach

The wealth approach to sustainable development originates from economics. It states that wealth is to be equally passed over to future generations. Wealth, however, is a rather vague concept in economics. Firstly, it has been suggested that sustainable development implies non-declining consumption indefinitely, i.e. sustainable, or 'Hicksian' income. The problem of non-declining consumption in a world with finite resources was investigated by Hartwick (1977) and has resulted in the 'Hartwick-rule' which prescribes that the receipts of extraction of current exhaustible resources should be reinvested in reproducible capital such that per capita consumption can remain constant. The resource rents should thus be invested in man-made capital such that the accumulation of man-made capital offsets the inevitable decline in natural capital due to extraction. Hence, natural capital and man-made capital (or 'human capital') can be substituted for each other as long as the total capital base does not decline (see Figure 3.1). Sustainable development requires then that the aggregated value of all types of capital is to be maintained. This has been labelled as the 'weak sustainability' concept (Pearce *et al*., 1990), which contrasts with the strong sustainability concept where the natural capital base is to be maintained (see below).[2]

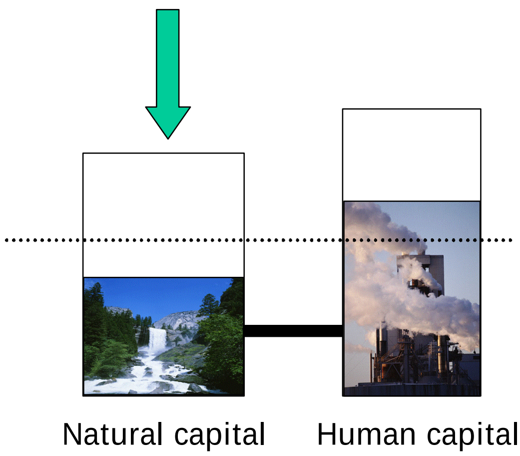

Figure 3.1 Under the weak sustainability approach natural capital and human (man-made) capital can be substituted for each other, as long as the total capital base remains the same. In the strong sustainability approach, such a substitution is not allowed. Each type of capital has to be maintained.

[2] The weak sustainability paradigm has been especially popular in empirical work (see Bartelmus, 1997 for an overview).

Applying the Hartwick rule assures that sustainable development is feasible (Hamilton, 1995). It requires perfect substitutability between natural and man-made (reproducible) capital. The natural capital base will be eroded along the way of economic growth.[3]

Secondly, it has been suggested that sustainable development requires a non-declining natural capital base, which has been labelled as strong sustainability. Under strong sustainability each type of capital itself has to be maintained. Hence strong sustainability limits the substitution possibilities between natural and man-made capital. There is some ambiguity whether strong sustainability requires that the *physical* natural capital base must remain constant, or the *value* of the natural capital base. If the latter approach is chosen, strong sustainability may still result in environmental decay. Suppose that over time positive economic growth rates prevail and that the rises in income have two effects: (i) a smaller natural capital base (environmental decay); and (ii) higher preference for environmental quality. There can be, in theory at least, a path where the physical natural capital base declines but the value remains constant due to higher preferences such that the strong sustainability criterion is met.

Concluding, the wealth approach to sustainable development may assure that wealth is passed over to next generations, but does not assure that nature is passed over to next generations. The wealth approach seems only be taken seriously in economics. None of the international organisations dealing with sustainable development has taken one of the above described concepts as a guiding principle for sustainable development.

3.2.2 The mosaic-systems approach

The mosaic-systems approach has become popular at the World Bank. This approach distinguishes various development dimensions, or systems, relevant for sustainable development. At the World Bank (Munashinghe, 1996), three systems are distinguished: the economic system, the environmental system and the socio-cultural system (see Figure 3.2). Each system has its own characteristics and its own requirements for maintenance. Sustainable development would then require a balanced maintenance for each system, indicated by the shaded area in Figure 3.2.

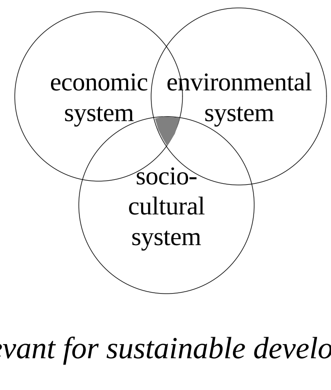

Figure 3.2 Three systems relevant for sustainable development.

[3] The disutility stemming from environmental decay is normally not included in the analysis of sustainable income, but can be classified as a special category of natural capital.

According to the mosaic view, sustainable development includes in its development vector *D* more arguments than traditional economic arguments. With current economic development and policy making mainly oriented on short-term economic goals, sustainable development can be seen as an alternative in which also environmental and socio-cultural aspects come to the foreground. In the literature, also other classification schemes for relevant systems can be found. Crabtree and Bayfield (1998), for example, distinguish socio-economic, environmental and institutional systems. Nature and culture are other two systems that are sometimes distinguished on this level.

Box 4 The importance of improving social conditions as an element of the mosaic-systems approach

Social conditions are an important aspect for sustainable development. Economic production is not an accidental process, but is ultimately driven by human and societal needs. Human and societal needs do not necessarily relate directly to economic activities: human activities relate to survival and to certain valuable things in life such as affection, power, security, peace of mind and pleasure. Needs can then broadly be defined in terms of basic needs such as 'nutrition', 'shelter', 'clothing', 'education', 'health' or 'clean drinking water', or in terms of wants, i.e. diversity of food and clothes, consumer durables etc. Needs also enclose intangible assets, such as broader conceptual terms of 'welfare', 'well-being', 'human rights', 'peace' and 'self-realisation' (for example through employment). These needs in its broadest sense drive, individually and collectively, economic activities and thereby also environmental impacts.

Poverty in itself is recognised as a major threat to environmental quality (World Bank, 1992; Munasinghe, 1996). Unsustainable practices will be enforced when basic human needs are at stake. Lack of education may result in lack of opportunities to adapt to societal changes so that unsustainable practices are introduced in a local community that transforms from subsistence farming to deliveries for the wider economy. For these reasons, providing basic human needs and opportunities for welfare, self-realisation, etc., are major concerns for any strategy towards sustainable development. Important in this aspect is, for example, the question whether benefits resulted from extraction of resource stocks accrue to the local community, or are transferred to other places and people. The latter can hardly be identified as sustainable.

The mosaic systems approach seems consistent with most of the definitions of sustainable development, in the sense that it reflects the dimensions that are relevant in the concept. However, it is not entirely clear which are the key-dimensions. Moreover, each dimension breaks down in numerous sub-dimensions, which can bring difficulties when defining sustainable development in operational terms. For example, the environmental dimension captures, amongst others, global warming, biodiversity, ozone layer protection and numerous localised types of pollution. Alternative approaches are summarised in Box 5 and Box 6. Trade-offs between the various dimensions (and sub-dimensions) are very difficult to assess when using this approach.

3.2.3 The mosaic-principle approach

The mosaic principle approach is closely connected to the above stated mosaic-systems approach, but focuses on main principles of importance in the concept of sustainable development. Morati *et al*. (1993) and De Bruyn (1999, ch.2) identify three main principles inherent in the concept of sustainable development: economic principles, ecological principles and equity-principles. The principles can be given as:

Economic principles

- maximising welfare;
- improving efficiency.

Ecological principles

- living within carrying capacities;
- conservation of resources (i.e. exhaustible and renewable resources and biodiversity).

Equity-principles

- intragenerational equity (North-South division of wealth, human rights, etc.);
- intergenerational equity (fair division of wealth and nature among generations).

Box 5: Improving efficiency

'Doing more with less' has also been proposed as a strategy to achieve sustainable development. Improving efficiency is the key-element in research efforts that have plead for achieving a Factor 4 or 10 reduction in materials intensity, as has been elaborated by Von Weiszäcker *et al*. (1997) and the Factor 10-Club. A reduction of a Factor 4 aims to halving resource use while doubling wealth (income). A Factor 4 reduction translates itself into a Factor 10 reduction for developed economies if also the current unequal distribution of resource use is to be eliminated. It is based on the notion that the world's total material throughput should be reduced by 50% and OECD countries currently consume 5 times more throughput than the world average (cf. Weterings and Opschoor, 1992).

Decreasing the MIPS (Material Input Per Unit of Service) can be used as tool to improve efficiency. MIPS is a measure that estimates the material use for providing a certain service from 'cradle to grave' (Schmidt-Bleek, 1994). MIPS can be an important tool for the benchmarking of individual products or production processes.

Improving efficiency implies that economic growth is to be delinked from its environmental impacts. The 'de-linking' imperative is conceived as a necessary step towards achieving ecosystem's stability. It is derived from a number of theoretical studies that have plead for a reduction of the throughput of our economic system (cf. Daly, 1991; Georgescu-Roegen, 1971). The concept of de-linking has also gained political interest. For example, it has formed the cornerstone for environmental policy in the Netherlands (cf. VROM, 1997).

The economic aspects constitute elements relevant for societies nowadays, such as the strive for more welfare. Ecological aspects reflect the ecosystem that is to be preserved for future generations of both human and non-human species. Equitable aspects reflect aspects of inter- and intragenerational fairness (i.e. a fair distribution of welfare over time and regions). When these elements are combined, they may result in a description of the concept of sustainable development where it's definition chosen may fall within a plane -a triangle- of which the corners are given by the three E's, ecology, economy and equity (see Figure 3.3). To a certain extent these principles conflict with each other and a few examples of such conflicts are also given in Figure 3.3.

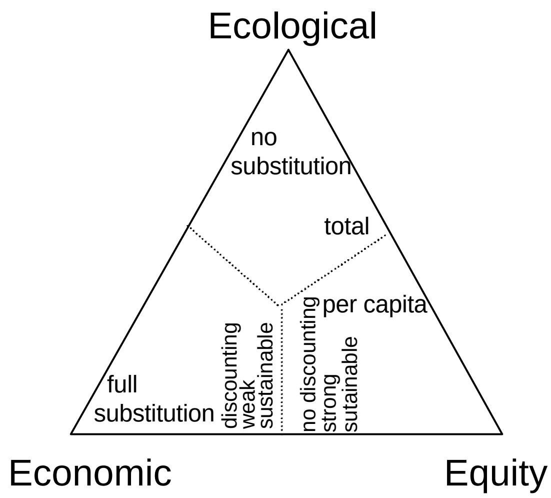

Figure 3.3 Three different paradigms in sustainable development.

Box 6: Carrying capacity and the 'Environmental Utilisation Space'

An important imperative for sustainable development, which has been put forward in the literature, proposes to stay within the carrying capacity of ecosystems. The concept of the Environmental Utilisation Space (EUS), introduced by Siebert (1982) and advanced by Opschoor (1987, 1992), can be seen as a heuristic tool for describing the functioning of the ecosystem as a constraint to economic development. According to Opschoor and Weterings (1994), the EUS represents "the locus of all feasible combinations of environmental services that represent steady states in terms of levels of relevant environmental quality and stocks of renewable resources". The environmental services can be perceived as functions ecosystems provide to mankind. These functions can be maintained over time subject to the constraint that the potential environmental decay due to human activities (environmental pressure) does not exceed the regeneration function of the environment, at least not enduring. That is: one should not harvest more from the stock than the stock grows each year, or the next year returns a lower stock available for providing environmental services. This is similar to the well-known theory of carrying capacity and renewable resources (Clark, 1976), for example in the area of fishery. The EUS expands on this theory by allowing two kind of harvesting: either using the environment as a source (through extraction of resources, recreation, etc.) or using the environment as a sink (to absorb wastes and emissions). The source and sink functions are interrelated: if too much pollution is generated, also the source function will be affected negatively (see Appendix II).

There is some empirical evidence that the current use of the environment as a sink in European countries has exceeded the EUS considerably. Adriaanse (1993) has developed several sink indicators and concludes that the present levels of pollutants in the Netherlands are above the steady state levels. Similarly, current emissions of sulphur in Europe exceed the EUS, interpreted in terms of the critical loads, in the majority of places (Posch *et al.*, 1995). In cases where the exact borders of the EUS can not be determined scientifically, Opschoor and Reynders (1991) have proposed that the trend towards the assumed direction of the steady state could be taken as a first guiding principle for public policy. They suggest that in many cases the assumed direction can be supposed to lay below the current levels of environmental pressure in developed economies. It implies that environmental pressure must be delinked from economic growth in absolute terms if the limits posed by the EUS are not be violated (see De Bruyn and Opschoor, 1997).

The mosaic-principles approach results in some guidelines towards sustainable development and can therefore essentially be interpreted as a normative variant of the mosaic-systems approach. It essentially provides reference values for the phenomena distinguished in the mosaic-systems approach. The same disadvantages applied to the mosaic-systems approach therefore also apply to the mosaic-principles approach: the number of dimensions and sub-dimensions to be distinguished are rather extensive. However, trade-offs between efficiency and equity, or efficiency and carrying capacities, are made explicit.

3.2.4 The systematic-principles approach

A totally different conception of what sustainable development implies, comes from the system-theoretical approach. The elements of importance for the development vector D are here derived from the need of systems to reproduce themselves; i.e. to sustain. Bossel (1996), in his highly original contribution, has taken such approach and comes to a classification of basic orientors, characteristics essential for any system to sustain itself. The orientors are: existence, effectiveness, freedom of action, security, adaptability, coexistence and psychological needs. These orientors give information on the capacity of a system to sustain and can therefore be seen as elements of the development vector D. Figure 3.4 gives an example of the application of basic orientors on various subsystems that are relevant for sustainable development.

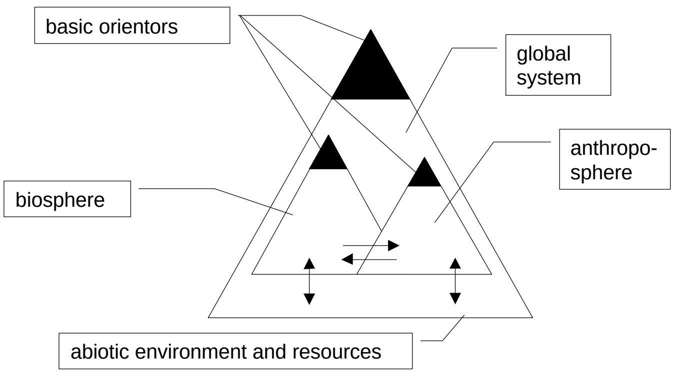

Figure 3.4 Basic orientors applied on various systems relevant for sustainable development.

Also the INSURED (Instruments for Sustainable Regional Development) project (Schleicher-Tappeser *et al*., 1998) has underlined the importance of paying attention to the 'systemic principles' that are essential for vital systems and relationships.[4]

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[4] Starting from the orientors, and focusing on various subsystems, such as infrastructure, economic and social systems, Bossel arrives at 220 indicators relevant for sustainable development.

The system-analytical approach is useful for outlying the essential characteristics of sustainable systems; however, it does not very well connect to most of the political efforts undertaken so far at, for example, the World Bank, OECD or UN. The system-analytical approach is a field in development, nevertheless with a high potential for a re-orientation towards questions related to sustainable development in the future.

3.2.5 The political approach

Finally, it has been suggested that the definition of what sustainable development is, depends on the outcome of a voluntary agreed decision making process. Democratic governments and NGOs may formulate policies to achieve sustainable development. When they start to negotiate on the content of sustainable development, the outcome may come close to what sustainable development is according to various stakeholders. The outcome of the negotiations, including the targets they have identified, can then be considered as sustainable development as they may reflect the outcome of negotiations on the content of sustainable development for actual policy making and policy guidance.

Adriaanse (1993) has discussed this approach in the policy context of the Netherlands: from environmental policy targets he achieves various indicators which can measure whether the policy targets will be met. These indicators can then be integrated with each other in a ‘distance to target’ approach, which measures how far the current situation is from the desired situation.

Box 7: Issues in Agenda 21 relevant for sustainable development

The forty chapters of Agenda 21 are divided into four sections:

1. Social and Economic Dimensions (chapters 1-9): examining the underlying human factors and problems of development, along with the key issues of trade and integrated decision-making;

2. Conservation and Management of Resources for Development (chapters 10-22): presenting the range of resources, ecosystems and other environmental issues (i.e. forests, water, nuclear hazards), all of which must be examined in detail if sustainable development is to be achieved at global, national and local levels;

3. Strengthening the Role of Major Groups (chapters 23-32): investigating the social partnerships necessary if sustainable development is to become a reality. It recognises that governments and international agencies cannot alone achieve sustainable development and that the community, through interest groups, must be a key player in the development of policy and in achieving the necessary changes.

4. Means of Implementation (chapter 33-40): examines the question "how do we get there?" This section looks at the resources which must be mobilised in support of sustainable futures. While finance and technology are key elements, this section also deals with aspects of education, institutional and legal structures, data and information requirements and the establishment of capacity and knowledge in the relevant scientific disciplines.

In the international context, the UNCED-conference in Rio de Janeiro forms an important international debate on what sustainable development implies (Box 7). Governments have decided to adopt Agenda 21, in which various issues of importance for sustainable development, both locally and globally, have been defined. When sustainable development is interpreted as the outcome of a voluntary political decision making process, the various chapters of Agenda 21 may come closest to a definition of what sustainable development implies for the global community. This idea will be elaborated further in Section 5.1.

The political approach towards sustainable development is, from a scientific perspective, not very satisfactory. In the worst case, sustainable development is tautologically defined: sustainable development is what politicians think that sustainable development is. In the best case it defines sustainable development as a dialectic process of information gathering and negotiations, though which the definition of sustainable development is altered in various rounds of (inter)national policy consultations. In that case, Agenda 21 may reflect the current state of the art in defining sustainable development internationally.

4. Indicators for sustainable development

Chapter 40.4 of Agenda 21 states that: "Methods for assessing interactions between different sectoral, environmental, demographic, social, and developmental parameters are not sufficiently developed or applied. Indicators of sustainable development need to be developed to provide a solid basis for decision-making at all levels and to contribute to a self-regulating sustainability of integrated environment and development systems." The need for indicators of sustainable development, was underlined shortly after the publication of the Brundtland-report. Liverman *et al*. (1988) can be regarded as an early attempt of deriving indicators for sustainable development.[56] The emphasis on deriving indicators was underlined by the United Nations Commission on Sustainable Development. This commissions aims to monitor progress in the achievement of Agenda 21 worldwide. For this monitoring function, indicators are necessary.

How can we assess whether a country moves on towards sustainable development? Or how can we analyse whether an investment project in a country contributes or harms sustainable development? For that, one needs indicators. As Bossel (1996) remarks: "We live by indicators. A smile signals friendliness, a grey sky: possible rain, a red traffic light: danger of collision, the hands of a watch: the time of day, a high body temperature: illness, rising unemployment: social trouble. The more complex our environment, the more indicators we have to watch. If we want to compare future paths and their impacts, we have to look at representative indicators".

There have been many definitions of indicators for sustainable development. Here the following definition is used: A sustainable development indicator is the quantitative representation of a certain parameter that provides information about a phenomenon that is relevant for sustainable development. For example, the phenomenon can be acid rain, the parameter SO_2 emissions, and the quantitative representation in kilotons, index numbers or percentage changes. Indicators compress information at the costs of completeness. For example, SO_2 emissions can be perceived as an indicator for the state of the environment. However, these emissions are only weakly related to the environmental *impacts* of acid rain, due to climatic conditions (including transboundary transport), the fact that NO_x and NH_3 emissions determine the acidity of wet deposition as well and the different sensitivity of various eco-systems for acid rain.

4.1 Indicators depend on the definition of sustainable development

It will be obvious that indicators for sustainable development depend on the perspective that is chosen to define sustainable development. Therefore, central in the choice for sustainable development indicators is the choice for one of the five perspectives on sustainable development, as outlined in Chapter 3. It is evident that the systematic-principle approach will come up with a completely different set of indicators than the political ap-

[5] Attempts to measure 'sustainable development' started also prior to the Brundtland report (see the summaries in Liverman *et al*., 1988 and Morati *et al*., 1993).

proach. Table 4.1 gives an overview of the main focus of indicators for each approach of sustainable development.

Table 4.1 Various approaches towards indicators for sustainable development.

Approach	Phenomena relevant for sustainable development	Examples of indicators	Literature where indicators can be found
Wealth	Welfare and possibilities to reproduce welfare	ISEW, MEW, EDP (=various GDP or capital investments-modifications)	Daly and Cobb (1989); Bartelmus (1997)
Mosaic-systems	Environmental, economic and social conditions for satisfying human needs	Environmental pressure, state, response; social (GPI, HDI) and economic indicators (GDP). Ratios	OECD (1993); World Bank
Mosaic-principles	Economic and ecological principles, equity	Efficiency measures (material, energy intensities), carrying capacity (critical loads), wealth maintenance (MEW)	Various partial indicators are used in different studies
Systematic principles	Ability of system to reproduce itself	Indicators for existence, psychological needs, effectiveness, freedom, security, adaptability, co-existence	Bossel (1996)
Political	Progress on implementation of Agenda 21	Indicators on various chapters of Agenda 21	UN, Earth Summit 5+

The wealth approach essentially measures intergenerational wealth that is to be passed over to the next generations. The proposed schemes of ISEW (Indicator of Sustainable Economic Welfare) and others, attempt to correct GDP for social and environmental losses; i.e. they correct for the loss of capital that can be passed over to the next generations. The mosaic-systems approach measures elements of importance for the distinguished dimensions relevant for sustainable development. As this approach distinguishes more than one dimension, ratios are often useful expression of an indicator, where, for example, both ecological and economic aspects are combined. For example, the development of the ratio of CO_2 emissions per employed person says something about developments in both environmental and social goals. Mosaic-principle indicators focus more on specific sets of indicators that can measure efficiency, wealth maintenance and carrying capacities. Energy and material intensities say something about the materials and energy required to obtain one unit of income. Improvements in such indicators reflect a movement towards greater efficiency and reducing environmental stresses and therefore enhancing sustainable development. Systemic-principle indicators measure the ability of systems to sustain. These are grouped by Bossel (1996) according to seven orientors, basic characteristics of the reproduction of viable systems. Political indicators, finally, measure whether political agreements are being reached. Hence, Agenda 21 indicators measure whether Agenda 21 is being implemented.

Sometimes, various indicators schemes are combined. For example, the INSURED-project (Schleicher-Tappeser *et al.*, 1998) has constructed indicators from combining the mosaic-systems approach, the mosaic-principle approach and the systemic-principles approach.

4.2 Basic modelling approaches towards indicators

The literature on indicators has proposed two approaches for constructing indicators and in particular for classifying the phenomena that the indicator parameterises. These can be called:

1. the use or *function* approach;
2. the *causal* relations approach.

The first approach, the functionalistic approach, emphasises use, or functions, of various systems for sustainable development. Economic, environmental and social systems have various functions in satisfying human needs. Maintaining these functions for future generations, can be perceived as one of the elements of sustainable development. There has been some literature on the importance of the various functions of nature for satisfying human needs (De Groot, 1992; Hammond *et al*., 1995). A large number of functions has been distinguished, but in its most general form these belong to the following three groups: (i) the production function that defines the function of nature as the source of exhaustible and renewable resources; (ii) the regulation function that defines the function of nature as a sink to absorb pollution; and (iii) the life support and carrier functions that define the functions of nature as the capacity to sustain human and non-human life through biodiversity and the impacts of the environment on human welfare with respect to settlement and health.[7] Similar functions of economic and social systems can be distinguished. From these functions, then, indicators can be perceived that monitor the state, or 'health' of such functions.

The second approach towards indicator building, the causalistic approach, is based on the OECD Pressure-State-Response framework for monitoring environmental performance. This approach assumes a causal link between the pressure of human actions, the state of the environment and the societal responses (OECD, 1993; Bartelmus, 1994). Human actions result in pressures on the environment, such as energy use with associated emissions or timber logging. These pressures are called environmental pressures. Indicators for environmental pressure are either input or output based. Input based indicators focus on the input in production processes, such as energy consumption, land use, or materials use, whereas output based indicators focus on the environmentally relevant output of the production process, such as emissions and wastes. The pressure that stems from human activities results in environmental impacts which can alter the state of the environment. This gives the second category of indicators: state indicators. Examples of such indicators are the depletion of the ozone layer, loss of species or vitality of forests. Finally, the modifications in the state of the environment may trigger societal responses, such as a greater amount of income spend on environmental protection or the emergence of green political parties. Information about such responses is reflected in the response indicators. Such responses will ultimately result in modifications of environmental pres-

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[7] The importance of biodiversity is sometimes also referred to as the information function for genetic resources.

sure and subsequently in the state of the environment. Figure 4.1. schematically shows the PSR framework.

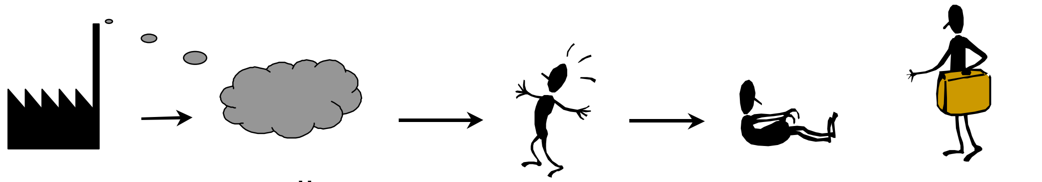

Figure 4.1 The OECD Pressure-State-Response framework assumes a causal link between the pressure of human actions, the state of the environment and the societal responses.

The Commission of Sustainable Development of the United Nations has suggested that the pressure-state-response framework may also be applicable to social and economic indicators. For example, Gini-indexes may give information on economic inequalities. This is a state-indicator. However, income inequality may be influenced by the lack of sufficient employment for the population. Employment rates can then be perceived as pressure indicators.[8] Participation rates in trade unions can be viewed as a response indicator aiming at improving the salaries and conditions of the work.

The PSR framework has received a lot of criticism, especially because the links between pressures, states and responses are often not as straightforward as suggested in this model. It neglects the systemic (and dynamic) nature of the processes, and their embedding in a larger total system containing many feedback loops. Impacts in one causal chain can be pressures, or states in another, and vice versa. Multiple pressures and impacts are not considered (Bossel, 1996). For instance, global warming has many different causes and emissions of NO_X have many different effects. However, it is a widely accepted framework in international indicator building. Both the OECD and the UN Commission for Sustainable Development have developed their set of indicators based on this framework (see also Annexes I and II for sets of indicators based on the PSR framework).

4.3 Basic criteria for indicators

The literature on sustainable development indicators has proposed various selection criteria that enable to distinguish good indicators from bad indicators. The following main selection criteria can be mentioned (Liverman *et al.*, 1988; Braat, 1991):

1. Data availability and reliability;
2. Scientific values;
- Scientific validity and significance;

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[8] The UN rather speaks of 'driving force' indicators instead of pressure indicators. Driving force indicators are defined as: indicators that indicate human activities, processes and patterns that impact on sustainable development. This definition seems to be similar to the OECD's pressure indicators.

- Applicability;
- Sensitivity to change in time, across space and over social distribution;
- Sensitivity to reversibility and controllability;
- Predictive ability;

3. Communicative values;

- Symbolic relevance;
- Integrative and aggregative values;

4. Reference values.

Data availability and reliability is obviously the most important selection criterion. In fact, data availability often determines the final indicator set to be used. However, the chosen indicators must also make sense scientifically. They must say something about the underlying processes they attempt to describe, and must have a significant correlation with these processes. They must have predictive value, in the sense that a changing condition in phenomena relevant for sustainable development must be indicated.

Discussions of sustainability often focus on rates of change over time, toward or away from conditions identified as sustainable. An indicator must, therefore, be collected at a frequent enough time intervals to detect significant trends and variations, and ideally should be part of a historic time series that can illustrate long-term trends. The very long-term changes and cycles, spanning centuries or longer in the case of physical and chemical phenomena, are more difficult to measure, but can sometimes be reconstructed, as in the case of biological proxies for climatic change. Of course, change alone does not necessarily imply movement to or from sustainability, but can be part of the healthy functioning of a system (for example, seasonal cycles). A good indicator should be able to separate such normal cycles from trends away from a sustainable state.

From a management perspective, it is critical to identify indicators which reveal whether changes are reversible and controllable. Perhaps the most critical changes to life support systems are those which involve a permanent and irreversible shift in conditions. Such changes might include the total removal of topsoil, destruction of tropical forests, desertification, and the release of non-degradable toxic materials.

Finally, the indicators must also have communicative values. For instance, a decreasing number of seals appeal better to the public than a decreasing number of snakes. The data should also be presented in an attractive format for the target group (scientists, policy makers, public). As sustainable development is a multidimensional concept, issues of aggregation and integration between the various dimensions are important in order to compress information and to communicate the indicators to the public and politicians. Moreover, the chosen indicators must be compared to desired developments; i.e. reference values are required in order to interpret whether a change in the chosen indicator reflects a movement away from, or towards sustainable development. This will be elaborated in the next section.

Reference values versus desired movements

Reference values are required in order to interpret whether the change in the indicator has contributed to sustainable development or not. The problem is that in most cases, clear reference values are not available. Sustainable development remains a rather vague concept, from which often no direct criteria can be derived. Opschoor and Reijnders (1991) have suggested that in cases where clear reference values are not available due to scientific uncertainty, the movement towards desirable levels is taken as a guiding principle. For example, we cannot know for certain what level of material consumption is sustainable for modern societies. But if one accepts the idea that lowering the metabolism of societies is contributing towards sustainable development, the rate of change in reducing materials consumption can be taken as a guideline towards sustainable development.

Unit of analysis and spillover effects

Indicators for sustainable development must be designed on the spatial unit investigated. Analysing the policies of a country may require different indicators than the indicators for assessing a specific project, such as hydroelectric power generation in a river. Issues of sustainable development are differently defined on the level of a local community than on the global level.

One of the differences between the local, the national level or the global level may be due to the presence of so-called spillover effects. Spillover effects are present when the pursuit of sustainable development at the local community has adverse effects on issues of sustainable development on other local communities. Spillover effects are not sustainable. Sustainable development requires an equal distribution of wealth (or assets) over time, but also over space.

The presence of spillover effects puts additional demands on indicators, as we would prefer to use indicators that correct for such spillover effects. In De Bruyn (1999) a model is presented that shows how national indicators for environmental quality can be biased as the result of international trade and transboundary air pollution.

Timeframe

A critical issue is also the timeframe of analysis. Sustainability questions should have a long time range in mind. The concept of sustainable development, as outlined in Chapter 3, is that a vector of desirable social objectives, does not decrease over time. Therefore, indicators should reflect movements over time in order to assess whether development is sustainable or not. A problem with this approach, however, is that the effects over time are often uncertain. What seems sustainable now, can be unsustainable in the long run. In the light of these considerations, it has been suggested by, amongst others, Smith and McDonald (1998), to focus on indicators of *un*sustainability, as these are often more easy to identify. From the past, we know what kind of practices have proved to be unsustainable. Given this information, one can develop indicators that tell us whether we avoid getting caught in the same trap again.

Issues of aggregation

As sustainable development is a multidimensional concept, there will be many indicators relevant for assessing whether a country, or a project, is moving towards sustainable development. Bossel (1996) distinguished 220 indicators for the systemic principle approach. The United Nations Commission on Sustainable Development has listed over 120 indicators indicating sustainable development according to the political approach.

With so many indicators it is difficult to give an overall judgement whether a project or a nation moves towards sustainable development.

Therefore, aggregation of indicators is required to compress information. There exist basically 3 ways for aggregating multiple indicators into a single value.

1. Using physical or chemical properties;
2. Using monetary valuation;
3. Using multicriteria analysis on expert views or predetermined formulae.

Numerous ways exists for aggregating various indicators on a *physical* basis. These are: mass, land use, net energy use, volume, and chemical relationships. The most often applied physical conversion for source indicators of environmental pressure has been the aggregation over mass (see Section 5.3). The Wuppertal institute approach of ecological rucksacks aggregates material inputs in the economy in terms of their total mass including earth movements from mining (Bringezu *et al.*, 1994). Others, such as Wackernagel and Rees (1996) have attempted to employ hypothetical land use as the common conversion unit. Here all types of environmental pressure, including CO_2 emissions, are translated into occupied land that would be required to mitigate the harmful impact of these pressures[9]. Other schemes that have been proposed include net energy or entropy (see Ayres and Schmidt-Bleek, 1993 for an overview). It has often been proposed that energy stocks and flows are the key determinants of ecological systems. Adriaanse (1993) proposed to derive aggregation schemes from impacts of various substances on key topics of ecosystems. He uses chemical ratios to derive aggregated indicators, for example in the field of global warming or acidification.

Instead of physical aggregation, many economists would plea for monetary aggregation, e.g. valuing environmental and social impacts in monetary terms. Overviews of this approach for environmental problems can be found in Freeman (1993) and Hoevenagel (1994). Monetary conversion sums the costs on different types of defensive environmental expenditures with the shadow prices of environmental pollution in excess of the absorption capacity of the environment. In this way a uniform value is obtained of total costs of environmental impacts of society. The advantage of monetary conversion is then that environmental decay is valued at the marginal cost to society. The disadvantage relate to ethical and technical limitations of this approach. For example, shifts in social attitudes and improved information do not have a clear environmental impact but substantially matters for the valuation of environmental losses.

The third approach to arrive at a single indicator uses statistical techniques to integrate various indicators into a common value. Examples are multi-criteria analysis, factor analysis, ordinal ranking or deviations from an average value when comparing between countries (cf. Jänicke *et al.*, 1989). The indicator itself is then without dimensions but can fluctuate between certain values (for example 0 and 1). An example which has been often used is the Human Development Index (HDI), constructed by the United Nations. In the environmental sphere, the Index of Sustainable Economic Welfare (ISEW) can be mentioned, which combines both elements of statistical and monetary conversions (Daly and Cobb, 1989).

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9 The equivalent occupied land is called ‘the ecological footprint’.

The problem with most of the aggregation schemes is that they inadequately reflect the ecological processes they are supposed to describe in terms of toxicity or scarcity. However, aggregation may be meaningful if one wants to give a general overview of sustainable development issues.

5. Examples of use of indicators of sustainable development in PAC-countries

Most important in practical case studies on sustainable development is the unit of analysis. It will be obvious that assessing sustainable development of a country is a different matter than assessing sustainable development of a specific industry or a specific product. Besides, the orientation of sustainable development, as presented in Chapter 3 by five different approaches, will largely influence the measurement of sustainable development. This chapter will provide some examples how indicators can be used in the PAC region for assessing sustainable development.

5.1 Measuring sustainable development as the movements towards Agenda 21 for PAC countries

The chapters in Agenda 21 have constituted an important element for combining the traditional conflicting goals of combatting poverty with environmental improvements. It has bridged the traditional conflicting goals of national governments and environmental NGOs in many developing countries. Box 8 describes the history of environmental awareness and policy changes in Brazil.

Given the fact that Agenda 21 constitutes a main element in the discussion concerning sustainable development in PAC-countries, it seems to be logically consistent to use indicators that measure the progress towards sustainable development as identified by Agenda 21. At the UN commission for Sustainable Development, efforts have been undertaken to introduce and formulate indicators that can measure the progress of countries. In total, over a 120 indicators have been identified that measure the progress towards implementation of Agenda 21 in various chapters. These indicators have been classified according to:

1. Three systems reflected by social , economic and environmental conditions;
2. The various chapters of Agenda 21;
3. The Pressure-State-Response framework (which has been translated into Driving Force-State-Response indicators, where the Driving Forces are largely identical to Pressures).

Appendix I gives an overview of all the indicators that have been selected by the UN. Various countries have meanwhile reported the data availability of the chosen indicators and it is planned that this system of indicators will be operating in the year 2001.

Box 8: Policy history of sustainable development in Brazil

Environmental movements began in Brazil on the 70's (Agapan - Porto Alegre) and were directly influenced by the North-American environmental movements. In the beginning, campaigns were restricted to local actions aiming at denouncing environmental problems as well as educational campaigns of awareness of such problems. At the end of the 70's, the first national and regional campaigns were taken off.

The Stockholm conference in 1972 was an important milestone in the history of the environmental movement in the Amazon region and during this conference Brazil took a position against environmental issues, stating that the main form of pollution was poverty. At that time, the government policy of revitalisation of the Amazon region was at its peak, with various projects and programs that enhanced the migration of populations from the South and Northeast regions into the Amazon. The military government, concerned with the negative impact caused by this position, created the Special Secretariat for Environment, setting at that time the main environmental policy targets of pollution control and preservation of a few natural ecosystems. Regardless the targets set, the Amazon policy remained the same: maximum depletion of resources in order to backup the economic development of the country

More than a decade would pass before any change was introduced on the above-mentioned panorama. Two remarkable events took place in the mid 80's and made a difference:

- the discussions on the new 1988 Federal Constitution, and
- the decision of President Collor to host the United Nations Conference on Environment and Development (Rio 92).

Congressman Fábio Feldmann was the leader of a "green block" which was able to introduce several articles about environmental protection in the Federal Constitution, which consolidated the democratic regime in Brazil. At the same time, environmental entities increased their awareness about social problems as well. Economic and environmental issues were considered antagonistic problems until then.

Various factors accounted for such change. The economic crisis undergone by the country demanded the inclusion of environmental issues in the economic framework at the risk of losing its legitimateness. In the scenario of conservation policies, the International Union for the Conservation of Nature and Natural Resources proposed conservation with consideration of the traditional populations as a predominant issue. Besides that, the Brundtland Report, establishing a relationship between development and environment, begins to be widely recognised by the environmental movements in Brazil.

Governmental sectors in charge of environmental protection issues also began to change in the mid 80's. The National Council for the Environment was created and environmental issues were included in the agenda of the various offices in charge of public administration. President Sarney, who also created the Brazilian Institute of Environment and Renewable Natural Resources (IBAMA), created the Secretariat for the Environment together with federal agencies in charge of forestry, fishery and rubber in 1989. The difficulties resulting from the existence of different organs are the main obstacles for the efficiency of IBAMA.

In 1992, Brazil hosted the United Nations International Conference for Environment and Development (UNCED). During the preparatory meetings, the discussions about environmental issues and development strategies were finally unified. The non-governmental organisations which organised the *Earth Summit*, the parallel conference of Rio - 92, initiated a wide discussion on sustainable development.

In the early 90's the environmental movements in Brazil split into five main segments: associations and environmental groups; State environmental agencies; social environmentalism, (formed by mainly NGOs); scientific groups and institutes conducting researches on environmental issues; groups of company managers and owners wishing to base their productive processes on sustainable environmental criteria.

Not only the environmental movements began to change in the early 90's, but also the political scenario started to change, mainly in the cities where the elected mayors belonged to the Labor Party. Several environmental groups started to interfere directly in politics due to the seizure of political power by a party that has strong affinity with social movements. This also produced a change inside the environmental groups who shifted from normative to environmental management issues.

Box 8: Policy history of sustainable development in Brazil (continued)

Environmental management started to focus not only on environmental preservation and recuperation, but also on the improvement of quality of life, aiming at a conciliation between environmental protection and increasing well being of the population in general. Several experiences developed in the early 90's, mainly in the South and Southeast regions of Brazil, and presented typical characteristics, which are basically different from the European reality:

Environmental policies lacking social focus, not aiming at the well being of the poorest part of the population, seldom achieve political legitimacy.

There is not a direct relation between governmental ideology (progressive vs. conservative) and environmental actions (for example: the city of São Paulo, which concentrates 10% of the population of Brazil, has not come up with a diagnosis of its environmental status despite its Labor Party government).

However, if in the South and Southeast regions of the country public programs include environmental issues, in the Amazon region the situation is entirely different. Governmental actions are restricted to the federal agencies (IBAMA, etc.) and State agencies (Secretariat for the Environment). In the specific case of Belém, the largest city of the Amazon region, with more than one million inhabitants, environmental concerns have not been an issue for the city government, which belongs to the Labor Party since 1998. This is also true for practically the majority of the cities in the Amazon region. New environmental management impulses have been felt in the North region through the NGO's which were able to obtain financial support for the demonstrative projects of the Pilot Program. Such NGO's were also able to implement some innovative actions.

When we assess these indicators based on the discussion in Chapter 4 on the criteria for indicators, we can find that:

1. The data availability is in general good; various countries have reported that implementation of this set of indicators is possible.
2. The scientific values are more doubtful; it is not entirely clear why these indicators have been selected, in many cases a different set of indicators is also imaginable.
3. The communicative values are mixed; the symbolic relevance of the chosen indicators is obviously good (as it deals with Agenda 21 and has been selected by the UN), however, aggregation of these 120 indicators seems to be a major problem. The indicators do not allow for a uniform answer whether a country is moving into the direction of sustainable development as represented by Agenda 21.

Weights for aggregation could in principle be formed by using insights from expert panels, which identify the relative importance of each indicator for sustainable development. This, however, is a step that is still to be put in operation.

5.2 Sustainable development of a specific industry: the mosaic principle approach

In most business organisations, economic principles play a dominant role. Most organisations shape their goals and targets according to stockholder value, profits, or employability. With sustainable development acting as a new overarching principle, also other principles than traditional economic principles have come to the foreground.

As an example of the use of sustainable development indicators from the mosaic principle approach can serve the assessment of an electricity power plant in the Amazonia region. According to the mosaic principle approach, issues of sustainability are assessed according to the interplay between various principles, which may be conflicting with each other. The following principles may be important for the sustainable operation of the power plant:

- environment (minimise emissions, damage to nature and landscape, resource depletion);
- economy (minimise investment and running costs; maximise efficiency, opportunities for economic developments);
- equity (maximising accessibility to electricity, employment, safety, reliability, minimising relocation, damage).

The objectives themselves are, unfortunately, not very helpful in decision making processes. In order to be useful in such processes, they need to be operationalised. Therefore, *criteria* must be identified that give information on the extent to which an objective is met. Hence, these criteria must be measurable in one way or another. In fact these criteria can be used as a basis for indicators, as described in Section 4.3 and should fulfil the same conditions. Three other important rules are important with respect to the choice of the criteria:

- Make sure all criteria are met;
- Avoid double counting;
- Always keep the objectives in mind.

Figure 5.1 shows a fictive example of an objective tree and subsequent criteria for establishing a sustainable energy supply in the Amazon region.

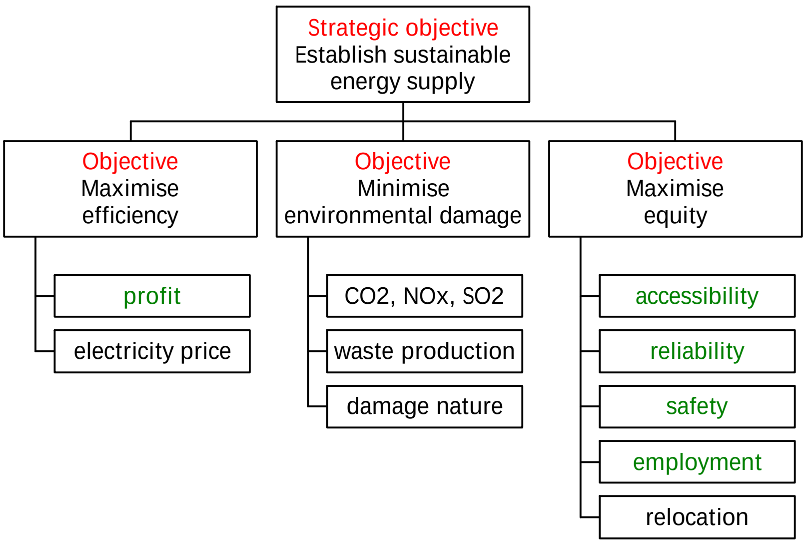

Figure 5.1 Various objectives for a sustainable operation of a power plant in Amazonia.

In many cases, the environmental criteria can follow the Life Cycle Assessment (LCA) approach if the decision concerns alternative products or processes (e.g. Heijungs, 1992).

Once the objectives are known, alternatives for solving problems can be worked out. In the case of the energy supply, such alternatives could include building of new power plants (hydro, coal, natural gas), alternative energy sources (PV, wind, biomass), efficiency increases, and demand side management (energy saving programs). Usually no alternative can meet all criteria and therefore trade-offs must be made. By scoring (or operationalising) criteria for all alternatives considered, these trade-offs can be made explicit.

In the following paragraph, a strongly simplified example is shown in which three indicators (one for economy, one for ecology and one for equity) are considered for assessing two alternatives (1 and 2; see Table 5.1).

Table 5.1 Three indicators (one for economy, one for ecology and one for equity) are considered for assessing two alternatives (1 and 2). This table is often referred to as performance table.

Indicator	*Current situation*	*Alternative 1*	*Alternative 2*
Economy	150	200	300
Ecology	30	25	18
Equity	10	10	14

By standardisation, the three indicators can be compared more easily and plotted in one graph (Table 5.2 and Figure 5.1).

Table 5.2 Standardised performance table.

Indicator	*Current situation*	*Alternative 1*	*Alternative 2*
Economy	1	1.3	2.0
Ecology	1	0.8	0.6
Equity	1	1.0	1.4

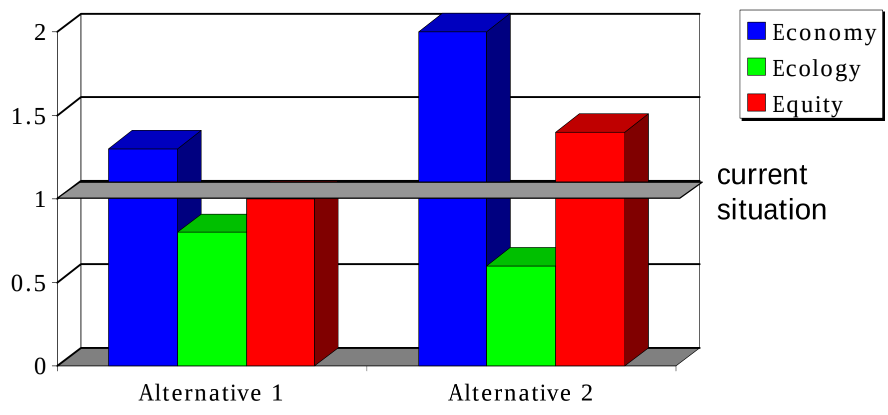

Figure 5.2 Standardised scores of the three indicators for the two alternatives compared to the current situation.

There are several ways to weigh the indicators against each other, such as the use of expert panels (Box 9), the distance-to-target method and economic valuation. However, the treatment of such methods is beyond the scope of this report. In this case, the decision which alternative to chose cannot be based on scientific arguments alone. In the end, the choice is a political decision.

Box 9: Pros and cons of expert panels

Expert panels

- A panel of experts systematically evaluates the weights of all criteria investigated
- Often pairwise comparison is used
- Special techniques guarantee the consistency of the answers

Pros

- Objective methodology
- Relatively easy to carry out
- No monetarisation required
- Reflects preferences of experts
- Criteria of different kinds can be compared

Cons

- Preferences are subjective
- Variety of weights possible
- Sometimes acceptance is low

5.3 Minimising throughput as a strategy of sustainable development

Herman Daly (1977, 1991) has often emphasised that minimising throughput is a first step on the road towards sustainable development. Throughput is defined by Daly (1991, p. 36) as "The entropic physical flow of energy-matter from the environment through the economy to nature's sinks". Minimising throughput hence implies that energy and material flows will be minimised. Sustainable throughput flows then probably implies that the material flows are captured within certain boundaries, determined by, for example, the capacity of nature's sinks to absorb waste products.

From material flow analysis (MFA) indicators can be derived which give information on the *materials intensity* of a region (usually a country). The Total Material Input (TMI) may be regarded as a highly aggregated index that relates to the global environmental pressure associated with the physical basis of an economy. It comprises the domestic and foreign extraction of raw materials taken from nature, which is associated with that economy in a certain period (usually one year). Depending on actual technology, no economy would work without the yearly input of materials, either from domestic or foreign origin. Thus, TMI can be interpreted as an indicator for the environmental pressure associated especially with the production of the economy. For practical reasons, TMI should be confined to materials other than water and air (Brigenzu *et al.*, 1994).

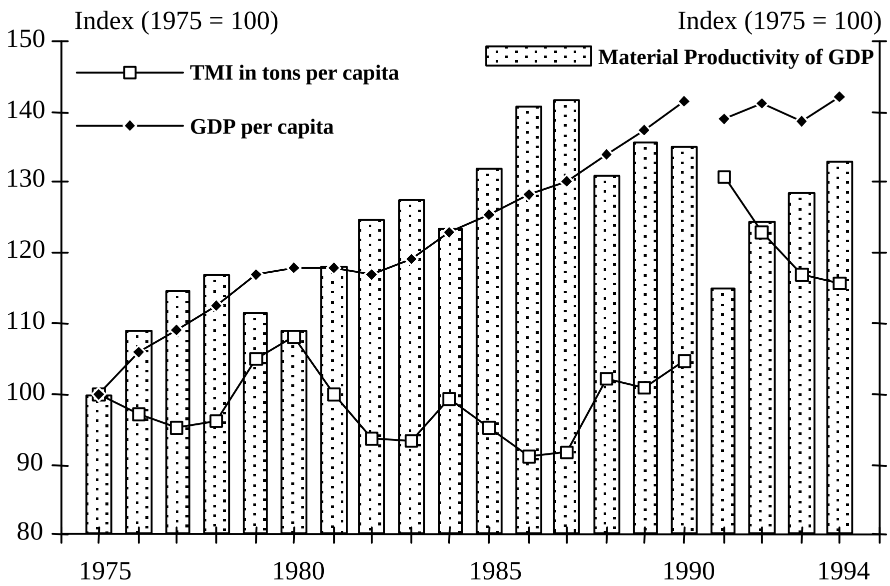

Figure 5.3 The trends of the Total Material Input, GDP and the Material Productivity of the GDP of the Federal Republic of Germany (up to 1990 Western Germany, since 1991 re-united Germany). Data compiled by Helmut Schütz (Wuppertal Institute).

TMI may be used as a basis to indicate the overall material productivity of an economy. The relation of GDP and TMI provides the material productivity of GDP. This indicator can be interpreted as a measure for eco-efficiency (Bringezu, 1993). However, increasing numbers of that indicator do not necessarily reflect a reduction of the absolute environmental pressure. The preliminary data indicate that the order of magnitude of TMI per capita remained nearly constant from 1975 to 1990, while GDP increased more or less steadily (Figure 5.3). This resulted in an increase of the material productivity of GDP. After the re-unification of Germany the lignite production in the eastern part results in somewhat increased TMI. In 1991 TMI was about 90 tonnes per capita (materials without water and air).

Although several approximations had to be made, the data quality seems to be sufficient to document some main trends. The results indicate a possible decoupling of the global Material Input and the economic performance. But the absolute environmental pressure due to the material flows is still far from what would be sustainable.

6. Short conclusions and recommendations

This report has emphasised the various ways sustainable development can be defined and measured. It has described the evolution of the concept of sustainable development in both the political and scientific arena. Many different definitions and operationalisations of the concept of sustainable development have come to the foreground. However, there does not exist a methodology that can scientifically prove which conception or operationalisation is to be preferred above the other ones. More problems arise when sustainable development is to be measured by indicators. Indicators schemes that have been provided in the literature seems to be defined ad-hoc at best.

For the study area of Amazonia, we believe that the Agenda 21 indicators can be a useful element in future studies. These indicators probably will become the main state of the art in sustainable development indicator building. Given the fact that Agenda 21 constitutes a main element in the discussion concerning sustainable development in PAC-countries, it seems to be logically and consistent to follow the indicators of progress towards sustainable development in the PAC-countries.

However, the precise set of indicators to be used depends also on the sustainability patterns to be investigated (economic sectors, regions, communities), the availability and reliability of the data necessary to construct the indicators, and the questions we want to answer.

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Appendix I. Agenda 21 indicators for sustainable development

Chapters of Agenda 21	Driving force indicators	State indicators	Response indicators
Category: Social			
Chapter 3: Combating poverty	• Unemployment rate	• Head count index of poverty • Poverty gap index • Squared poverty gap index • Gini index of income inequality • Ratio of average female wage to male wage	
Chapter 5: Demographic dynamics and sustainability	• Population growth rate • Net migration rate • Total fertility rate	• 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 ratio (gross & net) • Adult literacy rate	• Children reaching grade 5 of primary education • School life expectancy • Difference 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 • Area and population of urban formal and informal settlements • Floor area 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 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 resource management
Chapter 12: Managing fragile ecosystems: combating desertification and drought	• Population living below poverty line in dry-land 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 fertilisers • Irrigation percent of arable land • Energy use in agriculture	• Arable land per capita • Area affected by salinisation and waterlogging	• Agricultural education
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: Conservation 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 on nitrogen oxides • Consumption of ozone depleting substances	• Ambient concentrations of pollutants in urban areas	• Expenditure on air pollution abatement

Chapters of Agenda 21	Driving force indicators	State indicators	Response indicators
Chapter 21: Environmentally sound management of solid wastes and sewage-related issues	• Generation of industrial and municipal solid waste • Household waste disposed 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
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
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

Chapters of Agenda 21	Driving force indicators	State indicators	Response indicators
Chapter 40: Information for decision-making		• Main telephone lines per 100 inhabitants • Access to information	• 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

Source, UN Commission on Sustainable Development, 1999.

Appendix II. A classification of environmental indicators

Environmental indicators attempt to give information on the 'health' of the environmental system. Maintaining environmental quality can be perceived as an important step towards sustainable development.

Chapter 4 described that indicators can be build according to functionalistic and causalistic perspectives. Alberti and Layton (1996) are among the first who have attempted to combine both the functionalistic and causalistic approaches in environmental indicator building. Expanding upon their initiatory work, one may arrive at Table AII.1 which lists various indicators according to both approaches.[10] The rows in this table classify indicators according to the *functionalistic* perspective and the columns according to the *causalistic* perspective. The various indicators listed in the cells of this table can be seen as concrete examples, without making the claim that these are exhaustive or complete.

It should be emphasised that the critical functions nature provide to mankind, differ during the course of economic development, and that therefore important indicators are not similar for developing and developed economies. Baldwin (1995) has argued that economies typically move from subsistence farming to agriculture for export to industrial development towards service sectors. This implies that the chosen indicators according to the *functionalistic* approach are not similar for countries with different stages of economic development. In the first stages, the life support functions are a critical constraint. Subsistence economies rely heavily on the life support from nature. When economies are linked to the world-economy, the export of natural resources (food, minerals, etc.) becomes a dominant feature of development. Hence the source function is then critically affected. When industrialisation takes off, also the sink function of the environment will be used more intensively. Hence the choice for the indicators in the functionalistic approach can be given according to Figure AII.1. The diversity of issues relevant for sustainable development under different stages of economic development, highlights why common approaches to environmental problems in comparison of developed and developing economies fails.

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[10] There have been other efforts as well to integrate various indicators in one appropriate scheme (e.g. Alfsen and Saebo, 1993; Bakkes *et al.*, 1994). Especially the often used classification into *environmental compartments* (or media) is ignored in the currently used scheme.

Table AII.1: Matrix of environmental indicators.

Causal links functions	Environmental Pressures	State/Effects	Responses
I. Sources 1. Agriculture 2. Forest 3. Marine Resources 4. Water 5. Minerals/energy extraction	• Land use changes • Total material and energy use; • Material flows, rucksacks • Extraction rates	• Fertility of soils/Soil degradation • Area of forests, volume, distribution, value • Stock of marine species • Proven reserves	• Rural/urban terms of trade • Coverage of international protocols /conventions • Efficiency measures, intensity of use, reverse energy subsidies
II. Sinks 1. Climate 2. Ozone layer 3. Acidification 4. Eutrophication 5. Toxification 6. Land filling	• Emissions • Material use: dissipative and 'rucksacks' • Energy use • Use of nutrients in agriculture (4) • Generation of waste (6)	• Atmospheric concentration of greenhouse gasses • Thickness of ozone layer • Concentration of SO_2, NO_x, pH in precipitation • *BOD in rivers, dissolved oxygen*. • Concentration of lead, cadmium in soils and *rivers*. • Accumulation to date	• Energy efficiency investments/ renewable resources • Conversion/ substitution investments • *Abatement expenditures* • Sewage expenditures, % of population with treatment • % petrol unleaded, TRI • Recycling, re-use, expenditures
III. Life support 1. Biodiversity on land, oceans 2. Human health 3. Food/water security 4. Housing/urban 5. Natural disaster	• Land use changes, % of threatened and extinct species • Population density	• Habitat • Life expectancy at birth, *Faecal coliform in rivers* • Concentration of pollutants in air/rivers • *Access to safe water* • Climatic variability	• %Protected areas in a country • Money spend on health, vaccination • -Housing expenditures, ground prices • Expenditures on insurances

Note: items listed in italics have been used in empirical studies. Source: modified from Alberti and Layton, 1996 and De Bruyn, 1999.

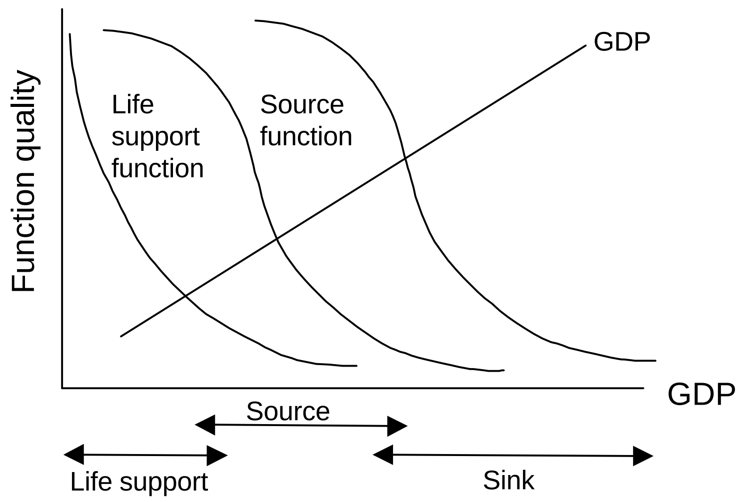

Figure AII.1 Economic development and the use of nature according to various functions.

In the worst case, society first destroys the ecosystem by overusing it as a source and starts to pollute afterwards. This may have happened in the Aral Sea where first the water resources have been exhausted for cotton crops and subsequently the rivers have been polluted with pesticides. Given the limited load of water available after the use for cotton irrigation, the pollution was too concentrated for the Aral Sea ecosystem to survive.