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Sustainable development and natural resource accounting

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PREFACE

The notion of sustainable development has gained in significance as a social objective since the publication of the 1987 report of the World Commission on Environment and Development.

Work on statistical system for describing natural resources and and the state of the environment known as natural resource accounting was begun in Finland in 1983, under auspices of the Natural Resources Council, a body functioning within the Ministry of Agriculture and Forestry. A preliminary study of social needs for such an accounting system was completed by the Central Statistical Office of Finland (CSO) in spring 1988.

The present report is concerned with the concept of sustainable development, the dependence of this development on the utilization of natural resources, and natural resource accounting as an instrument for promoting sustainable development. The report is a translation of a CSO study published in Finnish. In the translation, description of the systems of natural resource accounting in Norway, France, the Netherlands, Canada, Australia and the international organizations have been reduced to mere summaries of the points presented in the review of the litterature. The Finnish system of natural resource accounting has been described in more detail.

The researh recounted here was carried out as a part of the CSO project to develop natural resource accounting. The support of the project's steering committee and the project leader, Leo Kolttola is gratefully acknowledged. Special thanks are due to Dr. Kauko Hahtola, Professor of Land Use Economics at the University of Helsinki, for his generous assistance in the management and analysis of this complex topic. The competent translation of the report is by Malcolm Hicks.

Helsinki, June 1990

Olavi E. Niitamo

Markku Suur-Kujala

ABSTRACT

This paper is concerned with the connections between sustainable development and the use of natural resources, and with means for describing these connections. A discussion of the concept of sustainable development and a review of ideas on the interrelations between it and natural resource use provide a background for examining natural resource accounting. The theoretical foundations of natural resource accounting are presented, along with the premises, objectives, methodologies and lines of development of the accounting systems in operation or under development in different countries.

Sustainable development and natural resource use are discussed mainly from the perspectives of economics and ecology. Description of the natural resource base for sustainable development and the economic and ecological dimensions of natural resource use calls in particular for information on resource stocks and the quantities used, resource flows involved in the domestic product, the efficiency of the use made of natural resources and their replaceability, waste and the impact of recycling.

Basically, the premises, objectives and methodologies of natural resource accounting in different countries meet the information needs associated with the description of the economic and ecological factors involved in sustainable development. In addition to their use at the national level, these accounts are also usable in supranational contexts and at the regional and local levels.

The potential use and development of natural resource accounting as an instrument of planning and decision making depends essentially on the availability of basic data on natural resources, the focusing of the accounts on different stages of resource use, the mode of presentation of the data derived from the accounts, the use of the results as a data file for further investigation, and the resources and organisation of the work carried out to establish the system of resource accounting. When describing sustainable development beyond the limits of its economic and ecological dimensions, account should also be taken of the social factors influencing the development of societies.

SUSTAINABLE DEVELOPMENT AND NATURAL RESOURCE ACCOUNTING

CONTENTS

1. INTRODUCTION

Work was commenced in the 1970's on the elaboration of natural resources accounting as a means of providing information on natural resources and the effects of their utilization for the purposes of economic planning and decision making. The pioneer countries in this were Norway and France, the work being later taken up in many other western European countries, Canada and Australia and on a joint international basis in the United Nations, the OECD and the Nordic Council.

Interest in natural resource accounting has increased markedly as it has become customary to examine the objectives and contexts of economic and environmental policy as a single major entity from the point of view of society. Political support for natural resource planning was obtained from the governments of the OECD countries, for example, when these indicated their intention in 1985 to pursue long-term, sustainable environmental and economic policies and to develop systems of natural resource accounting for this purpose.

The view of the World Commission on Environment and Development regarding sustainable development as a common framework for economic policy, environmental policy and development strategies has led to a further increase in the need for elaborating systems of natural resource accounting. According to the commission, "Where resources and data permit, an annual report and an audit on changes in environmental quality and in the stock of the nation's environmental resource assets are needed to complement the traditional annual fiscal budget and economic development plans. These are essential to obtain an accurate picture of the true health and wealth of the national economy, and to assess progress towards sustainable development." (World Commission on Environment and Development (WCED) 1987: 314.)

The commission's report and the objective of sustainable development attracted considerable international and national attention. The report was discussed in numerous international organizations[1] and sustainable development was examined from many angles and measures discussed for implementing it in various countries[2].

This present report is concerned with the connections between sustainable development and the use of natural resources and the possibilities existing for describing these. An examination of the concept of sustainable development and a survey of views on the relations between it and the utilization of natural resources form a background for studying natural resource accounting as such, which is presented in terms of both its theoretical foundations and the premises, objectives, methods and lines of development of accounting systems operating or under development in different countries.

An attempt is made to base the description of sustainable development on the more recent literature and papers published in journals, with the aim of achieving a comprehensive review which no longer distinguishes in detail the sustainability of individual human and natural functions. Similarly, no reference will be made here to numerical estimates and predictions of the sufficiency of natural resources or the possibilities for continued economic growth as set out in the Limits of Growth and Global 2000 reports.

New papers on natural resource accounting, and particularly sustainable development, have been published throughout the time that this work has been in progress, and it has been impossible to examine all the points raised in them. Some of these works are nevertheless included in the bibliography in order to maintain it up to date.

[1] including the UN, OECD, EC, IUCN and WWF.

[2] including committees set up for this purpose in Finland, Norway and Canada.

2. PURPOSE OF THE RESEARCH

The opportunities that exist for employing natural resource accounting as an instrument of economic and environmental policy depend greatly on the social objectives for which it was first decided to develop this accounting. The purpose of the present paper is to raise certain points connected with one such objective, that of sustainable development, and to study the applicability of natural resource accounting as a means for the description of these and for achieving sustainability.

I will attempt to specify the concept of sustainable development and its connections with natural resources more precisely by presenting various interpretations of the relations between it and natural resource use, for the purpose of identifying the principal factors in sustainable development upon which the use of natural resources can have a significant impact.

As far as natural resource accounting is concerned, the aim is to determine how it generates information on natural resources and the use being made of them and how this information can be employed as an indicator of sustainable development and as a basis for the measures required to achieve this.

This paper will concentrate on development and the utilization of natural resources from the viewpoint of countries with a market economy, as natural resource accounting is being developed mostly in the western industrialized countries. No attempt will be made to consider separately the particular problems facing developing countries or the interpretations placed upon the sufficiency of natural resources by the socialist countries. Similarly, I will not go into the details of the effects of international or social inequality or injustice on sustainable development, even though much emphasis has been laid upon these aspects in various statements and publications on sustainable development.

3. THE CONCEPT OF SUSTAINABLE DEVELOPMENT

3.1. Viewpoints on sustainability

The topic of sustainability in interactions between man and his environment has been discussed in the literature of the 1980's largely in the context of the sustainability of the use of biological resources, agriculture, the carrying capacity of ecosystems, fuel supplies, economic growth and development within society. Brown et al. (1987: 716, 717) identify three main points of view, which they use to define social, ecological and economic sustainability.

1. Social sustainability refers to the continued satisfaction of the basic human needs, food, water and shelter, and higher social and cultural needs such as security, freedom, education, employment and recreation. This viewpoint is focused more on the needs of the individual than on communities as a whole.

2. Ecological sustainability implies the continued productivity and functionality of biological processes and ecosystems. Long-term ecological sustainability presupposes the conservation and protection of genetic resources and biological diversity, although short-term adjustments are often essential to the long-term permanence of ecosystems.

3. Economic sustainability can in principle be approached in two ways. In the first, the crucial element in a sustainable economy is constant economic growth, which may be regarded as a consequence of population growth, the natural human instinct to make progress and the achievement of technological innovations. The second approach claims that sustainability can only be achieved through a stable economy or zero growth, since economic growth is restricted by the laws of thermodynamics, social factors and the market-independent values of ecosystems and common welfare, which are often so difficult to measure.

3.2. Definitions of sustainable development

Sustainable development as a universal developmental goal and operational strategy is a fairly new concept, general definitions of which include social, ecological and economic features.

The United Nations Commission on Environment and Development defines sustainable development as a development that meets the needs of the present without compromising the ability of future generations to meet their own needs. The commission characterizes sustainable development as fundamentally a series of changes in which the exploitation of natural resources, the steering of investments, the orientation of technological development and institutional changes are all in harmony one with another and promote the abilities of both present and future generations to fulfil human needs and aspirations (WCED 1987: 43-46).

The World Resource Institute regards as sustainable development a strategy in which natural resources, human resources and finance are managed and used in a manner which will increase wealth and wellbeing (The Global Possible 1985). According to Pearson (1985) the idea at the core of sustainable development is that present-day decisions should not damage prospects for maintaining or improving standards of living in the future (Brown et al. 1987: 716).

Liverman et al. (1988: 133) define sustainability as the indefinite survival of the human species with the quality of life beyond mere biological survival. Sustainable development then presupposes a maintenance of basic life-supporting systems (the atmosphere, hydrosphere, land and biota) and the existence of infrastructures and institutions to distribute and protect the components of these.

Sustainable development can be defined, in the opinion of Goodland and Ledec (1987: 36, 37), as a pattern of social and structural economic transformations which optimizes economic and other social benefits available in the present without jeopardizing the likely potential for similar benefits in the future. This definition stresses the effects of current social-economic development on natural resources, which form the foundation for our future wellbeing. Sustainability does not involve any clear-cut limits but rather a kind of warning zone based on planners' and administrators' estimates of the quality and quantity of the natural resources that should be left for the use of coming generations (Voss 1986: 3).

3.3. Natural resources and the environment in sustainable development

Definitions of sustainable development lay emphasis on satisfying the needs of present and future generations and ensuring their wellbeing, functions in which natural resources and their utilization can be assumed to play a major part. The management and use of natural resources is connected with the vital aims of human society: to alleviate poverty, to achieve steady economic growth, to promote health, to cope with the rapid expansion in population and to ensure political and economic stability (World Resources 1986: ix).

Sustainable development is usually viewed in relation to the environment, natural resources, human economic activity and the interaction between these. The dependence of wellbeing and sustainability on these factors is described in the coevolutionary development theory of Nijkamp and Soeteman (1988: 624). This theory assumes that environmental systems and human socio-economic systems influence each other and in turn affect human welfare through the medium of economic development and ecological resilience.

Welfare in this sense implies an entity composed of the satisfaction of the whole range of qualitatively distinct human needs[3], the factors contributing to the satisfaction of these being

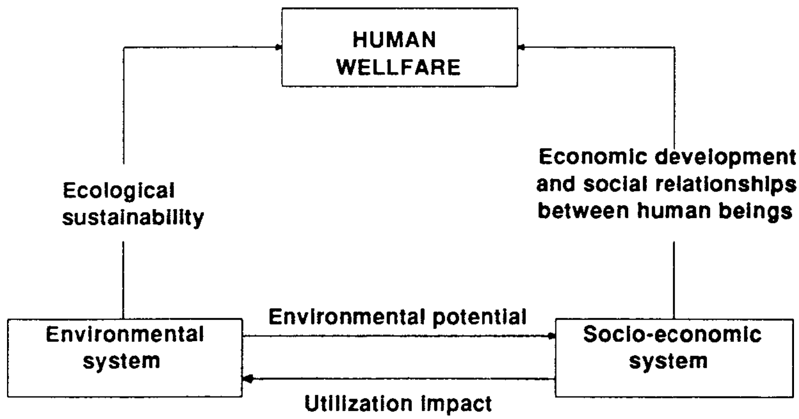
- material resources
- human interaction relations
- man's relation with society

(Allardt 1973).

Human interaction relations and relations with society together form the network of man's social relationships, which are in turn closely associated with socio-economic systems and may be likened to ecological sustainability and economic development in their function as instruments for attaining wellbeing.

[3] In Maslow's terms, these comprise man's physiological needs (nutrition, rest, health, etc.) and also those of security, love and companionship, influence and esteem, self-fulfilment, knowledge and understanding.

Figure 1. Connections between sustainability, development, environmental systems and socio-economic systems. (Based on Nijkamp & Soeteman 1988: 624.)



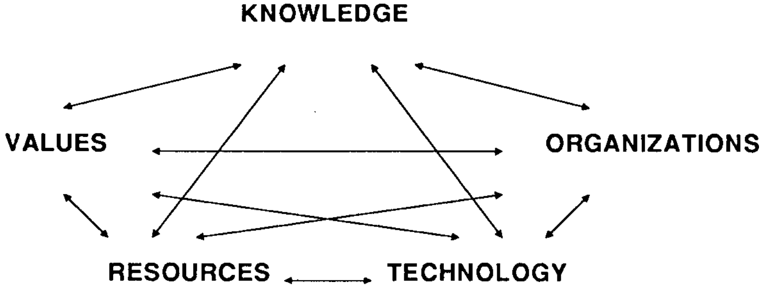
The sources for this wellbeing are environmental systems and socio-economic systems, the interaction between which may be described in terms of environmental potential and exploitation effect. The first of these refers to the ability of the environmental systems to influence the socio-economic systems in a manner likely to increase wellbeing, without producing commodities or properties that detract from ecological sustainability. In an economic sense, this environmental potential is frequently a production factor, although it is not always necessary to pay a price for it. The latter concept, exploitation effect, subsumes all the changes in environmental potential occasioned by the socio-economic systems as production and consumption exert their influence on ecological sustainability.

Environmental potential and exploitation effect are bound together in the long term, a higher level of one being associated with a low level of the other. Knowledge of the threshold values and minimum achievement levels for sustainability is a prerequisite for ensuring the correct functioning of environmental and socio-economic systems (Nijkamp & Soeteman 1988: 622).

Coevolutionary development will guarantee a balance between the development of environmental systems and socio-economic systems. Ecological sustainability may be said to comprise the quantitative and qualitative events occurring within environmental systems which serve to improve the environment and increase human wellbeing, while economic development comprises the quantitative and qualitative changes in the economy necessary to increase wellbeing. Wellbeing may be understood here as implying individual and collective benefits and the satisfaction of needs, whether measurable in monetary terms or not.

The coevolutionary theory of Richard B. Norgaard regards sustainability of the fluctuating interactions between human beings and their environment as the essential element in sustainable development. The development process consists of interactions between environmental systems, social organizations, information, technology and sets of values. The process is symmetrical, so that each element can be understood only in association with all the others. None of them offers a more obvious starting point for comprehending the whole than any of the others, nor does any one occupy a position of dominance over the others. All the elements in development are subject to change, and changes in any one of them will affect the development of the others. One requirement for sustainable development is that the diversity and productivity of each one of these elements should be maintained and improved (Norgaard 1988: 607, 616, 617).

Figure 2. A coevolutionary view of the development process (Norgaard 1988: 616).



3.4. A framework for studying sustainable development

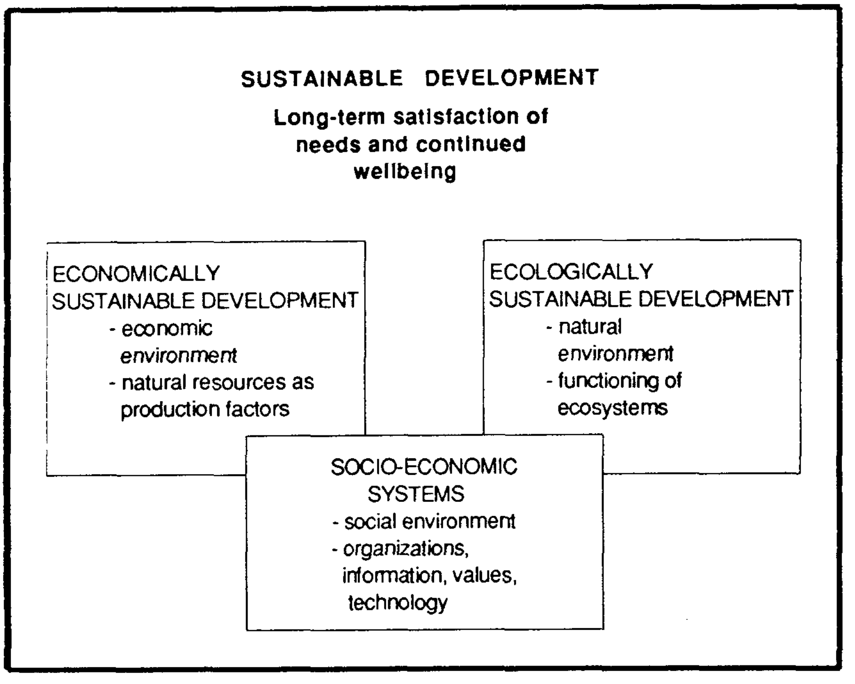
In accordance with the coevolutionary approach, sustainable development may be regarded as a continuous capacity on the part of environmental systems and human socio-economic systems to function as sources of human wellbeing and the satisfaction of human needs. Environmental systems comprise natural resources and the functions of ecosystems, and socio-economic systems make use of these in order to increase wellbeing through the medium of economic development. The welfare goals of the socio-economic systems are influenced by various social organizations, sets of values and forms of information and technology, as are the methods employed for achieving these goals.

The discussion recognizes separately economically and ecologically sustainable development, this being based on the coevolutionary theory, an extended definition of the economy and an analysis of environmental parameters. This division is nevertheless largely a matter of differences in emphasis, as the interactions and dependence relations between the environment and the economy make it impossible to examine them as entirely separate parts of sustainable development.

In the terms of Randall (1987: 47), an economy is a system which organizes the production of commodities and services and their distribution within the community. It is connected with environmental systems and social systems, and all human activity is either part of an economic system or essentially connected with one.

The environment will be divided, in accordance with the pragmatic-hermeneutic view of society propounded by Hahtola (1989: 14), into the natural environment (man and nature), the economic environment (resources) and the social environment (society). An economy comprises a form of activity aimed at employing the material means afforded by the environment to alter that environment in order to achieve wellbeing.

Figure 3. A framework for studying sustainable development.



Ecologically sustainable development lays emphasis on the natural environment, the proper functioning of ecosystems and natural resources from the viewpoint of the natural sciences, while economically sustainable development assigns a crucial role to the economic dimension of the environment, so that the starting points for examining it lie in neoclassical economics and the resulting discipline of environmental economics.

This paper will concentrate on the economic and ecological areas of sustainable development, paying attention to socio-economic systems only insofar as these are closely associated with the various views on economically sustainable and ecologically sustainable development. This emphasis on economics and the natural sciences arises out of the relevance of these to natural resource accounting, and does not imply any attempt to place the various aspects in order of importance.

4. MAIN FEATURES OF SUSTAINABLE DEVELOPMENT AND ITS PRINCIPAL INDICATORS

4.1. Economically sustainable development

Economic development and economic growth

The economic approach to sustainable development usually lays emphasis on the continuity of economic growth as an essential although not sufficient condition for development. Economic development includes the principle of growth in real per capita incomes within the national economy, and also with other factors implying social wellbeing and structural changes in the economy and society (Turner 1988: 352).

According to Gillis et al. (1987: 7,8), economic growth entails an increase in the production of goods and services and in per capita incomes no matter how this is attained, whereas economic development is a broader concept. Growth in incomes is only one part of structural change in a country's economy, the other elements being an increase in the proportion of the national product obtained from industry and a decrease in that obtained from primary production, an increase in the urban population relative to that of rural areas, a slowing down of population growth, a distinct change in the age structure of the population and changes in patterns of consumption. It is also essential from the point of view of development that the whole population should participate in these processes of change and in the generation and enjoyment of the resulting benefits. Growth which benefits only a minority is not development.

Pezzey (1989: 14) emphasizes economic growth as a measure which can be assessed in monetary terms, an increase in the total value of consumption or production, not necessarily with any accompanying physical growth in the material or fuels used, whereas development can be defined in a variety of ways, e.g. as growth in consumption or total benefits as a function of consumption, natural resources and pollution (see Table 1, p. 24). Pearce, Barbier and Markandya (1988: 4) regard development as a vector of social objectives, the components of which, in addition to growth in incomes, are improved nutrition, health and education, accessibility of natural resources, equality in the distribution of incomes and increases in basic freedoms within society.

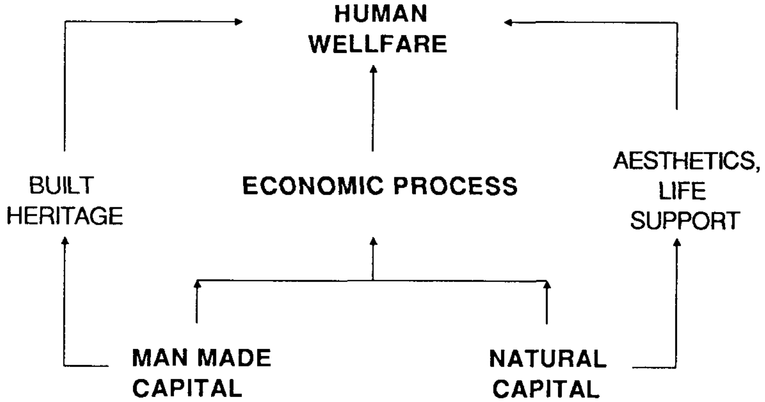
Natural and man-made capital

Pearce (1988a: 598, 599) claims that an examination of sustainable development should take account of all the processes of economic development aimed at increasing human wellbeing. The basis for economic processes and affluence is provided by the supply of natural and man-made capital. Sustainability as far as an economic interpretation of sustainable growth is concerned requires at least a stable pool of natural capital composed of all the resources available from the environment. In this sense the natural environment forms a pool of factors to serve economic functions, outstanding among which are

- natural resources as inputs to ecenomic production processes (e.g. biomass, water, genetic diversity, soil quality),
- the environment as a recipient of waste from economic processes,
- the environment as a source of wellbeing in terms of aesthetic and spiritual values,
- life-supporting systems.

Natural capital affects wellbeing both directly and via economic processes, while man-made capital, comprising machinery, infrastructures, factories and forms of technology, affects it largely through the medium of economic processes, but also directly to some extent in the form of various built structures and heritage (Pearce 1988: 599). The influence of capital on wellbeing is illustrated in Figure 4.

Figure 4. Capital and the economic process (Pearce 1988a: 600).



The basic connection between capital and sustainability is formed by resilience. Natural capital improves the resilience of the economy in the face of major changes such as fluctuations in climate, natural catastrophes and the cumulative effects of long-term processes. Thus a reduction in natural capital will correlate with a reduction in sustainability. The strength of the correlation varies from one country to another, but reductions in natural capital at the global level can be a source of economic loss to all societies.

Natural capital and man-made capital can replace each other only up to a certain point, and the opportunities open to future generations will depend on the natural capital available to them, as man-made capital can always be altered as required, but changes in natural capital are frequently irreversible. A large stock of natural capital will increase the choices open to man, and also extend non-human rights, since it will provide more habitats for wild animals and plants and increase biological diversity (Pearce 1988a: 601, 602).

The range of choices available in the future is an aspect that is also emphasized in Turner's view of sustainable economic development. He takes sustainable development to imply maximization of net economic benefits in a manner which will enable the quality of the natural resources and the services provided by them to be maintained in the course of time. It is possible to retain freedom of choice even when the physical reserves of these resources are diminishing, since technology can enable improvements to be achieved in the quality of the environment and the level of the services that it affords.

Various economic incentives can be used to reduce the non-sustainable use of natural resources, but the crucial aspect is care in the use of methods which have irreversible effects and costs and the attachment of particular value to benefits which are likely to be lost as the reserve of natural capital dwindles (Turner 1988: 357).

Beyond a certain level, economic development will lead to a reduction in some environmental stocks and functions. Available low-entropy reserves (see p. 57) will diminish as a result of the use of natural resources and the generation of waste, so that economic production systems will become more indirect and complex (Turner 1988: 357). Complementary use of natural and man-made capital has reverted to a competition between economic development and the reserves of natural capital (Turner 1988: 357; Pearce 1988a: 603).

The quest for economic efficiency has favoured the development of man-made capital, because this is a marketable product. Also, the inputs of natural capital into production processes frequently have no price attached to them and are not in such short supply, so that insufficient economic incentives exist for increasing this capital (Pearce 1988: 603).

In the opinion of both Pearce and Turner, the maintenance of natural resources in the midst of economic development calls for an appreciation of these multi-dimensional and multifunctional resources and the quantities, values and types of values (user, non-user) associated with the environment. Pearce believes that the choice between natural capital and man-made capital must take place within certain limits, and minimum levels should be defined below which stocks of natural resources must not be allowed to fall in order to avoid their total destruction (Pearce 1988a: 604; Turner 1988: 357-358).

The essential conditions for sustainable development laid down by the World Commission on Environment and Development include

- reviving growth and changing the quality of growth
- conservation and enhancement of natural resource base
- merging environment and economics in decision making

World-wide sustainable development would in the opinion of the Commission require an annual growth in gross national product of at least 3% in both the industrialized and the developing countries. At the same time, it is seen as essential in order to preserve our ecological capital and reduce our susceptibility to economic crises for this growth to be adjusted in terms of content so that it is less dominated by the consumption of raw materials and fuels (WCED 1987: 49-51, 57-64).

Energy and sustainable development

Fuels and the capacity of the biosphere for absorbing the waste products of their combustion occupy a critical position as far as sustainable development is concerned (WCED 1987: 57-59). Sustainable development implies an adequate supply of fuels for centuries to come in a form in which the economic and environmental consequences of their use do not impose too great a burden on society (Kristoferson 1988: 94).

Pirages (1977: 110,111) stresses the importance of fuels for the continuity of economic growth, and sees sustainable development as economic growth which will continue to be supported by the physical and social environment in the foreseeable future and which is primarily dependent on the sources of energy available. According to Norgaard, economic activity, social organizations and technological systems have adapted themselves to the use of fossil fuels, and it is this that has freed societies from the immediate limitations imposed by the environment. Development in the long term will nevertheless be possible only with the aid of renewable sources of energy, as the finite supplies of fossil fuels and the capacity of the atmosphere and oceans to absorb carbon dioxide will otherwise eventually place limits upon it (Norgaard 1988: 617).

Another major issue as far as sustainable development is concerned is the achievement of greater efficiency and economies in the use of energy in order to limit the consumption of non-renewable sources and reduce the resulting environmental hazards. One recommended approach to more efficient utilization of these resources and reduction of the political and technical risks involved is to maintain the highest possible level of diversity in sources of energy (Kristoferson 1988: 94, 95; Goldemberg et al. 1988: 64).

Since the organisms that make use of renewable solar energy consume only a very small fraction of what is available, Boulding (1988: 111) believes that this source will offer large potential reserves as soon as fossil fuel prices rise sufficiently high. The use of actual material sources could well become one of the main problems of sustainable development in the long term, as the world is a closed system in this respect, constantly consuming its reserves and disposing of the resulting waste on the land, in the sea and in the atmosphere. Although economists stress the effects of limited supplies and rising prices in reducing the use of material fuels and encouraging the search for alternatives, the possibility of reserves being exhausted completely cannot be entirely rejected.

Economic models for sustainability

Traditional models and production functions for economic development are often unsuccessful as far as sustainable development is concerned, because they contain powerful inbuilt assumptions and constants which are not realized in practice or apply only under certain circumstances. If production is defined as a function of natural resources, labour and capital, in the manner of Cobb-Douglas[4], a standard of living based on non-renewable natural resources should be capable of being maintained indefinitely by replacing these with labour and capital inputs. On the other hand, the discount manner of thinking could prove the downfall of human civilization at some time in the future, since we are apt to value present benefits much more highly than benefits accruing to future generations (Randall 1987: 30, 31).

Boulding emphasizes the importance of the ratio of capital to incomes from the point of view of economic models. These models discuss capital in monetary terms, even though its physical structure is a more essential matter as far as development is concerned (Boulding 1988: 111, 112).

The economy/environment model of Pezzey assumes that the total human benefit and wellbeing achieved will be influenced by the level of consumption permitted by production activity and the recreational amenities afforded by the environment[5]. The inputs available for production purposes are capital, technology, labour and the quality of the environment and its resources. Production and consumption in turn generate flows of waste which affect the quality of the environment and its resources, and thereby have repercussions for production and recreation.

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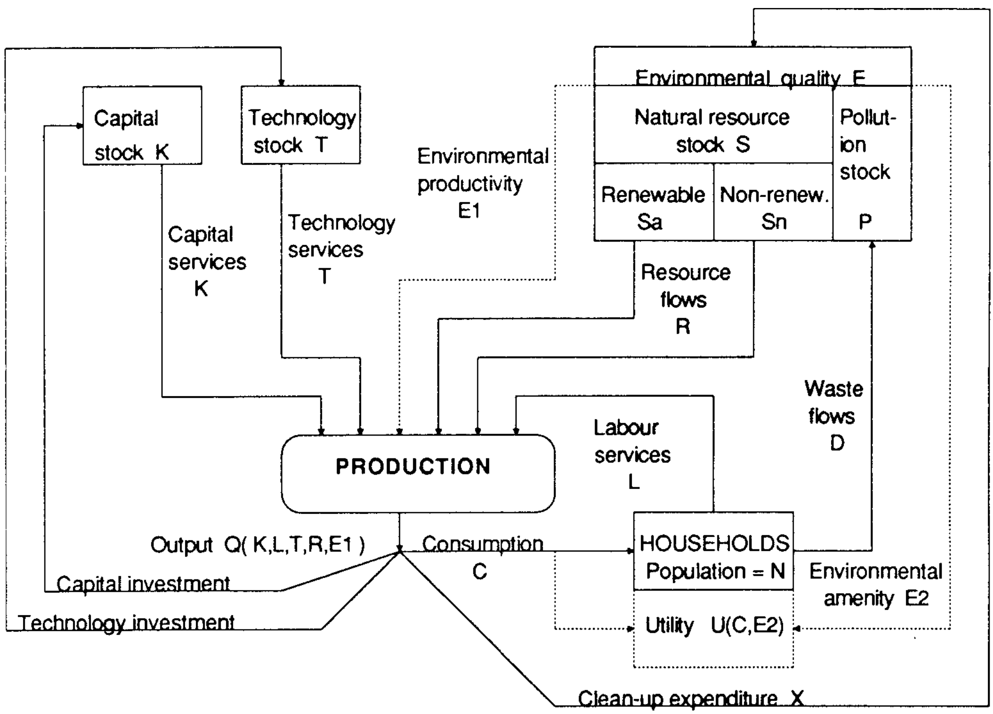
[4] On the Cobb-Douglas version of the production function, see Randall 1987: 30, 31).

[5] Recreation amenities may include factors which are of no immediate economic or instrumental significance to man, e.g. the right of other species to exist and survive, or biological and geomorphological diversity, etc. (Pezzey 1989: 17, 18).

In terms of this model, sustainable development can be defined as a form of development in which the benefit per person does not decline with time and in which the level of consumption is higher than that required to supply man's basic needs but does not exceed the ecological tolerance level of the environment (Pezzey 1989: 13).

Figure 5. Stocks and flows in economy and environment (Pezzey 1989: 8).



The model can also be used to derive other criteria such as sustainable growth and sustainable utilization of natural resources, most of them in the form of inequalities (Table 1), and differing in this way from the optimization and maximization criteria traditionally employed in economic models. If optimization is defined as the maximization of benefits discounted at their present value, sustainability is a restriction on optimization and not an alternative to it (Pezzey 1989: 14).

Table 1. Sustainability criteria derived from the economy/environment model (Pezzey 1989: 13).

SUSTAINABLE GROWTH	1. Non-declining Q or C 2. Positive and non-declining Q/N or C/N
SUSTAINABLE RESOURCE USE	1. Non-declining S 2. Non-declining Sa 3. Non-declining $\underline{Sa}$; $\underline{Sa}$ = individual renewable resources 4. Non-declining $\underline{Sa}$ and non-increasing $\underline{P}$; $\underline{P}$= individual pollution stocks
SUSTAINABLE DEVELOPMENT	1. Non-declining U 2. Non-declining U and min$\underline{C}$ decreasing; min$\underline{C}$ = minimum consumption of individual consumers 3. Non-declining U, when min$\underline{C}$ > $\underline{C}$bn and max$\underline{C}$ < $\underline{C}$es; bn = basic needs es = ecologically sustainable

In Pezzey's opinion sustainability can be achieved in numerous alternative ways, the optimum being that form of development which leads at the same time to the largest possible benefits discounted at current value. Long-term optimization differs radically from the short-term maximization philosophy, since consistently high growth in consumption and benefits in the future can only be achieved by assuming less than maximal levels at the present moment (Pezzey 1989: 23, 37).

The World Bank has also drawn attention to the length of the time scale involved, regarding the promotion of economic growth, the alleviation of poverty and conservation of the environment as mutually supportive objectives in the long term even though they may conflict one with another in the short run (World Bank 1987).

The discounting process and the interest rates employed in it have a considerable effect on calculated sustainability, since it is these that determine the weights placed on current and future benefits and costs when investment decisions are being taken. Thus high interest rates lead to greater investments in the utilization of natural resources than in their preservation. This utilization of resources in turn exerts undesirable external effects on the economy, the internalization of which can cause a rise in the prices attached to the natural resources, increase investments in their preservation and reduce the total extent of the demand for investments (Pezzey 1989: vii).

As far as the supply of investment capital is concerned, interest rates are both an economic and a moral issue. Consumers should be able to discount their benefits at a low rate of interest for the sake of coming generations, but if people are unaware of the finite nature of economic growth and expectations of an increase in consumption in the future are unreasonably high, investment capital will be in short supply and interest rates excessively high (Pezzey 1989: vii, viii).

Practical implementation of the sustainability criteria requires, in the view of Pezzey, proper definition of the levels of organization to which they are to apply, e.g. species, ecosystem, national, global. Such a definition is essential as sustainability demands differ from one system to another, and as the environmental effects external to the systems and the prices of the resources also vary from one level to another.

The major natural resources, together with man-made capital affect production and affluence, and the replacement relations that operate between these two must be known. In defining these it is necessary to take account of the multidimensional nature of the functioning of renewable natural resources and the limits imposed on replaceability by ecological threshold values (Pezzey 1989: vii, 60).

It is possible to influence the use of the principal natural resources with respect to sustainability through restrictive measures of both an economic and an administrative kind. These will raise the prices of the resources concerned and provide an incentive for preserving them within the system in question. One central task of environmental policy is the internalization of external effects, which may be accomplished not only by means of restrictions or financial incentives but also by defining and implementing a system of rights of ownership over natural resources and the environment (Pezzey 1989: vii, 37, 56).

A critique of economic models

Many approaches and economic models based on neoclassical economics ignore the cultural, social, ethical and moral factors affecting production and affluence functions[6]. One question which is particularly crucial as far as the utilization of natural resources and the wellbeing of future generations in concerned is that of replaceability. Do existing generations have the right to spoil the environ-ment and reduce the reserve of natural resources if they compensate future generations for this by increasing the volume of man-made capital and technical knowhow?

Arguments in favour of the preservation of stocks of natural resources include our uncertainty and lack of knowledge regarding future conditions and expectations, and also the threshold values which may exist in nature. Pezzey (1989: 60, 61) is of the opinion that in spite of its defects, the neoclassical approach to sustainability does provide those responsible for environmental policy with information on what can be done to make the economy more sustainable, at least as a by-product of its other objectives.

Market forces are unable, according to Daly (1986: 320), of reflecting the physical restrictions imposed on production by the basic laws of thermodynamics, since the paretoefficiency-based assignment of resources assumed in neoclassical economics does not consider the ecological sustainability of the resource flows. This means that material and energy flows from ecosystems into the economy and back into the ecosystems should be restricted by reference to sustainability criteria and not only by relative price levels.

If sustainable development is set up as one of the goals of society, the occurrence of external effects caused by the accumulation of waste should mean that an attempt is made to keep production volumes at a level which will not permanently detract from the capacity of the ecosystems to absorb this waste. Optimal production prices required for sustainable development will then be higher than those determined on the principle of maximum profits or pareto-optimality (Pearce 1988b: 60-65).

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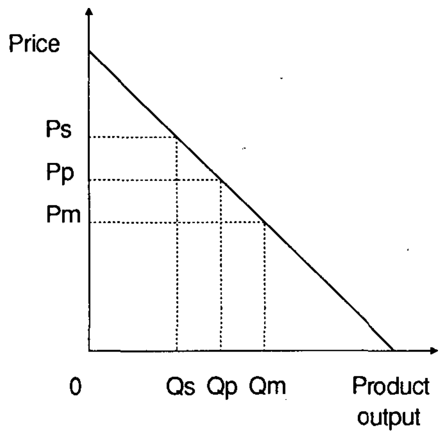
[6] for further criticism of neoclassical models, see Pezzey 1989: 10, 12; Norgaard 1985 and Page 1983.

Figure 6. Optimal prices under conditions of sustainable development. (Based on Pearce 1988b: 64.)



Ps = Sustainable optimal price = Lowest price consistent with sustainability

Qs = Product output, in which the amount of waste is lower than the waste assimilation capacity of ecosystems

Pp = Pareto-optimal price

Pm = Profit maximizing price

4.2. Ecologically sustainable development

Avoidance of ecological damage

Discussions of economically sustainable development are usually based on the notion that growth in production and per capita incomes with time can be achieved in a manner which is not harmful to the environment, or at least does not involve any serious environmental risks (Turner 1988: 352). The concept of ecologically sustainable development, on the other hand, takes as its starting point the sustainability of the functioning of the whole biosphere under the influence of a continuous increase in population and exploitation of natural resources. The background to this is commonly provided by a Malthusian philosophy or an ecocentric viewpoint. According to Malthus, the growth in population cannot exceed the limits imposed by our natural resources, whereas the major problem from the ecocentric point of view is not the balance between population and resources but the expectations which are laid upon natural resources when striving for economic growth (see Redclift 1988; Munn 1987; O'Riordan 1981).

Munn regards development as sustainable in the long term only if it is ecologically sustainable. The use made of materials and fuels sets the limits in principle for the population that the world or any given region in it can support, and a sufficiently large increase in population will lead to a deterioration in the quality of the environment and a reduction in the reserves of renewable natural resources. In other words, there are external limits on the exploitation of natural resources, the exceeding of which will lead to ecological catastrophe in the long term.

It is extremely difficult to determine these limits, however, on account of the interactions that exist between the environment, natural resources, population and technology. Prediction of the direction of development is complicated by such factors as physical conditions in different areas, intra-species and inter-species interaction and feedback mechanisms in nature and non-linearities and discontinuities in the functioning of geophysical, ecological and socio-economic systems (Munn 1987: 8, 9).

Glaeser (1988: 672-674) already perceives the destruction of the foundations of human life as a distinct possibility on account of the deterioration of the natural environment, its over-exploitation and the exhaustion of its resources. Human interaction with nature has for a long time consisted of the excess extraction of natural resources and destruction by means of the technical production systems set up by human communities. Even man himself, the human producer, can be said to serve as an exploitable, renewable resource in this process. Glaeser's approach to sustainable development is thus a human-ecological one, the distinguishing feature of which is his holistic view of development. A comprehensive understanding of development calls for a knowledge of the interaction between man and the systems operating in the environment and the adoption of a holistic, preventive environmental policy rather than a sectorized policy devoted largely to the repair of existing damage.

Conservation of biological resources

The World Conservation Strategy of 1980 defines development as the satisfaction of human needs and improvement of the quality of human life. The goal of this strategy is to achieve sustainable development by protecting the whole of the biosphere, and particularly its biological resources. The principle components of sustainable development and conservation of the biosphere are

1. maintenance of essential ecological processes and life-supporting systems,
2. preservation of genetic diversity, and
3. sustainable utilization of species and ecosystems.

The ecological processes concerned vary in scale from local to global ones. Particularly essential as far as human survival and wellbeing are concerned are soil formation and preservation, the nutrient cycle and the purification of air and water. These processes are supported and influenced to a pronounced extent by the various ecosystems - plants, animals, micro-organisms and the inorganic environment that surrounds them. The maintenance of these supporting systems is an essential for all societies no matter what their stage of development.

Genetic diversity is a matter of the genetic forms and variations of the organisms present on the earth, species, subspecies, strains, plant, animal and micro-organism populations and life-forms. A large proportion of the variation is essential

- for maintaining the production of raw materials and nutritive substances,
- for ensuring sufficient alternatives in the future,
- as a buffer against environmental changes, and
- as a source of material for scientific innovations and industrial needs.

The preservation of genetic diversity may be looked on as an ecological form of "insurance and investment" which calls for action to prevent the extinction of species and to preserve the maximum degree of the variation within species.

The sustainable utilization of species and ecosystems is a form of utilization which in its extent and the means it employs sets out to ensure the continued renewal of these species and ecosystems. The importance attached to guaranteeing this sustainability varies according to the dependence of society upon the given natural resource, the most critical species groups and ecosystems being those whose products are of commercial value, forests and grazing lands. Diversity and flexibility in the economy can reduce the need for sustainability in a given natural resource, but any reduction in sustainability will conversely detract from the chances of an economy achieving diversity and flexibility (Allen 1980: 18-20).

The World Commission on Environment and Development also regards conservation of biological resources and their inorganic environments as essential for ensuring sustainable development. Development in the future is expected to become increasingly dependent on plant and animal species and their genetic material and variability. Sustainable development calls for conservation of the whole complex of species, ecosystems and the essential chains of events in nature that support life. This will be vital for economic reasons, but it is also desirable for scientific, ethical and aesthetic reasons (WCED 1987: 147).

Ecodevelopment

The principal aim in the ecodevelopment approach is development in equilibrium with nature, the idea lying behind it being that of a compromise between ecological demands and economic development so that the changes in the environment brought about by the development process will not endanger the tolerance of organic nature in the long term.

The objective is a state of balance between man and nature in which flows of renewable natural resources are used as efficiently as possible and the stocks of natural capital are depleted as little as possible. One essential requirement for sustainable development in this sense is ecologically sustainable use and management of the systems that serve to maintain the renewable resources, e.g. soils, water, forests and the climate. A major challenge for environmental conservation and the utilization of natural resources is to shape man-made production processes in such a way that their inputs and outputs are compatible with the functioning of ecosystems and the cycles operating in nature (Sachs 1984: 213-217).

Development calls for a revision of our existing models of consumption and ways of life (on the demand side) and means of production (on the supply side) in conjunction with technological choices and spatial distribution patterns. The criteria for equilibrium between development and the environment may be regarded as being the uses made of fuels, natural resources and space and the effects of these on the environment (Sachs 1984: 214-217).

The basic elements of ecodevelopment include

- conservation and preservation of the ecological basis for economic development, and
- self-sufficiency in the utilization of local natural resources and human resources (Glaeser 1984: 1).

Ecodevelopment offers an alternative to the kind of development that is grounded exclusively in the continuity of economic growth in terms of gross national product. For physical, ecological, social and human reasons, growth involves certain boundary zones in which the costs and other problems increase significantly and the resulting benefits diminish. The criteria of efficiency and the minimization of costs are replaced in ecodevelopment by minimization of waste and pollution, reduction in vulnerability and maximization of properties such as flexibility and safety. The measurement of development then calls for indicators that will enable the degree of exploitation of nature to be monitored and described, together with the flows of natural resources entailed in the formation of the national product and the social and human costs of economic growth (Glaeser 1984: 210, 211; Brown 1979: 16).

The principles of ecodevelopment are also to the fore in Lester Brown's views on a sustainable society, in which the main features of such a society are held to include more efficient use of fuels, an economy based on renewable sources of energy, local self-sufficiency and replacement of the objective of economic growth by that of sustainability. The central principles of the economy should be flexibility and the recycling of natural resources, the reserves of which should be looked on as sources for topping up existing stocks and not only as primary stocks of raw materials as at present (Brown 1981: 247, 248).

Sustainable development in agriculture and forestry

Production in agriculture and forestry can, in the opinion of the World Commission on Environment and Development, be sustainable only if pollution of the soil, water and forests on which it relies can be avoided. Short-sighted expansion of agriculture and forestry at the expense of environmental considerations, the use of fuels, industrial production and population pressure are liable to destroy the resource base which it is so essential to protect and strengthen in order to maintain the level of food production required under the principles of sustainable development.

The first task in protecting and developing this resource base is to classify land into

- enhancement areas, which allow intensive agriculture and support high levels of population and consumption,
- prevention areas, in which intensive agriculture is not practised, and
- restoration areas, in which the land has totally or partially lost its productive capacity.

Different areas should be used for the purposes most appropriate to them, bearing in mind regional factors connected with the balance between conservation on the one hand and the use of agricultural technology and chemicals and the needs of commercial forestry on the other. Management of water sources and the efficient use of water occupy a significant position with regard to pollution of the natural resource base, growth in agricultural productivity and the production of foodstuffs (WCED 1987: 125-140).

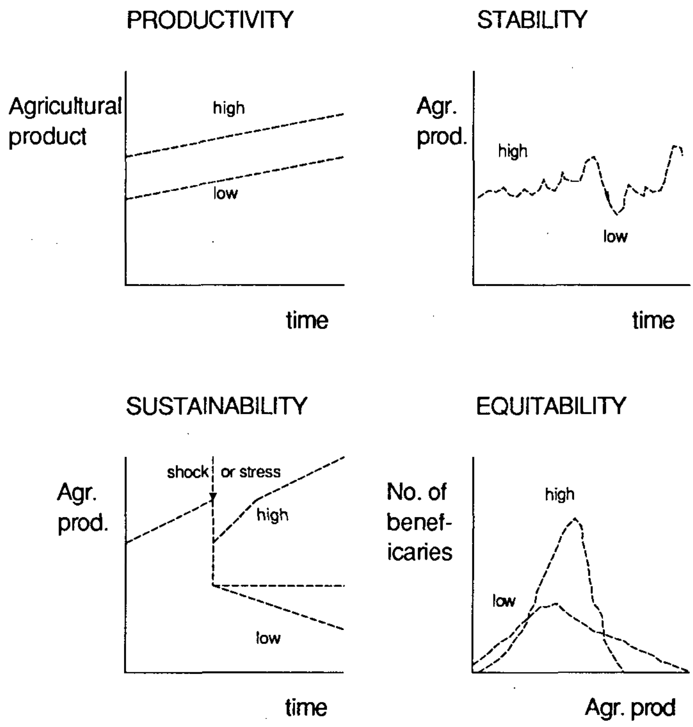
Conway and Barbier (1988) also emphasis the importance of the natural resource base for sustainable development in the agricultural sphere. Sustainability in agriculture can be looked on as a function of

- natural-based factors in production systems,
- slow, cumulative changes,
- sudden, relatively pronounced, unpredictable changes and
- human inputs available to counteract these changes.

Development is then dependent on the exploitation of natural and man-made resources by the agency of human skills and labour, although a critical position is occupied by the sustainability of agriculture in the face of quantitative and qualitative changes in natural resources. Agricultural development cannot be sustainable in the long term if the reduction in natural resources and decline in their quality detract from the ability to maintain agricultural productivity in the face of economic and ecological changes.

Major considerations in agricultural development in addition to sustainability and productivity are stability and a equitability. Sustainable development consists of preserving a balance between the above factors from the level of the individual farmer up to national and regional levels (Conway & Barbier 1988: 653-655).

Figure 7. Factors contributing to agricultural development (Conway & Barbier 1988: 654).



The hydrological cycle and sustainable development

A more detailed approach to ecologically sustainable development is represented by the view of Falkenmark on the significance of the hydrological cycle in this respect. He sees human life as restricted by the global hydrological cycle and the natural laws which regulate this, so that a sustainable interaction between human societies and this cycle will be decisive for sustainable development as a whole. The hydrological factor is affected, both directly and via the ecosystems that maintain it, by very many things, including land use and many other functions of human communities.

Essential hydrological considerations now and in the future are held to be

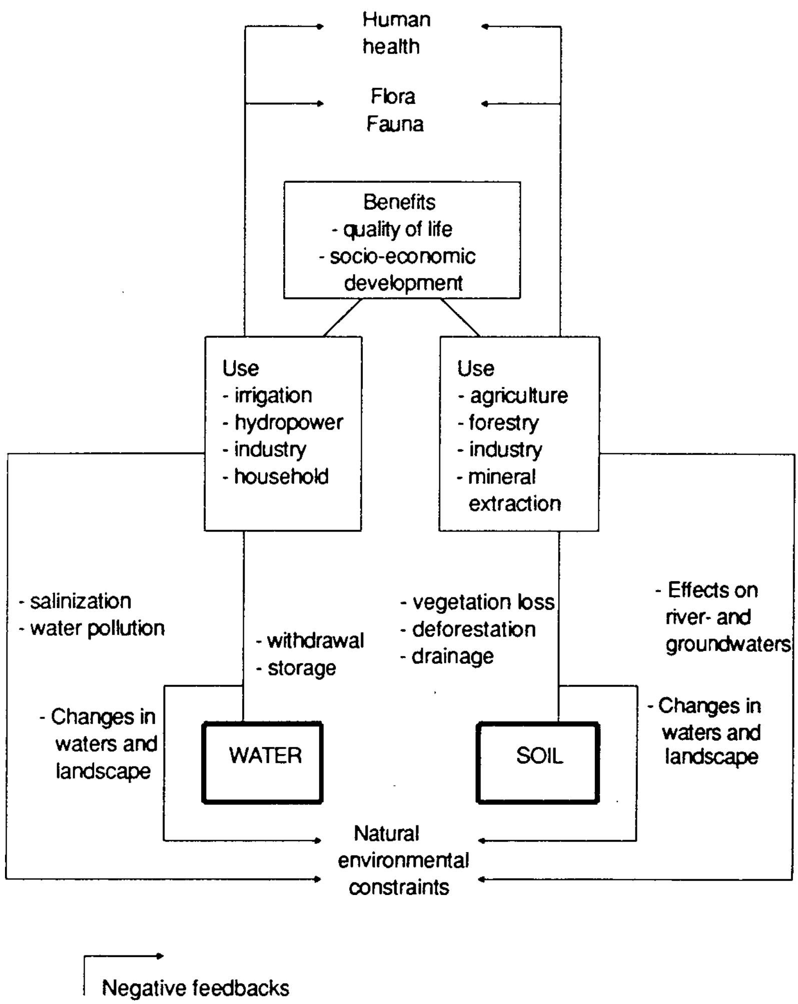
- soil permeability and water retention capacity as factors ensuring biomass production,
- availability of drinking water,
- sufficiency of water supplies for general hygienic purposes, and
- edibility of fish.

The water present in the root layer of the soil, the groundwater and the water contained in rivers, lakes and seas are all equally important for life, and any deterioration in their quality or change in their quantity may be interpreted as a mark of non-sustainability. The main types of human activity that pose such a threat are

- interference with interactions between the soil and the vegetation cover on it,
- processing and emission of pollutants, and
- removal of water from natural waterway systems and its replacement after use.

Among the limits that the environment imposes on the ability of given societies to satisfy people's needs are factors such as the extent of the renewable water resources available through the hydrological cycle and the potential vulnerability of the soil and the land and water ecosystems to interference from the activities of man. These activities involve inescapable reactions in the hydrological sphere, and sustainable development calls for measures to counteract such effects. Crucial features from this point of view are the interactions between water, soils and the vegetation and the continued functioning of these under different climatic conditions (Falkenmark 1988: 71-76).

Figure 8. Effects of human activity and the natural environment on soils and the hydrological cycle (Falkenmark 1988: 76.)



4.3. Indicators of sustainable development

Indicators employed to evaluate sustainability

Numerous variables and indices derived from economic, ecological and social data have been used to describe and monitor the utilization of natural resources and the durability of the environment. These variables and indicators will be referred to below as indicators of sustainable development. Most of them are macroindicators comprising aggregated data on various areas and topics. A selection of indicators employed for the estimation and comparison of sustainability on a global, regional or local scale are presented in Table 2 on p. 37.

The majority of indicators of sustainability are not based on any particular consistent approach or theory regarding sustainable development or resource use, but rather they tend to rely on easily obtainable, internationally comparable data without being weighted towards any interactions or relations that would provide clear information on changes, threshold values or non-sustainable directions of development (Liverman et al. 1988: 134).

The relationship between population and the state of natural resources is a particularly difficult one to describe, because capital investments, scientific discoveries and new technologies can compensate for the effects of population growth on the use made of natural resources (World Resources 1986: xii). In addition, such factors as the distribution of incomes, land ownership and technology frequently have more effect on the pressures exerted on individuals and societies to use resources in a non-sustainable manner than does population growth (see George & Paige 1982).

The use of ecological indicators such as carrying capacity, sustainable yield and erosion as measures of sustainable development is restricted above all by the difficulties encountered in defining threshold and optimum values and deficient data on reserves and the factors influencing them (Holling 1977; Liverman et al. 1988), while the major problem with economic indicators is that they fail to cover every forms of economic activity or of changes taking place in natural resources. Thus the use of indicators derived from national economies can give a false impression of the economic potential of a nation in the long term (World Resources 1986: 227).

Table 2. Indicators of sustainability (source: chiefly Liverman et al. 1988).

INDICATORS	DESCRIBING	INTERPRETATION
Gross National Product per capita Fossil fuel consumption per capita	The trends and substance of economic growth	A society is nonsustainable when the cost of growth (ie. climate change, erosion) exceeds the benefits brought by growth
Net present value-, Conservation- and Equity criterions	Economic sustainability	Maximum output/minimum input, productivity maintained for the next generation and equal distribution of income
Population density Agricultural production density Energy consumption density	Sustainability of the biosphere	People per unit of area, value added per hectare per annum and oil equivivalent/ha/a
Maximum sustainable yield	Exploitation of renewable biological resources	Maximum level of production, while maintaining the stock and its natural renewal capacity
Threshold values	Verges between sustainability and nonsustainability	Tree tolerance to pollution damages, athmoshpheric carbon dioxide etc.
Carrying capacity	Potential population supported by different ecological zones	Consists of biological productivity, imports of materials and energy and infusions of capital and technology
Topsoil losses Deforestation Water supply disruption Fishery disruption	Nonsustainable natural resource use	Exploitation of species is non-sustainable, if their value to human beings is completely or substantially lost
Use of renewable resources/Sust. yield Raw material recycling Balanced population growth	Sustainability of societies	

Elements of the measurement of sustainable development

According to Svedin (1988: 18), the achievement of sustainability calls for the use of key indicators, a checklist regarding the direction in which sustainability is progressing at a given moment and in a given situation. The purpose of these indicators is to demonstrate the sustainability or non-sustainability of the current trend in development in the long term, and they should not be used as instruments to define optimal sustainability.

The minimum requirement for measuring sustainable development, in the terms of Voss (1986: 4-12), is information on the connections between socio-economic functions and the natural resources they use and standards and warning ranges for the sustainability of various resources and ecosystems. Correspondingly, systems for performing such measurements should comprise the following elements:

- Sources: human socio-economic functions divided where necessary into sectors such as agriculture, forestry and industry. Sources also include natural events occurring in the environment, e.g. climatic changes, floods and droughts.
- Receptors: nature and the environment as ecosystems and life-supporting systems.
- Responses: actions taken against undesirable environmental effects, e.g. conservation programmes, restrictions on emissions.
- Standards related to the receptors concerned for evaluating the sustainability of ecosystems and life-supporting systems.

The effects exerted on nature and the environment are the cumulative consequences of human activities, natural events and counter-effects. Once a given time has expired, the estimated effects can be matched against the standards to yield time-dependent development estimates for different components of nature and the environment. Measurements of this kind when applied in practice are often problem-centred and require the distinction of socio-economic and environmental components and their subclassification into inputs, outputs, fuel consumption and areas, species or diversities, etc. A general framework for the compilation and analysis of key data is presented in Fig. 9.

Figure 9. Framework for the evaluation of sustainability (Voss 1986: 5).

	Nature/Environment 1. 2. 3. ...	Standards 1. 2. ...
Socio-economic activities 1. 2. 3. ...	(Impacts; -)	
Natural events	(Impacts; -/+)	
Responses	(Impacts; +)	
Balance	(Impacts; -/+) →	(Standards) ↔ (SUSTAINABILITY)

Indicators for measuring directions of development can be used to describe cause and effect and interaction relations in the source/recptor/response chain and trends distinguishable in these. The extent or strength of the influence exerted by socio-economic activity can be taken as an indicator of the nature of the next element in the chain, which will increase the chances of being able to understand and identify the connections. Time series for the variables being used will denote the direction of development, and where these time series are not available, comparison of the observations with standards will provide information on the quality and state of the environment.

Liverman et al. (1988: 135-137) have evolved a set of general guidelines which form a framework for the evaluation and elaboration of sustainability indicators at the global, regional and local levels. This framework is built up of criteria for such indicators, so that the degree to which each indicator meets up to these reflects its usefulness for describing sustainability. No indicator necessarily fulfils all the criteria, and the criteria themselves may even be mutually exclusive, but features of the following kinds can be regarded as central to indicators of sustainable development:

1. <u>Sensitivity to change in time</u>. The time interval for gathering data for the indicator should be sufficiently short that changes and directions of development can be described at a relatively early stage. Historical time series are important for estimating the long-term or very long-term sustainability of development, and the indicator should also be capable of distinguishing normal periodic fluctuations from trends denoting a decline in sustainability.

2. <u>Sensitive to change accross space or within groups</u>. Measures based on mean values can obscure significant factors and changes on account of various regional, social and natural influences. When measuring sustainability, attention has to be paid to the distribution of the background conditions spatially and between human groups, and the indicators should also be capable of describing the situation as it affects various risk groups, minority groups and ecologically marginal regions.

3. <u>Predictive and anticipatory</u>. Of particular value in decision making and the shaping of policies are indicators which enable changes towards unendurable circumstances to be predicted in advance. Time series allow extrapolation and the construction of models, and it is often possible by combining empirical estimates and theoretical assumptions to predict the sustainability of development in the long term.

4. <u>Reference and threshold values available</u>. Estimates of the directions of development of environmental and socio-economic systems can be quite meaningless unless they can be related to initial values or information on potential ranges of variation[7]. Threshold values are often critical for the very existence of a system or species, so that the presence or absence of these should be clearly visible in the interpretation of an indicator.

5. <u>Unbiased</u>. Many indicators of development and the quality of the environment are based on group-centred values or values prevailing in given societies which are weighted in different ways from one cultural sphere or society to another. Thus cultural values affect the shaping of the indicators at different stages and levels, determining what is measured, how, where and when, what is emphasized most and how the results are presented. It must be possible to take

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[7] E.g. estimation of life expectancy, grain crops in relation to potential yields within the limits of photosynthesis, or calorie availability per person in relation to the minimum required for survival.

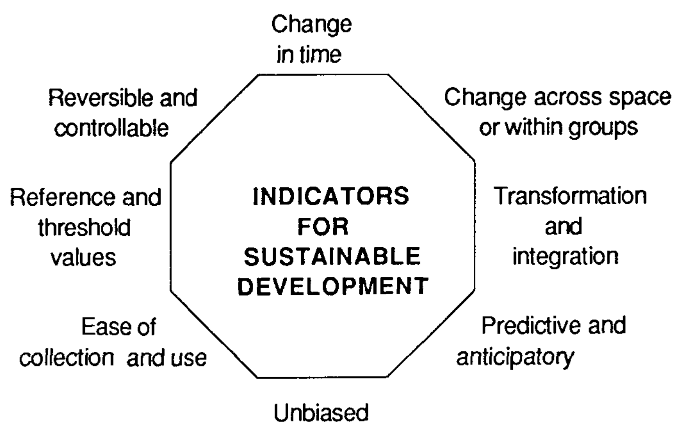
such values into account when interpreting the indicators.

6. Reversible and controllable. It is essential from the point of view of the use and management of natural resources to be able to identify indicators that express the possibilities available for controlling and directing the changes that have taken place and are taking place. Of particular importance in this respect are changes in life-supporting systems which have permanent, irreversible effects. Indicators are also needed for measuring the costs of controlling changes.

7. Data transformation and integration. Raw data will not always provide information on sustainability, and it is often necessary to transform data on natural resources and their changes or combine them with figures referring to population, the relation between resource use and reserves or initial levels and possible threshold levels. The transformation and combination of various indicators and types of data may be affected by problems of weighting or commensurability of components.

8. Ease of collection and use. When selecting indicators of sustainability and trends in it, recourse should be had in the first instance to existing data acquisition and monitoring systems and the opportunities available for adapting these. At the same time, however, every effort should be made to correct deficiencies, especially in the accessibility of data, organizational overlapping or conflicts between planning and research (e.g. minimization or costs vs. usefulness of data).

Figure 10. Requirements placed on indicators of sustainable development.



5. NATURAL RESOURCE ACCOUNTING FOR SUSTAINABLE DEVELOPMENT

5.1. Information requirements for describing sustainable development

Sustainable development is a multidimensional concept, and factors of many kinds are involved in its achievement: human objectives and modes of action in relation to the utilization of resources, regional peculiarities and ecological boundary conditions. The evaluation and description of sustainable development is in practice frequently a matter of measuring and monitoring particular areas contributing to this development, the information on which can then be combined and interpreted in order to determine the direction of development.

The multidimensional character of sustainable development makes it difficult to define and operationalize in a distinct manner, either as a single entity or in terms of its ecological, economic and social features separately. The emergence of problems of definition, objectives, valuation and operationalization and the opportunities for solving these are influenced by economic, ecological and socio-economic factors and the interactions between them. When attempting to describe economically and ecologically sustainable development, one should above all be able to

- monitor variables and processes relevant to natural resources in order to obtain data on their sustainability and factors influencing this,
- assess trends in the main variables and processes and their interrelations, and
- generate information as a basis for defining objectives and taking decisions aimed at sustainable development (see Gilbert & James 1987).

When selecting criteria for use in the context of economic and environmental policy, it is necessary, in the opinion of Pezzey, to know

- what natural resources and man-made processes act as major inputs to production and human wellbeing, and
- how essential or replaceable they are.

Alongside individual stocks and flows of natural resources (see pp. 23 and 48), it is also necessary to measure the relations existing between the various resources. The total volumes of these stocks and flows are obtained by aggregation and summation, taking into account at the same time their prices and the weightings derived from their mutual proportions, since the latter can be used in principle to calculate their complementation and replacement relations. Available information on stocks of natural resources, the extent of economic growth and possible combinations of resources is of particular importance in the developing countries (Pezzey 1989: v, vii, 5, 15, 45).

Gilbert and James (1987) regard the sustainable use of renewable and non-renewable natural resources as being relatively easy to define. In the case of renewable resources, the simplest expression for their sustainable use is the equation

So + I + N = H + M + E+ Si, in which

So = quantity of stock at time t=0,
I = imports to stock,
N = generation of new stock,
H = harvest of stock,
M = loss from stock,
E = exports from stock,
Si = volume of stock at time t=1.

Sustainability can be achieved in principle by selecting **H** so that **So** = **Si**. In practice, however, at least the following factors affect the implementation, assessment and monitoring of sustainable use:

- All the variables must be measurable in terms of a given state and time.
- Account must be taken of the effects of exploitation of the stocks on other variables.
- The sustainable use of natural resources is a complex matter, involving questions such as their order of priority, the different units used for measuring them, regional restrictions on sustainability and definition of the object concerned (species, ecosystem, source of livelihood, "net" sustainability relative to a certain aggregate, etc.).

A knowledge of the stocks available is just the beginning of the description of sustainability or non-sustainability in the opinion of Gilbert and James, for the evaluation, monitoring and achievement of sustainable development also calls for a more precise definition of objectives and an acquaintance with the connections between economics and the environment.

The crucial aspect as far as the sustainable exploitation of non-renewable natural resources is concerned is the use made of incomes from this exploitation, what is consumed now and what in the future, and what investments are made in alternative economic functions.

Income and investment relative to the expected sufficiency of the reserves and the interest rates employed for discounting purposes can give no more than an impression of whether exploitation is sustainable or not, and information is also needed on how sustainability is affected by

- investment in research,
- investment in the developing of reserves,
- technological changes,
- replaceability relations between natural resources,
- changes in natural conditions,
- unpredictability of market forces, and
- changing social preferences.

It is difficult to achieve a complete integration of economic and ecological principles in the use of natural resources (Lone 1987a: 3, 23), because the starting points are so different. Some reconciliation of the two viewpoints is nevertheless required in order to achieve sustainable development, yielding an economic-ecological approach, which is of importance when examining

- the objectives of resource use: gross national product as a measure of development needs to be filled out with indicators describing natural resources and the environment and social indicators,
- volume of resource use: calculations of economic efficiency should take ecological limitations and indicators into consideration,
- order of development and use of resources: economically advantageous resources are usually used first, but decisions should also take note of physical and ecological factors,
- time horizon of resource use: future sustainability should be pursued by getting the correct values and setting the necessary limits to sustain natural environments, not by fiddling the rate of discount.

5.2. Objects of description for natural resource accounting in the context of sustainable development

To sum up section 4, the following may be listed as factors affecting economically and ecologically sustainable development. They are divided here into economic and ecological factors on the basis of the theoretical considerations put forward above, even though many of them can in practice be approached from either angle.

Factors affecting economic sustainability

- availability of natural resources
- natural resource inputs to economic production processes
- replaceability of natural resources and environmental inputs
- alternatives and choices in the use of natural resources
- natural resources and the environment as a recipient of emissions
- natural resources and the environment as a source of human wellbeing through intellectual and spiritual values
- changes in consumption patterns and volumes
- contributions of raw materials and energy to economic growth
- internalization of the external effects of economic activity
- regional factors affecting economic activity
- adaptation to changes in the natural resource base and productivity, technological and institutional reactions

Factors affecting ecological sustainability

- functionality of life-supporting systems
- renewal of species and ecosystems
- preservation of genetic diversity
- adaptation of systems of production to the functioning of ecosystems and cycles in nature
- physical conditions in different areas
- areal distribution of production and consumption
- local self-sufficiency
- recycling of natural resources
- volumes of waste and pollution and their effects
- adaptation of developmental norms to differing natural and cultural environments
- limits placed on population expansion by the use of natural resources

A knowledge of the various branches of sustainable development and the planning and use of procedures aimed at achieving sustainability call for information on the above factors and their interactions. The purpose of such information and the macroindicators derived from it is to describe

- natural resources and the environment, qualitatively and quantitatively
- quantitative and qualitative changes and trends
- interactions and cause and effect relations between economic activity and natural resources

According to coevolutionary theory, continued wellbeing and satisfaction of human needs is possible in the long term through the agency of economic and ecological coevolution, in which the utilization of natural resources now and in the future occupies a major role as far as sustainable development is concerned. The following list contains the main objects requiring description with respect to the economic and ecological dimensions of the natural resource base and the utilization of such resources.

1. Stocks of natural resources and utilization volumes:

- how much is left
- how much is being harvested and used
- which are becoming exhausted and which are increasing
- characteristics of the reserves (e.g. species composition, rotation times, ore concentrations)
- values and their types (e.g. user, non-user)
- location of the reserves
- what will be available in the future

2. Flows of natural resources in the structure of the national product:

- raw material and fuel intensiveness of economic growth
- degree of use of natural resources in the various economic sectors
- multiplier effects
- nature of end use
- imports and exports
- costs of destroying natural resources and generating waste

3. Efficiency of the use of natural resources

- input-output relations
- thermodynamic efficiency
- re-use and recycling of materials and energy
- utilization and cycling times in the economy
- generation of waste
- transport of raw materials and products

4. Replaceability of natural resources

- in production and consumption
- in relation to labour, capital and technology

5. Waste and its effects

- volume and nature of the waste created
- duration of effects
- production processes and uses in which the waste is generated
- where the waste ends up
- effects on the use of natural resources and on human health and welfare now and in the future

6. Effects of economic and political instruments and procedures

- effects of prices on the use of natural resources
- effects of discounting on the use and conservation of natural resources
- future demands for natural resources and price levels
- effects of administrative factors (restrictions, ownership rights)
- effects of socio-economic factors (see p. 16) on changes in supply and demand)

6. PRINCIPLES OF NATURAL RESOURCE ACCOUNTING

6.1. Definition of natural resources and the environment

The term 'natural resources' in connection with natural resource accounting refers to that proportion of the materials and processes existing in nature that it is reasonable for man to consider exploiting. This is a general term that covers the whole cycle of a resource in the economy, in the course of which it may act as a reserve, a raw material, a product constituent or intermediate product and an item of waste (Kolttola et al. 1988: 13, 14; Pulliainen 1979a: 26, 27).

Reserves are natural resources which it is technically feasible and economically viable to use, although the term may also be extended to cover sources that are economically unprofitable and less reliable.

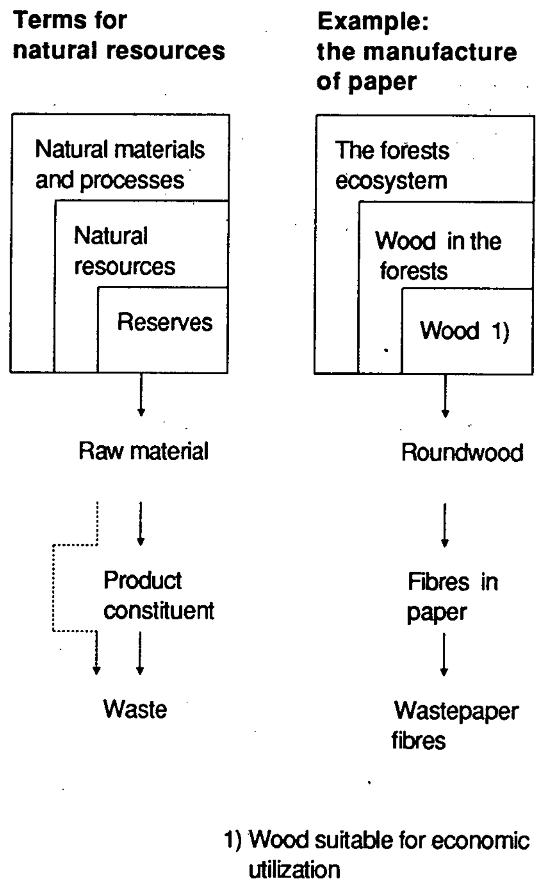
Raw materials are natural resources for which methods of extraction, refinement and utilization are already in existence.

A raw material become a product constituent as the result of a production process, which will take place if and when this is economically viable, i.e. there is a demand for the product or a decision has been made to produce it for some other reason.

A product component becomes waste when the product ceases to be used. Waste may also be generated as the product wears out in the course of use, and a proportion of the raw material remains as waste in the production process. Some of the waste can be recycled as raw materials or returned to nature.

Stocks and flows as means of examining natural resources differ on the time dimension. A stock is the amount of a resource available at a given moment, e.g. by weight, volume or number of items, while a flow always possesses a time dimension and is expressed as an amount per unit of time.

Figure 11. Nature in the human economy (Kolttola et al. 1988:15).



The environment is a much broader concept than a natural resource defined on economic grounds. In the terms of Friend (1986: 38), the environment comprises

- natural resources, i.e. stocks and flows of materials and services available from the environment, and
- the dynamic character of ecosystems, i.e. the quality of the environment, the state of the flora and fauna, human health and pollution.

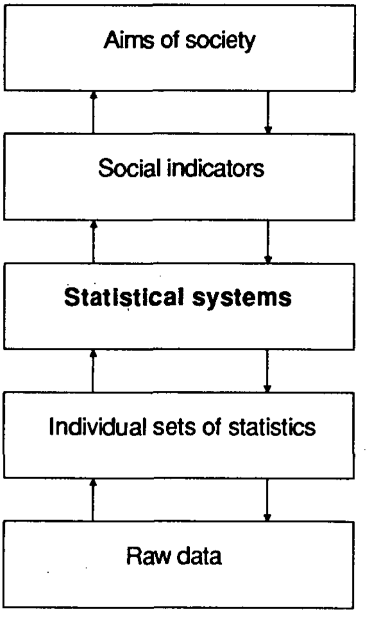
The environment can be regarded in connection with natural resource accounting as a cover term for the physical reality in which natural resources are used to obtain certain benefits (cf. dimensions of the environment, p. 15). The use of the term 'environment' in the classification of natural resources will be discussed in the context of natural resource accounting in chapter 7.

6.2. Natural resource accounting in a system of national statistics

6.2.1. Statistical systems

Statistical systems are employed to consolidate sets of statistical material and statistics of various kinds and gather them together into a consistent framework (Laihonen 1973: 10; Kolttola et al. 1988: 10). Once compiled, this information can be further refined to form indicators of social conditions or welfare, the aim of which is to condense as wide a range of information on human wellbeing and aspirations as possible into a small number of indices (Laihonen 1973: 10).

Figure 12. A system of statistical information for a society (Laihonen 1973: 10).



That part of reality that is of human relevance can be divided into three aspects at the level of statistical systems (Laihonen 1973: 11-12). These aspects and the statistic-al systems recommended for them by the United Nations are presented in Table 3.

Table 3. Statistical systems and the aspects of reality which they describe.

System of National Accounts (SNA)	Economy 1)
Framework for Social and Demographic Statistics (FSDS)	People as individuals and inter-personal social relations
Framework for the Development of Environmental Statistics (FDES)	Physical environment, natural and constructed

1) This differs in part from the definitions of economy given on page 15. SNA describes only activity taking place in a market context and measurable in monetary terms

<u>The System of National Accounts</u> is the oldest and best developed of these, being based for the most part on the Keynesian economic theory of the 1930's. It is in use in all the countries with a market economy, following United Nations accounting recommendations dating from 1968.

The System of National Accounts is a consistent framework for accounting which aims at describing a national market economy in terms of

- production of commodities (goods and services) and their use
- incomes and their use
- composition of wealth and its financing
- economic dealings with other countries

The description is framed in terms of monetary units, and comprises functional accounting, covering the production of commodities and the demand for these, and institutional accounting, covering incomes, their use and the composition of wealth.

Information from the functional commodity accounts and production accounts is combined in the form of input-output tables which describe the use made of commodity supplies, i.e. the sum of production and imports, as intermediate and final products of the various sectors (Sourama et al. 1980: 3, 6, 9).

Figure 13. Structure of a simplified input-output table.

Outputs / Inputs	Sector of economy			Demand for final product	Total outputs
Sector 1					
Sector 2					
Sector 3					
Value added					
Total					

The principal indicator used in the system of national accounts and international comparison is the gross national product (GNP), i.e. the total value of goods and services produced within the economy of the nation in a given year (see Samuelson & Nordhaus 1986: 4).

The Framework for the Development of Environmental Statistics applies to the natural environment and the man-made, constructed environment and the influence of human activities on these and on wellbeing. These statistics contain and gather together economic data on production units, ecological data referring to geographical areas, data from measurement and monitoring stations and social and demographic data from individuals and households (Statistical Papers 1984: 4, 5).

This Framework supports the development, coordination and organization of a wide variety of environmental statistics by cataloguing environmental problems and defining the measurable factors associated with them,

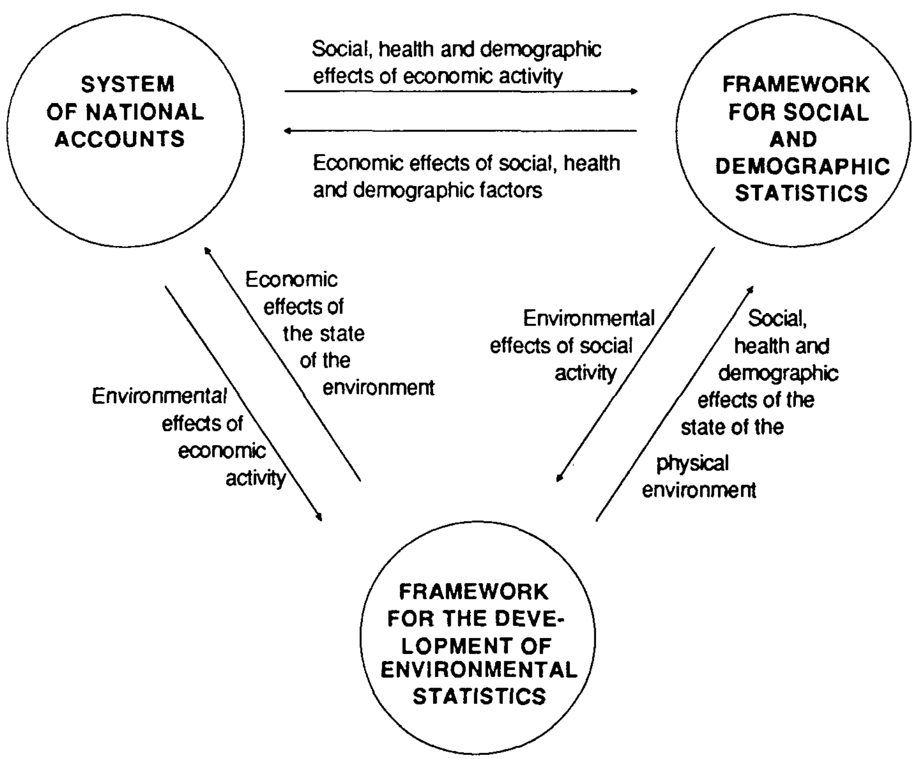
- by identifying variables which could be used to evaluate these factors,
- by analysing sources of information, needs for information and the accessibility of information, and
- by regulating the structure of databases, data systems and statistical publications (Statistical Papers 1984: 9; Kolttola et al. 1988: 11).

The focus of attention in the Framework for Social and Demographic Statistics is on describing the living conditions of families and individuals and inter-personal social relations. Objects of description include demographic characteristics of the population, education, the labour supply, health and public health services, leisure-time activities and services, housing, distribution of incomes, consumption and wealth, and social mobility.

The two last-mentioned statistical systems are commonly referred to as 'frameworks' and do not incorporate, even in the ideal case, the same notion of a systematic form of accounting as does the first. Work on developing the Framework for Social and Demographic Statistics began internationally in 1968 and that on the Framework for the Development of Environmental Statistics in 1973 (Kolttola et al. 1988: 11).

Factors connected with the aspects covered by the above three statistical systems can be combined by rendering the classifications and definitions compatible as far as related factors are concerned. The formal connections between the three systems are depicted in Figure 14 (Laihonen 1972: 17, 18).

Figure 14. Formal connections between the statistical systems (based on Laihonen 1973).



6.2.2. Natural resource accounting and its relation to other statistical systems

Natural resource accounting forms a framework for the organization of data concerning stocks, flows and state of natural resources and their integration with data contained in other statistical systems. It is particularly concerned with describing interactions between economic phenomena and the physical environment. Friend (1986: 6) regards it as forming a database for describing above all:

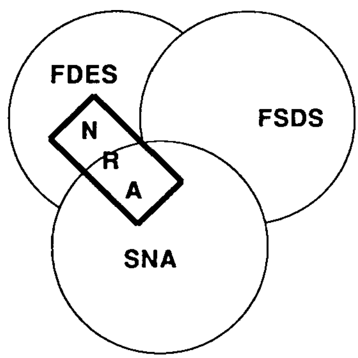
- stocks of natural resources,
- connections between natural resources and economic production,
- the significance of natural resources for economic development, and
- different sectors of natural resource use within a single framework.

The chief motivation for natural resource accounting arises from the limitations of the System of National Accounts for describing the relations between natural resources, the environment and the economy. The following drawbacks have been pointed out in the SNA:

- The SNA takes account only of those stocks and flows which come onto the markets. It does not include data on other stocks of natural resources, nor on many forms of services generated by the environment (Gilbert & Hafkamp 1986: 2).
- The economic value added in the course of production does not allow for depreciation due to the exhaustion of natural resources and the destruction or deterioration of the human living environment (Niitamo 1970: 184).
- The SNA does not identify separately functions that lead to the exhaustion of natural resources or reduce the services provided by the environment, nor functions that reduce dependence on natural resources or increase the benefits obtainable from the environment.
- The main emphasis is on economic growth, indicators of which are also used to measure social wellbeing. The long-term sustainability of growth and problems of the distribution of incomes are ignored (Gilbert & Hafkamp 1986: 2).
- The degree to which future generations are taken into account in production depends on the discounting method and the interest rates used (Friend 1986: 19).

The purpose of natural resource accounting is to complement the SNA, improve economic planning and add ecological and social resource use dimensions to the planning and decision making processes at various levels (Gilbert & Hafkamp 1986: 3). Natural resource accounting is more or less intermediate between the Framework for the Development of Environmental Statistics and the System of National Accounts in the overall scheme of statistical information systems in society, while still impinging on the Framework for Social and Demographic Statistics to some extent (Kolttola et al. 1988: 12).

Figure 15. Location of natural resource accounting in the field of statistical systems.



NRA = Natural Resource Accounting

6.3. Methods of natural resource accounting

6.3.1. Economic methods

Natural resource accounting involves the presentation of data on natural resources, the environment and their use in the form of accounts and balance-sheets. The approaches and methods used can be divided into those of an economic and a physical nature and combinations of these (Gilbert & Hafkamp 1986: 5).

The economic approach lays emphasis on the role of economic data, the SNA and its indicators in economic and political planning and decision making (Gilbert & James 1987), and its methods are concentrated on extension of the SNA and transformation of its indicators (Gilbert & Hafkamp 1986: 5). The aim of the latter is to enable the description of a more broadly defined social wellbeing as well as economic functions and to take account of detrimental effects on the environment and reductions in natural resources. Possible transformations that have been used include

- subtraction of pollution damage from the gross national product,
- an indicator of national welfare derived from the national income[8] and deterioration in the environment, and
- net national product[9] corrected by the extent of the reduction in natural capital.

An attempt is made to include the environment and its natural resources in the SNA in the form of a decreasing item of capital which serves to create incomes, a producer of services and a set of environmental hazards for the consumer arising on account of the use made of these resources (Gilbert & Hafkamp 1986: 5; Gilbert & James 1987).

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[8] The national income is the sum of wages earned in production plus the difference between indirect taxation and subventions.

[9] NNP = GNP - depreciation of instruments of product and capital (Samuelson & Nordhaus 1985: 114,115).

6.3.2. Physical methods

Physical methods describe stocks and flows of natural resources in terms of physical units, i.e. material and energy balances. This approach is based principally on the materials flow models of Robert Ayres and Allen Kneese, which Ayres later complemented with a description of energy flows.

Ayres, Kneese and D'Arge applied the law of the indestructibility of matter and energy, the First Law of Thermodynamics, to economic theory and national economies. This approach started out from the idea of the external effects on economic activity as a normal part of production and consumption, whereas they had usually been regarded in economic theory as exceptional cases (Ayres & Kneese 1969: 282; Kneese, Ayres & D'Arge 1972: 4, 5).

This approach was applied to the study of the connections between environmental pollution and the functioning of a national economy. In accordance with the materials flow model, the volume of emissions into the environment in a closed economy, in which there is no net accumulation formation of capital, must be equal to the sum of the raw materials, fuels and food used in production and the amount of oxygen extracted from the atmosphere (Kneese et al. 1972: 7,8).

Ayres further applied the law of increasing entropy[10], the Second Law of Thermodynamics, to the materials flow model and added descriptions of energy flows. Complex, multispecies systems in nature represent a low level of entropy in Ayres' view. The use of natural resources results in the emission of waste into the environment, which in the long term reduces the productivity and stability of the natural systems. This is compensated for by the use of energy derived from non-renewable natural resources. Technology enables the use of natural resources of progressively poorer quality and with progressively higher levels of entropy, so that the entropy of non-renewable resources increases constantly (Ayres 1978:44-49).

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[10] Entropy is a measure of the capacity of a system to perform work for the benefit of another system. The lower the entropy of a system, the more useful it is. The Second Law of Thermodynamics holds that the entropy always increases in a closed system (Ayres 1978: 44, 45).

Ayres looks on an economy from a materials and energy point of view as a system for the transformation of natural resources and raw materials which comprises four consecutive levels:

1. Transformation of natural resources into materials and energy
2. Transformation into material products and structures
3. Transformation into services
4. Transformation into utility and elements of human wellfare.

The first two of these levels are physical in character, and their products are not 'consumed' in any literal sense but recycled as alternative sources of materials or returned to the environment. Transformation into materials and energy takes place in processes in which the inputs are raw materials, labour, labour-saving capital investments (machines) and intermediate products (fuels, fertilizers, etc.). The inputs to the transformation processes at the second level are materials and forms of energy, labour, capital and intermediate products.

The material commodities and structures generated as products at this second level are then transformed into non-material services at the third, the other inputs being labour, capital investments and durable consumer goods. All the material inputs at the third level are converted into waste.

At the fourth level the services are transformed into abstract benefits and elements of human wellbeing. Maximization of the benefits can be achieved in principle by correct targeting of the costs arising from the obtaining of the consumers' incomes and eventual benefits. Since there are no markets for the eventual benefits as such, the costs have to be derived from the material commodities and services.

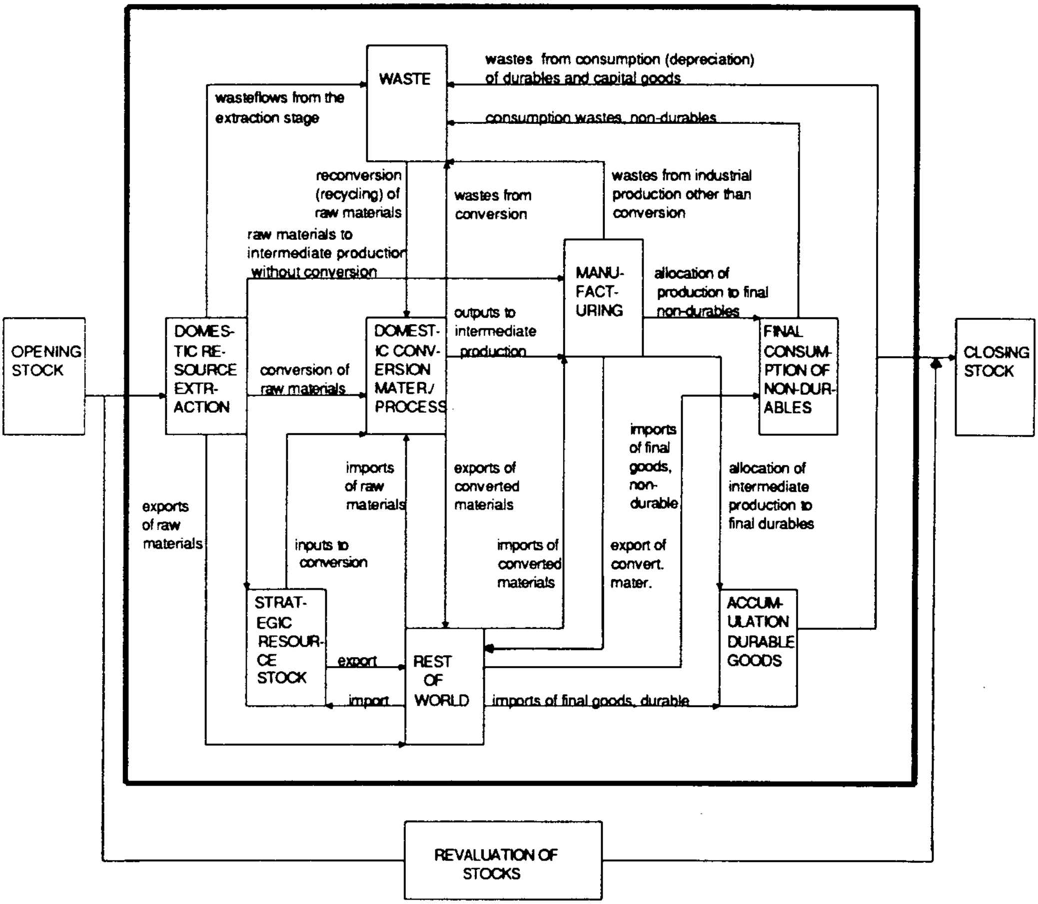
Numerous different combinations of inputs are available at each level of transformation, each of which may be sufficient but not essential for obtaining the output. Materials and energy are essential for the production of commodities and most services, but no single set of material/energy inputs is irreplaceable for the achievement of a given combination of services or level of benefits. The task of economics in the case of the physical transformation levels is to identify the optimal input combinations within limits laid down by the availability of raw materials, materials and energy and the relative prices of materials, energy, labour and capital (Ayres 1978: 67, 68).

Ayres' theory has been applied statistically in the form of the MEBSS[11], the point of departure for which is the preservation of materials and energy. This requires that all the material and energy inputs into the economies of the world and its nations should be accounted for in terms of outputs or changes in stocks, including durable consumer goods in current use and those held in store.

The crucial identity in accounting is the correspondence between flows and changes in stocks. Stocks are bodies of natural resources set aside on physical grounds or defined for accounting purposes and classified in terms of the rights of ownership over them, the production processes for which they are designated, etc. Flows are then quantitative reductions or increases in physical resources, changes from one physical form to another or transfers between accounting categories. Changes in stocks can be determined directly by cataloguing and measuring them or derived from the corresponding input-output flows by measurement and summation (Ayres 1978: 172).

[11] Materials/Energy Balance Statistical System (Ayres 1978).

Figure 16. Outlines of of the materials and energy method. Diagrammatic form. (Ayres 1978: 173).



6.3.3. Combinations of physical and economic methods

Existing natural resource accounting systems and those under development are based for the most part on the combination of physical data on material and energy balances with monetary data generated by SNA. Characteristic features of such combined methods are

- the description of natural processes and interactions by means of accounts constructed on physical principles,
- transformation of the SNA to give prominence to monetary flows connected with the maintenance of stocks of natural resources and their quality, and
- combination of the above by defining flows between the environment and the economy in physical and monetary terms (Gilbert & Hafkamp 1986: 7; Gilbert & James 1987).

The aims of these combinations is to avoid the difficulties associated with purely economic or physical methods. There are many subjective factors attached to the value placed on natural resources and the environment, and economic theories are inadequate for describing all the stocks and flows of resources and the services provided by the environment in economic terms. At the same time, purely physical information is of little use as a basis for economic or political decisions, nor is physical information even available regarding all the reserves and flows (Gilbert & Hafkamp 1986: 7).

In addition, the inclusion of all material and energy flows in one statistical information system is an extremely large task.Decisions on the natural resources and associated production processes for which statistics should be compiled need to be made on both economic and physical grounds (Ayres 1978: 186, 187).

7 NATURAL RESOURCE ACCOUNTING IN VARIOUS COUNTRIES

7.1. Finland

7.1.1. Point of departure and development to date

The development of natural resource accounting in Finland was commenced in the Natural Resources Council, a body affiliated to the Ministry of Agriculture and Forestry, in 1983. The arguments for the necessity of such a system included the lack of reliable data on natural resources, practical planning needs for the purposes of natural resources policy and the poor connections between those responsible for short-term and long-term natural resource planning. Attention was also drawn to the dearth of natural resource utilization policy at the national and regional levels and the sectoral nature of the policy that did exist (Natural Resources Council 1983).

At the same time, the change in the significance of nature conservation had meant that the focus of attention in the use of natural resources had shifted from the opportunities for their use to its effects. Data was required in particular on the environmental consequences of taking given reserves of natural resources into use and the implications for the utilization of other reserves, and also on resources which would end up as waste, outside the natural cycle, during manufacture and use.

Determination of the effects of the use of natural resources was regarded as calling for a monitoring of the balance of material and energy flows that was in the nature of an accounting process, even though not necessarily bound to monetary costs. One important feature of the system was regarded as being compatibility with assessments of the economy as a whole and other descriptions and statistics generated concerning the environment and its resources (Natural Resources Council 1983).

The basic idea behind the Finnish natural resources accounting system is that of extending the accounting used for the national economy to include a description of the physical quantities involved in the principal natural resource flows and reserves (Kolttola et al. 1988: 16). The main theoretical foundations are provided by the materials and energy method and economic input-output methods and models.

Natural resource accounting was developed in the Central Statistical Office chiefly on the basis of the Norwegian system. Preliminary research into the demand for natural resource accounting in society, the use that would be made of it and the methods to be employed was completed in 1988 and the report on energy accounting in 1989. The focus of attention at the present moment is on developing systems for forest, energy and land use accounting.

7.1.2. Objectives

The principal objective is to improve economic decision-making processes by associating with them certain goals regarding continuity which do not take account of market forces and pricing processes. These goals are in particular:

- economical and sustainable utilization of natural resources
- environmental protection
- self-sufficiency and material security
- regional equilibrium.

The purpose of the accounting system is to improve decision-making in both economic administration as such and also in questions connected with the environment and its resources. As a means of combining economic data with physical data on the environment and its resources, the aims of natural resource accounting are above all

1. to describe the natural resource base and the state of the environment in a consistent and standardized format,

2. to identify the key variables and relationships in resource and environmental management,

3. to monitor and summarize their trends and the presentation of this information via indicators,

4. to evaluate problems, preferably at a variety of spatial/management levels and

5. to serve as a basic set of data for higher-level activities such as simulation/optimization models (Kolttola et al. 1988: 25-32).

7.1.3. Structure of the accounts

Natural resource accounting is divided into two main systems:

1. materials and energy accounting, comprising
   - reserve accounting and
   - energy accounting, and

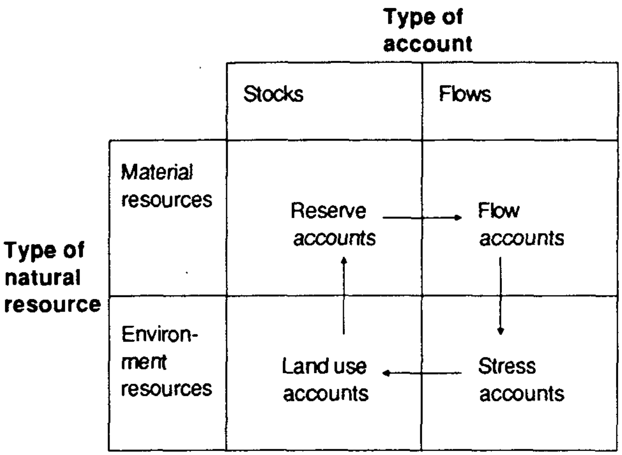
2. environmental accounting, comprising
   - land use accounting and
   - stress accounting.

This division is based on a classification of natural resources derived from the Norwegian model (see table 4), with a distinction made between assessments in terms of stocks and flows. Materials and energy accounting describes the stocks of material resources and the flows of materials and energy from nature into the economy and within economic processes. Environmental accounting is then responsible for examining conditionally renewable natural resources whose value is dependent on the state and quality of the environment. The salient feature of the latter is geographical investigation and the spatial description of natural resources (Kolttola et al. 1988: 35-46).

Table 4. Classification of natural resources (Ressursregnskap 1981: 23).

ECONOMIC CLASSIFICATION	PHYSICAL CLASSIFICATION	PHYSICAL PROPERTIES
Material resources	Mineral resources - elements - minerals - hydrocarbons - stone, gravel sand	Non-renewable
	Biotic resources - life on land - life in water - life in air	Conditionally renewable
	Inflowing resources - solar radiation - hydrologic cycle - wind - ocean currents	Renewable
Environment resources	State resources - soil - land (area) - water - air	Conditionally renewable

Figure 17. Divisions of natural resource accounting in Finland (Kolttola et al. 1988: 35).



Reserve accounts are mainly used to describe economically and technically exploitable natural resources, although they may also be used for reserves that could possibly be exploited or even those for which this is unlikely. Reserves are divided into those which are available for immediate use[12] and those which are not, in order to obtain an impression of the degree of freedom obtaining within the exploitation of these resources now and in the future (Kolttola et al. 1988: 40-42).

Table 5. Items included in reserve accounting (Kolttola et al. 1988: 42).

1. Undeveloped reserves - beginning of the year
2. +/- Revaluation
3. + Discoveries
4. - Development

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5. Undeveloped reserves - end of the year

6. Developed reserves - beginning of the year
7. +/- Revaluation
8. + Development
9. - Extraction

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10. Developed reserves - end of the year

11. (5+10) Total reserves - end of the year

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[12] A reserve is available for use when the majority of the basic investment needed has been carried out and work on exploiting it has commenced.

Flow accounting consists of the monitoring of flows of materials and energy through the exploitation and transformation phases until they are taken into use in industry, for domestic purposes or for export. The classifications into commodity groups and branches of industry follow almost without exception those used in the system of national accounts, the principal difference being in the measurement units used, which are physical instead of monetary, i.e. tonnes, litres, joules, etc.

This flow accounting serves to expand the economic input-output method to provide a means of analysing the interaction between the economy and its physical environment. This can happen in a variety of ways in practice, e.g. by employing an ecological input-output model in which the monetary model is complemented with matrices representing raw material inputs and waste outputs. The model may then be used to calculate the raw material input required to satisfy a given demand for the eventual product and the resulting waste yield with all their multiplier effects[13].

The ecological input-output model is concerned with examining only the raw material inputs into the economy and the outputs in the form of waste, but it may also be filled out with descriptions of transfers and transformations of materials and energy within the economy (Kolttola et al. 1988: 43-45).

The techniques of reserve and flow accounting have been applied to the production of wood material and energy accounts. The former depict the total biomass stocks held in the form of standing timber and the biomass flows within the economic processes that use this raw material, namely

- extraction, i.e. harvesting of the timber from the forest,
- mechanical and chemical transformation in the wood-processing industry,
- use in other branches and as final products,
- deposition, i.e. removal of various residues into the environment, either directly or after treatment, or their recycling.

The common unit of measurement for these wood material accounts is the dry weight tonne, although other typical measures suitable in individual branches of the accounts are used. The data are gathered principally from the results of the national forest inventories, investigations into wood utilization and total drain, industrial statistics, foreign trade statistics, waste disposal statistics and the

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[13] For more details on the ecological input-output model, see Pulliainen 1979b: 9-10.

national economic accounting system (Kolttola et al. 1988: 59-65).

The assessment of energy and its utilization in the context of energy accounting takes place at three levels:

1. Energy type: energy as a product definable by its physical properties and economic value.

2. Energy functions: changes in the properties and value of energy as a consequence of physical and technical operations.

3. Economic functions: energy as an object of economic exchange, involving alterations in rights of ownership over it, possession of it and its economic value while its physical properties remain the same.

Energy accounting includes assessments of the amounts of energy handled by those economic units responsible for generating and/or using it, its value and total supplies by type of energy. The principal sources of information for this are energy statistics, industrial statistics, enterprises, organizations representing the various branches of industry, household enquiries and statistics and research reports describing the public sector (Niemi & Väisänen 1989: 29-39).

Land use accounting is a data management system which produces information mainly on

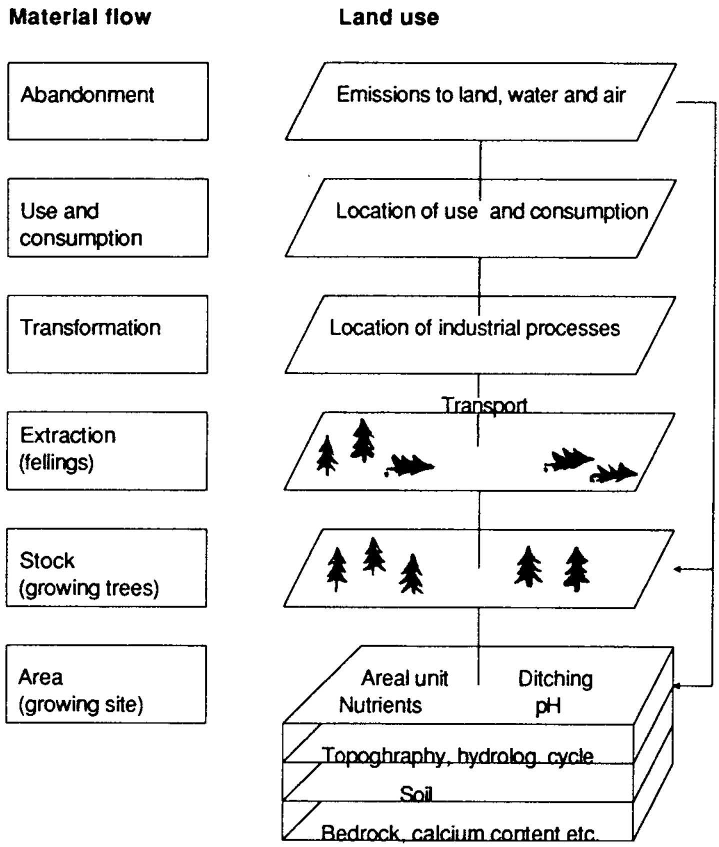
- the present, future and possible use of land
- changes in the use made of land, and
- the state of land as recipients of waste and effluents.

The significance of a land as a natural resource is derived from its physical geography and location factors. The purposes of land use accounting as one element in natural resource accounting are

- to describe land areas as multidimensional natural resources and monitor their utilization, and
- to determine location factors for estimating the usability and value of natural resources.

A consistent frame of reference is obtained by assigning the data used in materials and energy accounting to land areas and making allowances for the interaction of material flows with the state of the environment.

Figure 18. Land use accounting in relation to natural resource accounting. The example shows connections with wood material use and material flows (Kolttola et al. 1988: 89).



The methods available for land use accounting include integration techniques and point sampling. The integration method links the geographical properties of areas to their current and future land use characteristics by means of location data, while point sampling can be employed to record the use being made of land areas, the relative extents of land use categories and the statistical processing of areal data. The main data sources are maps, remote sensing surveys, registers, various censuses and sampling methods (Kolttola et al. 1988: 72-83; Tammilehto-Luode 1988).

<u>Stress accounting</u> assesses the environment as an element in material and energy flows from households and industry. This is largely a matter of flow accounting, but with the added dimension of monitoring the affects of loading on natural reserves.

The province of stress accounting includes waste and pollution which is not re-used by the households or industries. Stress can also impinge on non-material values such as landscapes. The chief source of data consists of industrial and household waste statistics (Kolttola et al. 1988:47).

7.1.4. Directions for future development

The aim of the development work is to be able to commence the production of regular accounts and construct descriptions of the structures of the principal resource sectors at approximately five-year intervals. In the case of the wood material and energy accounts referred to above it is intended to publish statistics for the period 1980-1990, and to add greater depth to these pioneer sectors by increasing the degree of areal detail and gradually to extend the accounting to new sectors.

The methods employed for land use accounting will be developed by studying the compatibility and practicability of cartographical, remote sensing and register data as basic sources. At the same time it is hoped to promote the use of the accounting data for planning and administration purposes by making test calculations for a small number of experimental areas. The possibilities for using digital mode data files will be explored, especially with nation-wide needs in mind.

In addition to the above, test calculations and feasibility studies will be carried out with a view to constructing systems of water and extractable earth resource accounting, developing the waste statistics into a comparable waste account and establishing connections between natural resource accounting and the various sets of environmental statistics.

The present project for developing natural resource accounting will be continued, with the participation of some of the principal users of CSO data in its organization. The principal collaborators to date have been the Ministry of Environment, Ministry of Commerce and Industry, Forest Research Institute, National Board of Survey and National Board of Waters and the Environment. Participation at the international level takes place mostly through the UN and OECD (Kolttola et al. 1988: 84-87).

7.2. Norway

Starting points and development to date

- to meet the needs of environmental administration
- to remedy deficiencies in the SNA
- to combine physical and financial data on material and energy flows
- to describe natural resources of economic and political importance

- development commenced in the Ministry of the Environment in 1974
- regular production of statistics by the Statistical Office

Objectives

- to support economic and social planning
- to produce annual reports on the principal natural resources and the state of the environment
- to produce plans and programmes for the use and conservation of natural resources
- to provide a statistical system to complement the SNA

Structure of the accounts

1. Reserve Accounts
   - reserves in physical units
2. Extraction, Conversion and Trade Accounts
   - by branch of industry
3. Consumption Accounts
   - domestic consumption in physical units, connections with the SNA
4. Land Use Accounts
5. Emissions into the Air

Use of the statistics

- annual reports
- compendia of environmental statistics
- analyses and forecasts
- natural resource budget

Experiences

- Energy accounts have proved useful for the purposes of energy policy.
- Forecasting of emissions into the air has been successful.
- Land use and water accounting are complicated by the extent of the area involved and the high costs of surveying.
- Little use is made of many reserve accounts.
- There is a lack of cooperation between officials in different fields.
- There is a lack of experts with a multisectorial background.
- Little use is made of the accounts for forecasting and preventing damage to the environment.
- Problems occur in the use of the accounts at the regional level.

Focus of future development

- environmental effects
- environmental space reserves
- responsibility for sectoral administration
- importance of local and regional levels
- international aspects

Sources: Alfsen et al. 1987, Lone 1987b,
Naturressurser og miljö 1982-1987.

7.3. France

Starting points and development to date

- linking of data on natural resources with economic development
- dispersed nature of data on natural resources and their unsuitability for the needs of various planning systems
- criticism of the SNA
- description of the principal natural resources
- economic, ecological and socio-cultural dimensions of natural resources

- development begun in 1978
- experimental accounts kept in the Ministry for the Environment and the Statistical Office.

Objectives

- a consistent framework for describing relations between man and nature
- estimates of reserves, services provided by nature and the effects of exploitation
- complementation of the SNA and social statistics with ecological accounts

Structure of the accounts

1. Central Accounts
   - reserves and their changes in physical units
2. Peripheral Accounts
   - relations between resources and with human activity
3. Agent Accounts
   - flows from natural resources into the economy in physical units
   - financial costs of maintaining, supervising and developing natural resources.

Use of the statistics

- one part of an environmental data system
- an instrument for "bargaining and discussion" between economic, ecological and social functions of natural resources

Experiences

- Concentration on the most important natural resources has speeded up the development work
- Potential users have been enlisted for the development work to introduce practical expertise and initiative into the research
- There is disagreement over the use of market prices, discounting and alternative costs

Focus of future development

- shift of emphasis from individual resources to ecosystems and regions
- estimation of reserves, effects of their use, and services provided by the natural environment

Sources: Corniere 1986, Les comptes du patrimoine naturel 1986, Lone 1987b, Theys 1984.

7.4. The Netherlands

Starting points and development to date

- drawbacks in the SNA as an instrument for planning
- complementation of economic planning
- regional interests
- national and international levels

- development project established at the Free University of Amsterdam as part of the European system for the modelling of renewable natural resources

Objectives

- analysis of renewable natural resources at the level of the whole European Community
- long-term forecasting
- identification of cause and effect relations
- feasibility studies of strategies and political measures

Structure of the accounts

1. Stock Accounts
   - stocks and flows in the environment, in physical units
   - quantitative and qualitative changes as a result of various cause and effect relations
2. Socio-economic Accounts
   - stocks and flows in the economy, in monetary units
   - classification by branches of industry according to the SNA
   - relations between population and the environment
3. User Accounts
   - stocks and flows in the economic/environment interface
   - physical and monetary units

Use of the statistics

- as a databank
- coordination of data acquisition and definition of data requirements
- interpretation by the user. Distribution of the system allows data to be obtained according to the user's needs.

Experiences

- Economic, socio-economic and ecological data are collected at different intervals, and this complicates comparison between countries.

Focus of future development

- regional and local levels
- on-renewable natural resources
- the value of the accounts as an instrument of natural resource policy

Sources: Gilbert and James 1987, Gilbert and Hafkamp 1986.

7.5. Canada

Starting points and development to date

- deficiencies in the SNA
- the thermodynamic model

- a preliminary model
- recommendations for further development

Objectives

- identification of the variables necessary for assessing economic and ecological sustainability
- a framework for organizing data on reserves and flows
- compatibility with socio-economic statistics at the national and regional levels

Structure of the accounts

1. Stock Accounts
   - quantities and areal distribution
2. Accretion and Depletion Accounts
   - alterations in stocks
3. Resource Status Accounts
   - use of natural resources and effects on the environment
   - environmental stress-response indicators
4. Sector Accounts
   - flows in various branches of the economy, in physical and monetary units
   - extensions of the input-output model

Use of the statistics

- as a planning instrument for achieving economic and ecological development
- in conjunction with the SNA and environmental statistics

Directions of development

- based on existing natural resource data
- periodic reports on selected natural resources and indicators
- assignment of monetary values

Source: Friend 1986.

7.6. Australia

Starting points and development to date

- nature conservation
- examples from international organizations

- preliminary investigations
- recommendations for further development

Objectives

- to broaden the outlook on the use of natural resources
- to provide an instrument for sustainable economic development

Use of the statistics

- for measuring economic development

Directions of development

- to point out opportunities for using such forms of accounting
- regional input-output assessments

Sources: Gilbert and James 1987, James 1987, Repetto 1987.

7.7. International organizations

Starting points and development to date

- OECD: the need to ensure environmentally and economically sustainable development
- UN and WB: economic and environmental problems in developing countries
- Nordic Council: similarities between the Nordic Countries in their environmental problems and resource base

- OECD: experimental accounts
- UN: recommended measures for developing countries and experimental accounts
- Nordic Council: recommendations

Objectives

- OECD: see Norway
- UN: environmental data systems for the developing countries based on the Norwegian and French models
- Nordic Council: a common database and set of methods for solving environmental problems for all the Nordic Countries

Sources: Proposed project... 1987, Theys 1985, Vogt 1987.

8. NATURAL RESOURCE ACCOUNTING AS A MEANS OF MONITORING SUSTAINABLE DEVELOPMENT

8.1. Economically and ecologically sustainable development

The starting points, objectives and methods of natural resource accounting correspond in most essential respects to the data requirements imposed by the description of the economic and ecological dimensions of sustainable development. Information generated by natural resource accounting can be used

- to demonstrate interactions between economic and ecological sustainability factors
- to promote the understanding of sustainable development as a multidimensional process of change involving numerous factors and the relations between them
- to evaluate trends in economic and ecological development on the basis of flows and stocks of natural resources, and
- to evaluate the benefits and drawbacks attached to the use of natural resources and their effects on human wellfare in future.

The weight attached to the economic and ecological factors involved in sustainable development in the context of natural resource planning arises from the theoretical starting points and principles, in which the laws of thermodynamics are applied to Keynesian economic theories and functional models for a national economy and natural resource accounting is developed as a new framework for the compilation of economic and environmental statistics in particular. It does not suffice to generate clear, unambiguous indicators of development and wellbeing, however, but simply provides data to serve as a basis for assessing economic and ecological trends.

The possibilities for employing natural resource accounting as a means of monitoring sustainability in the long term depend on whether it is weighted towards economic or ecological considerations. An economic weighting may reduce the time-scale, as economic planning and decision making are traditionally concentrated in the short or medium term.

The focus of attention as far as the further development of natural resource accounting is concerned is on the description of those reserves and flows which are of importance for the economy at the present moment, and it is by reference to these that a case is usually made out for the usefulness and necessity of such an accounting system alongside existing bodies of economic data. These accounts can also be used to demonstrate how the use made of natural resources can affect the scope of the nation's economy in the future, through changes in reserves, pollution of the environment and the increasing costs of eliminating the effects of this pollution.

Ecological sustainability can be emphasized by setting long-term quantitative and qualitative objects for natural resources and the environment. The data and indicators produced by natural resource accounting can be used to predict the limits likely to be imposed by ecological sustainability on economic activities aimed at achieving the stated objects, and also to plan and compare various means of achieving the objects with alternative combinations of material, labour and capital inputs.

8.2. Sustainable development at the international, national and regional levels

Although natural resource accounting is concerned mainly on the national use of such resources, it can also be applied in a supranational context and at the regional and local levels. These regional and local surveys in fact provide a link between the stock and flow accounts and the land use accounts and allow particular regional and local features to be taken into consideration more easily when evaluating trends.

The need for international accounting is underlined by such environmental features as the long-distance transport of air-borne particles and pollution of the seas. The availability of comparable data on the situation in different countries may help to clarify international cause and effect relations existing in economic activities and environmental impacts. Natural resource accounting enables data on emissions, transport and deposition to be combined with information on the economic functions leading to such emissions, the benefits produced by these functions, the effects of reductions in emissions and changes in the quality of the environment.

8.3. Opportunities for extending the scope of natural resource accounting

Although a combination of material and energy balances and monetary data on these may provide a broader view of the development taking place in society than a system of national accounts (SNA), even combined data of this kind can only cover a limited range of factors affecting human wellbeing. The description of sustainable development in a manner which goes beyond its economic and ecological dimensions calls in addition for data on the social factors which affect the objectives laid down for these of natural resources, data which are contained in sets of social statistics.

Attempts should also be made to examine the information on economic activity and the physical environment generated by natural resource accounting in relation to that contained in the social statistics. A knowledge of the interactions between the use of natural resources and social, demographic and health factors concerning the population could also lead to a widening of the criteria for including natural resources in the accounting scheme, enabling accounting to be directed at those resources which are regarded as being of importance on either economic, ecological or social grounds.

Data from sets of social statistics can be combined with economic and ecological data when figures generated by natural resource accounting are being used as material for research, analysis, forecasting or modelling. When setting out to develop natural resource accounting further it will be worthwhile examining the social statistics and the indices derived from them from the sustainability point of view, in order to perceive what information is of most importance for long-term development, what could perhaps be used for describing sustainable development and what further elements could be introduced to complement natural resource accounting.

Many categories of information regarding economic activity and the environment could be re-interpreted and combined in order to describe factors affecting sustainable development. Facts such as the proportion of personal travel taking place by public transport, or the recycling of raw materials in relation to the use of non-renewable raw materials in different branches of industry could provide information on the sustainability of a society's current level of utilization of fuel and raw materials.

When describing long-term development, attempts are also made to include in the accounting system natural resources which are still increasing in importance or are likely to do so in coming generations.

'Prospective' natural resource accounting in Finland would allow one to study lake shores and river banks and factors affecting the use made of them. These shores are highly valuable in economic terms and make a significant contribution to human wellbeing by virtue of their recreational value. Information on the lengths of such shores, their quality, their value, their location, the use being made of them and the opportunities available for using them are necessary for both national and regional land use planning.

The lengths of lake shores and river banks available for use are not diminishing in a physical sense, but changes in the state of the environment, the increase in their use for recreational purposes and transfers of ownership affect the benefits extractable from them. The data produced by natural resource accounting enable the sustainability of the use of such shores to be assessed and can lead to an attempt to reduce activities likely to cause irreparable damage to them.

8.4. Natural resource accounting as an instrument for achieving sustainable development

Relatively little information is available to date on the use being made of natural resource accounting in the context of environmental and economic policy, although the emergence of the objective of sustainable development is likely to increase the demands placed upon it. The opportunities for utilizing and developing this form of accounting as an instrument in planning and decision making would seem to be largely dependent on the following factors:

1. Availability of source data

Large amounts of information are available for describing and evaluating sustainable development, but this information is usually widely dispersed, compiled and classified on variable principles, applicable to different periods of time and difficult to combine in a satisfactory manner. The system of natural resource accounting has already drawn attention to certain defects and overlaps in existing sets of statistics and raw data, but it should also attempt to

- interpret and combine sets of data from a broader viewpoint,
- persuade those responsible for collecting the data and compiling the statistics to minimize gaps and points of overlap.

2. Information produced by accounting

The whole cycle of natural resources as far as human use is concerned is visible only when data on existing stocks and flows have been combined with data on wastage and areal distribution. In addition, the estimation of future trends calls for time series of such data and figures for the duration of use of natural resources and the duration of influence of the waste generated.

All stages in the cycle are of importance for the assessment of long-term sustainable development, whereas concentration on reserves and the internal flows within production processes will lead instead to a description of short-term sustainable economic development.

3. Presentation of data

Materials and energy balance sheets and accounts are frequently difficult to understand and the interpretation of the aggregated data contained in them is laborious. Environmental resources are easier to describe on account of the problem-centred nature of the topics involved and the possibilities for cartographical presentation.

The use of these accounts as sources of information and the interest aroused by them can be increased by breaking the tables up to represent separate branches of industry, regions or periods of time, and their interpretation and use can be facilitated by concise explanations of the aims of the accounting process, what it sets out to describe, the theoretical background, the methods used, the need for further information and the sources of the data.

4. Data as material for further research

Various analyses, surveys, research papers, models and estimates of trends provide natural resource accounting data in a condensed form for the use of the general public, planners and administrators. Its use in the context of reports on the state of the environment can serve to strengthen attitudes and values which are favourable to the sustainability philosophy, guide consumption along compatible lines and promote the sparing use of natural resources for industrial production purposes.

Planners and administrators require concise, easily interpretable information in order to regulate the use of natural resources, in addition to which the accounting system can provide basic data on such matters as the effects of economic and administrative measures on natural resource stocks and flows.

The data can also be used to compare the use of different resources in terms of benefits, drawbacks and efficiency, e.g. in environmental impact assesment, cost-benefit analyses and input-output analyses.

The goal of conciseness does not imply commensurability among all natural resources and the effects of their use. The problems of measuring resources in physical quantities and qualitatively in monetary terms have not yet been resolved in any country engaged in developing a system of this kind. Data generated by natural resource accounting system may also be used to demonstrate that many of the benefits and draw-backs are of significance for development and human wellbeing regardless of whether a monetary value can be assigned to them.

5. Resources and organization

The facilities available for developing natural resource accounting are limited in every country by comparison with the goals set for the system, but certain means are available for making efficient use of those that do exist:

- concentration on a few natural resources and economic functions which are of greater importance
- involvement of the users of the accounts in planning the objectives of the work and developing the methods
- concentration by those responsible for the development work on theoretical foundations, establishment of accounting as a system, experimental accounts and methodological descriptions
- participation of the natural resources administration and user sectors in production of the accounts
- utilization of administrative, economic ecological and sociological research papers and reports on sustainable development and the long-term use of natural resources
- recognition of the data requirements of sustained development when developing other statistical systems.

The willingness of planning and decision-making bodies to make use of natural resource accounts, and their ability to do so, varies from one country to another. Detailed evaluation of the opportunities for doing so in a given country would require research into such bodies and the community objectives which govern their operation.

The use of natural resource accounting as a means of promoting affluence and the satisfaction of human needs now and in the future is dependent on the role assigned to sustainable development alongside other aspirations which society may entertain. Being a fairly flexible system, this accounting can be adapted to a wide variety of goals within society, but it can also be used to influence the order of priority in which these goals are placed, e.g. by generating information on the inevitable interaction relations existing between economic and ecological development factors. These interactions may be examined relative to socio-economic factors affecting development, whereupon the sustainability of this development may be evaluated as a product of its contributory ecological, economic and social elements.

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Sustainable development and natural resource accounting

Jukka Muukkonen

The study is concerned with the connections between sustainable development and the use of natural resources, and with means for describing these connections. A discussion of the concept of sustainable development and a review of ideas on the interrelations between it and natural resource use provide a backround for examining natural resource accounting.

The theoretical foundations of natural resource accounting are presented, along with the premises, objectives, methodologies and lines of development of the accounting systems in operation or under development in different countries.

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