JARI KAIVO-OJA

Analyses of Historical and Future Problems of Sustainable Development

Research Articles in Spatial Sustainability Analysis, Planning and Evaluation

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ACADEMIC DISSERTATION
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In Turku, September 12, 2004

Jari Kaivo-oja

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SUMMARY ARTICLE

Sustainability as spatial evaluation and planning challenge: developing new analysis tools

1. Research tasks and contributions of research

My statement of this thesis is that there are certain pre-conditions of sustainable development in regional development process. In my thesis I present empirical evidence that sustainable development process is not achieved automatically just relying on the existence of Environmental Kuznets Curve type of evolutionary process, but we need futures oriented evaluation and planning frameworks, which help us to evaluate whether local, regional and national societies are actually developing towards sustainability. In this thesis, three different kinds of scenario evaluation frameworks are presented. These kinds of evaluation frameworks help us to evaluate the true nature of societal and regional development processes.

Information society is seen as a specific case of ecological modernisation. However, in spite of this kind of general policy statement, we must analyse critically whether information society actually can be seen as a specific case of ecological modernization. In this thesis I show a lot of empirical evidence that de-linking of pollution from economic growth and dematerialisation are not necessary happening in the most developed post-industrial information societies. Another important statement of my thesis is that information society type of evolutionary development process does not guarantee that ecological modernization process happens automatically on the basis of modern information society infrastructures. This is one important conclusion of the thesis.

On the basis of these empirical results presented in this thesis, we can suggest that some kind of new governance and planning structures are needed in order to promote sustainability in the modern information societies. I propose that futures studies, which include trend analyses, scenario planning studies and weak signal analyses, provide useful tools for new governance and planning structures of sustainable development management.

Sustainable development is the catch phrase of the 1990s and starting century. Governments around the world, international institutions, national institutions, local governments and non-governmental organisations have different kind of interpretations of sustainability principles. "Sustainable development" is difficult to define - let alone implement. One key challenge of this thesis is to clarify the concept of sustainable development and provide new perspectives to sustainability discussion. There are many alternative interpretations of sustainable development and many interpretations are connected to political and social interests. For example, if we analyse the problems of sustainable development from global North-South perspective, different kinds issues are usually emphasised compared with a conventional Northern industrialised country perspective. Sustainable development needs to be understood as a social and political construct. The study of the operationalisation of sustainable development is always connected to specific views and theoretical assumptions (Baker, Kousis, Richardson and Young 1997, 1-2). In this article I do not present detailed analysis of different sustainability concepts because I have done it in longer survey article (Kaivo-oja 2003).

Actually there is an urgent need to develop new frameworks for sustainability evaluation. This thesis includes some new ideas and suggestions, as to what kinds of new frameworks could be used in spatial sustainability evaluation and planning. The most important contributions of this thesis are the development of new frameworks in sustainability evaluation. These new frameworks are developed in connection to:

- Advanced Sustainability Analysis (ASA) (articles 1, 8 and 9);
- Decomposition methodology of sustainability analysis (articles 1, 10, 11 and 12);
- Equity-Economic Growth-Environmental Stock -scenario framework (articles 1, 6, 7 and 13);
- Environmental Kuznets Curve evaluation framework (articles 1 and 13);
- Welfare-Environmental Stress-Economic Growth - Scenario evaluation framework (articles 1, 8 and 9); and
- Secure/Insecure-Developed/Underdeveloped -Scenario evaluation framework (articles 1 and 2).

All these evaluation frameworks can be used, when we analyse the critical policy question of, whether modern information societies can be transformed towards increasing sustainability. All these methodologies also help us to assess, whether the vision of sustainable information society is actually possible (articles 3, 4 and 5), when the transformation of our economies goes on. In this sense all the contributions of this thesis are complementary and constitute a logical academic research entity. Generally speaking, this thesis is a part of interplay between futures studies and regional studies. A lot of scientific effort has been made in order to form consistent scenarios and analyse critical trends that could lead us to a sustainable future. (See a survey of Greeuw et al 2000 and Malaska1995).

2. Evolutionary paths to sustainable development?

The basic ideas of this thesis are closely connected to ideas of evolutionary economics and especially to the ideas of the Austrian school of economics. Basic aim of futures oriented planning tools and evaluation frameworks is to promote ways, we can move towards a "good society" through evolution and planning designs. All methodologies and empirical evaluation tools presented in the thesis can be seen as tools for discovering a good society through evolution and design (see Vihanto 1994, 18-35). In a way this thesis focuses on "planning designs of sustainable societies", which in the best case can promote the emergence and evolution of more sustainable societies. According to my personal view, usually "planning designs of sustainable societies" are some kind of evaluation tools, which are connected to action oriented programmes and policies. In this regards the thesis is also connected to the tradition of evaluation research. Evaluation research is "the systematic application of social research procedures for assessing the conceptualisation, design, implementation, and utility of social intervention programs" (see e.g. Rossi and Freeman 1993, 5). In sustainability evaluations one must usually use some kinds of diagnostic procedures. This thesis provides new future oriented diagnostic procedures like new scenario frameworks and advanced sustainability evaluation tools. Diagnostic procedures are needed in order to find and design the right kinds of actions and policy programmes for promoting sustainable development.

These kinds of new methodologies provide us new ways of understanding complex spatial processes, which are actualised in different spaces and time frames. Actually, these tools enable us to assess, which kinds of spatial processes are more sustainable than others.

Environmental Kuznets hypothesis

The key problems of this thesis are related to the challenge of sustainable development in regional planning and sustainability analysis. Sustainable development is a general concept and there are many alternative ways to interpret it, some of which are discussed in this summary article. Basically, interpretations in this thesis concerning sustainable development are connected to two different kinds of scenario analysis frameworks and theories, which help us to make clarifications in relation to the concept of sustainable development. These frameworks can also be used as general evaluation frameworks of spatial policies. One possible scenario path related to the sustainability processes in so-called Environmental Kuznets Curve (EKC) path. Defenders of the standard paradigm of trade and economic growth have relied on sustainability evaluation that has come to be known as the Environmental Kuznets Curve (or EKC) principle, which asserts that environmental damage increases in early stages of growth, but diminishes once nationals reach higher levels of income (see e.g. Rothman and de Bruyn 1998, Borghesi 1999). One can on theoretical level also expect that the current development of information society or knowledge based economy could promote sustainable development. Scientific identification of EK curve could strengthen this kind of hypothesis of "sustainable information society". In this thesis, the EKC hypothesis is tested by direct material flow data of five industrial countries in the last article of the thesis "*The EKC hypothesis does not hold for direct material flows. An environmental Kuznets curve hypothesis tests for direct material flows in 5 industrial counties*" (The U.S., Japan, Germany, the Netherlands and Finland, see Seppälä, Haukioja and Kaivo-oja 2001).

The structure of economic growth is another important determinant of environmental degradation. Numerous scientific studies during the past three of four decades have established view that low-income countries depend primarily on agriculture and primary products. As development accelerates, manufacturing becomes a more important contributor to the gross domestic product (GDP), starting with light industries and moving to heavy industries including steel and cement. In this stage corresponding to middle income or newly industrializing countries (NICs), intensity of natural resource use increases to support the urban industrial centres and pollution level increases rapidly – especially where growth rates of GDP exceeding 5 percent per annum are commonplace. As countries move into the more mature, post-industrial phase of development like most EU-15 countries, the share of information technology and services is GDP rises, while industrial activity flattens out. Reductions in the intensity of raw material use and polluting emissions per unit of economic activity help to diminish the environmental burden. In this case so called Environmental Kuznets Curve hypothesis discussion is very relevant (Munasighe 2002, xxxi).

Empirical research in resource economics has found that for example metal use intensity (defined as metal consumption per unit GDP) can be described as a function of per capita income. This function varies among countries and materials, but its general shape follows an inverse U-shaped curve (Malenbaum 1978, Roberts 1996, Kaivo-oja 1999, Seppälä, Haukioja and Kaivo-oja 2002, Kaivo-oja 2002). Similar inverted U-shaped functions are also found for environmental stress, which is referred to as environmental Kuznets curve. The inverted U shape can be explained in terms of superposition of three different trends (van Vuuren, Strengers and de Vries 2002, 369, see Figure 1):

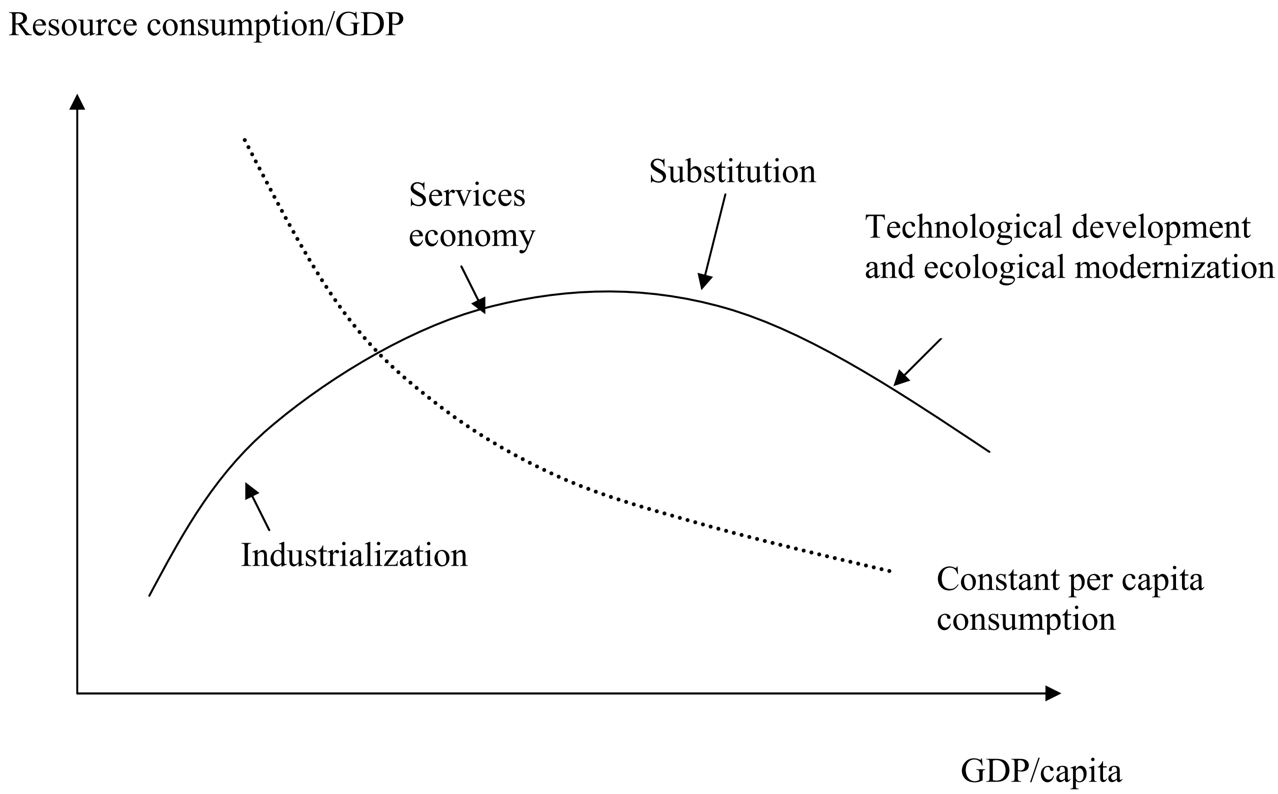

Figure 1. Intensity use hypothesis and economic development process (van Vuuren, Strengers and de Vries 2002, 369)

1. Intensity of use (IU): the changes in natural resource requirements in different phases of the economic transition from agriculture (low IU) to manufacturing and construction (high IU) and then to services (low IU) (Tilton 1986). For a wide range of countries, the size of different sectors has been found to correlate (at least partly) with per capita income (Maddison 1989). The shift to a higher share manufacturing and construction requires large material investments in building industrial infrastructures.
2. The changes in material type requirements as a result of substitution: the demand cycle of material generally follows a pattern, in which the first stage of rapid growth after introduction is followed by a stabilization phase and a final phase, in which the markets for the material become saturated. At the same time, cheaper or better materials might penetrate the market and replace the original material. The reversal of growth can be so complete that even per capita or absolute consumption levels may begin to decline.
3. The changes in material use requirements as a result of technological development, which lead to more efficient use in the production of final goods (dematerialization) or satisfaction of consumer functions (immaterialization).

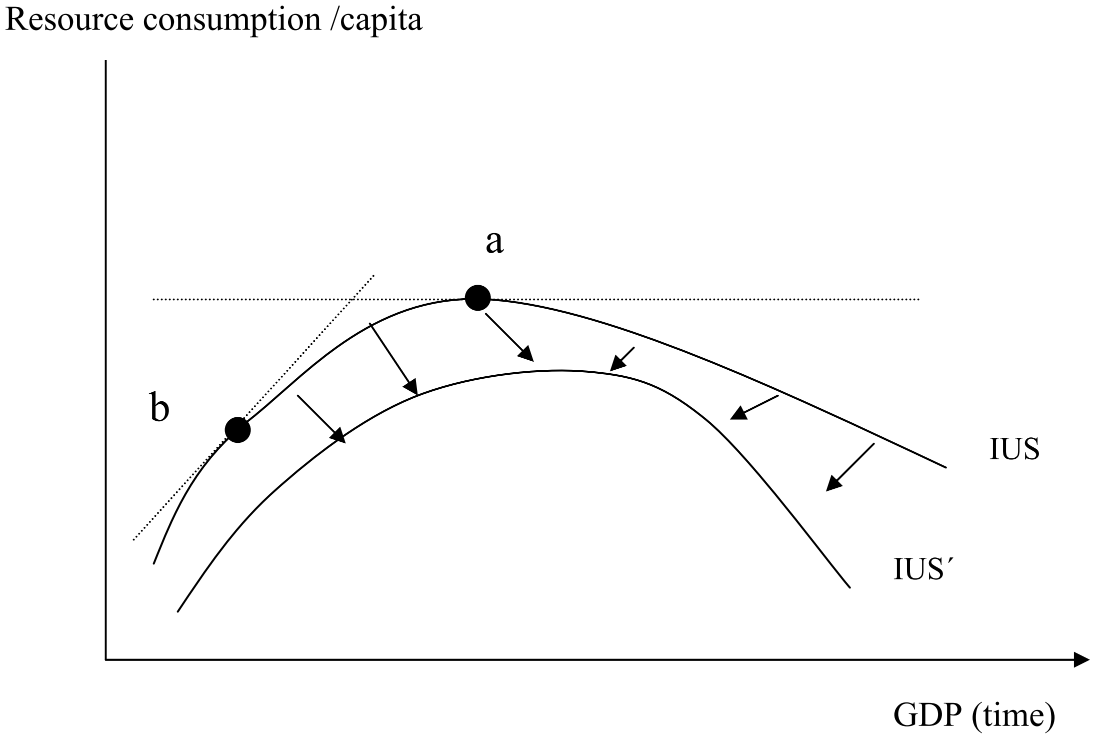

Figure 2. The "intensity of use" hypothesis and the influence of technological change

Explanations for the slackening of materials demand were formulated by Malenbaum (1978) as the intensity of use hypothesis (IU hypothesis). According to this IU hypothesis, the demand for materials is derived from the demand for final goods: from housing and automobiles to beer cans. Because raw material costs form only a small proportion of finished product cost, they have an insignificant influence on demand. Instead, income is the explanatory factor in materials consumption. Thus Malenbaum depicited the relationship between materials demand and income as an inverted U-shaped curve (IUS in Fig. 2 with the lower and higher turning points at b and at a). Technological change has the effect of shifting the relationship between materials demand and income downwards. The same economic value can be generated with less material input because of technological improvements in materials processing, product design and product development. Late developing countries flow a less materials-intensive development trajectory. The implication of Malenbaum's theory is that, in the long run, the growth in world materials consumption levels off and eventually starts to decline. This last stage is labelled to be "strong dematerialization", implying an absolute decrease in the consumption of materials (de Bruyn and Opschoor 1997, de Bruyn 2002, 212-213). Such dematerialization processes can be driven only by very strong economic forces. Some studies (Romm 1999) have concluded that e-commerce has the potential for significant dematerialization and decarbonisation of at least developed economies. However, this study have been heavily criticized (for example Lake 2000) and are, at a minimum, premature, because the Romm study overlooks the well-known phenomenon that microeconomic efficiencies tend to translate at the macroeconomic level into shifts in supply and demand curves that result in higher consumption, thus swamping any economy wide environmental efficiency (Grübler 1998). For example, new technological innovations of information and communication technology cannot be implemented so rapidly that is often expected by technical experts because of long planning time scales of basic infrastructure investments like transportation and tele-network investments (see e.g. Grübler 1990, 1996). Thus key question of information age is: will dematerialization continue in Western industrialised countries?

Figure 3 is stylised curve showing the relationship economic progress (GNP per capita) and environmental risk (e.g. CO_2 emissions per capita). This type of curve has been dubbed the environmental Kuznets curve or EKC. A typical industrial country is often expected be at the point C, while a representative developing country could be at the lower point B. Ideally, industrial countries (which have exceeded safe limits like many EU countries) should seek to increase their environmental protection efforts and follow a future growth path such as CE path in Figure 3. In ideal situation developing countries could learn from past experiences of the industrialized world by adopting measures that would permit them to “tunnel” through the peak – preferably below the safe limit beyond which at least some types of environmental damage (like climate change or biodiversity loss) could become irreversible. Thus, the high peak path ABCE in Figure 3 could be interpreted as the result of economic imperfections that make private decisions deviate from socially optimal ones. The adoption of right kind of corrective EU policies would help to reduce such divergences and permit movement through the safety tunnel BDE. However, it is not self-evident fact that different economies follow either ECK curve path or can be managed to “safety tunnel” scenario path. If this does not happen, more problem-oriented policies are needed (see detailed scenario analysis framework of Kaivo-oja (1999, 2002)

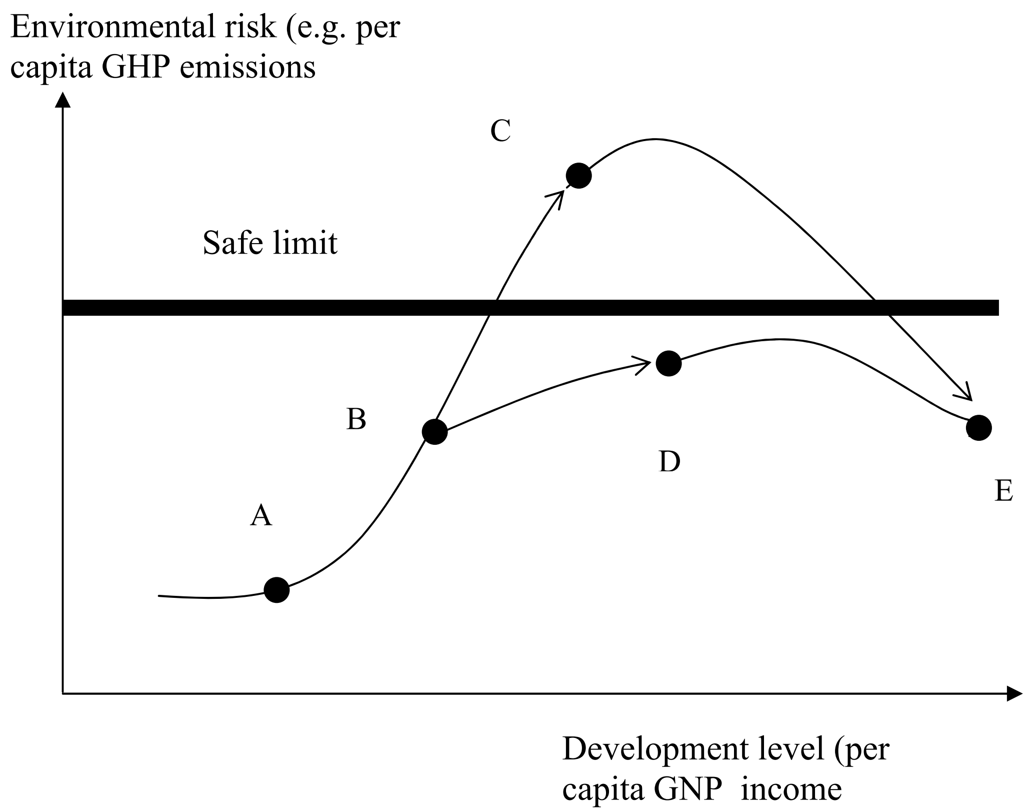

Figure 3. EKC hypothesis

This kind of corrective policies are needed both in the industrialised countries, but also globally in developing countries. The scientific discussion suggest that there are several actions that might help decision-makers in finding such a "safety tunnel" (Munasinghe 2002, xxxix):

1. Actively seeking "win-win" policies that simultaneously yield both economically, environmentally and socially sustainable paths – especially in the context of economy wide liberalization and market-based reforms.
2. Pre-empting excessive environmental and social harm through a variety of measures including ex-ante environmental and social assessment of projects and policies, promptly introducing remedies that eliminate imperfections (like policy distortions, market failures and institutional constraints) and strengthening the capacity for environmental regulation and enforcement of standards.
3. Critically examining the effects of growth-inducing economy wide policies, and considering the fine-tuning of such policies (e.g. altering their timing and sequencing) especially in cases where severe environmental and social damage could be anticipated.

On the basis of this hypothesis test we can conclude that sustainable development may not necessary happen automatically and EKC hypothesis is not universally valid (Seppälä, Haukioja and Kaivo-oja 2002). In this sense there is not need for uncritical optimism. This implies that that there is still need to develop planning systems and public and private sector governance systems, which help direct socio-economic processes towards sustainability.

De-linking and re-linking process

The conditions for weak de-linking, strong de-linking and re-linking define, in absolute terms, the relationship between environmental stress and economic growth during a certain time period. In the previous literature, de Bruyn and Opschoor (1997) have defined five stages of de-linking and re-linking (Figure 4). The whole process is usually called as N-shaped figure. If the last stage of re-linking (stage e in Figure 4) does not take place, one may speak about genuine inverted U-shaped curves or environmental Kuznets curves (Panayotou, 1993, Seppälä, Haukioja and Kaivo-oja, 2001).

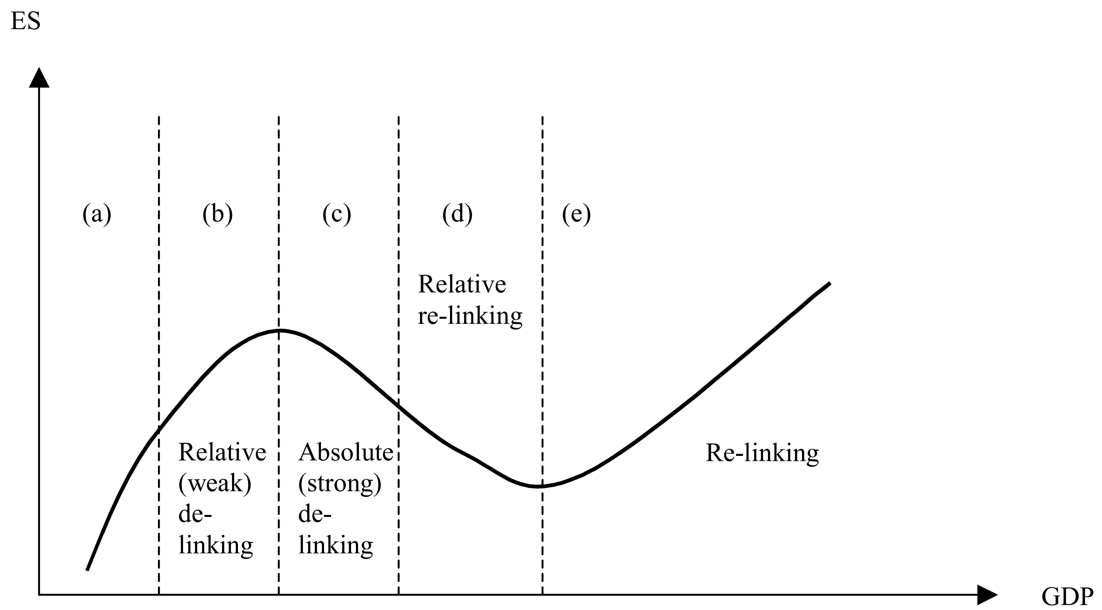

Figure 4. Five stages of the de-linking and re-linking process (de Bruyn, 2000, 64, modified by the authors).

The concept of de-linking embraces the dematerialization issue. De-linking refers to the process whereby aggregate economic activity gives rise to reduced environmental stress (ES). We can separate two forms of de-linking (or dematerialization in this case) in a growing economy: weak and strong de-linking. For de-linking to be called weak, the ES intensity must fall (see e.g. de Bruyn, 2000, 62). Hence, a sufficient condition for weak de-linking is (see Vehmas, Kaivo-oja and Luukkanen 2003):

$\Delta(ES/GDP) < 0$ (1)

Weak de-linking implies that the ES intensity decreases over time. However, environmental stress can still increase, albeit necessarily at a lower rate than the growth of the economy. For de-linking to be called strong, environmental stress must reduce over time. This strong de-linking rule implies that is (see Vehmas, Kaivo-oja and Luukkanen 2003)

$\Delta ES < 0$ (2)

Some supporters of economic growth have argued that such transformation processes are enhanced by economic growth, and hence ΔES is a non-positive function of ΔGDP. This idea has also been labeled as the "environmental Kuznets curve hypothesis" (see e.g. Grossman and Krueger, 1995 and Borghesi, 1999). This hypothesis states that economic growth endogenously or "automatically" reduces environmental stress through positive income elasticity for environmental goods, technological progress and shifts towards less environmentally intensive activities (service sectors). According to the EKC hypothesis after a certain level of GDP environmental stress starts to decrease.

There are still doubts as to whether the observed dematerialization or improvements in environmental efficiency can be extrapolated into the future. There may come a time, or income level, where weak or strong de-linking conditions do not hold simply because the possibilities for improving material and energy efficiencies may have a technological (thermodynamic) or economic upper limit. From that point onward, the economic growth component may become more dominant and ES and GDP will be re-linked, at least until further technical or social innovation breakthroughs in research and development. Such changes may be connected to information technology, energy technology, or other technologies and occur as more intensive applications of environmental policy instruments are implemented. This prediction is called the "re-linking hypothesis" (de Bruyn and Opschoor, 1997) and it can be defined as the empirical validation of a process in which ES intensity has been stabilized or starts to rise again, thus formally (see de Bruyn 2000, 61-64)

$\Delta (ES/GDP) \geq 0$ (3)

Re-linking implies that environmental stress increases with economic growth.

The de-linking and re-linking issue deals with change in GDP (ΔGDP), change in environmental stress (ΔES) and change in environmental intensity of the GDP (Δ (ES/GDP)). All these variables can be put in the coordinates of GDP and ES so that the horizontal axis represents GDP and the vertical axis represents environmental stress (ES). A constant relationship between ES and GDP can be marked as a straight line. On the basis of Figure 5, we can define the different degrees of the de-linking and re-linking process is (see Vehmas, Kaivo-oja and Luukkanen 2003).

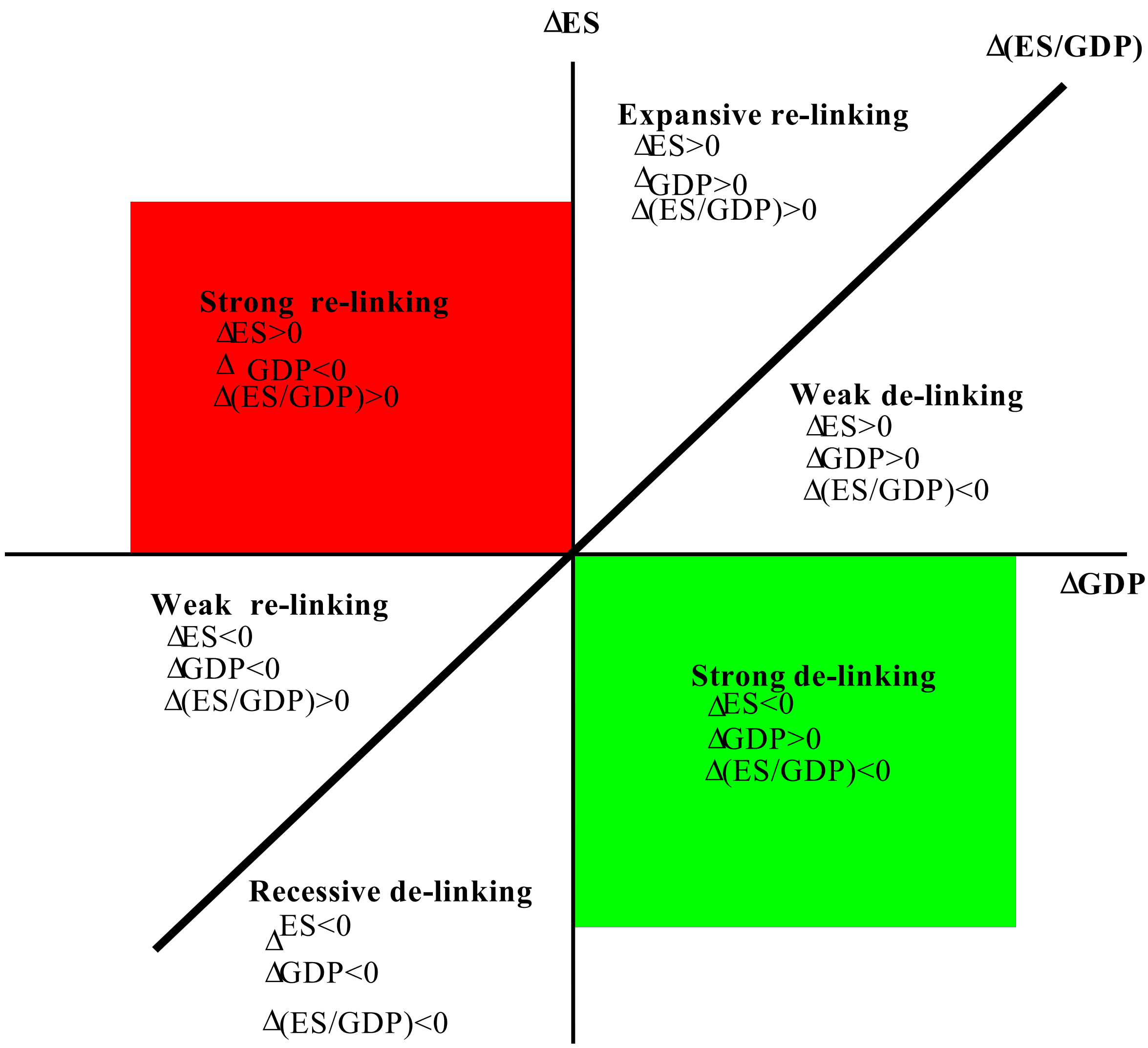

Figure 5. Definitions of the de-linking and re-linking concepts.

The area above the line (ΔES/GDP) in Figure 5 represents *re-linking* and the area below the line represents *de-linking*. For both de-linking and re-linking, three different degrees can be defined and conceptualised according to the directions of change in the three variables (GDP, ES and ES/GDP after a selected base year). (see Vehmas, Kaivo-oja and Luukkanen 2003)

The area where change in GDP is positive, change in ES is negative and the relationship ES/GDP decreases, can be defined as **strong de-linking**. In practice, strong de-linking means that economic growth is performed by more efficient technology with decreasing environmental stress. The area with positive changes in both GDP and ES but decreasing ES/GDP can be defined as **weak de-linking**, by following the rules by de Bruyn (2000). In practice, weak de-linking means that despite efficiency improvements, environmental stress increases within GDP growth. The third area of de-linking, where the values of all variables (GDP, ES and ES/GDP) are decreasing, can be defined as **recessive de-linking**. In this case, negative change in GDP causes also negative change in environmental stress, but also efficiency improvements take place at the same time. This is a new concept, because de Bruyn (2000) does not take into account a possibility for decreasing GDP. (Vehmas, Kaivo-oja and Luukkanen 2003)

The area above the ES/GDP line in Figure 5 represents re-linking, and three different degrees can be defined like in the case of de-linking. In relation to the analysis of de Bruyn (2000), three new concepts also emerge here. The area where the change of GDP is negative, change in environmental stress (ES) is positive and the relationship ES/GDP increases, can be defined as **strong re-linking**. Here environmental stress increases despite of negative economic growth, because of decreasing environmental efficiency (increasing environmental intensity). The area with negative changes in GDP and ES but an increase in the relationship ES/GDP, can be defined as **weak re-linking**. Here environmental stress decreases due to decreasing GDP, although environmental intensity increases like in all other re-linking areas. The third area, where changes both in GDP and ES are positive and the relationship ES/GDP increases, can be conceptualised as **expansive re-linking.** In practice, this case implies that economic growth is performed by more inefficient technology with increasing environmental stress. (Vehmas, Kaivo-oja and Luukkanen 2003)

Table 1 summarizes the above-presented degrees of de-linking and re-linking:

Table 1. Degrees of de-linking and re-linking environmental stress (ES) from economic growth. (GDP) is (Vehmas, Kaivo-oja and Luukkanen 2003)

Degrees of linking	**ΔGDP**	**ΔES**	**Δ (ES/GDP)**
Strong re-linking	<0	>0	>0
Weak re-linking	<0	<0	>0
Expansive re-linking	>0	>0	>0
Strong de-linking	>0	<0	<0
Weak de-linking	>0	>0	<0
Recessive de-linking	<0	<0	<0

It is obvious that the empirical results of de-linking and re-linking analysis gives different results depending on the chosen indicator of environmental stress – such as material flows, energy consumption, discharge emissions to air, water and soil, and wastes, etc. (see e.g. Vehmas, Kaivo-oja and Luukkanen 2003).

Sustainable information society

A central issue of this dissertation is the future challenge of sustainable information society. The information society topics and sustainability issues are discussed in three articles in this dissertation. Firstly, the eighth article "*Advanced sustainability analysis*" of the thesis provides a review of the most important sustainability issues in an "information society". These kinds of issues are also discussed in this introductory article. In the eighth article, it is postulated that a necessary condition, derivable from the definition of sustainable development is that the total environmental stress imposed by human activity should not increase in the sustainable information society. Three directions for sustainable development, which are important at the moment, are identified in the article: the dematerialization of production, the immaterialization of consumption combined with the elimination of the rebound effect, and of course, population management. These three concepts are often studied as separate problems, whilst they should be analysed as a complex entity. One example of this kind of research field is the immaterialization of consumption combined with the increasing welfare productivity of GDP and the reduction of rebound effects. In poor developing countries population policy analyses and policy actions are still very important for achieving sustainable development. However, this topic is not analysed in this thesis. The third article of the thesis "*Environment in an "information society: Transition stage towards sustainable development?"* provides one of the first academic theoretical discussions of the vision of sustainable information society. The main contribution of this paper is that it combines the literature of information society to the literature of sustainable development. In the fourth article the promises of the development of an information society in relation to the challenges of sustainable development are discussed widely. The fourth article of the thesis "*The ecological transparency of the information society"* deepens the discussion of article 3 and provides new perspectives to the on-going discussion of sustainable information society. A crucial contribution of this article is the new concept of ecological transparency of the information society. The idea of this paper is to give new insights into the discussion of sustainable information society, which can be seen as a specific case of ecological modernisation. In this theoretically oriented paper we conclude that a de-linking of pollution from economic growth and de-materialisation can probably be seen as the most important single characteristic of sustainable development.

On the basis of these two articles we can note information society can be seen as a necessary condition for sustainable society, but the realisation of modern information society does not necessary be sufficient condition for sustainable information society.

3. Conventional and new planning tools of sustainable development

3.1. Tools for promoting sustainable development

There are many evaluation tools available to promote spatial sustainable development such as; strategic EIA tools, environmental CBA tools, biodiversity monitoring tools, environmental accounting systems, etc. (see e.g. Wathern 1988, Lee and Wood, 1992, Kivisaari and Lovio 1996, Sadler 1998, Lovio 1999a, 1999b, European Commission 2001).

However, societies are increasingly confronted with complex issues. As a consequence, decision-makers and ordinary people are ever more struggling with complexity of society. The features of today's complexity are that (van Asselt and Rotmans 2001, 7):

- There is not one problem, but a tangled web of related problems (multi-problem).
- It lies across, or at the intersection of, many disciplines, i.e. it has an economic, environmental, socio-cultural and institutional/political dimension (multi-domain).
- The underlying processes interact on various scale levels (local, regional, national, continental and global) and on different temporal scales (multi-scale).
- Many different actors are involved (multi-actor).

Due to complexity, the role of scientific decision-support is undergoing a fundamental change: from "speaking-truth-to-power" to "mutual construction" and from giving answers to highlighting uncertainty, risk and robust strategies. Taking these features of complexity into account, it is clear that disciplinary approaches and classical decision-making fail to address complex issues adequately. Scientific breakthroughs are especially needed through synergy of disciplines (van Asselt and Rotmans 2001, 7). Futures studies and methodologies are always been building bridges between natural and social sciences, and between science and decision-making. That is the reason why I am in this thesis focusing on these kinds of futures studies methodologies, which can be utilised as a part of Integrated Assessment (IA) methodology (see e.g. Rotmans and van Asselt 1996, 1999, van Asselt, Rotmans and Greeuw 2001).

3.2. New tools for analysing spatial sustainability processes

In this thesis, my interest is to develop some new planning tools, which may even be more effective tools than the current tools for spatial planning processes, which seem in many cases neglect the features of complexity. I propose that futures studies can play an important role when we develop new adaptive feedback mechanisms for the actual needs of spatial evaluation and planning. When it comes to decision making in the field of sustainability, there is still a lack of useful decision aid methods. I also expect that it is easy to connect the use of futures oriented methods to quantitative and qualitative multi-criteria decision-making as well as to Integrated Assessment methodologies (see e.g. Omann 2000, Asselt, Rotmans and Greeuw 2001).

Sustainability is a key watchword for the new millennium, and a guiding theme for all human activity. It is a never-ending quest to have not only economic growth with social justice, but environmental protection into the bargain. Today, for the "developed" nations of the North, the race for affluence stretches their environmental limits while at the same time their social fabric is facing social fragmentation, unemployment problems, exclusion and social alienation. For the "developing" nations of the South the need for basic shelter and services is overwhelming, but "development" too often destroys their natural resource base. For the world in total, problems such as climate change and species loss are raising the stakes of economic development to the brink of catastrophe - and if current six billion people are to reach our Western levels of affluence, current trends cannot continue. Thus, a critical question in regional planning is; how can a global environmental agenda be incorporated into regional sustainability planning? The answer is holistic regeneration that ensures sustainable development, which inherently demands new forms of regional planning and managing regional activities. (see an example, Kaivo-oja, Luukkanen and Wilenius 2004).

In this introductory article I shall make a short review of the issue of sustainability in regional studies. Scientists from many disciplines seek to understand how places, landscapes, and ways of life come to be, are sustained, and are eventually transformed. Hence there exists the need for better integration between the fields of human geography, ecology and the new ecological economics (Zimmener 1994, Courteney and Hardwick 1995, Isard 1996, Isard 1997, Hinterberger, Luks and Schmidt-Beck 1997, Dryzek 1997, Meadowcroft, 2000). Obviously, multi-directional cross-fertilizations between social and natural sciences have been pursued before (see e.g. Hirschleifer 1977). Today those scientists are interested in futures and foresight studies, because it is almost impossible to analyse the problems of sustainability without having a futures perspective. The reason for the growing interest is that regional planning studies can utilise various futures studies methods as a part of their planning process. For example, Isard (1997, 291) postulates:

"*To me, to probe the future means to project space-time paths - space-time-paths of individuals, groups, species, organisations, institutions, communities, nations, cultures, societies, the international system - and even ecological systems, the planet, the "Milky Way", galaxy systems and the universe - to mention only some of the many units or aggregates one may consider*".

Isard's statement implies an extremely broad view of the discipline of geography or regional science. Regional science involves analysing the space-time paths of many units and aggregates. It also analyses the changing spatial distributions over time of these units and aggregates. Thus, aggregation is an elementary part of regional analysis and planning, a regional scientist cannot avoid the problem of aggregation, because regional units consist of various sub-units and entities. As Schelling has noted that human micro motives direct and re-direct macro-behaviour (Schelling 1978). This implies that regional science must analyse both micro-motives and macro-behaviour, because all behaviour in different regions is in a way macro-behaviour, which is based on micro-motives. Thus, geography has very important intersections with history, futures studies and embraces the dynamic analysis of changing regional systems and sub-systems. The socio-cultural evolution of different regions and places is always connected to some kind of futures oriented self-organisation process (see Boulding 1978, 1981, Jantsch 1980, Nelson and Winter 1982, 23-48, Courteney and Hardwick 1995, Mannermaa 1998). This suggests that a future oriented thinking by regional planners and citizens is always present in this type of intentional self-organisation processes. Generally, speaking human action cannot usually be explained causally by some scientific laws, but must be understood intentionally. The basic model of intentionality is the practical syllogism, which explains action by logical connection with wants and beliefs. (See e.g. von Wright 1971).

More complex cases can be analysed by poly-syllogisms, a series of syllogisms connected by the fact that the conclusion of one syllogism becomes a premise in another. For example, in scenario analysis, it is possible to analyse events and action by the logic of syllogisms. I think that basically rational choice theory, which is usually based on some kind of causality assumption, can yield predictions of events and actions, but not explanations, if the latter we mean some kind of causal story. This does not imply that rational-choice theory is useless in the context of regional planning and futures studies, because there are strong a priori grounds for assuming that people, by and large, behave rationally. Generally speaking, we all want to be rational, not irrational. We must assume that, by and large, people have consistent desires and beliefs and act consistently upon them, but in strict sense people are not rational. The alternative to this assumption is not total irrationality, which can only be predicted on a broad background of rationality, but chaos (see discussions in Elster 1986, 1-27, Elster 1996, Elster 2000).

Personally, I regard *all kinds of learning connected* to futures oriented decision-making as being very important to the spatial development processes. Futures oriented, or scenario learning can be seen as a selective trial and error search as Herbert Simon (1959) has postulated (see also Senge (1990), Fahey and Randall 1998). If a human agent is trying to solve a problem, the agent's attempts to do so are assumed to be informed "negatively" by past failures and forecast errors; and "positively" by successful attempts to solve similar problems. The latter gives direction to the agent's further attempts at problem solving. The satisfactory rules of thumb (or processes or routines) that the agent has developed serve as positive heuristics, they instruct the agent on how to tackle future problems. When a searching agent hits on a satisfactory 'solution' to the same problem, the agent will tend to try this solution again when faced with the same or a similar problem. Thus, according to Simon, learning or adaptation refers to the process of gradually (and on the basis of experience) responding more frequently with the choice that, in the past, has been most frequently rewarded Simon (1959, 271). This means that human learning works essentially via an adaptive feedback mechanism (Simon 1982, 3). This means that "good enough" solutions are looked for rather than optimal ones.

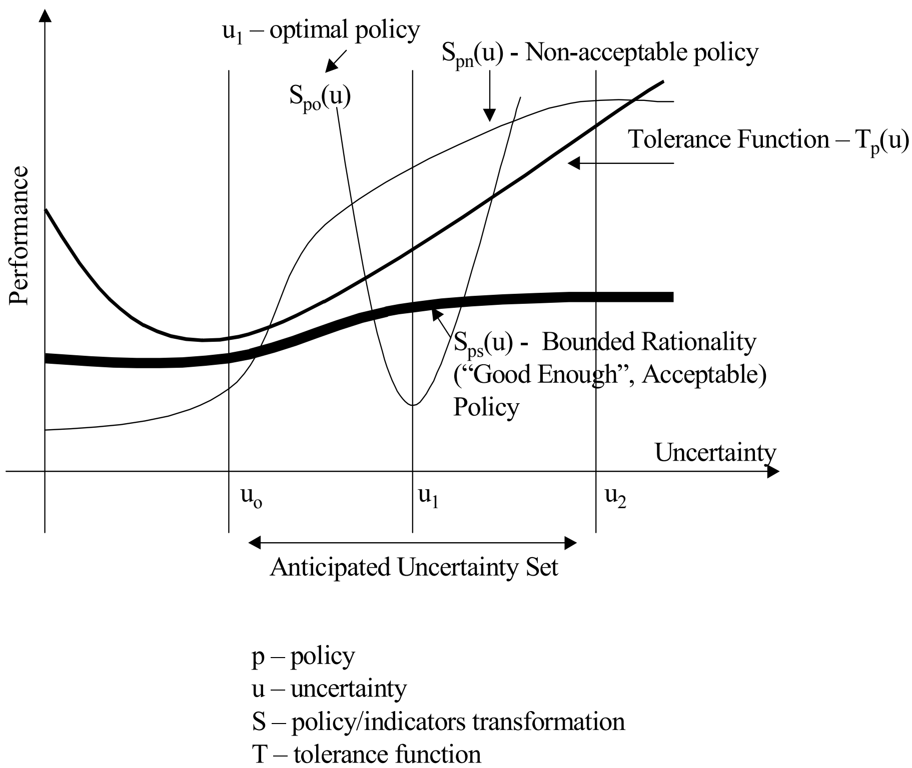

Figure 6. Bounded rationality principle (Mesarovic 2001b, 4)

The easiest way to explain the Bounded Rationality principle may be in terms of the graphs given in Figure 6 (Mesarovic 2001b, 6). The very basic idea of scenario analysis is to analyse real uncertainty problems like sustainable development issues. The uncertainty is represented on the horizontal axis while the performance indicator is on the vertical axis. The uncertainty ranges from u_o to u_2. A tolerance function, T_p, is provided that specifies the acceptable, tolerable, performance for any uncertainty in the range. Notice that the level of tolerance is not constant across the uncertainty range. For uncertainties that are more damaging, a lower performance could be accepted, while for less damaging outcomes a higher level of performance is required. The performance functions for the three decisions, p_s, p_n, and p_o, are indicated. The curve $S_{ps}(u)$ shows the performance of an acceptable decision, since $S_{ps}(u)$ is below the tolerance level, $T_p(u)$, for all u's. The decision, p_n, is not acceptable since it violates the tolerance for at least some uncertainty occurrences. The decision p_o is optimal for one of the uncertainties; i.e., u_1, but violates the limits if some other uncertainties come to pass. (Mesarovic 2001b, 6).

Thus actual behaviour falls short, in at least three ways, of objective rationality (see e.g. Simon 1997, 93-94):

(1) Rationality requires a complete knowledge and anticipation of the consequences that will follow on each choice. In fact, knowledge of consequences is always fragmentary.
(2) Since the consequences of decision-making lie in the future, imagination (or the use of futures studies) must supply the lack of experienced feeling in attaining value to them. But values can be only imperfectly anticipated.
(3) Rationality requires a choice among all possible alternative behaviours. In actual behaviour, only a very few of all these possible alternatives ever come to mind. Especially the emergence of surprising Wild Cards and the impacts of weak signals are difficult to forecast.

Today many authors emphasise *the importance of precautionary principle* in the context of sustainable decision-making. For example, many scholars think that the responsible scientific community cannot rule out the possibility of catastrophic outcomes that climate mitigation studies are proposing. For the enormously complex and serious problems that now face the world - global warming, loss of biodiversity, toxins in the environment - science doesn't have all the answers, and traditional risk assessment and management may not be up to the job, because all cause-and-effect relationships are not fully established scientifically. The class of problems for which the precautionary principle is advocated includes those in which both the level of fundamental uncertainty and the potential costs or stakes are high (see e.g. Hinterberger and Wegner 1997, Schneider 2002). The precautionary principle does indeed involve a highly normative judgement about the responsibility borne by present generations towards future generations.

In the tradition of regional science today, almost all scientists acknowledge that we are facing the serious challenge of sustainable development. One of the most problematic issues in regional studies is; how we can promote spatial learning processes, which will strengthen local, regional, national or even global level sustainability (Lee and Wood, 1992, Lovio 1999a, 1999b, European Commission 2001). This challenge implies that we must develop effective adaptive feedback mechanisms for the needs of spatial planning and implementation processes. Most contributions to this thesis can be seen as developments in adaptive feedback mechanisms for spatial planning. Adaptive feedback mechanisms are usually evaluation tools of spatial development, which are developed in this thesis. In thesis I propose that evaluation tools are important element of adaptive feedback mechanisms.

Decomposition analysis of sustainability trends

In energy studies, the main objective of decomposition analysis is to quantify various underlying factors that contribute to changes in energy and environmental indicators over time. Considering the intertemporal nature of global climate change and long lead times required for mitigation efforts, accurate trend analysis of carbon emissions is a primary issue of current policy discussion. Total levels of emissions of carbon dioxide as a by-product of energy consumption have been increasing during modern times. Emission levels, however, have not risen at the rate of increase of economic output. Reasons for changes in emission trends can be analysed by decomposition analyses. Contributions of this thesis aim at identifying the factors that have influenced changes in the level of CO_2 emissions.

Several decomposition methods have been proposed previously. Two methods that have most often appeared in the literature are the Laspeyres index method and the Divisia index method, which uses an arithmetic mean weight functions. Ang and Choi (1997) have pointed out two major problems in the application of these two methods. The first problem is the existence of a residual in the decomposition result. This residual is often large in the case of the Laspeyres index method. The second problem involves zero values in the data set. Computational problems may arise in the application of the Divisia index method with an arithmetic mean weight function when the data set contains zero values.

Decomposition analysis has widely been utilised in energy efficiency analysis in different countries. In the last two decades, numerous studies have been presented, where Divisia or Laspeyres (Paasche) indices are used for decomposing the change of energy consumption or energy intensity into factor contributions or decomposing the change of environmental pollution (CO_2 and others) into contributions generated by relevant factors. These decomposition models reveal the quantitative relationship between economic development and energy use, and the relationship between energy use and environmental pollution. They are the basic analytical tools of energy economics and energy policy. I do not discuss the analytical differences of different decomposition methods in detail because that has been done widely elsewhere (see e.g. Boyd, Hanson and Sterner 1988, Sun 1996, 1998, de Bruyn 2000, Ang and Zhang 2000).

Several methods have been developed for the decomposition analysis. In the Factor Isolation Method the activity effect is defined as the multiplication of the change in GDP and base year intensity. The sectoral intensity effect is defined as the multiplication of sectoral changes in energy intensities and the sectoral economic output of the end year. The structural shift effect is established when the summation of sectoral intensity effects and the activity effect are subtracted from the total change of energy consumption. In the Combination Method the basic idea is the same as in the Factor Isolation Method, but the Combination Method uses the average values of the quantities of the base and the end year. (see e.g. Sun 1996, 39-40).

The Laspeyres and Paasche Indices differ from each other only in their prospective and retrospective perspectives. The end year energy consumption is the multiplication of base year energy consumption, activity effect, sectoral intensity effect and structural shift effect. The Divisia Index method is adopted in many decomposition studies. The common feature of these approaches is that the Divisia Index uses a continuous time rather than the discrete time used in other index methods. The difference method and the Simple Index Method are also used in the decomposition calculations of energy studies. (see e.g. Sun 1996, 40-46).

Decomposition, or factorisation, can be carried out for quantities, which can be expressed mathematically in the form of multiplication by two or more variables. The variables under considerations form a time series and the first year of the time series is often chosen as the point at which the changes are compared. The models can be formulated either in absolute monetary and physical units or as indices. By means of decomposition the explanation of change compared to the base year situation is allocated to the additive effects of the explanatory factors. (Sun 1996, 47-53). One interest of this article is the limitations of several decomposition applications. A common problem of decomposition is the so-called residual term. In some studies the residual is just omitted, resulting in an approximate decomposition and an estimation error. In some other studies the residual is called an interaction term, which in turn causes a problem of interrelation for the reader.

An exact decomposition approach was developed and applied by Malaska and Sun (1995), Sun (1996, 1998) and Sun and Malaska (1998) in a world energy efficiency study with a zero residual and complete allocation. Here we do not present a comprehensive review of the topics because one can find them in the above-mentioned publications (see e.g. Sun 1996, de Bruyn 2000, Ang and Zhang 2000, Ang 2003). To reach a complete decomposition the principle "jointly created and equally distributed" for the allocation of the factor effects has been implemented; i.e. the residual has been divided equally to each factor contribution. In this way the models presented here reflect the economic system better and provide more useful information for policy-making.

In thesis I demonstrate the use of decomposition methodology in three spatial scales: (i) country level scale (Finland), (ii) European scale and in the world level scale. In this thesis article 10 "*Decomposition analysis of Finnish material flows: 1960-1996*", article 11 *"The European Union balancing between CO_2 reduction commitments and growth policies: decomposition analyses"* and *"G-7 Countries on the Way to Sustainable Energy Systems?"* are utilising decomposition analysis methods (see Hoffrén, Luukkanen and Kaivo-oja 2001, Luukkanen and Kaivo-oja 2002a, 2002b, 2002c, 2000d, 2003, Kaivo-oja and Luukkanen 2003, see also Bruyn 2000, 163-181, Ang and Zhang 2000). My special contribution is thesis concerning decomposition methods is that I have provided decomposition analysis for policymaking in global CO_2 emission reduction analysis. As far as I know Luukkanen and me provided first decomposition analyses of the whole global economy with major regions as well as complete decomposition analysis concerning EU-15 countries CO_2 emission trends. Also we (Hoffrén, Luukkanen and me) provided first scientific national level complete decomposition analyses concerning sectoral material flow data of a nation (Finland). Also the fundamental idea to apply decomposition analysis in the regional nation-level trends of Kyoto process evaluation is ours.

Since researchers proposed and adopted what is often referred to as the index decomposition analysis to study the impacts of structural change and sectoral energy intensity change (changes in the energy intensities of industrial sectors) on trends in energy use in industries in the late 1970s, its application has increased substantially in scope over the years. In this doctoral dissertation we have utilised the fundamental idea to see national economies as "sectors". This scientific idea is also quite new and fresh. Before us, for example, Sun (1996) made the same kinds of analyses in his dissertation. We performed the same kind of analyses with best available IEA data. This is a remarkable scientific achievement of the thesis articles published here.

These methods can be used in various kinds of spatial comparative sustainability and climate policy analyses (see e.g. Malaska, Luukkanen. and Kaivo-oja 1999, Luukkanen, Kaivo-oja, Vehmas and Tirkkonen 2000, Bruyn 2000, Ang and Zhang 2000, Luukkanen, Kaivo-oja and Vehmas 2000, Kaivo-oja and Luukkanen 2002a, 2002b, Luukkanen and Kaivo-oja 2002a, 2002b, 2002c, 2002d, Kaivo-oja and Luukkanen 2003). Especially comparative benchmarking evaluation of various kinds of sustainability trends can be performed by this kind of methodology. I hope that we can provide later more interesting results in this field. We have already provided regional analyses concerning Nordic countries, key developing countries and OECD and non-OECD countries. We made also comprehencive ASA study concerning EU-15 countries by combining decomposition methods and ASA tools (see also 2002a, 2002b, 2002c, Vehmas, Malaska, Luukkanen, Jyrki, Kaivo-oja, Hietanen, Vinnari and Ilvonen 2003). These contributions are not published as a part of this study but these published studies underline the scientific importance of the evaluation approach and tool developed.

Advanced Sustainability Analysis (ASA)

In this section the basic starting points of the so-called Advanced Sustainability Analysis (ASA) approach are presented. The approach is demonstrated by using the Finnish data. Articles 1, 8 and 9 are connected different aspects of ASA approach (Malaska and Kaivo-oja 1997, Malaska, Kaivo-oja, and Luukkanen 1999, Kaivo-oja, Luukkanen and Malaska 2001a, Kaivo-oja, Malaska and Luukkanen 2001b).[1] In this section theoretical concepts are operationalised by the Finnish data. The Finnish national data is collected from various sources (UNDP 1990-2000, Hoffrén 2001, IEA 2001, Ympäristöministeriö and Tilastokeskus 2001).

Conceptualisation of sustainability evaluation framework for regional analyses

In co-operation with Malaska, Luukkanen and Kaivo-oja (Malaska, Kaivo-oja, and Luukkanen 1999, Kaivo-oja, Luukkanen and Malaska 2001a, 2001b, Vehmas, Kaivo-oja and Luukkanen 2003, Vehmas, Malaska, Luukkanen, Kaivo-oja, Hietanen, Vinnari and Ilvonen 2003) a theoretical framework and empirical analysis of the potential for sustainability in its relation to economic growth and welfare policies was defined. This part of thesis relies on these original contributions. It was formulated as a set of necessary conditions for improving sustainability.

The theory can be called the Advanced Sustainability Analysis (ASA) approach and is based on the two basic postulates for improving sustainability and the conditions suitable for empirical analyses and for policy formulations, are derived mathematically from four identities called the master equations of the theory. They relate the environmental stress variable (ES) chosen for an analysis with basic indicators of economic, technological and social development. The explanatory power of the theory relies on new concepts and formulas for sustainable policy making and on the new empirical results for comparisons between countries and regions as well as between policy targets and reality. The Environmental Stress (ES) concept is a multiple attribute concept that has total material flow, energy consumption, total water use, CO_2 emissions, and waste discharge as some of its obvious attributes for ES-analysis. Welfare is another main concept of the ASA approach. It is also a multiple attribute concept with Human Development Index, economic consumption, Index of Sustainable Economic Welfare (ISEW) as some of its obvious attributes (see e.g. Hoffrén 2001).

The ASA approach offers decision-makers a new and advanced tool for policy analyses and policy formulations regarding sustainable development issues, which

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[1] Here I use the term of ASA approach instead of ES or TES approach because it given a better view of the various dimensions of sustainability analysis, which is not only to connect to environmental stress variables. After publication of these articles, we have developed ASA framework further and even changed and re-defined contents of some basic concepts.

are related to conventional economic and welfare policies. Policy relevant questions, which can be analysed by the ASA approach, are the following ones:

1. The analysis of the different dimensions of the sustainability of different historical development processes (ex-post analysis of sustainability);
2. The analysis of the different dimensions of the sustainability of future scenarios or predictions (ex-ante analysis of sustainability);
3. The analysis of the dematerialization of production and the immaterialization of consumption;
4. The analysis of the rebound effects of growth;
5. The analysis of the structural shifts needed for sustainable development;
6. The analysis of sustainable technological development (e.g. so called Factor 4 and Factor 10 analyses);
7. The analysis of sustainable economic growth; and
8. The analysis of de-linking and re-linking.

All these analyses are connected to advanced sustainability analyses of different kinds of societies and regions. When the ASA approach is linked to macroeconomic or regional growth models, it can be used for the analysis of different practical policy alternatives on a national level and on a more sub-regional level, too. If data is available, the ASA approach can be used at all the levels of regional planning. Empirical results presented here indicate that there can be sustainable transition strategies, diminishing the environmental stress, but all observed trends are favourable for sustainability. The ASA approach provides us a realistic approach and empirical analysis concerning crucial sustainability challenges.

In this thesis articles 8 and 9 present some main ideas of ASA approach. Larger operationalisation of ASA approach concerning EU countries developments is presented TERRA2000-project's final reports (see Vehmas, Malaska, Luukkanen, Kaivo-oja, Hietanen, Vinnari, and Ilvonen (2003), Vehmas, Kaivo-oja, and Luukkanen (2003).

3.3. Scenario planning frameworks

The scenario method is a well-tested technique within futures studies. There are various definitions of the term 'scenario', the broadest being that scenarios tend to clarify the present possibilities for decision making by indicating the guidelines for decisions. The term is usually used in the plural because the main characteristic of this method is tied to the concept of there being several potential futures. A scenario can also be defined as a description of possible and probable development. By setting up several scenarios for future development, one can say that one is stretching out a space, within which future development will occur. In this way simplified single dimension evaluations are avoided.

Scenario building, or scenarios, can be described as an instrument that aids decision-makers, by providing a context for planning and programming. It thus lowers the level of uncertainty and raises the level of information and knowledge, in relation to the consequences of actions, which have been taken, or are going to be taken, in the present. (Masini 1993, 90, Kaivo-oja 2001c).

Scenarios are often written in the past tense – as if one were standing at a point in the future and looking back towards the historical development, which has taken place within a certain period. In this manner, one creates a possible future to which one can adopt a concrete attitude. By setting up several scenarios or several historical accounts, one creates the possibility of adopting an attitude towards several specified future developments. This will also mean that there is nothing especially mysterious in scenario planning. It is, rather, a question of common sense.

If we look at developments over the past 25 years, one clear lesson can be learned from the projections made in the 1970s: Dogmatic predictions regarding the Earth's future, are unreliable and can be politically counterproductive (UN 1997). Therefore many organisations are interested in the use of scenarios in decision-making processes. For example, in the European Community context EC DXXI (1996) has noted that "scenarios are perhaps most effective when seen as a powerful tool to broaden perspectives, raise questions and challenge conventional thinking". Scenarios cannot "predict", but they paint pictures of possible futures and explore the different outcomes associated with "what if" questions.

A multitude of scenario definitions exists in scientific literature. Wiener and Kahn (1967, 6) used the following definition: "Scenarios are hypothetical sequences of events, built in the intent of attracting attention to causal processes and points of decision". Miles has quite a similar definition: "Scenarios are a sequence of processes or events whereby the present of the world, nation or construction develops into some future state of the world, nation or constitution" (Miles 1986). According to Jantsch, "scenarios are attempts to set up a logical sequence of events in order to show how, starting from the present situation, they may evolve step by step" (Jantsch 1967, 180). Martino (1972) has summed up many definitions by saying "a scenario is a picture of an intensely consistent situation, which in turn, is the plausible outcome of a sequence of events". Also a respected scholar of scenario planning Godet 1987, 21) defines scenarios as "the description of a future situation together with the progression of events leading from the base situation to the future situation". Rotmans and van Asselt (1997) have presented the following new definition: "Scenarios are archetypical descriptions of alternative images of the future, created from mental maps or models that reflect different perspectives on past, present and future developments". A scenario is thus an internally consistent story about the path from the present to the future. Herman Kahn states that scenarios are an answer to two basic questions: how does a hypothetical situation develop in the future step by step, and what are the alternatives in each moment of decision which divert, facilitate or stop the process (see Kahn 1962, Kahn 1965, Kahn and Wiener 1967).

The future can never be accurately or completely known because of the multiplicity of evolutionary driving forces that shape the future, their interactions and complexity. Consequently, most regional planners and decision-makers today reject the idea that planning should be conducted against a single most likely image of the future. Management of uncertainty is seen to be a key challenge of regional and local planning (see e.g. Sotarauta 1996, 9-83). Rather, a set of scenarios should be used as an integrative part of planning and decision-making processes. If the sets encompass a broad span of futures and plans are generated to cope with their eventualities, then the plans will be robust and the future can be met with some degree of confidence. The scenario approach is a policy analysis tool that describes a possible set of the future conditions.

Thus, scenarios are narrative descriptions of the future that focus attention on causal processes and decision points (Kahn 1995, Kahn and Wiener 1967). According to Anastasi (1999) the features of a good scenario are: (1) It is plausible, (2) it is recognisable from the signals of the present, (3) it is relevant and has some consequences, (4) it is challenging and (5) it is an internally consistent story. Scenarios can be used (1) to aid in the recognition of "weak signals" of change, (2) to avoid being caught off guard ("live the future in advance"), (3) as a language for discussion - and to challenge "mental maps", (4) as way to test strategies for robustness - with "what if" questions and (5) as an improved method of understanding the world - and (6) a method for making better decisions. Scenarios that have a strong narrative are able to engage key stakeholders. Active dissemination is needed to get the best out of scenarios.

Thus, measures of good scenario are (1) plausibility (a rational route from here to there), (2) internal consistence, (3) description of causal processes and (4) usefulness in decision-making. Accuracy is not the first priority in the scenario building process. The most useful scenarios are those that display the conditions of important variables over time. In this approach it is typical that the quantitative underpinning enriches the narrative evolution of conditions or the variables. Narratives describe the important events and developments that shape the variables. When scenarios are used in policy analysis and spatial decision-making process, the nature of evolutionary paths is often important since policies can deflect those paths. In spatial policy studies, families of scenarios are often used to illustrate the consequences of different initial assumptions, different evolutionary conditions, or both.

Numerous methods have been developed to create scenarios, ranging from simplistic to complex, qualitative to quantitative. Many methods have similarities, although they may have unique features and use different terminology. Most approaches recognize the need to understand the system under study and identify the trends, issues, and events that are critical to the system. In this summary article

I shall not present details of different scenario building or constructing methods. Valuable sources for studying scenario construction/building methods are Klein and Linneman (1981), Becker (1983), von Reibnitz (1988), Becker (1989), Whipple (1989). Werner (1990), Schwartz (1991), Simpson (1992), Mandel and Wilson (1993) and Godet (1990, 1993a, 1993b, 2001, Schwartz and Ogilvy 1998).

Instead of working out one prognosis as a strategic basis, which can very easily come to work as an approximated truth about the future, one can take a starting point in the uncertainty itself, when we start analysing scenarios. By focusing on the uncertainty through descriptions of several different possible and probable futures, an opening is made for the discussion of goals, desires, values, missions and visions. These kinds of questions, which are connected to visionary management are discussed in article 5 "*Challenges of visionary management in multilevel planning environment: How Murphy's laws may emerge in global sustainability policy?*" (Kaivo-oja 2001a). This paper is a complementary contribution to a paper of Malaska and Holstius (1999), which defined the basic ideas of futures oriented visionary management.

A scenario is precisely a description of a possible and probable future. The difference between prognoses and scenarios is illustrated in Table 2.

Table 2. The difference between prognoses and scenarios: basic assumptions

PROGNOSES/FORECASTS	**SCENARIOS**
The future is certain	The future is uncertain
The probable development assumed to be the reality	Several different, possible and probable developments
The future cannot be influenced	The future can be developed
Consequences	Possibilities and risks
Passive adaptation	Proactive
Traditional planning	Strategic development

In regional planning the future space of a region is described by various scenarios. Figure 7 illustrates this basic idea of scenario approach:

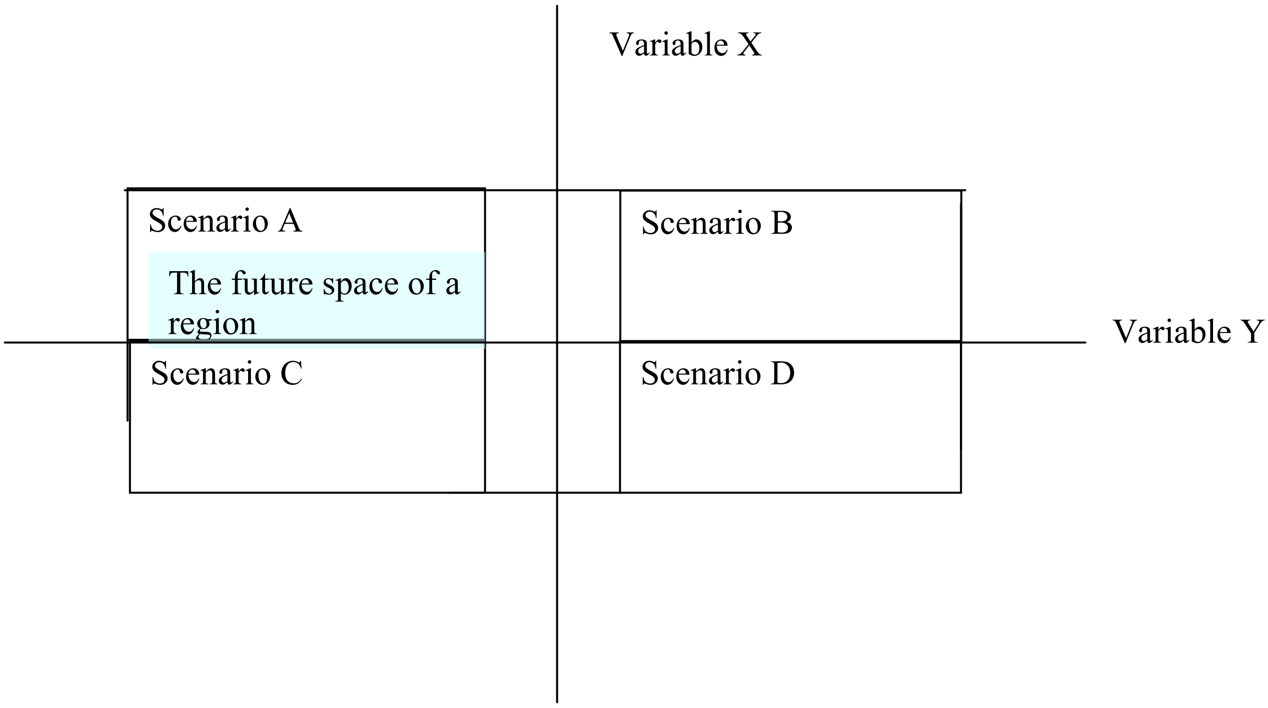

Figure 7. The future state of a region (compare e.g. Schwartz and Ogilvy 1999, 65)

This kind of framework is discussed in article 2 "*Scenario learning and potential sustainable development processes in spatial contexts: towards risk society or ecological modernization scenarios?"* (Kaivo-oja 2001c) in this thesis.

There are various alternative ways to define the future state of a region. Usually this kind of "criss-cross"-method is used in scenario analyses. Scenarios are generated by systematic variable variation. The basis is thus some opposites, as shown in Table 3 below:

Table 3. Some opposites relevant for regional planning and scenario generation (The Copenhagen Institute for Futures Studies 1996, 46 with authors' additional remarks)

High growth	Low growth
Market	Regulation
High environmental pressure	Low environmental pressure
High welfare level	Low welfare level
Equality	Inequality
High population density	Low population density
Centralisation	Decentralisation
Urban	Rural
Male orientated	Female orientated
Junior dominated	Senior dominated
Material	Immaterial
Leftist parties	Conservative parties
Locally orientated	Globally orientated
Past-orientated	Future-orientated
Individualism	Collectivism
Rationality	Irrationality
Faith	Knowledge
Technological environmental solutions	Social environmental solutions
Out-sourcing	In-sourcing
Hierarchy	Autonomy
Proactive	Reactive
Singles culture	Nuclear family culture
Generalisation	Specialisation
Techno-culture	Human culture
Global	Local
Integrated	Fragmented
Real	Virtual
High-quality	Low-quality
Mobility	Non-mobility

In some cases it is not suitable to work with opposites from one extreme to the other, but rather with scales. Usually a scenario team should carefully find and discuss: the relevant variables for decision-making and produce scenario families on the basis of the discussion.

Michael Godet (2001, 16-17) has emphasised that in the process of creating futures it is wise to move from anticipation to action through appropriation. According to Godet, anticipation includes prospective thought, appropriation includes the element of collective mobilisation and action includes the element of strategic will. Scenarios are usually connected to these three critical elements of the "Greek Triangle": (1) "*Logos*" (thought, rationality and discourse), (2) "*Epithumia*" (desire in all its noble and not so noble aspects) and (3)"*Ergo*" (action or realisation). My own personal view is that all key elements of the "Greek Triangle" are needed in spatial sustainability policy.

Although there are several scenario methods, which can be defined in various ways, we can consider scenario planning or scenario building to be a reality oriented analysis method, insofar as it is mainly based on data and information. It can be seen a scientific method, insofar as it is mainly based on theoretical hypotheses and scientific theories. Sometimes it is also a multiple method, since it considers and uses subjective methods like surveys, the Delphi techniques, expert interviews, etc (see Armstrong 2001). Usually scenarios are synoptic as well as simultaneous, since various variables are analysed at the same time. The starting point of the method is the present. The analyst usually chooses the main direction of a scenario and its basic assumptions.

Notwithstanding the variety of definitions, scenarios have common features. Scenarios describe potential futures, representing sequences of events over a certain period of time. Further, scenarios usually contain elements that are judged with respect to importance, desirability, and/or probability (see e.g. Amara 1981a, 1981b, Rubin and Kaivo-oja 1999). As follows from both definitions presented above, the evaluation of possible decisions and/or policy strategies is inherent in scenario building processes. Finally, scenarios include the depiction of an initial state, usually lying in the present, and/or a final state at a fixed time horizon. In spatial planning processes it is important to discuss these kinds of issues systematically (see e.g. case-study analyses of Kaivo-oja. and Hovi 1996, Järvinen and Kaivo-oja 2000, Checkland 1984, Checkland and Scholes 1993, 1999).

Scenarios can be seen as translator devices for the findings of social theories. The scenario framework of article 2 "*Scenario learning and potential sustainable development processes in spatial contexts: towards risk society or ecological modernization scenarios?*" is a typical example of this kind scenario analysis (Kaivo-oja 2001c). Scenarios have the potential to make theory, stylised facts and social science methods useful for organisational management both in public and private sector organisations. Mendonca (2001, 97) has presented an idea that the results of the scenario-building process have a potentially beneficial impact upon managerial know-how and strategic visions. In a way scenarios can be seen as a socio-technology. The term socio-technology can be used as a basic term in order to avoid associations with the idea of social engineering. Social engineering is an essentially modernistic belief that an improvement in the quality of life could come about by the rational manipulation of social relations by enlightened bureaucrats. (Mendonca 2001, 96-97). The underlying framework of analysis is represented in the Figure 8 below.

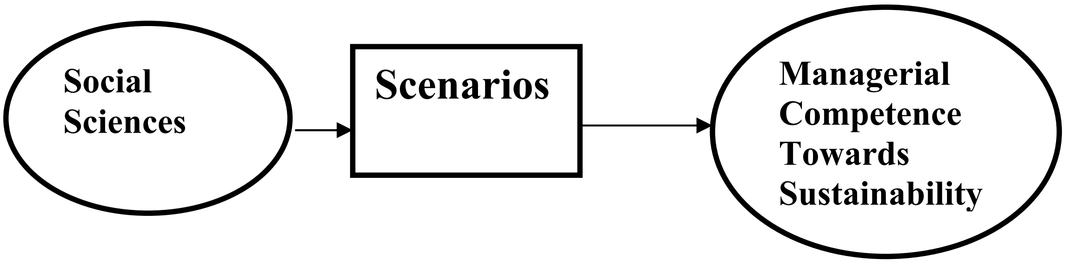

Figure 8. A framework of analysis (a modified version of Mendonca 2001, 97)

Personally, I see scenario analysis as an integrative tool in social sciences and regional studies. In scenario analysis a scenario team combines the use of various futures studies, networking tools and planning and strategic analysis methods. Today these kinds of studies are often called regional foresight analyses (Di Bartolomeo, Farhl, Gapriati, Gavigan, Keenan, Lecog, Miles, Scapolo 2001). Typical steps to develop a strategic plan are (Barry 1998, 13-19):

1. Get organised,
2. Take stock and made a situation analysis,
3. Set direction,
4. Refine and adopt a the plan, and
5. Implement the plan.

Usually scenario approach is used especially in the context of steps (2), (3), (4) and (5). Scenario approach is usually needed when an organisation develops a vision of its future and determines how to move the organisation towards its future (see e.g. Kaivo-oja 2001a).

In Table 4 we can summarise this view by the description of the inputs, outputs and by-products of scenario analysis and planning tools.

Going beyond the mere extrapolations of historical time-series, scenario approach addresses the future by indicating the weak signals and the underlying long-term driving forces that may be expected to propel the socio-economic and physical environment into the future, be it the local economy, the regional or global economy. In this sense scenario methodologies and techniques are flexible are there are variations in scenario techniques. Scenario analysis with the use of futures studies methods can be seen as a general flexible methodology that creates a forward-looking attitude without trapping the decision-maker into a pre-established/common sense vision of what might happen. The construction of stylised storylines of alternative futures, in which the contrast between the outcomes of actual and potential trajectories can be depicted, provides an early warning system helping strategic decision-makers and stakeholders to act in the face of potential crisis and potential success.

Usually it is wise to organise scenario building and work analysis in the regional planning process. This organisation, as a specialised team, is assigned a research and consulting role in various contexts of regional planning activities. It can be seen as an in-house think-thank devoted to enquiring about the ways in which a region's development potential towards sustainability can be improved in an evolving, unpredictable context.

Scenarios are more than simple tools for management guidance. The scenario methodology is a set of complex analytical components much like a piece of sophisticated machinery. Scenario building articulates several autonomous sub-systems of information gathering and processing, each one with its autonomous logic. The analytical elements of the future scenario approach are the following ones (compare Mendonca 2001, 103, see also Armstrong 2001, Slaughter 1996a, 1996b, American Council for the United Nations University 1999):

- Brainstorming
- Literature search
- Data gathering of scientific economic, social and ecological variables like bibliometric research or patent scanning
- Data-processing techniques like time-series analysis tools or the basic statistical analysis of survey data
- Modelling and computer simulations
- Cross-impact analysis
- Uncertainty/impact analysis
- Interviews, surveys and consensus meeting
- Stocking up ideas about possible disruptive events or wild cards (or weak signals) and
- Story line building.

The scenario methodology in its various forms is a process that systematically attempts to convey an integrated picture of the possible future evolutionary paths of the assessed social and physical phenomena. In Table 4 typical inputs, outputs and by-products of foresight/futures studies are outlined.

Table 4. Description of inputs, outputs and by-products (Mendonca 2001, 98 with additional remarks by the author)

INPUTS	OUTPUTS	BY-PRODUCTS
Data	Scenario reports	Books
Hunched and informed guesses	Tacit scenario building knowledge	Articles
Tacit knowledge	Statistical trend information and knowledge	Workshops
Multi-disciplinary expertise	Workshops and training	Planning documents
Simulation models and other planning models	New managerial perspectives	Plans
Reports, articles, surveys, books	Creation of networks	Vision, mission and strategic development programmes
Planning expertise	Quantitative and qualitative analyses	Consultancy spin-offs
Other futures studies methods (Delphi, trend analysis, regression analysis, expert interviews, Brainstorming, Weak signal/Wild Cards analysis, simulation analysis, S-curve analysis	Direct action based on inputs	Indirect actions based on inputs

Thus, Wild Card analysis increases the possibility that some major future negative events might be averted, but also that positive action can be implemented. Basically, many sustainability problems are caused by actions, which are made too early or too late. Weak signal analysis can help us to avoid such undesirable actions. In the final stages of scenario analysis, where actual recommendations can be presented, it is also possible to articulate the analysis with more policy-oriented tools. The different scenarios represent basic core statements about the socio-economic and physical environment potentially facing regional planning systems. The opportunities and risks facing the region in different scenarios can be translated into the action agenda by adding priority-setting devices in a modular fashion. Such instruments can be classical SWOT analysis, benchmarking techniques, Delphi methods (especially Policy Delphi), risk analysis, probability comparisons etc. With these planning tools and methods different aspects of regional sustainability policy can be analysed. The scenario methodology bridges new knowledge and, if effective and successful, organisational change. (Mendonca 2001, 103-104, Mendonca, Cunha, Kaivo-oja and Ruff 2002).

Scenario approaches can be an element in the strategy change cycle of regional planning organisations. Bryson (1995, 21) has presented the planning process, which is called the Strategy Change Cycle. It includes the following activities:

- Setting the organisations' s direction
- Formulating broad policies
- Making internal and external assessments
- Paying attention to the needs of key stakeholders
- Identifying key issues
- Developing strategies to deal with each issue
- Planning review and adoption procedures
- Implementing planning
- Making fundamental decisions
- Taking action and
- Continually monitoring and assessing the results.

A detailed Strategy Change Cycle includes a ten-step strategic planning process (Bryson 1995, 22-23):

1. Initiate and agree upon a strategic planning process,
2. Identify organisational mandates,
3. Clarify organisational mission and values,
4. Assess the organisation's external and internal environments to identify strengths, weaknesses, opportunities, and threats,
5. Identify the strategic issues facing the organisation,
6. Formulate strategies to manage these issues,
7. Review and adopt the strategic plan or plans,
8. Establish an effective organisational vision,
9. Develop an effective implementation process, and
10. Reassess strategies and the strategic planning processes.

These ten steps should lead to actions, results and evaluation. It must be emphasised that action, results and evaluative judgements should emerge at each step in the process. Scenarios can be used in the formulation of strategies (see e.g. Whipple III 1989). This kind of process is applicable to public and non-profit organisations, boundary crossing services, inter-organisational networks, and communities (Bryson 1995, 23). Usually the only general requirements are a "dominant coalition" that is willing to sponsor and follow the process and a process leader who is willing to push it. In the case of regional sustainability planning all these steps should be connected to the regional sustainability issues and challenges. In practical regional planning this is not always the case, because regional planning activities are often connected to other kinds of challenges like, regional competitiveness and the economic growth needs of a region. These kinds of questions, which are connected to visionary management and multi-level planning, are discussed in article 5 "*Challenges of visionary management in* *multilevel planning environment: How Murphy´s laws may emerge in global sustainability policy?*" (Kaivo-oja 2001a).

Usually scenario analysis should be made before the final setting of the organisation's direction and vision. However, scenario analysis can also be made simultaneously, but it requires very good co-ordination machinery to be a successful way of managing the process properly. The Strategy Change Cycle is as much a strategic management process, as it is a strategic process. Usually scenarios can be used in the contexts of strategy issue identification, strategy selection and also in action plan approval and implementation. Thus scenario approaches can be a part of policy guidance, the development of strategic alternatives and a regional action plan development.

In Figure 9 one can see that scenario approaches in regional planning can always be linked to the analysis of a present situation, to the sustainability mission and in the end, to the vision of sustainable development, if this framework is used. Bryson (1995, 155) has noted that while many public and non-profit organisations have developed useful mission statements in recent years, far fewer have a clear, succinct, and useful vision of success. There are only a few regions, which have a clear spatial vision for sustainable development. Part of the reason is that a vision, while it includes a mission, goes well beyond it. A mission outlines the organisational purpose while a vision goes on to describe how the organisation should look when it is working extremely well in relation to its environment and its key stakeholders. Developing this description is more time consuming than formulating a mission statement (Senge 1990). It is also more difficult, particularly because most organisations are coalitional (Pfeffer 1992), and thus the vision must usually be a treaty negotiated among rival coalitions. However, the principles of sustainable development give a very firm basis for the description of a vision of spatial sustainability.

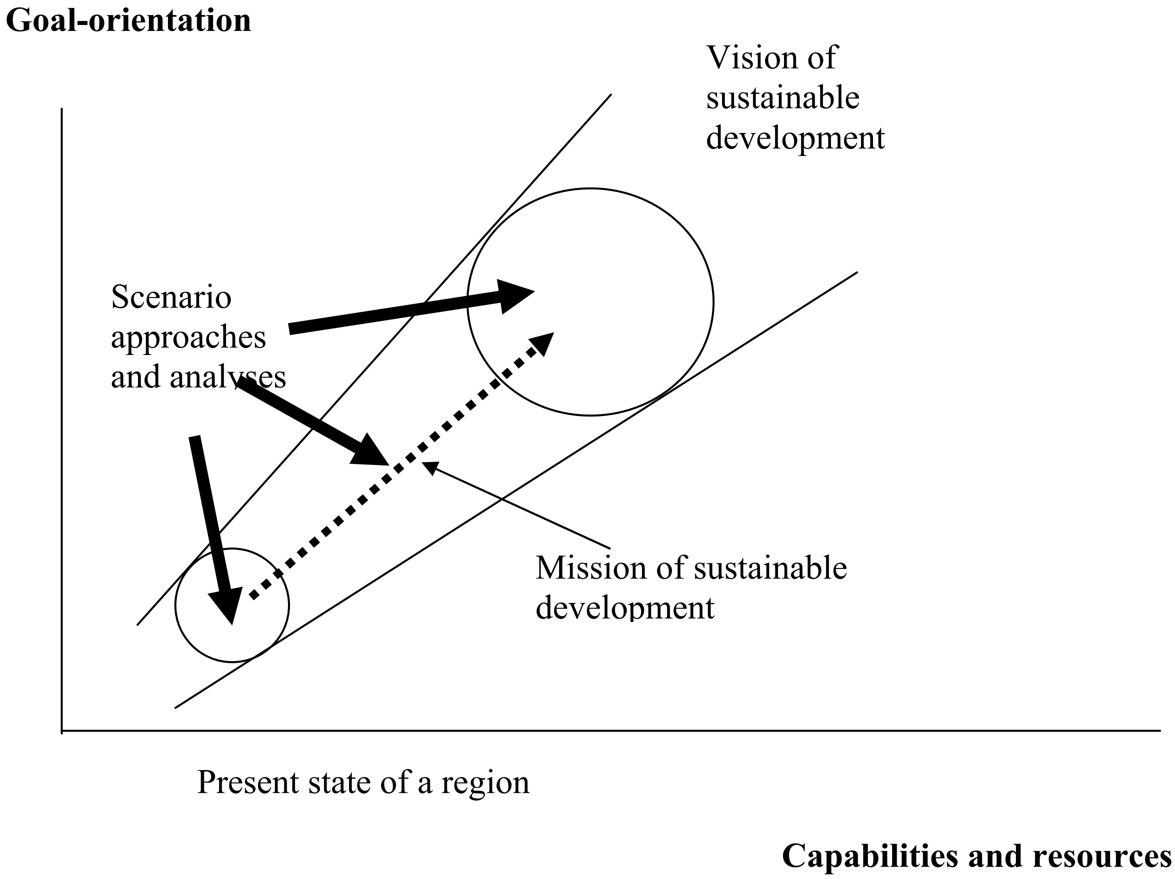

Figure 9. Syntax of vision, present state and mission in sustainability planning

On the basis of risk society theory and theories about ecological modernisation we can postulate that visions of sustainable development are very closely connected to the idea of an ecologically modern society or the problem solving strategies of risk societies (see Cohen 1997). Also transition towards information or knowledge intensive society can be seen as a part of ecological modernisation process. These kinds of ecological modernisation questions are discussed in article 3 " *Environment in an "information society": Transition stage towards sustainable development?"* and in article 4 "*The ecological transparency of the information society*" (Jokinen, Malaska and Kaivo-oja 1998, Heinonen, Jokinen and Kaivo-oja 2001).

When we are discussing what kinds of issues are important in relation to the vision of sustainable development, one of the most sustained efforts to do so has been a growing number of publications, which can be brought together under the label of "ecological modernisation". The core of all studies in the tradition of ecological modernisation research focuses on environmental reforms in social practices, institutional designs and societal and policy discourses to safeguard societies' sustainability bases. (Mol and Sonnenfeld 2000). Some authors emphasise that these social transformations in institutions, practices and discourses are paralleled by physical changes in tendencies of environmental disruptions and material flows. (Jänicke and Weidner 1995, Spangenberg, Hinterberger, Moll and Schütz 1999, Spangenberg, Femia, Hinterberger and Schütz 1999). Considerable debate has emerged about whether these improvements have actually taken place and to what extent any such improvements are structural or incidental. (Jokinen and Koskinen 1998, Mol and Sonnenfeld 2000).

Mol and Sonnenfeld have emphasised that it is not physical improvements per se, however, but rather social and institutional transformations, which have been and still are at core of current scholarship on ecological modernisation. Key forms of transformation in ecological modernisation process are (Mol and Sonnenfeld 2000):

(1) Changing role of science and technology;
(2) Increasing importance of market dynamics and economic agents;
(3) Transformations in the role of the nation-state;
(4) Modification in the position, role, and ideology of social movements; and
(5) Changing discursive practices and emerging new ideologies.

Science and technology not only are judged for their role in the emergence of environmental problems but also valued for their actual and potential role in curing and preventing them. Ecological modernisation approach emphasises the need to replace traditional curative and repair options with preventive socio-technological approaches incorporating environmental considerations from the design stage of technological and organisational innovations. These kinds of science related general sustainability issues are discussed in the article of Malaska and Kaivo-oja (1996, 1997).

Market dynamics and economic agents include issues such as producers, customers, financial institutions, insurance companies and other market agencies, which can carry out ecological restructuring and reform. More decentralised, flexible and consensual styles of public governance are emerging and this implies that there will be less top-down, national command-and-control environmental regulation. Emergent supra-national institutions also undermine the nation-state's traditional role in environmental reform. Increasingly, social movements and NGOs are involved in public and private decision-making institutions regarding environmental and social reforms, in contrast to having been limited to the periphery or even outside such processes. An important part of transformation process is that complete neglect of the environmental and the counter-positioning of economic and environmental interests are no longer accepted as legitimate positions (Spaargaren and Mol 1992, Mol and Sonnenfeld 2000). Such social transformations feature as central topics of scholarship on ecological modernisation in Western industrialised countries, and increasingly elsewhere in the world as well.

Interpretations of ecological modernisation are still maturing, but Aalbu, Hallin and Mariussen (1999, 150-151) have identified four themes that consistently appear:

- Integration, referring to the realignment of policy goals in areas such as economics, energy and transport so that environmental consequences are considered in decision-making, programme formulation and implementation. Ideally, such integration should ultimately produce more efficiency and mutually supportive policies.

- Synergies, representing a move from conflict management to actually gaining advantage through interactions between environmental protection and economic development. Policies to improve the environment can lead to increased efficiency and speedier change, and in fact become catalysts for economic development.

- Innovative policy measures, such as "economising the environment by placing an economic value on nature comparable to the values traditionally placed on labour and capital. Other examples include a widespread realignment of fiscal structures to create environmentally benign, labour-intensive development paths, using economic rationality to enhance - not to undermine - environmental quality, while reinforcing employment opportunities.

- New clean or cleaner technologies, to facilitate improved environmental and economic performance. This technological imperative is considered essential for de-coupling economic development and negative environmental impact.

A scenario of ecological modernisation implies an attempt to provide scope for a proactive response and environmental gains. In this scenario regional and local authorities may actively create opportunities for forward-looking measures to bring broader benefits to regions, both environmentally and in terms of sustainability (see Table 5 below, Aalbu, Hallin and Mariussen 1999, 151-152).

Table 5. Stages in integrating economic development and environmental management (process toward ecological modernisation)

ENVIRON-MENTAL LOSS (passive)	**ENVIRON-MENTAL PROTECTION (reactive)**	**ENVIRON-MENTAL GAIN (proactive)**	**ENVIRON-MENTAL COMPETITI-VENESS (interactive)**
• Habital destruction • Loss of plants and wildlife • Water pollution • Emissions to air • Soil contamination • Aesthetic losses	• Planning conditions • Filter systems for industry • Land-use zoning • Brownfield sites • Repairing damage	• Land reclamation • Pollution reduction • Water purification • Air purification • Ecological enrichment • Awareness-raising	• Regional environmental promotion • Business parks based on industrial ecology principles • Development of environ-mental services • Promotion of innovative environmental practices

However, it is not a self-evident fact that all regions adopt this kind of progressive ecological modernisation strategy option. That is why we must analyse things in a problem-oriented context. Different regions have different situations. In Figure 10 the main alternative paths are shown by the direction of the arrows. For example, it is possible that regions have situations of A, B, C, D, or E. There are many alternative development paths. This implies that regional sustainability strategies should always be tailored from problem-oriented perspectives.

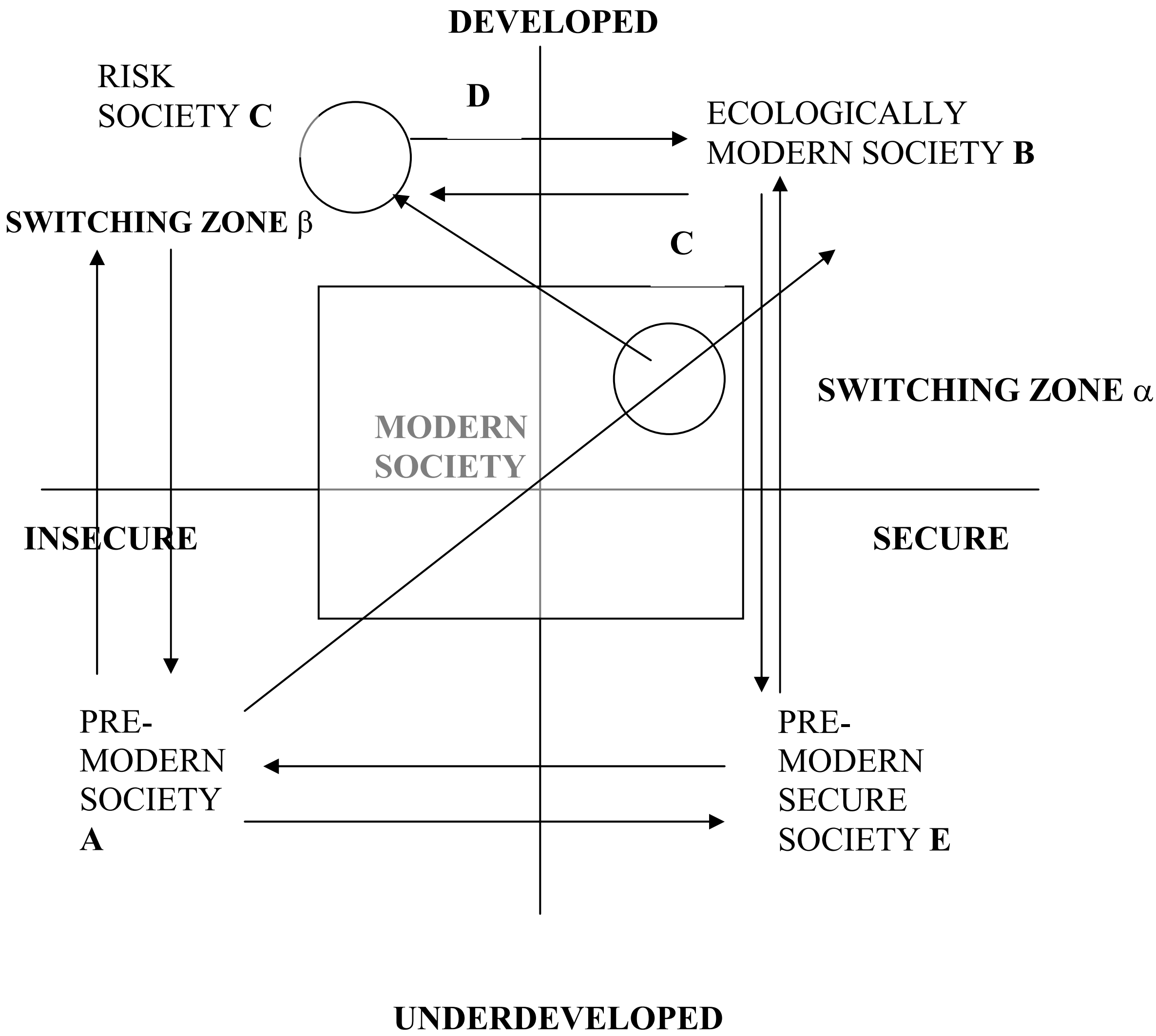

Figure 10. Technological-environmental risk and development (a modified version of Cohen 1997, 110)

At scenario point A society is a pre-modern society. It is typically expected that in an ideal modernisation process societies develop towards ecologically modern society, from point A to point B. Alternative scenario paths are from A point to C or E scenarios where a society is developed either towards risk society (point C) or towards secure pre-modern society (point E). It is also possible that pre-modern societies first are developed towards ecologically modern society (point C), but then they are transformed towards risk society (point C). It is also possible that secure pre-modern societies are developed towards ecological modernisation (scenario path from B to E). Thus, also regressive counter-cyclical processes are possible in different societies. We cannot assume that ecologically modern society is a status quo society. Also risk societies can be developed towards ecological modernisation (a scenario path from C to D). If we really want to develop ecologically modern societies, our educational, political, and economic institutions must also become involved in a full-throttle, turbo-charged effort to advance the sustainability of spatial life-support systems (see Figure 10).

The basic idea of scenario analysis is to analyse various uncertainties in the socio-economic and physical environments of particular regions. There are a lot of uncertainties concerning sustainable development in different regions. Also because uncertainty is multi-dimensional, it is unlikely that a single approach will suffice for all the salient forces of uncertainty. Different approaches address different types and sources of uncertainty in different ways. Usually a complementary use of various methods is needed in order to be able provide a comprehensive insight into the extent and scope of uncertainty. Some scholars like Marjolein Asselt and Jan Rotmans have developed in many studies so called Integrated Assessment modelling approaches to help and support spatial decision-making (Rotmans and Asselt 1994, 1999, van Asselt 2000, Rotmans 1998, Rotmans 1999). In spatial IA studies one can identify demand-driven and supply-driven IA-studies (Figure 11). In a supply-driven IA study, a group of scientists anticipates the societal relevance of a complex theme. In this case the definition of a scientific problem frames the assessment. A demand-driven IA is a participatory endeavour in which decision-makers and stakeholders (and scientists) explore which complex issues are highly relevant for a future society. The resulting common agenda and exploratory assessment then frames the integrated assessment (van Asselt 2000, 32).

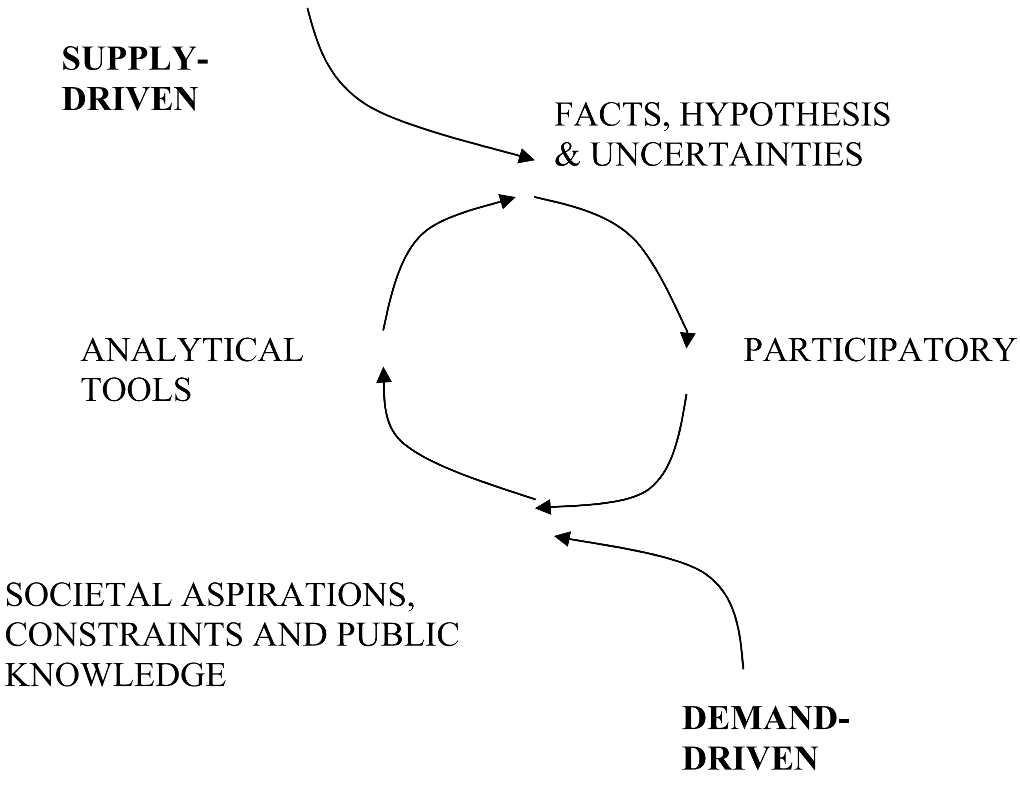

Figure 11. Demand-driven versus supply-driven IA (van Asselt 2000, 33)

In the context of scenario analysis, the major difference between the two thus involves who is defining the problem and thus the starting points of scenario analysis and the strategy process. Scenario analyses can be either quantitative (model-based) or qualitative (expert- or layman-based) studies.

Figure 12 is an attempt to visualise the typical scenario concept, starting from a historical or current situation, extending till the chosen time horizon (van Asselt, Storms, Rijkens-Klomp, Rotmans 1998, 11).

Different subdivisions of scenarios exist. A sub-division can be made between forecasting and backcasting scenarios. Forecasting scenarios explore alternative developments, starting from the current situation with or without expected/desired policy efforts. Many scenario studies can be characterised as forecasting exercises (see e.g. EC DXXVII 1990). Backcasting scenarios reason from a desired future situation and offer a number of different strategies to reach this situation.

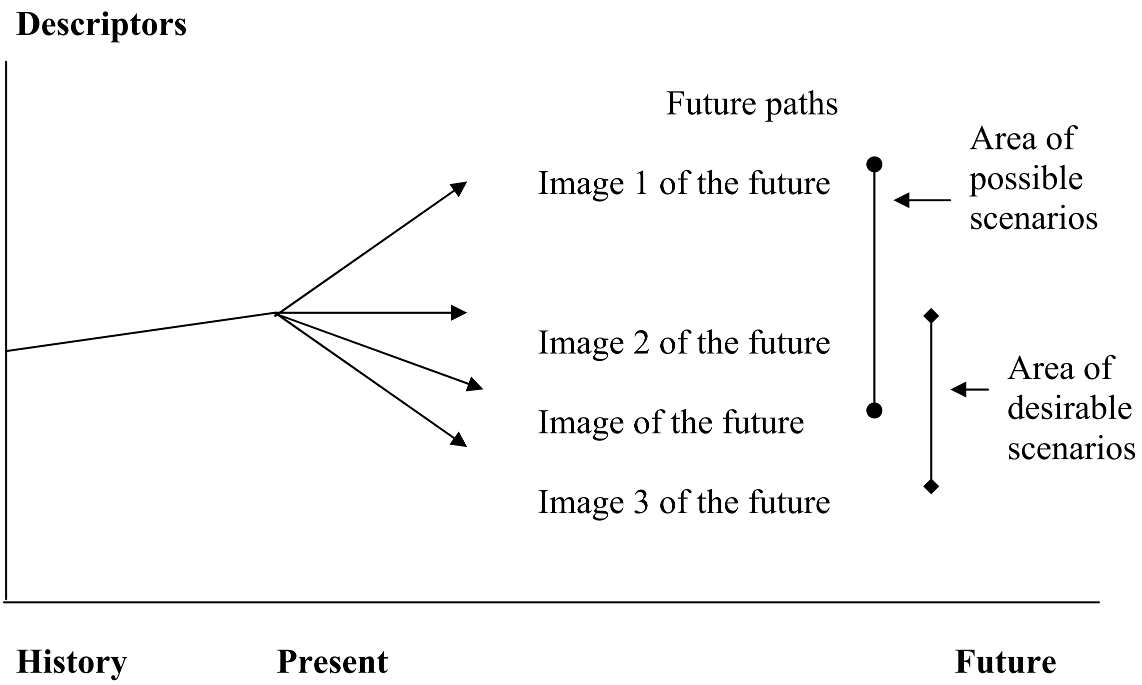

Figure 12. Elements in scenarios and the time horizon (see e.g. Godet 2001, 77)

Secondly, we can also distinguish between descriptive and normative scenarios. Descriptive scenarios state an ordered set of possible events irrespective of their desirability or undesirability, while normative scenarios take values and interests into account. For example, the Intergovernmental panel of climate change (IPCC) study (1995, 1996) presents six descriptive emission scenarios.

Ducot and Lubben (1980) have distinguished between trend and peripheral scenarios. A trend scenario represents the extrapolation of the current trends, while a peripheral scenario includes unlikely and extreme events. In this context, Schwartz (1991) states that scenarios should include surprises in order to break with old stereotypes. However, scenarios often are explorations of current trends. Many scenarios have such a ”Business as Usual” (BAU) character that assumes current trends and conditions will continue to exist for decades, which is highly implausible (see e.g. Rotmans and van Asselt 1997, 1999). Most scenario studies go beyond trend scenarios, but cannot be adequately characterised as peripheral scenarios, because quite often the anticipated changes are merely incremental. A good example of trend scenario is the Conventional Wisdom scenario in the "*Energy in Europe*" study (EC DGXVII 1990, 1996). An example of a study attempting to include peripheral scenarios is the Shell study (Volkskrant 1996) in which two extreme scenarios, named "Just Do It" and "Da Wo" are explored. In many long-term scenario studies, surprises and bifurcations are not taken into account although they may be mentioned briefly. Also in this new SHELL scenario study just two extreme scenarios are presented for media and public discussion (see e.g. Shell International 2002). In many organisations Wild Card/weak signal evaluations are not public information for all the people. However, the inclusion of surprises is important since history shows us that historical trends are characterised by strong fluctuations rather than smooth curves, often triggered by unexpected changes (see Rotmans 1997). Van Asselt et al (1999, 12) have categorised surprises in the following way:

(1) Unimaginable surprises (like a journey to the Earth's centre in the time of Jules Verne),
(2) Imaginable surprises that are improbable (like a global nuclear war),
(3) Imaginable surprises that are probable (like an oil price shock and an invasion of ecological refugees), and
(4) Certain surprises (like earthquakes).

It is important to understand that scenarios have different functions in the regional planning process. Scenarios can be useful tools to; (i) help us articulate our key considerations and assumptions; (ii) to identify gaps, inconsistencies, dilemmas, uncertainties and indeterminancies and to understand complexity; (iii) to help us expand our thinking, take on and explore possibilities that are new, or challenge conventional thinking (Rotmans and van Asselt 1996, 1997, 1999). Scenarios ideally have the function to inform and/or advise decision-making. Scenarios can also be useful for decision-making in business, but also in non-profit organisations and in public sector organisations. The organisation of scenario development can include (Anastasi 1999):

(1) a core team who collect relevant information and makes expert analyses,
(2) a facilitation team, who organise scenario workshops,
(3) a modelling team, who underpin exercises,
(4) diverse audiences, who give responses to the analysis, and
(5) a presentation team that produces materials for workshops and seminars.

Scenario studies can be worked out on different geographical scales: (1) global, (2) international regions such as OECD or EU), (3) national, (4) sub-national regions. Examples of global scenarios are the WEC and IIASA study ”Global energy perspectives (1995), the IPCC study on emission and climate change scenarios (IPCC 1995, 1996) and the TARGETS scenarios (Rotmans and de Vries 1997). The OECD scenarios "the world in 2020" is also a well-known example on the global economy (OECD 1997, 1999).

It is also possible to integrate different spatial scale levels. In the Visions project there was a two-way integration across scales (see Figure 13). In this project the integration went both ways: bottom-up and top-down. It is also possible to make theme-specific scenarios.

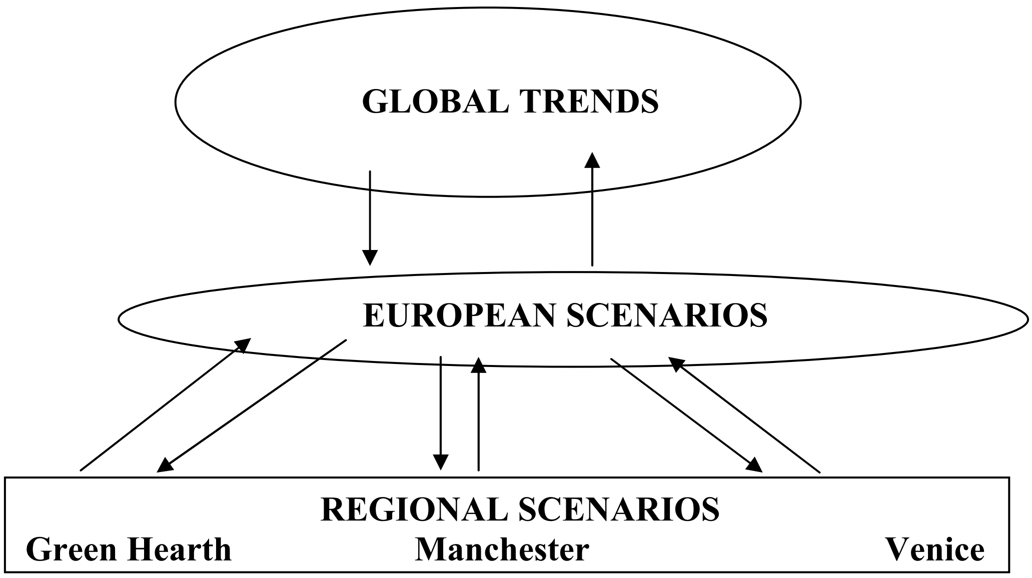

Figure 13. Integration of different scale levels in the Visions project (Visions team 2001)

Usually in local level planning it is useful to analyse three highly relevant things: (1) global trends, (2) locally relevant scenario families and (3) Wild Card -factors or weak signals. In this case the spatial planning process has the following structure for decision-making (Figure 14):

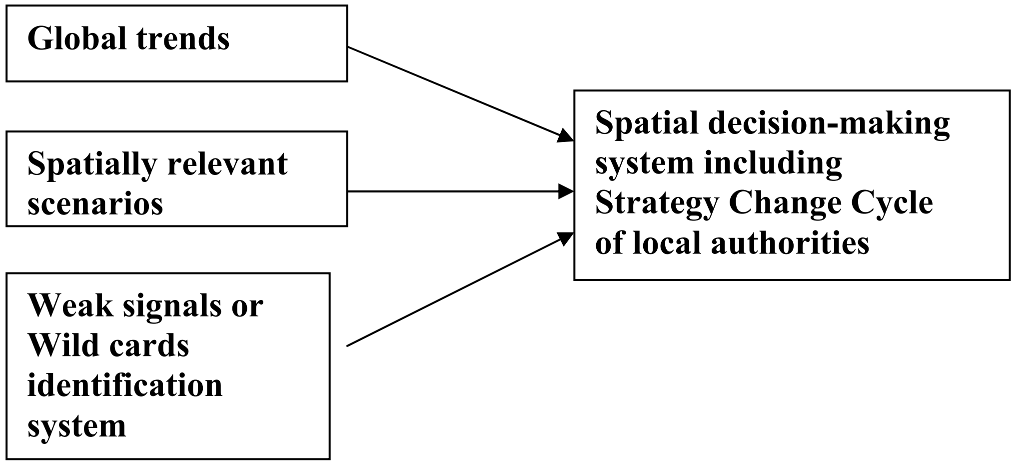

Figure 14. The regional foresight system in a nutshell

Scenarios differ with regard to the time-horizon addressed. They can be worked on the short and long term. Scenarios always, either implicitly or explicitly, embody the perceptions of their designers. Instead of hiding the crucial assumptions, uncertainties and choices underlying the scenarios, it is preferable to make them transparent. Related to transparency, is the issue of whether fundamentally different perspectives are taken into account. Perspectives are consistent descriptors of how the world functions and how decision-makers should act upon it (Rotmans and van Asselt 1996, 1999). Rotmans and van Asselt (1997) argue that the majority of current scenarios developed from a narrow, disciplinary based perspective display a lack of diversity. The incorporation of multiple perspectives may enable us to make subjective and normative choices explicit and to explore the frontiers of our knowledge. In contrast to scenario studies set, in which the set of scenarios is merely a variation on one scenario, scenario studies that comprise multiple perspectives have much more potential for informing and facilitating societal debate (see e.g. Tapio 2002). For an example of a scenario studies set see IPCC scenarios (1995) in which six scenarios, IS92a, IS92b, IS92c, IS92d, IS92e and IS92f are all simple variations on the IS92a scenario. Updated version of these IPCC trend variation scenarios is presented in (Nakicenovic and Swart 2000, Houghton, Ding, Griggs, Noguer, van der Linden and Xiaosu 2001, McCarthy, Canziani, Leary, Dokken and White 2001, Metz, Davidson, Swart and Pan 2001) "*Perspectives on global change. The TARGETS approach*" (Rotmans and de Vries 1997) is an example of a study adopting a multiple perspectives approach.

Scenarios can furthermore be characterised by the level of integration. To what extent is the mutual interplay between the considered social, economic, environmental and institutional development considered? A minimum condition to arrive at an integrated evaluation of the future is that the underlying scenario development process is interdisciplinary. An ideal integrated scenario study addresses both different cause-effect chains within one sector (vertical integration) as well as between different sectors and issues (horizontal integration) (Rotmans and van Asselt 1994, 1999).

Scenario methods can be classified according to (1) the character of the tools and (2) the focus of the scenario exercise. With regard to the first, we can distinguish between modelling, narrative and participatory methods. According to Anastasi (1997) a distinction can be made between the following scenario development approaches according to the focus of the scenario-exercise: (1) the global scenario approach, (2) the focused scenario approach and (3) single issue approaches.

Modelling methods involve the use of computer models, either as central means to explore the future consequences of a set of assumptions or as a tool to check the consistency of the developed scenarios. Narrative methods are usually deployed in cases where data is weak or missing. Pathways into the future are then qualitatively described. These two classes of methods are usually adopted in scenario projects involving a small "core" group of experts.

In contrast, participatory methods refer to approaches in which non-scientists, such as policy people, stakeholders and/or lay people play an active role. Rotmans and van Asselt (1999) distinguish three classes of participatory methods: dialogue methods, policy exercises and mutual learning methods. The dialogue method can be applied in cases where the intended users are considered as a source of information necessary for the experts to develop scenarios. In a policy exercise, a game is set up that represents a negotiation process in which the different teams are responsible for a certain country or region. The strategies used resulting from negotiation then provide the basis for the set of scenarios to be developed. In the mutual learning method, the participation of stakeholders and citizens enriches the assessment via a multiplicity of perspectives, skills and competence. The participants are all co-designers of the scenarios. The use of participatory approaches in scenario development is advocated with the argument that complementary heterogeneity in perspectives, expertise and knowledge is needed to guarantee sufficient "richness" (Anastasi 1997).

Futures studies have always worked with three problem fields: the probable, the possible and the desirable futures. They naturally demand somewhat different methods. The Copenhagen Institute for Futures Studies has summarised, on the basis of Roy Amara's ideas, the synopsis of the field of futures studies in Table 6 (The Copenhagen Institute for Futures Studies 1996, 8, Amara 1981a, 1981b):

Table 6. Synopsis of the futures studies (The Copenhagen Institute for Futures Studies 1996, 8)

	Possible	**Probable**	**Desirable**
Goal	Open up Wake Stimulate	Analyse Evaluate Systematise	Preparing preferences Winning support Supporting choice
Roles	Driven by images Visions	Driven by analysis	Driven by values
Tools	Realisable	Structural	Participation-Oriented
Agents	Visionaries Geniuses Writers Futurists	Analysts Methodologists Futurists	Charismatic leaders Social reformers Writers Futurists
Organi-sational form	None or one-person dominated Think tank	Think tank	Lobby group Idea organisation Businesses Companies

Thus it is important to understand that to work with futures is not to focus on the "creation of certainty", but to recognise a practical limitation in connection with the work regarding the handling of uncertainty.

In summary we note that there are various kinds of scenarios and there exist different kinds of classifications. The typical classifications are (see for example, the Copenhagen Institute for Futures Studies 1996):

- High probability-Low probability scenarios;
- Desirable-Non-desirable scenarios;
- Feasible-Non-feasible scenarios;
- Forecasting - Back-casting scenarios;
- Quantitative - Qualitative scenarios;
- Local - National – International - Global scenarios;
- Integrative - Non-integrative scenarios;
- Topical - Multi-topical scenarios;
- Internal - external scenarios;
- Scientific-Normative scenarios;
- Mono-sectoral – Multi-sectoral scenarios; and
- Short-Medium -Long run scenarios.

All these kinds of scenarios can be connected to sustainability analyses.

The use of indicators and indices is central to all scenario developments, irrespective of the method used. Indicators are pieces of information designed to communicate complex messages in a simplified, quantitative manner. Indices are aggregates, comprising and relating to different indicators.

One way to use scenarios is to combine scenarios to an Integrated Assessment (IA) approach. Rotmans and van Asselt (1996) define IA as: "Integrated assessment is an interdisciplinary and participatory process of combining, interpreting and communicating knowledge from diverse scientific disciplines to allow a better understanding of complex phenomena". The key objective of Integrated Assessment is to support public decision making by developing a coherent framework for assessing trade-offs between social, economic, institutional and ecological determinants and impacts (Rotmans et al 1997). Scenarios are useful tools in Integrated Assessment efforts. The development of scenarios can be seen as an aid in the process of assessing complex issues. Rotmans and van Asselt (1998) suggest how scenarios can be sensibly integrated in an IA tool-kit (see Figure 15):

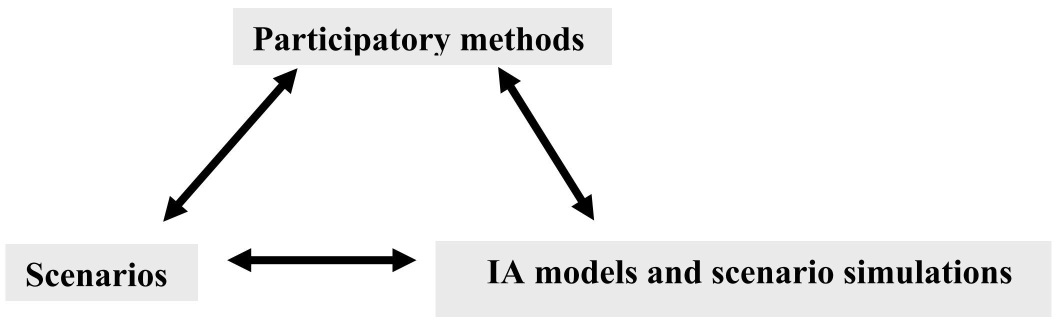

Figure 15. Scenarios integrated in a IA tool-kit (Rotmans and van Asselt 1998, van Asselt et al 1999, 15)

Many of the presented scenarios are far from integrated, due to a variety of reasons. First of all, they are incomplete and inconsistent with regard to both the assumptions and the resulting images of the future. Secondly, social, environmental, economic and institutional developments are not treated in a balanced way. Thirdly, scenario studies also mainly focus on just one geographical scale, and do not intend to incorporate dynamics between various scales. Fourthly, in addition, most scenarios are extrapolations of current trends and do not include surprises and bifurcations (trend versus peripheral scenarios). Fifthly, too many scenarios reason from one narrow perspective and thereby lack the requisite variety. Sixthly, they are not the result of a participatory or interdisciplinary process. Finally, policy recommendations are quite often lacking, or are conventional, vague and unrealistic (van Asselt et al 1999, 16, Kaivo-oja and Rillaers 2001).

Because of these identified problems, an ideal Integrated Assessment study should (van Asselt 1999, 16):

(1) describe dynamic patterns of changes,
(2) be transparent with regard to assumptions and choices,
(3) include a variety of perspectives,
(4) include both social, economic, environmental and institutional indicators,
(5) be consistent among different sectors, problems and scales,
(6) be coherent in the sense that (i) all relevant dimensions are addressed and (ii) all relevant interactions between the various processes are considered,
(7) indicate what are plausible and implausible prospects for the future,
(8) be challenging, with strong narrative as well as quantitative components,
(9) be developed in an interactive way involving a balanced and heterogeneous group of people,
(10) be actively disseminated among the target groups.

The use of indicators and indices is central to all scenario development, irrespective of the method used. Usually it would be wise to develop knowledge management systems in co-ordination with scenario analyses, because indicators are pieces of information designed to communicate complex messages in a simplified, quantitative manner.

In the following sections we analyse the basic frameworks for sustainability analysis. These frameworks can be used as part of a scenario analysis and as part of a regional planning process.

Basic scenario frameworks for sustainability analysis

In this study two basic frameworks for the sustainability analysis have been developed. The first framework includes the dimensions of economic growth, equity and environmental stock. The second framework includes the dimensions of economic growth, welfare and environmental stress. Both frameworks can be useful in regional sustainability analysis, because these frameworks include the basic triangular approach to sustainable development. In the next section, I will present some theoretical discussions, which are connected to the Equity - Economic growth - Environmental stock scenario framework. In the following sections I will present some short theoretical discussions concerning the Welfare - Economic growth - Environmental stress scenario framework.

Equity-Economic growth-Environmental Stock -scenario framework

In this thesis Equity-Economic growth-Environmental Stock -scenario framework is presented in detail in article 1, article 6 "*Alternative scenarios of social development: Is analytical sustainability policy analysis possible? How?*" and in article 7 "*Social and ecological destruction in the first class: a plausible social development scenario*" (Kaivo-oja 1999, Kaivo-oja 2002). The main point of these contributions is that environmental problems may result from differing developmental processes in different national contexts, depending upon "the pattern of structural change in natural and man-made capital stock,...and technological capabilities." Sustainability must be defined within this framework, ensuring "at least a minimum socially desired rate of growth in the long-run" (Karshenas 1994). This implies that sustainable development policies will not be identical in industrialized and developing economies as well as in different kinds of regions and more problem-oriented sustainability policies are needed. Given these differences, we argue that environmental policies cannot be uniformly applied to industrialized and developing nations. (Karshenas 1994, Kaivo-oja 1999, 2002)

In the case of advanced countries like Finland we are dealing with post-industrial economies, characterised by a growing share of services in both the national income and in exports. Economic growth in such economies is embodied in the production of goods and services with high and increasing technological sophistication and skill intensity, and declining natural resource intensity. Unemployment in these economies is either cyclical, a unique phenomenon or one that is related to a high rate of automation in the economy rather than to a shortage of capital and other complementary resources. Environmental concerns at the local level have more to do with improving the quality of life than with warding off threats to subsistence posed by environmental degradation. Despite the relatively low and declining natural resource/value added ratio in final output, post-industrial countries are nevertheless the major consumers of natural resources at a global level (see the e.g. Luukkanen and Kaivo-oja 1999, Kaivo-oja 2000). These wealthy countries are the main sources of worldwide environmental problems such as global warming, ozone layer depletion, acid rain etc. In this sense, these post-industrial countries face enormous challenges in their sustainability policies. Equity related problems are a part of that challenge (Kaivo-oja 2000).

The developing countries are still in the process of changing from primary sector based economies into industrial economies. The natural resource/value added ratio in these economies is much higher than in the advanced economies. In addition, they still have a higher output elasticity of natural resource use than the post-industrialised countries. The majority of the population in these countries is immediately dependent for their livelihood on their natural resource use. Their man-made capital stock is meagre and technologically they are well behind the advanced countries. They also suffer from the massive unemployment and under-employment of labour, which is the result of a shortage of man-made capital and complementary resources rather than a cyclical phenomenon or one related to high rates of automation. Throughout the world, environmental degradation in many instances is related to economic backwardness and slow economic growth rather than being a matter of a growing economy pressing against the limits of the natural resource base.

According to Karshenas environmental problems can be classified into two groups. In the first group are those related to the application of modern technology, to economic growth, to advances in technology and to higher income and consumption levels. In the second group are the problems related to economic backwardness, poverty, unemployment, stagnant technology and slow growth in general. The first group of problems is shared by both the advanced countries and the modern sectors of the developing countries. The second group is largely specific to the marginal sub-sector of the developing economies (Karshenas 1994, 743).

The literature on environmental or ecological economics has grown steadily in recent years (see e.g. Taylor 1996, Hanley, Shogren and White 1997, Köhn, Gowdy, Hinterberger and van der Straaten 1999). This literature has been mainly concerned with the evaluation of environmental resources and environmental policy implementation in the context of market economies where missing or incomplete markets are confined to the environmental resources in question. Karshenas (1994, 723) has noted that where market failures are more generalised, the existing paradigm may not be adequate. In many societies interactions between employment, technology and environment, are critical in the process of development. Sustainable development can be defined in terms of the pattern of structural change in natural and man-made capital stock, inclusive of human capital and technological capabilities, which ensures the feasibility of at least a minimum socially desired rate of growth in the long-run perspective. It can be argued that below this minimum, options open to the economy in terms of environmental resource depletion rates become increasingly limited, and a process of forced degradation will take place.

Karshenas´s new theory of sustainable development allows a crucial distinction to be made between environmental problems associated with high-income levels and technological progress and those associated with stagnation. In the case of economies at or below the forced environmental degradation frontier, it is argued, there exists an unmistakably complementary relation between employment generation (and higher income levels) and environmental pressures.

Natural resource constraints have been neglected in mainstream economic theorising until very recently. With some classical political economists they received some treatment with the assumptions of land scarcity and diminishing returns, which figure most prominently in the Ricardian theory of rent and his discussion of long-term stationary states. Observing the enormous powers of technological change, which in practice had more than compensated the forces driving towards the Ricardo-Malthus stationary state, modern economic theory found it convenient to abstract totally from natural resource scarcities. In both the static general equilibrium models and the dynamic growth models natural resources were treated as free gifts of nature (Malthus1978, Karshenas 1994, 725).

It would, however, be a mistake to regard the neglect of environmental resources as a shortcoming of the economics discipline as such - or one that essentially originated in economics or any other social science (including regional science). Environmental problems are normally associated with renewable natural resources, which are in danger of exhaustion or irreversible depletion as a result of ”excessive” use. Such renewable resources are regenerated at naturally given rates, and it is in relation to this natural rate of regeneration that ”excessive use” is defined. The rate of regeneration could itself also be damaged by excessive use or over-pollution of the resource. Of the numerous examples of environmental damage highlighted by ecologists in recent years, almost all refer to renewable resources. (Karshenas 1994, 725). However, there are many environmental problems, which are connected to non-renewable resources.

Global problems related to atmospheric pollution, such as the greenhouse effect, ozone layer depletion and acid rain, plus those related to soil degradation, deforestation, water resource depletion and pollution are all examples of the depletion or degradation of what essentially are renewable resources (Luukkanen and Kaivo-oja 1999). These resources contrast with the exhaustible natural resources, where any rate of resource depletion will lead to the ultimate exhaustion of the resources with limited stock. The earth's atmosphere can regenerate its composition up to a certain limit of the flow of atmospheric pollutants. The productive powers of arable land and grazing land are regenerated depending on the rate of use and type of vegetation cover. Both the quantity and quality of recoverable water from aquifers depends on the rate at which they are depleted. The reproduction of the populations of animals, plants, birds and fish are also subject to the same natural regeneration process. (Karshenas 1994, 724-725).

Under circumstances where the rate of use of the environmental resources is below their natural regeneration rate, such resources could in effect be regarded as having an infinite supply. In that case they will not command any scarcity value or rent, and the assumptions of the free disposal and free gifts of nature can be said to apply. However, the concern over environmental degradation at a global level is indicative of the change in the perception of the closeness of the world economy to exceeding the limits for the regeneration natural resources. A new consensus seems to have emerged to the effect that the rate of global environmental resource depletion has by far surpassed the natural regeneration rate, and human economic activity is depleting the natural resource base at an unsustainable rate (Karshenas 1994, 726). The fact is that this realisation is only a recent one - the Club of Rome report presented by Meadows et al (1972) sounded the first real alarm bells.

It must be said that there is still a lack of scientific knowledge and there exist many uncertainties. Incomplete scientific knowledge is one source of uncertainty connected with environmental issues. Another source of uncertainty is technological development. A central link in economy-environment interactions is technology and a lack of knowledge about possible future technological trajectories is another important source of uncertainty with regard to environmental processes. While the scientific uncertainty connected with environmental issues can be expected to diminish with the growth of the scientific knowledge of ecosystems, the technological uncertainty will always be present. Uncertainty over the potential future use of the resources becomes particularly important when combined with the irreversibility of resource depletion. (Karshenas 1994, 726).

Another important feature of environmental degradation processes is their irreversibility. Loss of biological diversity and the extinction of plant and animal species are obvious examples of irreversibility. In the majority of cases, however, it is the prohibitive cost of repairs or the time scales involved, which makes these processes practically irreversible. For example, the accumulation of greenhouse gases, and in particular carbon dioxide, is irreversible over periods of hundreds of years (Cline 1991).

Various environmental resources have the character of public goods, in the sense that the damage done by one agent has inevitable repercussions for various other economic agents as well. Usually it is difficult to exclude one from being affected by the damage. The lack of excludability often implies that the costs cannot be reflected in actual or potential market exchanges. Environmental problems are therefore often associated with incomplete or missing markets.

At rates of use or pollution below the natural regeneration rate one can judiciously ignore the renewable environmental resources, while at higher rates, where the depletion of such resources sets in, it becomes crucial to introduce these resources as economic goods. In that case, the analysis of the depletion of renewable natural resources would have much in common with the exhaustible resource theory (see e.g. Dasgupta and Heal 1979, Fisher 1988), which was largely inspired by Hotelling´s seminal paper of 1931). The resources covered in that literature were natural resources for which a market exists. They were natural resources being exchanged in the market as commodities. On the other hand, a distinguished feature of environmental resources, related to the ”externality” aspect discussed above, is that for them a market does not or cannot exist. They are natural resources with missing or incomplete markets (Cornes and Sandler 1986). The dominant theoretical paradigm in the new economics of environment is therefore constructed by a combination of elements from the exhaustible resource theory and the theory of externalities, integrated into the main body of the general equilibrium theory. The exhaustible resource theory provides the elements for the valuation of environmental resources in an inter-temporal context. Secondly, the externality theory furnishes the basis for the valuation of environmental costs arising from the interdependence of economic activities as well as policy interventions in the face of missing markets.

This dominant paradigm is problematic. Problems are connected to the valuation of environmental resources (i.e. the optimum depletion of resources) and to the question of implementation (i.e. environmental policy intervention in the face of missing markets). The laissez-faire or free-market approach to the environmental question draws upon Coase´s famous article (1960) to suggest a solution to both valuation and implementation problems at one go. This approach identifies the problem of missing markets with the lack of the assignment of property rights by referring to environmental resources as global commons.

According to the Coase theorem (1960), the degradation of environmental assets such as the atmosphere, oceans, lakes, grazing land, forests, etc. arises from the lack of existence of property rights in these natural assets. With the strict definition of property rights the problem of missing markets would be taken care of, and the question of valuation would be dealt with by the market itself in a similar way to other commodities exchanged in the market. If the property rights are vested in the polluter, the affected stakeholders can negotiate with the polluter to reduce pollution in lieu of the payment of monetary compensation. Alternatively, with the property rights given to the affected stakeholders, the polluter has to buy the right to pollute. With the assignment of property rights the market is complete and it expected to reach a Pareto efficient outcome under perfect competition. Coase´s theorem was put forward in the context of externalities involving only two agents, and abstracted from intergenerational externalities (see Farrell 1987, Kirman 1992). However, this simple approach excludes the majority of environmental resources highlighted in recent literature. With the increase in the number of agents transaction costs may became prohibitive and an efficient market solution may not emerge. Furthermore, the intergenerational aspects of environmental problems make the assignment of property rights impossible.

Work on the valuation of environmental resources has grown rapidly in recent years, both in the literature on cost-benefit analysis (CBA) and in the national accounting literature. However, the valuation issue poses acute problems. Some of these arise from the complex interdependencies between different economic activities and the multifaceted aspect of externalities arising out of any particular environmental resource-using activity. The informational problems thus posed for the evaluator are further compounded by the difficulties of inducing the economic agents to reveal the correct information (Kirman 1992). Another important source of difficulty is the inter-temporal aspect of environmental resource use and the question of uncertainty. In this case, a lack of information about the potential future use of the resources, which may be made possible by future technological developments, makes the assignment of probabilities to all possible future outcomes, and hence the use of choice theoretical calculus under uncertainty, extremely problematic. It may also be good to know that Perrings (1987, 1989) has pointed out; under these circumstances one may not even know the possible set of future outcomes, let alone be able to assign probabilities to them. These problems are still further compounded by factors such as the irreversibility of many environmental depletion processes, which entails added intrinsic value to the preservation of the resources. The intrinsic value of the environmental resources for the community - the non-use value or existence value of the resources and intergenerational welfare comparison are both basically moral issues. (Karshenas 1994, 729). The valuation of moral issues is always very problematic issue.

In real-life the valuator has to do his best, given the available information. The present evidence, which suggests the excessive depletion of environmental resources (see e.g. Brown et al 2000), is indicative of the fact that we can certainly do better than the zero valuation of environmental resources currently prevailing. These complications do render the definition of sustainable development, in terms of optimum depletion paths, problematic.

So there are serious problems in applying this theoretical approach in real-life contexts. Both the valuation problem (optimum depletion of the resource) and the implementation problem (the policy in the face of missing markets) remain unsolved in many modern societies. In these circumstances it would be more useful to define sustainable development in terms of the feasibility of the growth path.

Economists did not seriously discuss the question of the sustainability of the economy before the recent concerns about the environment brought it to the fore. Kuznets (1955, 1966) in fact defined economic growth in terms of sustained increases in per capita income and sustained structural change in the economy. A crucial and important element in the very definition of income in Hicks (1946) is its sustainability. However, these earlier approaches to sustainability were concerned with an open economic system with unlimited access to "free gifts of nature". Sustainability was thus defined in terms of an adequate structure and rate of accumulation of man-made capital stock. Many of the recent attempts to define sustainability in relation to the economy-environment interactions are nothing but technical extensions of these earlier definitions to the new, broader context.

Various definitions of the concept of sustainable development have been put forward. The Brundtland report defines sustainable development as: "*Development that meets the needs of the present without compromising the ability of future generations to meet their own needs. A process of change in which the exploitation of resources, the direction of investments, the reorientation of technology development, and institutional change are all in harmony and enhance both current and future potential to meet human needs and aspirations*" (WCED 1987, 43-46). By making the long-term realisation of human needs and aspirations central to the concept of sustainable development, the Brundtland Commission's definition distances itself from the eco-centrist definition of sustainable development in the so called "deep ecology" approach (Devall and Sessions 1985, Naess 1973). Deep ecologists define sustainable development in terms of the imperatives for the preservation of the ecosystem rather than the satisfaction of "human needs and aspirations". Deep ecologists usually assume that technological fixes would likely to lead to more intractable and costly environmental problems and by implication, given their prognosis that the world's economy has long been on an unsustainable path, they adopt an anti-growth stance. At the extreme, some of the advocates of the deep ecology approach expect the whole world to return to pre-industrial, rural lifestyles and standards of living (Colby 1990).

Karshenas (1994, 733) has pointed out that even if one shares in the technological pessimism of the deep ecologists, and their contention that the world's economy is on an unsustainable path, –(both of which seem to be contrary to the evidence) their anti-growth stance still does not withstand the test of rigorous examination. Many problems of environmental degradation arise from a lack of development and growth rather than excessive growth. One of the most important reasons for this may be a positive connection between investing or saving and the average economic growth rates (Bretschger 1999, 5-6). Pearce and Markadya (1989, see also Pearce, Markandya and Barbier 1989, Pearce 1993a, 1993b, 1998a, 198b, Pearce, Barbier and Markandya 1990, Pearce and Atkinson 1995) have used the same general definition of sustainability as the Brundtland Report and shunning the technological pessimism and anti-growth stance of the deep ecologist, still define the condition of sustainability in terms of the constancy of the natural capital stock. They have presented the following definition of sustainable development:

"We can summarise the necessary conditions for sustainable development as constancy of the natural capital stock; more strictly, the requirement for non-negative changes in the stock of natural resources, such as soil and soil quality, ground and surface water and their quality, land biomass, water biomass, an the water-assimilation capacity of the receiving environments" (Pearce et al 1988, 6). Dasgupta and Maler (1990) have criticised the above definition as a "common misconception" which confuses "the determinants of well-being with the constituents of well-being". This kind of criticism is fair enough, but its validity depends largely on the assumption that the economy or society is well within what Karshenas calls the "sustainability frontier". On the other hand, this definition to a large extent abstracts from two important features of environmental resources, namely, uncertainty and irreversibility (Karshenas 1994, 734-742).

Dasgupta´s and Maler´s (1990) own definition of sustainable development in terms of their optimum depletion paths leaves much to be desired especially in terms of its operational value. Given the problems of uncertainty, irreversibility, lack of information, and the complex interdependence between different resource-using activities in a dynamic setting, the concept of an optimal depletion path, though theoretically rigorous, contributes little to the understanding of the processes of technological development and policy requirements.

An illuminating and operationally useful concept of sustainable development is to define it in terms of feasible growth paths. Then sustainable development may be defined in terms of structural change in natural and man-made capital stock (including human capital and technological capabilities), that ensures the feasibility of at least a minimum socially desired rate of growth in the long run. A minimum socially desired rate of growth could be defined in different ways depending on the level of development and specific socio-historical characteristics of the country (or region) in question. For the majority of Third World countries a useful definition may be a rate of growth, which is necessary to cater for the basic needs of the population. Forced environmental degradation can also take place in an economy, which is witnessing rapid growth, because of a lack of adequate employment generation, the maldistribution of income and pervasive poverty in increasingly marginalised sections of the population. To the extent that this pattern of lopsided or uneven growth leads to environmental degradation on a scale, which endangers the long-term viability of the growth process (thus the minimal growth process defined above), then it falls outside Karshenas´s definition of sustainable development. In real life it is possible that in cases where lopsided or uneven development paths can be shown to fulfil the conditions of environmental sustainability, one may still find unsustainable sub-economies consisting of the marginalised sectors within such economies. The definition of sustainability with regard to sub-economies carries the danger of losing sight of the inter-linkages between the overall pattern of development and the prevailing economic conditions in the marginalised sub-economies.

The fundamental idea of Karshenas´s theory of sustainable development is that sustainable development in essence refers to the ability of a growing economic system to avoid approaching the catastrophic danger zones of economic growth rates and environmental stock levels. Sustainability is a concept, which refers to the performance of the economy over the very long term. It therefore entails plenty of foresight. The problem is that we do not have complete knowledge about environmental processes and perfect foresight over the very long term (Karshenas 1994, 736-742). Hence, we have to live with a large element of uncertainty. The stock of natural capital cannot be interpreted as a single specific value of the stock of natural capital, but rather a band or a region where the likelihood of disasters becomes high and the ecosystem's stability is diminished. A similar argument holds in relation to income levels per capita, which in addition to being partly determined by the natural capital stock is also subject to other external shocks. The closer to the left and bottom of this area the economy approaches, the higher the ecosystem instability would be, in the sense that shocks to the system tend to have increasingly more persistent and severe effects. This kind of broader notion of sustainability, which incorporates the uncertainty aspect of the environmental aspect of environmental resources, corresponds to Conways´s definition of sustainability as "the ability of a system to maintain its productivity when subject to stress or shock" (quoted in Barbier 1989b, 441). The minimum levels of income level and environmental stock in this stochastic interpretation of sustainability can be interpreted as absorbing states which should be avoided by keeping the system as far as away from them as possible. If the critical minimum level of environmental stock is exceeded the system will collapse. Below a critical income level it will be inevitable that the system is forced into an environmental degradation trap.

Karshenas´s definition of sustainable development in terms of minimal feasible growth paths brings to the fore the case of the least developed countries or regions or sub-sectors within countries which are perilously close to the forced environmental degradation frontier. It also warns against treating every case of environmental resource depletion as environmental degradation and a cause for policy action. The central policy question is whether such resource depletion is accompanied by the simultaneous accumulation of man-made capital stock, the acquisition of technological know-how and an appropriate pattern of structural change and growth that ensures the sustainability of the development process. This in turn points to the important fact that environmental resources should not be treated as exogenous constraints to the growth of the economy. Rather, they are endogenous to the development process in the sense that the same rate of growth may be achieved at different rates of resource depletion, depending on the pattern of growth and the acquired technological capabilities of the economy. This raises the more general question of complementarity and the trade-offs between the environment and economic growth.

In Karshenas´s theory of sustainable development there is a strong relation between basic needs and the environment. This relation was discussed already in the 1970s and was, for example, a central issue in the Bariloche report (Herrera et al 1976) and in the paper by Matthews (1976), as clearly suggested by its title "*Outer Limits and Human Needs*". However, in all economies, even those which are on a sustainable development path, it may be possible to increase the efficiency of resource use and achieve higher rates of growth with the same rate of resource use and achieve higher rates of growth with the same rate of resource depletion. In this sense, the limits of potential sustainability measures in different economies and regions are vague.

Let us consider the case of an economy in full employment equilibrium and growing along a steady growth path at a rate equal to the rate of population growth. The technology is given and the economy has full employment. Steady state growth in the present context means that the rate of environmental resource depletion is at or below the natural regeneration rate, and therefore the environmental constraints can be ignored. This is the paradigm within which most of the conventional economic growth theory is discussed in the literature (see e.g. Bretschger 1999, 187-200).

Now let us assume that at a certain point in time it is realised that, given the environmental constraints, the prevailing growth path is no longer sustainable. In this case, measures have to be introduced to protect the environment in order to avert the collapse of economic growth in the long term. In real life three types of environmental protection are possible. The first are preventive policies aimed at reducing the rate of environmental resource depletion at source. The polluter-pays principle and various other policy instruments discussed above are examples of such measures, which attempt to influence the behaviour of polluters. The second types of policy are corrective policies. These normally take the form of investments aimed at cleaning up pollution or compensating for the environmental resource depletion after the damage is done. The third types of policies are adaptive policies. These policy measures often take the form of investments that adapt the economy to be able to cope with the undesirable side effects of environmental degradation.

What is common to these three policy types is that in all the cases the economy incurs an economic cost in terms of the real resources, which have to be devoted to environmental protection. Given that the economy is assumed to be in full employment equilibrium, these resources have to be diverted from other activities. Then environmental protection appears to be taking place at the expense of economic growth. It is quite clear that the addition of an extra binding constraint (the environmental resource constraint) would lead to a reduction in the rate of growth of the economy.

In thesis I have used Karshenas (1994) approach as a starting point in scenario construction. In Figure 16 there is a graphic presentation, which describes the basic ideas of this approach. In Figure 16 the vertical axis represents the stock of environmental resources (denoted by ER), and the horizontal axis indicates some measure of wellbeing or standard of living (denoted by Y). In this thesis I have used as a measure of standard of living GDP per growth index. Er_{min} is the minimum stock of environmental resources below which the stability of the ecosystem would be disrupted and the natural resource base cease to be sustainable even for the minimum subsistence requirements of the economy. Environmental resource depletion would continuously move the economy towards ER_{min}. Along such a path, welfare would decline as a result of the loss of natural resources. Arrows in Figure 16 mark these types of paths. This may, however, be compensated for through the accumulation of man-made capital and technological progress, which leads to higher standards of living and thus a higher GDP per capita level. The region to the left of NR_{min} indicates ecological catastrophe where welfare would fall to zero, and hence has to be avoided. Sustainable development in essence refers to the ability of a growing economic system to avoid approaching the catastrophic region to the left of NR_{min}.

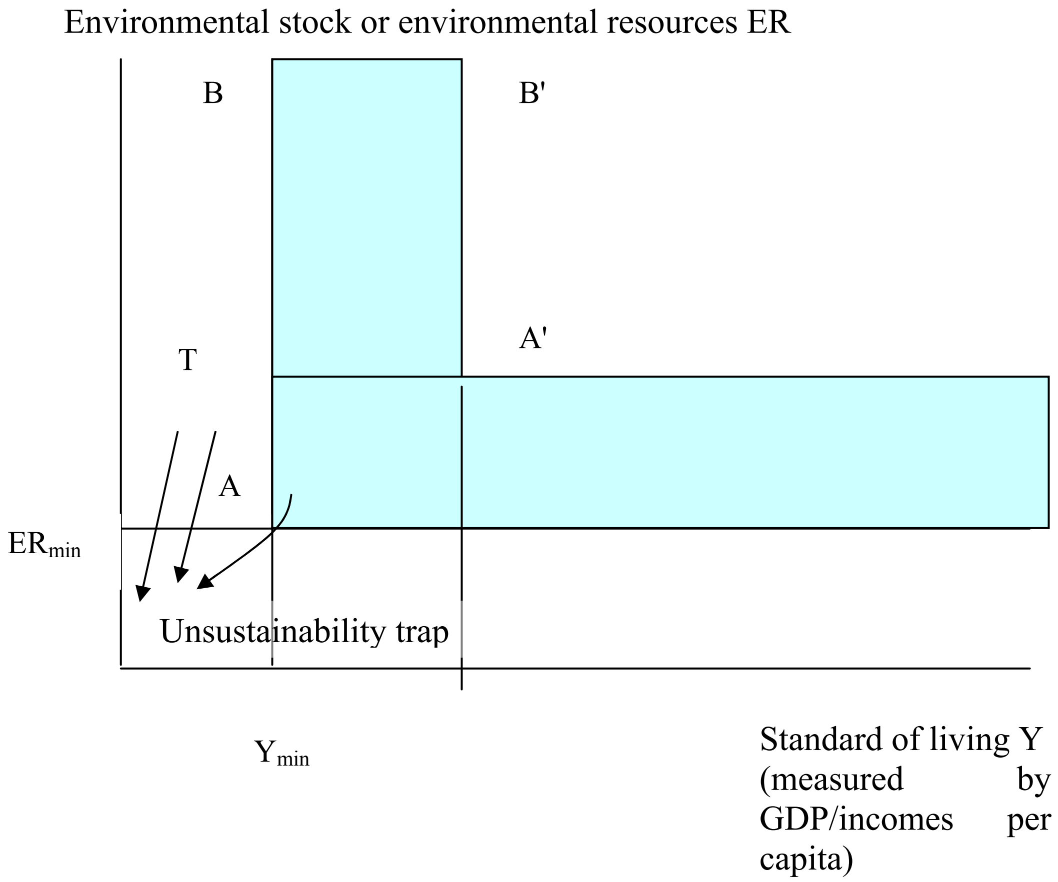

Figure 16. Sustainable and non-sustainable zones (Karshenas 1994)

Y_{min} refers to the minimum standard of wellbeing characterised by the basic needs of the population, which, are assumed measured by GDP per capita levels. Y_{min} refers to the absolute level of wellbeing. Below Y_{min} the regional economy would be caught in the forced environmental degradation trap. The development of such a regional economy is characterised by the arrows in the figure, along which the declining natural resource base may even be accompanied by a further decline in the standard of living. This may be the situation of a regional economy with a stagnant technology, low investment and capital stock, and a growing population, which eats into the natural capital stock in order to survive. According to some analyses this portrays the prevailing conditions in a number of Sub-Saharan African economies. Such an economy is surely non-sustainable, and without external assistance it would end up in a Malthusian catastrophe as the regional economy approaches Nk_{min} (Malthus1978, Karshenas 1994, 736-737). I call this situation to be an unsustainability trap situation.

It should be noted that sustainability does not refer solely to the condition of the economy as it exists now or will exist in a few years' time. It is rather a concept that refers to the performance of the economy over a very long term. It therefore entails plenty of foresight. The problem is that we do not have complete knowledge about the environmental processes, and perfect foresight over the very long term. That is why there is an urgent need for futures studies in this field. NR_{min} as interpreted above cannot be a single specific value of the stock of natural capital, but rather a band or a region where the likelihood of disasters becomes high and the ecosystem’s stability is diminished. This broader notion of sustainability, which incorporates the uncertainty aspect of environmental resources corresponds to Conway's definition of sustainability as 'the ability of a system to maintain its productivity when subject to stress or shock' (quoted in Barbier 1989, 441). The two lower limits of NR_{min} and Y_{min} in this stochastic interpretation of sustainability can be interpreted as absorbing states, which should be avoided by keeping the system as far away from them as possible. To the left of the NR_{min} line the regional system would collapse, and below the Y_{min} line it will inevitably be caught in the forced environmental degradation trap. (Karshenas 1994, 737).

The region in the top right-hand side of Figure 17 bounded below by the B'A'C' - line is the sustainable development region. As long as the economy remains above this line, it could be regarded as being on a sustainable development path. For example, Pearce et al (1989) in defining the constancy of the natural capital stock as the condition of sustainability implicitly assume that the regional economies are always very close to or actually in the un-sustainability region. This issue is demonstrated in Figure 17. Here the economy is moving along the path denoted by g, which is well within the sustainability frontier. At point x, however, the regional economy is too close to the non-sustainability frontier and the least it can do in remaining sustainable while maintaining its growth is to travel along the x-w path, that is keep the natural capital stock constant. The whole of the dotted region above the w-x-u line is considered the growth-maintaining sustainable region for an economy, which is at point x. Which particular future path within that region is adopted depends on factors such as technological progress, the degree of the reversibility of technological processes, population growth, the adopted rate of growth of the economy, etc. (Karshenas 1994, 738).

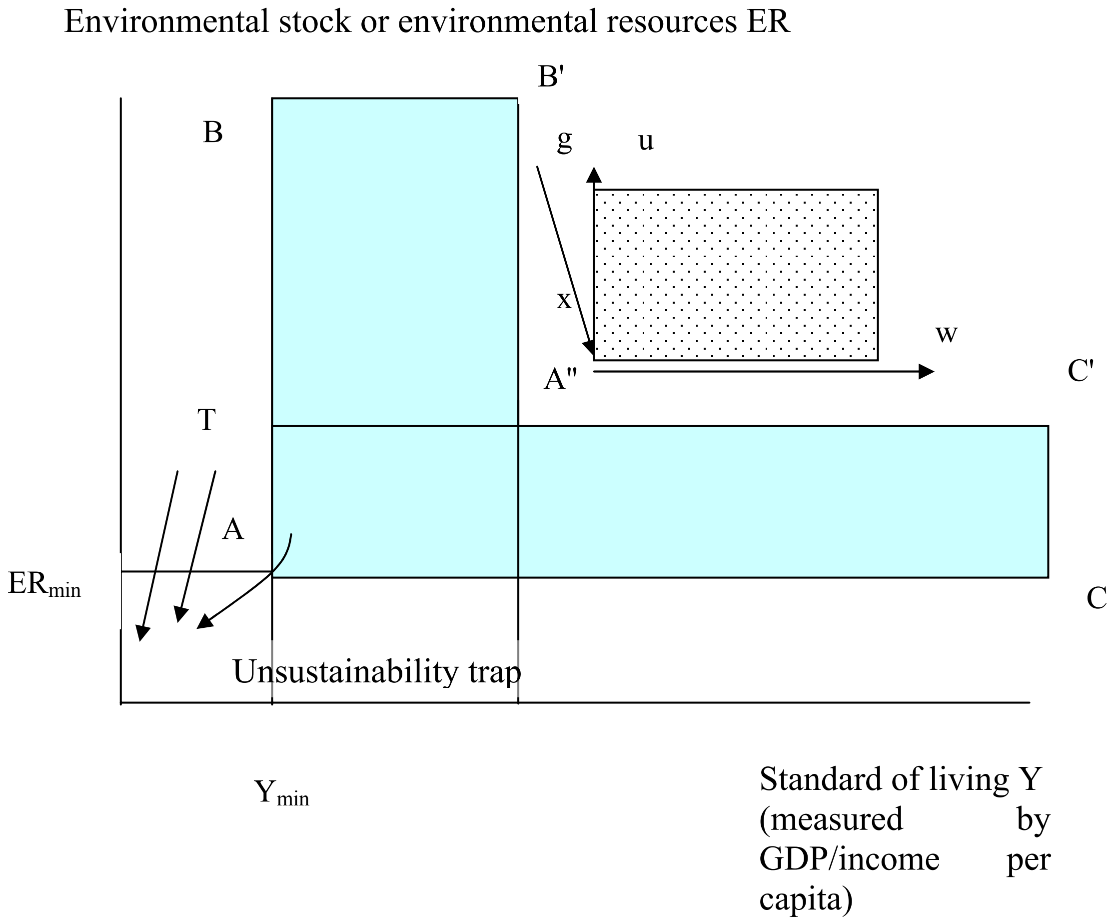

Figure 17. Sustainable development (Pearce et al 1988)

Pearce et al's (Pearce, Barbier Markandya 1990, Pearce and Atkinson 1993) definition of sustainable development is not generally valid for all environmental resources and all parts of the world. It is possible that some regional economies are travelling along a development path such as D in Figure 18. This economy is well endowed in terms of the stock of natural resources, though it clearly follows an unsustainable development path. The reason for non-sustainability in this case may be low stock and an increase in man-made capital stock, technological backwardness and stagnation combined with population growth which forces the economy to eat into its natural capital stock, and results in a clear case of forced environmental degradation. In some cases it may be efficient for a developing economy, in transition from a natural resource based economy to an industrial economy, initially to run down its natural resource base in order to accumulate man-made capital. This case is depicted in the development path G in Figure 18. This strategy requires, however, that these economies can reconstruct their natural capital stock depleted in earlier stages of their development. In a way, this strategy is analogous to the environmental Kuznets curve hypothesis process.

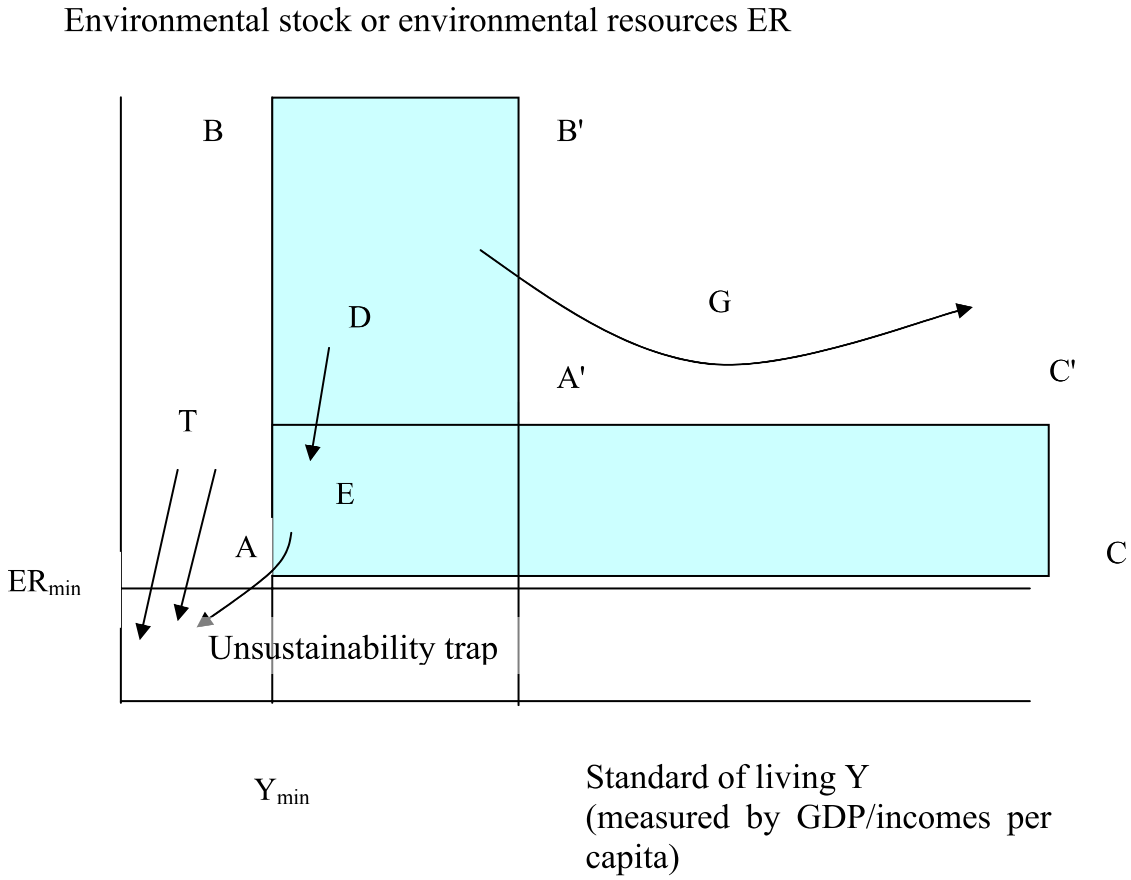

Figure 18. Sustainable development (Pearce et al 1988)

In many economies there are two strategies available. It may adopt policies with the immediate aim of replenishing the stock of environmental resources as its priority. This make take the economy along path, where income levels continue to decline while initially the stock of natural capital stock is being augmented. On the other hand, an alternative path may be a development-oriented approach where the stock of natural capital stock may continue to decline in the short run while man-made capital stock is being accumulated and alternative employment is created for marginalised labour. The regional economy according to this second alternative may travel along a path similar to G, while path E may lead to disaster as the level of income falls below Y_{min}. Along path G it may be possible to replenish the stock of natural capital at a later stage when the standard of living is high enough and the economy has the technological capability to make such a task affordable. (Karshenas 1994, 753)

In this section I presented the analytical background of Karshenas's (1994) new sustainability approach. This approach is connected to the growth-equity-trade off theory in this thesis (see e.g. Okun 1975, 1997). In this thesis I connected equity aspects to Karshenas's theory (in articles 6 and 7). In his study Okun: (1975, 88) has noted that: "If both equality and efficiency are valued, and neither takes absolute priority over the other, then, in places where they conflict, compromises ought to be struck. In such cases, some equality will be sacrificed for the sake of efficiency, and some efficiency for the sake of equality." Figure 19 shows the equity-efficiency frontier. The idea of an equity-efficiency trade-off frontier is that there is an actual trade-off between equity and efficiency and it is important to emphasise that the equity-efficiency trade-off is encountered repeatedly in the evaluation of the detailed provisions of any regional development programme.

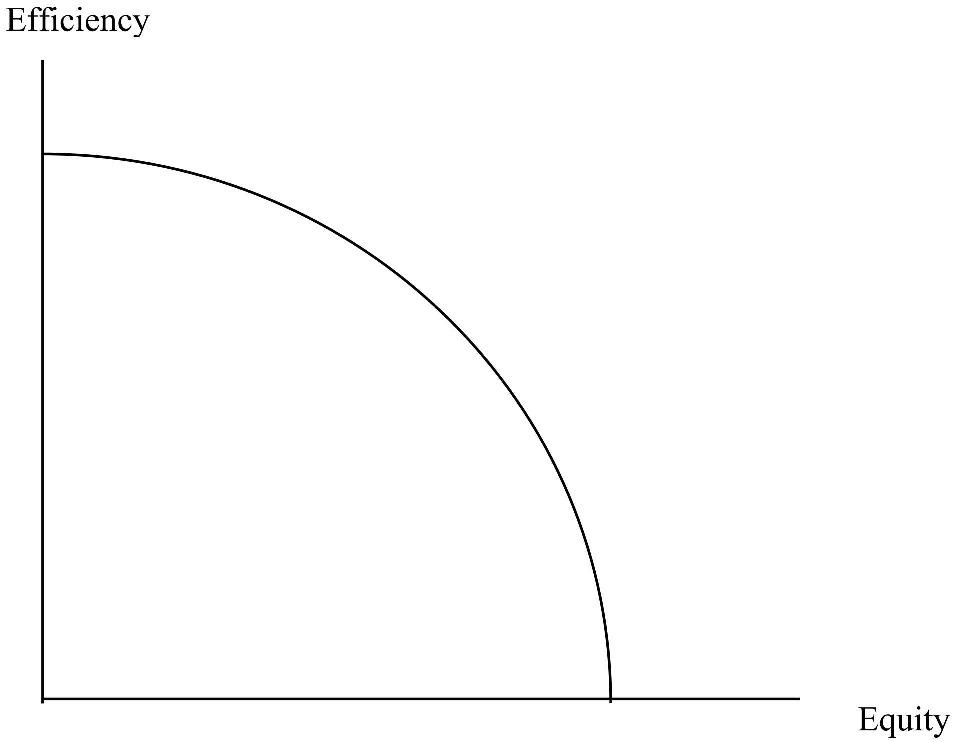

Figure 19. Efficiency-equity trade-offs (Stiglitz 1988, 251, Okun 1975, Okun 1997)

In two articles (articles 6 and 7) if this thesis I have connected this approach to Karhenas's (1994) ideas of sustainable development. I have assumed that efficiency is correlated to living conditions and Gross Domestic Product per capita and thus available incomes per capita in the economy. The basic idea of the scenario framework developed here is that equity and economic growth and other variables are measured by different measurement methods. Usually equity is measured by Gini-coefficients. I have also assumed in the developed scenario framework that environmental stock per capita enables different levels of efficiency-equity trade-offs in the long run (see Figure 20). I call this assumption the Kaivo-oja -hypothesis of equity-efficiency-environmental trade-offs (Figure 20).

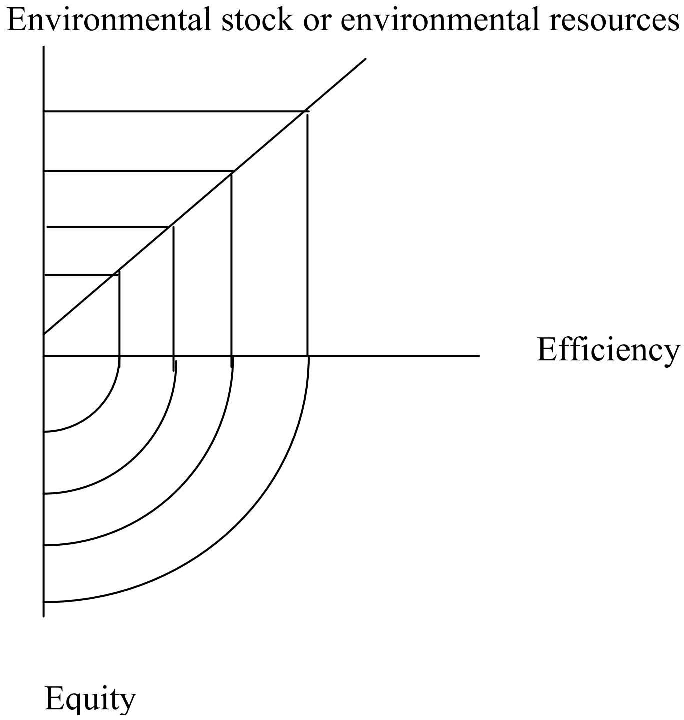

Figure 20. Equity-efficiency trade-offs and environmental stock of resources

This assumption implies that environmental stock available determines possible equity-efficiency, at least to some extent. Regional authorities and governments must always decide, how they emphasise equity and efficiency issues in their sustainability policies. Breit (1974) has illustrated this policy choice by the very simple "geometrical artefact". This shows how society's chosen combinations of efficiency and inequality can be explained. Breit posits a relationship between output and inequality via monetary income - the output possibilities curve in which output is a concave function of the Gini coefficient (see Lambert 1993, 42-45).

In Figure 21 output is maximised at point A in the absence of any government intervention to redistribute income. Such intervention induces resources away from their most efficient uses. In this situation the problematic question is; if unequal rewards are necessary for the maximal production of wealth, to what extent should a government intervene in determining distribution? Usually output (or total per capita Gross Domestic Product or income is a social "good" and inequality (as measured in this instance by the Gini coefficient) is a social "bad". In Figure 21 the social preference relation, expressed over Gini-output-combinations, is represented by convex upward-sloping indifference curves. The resulting optimum defines society's choice of re-distributive instruments and thus, some output is traded away for a limited reduction in inequality.

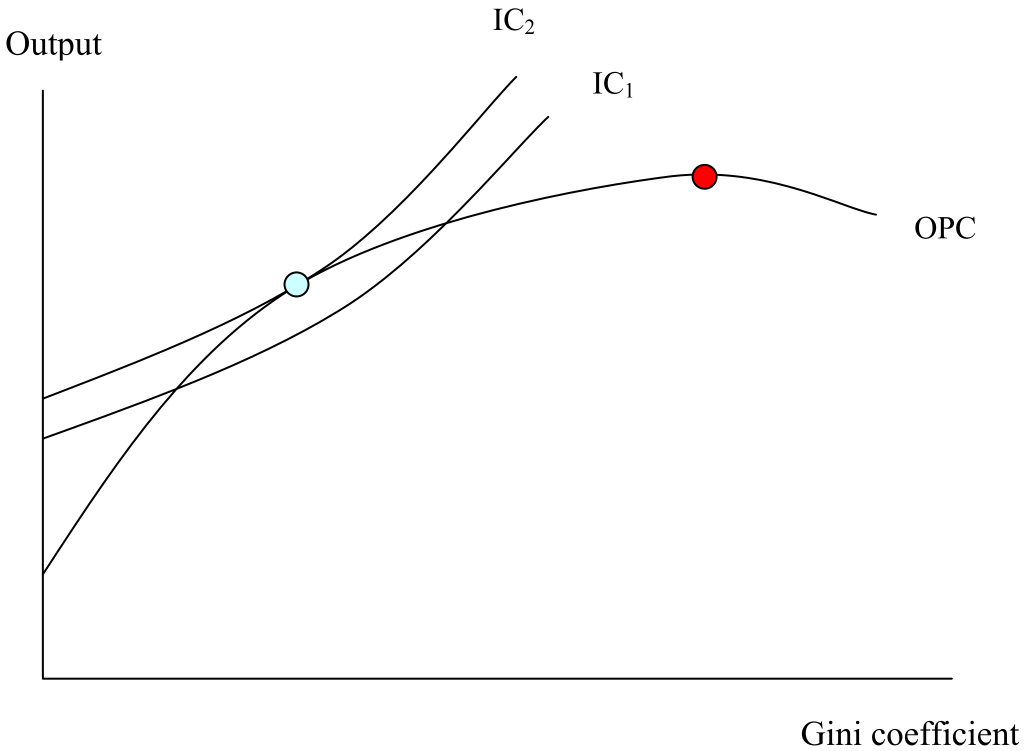

Figure 21. Breit's output possibilities curve and social preferences: IC_1, IC_2 are indifference curves and OPC is an output possibilities curve (see Lambert 1993, 42-45)

It is worth noting that inequality itself has a great number of adverse efficiency consequences. Inequality is bad, not only in terms of social justice, but also in terms of efficiency. In reality some re-distributive projects may actually enhance productive efficiency rather than reduce it and, on the issue of trickle-down, quite often, especially in many poor countries, it is not enough. In fact, the empirical evidence of some countries in Latin America and Africa shows that growth has not always been associated with social justice and significant trickle-down. The traditional debate about equality and re-distributive policies pitted one partial and incomplete viewpoint against another. Egalitarians favoured an idealised conception of government intervention, downplaying the incentive problems in the public sector. Their opponents, on the other hand, opposed these interventions in favour of an idealised view of the private economy, overlooking the incentive problems caused by inequality itself in the process of private exchange. (Magnoli 2002).

Recent developments in economic thinking about the role of information, incentives and institutions, and recent developments in the political economy of market and government failures now give us a more balanced framework for analysing the efficiency-equity relationship. Even in some of the by now old branches of economics, the objectives of equity and of efficiency were reconciled through aggregate demand. Let's take, for example, the case of Keynesian economics, where there was support for redistribution to the working class, from the point of view of both equity and efficiency. When resources are redistributed to the working class, they are mainly spent on consumption. This generates a higher aggregate demand for consumer goods and thus alleviates the socially inefficient phenomenon of mass unemployment. So traditional Keynesian economics and regional policies also combined efficiency and equity issues, see for example in the case Finland (Keynes 1936, Kultalahti 1975, Siirilä 1984, Stiglitz 1994). An interesting international scientific discussion concerning these kinds of political issue is provided by Hinterberger, Luks and Stewen (1996).

Nowadays the future prospects for such a Keynesian demand expansion today in a globalised economy are highly limited – particularly in economies where there is not a great deal of slack or excess capacity, and when capital is internationally mobile (see e.g. Dicken 1992, Fujita, Krugman and Venables 1999, Dicken 1999). This kind of global change has always had impacts on regional policies. For example, nowadays many regional development strategies are more oriented to spatial competition policies (see e.g. Sotarauta and Linnainmaa 1997, Sotarauta and Mustikkamäki 2001). Often so-called *Local Agenda 21* programmes are not connected to competition policies and projects (see e.g. Lafferty and Eckerberg 1997). This kind regional policy orientation emphasises efficiency and competition policies instead of equality and real sustainability policies.

This case is, of course, a highly simplified depiction. In reality economists are not able to tell policy-makers the precise terms of the equity-efficiency trade-offs which they must face. However, it tells us something about the basic problems of social sustainability policies. We can expect that both too high an efficiency target and too high an equity level target may produce sustainability problems for societies. One of the key tasks of political decision-makers is to decide the actual equity-efficiency trade-off relation in a society. These issues are connected to the problems of the distribution and redistribution of income and wealth. Thus, taxation and redistribution systems are very important parts of a socially sustainable policy (see details in Lambert 1993, see also Malaska, Luukkanen, Vehmas and Kaivo-oja 1997, Vehmas, Kaivo-oja, Luukkanen and Malaska 1999).

Welfare-Economic growth-Environmental stress scenario framework

In this thesis the other scenario framework is a Welfare - Economic growth - Environmental stress approach. Historically this approach is partially based on the IPAT model (Commoner 1971, Ehrlich and Holdren 1971, Commoner, Ehrlich and Holdren 1972). Ehrlich and Ehrlich 1972, Ehrlich 1989, Ehrlich and Ehrlich 1990) that postulates that environmental impact (I) is the product of population (P), per capita affluence (A) and technology (T). This kind of IPAT model is in this thesis connected to various important topics of sustainable development like the problems of dematerialization, immaterialization, employment, welfare, automation, rebound effect analysis and structural change in the economy etc. In this sense the approach to the analysis of sustainability is broader than the simple IPAT framework.

Thomas Dietz and Eugene Rosa (1994) pointed out in a previous discussion that: "*The IPAT model has appealing features. It has structured much the debate about the effects of population, affluence and technology on the environment, and has been a widely adopted perspective in ecology. But the model has serious limitations. Key among these is that in its current form it does not provide an adequate framework of disentangling the various driving forces of anthropogenic environmental change. As a consequence, the IPAT model stifles efforts toward cumulative theory and empirical findings*."

In a way, the ASA approach can be seen as an answer to the challenges Dietz and Rosa (1994) noted above. In this thesis the term total or environmental stress approach is used instead of IPAT model. We think that the IPAT or the ASA may be an effective device for operationally bringing the differing perspectives - social sciences and natural sciences to these contemporary sustainability problems. The ASA may be a way to examine sustainability problems from a human and ecological point of view. This kind of research has been carried out before (Harrison 1992-1993, see also Malaska and Kaivo-oja 1996, 1997).

This scenario approach is useful, because it is important to point out that equity and welfare are not analogous concepts. It is also possible to evaluate different types of growth processes by the Welfare - Economic growth - Environmental stress approach. The T/ES approach or so-called ASA approach is presented in the articles 1, 8 and 9.

If we want to make a short summary concerning the scenario framework developed in this thesis it is possible to illustrate it in Table 7.

Table 7. Scenarios of the Welfare-Economic growth-Environmental stress scenario framework (Kaivo-oja, Luukkanen and Malaska 2001b)

Economic growth	**Welfare**	**T/ES**	**The name of scenario**
↑	↑	↑	”To Eco-destruction in the First Class”
↑	↑	↓	Strong Sustainable Development
↑	↓	↑	Destructive Growth
↑	↓	↓	Social Misery with Growth and Nature
↓	↑	↑	Happiness in a polluted ”Stone age”
↓	↑	↓	Deep Ecology
↓	↓	↑	Doomsday
↓	↓	↓	Hard life with the Nature

Explanation: Light colour refers to positive sustainability process and darker colour to negative sustainability process.

This framework can be used in the evaluation of spatial sustainable development. By the use this framework we can classify different kinds of socio-economic development processes.

Sustainability evaluation and scenarios

In a regional planning process, we can use scenarios systematically with soft system applications. Soft system methodology should be regarded as a contribution to problem solving, rather than a goal-directed methodology. This statement applies to all situations where the task itself cannot be entirely and objectively defined. Hard systems approach can be used to deal with structured problems, a soft system approach is necessary when dealing with unstructured problems. Thus where the definition of the regional problem(s) depends on the viewpoint adopted, it is important to make that viewpoint explicit, and to then work out the systemic consequences from that point. This is usually the case in the definition of spatial development problems. With unstructured problems, the definition of the problem and the designation of the objectives is problematic. In practice, this means that the precise sequence of the stages in the analysis of the situation and in the development of solutions cannot be maintained easily. The problem itself usually gets redefined -during the planning process. (Checkland 1984, Rapoport 1984, Checkland and Scholes 1990, 1993, 1999, Mannermaa1991, 1992, 1993, 1995).

The stages of a soft-system approach are the following:

- Reviewing the unstructured problem situation;
- Clarifying and expressing the problem situation;
- Defining the relevant regional or organisational systems and subsystems; whether these are formal or informal;
- Building conceptual models with the expressed situation;
- Comparing these models with the expressed situation;
- Effecting such changes as are currently both feasible and desirable; and
- Taking action to improve the problem situation.

The scenario frameworks and analysis tools developed in the context of this thesis can be a part of the soft system approach. This approach can be used in local level or city planning processes as well as in national planning processes (see e.g. Kaivo-oja 1996, Kaivo-oja and Hovi 1996, Uusimaa 2020, Kurkistuksia tulevaisuuteen 1997, Hukka 1998). Soft system approaches can help regional organisations to learn new things. Hukka (1998, 35) has summarised Soft systems methodology in futures research in the following way (Figure 22):

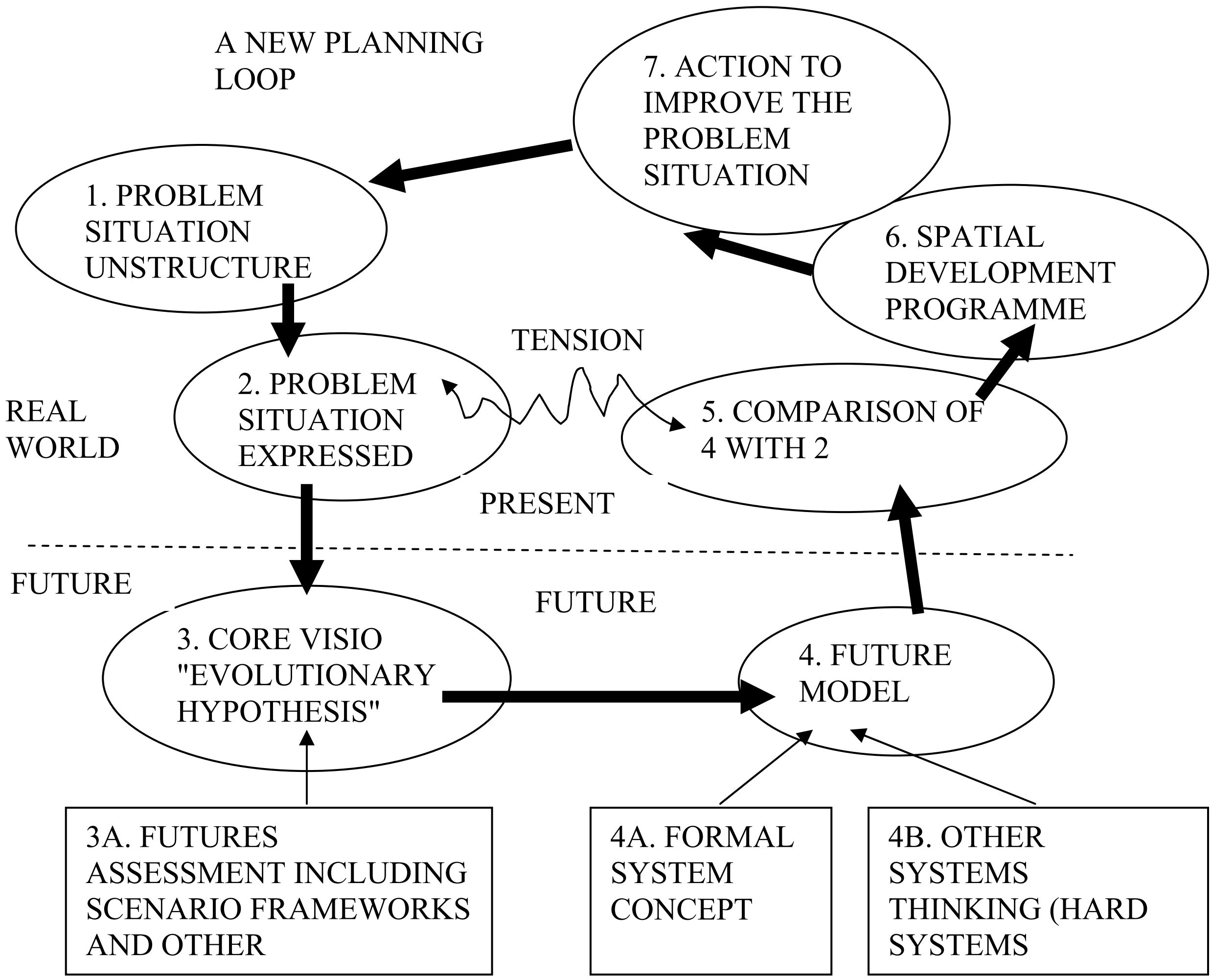

Figure 22. Soft system methodology in futures research (Checkland and Scholes 1999, 27, Mannermaa 1992, 1993 modified by Hukka (1998) and by the author)

Mannermaa (1992, 1993) has developed Checkland's original methodology into a direction more suitable for futures studies within the framework of the evolutionary paradigm. Figure 22 represents a chronological sequence of the methodology in the form of a diagram. Stages 1, 2, 5, 6 and 7 are the real-world activities necessary for involving people in solving the problem-situation. Stages 3, 3a, 4, 4a,and 4b are systems thinking activities, which may or may not involve those in solving the problem situation, depending upon the individual circumstances of the planning process. In principle a start can be made anywhere in the logical sequence. Backtracking and re-iteration are also essential as is working simultaneously at different levels of detail and on several stages.- This model has been used in real-life planning processes in Finland by the author (Kaivo-oja 1996, Kaivo-oja and Hovi 1996, see a case example of Uusimaa 2020-regional planning process, Uusimaa 2020, Kurkistuksia tulevaisuuteen 1997).

Learning regions and scenario learning process

If learning is to lead renewal, the organisation must constantly appraise its performance. It must seek to understand why it performs the ways it does. Usually that kind of understanding leads to new plans, new initiatives and new decisions. The basic characteristics of a learning organisation are restlessness, flexibility and its obsession with change. If a learning organisation is successful, it advances over time. Each successive journey round the learning loop leads to new insights, new decisions and new experiences, which are analysed and evaluated carefully. The learning organisation can steadily improve performance for as long as it is able to learn. (Kolb 1984, Boisot 1995, 1999). The same things are relevant for learning regions, because the political and administrative management of regions is made in co-operation with various kinds of organisations.

The basic idea of a scenario learning process is that scenarios offer an organisation a way to learn better and faster. They allow regional managers and stakeholders to continually test their perceptions of an uncertain future, for which there are two big payoffs (Marsh 1998, 52-53).

- Enhanced learning via the regional organisations;
- The successful continuance of the organisation towards its desired future.

The underlying premise of this thesis is that the use of futures studies methods and the scenario approach, as an integrating methodology should be an invaluable component of a regional planners and policy-makers' toolkit. Scenario approach can be a part of participatory integrated assessment methods (see e.g. European Environmental Agency 2001). They generate a distinctive form of knowledge. They provide a productive laboratory by which decision-makers can learn about the current and future world and spatial realities. They can also be integrated into the making of strategy and visions in multiple ways. For example the scenario approach can be part of the *Strategy Change Cycle*, evaluation diagnostics as well as part of the Soft System Methodology approach or the Integrated Assessment

(IA) processes. There are thus various planning tools and approaches, which can utilise a scenario approach. Thus, they provide a process for enhancing planners', managers' and political decision-makers' understanding of how to prepare for and manage change and how to thrive in future environments that may be strikingly different from the present. Scenarios should be an integral part of the strategic thinking of spatial sustainability policies. They provide fresh insight into the futures that tomorrow may bring, what is necessary is the need to develop more sustainable societies and local communities and how to set the stage for that success. In order to summarise learning regions and scenario learning processes the Figure 23 is presented.

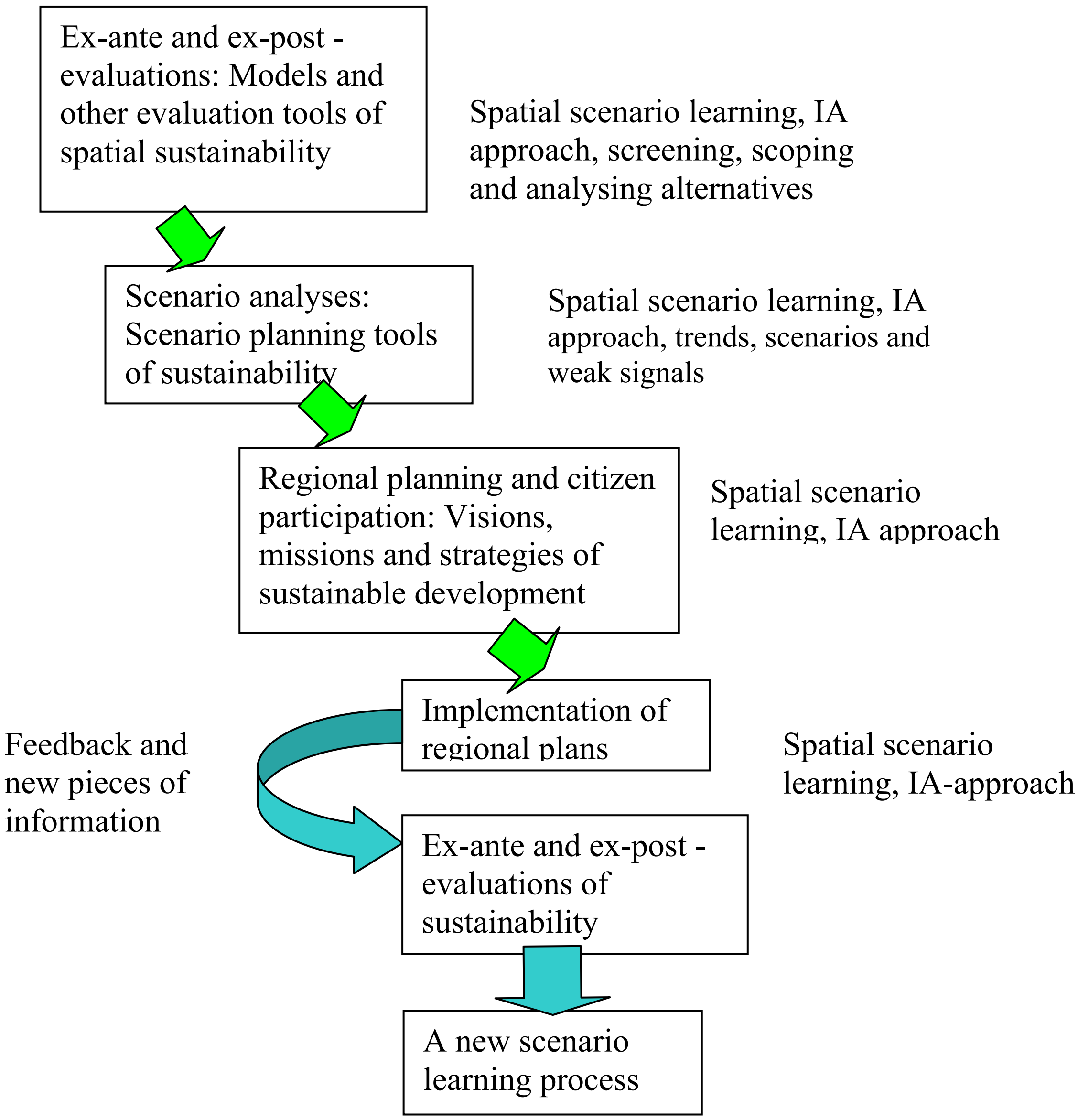

Figure 23. Scenario learning process and spatial planning process

The basic idea of this kind of approach is that humans, as individuals or in societal groups are really goal seeking adaptive systems. They are therefore, not predestined to follow trends embedded in the structure of change, but rather create the future in pursuit of their own goals.

3.4. Environmental scanning tools and weak signal analyses

On the basis of these analyses a planner can define the main global trends, build relevant scenarios and present a Wild Card/Weak Signal Analysis (see e.g. Hiltunen 2001, Mendonca, Cunha, Kaivo-oja and Ruff 2002, 2004). Usually the most problematic issue in regional foresight/futures studies is Wild Card analysis (see e.g. Petersen 1999). Figure 24 describes the impact of wild card events on identified scenario paths. In some studies scenarios are defined as (1) Trend scenarios, (2) Extreme scenarios and (3) Wild Card scenarios (see Figure 24).

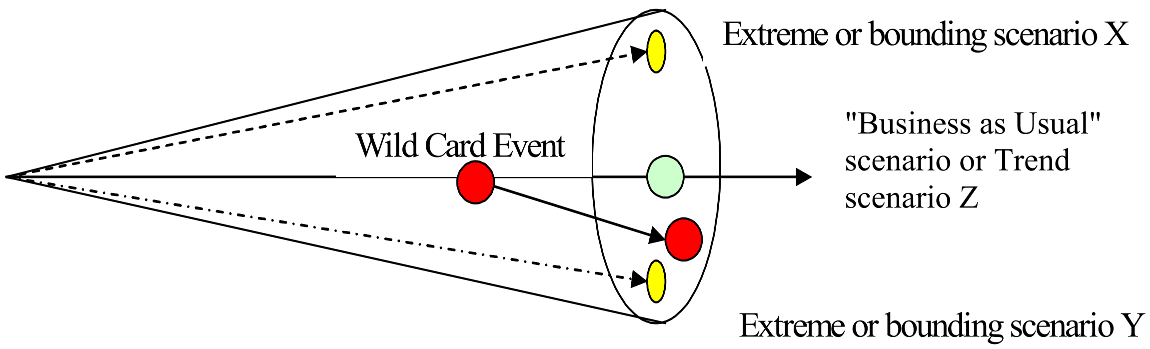

Figure 24. Wild card event and scenarios (compare e.g. Godet 2001, 77)

A wild card or weak signal is a description of an occurrence which is assumed to be improbable, but which would have large, immediate consequences for a region and its stakeholders, if it takes place. Furthermore, it is part of the definition that if the occurrence took place so quickly and powerfully, a normal, planned conversion process could not make allowances for it. It is also clear that a wild card, as it does not give the region any possibility of reaction, is irrelevant. For example, if a meteor hits the Earth, this is an occurrence for which one cannot rationally adopt a strategic or visionary attitude in a regional planning process. Petersen has noted also that (Petersen 1999, 13):

- Wild cards can originate anywhere.
- Wild cards can be driven by human perception.
- Wild Cards can be both positive and negative.
- One wild Card can set off more Wild Cards.
- Unrelated Wild Cards can have synergistic effects.
- The possibility of new Wild Cards invented by science.
- Some Wild Cards are "too big to let happen".

In a regional planning process one should analyse carefully major potential surprises, Wild Cards. Since Wild Cards are, by definition, surprises, it might be assumed that there is nothing we can do about them. If we neither take time to look at them nor consider how they might be anticipated, they are guaranteed to catch us off our guard. In a time of exponential change and uncertainty, it seems prudent to investigate the concept of Wild Cards and weak signals. Such an investigation would increase the possibility that some major future negative events might be averted or mitigated (Petersen 1999, 16). Some of these negative effects can be extremely harmful to sustainable development, like terrorism or international wars.

Wild Cards and weak signals discriminate themselves from other events in that each one (Petersen 1999, 17):
- Has a direct effect on the human condition,
- Has broad, large, important, and sometimes fundamental implications,
- Moves too fast for the whole of the system to adjust to the shock.

In regional planning, one can usually ask three major questions (Petersen 1999, 16):

- Which are the most important Wild Cards for a region?
- Can we anticipate their arrival?
- Is there anything we can do about them?

3.5. Visionary leadership and visionary management of sustainable development

In the fifth article the key problems of visionary management in a global and multilevel planning environment is analysed by the author. This article continues the discussion of the second article and provides some new insights into the discussion. It conceptualises the problem of potentially contradicting visions of regional development and gives some reflective answers to this basic problem of regional planning. This article demonstrates, on the basis of graphic demonstrations, that in a multilevel planning environment there are many potential possibilities for failure within sustainability policy-making. On the basis of the analyses presented in this article, some potential cases for policy failures in the global multilevel planning environment are:

1. Visions from some regional planning level may be impossible to be achieve, poorly defined or incorrect in their substance;

2. A mission may be wrongly defined in relation to a vision on some regional planning level and thus an action (including projects and programmes) is not rational in relation to the vision;

3. Both a mission and a vision on some regional planning level can be simultaneously incorrectly defined;

4. The starting points of a mission can be defined incorrectly on some planning level and thus the mission is directed wrongly and is not goal-rational;

5. The operational actions of missions do not succeed and goals are not fulfilled in practice on some regional planning level activities.

In these cases visionary management does not work properly. However, it is possible to avoid these potentially emerging "dead-end" situations if we

1. define our visions carefully and critically focus on the actual substance of the sustainable development process criteria;
2. define our missions carefully and critically in relation to the right kind of vision;
3. define critically all the possible visions and all the possible missions on the different levels of multilevel environment;
4. analyse and define the starting problem situation and the problematic position of a mission; and
5. begin operations in accordance with the defined missions and the defined visions,

Such conditions will ensure a management process, which fulfils the criteria of a visionary leadership model and culture. The analysis presented in this paper argues for rational thinking in global sustainability policy and visionary management. However, the procedural and communicative aspects of planning cannot be neglected. Planning in the global economy seems to be developing towards an increasing interplay between various actors on different levels. If we avoid these potential management failures in sustainable policy, a lot of progress in sustainability issues can be expected to occur. Of course, political and institutional problems may prevent this kind of progress. Optimism and pessimism work together in reality, so they should also be side-by-side in visionary management and planning.

We can conclude on the basis of this article that a crucial part of environmental and regional planning activity should be co-ordinated and its information shared between different planning levels. If planners do not discuss global and local visions and missions then we can expect that serious policy failures may happen. Thus it is important in a global planning environment to analyse what is happening in different planning environments and what kind of visions planners and decision-makers present.

The critical conclusion of this article is that the actual content of any spatial visions should be discussed critically. The itemisation presented in this article may only be of use when organisations critically assess their visions at different levels of regional and social planning. The identification of "golden projects", "projects to be avoided", "super projects" and "easy projects" in the context of visionary leadership is a very important part of any successful planning process. It is usually problematic to find future projects of a kind which are sufficiently challenging but do not require too much risk, excessive capability and resource inputs from the planning organisation. On the other hand, in implementing their visions in regional and social planning, organisations should avoid projects that require too much knowledge and resource investments in the future but which only involve low-level goals. On the other hand, there are also regional and social policies that require low-level goals and minor expertise and resource requirements. The problem in defining the vision may be that the organisations engaged in regional and social planning fail to specify the contents of their own vision sufficiently as regards their goal-orientation or the required capabilities and resources. Communicative action during planning should not be forgotten in the global planning environment. This kind of communicative perspective represents a shift from a view widely held over al least 30 years, that the planner’s role is mainly to deliver unbiased, professional advice and analysis to elected officials and the public, who in turn make decisions. In this view, information is a tool for policy makers to use to make decisions. The conventional planner’s task is to "speak truth to power" rather than to give feedback to other planners and evaluate the missions and visions of other planning levels’ planners and decision-makers. The analysis presented in this paper quite powerfully demonstrates that there is some potential for serious planning and implementation failures within global sustainability policy, if there is not enough information shared concerning the missions and visions of different regional planning levels.

4. Summary and summaries of the articles

This dissertation is closely connected to futures studies and historical trend analyses. Methods developed in this dissertation can be utilised both in historical and futures studies. Historical hindsight and insight analyses are always needed in planning and evaluation research. There is a fruitful convergence process going on between history and futures studies (Kaivo-oja, Seppälä and Katko 2004). I admit that there is still great need for ontological and epistemological development within futures field. This new field of knowledge and research demands novel ontological commitments to reality. Futures research has its syntax, semantics and pragmatics through which it is linked to logic and methods, to issues and problems. *Syntax* involves the logic behind the different methods and approaches. It is the content and subject-neutral body of futures research such as Delphi panel technique, the cross-impact method, the scenario analysis, mathematical and system models, statistical evaluation methods and tools. Futures research *semantics* consists of the meanings of the things. Some of the meanings are general, such as that of future as comprising many contingent alternatives. On the other hand, the semantics may stem from the specific content of the study, such as the meaning of sustainable development. Within the *pragmatic* constituent, there is the utilisation of knowledge through practical measures for the attainment of objectives. (Malaska 1995). A good example of pragmatic constituent is Kyoto process evaluation. In this thesis, all published articles are having own kind of syntax, semantics and pragmatics. I summarise these dimensions in tables of this summary.

Article 1: **Summary article 1:** Sustainability as spatial evaluation and planning challenge: developing new analysis tools

Syntactic constituent	General tools, trend analysis, scenario methodology, weak signals
Semantics	Sustainable development
Pragmatic constituent	Sustainability evaluation and planning

This first article presents some important interpretations of the concept of sustainable development, ranging from non-declining welfare over time, to the preservation of natural inputs and the stability of ecosystems. Key research questions relating to sustainable development, which includes the pattern of long-term dynamics, the role of uncertainty, the choice of rationality and the level of decision-making are discussed. All these kinds of questions are important in regional science, which conceptualises the fundamental problems of sustainability. On the basis of this discussion, we can see that there are two main approaches, namely neo-classical and evolutionary, which are relevant for sustainable regional policy analyses. Scenario approach can be seen as a planning tool to evaluate evolutionary processes. In this dissertation I have presented and developed further various scenario frameworks (especially Cohen-Kaivo-oja evaluation framework in article 1, Karhenas-Kaivo-oja evaluation framework in articles 6 and 7 and ASA scenario evaluation framework in article 9), which can be useful in sustainability evaluation activities.

There are many other schools of thought, which try to conceptualise the problems of sustainable development. But, in the end these two approaches are elementary perspectives. The neo-classical perspective regards sustainable development as a dynamic process best described as a sequence of equilibrium over time. Neo-classical models rely on the assumption of perfect rationality and on the existence of representative agents. Although many models do explicitly incorporate uncertainty, a few extensions and developments have been made in this direction. On the other hand, evolutionary models consider sustainable development to be driven by evolutionary forces, both in the economic and ecological sphere. A limited indeterminacy is at the core of this approach, and the path of development can evolve towards diverse dynamic configurations, characterised by terms such as self-organisation, path-dependency, bifurcation or chaos. In addition, evolutionary models assume bounded rationality and heterogeneous agents. (see e.g. Rotmans, Kemp, and van Asselt 2001)

It is very important to understand that evolutionary and neo-classical models serve different purposes. The neo-classical tradition aims to predict and provide clear-cut propositions for policy, but evolutionary models give powerful explanations and descriptions of the mechanisms involved. They can help to reproduce history or simulate alternative patterns of development. One can even claim that neo-classical and evolutionary models are truly complementary approaches. However, the scientific community has not yet provided definitive answers to the problems of sustainability. This means that further research must improve both fields.

Given unlimited resources, we would be able to meet the fundamental human needs of the present generation without having to consider whether our activities might deny similar opportunities to succeeding generation, whose fundamental basic needs will be quite similar to our own. In a finite world, however, in which human population is estimated to double and natural capital is depleted and degraded in increasing quantities, we cannot assume that resources exist in sufficient quantity to continue to meet fundamental needs. It is therefore important to try to formulate principles for the sustainable use of natural resources, now and in the future. In this introduction article these issues were discussed widely.

We can provide many quantitative measures and interpret them appropriately. It is possible to devise practicable policies based on the principles of sustainable development. However, no one knows with certainty how many fish we can catch or how many trees we can cut down or how much we will have to reduce emissions CO_2 and other greenhouse gases if we are to meet sustainability criteria. In many cases the sustainable rates of resource use are unknown. Many can probably only be established by trial and error over fairly lengthy time scales of more than a generation, possibly more that a human lifetime. For these reasons attempts to move towards spatial sustainable development will be haunted by fundamental uncertainty. The precautionary principle offers a way of living with uncertainties about limits and about impacts of economic activity or new technologies on ecosystems. It states simply that we should avoid risk and abandon or reject policies and practices that could have unsustainable outcomes or negative impacts on ecosystems.

The Advanced Sustainability Analysis approach, which is described in article 1 "*Sustainability as spatial evaluation and planning challenge",* article 8 "*Advanced sustainability analysis*" and article 9 "*A new sustainability evaluation framework and alternative analytical scenarios of national economies*", can be used in the evaluation on different kind of evolutionary processes (Malaska and Kaivo-oja 1997, Kaivo-oja, Luukkanen and Malaska 2001a). ASA approach can be seen as a strategic planning tool, which helps us to follow precautionary principle. Thus, the evaluation tools, which have been developed as a part of this dissertation, help decision-makers to understand which evolutionary processes are sustainable and which are not.[2]

Article 2: Scenario learning and potential sustainable development processes in spatial contexts: towards risk society or ecological modernization scenarios?

Syntactic constituent	Scenario approach, strategy formation
Semantics	Sustainable development, risk society, ecological modernisation, learning process
Pragmatic constituent	Sustainability evaluation and planning

Second article analyses the role of scenarios as a planning tool for spatial development. In this article one very important scenario framework is presented and discussed. Two prominent social theories have shaped the discourse of sustainability politics during recent years. Ulrich Beck's risk society theory contends that conventional definitions of social class are losing their significance in advanced nations due to the success of welfare states in reducing economic scarcity. As societies make the transition toward late modernity, new social cleavages based on the distribution of environmental and technological risks are gaining salience. Beck's risk theory contrasts with the theory of ecological modernisation originally advanced by Joseph Huber outlining a hyper-rational strategy for correcting the ecological flaws of contemporary production and practices. This paper combines the idea of Cohen's (1997) typology that joins the two theories into a unified framework with the most up to date ideas of strategic planning. This is one of the main scientific contributions of this paper. (Kaivo-oja 2001, Jokinen, Malaska and Kaivo-oja 1998).

[2] I wrote this paper alone and this part of PhD contribution is solely mine.

I point out in this paper that regional development authorities must discuss critically whether they are developing societies towards a risk society or towards ecologically modern societies. When they have decided the direction they must mobilise different types of socio-economic agents to support the sustainability strategy. It is also very important to understand that the direction in which a particular society or a region progresses will be conditioned by its predisposition to scientific rationality. Due to increasing public endorsement of alternative planning tools and epistemologies, most regions and nations will likely encounter great difficulty in achieving ecological modernisation, which can be seen as an ideal type of sustainable development process in spatial contexts. However, scenario planning and especially scenario learning processes may help regions and nations to strengthen conscious regional planning and strategy implementation processes, which can promote ecological modernisation or a managed shift away from a risk society. (Kaivo-oja 2001).[3]

Article 3: Environment in an "information society": Transition stage towards sustainable development?

Syntactic constituent	Trend analysis, scenario approach
Semantics	Sustainable development, information society, cultural evolution towards IS and SD, risk society, ecological modernisation
Pragmatic constituent	Sustainability evaluation and planning

In the third article the promises of the development of an information society in relation to the challenges of sustainable development are discussed. Undoubtedly, theories of the information society include technology-optimistic, even technology-deterministic ideas. However, if culture is taken solely as subordinate to technological structures, the idea of human progress is reduced to the development of technology. This being the case, the agents making social choices for a society, as well as the values behind such choices are unseen. It thus follows that cultural, societal and technological development should not he separated from each other in a simplistic way. New technology is basically a cultural product and a social undertaking, and, equally, some characteristics of society are primarily technological projects. Therefore technological decisions and solutions should be adapted to the models of society, which are regarded as most desirable. In other words, technological choices have to be based on societal ideals, value considerations and ethical discussions, and not only on technical considerations. However, according to Beck (1992, 1995), the reverse is true: in the late-industrial risk society, societal development is no longer under the control of the parliamentary system or of citizens. Rather, decisions on safety and environmental issues are made in the name of technology and science, which, again, is defined by a very limited circle of technological experts.

[3] I wrote this paper alone and this part of PhD contribution is solely mine.

Environmental issues form the central aspect of societal development. If the challenge of the "coming of the information society" is taken seriously, the challenge to provide evidence for the ecological benefits of this new mode also stands. This article investigates the relationship between the information society and environmental issues on theoretical and conceptual levels. With good reason, we agree with Marvin's conclusion (1997): the relationship is complex and contradictory, and we should not make any simple generalisations about the role of informational technologies in environmental policies. The subject requires additional research, especially at the empirical level. Further study is needed, for instance, in order to develop valid indicators, which could successfully unite the positive factors of the information society and help achieve sustainable development. Future projects could also investigate the kind of values and environmental impacts implicit in the political programmes of information society. Finally and most importantly, there must be continuous questioning of how the elements of these basic societal goals should and could be adapted to each other. (Jokinen, Malaska and Kaivo-oja 1998).[4]

Article 4: The ecological transparency of the information society

Syntactic constituent	Trend analysis, scenario approach
Semantics	Sustainable development, ecological transparency, risk society, ecological modernisation
Pragmatic constituent	Sustainability evaluation and planning

The fourth article of this thesis continues the discussion of the third article and gives new insights into the discussion of a sustainable information society, which can be seen as a specific case of ecological modernisation. In this paper we conclude that a de-linking of pollution from economic growth and de-materialisation can probably be seen as the most important single characteristic of sustainable development. This paper discusses the potential for successfully unifying and monitoring the positive factors of the information society and sustainable development. These necessary steps would include such things as the detailed life cycle analyses of ICT products, infrastructures and their applications. The set of sustainability indicators would provide a toolkit for policy-makers in the information society to help make strategies that can direct and evaluate development towards sustainable development. Planning for an information society would thus benefit the enhanced level of ecological transparency within the information society as presented via indicators. Ex ante and ex post evaluations of the various consequences arising from the ecological transparency of the information society would be needed for better decision-making at local, regional, national and global levels. The Fifth Framework Programme of the European Union largely replaces the terms "information and communication

[4] This article is written together with professor Pentti Malaska and Dr Pekka Jokinen as a part of FUTU-project. My personal contribution to this paper was that is constructed and discussed the basic ideas and contents of a paper with other authors and wrote independently many parts of the text.

technologies" and "telematics" with the broader term: Information Society Technologies (IST). Accordingly, prerequisites should be created for evaluating the implications of the information society and for applying related information society technologies. Such approaches and activities can be termed Information Society Assessment (ISA). It would, however, evoke a more encompassing concept than conventional technological assessment (TA). ISA would tackle the problematique of the consequences of the information society from economic, socio-cultural, technological and ecological viewpoints. Ultimately then, the increasing ecological transparency of the information society as achieved through the construction and use of scenarios and indicators would provide a significant contribution to the environmental dimension of Information Society Assessment. (Heinonen, Jokinen and Kaivo-oja 2001).[5]

Article 5: Challenges of visionary management in multilevel planning Environment: How Murphy´s laws may emerge in global sustainability policy?

In the fifth article the key problems of visionary management in a global and multilevel planning environment is analysed by the author. This article continues the discussion of the second article and provides some new insights into the discussion. It conceptualises the problem of potentially contradicting visions of regional development and gives some reflective answers to this basic problem of regional planning. This article demonstrates, on the basis of graphic demonstrations, that in a multilevel planning environment there are many potential possibilities for failure within sustainability policy-making. On the basis of the analyses presented in this article, some potential cases for policy failures in the global multilevel planning environment are (Kaivo-oja 2000):

1. Visions from some regional planning level may be impossible to be achieve, poorly defined or incorrect in their substance;

2. A mission may be wrongly defined in relation to a vision on some regional planning level and thus an action (including projects and programmes) is not rational in relation to the vision;

3. Both a mission and a vision on some regional planning level can be simultaneously incorrectly defined;

4. The starting points of a mission can be defined incorrectly on some planning level and thus the mission is directed wrongly and is not goal-rational;

5. The operational actions of missions do not succeed and goals are not fulfilled in practice on some regional planning level activities.

[5] This article is written together with Dr Sirkka Heinonen and Dr Pekka Jokinen as a part of FUTU-project. My personal contribution to this paper was that is constructed and discussed the basic ideas and contents of the paper with other authors and wrote independently many parts of the text. My special contribution to this paper was a presented scenario framework of the paper.

In these cases visionary management does not work properly. However, it is possible to avoid these potentially emerging "dead-end" situations if we

1. define our visions carefully and critically focus on the actual substance of the sustainable development process criteria;
2. define our missions carefully and critically in relation to the right kind of vision;
3. define critically all the possible visions and all the possible missions on the different levels of multilevel environment;
4. analyse and define the starting problem situation and the problematic position of a mission; and
5. begin operations in accordance with the defined missions and the defined visions,

Such conditions will ensure a management process, which fulfils the criteria of a visionary leadership model and culture.

The analysis presented in this paper argues for rational thinking in global sustainability policy and visionary management. However, the procedural and communicative aspects of planning cannot be neglected. Planning in the global economy seems to be developing towards an increasing interplay between various actors on different levels. If we avoid these potential management failures in sustainable policy, a lot of progress in sustainability issues can be expected to occur. Optimism and pessimism work together in reality, so they should also be side-by-side in visionary management and planning. (Kaivo-oja 2000).

We can conclude on the basis of this article that a crucial part of environmental and regional planning activity should be co-ordinated and its information shared between different planning levels. If planners do not discuss global and local visions and missions then we can expect that serious policy failures may happen. Thus it is important in a global planning environment to analyse what is happening in different planning environments and what kind of visions planners and decision-makers present. (Kaivo-oja 2000).

The critical conclusion of this article is that the actual content of any spatial visions should be discussed critically. The itemisation presented in this article may only be of use when organisations critically assess their visions at different levels of regional and social planning. The identification of "golden projects", "projects to be avoided", "super projects" and "easy projects" in the context of visionary leadership is a very important part of any successful planning process. It is usually problematic to find future projects of a kind which are sufficiently challenging but do not require too much risk, excessive capability and resource inputs from the planning organisation. On the other hand, in implementing their visions in regional and social planning, organisations should avoid projects that require too much knowledge and resource investments in the future but which only involve low-level goals. On the other hand, there are also regional and social policies that require low-level goals and minor expertise and resource requirements. The problem in defining the vision may be that the organisations engaged in regional and social planning fail to specify the contents of their own vision sufficiently as regards their goal-orientation or the required capabilities and resources. Communicative action during planning should not be forgotten in the global planning environment. This kind of communicative perspective represents a shift from a view widely held over al least 30 years, that the planner's role is mainly to deliver unbiased, professional advice and analysis to elected officials and the public, who in turn make decisions. In this view, information is a tool for policy makers to use to make decisions. The conventional planner's task is to "speak truth to power" rather than to give feedback to other planners and evaluate the missions and visions of other planning levels' planners and decision-makers. The analysis presented in this paper quite powerfully demonstrates that there is some potential for serious planning and implementation failures within global sustainability policy, if there is not enough information shared concerning the missions and visions of different regional planning levels. (Kaivo-oja 2000).[6]

Article 6: Alternative scenarios of social development: Is analytical sustainability policy analysis possible? How?

Syntactic constituent	Scenario approach, national level macro model of sustainable development
Semantics	Economic growth, equity, environmental stock
Pragmatic constituent	Sustainability evaluation and planning

In the sixth article a new scenario framework is presented for spatial planning needs by the author. It is mainly based on Karhenas's new theory of sustainable development, but it also includes the assumption of the "great trade-off theory of economic growth and equity" originally presented by Okun (1975) and other economists (Stiglitz 1988, Osberg 1995) are still discussing the relevance of great trade-off theory today. In the article some alternative scenarios of social development are presented and discussed in detail. The following scenarios are discussed: (i) the Deep Ecology Scenario,(ii) the Strong Sustainable Development Scenario, (iii) the Weak Sustainable Development Scenario, (iv) the Boomsday Scenario, (v) the Doomsday Scenario and (vi) the World Bank 'Policy Tunnel' Scenario. In the article, it is noted that the environmental EKC hypothesis can be connected theoretically to the Boomsday Scenario and loosely to the World Bank 'Policy Tunnel' Scenario. (Kaivo-oja 1999)

On the basis of scenario analysis, it is pointed out that sustainable development is not a conflict-free concept because the criteria of sustainability (environmental sustainability, economic efficiency and social equality) cannot be simultaneously

[6] I wrote this paper alone and this part of PhD contribution is solely mine.

met in most of the scenarios analysed. Global strategies that are based on general, simple concepts of sustainability can even be harmful for developing societies and regions. (Kaivo-oja 1999).[7]

Article 7: Social and ecological destruction in the first class: a plausible social development scenario

Syntactic constituent	Scenario approach, national level macro model of sustainable development
Semantics	Economic growth, equity, environmental stock
Pragmatic constituent	Sustainability evaluation and planning

The seventh article is a complementary contribution to the sixth article. In this article a plausible, the author presents seventh social development scenario. The name of the scenario is "Social and Ecological Destruction in the First Class". The basic idea of this scenario is presented in this article. This scenario should be taken into consideration in the strategic discussion of potential sustainable development paths. (Kaivo-oja 2001).[8]

Article 8: Advanced sustainability analysis

Syntactic constituent	National level macro evaluation of sustainable development
Semantics	Economic growth, welfare, environmental pressure
Pragmatic constituent	Sustainability evaluation and planning

The eight of articles presents the ASA approach to sustainability analysis. This article provides us with a new tool for spatial sustainability analyses. Fundamental principles of sustainable development are discussed in this paper. The sustainability approach presented is diachronic, statistical and macro-oriented, whereas synchronic issues concerning decomposition are not discussed. A new theoretical framework of the necessary conditions for achieving sustainability is formulated by relating the total environmental stress to the indicators and variables of economic, technological and social development. Empirical analyses of one country’s data (Finland) were conducted to demonstrate the applicability of the theory. The explanatory power of the theory was demonstrated through important new concepts and formulas as well as through empirical analyses using total material flow as the main measure for total environmental stress (see Spangenberg, Hinterberger, Moll and Schütz 1999). The results show that the theory works well in evaluating the ecological sustainability of economic and

[7] I wrote this paper alone and this part of PhD contribution is solely mine.

[8] I wrote this paper alone and this part of PhD contribution is solely mine.

social development. According to the theory the case country (Finland) has not made the achievement of sustainability a real priority when compared to economic growth, automation or employment. Sustainability is, de facto, a global ethos, where each country has a joint role with all other countries in achieving global sustainability. This theory needs to be supplemented with a global decomposition theory that enables us to conduct synchronic analyses in addition to the diachronic analyses now available. (Kaivo-oja, Luukkanen and Malaska 2001).[9]

Article 9: A new sustainability evaluation framework and alternative analytical scenarios of national economies

Syntactic constituent	Scenario approach, national level macro model of sustainable development
Semantics	Economic growth, equity, environmental stock
Pragmatic constituent	Sustainability evaluation and planning

The ninth article is a complementary contribution to the eighth article. The contribution of this article is a new scenario framework, which can be used in a spatial sustainability analysis. The results show clearly that the theory works well in evaluating the ecological and other dimensions of sustainability. The theoretical framework can be used for macroeconomic as well as more aggregated sustainability evaluation. In this paper we identified 8 alternative scenarios on the basis of the theoretical framework. Our analyses indicate that the economy of Finland has followed a scenario path of “To Destruction in the First Class”. In futures studies comparative analyses of different national economies should be carried out to test the applicability of the framework in sustainability planning. It would be especially interesting to connect the theoretical framework presented to the ongoing de- and re-linking debate and the empirical analysis on a larger scale. (Kaivo-oja, Malaska and Luukkanen 2001).[10]

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[9] This article is written together with professor Pentti Malaska and Dr, Academy Fellow Jyrki Luukkanen as a part of FUTU-project. My personal contribution to this paper was that is constructed and discussed the basic ideas and contents of the paper with other authors and wrote independently many parts of the text. I rewrote and re-checked this article about ten times. In this paper I am first author of the paper.

[10] This article is written together with professor Pentti Malaska and Dr, Academy Fellow Jyrki Luukkanen as a part of FUTU-project. My personal contribution to this paper was that is constructed and discussed the basic ideas and contents of the paper with other authors and wrote independently many parts of the text. Especially as a new contribution I developed ASA scenario framework of the paper together with Dr Jyrki Luukkanen. I am first author of the paper.

Article 10: Decomposition analysis of Finnish material flows: 1960-1996

Syntactic constituent	National level evaluation of sustainable development, trend analysis, statistical decomposition analysis
Semantics	Economic growth, environmental pressure, material flows
Pragmatic constituent	Sustainability evaluation and planning

The tenth article demonstrates the power of decomposition methodology via an analysis of spatial development in Finland. It shows that environmental impacts are the consequence of the magnitude of total material input into production in an economy and that reducing the use of materials— by concentrating on what has been called qualitative growth, can lessen them. This article presents a summary of Finnish resource use from 1960 – 1996 as a means of evaluating the trends in material use and providing a basis for assessments of sustainability. It adapts the technique of decomposition analysis developed in the field of energy studies to distinguish the effects of changes in aggregate economic activity ("activity effect"), the composition of industrial activity ("structural effect") and the material intensity of use ("intensity effect") on a sectoral basis. According to the analysis presented here, material consumption in Finland has grown substantially between 1960 and 1996 in the electricity, gas and water supply, pulp and paper production, civil engineering, and mining and quarrying sectors. In the same period, the ratio of GDP to material mass mobilised has improved 175 percent. Economic growth has caused the largest increase in material use especially in the building of infrastructures; for example roads, waterways, means of supplying electricity, gas and water, and in the production of paper and paper products. The areas of least growth were in basic metals production, and mining and quarrying sectors. (Hoffrén, Luukkanen and Kaivo-oja 2001).[11]

[11] This article is written together with Dr Jukka Hoffren and Dr, Academy Fellow Jyrki Luukkanen as a part of FUTU, ECOSTAT and FINSKEN-projects. My personal contribution to this paper was that is constructed and discussed the basic ideas and contents of the paper with other authors and wrote independently many parts of the text. The original idea to utilize national level material flow data in decomposition analysis was mine. Dr Jukka Hoffren from Statistics Finland kindly provided unique and valuable material flow data for this analysis. Dr Jyrki Luukkanen and me made together statistical analyses and interpretations of the analysis. I re-checked this article about 3 times. However, Dr Jukka Hoffren checked the final version of the paper.

Article 11: The European Union balancing between CO_2 reduction commitments and growth policies: decomposition analyses

Syntactic constituent	International and national level evaluation of sustainable development, trend analysis, statistical decomposition analysis
Semantics	Economic growth, environmental pressure, global CO_2 emission trends
Pragmatic constituent	Sustainability evaluation and planning, the Kyoto process

This article is an empirical study of the whole energy system development in the European Union. The analysis covers the years 1960-1998. The decomposition analysis of energy and CO_2 intensities of the different EU countries and Norway reveal large differences between the individual countries. The reasons for the differences in energy intensity changes are explained by the structural changes of the economies. The changes in CO_2 intensities are explained by the energy intensity changes and by the changes is fuel switching. The study verifies the conclusion that there are still big challenges in the harmonisation of energy and climate policy in the EU. (Kaivo-oja and Luukkanen 2004).

The results show that there exist quite different trends in the European Union energy sector development and there is room for energy policy harmonisation in the EU. On the one hand we must remember that the EU countries are in different phases of their economic and industrial development, which is one reason for the observed trends. On the other hand, we can ask whether the industrialisation process is the best option for the cohesion countries, especially if we take into account the environmental aspects, or could the Irish way of development, relying heavily on post-industrial information society development, offer better options also the Mediterranean countries. (Kaivo-oja and Luukkanen 2004).

With the introduction of new member countries the variations and differences still increase. The accession process will raise new challenges for the harmonisation of the energy and climate policy. The acceptability of different policy instruments varies among EU countries and different stakeholder groups and the decision making of the economically important issues is problematic (see discussions in Hacker and Pelchen 1999 and Vehmas et al 1999). The climate policy of EU has been based on the burden sharing within the EU bubble, but in the future the accession process will certainly have an effect on the policy formulations. (Kaivo-oja and Luukkanen 2004).

The results of the study indicate that only some EU countries have been able to follow the sustainable energy development path. Only Luxembourg, Norway, Belgium, Austria, Germany and the UK have been able to improve energy efficiency and decarbonise the energy system at the same time after the oil crises. A critical question in the future EU energy and climate policy is the interaction with the economic development policy. The structure of economic development is the main determinant for the development of the energy intensity of the society. In this respect several options are available and the EU policy planning has to evaluate the results of the different development paths. (Kaivo-oja and Luukkanen 2004).

So far the EU climate policy has been quite successful and the decision to allow the growth of emissions for the Mediterranean cohesion countries is a distinct choice to carry the burden elsewhere. Whether the present EU countries will carry the burden of the new member countries and how large space for environmentally unsustainable development will be allowed for them is an important question for the future policy formulation. (Kaivo-oja and Luukkanen 2004).[12]

Article 12: Energy and CO_2 efficiency dynamics in the world regions

Syntactic constituent	Global and national level evaluation of sustainable development, trend analysis, statistical decomposition analysis
Semantics	Economic growth, environmental pressure, global CO_2 emission trends
Pragmatic constituent	Sustainability evaluation and planning, the Kyoto process

Climate change has been described by scientists, environmentalists, and politicians as a threat unprecedented in human experience. Emissions of greenhouse gases from human activities constitute the proximate cause. Greenhouse gas emissions are related to the efficiency developments of spatial energy systems. The study analyses the efficiency development in the global world economy. This study is a comparative analysis of energy and CO_2 emission intensity effects in the world regions from the years 1971-1999. The analysed regions are: Latin America, USA, Africa, the Middle East, China, the rest of Asia and Europe. The comparative analyses are based on the complete decomposition methodology, from which authors provide the analysis of dynamic changes of energy consumption and CO_2 emission flows compared with economic performance in the larger regional economies of the world. In this article, authors report the activity effects, the structural effects and the intensity effects in the different world regions. (Kaivo-oja and Luukkanen 2002).

[12] This article is written together with Dr, Academy Fellow Jyrki Luukkanen as a part of a SEDCO - project. My personal contribution to this paper was that is constructed and discussed the basic ideas and contents of the paper with other author and wrote independently many parts of the text. I rewrote and re-checked this article about 3 times. I am first author of the paper.

Main results

European Union

Comparison of percentage changes in the intensity effects on energy and CO_2 emissions gives information of reasons behind the changes in CO_2 emissions. In EU the CO_2 intensity has decreased faster than the energy intensity indicating that part of the CO_2 emission reductions are caused by fuel switching to less carbon intensive energy production. Improved energy efficiency caused part of decrease in CO_2 emissions. (Kaivo-oja and Luukkanen 2002).

Middle East region

There has been almost no fuel switching in the Middle East region. The increase in CO_2 emissions has been caused by increased use of fossil energy sources utilising the domestic oil and gas resources. (Kaivo-oja and Luukkanen 2002).

Latin America

In Latin America energy intensity has decreased faster than CO_2 intensity in the years 1971-1982. In the years 1993-1994 there was not much fuel switching, but after year 1994 Latin America returned back to earlier trend, according to which the CO_2 intensity is increasing faster than energy intensity. Thus Latin America is having fuel-switching process to more carbon intensive energy production. The changes in the intensity effects have been quite small in Latin America. (Kaivo-oja and Luukkanen 2002)

Africa

There has been considerable fuel switch towards more carbon intensive energy use in Africa in the 1970s, but after that almost no fuel switching has taken place. Both energy and CO_2 intensity increased rapidly in the 1980s but the speed of changes has been quite small in the 1990s. (Kaivo-oja and Luukkanen 2002).

Asia

In Asia the energy intensity has decreased quite fast, but the CO_2 intensity has remained almost constant during the whole research period. This indicates that there has been a constant fuel switch towards more carbon intensive energy production, but the improved energy intensity has kept the CO_2 intensity constant resulting in a situation, where the CO_2 emissions have grown hand in hand with the economic growth. (Kaivo-oja and Luukkanen 2002).

China

In China both intensity effect on energy and CO_2 emissions have downward sloping trends after late 1970s. In China there has been a considerable fuel switch towards more carbon intensive energy system before 1990, but after that both intensity effects have decreased hand in hand. There has been speculation that the data of Chinese economy is not very reliable and the growth of GDP has been overestimated. (Kaivo-oja and Luukkanen 2002).

U.S.A.

In the U.S.A. both intensity effect on energy and CO_2 emissions are decreasing and having downward trends. There has been continuous slow decarbonisation process in US energy system up to the 1990s, but after that the decrease in CO_2 intensity has been caused by the decrease in energy intensity. (Kaivo-oja and Luukkanen 2002).

Summary

Decreasing trends towards less carbon intensive energy production systems can be observed in the European Union and the United States. Increasing trends towards more carbon intensive energy production systems can be observed in Asia, China and Africa (before the 1990s). In Latin America and the Middle East the fuel switching has been considerably slow. In the Africa, the Middle East, Latin America, Asia and China two counteracting processes have taken place: there has been switch from traditional renewable fuels to fossil fuels (especially in developing countries) and at the same time switch from coal to gas. (Kaivo-oja and Luukkanen 2002).

Article 13: The EKC hypothesis does not hold for direct material flows. An environmental Kuznets curve hypothesis tests for direct material flows in 5 industrial countries

Syntactic constituent	Global and national level evaluation of sustainable development, trend analysis, statistical regression analysis, EKC hypothesis
Semantics	Economic growth, environmental pressure, material flows
Pragmatic constituent	Sustainability evaluation and planning, existence of the EKC hypothesis

The thirteenth article concentrates on testing the Environmental Kuznets Curve hypothesis (Seppälä, Haukioja and Kaivo-oja 2001). This study analyses the Environmental Kuznets Curve hypothesis with material use data for the USA, Germany, Japan, the Netherlands and Finland. Studies on this issue have developed rapidly over the last few years. There has been a long discussion concerning the relevance of the EKC hypothesis, which claims that as countries become wealthier environmental stress will begin to decline at a certain income level. However, the EKC hypothesis has not been widely tested with direct material flow data. In this paper, we present an attempt to test the EKC hypothesis via direct material flows. The results of the empirical hypothesis tests conducted here indicate that the EKC hypothesis does not hold for industrialised countries such as Germany, Japan, the USA, the Netherlands and Finland. This is the main result of the article. However, there are some limits in the time series data that make it somewhat difficult to totally deny the EKC hypothesis. If a longer time series analysis could have been made, the inverted U-curve might be identified. On the basis of the analysis, it was concluded that in sustainability analyses and policy making it seems there will be significant future challenges for the management of material flows (see also Spangenberg, Hinterberger, Moll and Schütz 1999). This conclusion can be derived from the fact that none of the countries under investigation showed an inverted U-curve. (Seppälä, Haukioja and Kaivo-oja 2001).[13]

[13] This article is written together with professor Tomi Seppälä and research fellow Teemu Haukioja as a part of a FUTU-project. My personal contribution to this paper was that is constructed and discussed the basic ideas and contents of the paper with other author and wrote independently many parts of the text. The idea to apply to make EKC hypothesis tests concerning national material flow database was mine. I rewrote and re-checked this article about 6 times. Later, when new database was published by Eurostat we made comprehensive study concerning EU15-counties EKC-curve developments, see Vehmas, Luukkanen and Kaivo-oja (2003).

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SCENARIO LEARNING AND POTENTIAL SUSTAINABLE DEVELOPMENT PROCESSESESS IN SPATIAL CONTEXTS: TOWARDS RISK SOCIETY OR ECOLOGICAL MODERNIZATION SCENARIOS?

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Introduction

Sustainability in cities, regions and municipalities is the key agenda for the new millennium. Progressive environmental degradation and excessive levels of resource exploitation go hand in hand with mounting unemployment and rising criminality, economic and social polarization, and ethnic strife. For our societies to develop, and for their members to survive, some new orientation of spatial policies is needed. Laszlo has summarized the discussion of the sustainability problem and noted that we should make no choice that will decide whether we head for further evolution or final extinction where continuation of the present trends would place in jeopardy the future of industrial societies, as well as the future of life on Earth. (Laszlo 1994; Meadows, Meadows, Randers and Behrens 1972; Meadows, Meadows and Randers 1992). However, there are some signs of hope. For example, the technological and social development of the information society can help us to build more sustainable societies, thus avoiding the potential development of risk society and creating ecologically modern societies (Beck, 1992; Spaargaren, 1997; Jokinen, Malaska and Kaivo-oja 1998; Heinonen, Jokinen and Kaivo-oja 2001).

There are various planning and management models available for spatial planning. Some planning types emphasize rationality of the planning process, some others see planning as an incremental process, still others put more weight on democracy and citizenship participation in planning (Farnstein and Farnstein 1998). Many respected scholars think that human selfishness cannot save the environment in the long run (Ridely and Low 1998). Therefore we need good planning and management practices, which take the common goods into serious consideration. One of the most promising types of spatial planning and management is scenario learning from the future. The fundamental idea of scenario learning is to think about issues from long-run perspective (Schwartz 1992).

In this paper my purpose is to present some important notes concerning the scenario learning and potential sustainable development processes in spatial contexts. The paper is organized in the following way: in section one, I outline the role of scenario learning in the identification of a potential sustainable development (SD) process. In section two, I shall discuss how we actually can map the paths to desired futures, if we want to prefer sustainable development processes. In section three, the idea of a "Bermuda triangle" of vision, strategy and scenarios in a spatial contexts is presented. The key concepts are analyzed in this section. Alternative ways to construct and plot scenarios in spatial contexts are discussed in section four. A fundamental scenario framework in Western societies is then presented and discussed in detail. Summary of notes and key results of the discussion are presented in section five.

Scenario learning and identification of potential spatial SD processes

Today, many scholars advocate that all organizations, which seek to learn from the future use of a methodology that combines scenario development with the decision-making processes of strategy management. Usually, this process is called scenario learning. Scenario learning can help planning organizations responsible for sustainable spatial development processes understand how to manage its future strategically. Scenario learning involves two critical elements: (1) constructing or developing scenarios and (2) integrating the content of scenarios into decision making. In the identification of potential spatial sustainable processes, these two elements of scenario learning are very important. Both elements are central to what we mean by scenario learning. Neither one alone is sufficient for successful scenario use in spatial strategy formulation (Fahey and Randall 1998).

Today, many scholars prefer scenario learning to the more common term scenario planning for a number of reasons. Firstly, learning, as used in the management literature, is not just a means of generating or acquiring knowledge. Today we have lot knowledge concerning serious environmental problems. Today, the role of management is to put knowledge to use. Whether and how environmental knowledge and other pieces of knowledge are acted upon is essential to learning. Scenario learning reinforces the need for scenarios and decision making to be intimately interconnected (Fahey and Randall 1998).

Secondly, scenarios, by definition, challenge the mind-set of managers and planners by developing plausible alternatives. The degree of sustainability of these alternatives varies. For example, some alternatives may help us to "make money" and some other alternatives may "save the world". They take decision-makers into new substantive terrain. They require them to be willing to suspend their beliefs, assumptions, and preconceptions. Scenario learning not only emphasizes the role of scenarios as a generator of thought and reflection, but also explicitly challenges conventional wisdom, historic ways of thinking and operating systems, and long-held assumptions about important issues (Fahey and Randall 1998).

Thirdly, learning implies discussion and dialogue. Managers and others inside and outside the spatial management organization must engage each other in a free-ranging exchange of ideas, perceptions, concerns, alarms and new discoveries. Such communication and exchanges will invariably provoke some degree of tension - between individuals, organizations and functional operations of planning activities. Such tension is the essence of collective learning (Fahey and Randall 1998).

Fourthly, learning suggests that scenarios are a continual input to decision-making and that actions and decisions in turn spawn further reflection and thinking, i.e. further learning, which is an endless process of humankind in an ideal case. Scenarios provide views of the future against which managers can monitor and assess the world as it unfolds around them. For example, they can compare various scenarios with proposed SD scenarios (Fahey and Randall 1998).

A learning perspective suggest that the various tools and techniques involved in scenario development and use are a means to an end-aids to understanding how the world might unfold and how that understanding can be incorporated into decision- making. If this objective is to be achieved, scenario methodologies must not and cannot take on a life of their own as they have in some organizations. Scenarios are intended only to serve the purposes of augmenting understanding and informing good decisions.

Scenario learning and futures perspectives in spatial development

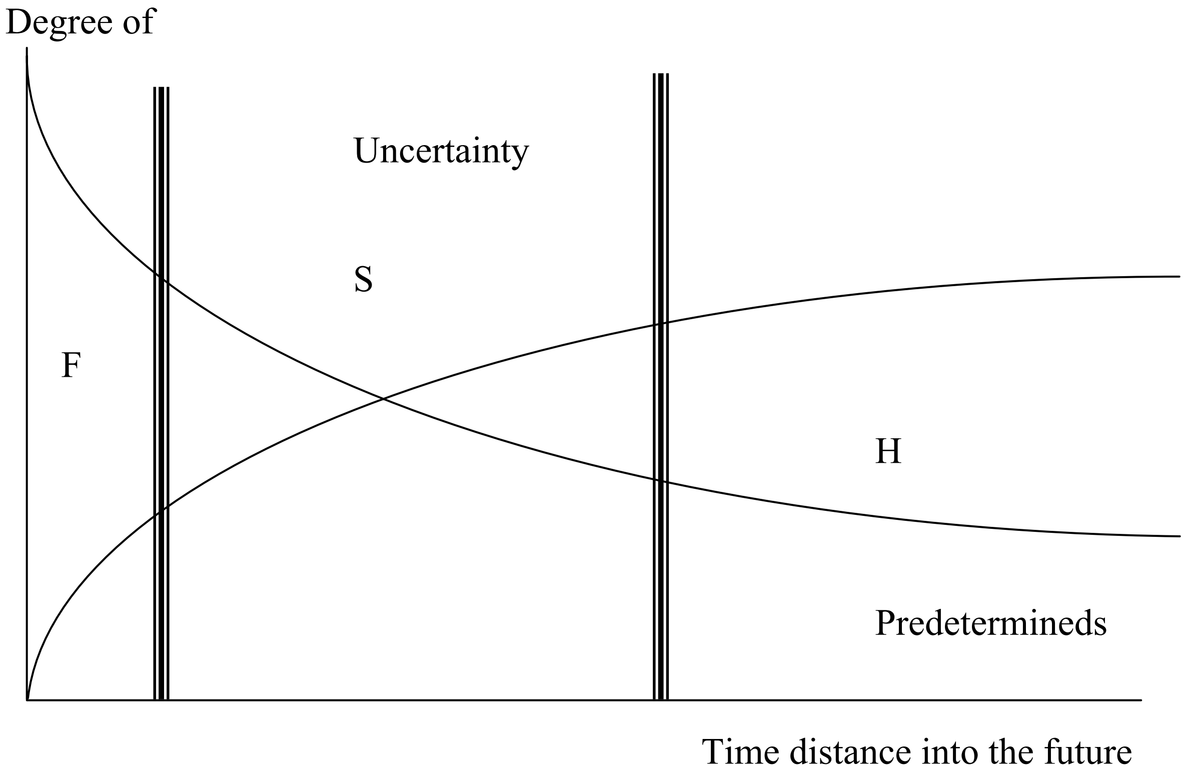
Scenarios are usually seen as a means to explain and manage uncertainty. Over the past decades we have learned that forecasts of anything are truly uncertain. In fact, predictions fail frequently. Frechtling (1996) has noted that there are three basic ways to see the future:

- The future is totally predictable (i.e. unalterable), implying sound forecasts are useless.

- The future is totally unpredictable (i.e. random), implying sound forecasts are impossible.

- The future is somewhat predictable and somewhat alterable, implying sound forecasts are useful and feasible.

Conventional wisdom in futures studies is that the third way is the relevant way to think about future events. In some situations forecasts are useful and sound. Figure 1 presents the elements of uncertainty and pre-determineds (van der Heijden 1996).



F = Forecasting, S = Scenarios and simulations, H = Hope connected to commitments and strong visions

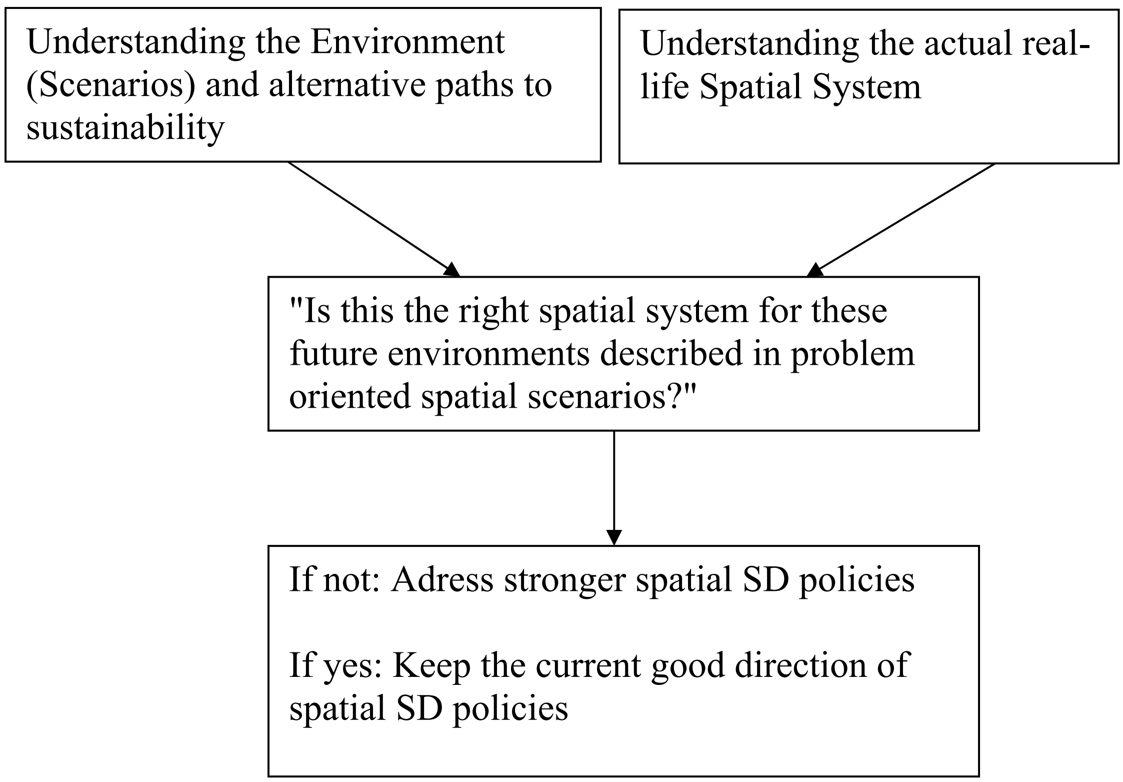
Figure 1. The balance between predictability and uncertainty (van der Heijden 1996, 92)

We see that the degree of uncertainty and predermineds changes in a time horizon. Time distance into the future is a crucial thing, when we try to manage future events. In the short run, we really can use forecasting methods, because predictability is high. In the middle zone, scenarios and simulation models are useful, because there is a considerable level of predictability, but also a considerable amount of uncertainty. In the very long-run, we do not have a very reliable basis to forecast the future, but we have, of course, our hopes, long-run transactions and commitments, because the very distant future provides us very few predermineds, but a lot of uncertainty. It is important to understand that our hopes and commitments can be connected to sustainable development alternatives. In this sense, we should also think of the very long-run effects of our current activities. However, in the very long-term, everything is uncertain and attempts to fix planning and decision-making demonstrate diminishing returns.

In Figure 1, the F-dimension is a short-run opportunistic perspective to the future, the S-dimension is a strategic perspective to the future, and the H-dimension is a visionary perspective to the future. If we think about the management challenges of the long-run sustainability, it seems that we should first learn to manage the F-dimension in order to reach the S-dimension, because if we make very wrong forecasts concerning sustainability issues, there is not going to be a resource base for strategic initiatives. If we learn to reach the S-dimension, then we have possibilities to reach the H-dimension i.e. visionary leadership criteria of sustainable development. Thus, traditional predict-and-control no longer works in the field of sustainability management, although many planning tools of environmental management are still connected to this kind of simplistic thinking.

On the basis of Figure 1, we can note that scenario learning is a crucial issue in middle- and long run futures studies. In short-run analyses, traditional forecasting may be useful and necessary in order to reach strategic level of management. However, we can note that middle- or long run perspectives are the necessary dimensions of management when we discuss sustainability issues in spatial contexts.

On the basis of scenarios, we can understand the environment of spatial systems. The key question in various spatial contexts is: "Is this the right spatial system for these future decision environments described in spatial scenarios?" It is very important to understand that the concept of sustainable development should always be problem-oriented. There is not a universal SD policy toolbox for all possible spatial contexts. Having gone through all relevant scenarios in this thinking mode, a judgement has to be made on whether the answers are positive enough to instill confidence in the future strength of the formula (see Fig. 2).



(modified version of van der Heijden 1996.)

Figure 2. Fit between the decision environment and the spatial system (van der Heijden 1996, 108)

The final answer of actual decision-makers may come out positive or negative. Depending on this outcome, scenario learning and the strategy process move in different directions. Also, a vision of spatial systems gets a different content, depending on a strategic conversation of shareholders of a spatial system.

"Bermuda triangle" of vision, strategy and scenarios in spatial contexts

In futures oriented management, one of the key challenges is to find a balance between spatial vision, strategies and scenarios of spatial development. I claim that there is a "Bermuda triangle" of management between these management concepts. If any of the three elements is missing in the spatial planning, there will be some problems in futures oriented management.

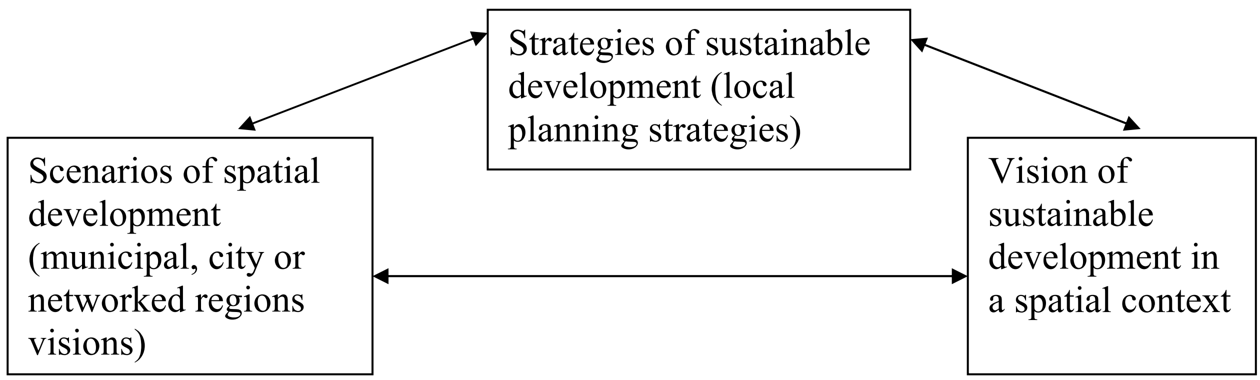


Figure 3. "Bermuda triangle" of vision, strategy and scenarios

The conventional dictionary definition of a scenario is "an outline of a natural or expected course of events." Thus, scenarios are descriptive narratives of plausible alternative projections of a specific part of the future (Fahey and Randall 1998). The function of scenarios in the management process is usually to make better strategies and well-argumented visions (Wilson 1992; Malaska and Holstius 1999). Scenario learning trains responsible spatial managers and planners to organize what they know and what they can imagine into logical, useful storylines about the future. They can also consider the logical implications of these "future stories for their current and future strategy choices." A benefit of scenario learning is that it prods the imagination, stimulating managers to think more audaciously about what is possible. It encourages managers to make informed, imaginative judgements about what they do not know. Reliable scenario sets of spatial development provide vividly contrasting narrative descriptions of how several uncertain aspects of the future might evolve. The scenarios are projections of a potential future. Some projections may be sustainable and some less sustainable, and some others even unsustainable.

Indeed, it is possible to present scenario framework for sustainable social development on the basis of socio-economic theories. (Kaivo-oja 1999). The problem of spatial planning can be that many cases do not utilize scenario learning methodologies in the formulation of local strategies and local visions. The same problem can be identified in the formulation of global sustainability strategies and visions (Luukkanen and Kaivo-oja 1999). If the scenario learning component is missing when we formulate visions and strategies, the management process tends to be inefficient. In non-scenario learning, risk options that we shall not reach sustainable spatial development process are greater than we use active scenario learning tools.

In the promotion of sustainable development, we need strategies in order to some day reach our visions concerning global sustainability. The conventional roles of strategic thinking are the following (Mintzberg, Ahlstrand and Lampel 1998):

- Set a direction of change,
- Focus efforts,
- Define responsible organizations, and
- Provide consistency.

In the context of scenario learning of sustainable development management, these issues are important. There are both advantages and disadvantages associated with strong strategies. A typical disadvantage is that strategic direction can also serve as a set of blinders to hide potential dangers. Setting out on a predetermined course in unknown waters is the perfect way to sail into an iceberg. Secondly, groupthinking arises when an effort is too carefully focused. There may also be peripheral visions and storylines, which open other possibilities. By scenario learning we may avoid too limited groupthinking in spatial management process. Thirdly, in some cases, defining responsible organizations too sharply may also mean defining them too simply, so that the rich complexity of the whole spatial system is totally lost. Scenario learning may help us to see the rich complexity in a better way. Fourthly, creativity thrives on inconsistency by finding new combinations of hitherto separate phenomena. Every strategy, like every theory, is a simplification that necessarily distorts reality. This means that every strategy can have a misrepresenting or distorting effect. That is the price of having a strategy of sustainable development. (Mintzberg, Ahlstrand and Lampel 1998). Strategies provide us future-oriented plans (intended activities), potential patterns positions (realize activities), analytical perspectives and plans, which may help us to reach our visions of sustainable development (Mintzberg, Ahlstrand and Lampel 1998).

Summarizing the discussion in this section, by effective scenario learning, we can prevent many disadvantages of rationalistic and too focused strategic thinking (Mintzberg, Ahlstrand and Lampel 1998,).

When we formulate strategies on the basis of scenario learning, there are many ways available to formulate strategy process in a spatial context. Mintzberg, Ahlstrand and Lampel (1998) have wonderfully summarized the history of strategic thinking. Their systematic evaluation work can be utilized also in the context of scenario learning. My point here is that, indeed, their synthesis helps us to make scenario learning an even more effective tool in SD management. Typical schools to study the strategy process are:

The Design School:	strategy formation as process of conception
The Planning School:	strategy formation as a formal process
The Positioning School:	strategy formation as an analytical process
The Entrepreneurial School:	strategy formation as a visionary process
The Cognitive School:	strategy formation as a mental process
The Learning School:	strategy formation as an emergent process
The Power School:	strategy formation as a process of negotiation
The Cultural School:	strategy formation as a collective process
The Environmental School:	strategy formation as a reactive process
The Configuration School:	strategy formation as a process of transformation

The fundamental ideas of these strategy process schools can be the source of scenario learning. If we view things widely enough, we can make scenario learning process very effective by

1. New strategic concepts,
2. Introducing new formal processes,
3. Analytical positioning processes
4. Introducing new visionary processes,
5. Mental change,
6. Emergent learning processes,
7. Intelligent target-minded negotiations,
8. Introducing and developing new collective processes,
9. Reactive processes, and
10. Multidimensional transformation processes (all these processes together).

Strategies should be constructed on the basis of alternative scenarios, but the actual nature of transformation processes can be different kinds of processes in different spatial cases (see e.g. Wilson 1994). In the scenario learning process, it is important to check and analyze all these alternative forms of strategic change. Different stakeholders (in the public sector) and shareholders (in the private sector) should be active in the selection of strategic initiatives and in the actual scenario learning process, because without the personal commitment of critical stakeholders and shareholders, strategies will be ineffective. When we construct scenarios, strategies and visions, we should keep in mind seven critical properties of sensemaking. Sensemaking is understood as a process that is (Weick 1995):

- Grounded in identity construction,
- Retrospective,
- Inactive of sensible environments,
- Social,
- Ongoing,
- Focused on and by extracted cues, and
- Driven by plausible rather than accuracy.

Thus, sensemaking can be seen as a part of the scenario learning process. If there is not enough sensemaking in spatial planning and management, typical pitfalls in the scenario process can be (Schoemaker 1998):

Pitfall 1: Failing to gain top management support early on
Pitfall 2: Lack of diverse inputs
Pitfall 3: Poor balance of line and staff people
Pitfall 4: Unrealistic goals and expectations
Pitfall 5: Confusion about roles
Pitfall 6: Failure to develop a clear road map
Pitfall 7: Developing too many scenarios
Pitfall 8: Insufficient time for learning scenarios
Pitfall 9: Failing to link into the planning process
Pitfall 10: Not tracking the scenarios via signposts

Pitfalls connected with the contents of scenarios are the following (Schoemaker 1998):

Pitfall 11: Inappropriate time frame and scope
Pitfall 12: Too limited a range of outcomes
Pitfall 13: Too much focus on trends
Pitfall 14: Lack of diversity of viewpoints
Pitfall 15: Internal inconsistencies in the scenarios
Pitfall 16: Insufficient focus on drivers
Pitfall 17: Not breaking out of the paradigm
Pitfall 18: Failing to tell a dynamic story
Pitfall 19: Failure to connect with managerial concerns
Pitfall 20: Failure to stimulate new strategic options.

This list can be used as a general checklist in the context of the spatial scenario learning projects and programs.

Strategic processes of local communities (cities, municipalities, regional networks etc.) should always to be connected to spatial visions. Too often, visions are not connected to strategic processes. There are many promising ways to make this connection work, for example, Soft System Methodology (SSM), Integrated Assessment and Integrated Planning tools (Checkland and Scholes 1993; Mannermaa, 1991; Kaivo-oja 1996; Ravetz 2000). According to Wilson (1992, 1995, 1996) as a concept of management, vision possesses real power in setting directions, motivating action, and guiding decisions. Vision is intensely practical, and —while it should reflect our values and aspirations—it must also be built on facts. Vision is also part emotional (the product of imagination, hunches, and values) and part rational (the product of analysis). It embraces the yin and the yang of strategy and performance. Wilson has also (1992, 1995, 1996) noted that *a vision must be coherent*, integrating goals, strategies, and action plans into a complete and recognizable picture of the future organization and its environment.

Personally, I think that all the analytical points of Wilson are very relevant in the context of spatial planning, although his key interest of study is in the business life. Thus, a vision can be an effective tool of local city or municipal management, if the vision motivates people widely and if it is connected to strategic activities and scenarios. In fact, a vision can be a "resource magnet of local operations and activities”. Strategic planning of local communities usually combines a shared vision of the local future, determining the best way to make this vision occur. By vision, we mean a shared picture of the future we seek to create - what we believe we can accomplish. If we want to create sustainable environments and societies, we need strong local visions of sustainable development.

Spatial scenario formulation process and sustainable development

Scenarios can be used to identify areas of uncertainty and provide some practical advice to local planners and managers about how to manage uncertainty. There are many uncertainties concerning global and local sustainability. A key issue in the construction of alternative scenarios is how these scenarios can identify key uncertainties of sustainable development. Scenarios should be written in sets of stories that describe the range of alternative futures most relevant to sustainability problems and challenges.

When we construct alternative scenarios, we should select the most critical uncertainties. Usually local decision-makers and planners have to have extensive discussion before they can define the critical uncertainties. There are two fundamentally different approaches to determining the basic premises of a small number of scenarios. One method is inductive, the other deductive.

The inductive method is less structured and relies largely on the patience of a group of experts and planning professionals to continue its discussion until consensus is reached. The group derives general logical principles from particular facts or inconsistencies. Another way, the deductive approach, uses simple techniques of prioritization to construct 2 x 2 or 2 x 2 x 2 matrixes based on the two most critical uncertainties.

The inductive method has two basic variants. In one, the expert or partly local layman team brainstorms different events that are typical of different scenarios. We can call this approach Important Events Identification Approach (IEIA). The phases of this method are the following (see e.g. Schwartz and Ogilvy 1998):

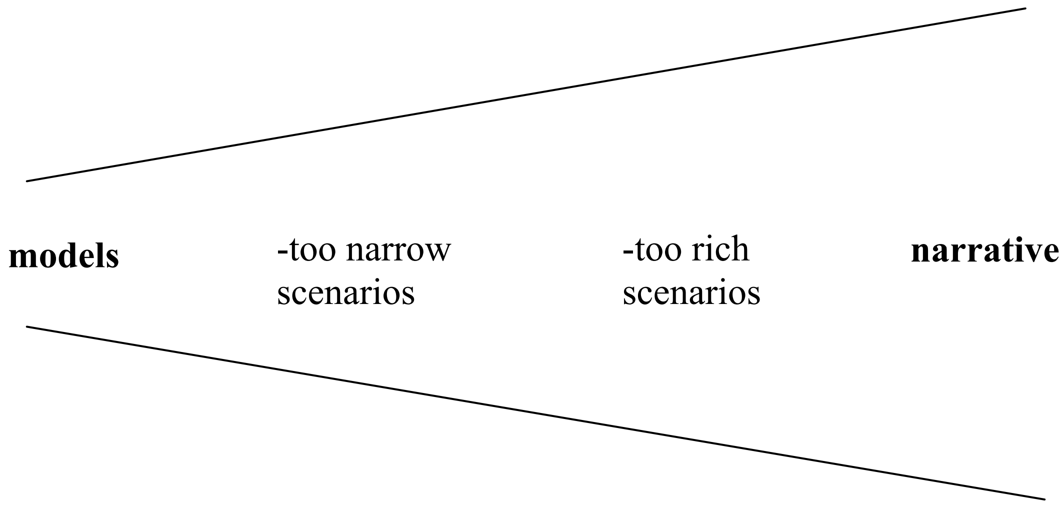
> 1. Important significant future events, which are crucial for sustainable development, are identified in an expert/layman group;
> 2. The expert/layman group spins larger story-lines around momentous events;
> various scenarios are presented and constructed on the basis of creative and imaginative group discussion. Some spatial scenarios are sustainable, some of them are more or less sustainable and some are unsustainable; and then
> 3. Scenarios are ready to be connected to local strategy process and visions.

In the other inductive approach, the group agrees on what an "official future" will look like and then searches for influences that could cause the actual future to deviate substantially from that path. We can call this method Official Future Approach (OFA). The typical phases of this method are the following (see e.g. Wack 1985, Schwartz 1992, Godet 1994, Schwartz and Ogilvy 1998):

- An expert group drafts one (or more) "official future". This official story-line may be the future that the decision-makers really believe will occur. This scenario is not usually one where critical sustainability issues are conceptualized.
- Important components of the official future are identified (key drivers) through interviews with the larger scenario team,
- Annual reports, forecasts, statistical analyses are done to provide more information to the more detailed scenario analysis and to the story-line writing process,
- After identifying the key driving forces and uncertainties, it is usually easy to discover which ones are most important and influential in the official future.
- The scenario group brainstorms variations to the official future that are based on possible but quite surprising changes in its key driving forces. Some spatial scenarios are sustainable, some of them are more or less sustainable and some are unsustainable;

- The scenario group then explores how different interactions between key forces might produce unexpected outcomes and build several new scenario logics.
- Scenarios are ready to be connected to local strategy process and visions.

It is also possible to combine these two methods - starting with the Official Future Approach (OFA) and then connecting with the Important Events Identification Approach (IEIA). However, a scenario study starting with various narratives results in scenarios too rich to be represented by a model. Scenario studies intended by a rich model almost always tend to result in scenarios that are too narrow (see Figure 4, Greuuw et al 2000).



(modified version of Greuuw et al, 2000)

Figure 4. The problem of scenario formation: the model - narrative flume (Modified version of Greuuw et al 2000, 133)

Problematic issues in scenario building and formation can be also:

- Participatory development of scenarios,
- Integration of time and space scales,
- Integration of weak signal analyses and trend analyses in more peripheral scenarios,
- Balanced integration of environmental, social, economic and institutional processes,
- Integration of various scenario methods,
- Explicit inclusion of a wide variety of perspectives, and
- Translation of long-term policy recommendations to short term policy agenda.

The deductive approach to scenario formulation starts from the idea to prioritize the long list of key factors and driving trends in order to find the two or three most critical uncertainties. The typical phases of this method are the following (see e.g. Schwartz and Ogilvy 1998):

- A scenario group makes a list of key factors and driving trends in order to find the two or three most critical uncertainties. Members of a scenario group are asked to bet on which important forces are most uncertain. This ranking exercise accelerates the discussion by narrowing the group's focus to the most important crucial forces. Another way is to utilize scientific knowledge in the ranking exercise. Scientific models and theories can contribute to the selection of key driving forces. These theoretical models can be used in the context of sustainability analysis. (see e.g. Kaivo-oja, 1999; Rubin and Kaivo-oja 1999; Malaska, Luukkanen and Kaivo-oja 2000); Selected key factors become the axes of scenario matrixes;

- 2 x 2 or 2 x 2 x 2 scenario matrixes are constructed;
- Alternative storylines of scenarios are described and reported; and
- Scenarios are ready to be connected to local strategy process and visions.

There are a number of advantages to building scenarios on a matrix. Firstly, using a matrix assures that scenarios are qualitatively different in a logical, nonrandom way. Secondly, a matrix assures that the top-scoring key factors will be drivers in all scenarios. Deciding upon the axes of a matrix is an interactive group or expert driven process, driven as much by challenge as by consensus. Schwartz and Ogilvy (1998) have suggested that three-dimensional, eight-celled frameworks sometimes prove to be too complex. However, eight-celled frameworks are necessary to bring all relevant factors into consideration in some complex analyses.

As a summary, a typical process of scenario learning can be presented in Figure 5.

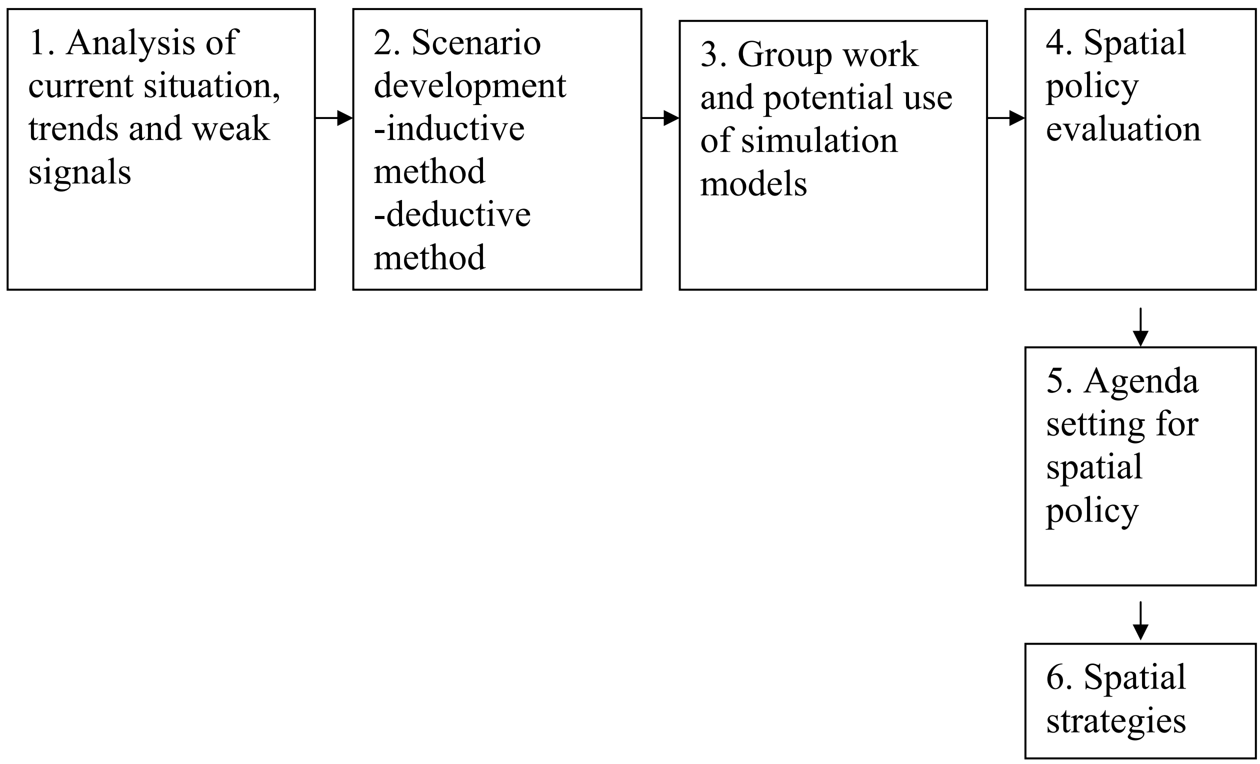


Figure 5. A typical process of scenario learning in a spatial context

There is not just one right way to design scenarios. Different planning cultures, organizational cultures, different facilitation styles may dictate the use of one or another of the approaches for settling on the basic logic of a few scenarios (Schwartz and Ogilvy 1998). In a recent assessment of 20 recent European and global scenario studies and models, the following weaknesses were identified by ICIS research group (Greuuw et al 2000):

- Detailed scenario is not the same as comprehensive.
- Integration of study is not merely addressing a variety of scales, sectors and issues. Crucial to integration is analysis of the mutual interplay and trade-offs.
- Using perspectives is no quarantine that all relevant uncertainties are addressed and that all assumptions are transparent. Stringent documentation remains needed.
- The composition of a participatory scenario group should be both heterogeneous as well as balanced.
- Most scenario studies are too technical. They miss the institutional dimension. If they are not desk studies, they miss the variety that they need.
- Methodological underpinnings of scenario studies are crucial. More research should be dedicated toward the methodology of scenarios.

In a ideal situation, models and scenarios are used in a complementary manner. However, this is not always possible in changing spatial contexts.

A fundamental theory-based SD scenario framework for Western societies

Two prominent social theories shaped the discourse of environmental policies and ways to see sustainability problems of Western societies during 1990s. These theories are interesting from the perspective of sustainability challenge. On the basis of these theories we can plot an interesting scenario framework, which can help us to discuss the SD scenario framework. This theoretical discussion produces a typical 2 x 2 matrix for scenarios.

Ulrich Beck´s risk society theory (Beck 1992) contends that conventional definitions of social class are losing their significance in industrialized nations due to the success of the welfare state in reducing economic scarcity. As societies transition toward late modernity, new social cleavages based on the distribution of environmental and technological risks are gaining salience. These technological threats are fundamentally different from those that existed in earlier eras for three reasons: (1) they are undetectable by direct human sensory perception; (2) they are capable of transcending generations; and (3) they exceed the capacity of current mechanisms for compensating victims (Cohen 1997).

Standing in contrast is the theory of ecological modernization original advanced by Joseph Huber (1985), Martin Jänicke (1990) and Udo Simonis (1988), outlining a hyper-rational strategy for correcting the ecological flaws of contemporary production and consumption practices. Ecological modernization is a theory that aims to harness the power of human ingenuity for the purposes of harmonizing economic advancement with environmental improvement. Thus, ecological modernization theory takes a more optimistic view than Beck´s risk society theory, when it calls for the refortification of industrial ingenuity to correct the environmental failings of contemporary production and consumption practices.

Cohen (1997) has presented a typology that joins the two theories into a unified framework and suggests that the direction toward which a particular society progresses will be conditioned by its predisposition of scientific rationality. In his study, Cohen pointed out that, due to increasing public endorsement of alternative epistemologies, most countries will likely encounter great difficulty achieving ecological modernization (see also Spaargaren 1997).

According to Cohen (1997, 1998) the theories of risk society and ecological modernization are positioned in opposition to one another. This statement provides the foundation for the two-dimensional typology presented in Figure 6. The horizontal axis in the schematic diagram measures, in conceptual terms, environmental and technological security from ’insecure’ to ’secure’. The vertical axis delineates development and ranges from typically third world, pre-modern societies to advanced industrial and post-industrial nations.

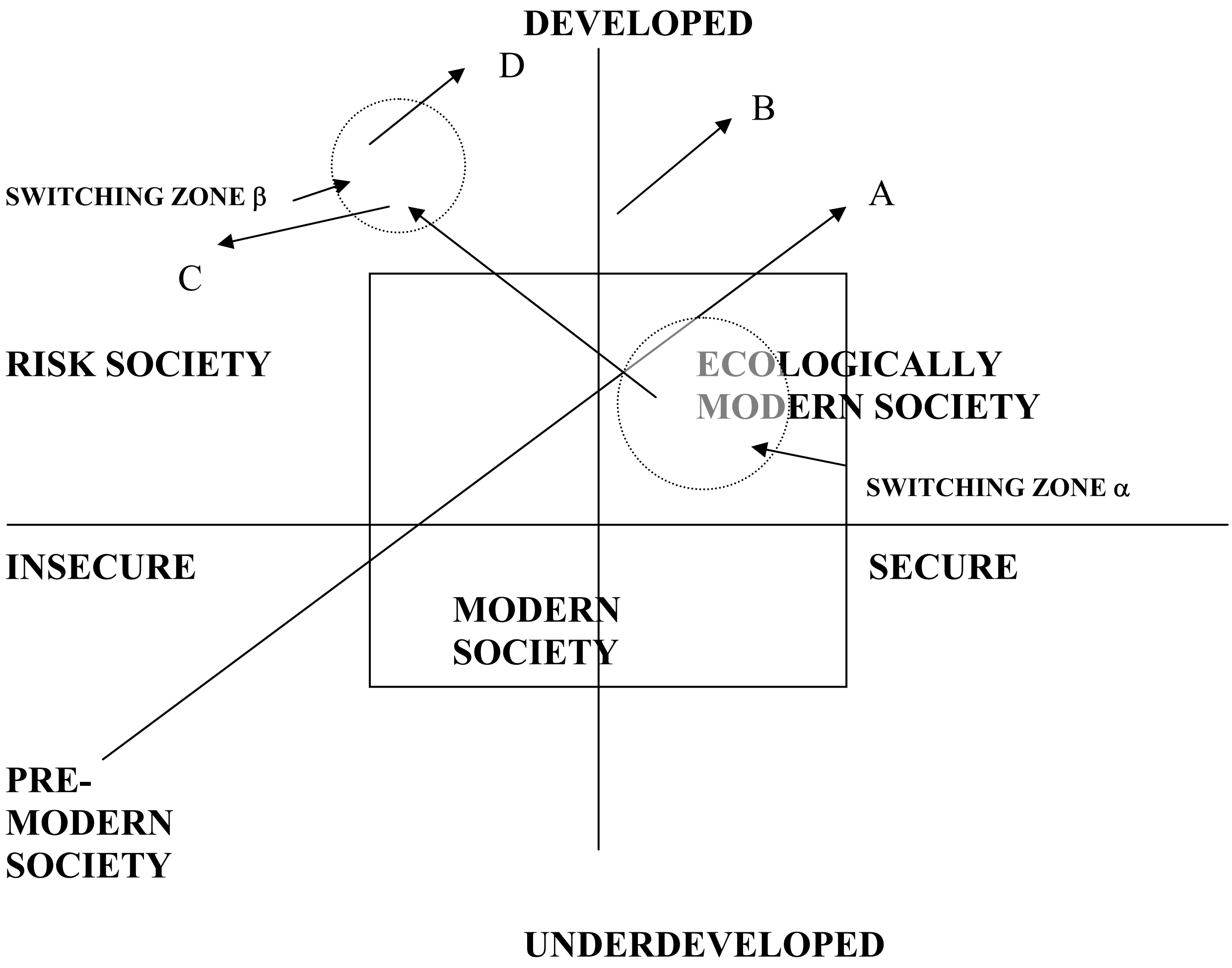


Figure 6. Technological-environmental risk and development (Cohen 1997, 110)

Located in the lower left-hand quadrant of this typology are societies still in their pre-modern phase. Relatively low levels of economic development and high insecurity characterize these kinds of societies. This vulnerability is a function of pre-modern societies' rudimentary technology that consigns them to exposure to the forces of the natural environment. Societies at this stage of social and economic development are intimately connected to nature, and the fate of individual lives is predicted on the benevolence of natural geophysical and meteorological forces (Cohen 1997). To contend with the unpredictability and inevitability of events such as hurricanes, earthquakes and floods, pre-modern societies have historically developed complex belief systems based on mysticism and superstition to impose a knowledge structure around these phenomena (Malinowsky 1984).

The diagram's central cell represents the second major stage of the conventional development trajectory in which societies become modern. Social theorists for whom distinctions between pre-modernity and modernity are important share no general agreement on the precise delineation between these two stages of development. For most social theorists, however, modernity is taken to be coterminous with the transcendence of feudal forms of social organization and the emergence of industrial production. Risk in modernity is characterized by a critical trade-off in which societies experience an increase in their proficiency for managing natural hazards, but are forced to confront acute and chronic threats arising from the widespread propagation of inadequately-controlled technology (Cohen 1997).

Ecological deterioration in modern society mounts as a byproduct of industrialization, but this is often considered an unavoidable cost in the process of material acquisition. This cycle of economic advancement and environmental degradation does not continue indefinitely. Once a society has attained a threshold level of economic progress in which marginal increases in material accumulation cease to bring commensurate returns, the transition from an acquisitive modernity to an era of ecological modernization is presumed to commence. As a modern society approaches this juncture, the environment begins to shift its status from an expendable resource to a valued amenity. This ethical transformation gives rise to the modification of existing technologies and institutions to better accommodate the protection of ecological assets and integrity (Cohen 1997).

Development theorists have typically posited that this route to a less environmentally destructive form of social organization is a linear extrapolation of the customary growth trajectory identified by Path A in Figure 6. This formulation is essentially a stage, or evolutionary-process, suggesting that over time a society will proceed from pre-modernity to modernity and finally ecological modernity. Usually, adherents of this deterministic approach fail to recognize that ecological modernization is neither pre-conditioned nor inevitable (Cohen 1997). Actually, it is a potential scenario of sustainable society.

To climb into the upper right-hand quadrant in Figure 6, a society must substantially modify its institutional structures, develop new policy tools, and adapt its life ways to accommodate environmental limits. Cohen (1997) notes that these adjustments require a society to disengage from its modern past and make the discontinuous leap to the trajectory represented by Path B. Once this ’jump’ has been successfully achieved, the newly ecologically modern society can assume a revised development path that will enable it to increase simultaneously both economic advancement and technological-environmental security. The opportunity for ecological modernization occurs when a society reaches switching zone α. This zone is marked by a period of indeterminacy during which a complex process of societal negotiation takes place to evaluate alternatives and assess political, economic, and cultural capabilities for this strenuous project (Cohen, 1997).

The transformation to ecological modernity is not assured and failure to make the necessary jump will cause a society to assume an alternative trajectory labeled as Path C. This is the route to the risk society characterized by erratic economic development and increasing lay insecurity arising from a preponderance of inadequately-managed hazardous technology. In risk societies, episodic environmental and technological crises expose the inadequacies of these political regimes and exacerbate insecurities among their publics. Risk societies are not consigned, however, to face a future of indefinite apprehension as there exist an opportunity for them to chart a development course that enables them to overcome their chronic anxiety. This scenario, referred to here as the trajectory of 'self-correcting risk society', is depicted by the Path D which becomes accessible at switching zone β. This development trajectory, which is more evolutionary than discontinuous (as is the case of ecological modernization), involves the promotion of humanity over economic determinism and the creation of accountable administrative structures for making technological decisions with collective ramifications.

Conclusion

Sustainable development implies a commitment to quality in every sense of the world. In developing a coherent spatial sustainability strategy, we need more systematic and in-depth analyses of municipal and city environments and other spatial entities. One way to improve the quality of spatial planning and management is to utilise a scenario learning approach to futures oriented spatial planning and strategy processes. In this paper, I have discussed various topics, which all are connected to the challenging concept of scenario learning. The most problematic topics in the scenario learning process are processes and contents of scenarios. When we study processes, the key question is: "How is the spatial scenario exercise conducted?" On the other hand, when we analyze contents of alternative spatial scenarios, the key question is: "What should the spatial scenarios focus on?" This article provides some new and old ideas to answer to these critical questions and summarises some key issues in the field.

Scenario learning can help managers to develop strategic management and visionary leadership, when they plan sustainability policies in various spatial contexts. Sustainability of local communities is a long-run question and that is why scenario learning is needed. Once the learning scenarios are revised and accepted, they can then serve as decision support of spatial strategic processes. However, scenario learning must be connected to sense making in spatial management and planning organizations, because there are many potential pitfalls of scenario learning. Some pitfalls are connected to processes and some are connected to the contents of scenarios. Following the guidelines presented in this paper, these obvious pitfalls can be avoided in the practice of spatial management and planning.

If we want to survive in the Bermuda triangle of vision, strategy and scenarios in spatial contexts, we should always connect these issues together. Often vision, scenarios and strategies are separated from each other. This is not the best practice for spatial management and planning. We have utilise the historical the historical leaning of strategic schools more consciously, if we want to connect scenarios and visions effectively to spatial strategies.

In the last section of this paper, an interesting scenario framework of sustainability politics was presented. This scenario framework is a good example of how scenario learning can be connected to scientific discussion. The message of Cohen´s (1997, 1998) scenario framework is that in Western societies, we have two basic orientations available in the spatial sustainability policy. One main scenario (and storyline) is connected to the scientific discourse of risk society; another is connected to the scientific discourse of ecological modernization. These kinds of scenario frameworks, which are based on scientific discussion and contributions, can also be used in the formations of spatial strategies and visions of sustainable development. The most important use of scenario learning is to devise new insights about the future decision environment. If these kind of new insights are not utilized effectively, there may be less hope concerning sustainability of spatial development processes.

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THE ENVIRONMENT IN AN 'INFORMATION SOCIETY':

A TRANSITION STAGE TOWARDS MORE SUSTAINABLE DEVELOPMENT?

By

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Information society: not only technological but also social upheaval?

It has been argued that, just as the neolithic and industrial revolutions were based on radical changes in the use of energy, the current third revolution of mankind is based on a completely new status of knowledge (Boisot 1995). Information and knowledge have been regarded as the determining factors of the late-modern period, because new scientific knowledge and technological innovations are leading to the transformation and reorganisation of societies and the world community. Giddens, among others, has emphasised the reflexive monitoring of knowledge in the renewal of systems: the praxes are being evaluated in the light of new knowledge and, also, the knowledge itself is susceptible to chronic revision due to new information (Giddens 1990).

Accordingly, numerous social scientists and futurists have suggested that societal development is advancing to a novel stage, to an ‘information society’. It might he still in blossom, or have already burst into bloom. The concept of information society is obviously of Japanese origin, but it has often been considered a logical extension or expansion of Daniel Bell’s notion of the ‘post-industrial society’ from the early 1970s (Dordik and Wang 1993, Bell 1974, Badham 1984, Marien 1994, McQual 1994). However, the most crucial qualifiers of this ‘new’ form of society are not unambiguous. The scope and progressiveness of the changes are disputable, as is the stage in which the changes become permanent characteristics of societies, and not only changes in the chain of changes. Among others, Castells has taken a critical stand on the notion of the information society (Castells 1996). Preferring the concept ‘informational society’, he argues that even though information has been a crucial factor in all societies, ‘informational’ indicates a novel attribute of a specific form of social organisation because of new technological conditions emerging in this historical period. Thus, the key feature of the informational society would be the networking logic of its basic structure. In sum, according to Castells, all societies are affected by capitalism and informationalism, but there is still a great diversity among informational societies.

Coincident with the revival of information society discourses, Webster has classified five diverse definitions of the concept (Webster 1995). These are based on technological, spatial, economic and cultural criteria, and on criteria connected with occupational changes. The technological definition naturally emphasises the significance of information technological innovations. It is assumed that the application of information technologies will permeate all fields of life, along with breakthroughs in processing information and communication. Thus, technological innovations are assumed to be sufficient to characterise the new form of society. In the spatial definition, again, the focus is on connecting localities with information technology networks. These networks are considered to have dramatically changed the organisation of time and space. Furthermore, the core criterion of definitions based on changes in economic or occupational structures is the dominance of the information sector in the spheres of production or employment. Finally, according to the cultural definition, it is essential that we live in a culture that is more engulfed by information than any of its predecessors.

Certainly, the technological and economic notions of the information society can be regarded as the most influential from the point of view of policies. This is clearly found in the very basic premises of international (Europe and the Global Information Society. Recommendations in the European Council 1994) as well as, for instance, of Finnish (Valtiovarainministeriö 1995) programmes of the information society. However, it seems to us that most of the definitions include a common basic presumption according to which the characteristics of the information society, whatever it may be, begin to dominate societal rationality once and for all at some unspecified point. Citizens are assumed to enter into a more or less 'ready' information society. This simple and one-sided view has to be met with reserve, however, because it easily excludes several fundamental factors, which are essential in social and political development. For instance, the technological definitions generally ignore the risk that the decisive power in the 'information society' may be used only by a limited élite of information experts (Webster 1995). In such a society citizens would above all be subordinated to information technology, which would generate resistance and societal tensions not to be ignored.

Social sciences and futures studies have contributed most strongly to the theoretical examination of the information society (Bell 1974, Kahn, Brown and Martel 1976, Masuda 1981, Toffler 1990, Naisbitt and Aburdene 1990, Boisot 1995). The increasing environmental stress and goals of sustainable development, however, create new practical challenges for information society studies. The need for a futures approach is evident in order to understand the complexity of societal changes, and to anticipate technological risks. In this paper, the theoretical and conceptual focus is on the relation of the information society to the environmental problematique. The aim is to examine the dynamics and opportunities as well as the risks, between the information society and the environmental goals of sustainable development. The broad framework is the theory of transient dynamics, according to which the information society is to be seen mainly as a transitional phase between the fading of the industrial society and the emerging of a new form of society. With reference to the notion of Daniel Bell, the latter term could be coined with his post-industrial society term. However, in order to put a positive connotation on the post-industrial term, we would like to underline the importance of human relations, and use the concept 'knowledge-based interaction society'. In all events, the new economy will supposedly be dominated by service consumption instead of the consumption of goods, and by service-intensive industry and service production.

The futures approach: the information society as a transition period to the post-industrial

Analysis of the information society must take place through a multi-disciplinary knowledge basis, and be connected with the understanding of problems of the economy, of culture, and of nature. The complex nature of society, as well as the need for concepts produced by different sciences in order to capture this complexity have certainly been identified in futures studies (Bell 1997). Some of the basic characteristics of the futures approach are the interaction of sciences, conscious evaluation of the complexity of phenomena, the evaluation of global evolutionary processes, and discussion of normative value questions (Masini 1993, 19-26, Bell 1997, 140-157).

The relation between the present and images of future is a dialectical and interactive process. Visions and alternative scenarios guide the choices made by current actors (Giddens 1990, Smart 1992, Boulding and Boulding 1995, Malaska 1995). Expectations and wishes concerning the future are thus part of the present. It follows that, at the same time, they limit the spectrum of possible futures. On the other hand, prevailing ideas in society about the future influence decision making and actions taken (Inayatullah 1993).[26] The theory of transition periods emphasises the transciency of the prevailing stage of society and its instability (Malaska 1991, Malaska 1994). Furthermore, the complexity carries unpredictability of change; the characteristics of the transitional period do not show what the characteristics of a possible future will be. According to this framework, the period of transition is a necessary adaptation and emergent phase between two successive and more stable periods of development.

In transition periods, the variety of options and future paths is wide, and the power of innovation fluctuates. Furthermore, visions of the future become very complex and diversified. Ultimately, however, even futures researchers have not been convinced about whether qualitative social changes take place by stepwise continuity (or even by a 'system break') or through a long transitional phase (Malaska & Salminen 1994). The former way of thinking recognises the changes at once as immediate and permanent features of the novel stage. On the other hand, according to the transitional perspective, 'the change will be changing', and, therefore, there is, instead of a stepwise change, a transition period as an essential element and prerequisite of societal dynamics. This is the view held in this paper.

Periods of transition last for decades rather than years. It is argued here that, at present, the western world is living in the middle of a transient period in which the prevailing rationale of manufacturing (industrial society) is losing its dominance to another type of rationale (*Figure 1*). This period of transition can more specifically be called an information society because of the essential role of information and information technology. However, if the development is put into a larger time frame of transition, it is more relevant to call the period a late-industrial period. It is still part of the industrial society stage, a stage which is ending and giving way to something new.

The inevitable advancement towards conscious technology will certainly overshadow what we understand now by information technology. As the development stages of society are assumed in this paper to be determined by emerging new needs, so the new type of society is expected to be transformed from one dominated by tangible needs to one in which intangible needs are of the highest priority. The germ of this transmutation is new scientific knowledge on a broad scale, and the innovations based on it, and new kinds of human communication and associated needs (Malaska 1991). It follows that education, research and new scientific knowledge, as well as the efficiency to transform knowledge into information and innovation, will increasingly take the key position in societal dynamics.

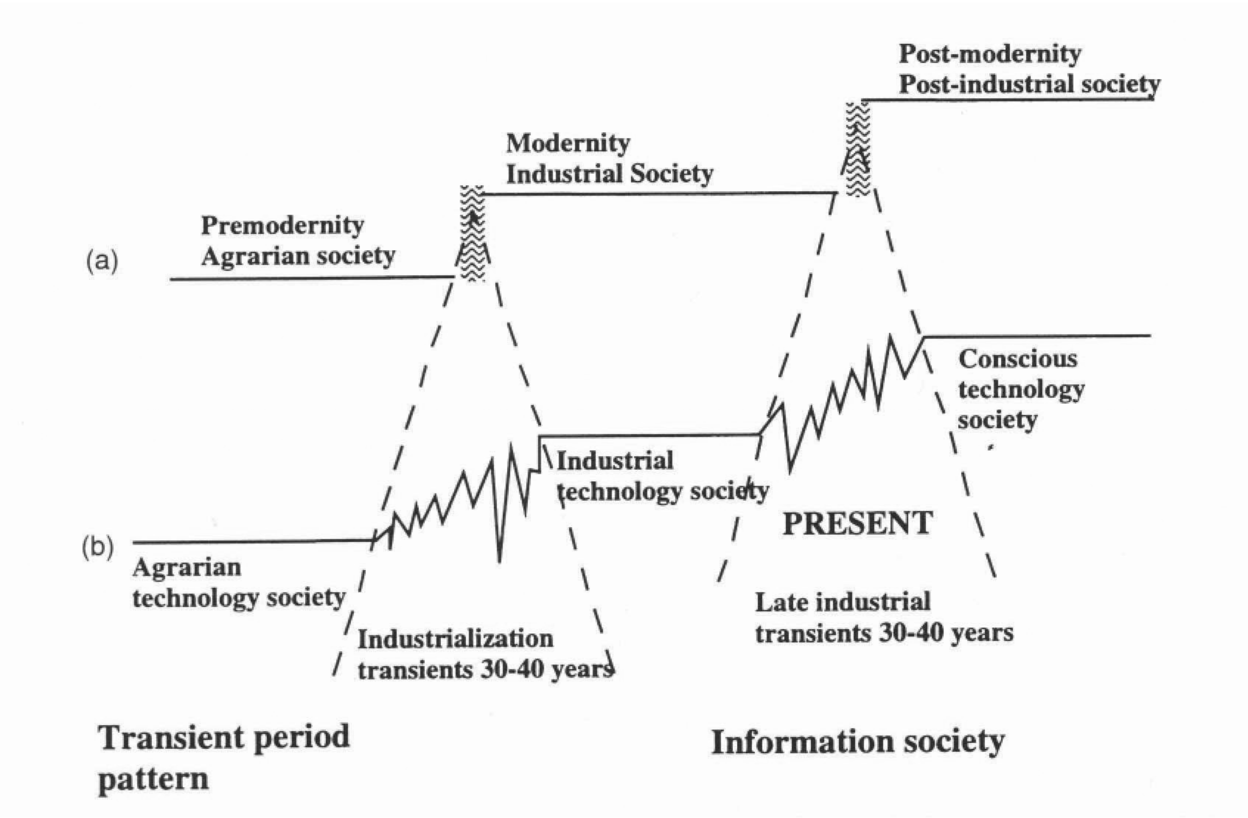

Figure 1. Two different perspectives of societal change: stepwise continuity or a transient period between development stages. (Malaska 1991)

Environmental question and development paradigms

Sustainable development has become a principal policy objective on international and national political agendas. In fact, the main ideas were already germinating at the first environmental conference of the United Nations in Stockholm in 1972. However, they were brought up as a policy strategy in the latter part of the 1980s by the well-known World Commission on Environment and Development (WCED). Sustainable development was presented as a new way of identifying and managing the mutual relations of economy, politics and the environment. Obviously because of its importance and flexible enough definition, the concept quickly took root especially in administrative discourses.

One of the basic objectives of sustainable development, as was stated by the WCED, is to bring economic growth and the environment into harmony. In addition, human needs and social welfare are connected with this relationship. Taken together, this would appear as a re-organisation of distributional issues at local, national and especially inter-national levels. Now, in the 1990s, it has been re-claimed in several authoritative action programmes and documents, such as the Rio conference declaration 'Agenda 21' (1992) and the EU's 'Towards Sustainability' (1993), that economic and social development should be linked to the improvement of the environment.

There has been a lot of scientific and political debate about an adequate definition of sustainable development-not least for the reason that the concept is actually based on political compromises rather than on new scientific achievements (Dietz, Simonis and van der Straaten 1992). The dominant model of sustainable development in political discourses has been considered both vague and atheoretical. In practice, in the arenas of nation-state policies and politics, different political actors are trying to push through their own definitions of what 'development' is and what 'sustainability' generally means (Jokinen and Koskinen 1998). For example, Hajer has shown that the hegemony of the discourse of sustainable development should not he seen as a product of any linear and value-free process (Hajer 1995). Rather, it is the result of the struggles between several unconventional political coalitions. Thus, sustainable development must be understood as the first global environmental discourse behind which there is on extensive coalition of actors with very differing views on the issues of the environment and development. According to Hajer, the paradox is that the sustainable development discourse coalition can only be held together around a very loose discourse at the same time as it demands radical social change.

The optimistic international strategy has given nation-states opportunities to legitimate very different activities in the name of sustainable development. It is fair to state that some of these practices may even be harmful with regard to welfare and the environment. However, as O'Riordan has put it, people want to believe in sustainable development, and it is also a moral guideline and an article of faith, similar, for instance, to freedom and justice (O'Riordan 1996, Achtenberg 1996, Blowers 1997). To complement policy goals, there is a need for visions, firstly, of the process aiming at less unsustainable society, and secondly, of the process aiming at the sustainable society, although the latter might also be considered an illusion as an end state.

As a response to such complex environmental and development questions, Milbrath has suggested that there are basically two ideal types of alternative paradigms, namely, the ‘old dominating social paradigm’ (DSP) and the ‘new environmental paradigm’ (NEP) (Milbrath 1994). These start from completely different basic assumptions. The dominating paradigm emphasises anthropocentric and instrumental approaches, whereas the new paradigm lays stress on eco-centric and evolutionary approaches. Overall, the ideal type of the latter strongly resembles descriptions of the ‘post-industrial’ or ‘post-material’ value complexes.

Milbrath suggests, firstly, that societies and communities will organise themselves along the lines of the two main paradigms and, secondly, that at the moment the new paradigm is challenging the dominating one. Furthermore, although slightly overstating the descriptive power of the dichotomic model, he argues that societies which continue to construct their futures on the basis of the DSP must be considered ‘unsustainable’. Conversely, societies based on the premises of the NEP will be ‘sustainable’. (Milbrath 1989, Myers 1993). One more theoretical debate concerning environment and development paradigms has recently been centred round the concept of ecological modernisation (EM). An interesting contribution to this discussion by means of the futures approach has been made by Cohen. He has aimed at combining the basic elements of the ecological modernisation perspective with those of the well-known risk society theory of Ulrich Beck (Cohen 1997). In the first place, it should be emphasised that it is somewhat difficult to integrate these conflicting theories into a unified theory of transformation, as well as into a social vision. The position of the EM paradigm might essentially be labelled technocentric and conservative from the societal point of view (Jokinen and Koskinen 1998, Blowers 1997). The risk society theory rather takes an extremely critical stand on technological development, and calls for a radical restructuring of the basic institutions of the ‘late-industrial’ society.

Cohen suggests, however, that the role of scientific rationally in promoting economic and environmental progress can be considered to justify joining these theories (Cohen 1997). It follows a two-dimensional typology of societies based on degrees of ‘development’ and ‘security’. According to Cohen, the risk society is defined as a developed but insecure one, whereas the ecologically modern society is, of course, both developed and secure. Furthermore, it is suggested that several advanced nations are arriving at the ‘switching zone’, a period of indeterminacy and societal negotiation, where they must respond to the challenge of ecological modernisation in order to avoid the route of the risk society. One of Cohen’s main conclusions is that there may be some vanguard nations in the process of EM, such as Japan and the Scandinavian countries, but that the overall evidence is still inconsistent and contradictory.

The long-term scenario calculations of the European Union might be considered a concrete example of the serious environmental problematique of societal development (Potential Benefits of Integration of Environmental and Economic Policies. An Incentive-based Approach to Policy Integration 1994). As far as the EU-6 countries are concerned, the options of social development have been evaluated up to the year 2010 on the basis of the DSP (the 'REF' and 'PIP' scenarios), and of the NEP (the 'INT' scenario). This scenario means the integration of environmental objectives with the economic and sector policies in the EU. Typical political choices are marked-based environmental taxes and fees such as emission and traffic fees and, most importantly, CO_2 taxes. In terms of the process of sustainable development, the INT scenario may be seen as the best of these alternative scenarios. Basically, when acting according to it, environmental advantages are produced in agreement with the objectives of economic growth. Therefore, it is apparent that at least some discussion is being held within the EU about the basis of social development and environmental policies, as well as about the scenarios formed on the competing paradigms referred to.

Intersections of the information society and sustainable development?

From the viewpoint of futures studies, a question of high importance is to what extent the construction of the information society will follow the principles of the above-mentioned dominating social paradigm, for instance, and those of the new environmental paradigm. It has been proposed that the gap between these two ideal types could be narrowed on the basis of a system theoretical approach (Healy 1995). However, it may rather be the case that we are living in a critical intermediate phase between two ages, and thus the tension between the development paradigms should rather be interpreted as a basic characteristic of the transition period.

Theoretically speaking, the main elements of social and environmental development can be divided into Information Society issues (eg information networks), Technology and Infrastructure issues (eg. technology and business) and Sustainable Development issues (eg dematerialisation and environmental technology) (Greiner, Rademacher and Rose 1996). As illustrated by the conceptual schemata in *Figure 2*, these issues do, of course, interrelate and overlap.

The information society and sustainable development most often manifest themselves, however, as competing scientific and socio-political discourses. They are simply used as mutually exclusive notions. For instance, Marien has concluded that researchers and promoters of the information society are not generally interested in sustainable development, and the same is valid vice versa (Marien 1994). Consistent with this, Marvin has noted that researchers and policy makers in urban environment and telecommunications sectors inhabit distinct worlds with different ways of conceptualising cities (Marvin 1997). As a result, visions of a 'sustainable city' and an 'informational city' do not coincide. Supposedly, this is due to the main actors' differing rationalities and value conflicts (eg about the desirability of economic growth and technological development), which are consonant with those which Milbrath has referred to as the concepts of DSP and NEP.

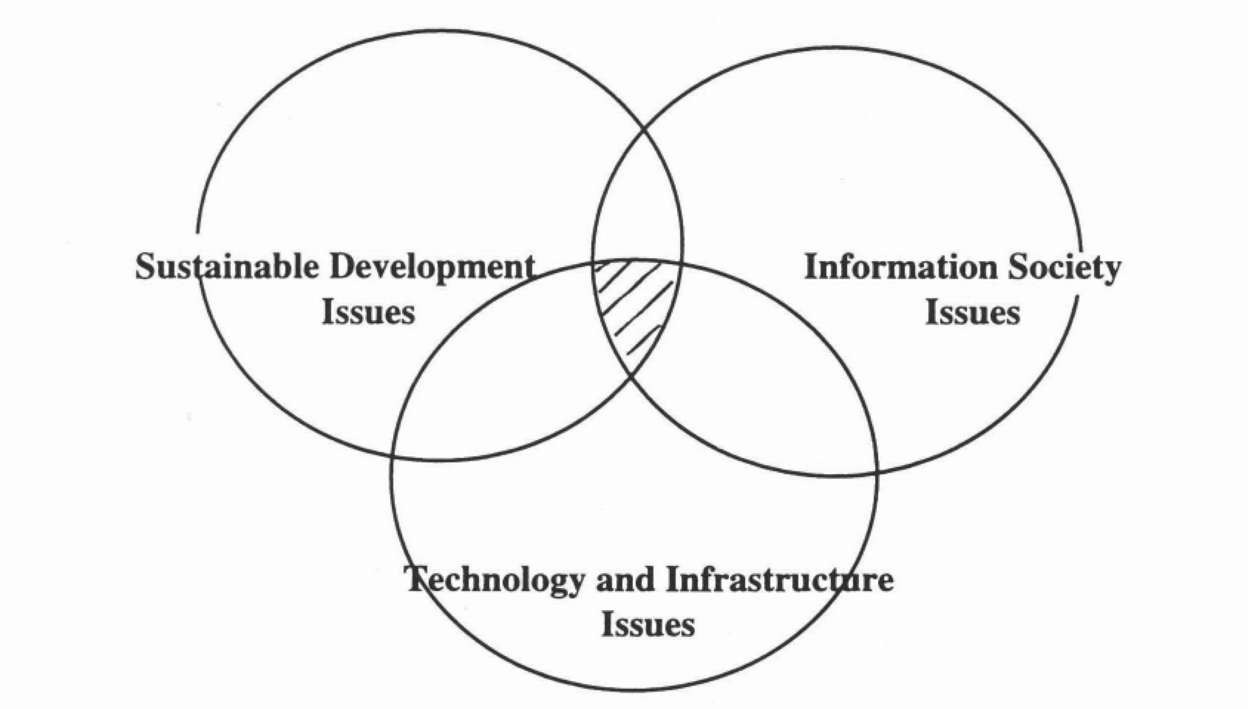

Figure 2. Issue areas of the information society, of technology and infrastructure, and of sustainable development (Greiner et al 1996, 12).

In our view, theoretical and empirical analyses of interaction and dynamics between the information society and sustainable development should have a crucial role in examining the potential for reducing the stress on the environment. However, the conceptualisation of the relation between the information society and environmental issues presented in *Figure 2*, is a static one. It easily directs attention away from the dependencies between the sectors. Thus, the model in *Figure 3* emphasises the dynamic interplay between the phenomena of the information society, technology and sustainable development (Malaska 1991). It is formed both by autonomous processes of growth (auto-catalytism) and by the interactive processes between them (cross-catalytism). According to this conceptual push-and-pull model, firstly, the main parts of an issue area have impacts on other issue areas and, secondly, the main parts change into input factors of the changes in the other areas. For instance, the impact of information technology on the environmental sustainability of a society is a complex mixture of positive and negative impacts.

Sustainable development, instead of being a final objective, has to be understood as a continuous process of change. The creation of its structural preconditions may require a societal form resembling an 'information society' (Greiner et al 1996). However, as emphasised above, sustainable development and the information society are not synonymous. Although there may be no comprehensive sustainable development without the information society, there certainly can be an information society, which does not enable sustainable development.

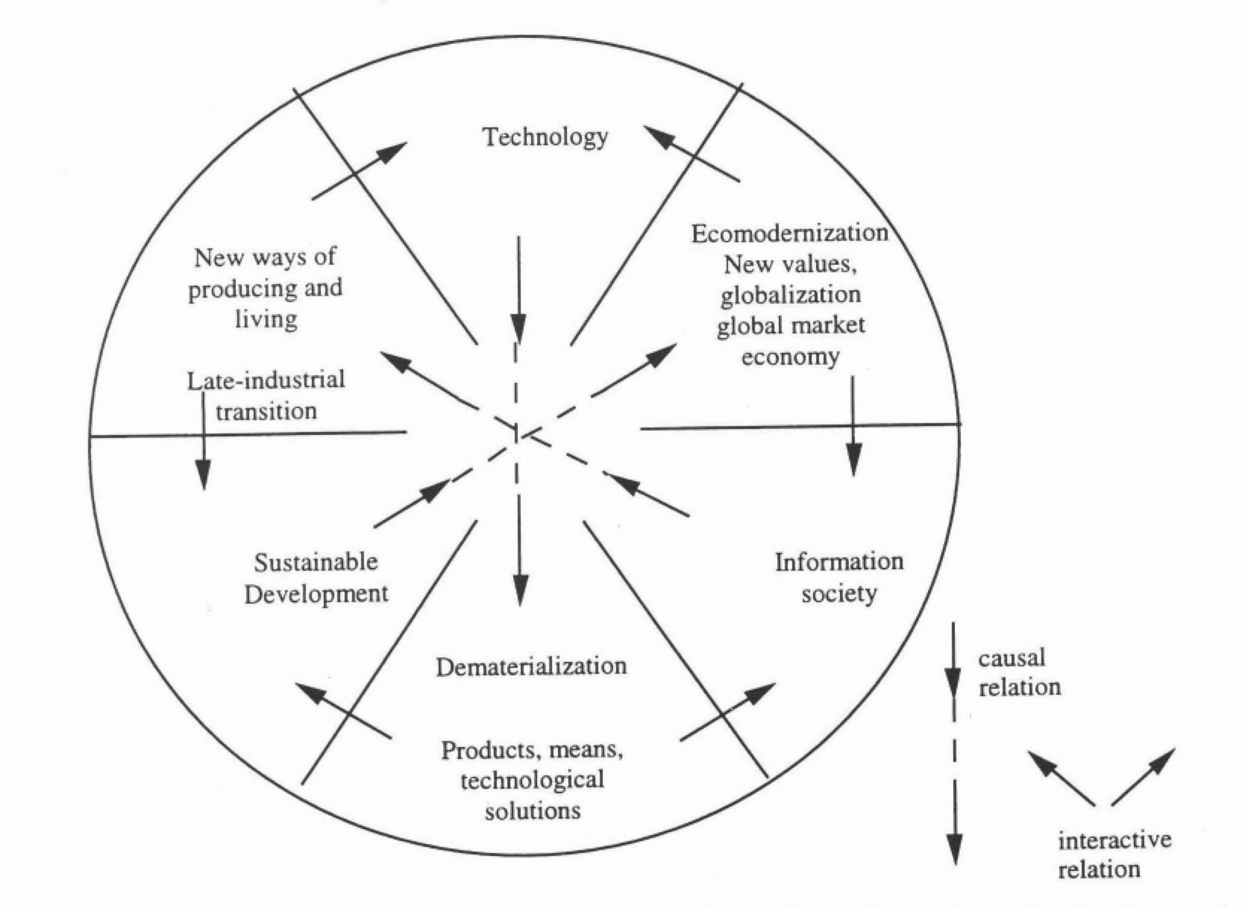

Figure 3. The dynamic interplay between phenomena of the information society, of technology and infrastructure, and sustainable development. (Malaska 1991)

For instance, the lack of equitable access to knowledge and information technology among citizens would lead in this direction. It should be noted that, in practice, the majority of EU citizens do not express strong trust in the social benefits of information technology, for instance (INRA 1993). Neither do they believe unreservedly in the capability of technological progress to make growing consumption and good environmental quality simultaneously possible (INRA 1993).[55]

Possibilities and risks: dematerialisation and rebound effects

Theories of information society make several optimistic assumptions concerning the state of the environment to be identified. The theories seem to include two interconnected structural ideas in particular, according to which environmental problems should decrease regardless of the level of economic growth (Paehlke 1989, Spaargaaren and Mol 1992, Simonis 1994). Firstly, it is supposed that the production, transformation and exchange of information will displace the production of tangible goods as the primary focus of economic activities. In other words, structural economic change should lead to the decline of the most polluting industries, ie of agriculture and manufacturing, and to the dominance of the non-polluting industries, ie the production of information and services.

The vision of an environmentally benign structural change is illustrated by Jänicke's two ideal types of development in western industrial countries, namely the 'superindustrial scenario' and the 'post-industrial scenario' (Jänicke 1990). The former characterises a future in which traditional ways of producing goods still strengthen, and in which the quantitative growth of production, and the centralisation arid internationalisation of capital and power, will continue. As a result, of course, there will also be an increase in environmental problems. The primary criteria for the ecologically motivated post-industrial scenario, on the other hand, is the preponderance of non-material production (Jänicke 1990). Jänicke does present other criteria for the 'ecologically desirable post-industrial society', such as preferences for qualitative, resource-saving growth, decentralisation (eg. small- and medium-scale enterprises and regional structures), and flexibility in innovations. These are primarily, however, to be thought of as sub-criteria for changes in economic structures. In other words, the change to information-intensive production is supposed to be a more or less necessary condition for these other criteria.

The model of ecological structural change equates environmental issues with the question of continuity and the development of the industrial society. Jänicke's scenario considers the (post-industrial) information society a form of society that is worth aspiring to on environmental grounds. Moreover, in a comparative empirical study (Jänicke, Mönch, Ranneberg and Simonis 1994), it was concluded that the de-linking of economic growth from material-intensive industrial production processes, and the resulting decrease of environmental impacts of the economy, is even evident in most western countries.

Information society theories suggest further grounds for environmental optimism, in addition to structural change, in the positive belief in technological progress. This refers to both information technology and other technologies. Generally speaking, technological innovations are assumed to promote, eg. pollution abatement and the efficient use of natural resources, according to the most optimistic visions almost infinitely. To be more concrete, examples of applications of information technology, which may directly contribute to the reducing of environmental stress, include pollution monitoring, online diagnostic services, remote sensing, and new information networks (Greiner et al 1996, Marvin 1997). Indirect environmental benefits might be achieved, for instance, by teleworking and the resulting decrease in mobility, by rural telematics projects, by new research alliances, and by new horizontal networks.

In sum, one of the basic entities of the information society, which is the emergence of information technologies and services, may, with the support of other new technologies, lead to the dematerialisation of production and the immaterialisation of consumption. It follows that, irrespective of the level of economic growth, environmental deterioration might be supposed to diminish. It could even be suggested that, from the environmental viewpoint, the process of economic dematerialisation is the most valid indicator of the process of sustainable development.

On the other hand, it must be emphasised that to be ecologically beneficial is not a self-evident structural attribute of the information society. The generic innovations of information technology, such as digital technology, are constantly increasing the productivity of the economy of tangibles. The benefits gained from the productivity growth are mainly directed to increasing total production. It follows that the total use of material resources may increase by more than the savings that have been brought about by dematerialisation. This phenomenon is labelled the ‘rebound effect’. It must be seen as purely negative with regard to environmental objectives: notwithstanding the decrease in the exploitation of natural resources and in the pollution per product unit, absolute environmental stress will still increase (Greiner et al 1996, Malaska 1997). Not many empirical measures of the rebound effect are to be found yet, despite the evidence in the case of world energy consumption (*Figure 4*). The findings indicate that the positive effect of dematerialisation and energy efficiency improvements has been overcome by the rebound effect caused by excessive economic growth. From these findings, sustainable economic growth can be estimated to be about 1.3% per annum. The same phenomenon can be observed with CO_2 data, for instance.

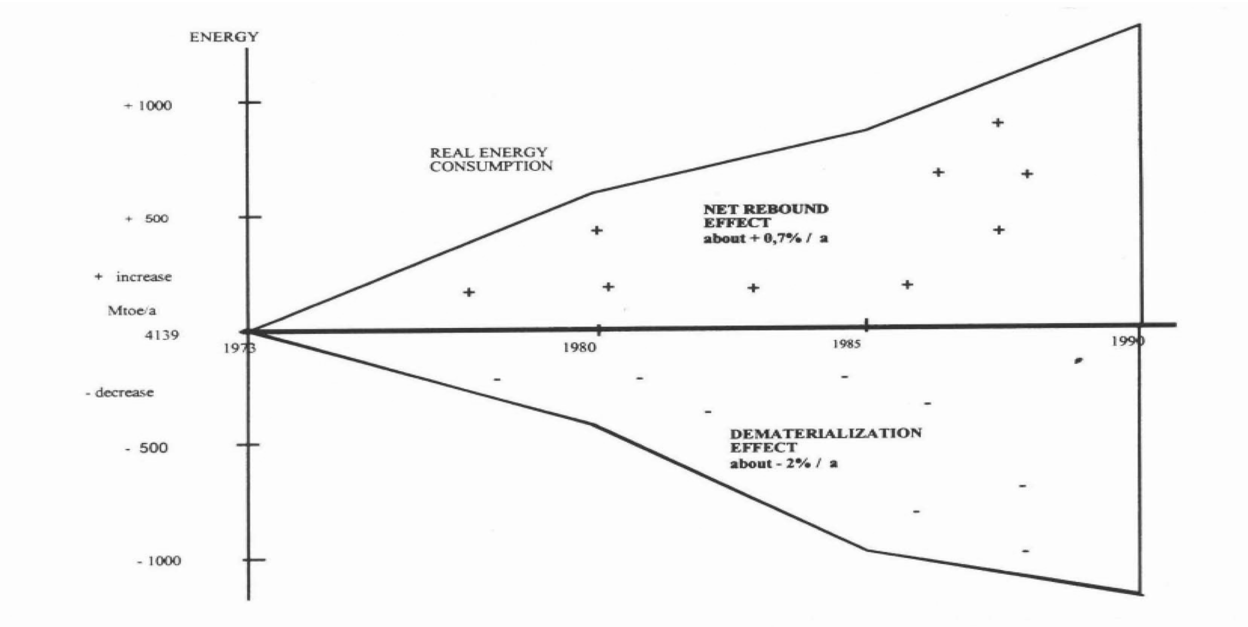

Figure 4. World energy consumption in 1973-1990 showing the dematerialisation and rebound effects (Sun 1996).

Finally, both the logic and the real positive effect of dematerialisation have been doubted. Starling from the assumption of the environmentally benign information society, Novek and Kampen have studied a case of two proposed Canadian pulp and paper mill projects (Novek and Kampen 1992). They asked whether there was evidence of the disappearance of the contradiction between economic development and environmental preservation. Their analysis does not give support to the notion of assumed non-polluting economic growth in the information society. On the contrary, it was concluded that the spread of information technology is, above all, part of the general commodification process. In other words, information technology rather promotes the consumption of commodities such as paper. The strengthening of production and information services (eg. the mass media, advertising, data processing and communication) would not mean diminishing environmental stress. This is in fact consistent with one conclusion to be found in Marvin's critical examination of the relationship between telecommunications systems and urban environmental policy (Marvin 1997). He points out that, instead of simply displacing the need for travel and cities, telecommunications can also generate or induce new demands for physical flow and movement.

Conclusions

Undoubtedly, information society theories include technology-optimistic, even technology-deterministic ideas. However, if culture is taken solely as subordinate to techno-logical structures, the idea of human progress is reduced to the development of technology. This being the case, the subjects making social choices, as well as the values behind such choices, are kept out of sight. It follows that cultural, societal and technological development should not he separated from each other in a simplistic way. New technology is basically a cultural product and a social undertaking, and, equally, some characteristics of society are primarily technological projects (Lyon 1988, Giddens 1990). Technological decisions and solutions should be adapted to the models of society, which are regarded as most desirable. In other words, technological choices have to be based on societal ideals, value considerations and ethical discussions, and not only on technical considerations (Archer 1971). However, according to Beck, the reverse is true: in the late-industrial risk society, societal development is no longer under the control of the parliamentary system or of citizens (Beck 1992). Rather, decisions on safety and environmental issues are made in the name of the state of technology and science, which, again, is defined by a very limited circle of technological experts.

Environmental issues form the central aspect of societal development. If the challenge of the 'coming of the information society' is taken seriously, the challenge to provide evidence for the ecological benefits of this new mode also stands. This paper investigated the relationship between the information society and environmental issues on theoretical and conceptual levels. With good reason, we agree with Marvin's (Marvin 1997, Beck 1995) conclusion: the relationship is complex and contradictory, and we should not make any simple generalisations about the role of informational technologies in environmental policies. The subject requires additional research, also at the empirical level. Further study is needed, for instance, in order to develop valid indicators which could successfully unite the positive factors of the information society and of sustainable development. Future projects could also investigate the kind of values and environmental impacts implicit in the authoritative political programmes of the information society. Finally and most importantly, there must be continuous questioning of how the elements of these basic societal goals should and could be adapted in each other.

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THE ECOLOGICAL TRANSPARENCY OF THE INFORMATION SOCIETY

by

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Introduction

We are currently living in a transition period that can, notwithstanding all terminological and contextual debates, be called “the information society” (Webster 1995, Castells 1996, Lacroix and Tremblay 1997). In order to evaluate the state, conditions and trends of the information society as regards sustainable development, the notion of ‘ecological transparency’ promises much. It is analogous with the idea of the general transparency of society. Vattimo has perceived our current society as a communication society characterised by media, which is complex and chaotic (Vattimo 1992). However, his ideal is a transparent society, where media could contribute to a self-conscious and enlightened society.

In a complex world of sophisticated technology, which demands expertise and is dominated by experts, it becomes ever harder for ordinary citizens to estimate the course of developments in society. Through advances in information and communication technologies (ICTs) the technology itself has become diversified and complicated and, thus, no individual can manage the whole field. Thus lack of insight into the workings of the information technology is bound to blur the transparency of the information society. With regard to this, the *ecological* transparency of the information society refers to the increased understanding of all human activities, processes and patterns that have an impact on the potential for sustainable development. The focus here is on perceiving the chain of events and cause-and-effect relations that influence the ecological dynamics of the information society through its various actors (government bodies, municipalities, citizens, households, activity groups etc.).

Ecological transparency is closely linked with the concept of the ‘ecological footprint’ imposed by the information society. The latter refers to the impacts of our way of life on the resources of the earth’s biosphere. Human activities cannot be separated from the natural world, since human economy is a sub-system dependent on the ecosphere (Rees and Wackernagel 1994). The link and use of ecological transparency to ecological footprinting is that it would bring forth the interconnections between human activity and natural conditions, whereas an ecological footprint more explicitly demonstrates human impacts on nature. Thus, increasing our knowledge of ecological footprints corroborates ecological transparency.

The need for ecological transparency is apparent because although ICT promises ecological benefits, in reality the ‘information society’ is still stuck with commodification processes. For instance, the paradox of the ‘paperless office’ is well known. Hopes for diminishing or even replacing the use of paper through advanced ICT have not been fulfilled. Instead, as a response to the needs of information services, more sophisticated technology has made it ever easier to print out and copy more sheets of paper (Marvin 1997).[1] Further, it must be noted that computers are industrial products, even though they process immaterial data and information. The estimated number of a billion personal computers is bound to leave their mark on the use of resources.[2]

Thus, the ecological footprint of the information society must be especially concerned with the environmental implications of the generation, application and disposability of ICT.

This paper focuses on the relationship between the information society and environmental issues. Evidently enough, the relationship is complex and contradictory, and there are no simple generalisations about the role of information technologies in environmental policies (Marvin 1997, Jokinen, Malaska and Kaivo-oja 1998). Theoretically speaking, the main elements of social and environmental development do interrelate and overlap with each other. However, in policy discourses and practices they usually are regarded as notions that are not connected with each other (Jokinen et al 1998). Thus, in any effort to combine these issues, a vital question is how to enforce the ecological transparency of the information society. In brief, this paper aims at developing scenarios, and a set of criteria, plus indicators as tools for identifying the various environmental impacts inherent in an information society. Furthermore it aims for the successful unification of the positive factors of the information society with ecologically sustainable development. To do this, representations of the ecological footprint of the information society might help to illuminate the complex interplay between the deeds and consequences of different societal actors. This, in turn, is a prerequisite for catalysing changes in, for example, production and consumption models, lifestyles and attitudes.

Information society and environmental policy objectives

In principle, social scientific theories about the information society have given cause for optimistic assumptions concerning environmental policies. They seem to include two[3] interconnected structural ideas in particular, according to which environmental problems should decrease regardless of the level of economic growth (Jokinen et al 1998). Firstly, it is supposed that the production,

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[1] Surfing the Internet is by no means a mere browsing activity, but a source for immense and numerous printing jobs of reports and other material easily available at millions of websites. A notorious example in point was given in September 1998 upon the publication of the Starr report on the Internet.

[2] Estimation according to Graig Barrett, Intel.

[3] We ignore here the issue of whether the rise of environmental movements and the growth of civil environmental consciousness is linked to ‘post-industrialisation’. Namely, it has been argued that environmental consciousness and the potential for environmental activism have arisen because an increasing proportion of the labour force working in marginal or completely outside the manufacturing-based sectors is found to be most sympathetic to environmental issues and weakly orientated in material issues.

transformation and exchange of information will displace the production of tangible goods as the primary focus of economic activity. Structural economic change should thus lead to the decline of the most polluting industries, i.e., of agriculture and manufacturing. At the same time the non-polluting industries would begin to dominate, i.e., industries related to information and services. Secondly, information society theories suggest grounds for environmental optimism based on the positive belief in technological progress. This refers to both information technologies and other technologies. Generally speaking, technological innovations are assumed to promote considerable pollution abatement and the efficient use of natural resources. Thus, the emergence of information technologies and services should, with the support of other technologies, lead to the "demateralisation" of production and to the "immaterialisation" of consumption.

As regards the potential for unifying environmental policies and the positive environmental aspects of the information society policies, the principles of ‘ecological modernisation’ may be the most promising of the prevailing environmental policy paradigms. Certainly, in environmental policy studies, there are both narrow and broad conceptualisations of ecological modernisation to be found (Schnaiberg 1997, Baker, Kousis, Richardson and Young 1997, Cohen 1997). Notwithstanding this, the core features of the policies of ecological modernisation can be identified (Gouldson and Murphy 1996, Hajer 1995, Weale 1995). Firstly, it is assumed that there can be synergy between environmental protection and economic development. Secondly, the aim is to integrate environmental policy goals into other policy areas and to introduce alternative and innovative policy measures. Thirdly, the technological dimension of ecological modernisation, which is the goal of developing cleaner technologies, must he emphasised.

On the other hand, to be ecologically beneficial should not be seen as a self-evident structural attribute of the information society (Greiner, Rademacher and Rose 1996, Malaska 1997). This is due to the fact that the generic innovations of information technology, such as digital technology, are constantly increasing the productivity of the economy of tangibles. The benefits gained from such productivity growth are mainly directed towards increasing total production. It therefore follows that the total use of material resources may increase by more than the savings that have been brought about by dematerialisation. This phenomenon is labelled the ‘rebound effect’, and means that despite the decrease in the exploitation of natural resources and in the pollution per product unit, absolute environmental stress will still increase.

Further, the supposedly negligible environmental impacts of service production are not completely self-evident either. There are certain forms of economic activities, classified as services, which may have per se even considerable impacts on the environment. Such forms are, for example, traffic and tourism. Ellger and Scheiner have (Ellger and Scheiner 1997) especially referred to the former by the notion that "service pollution is basically transport pollution", because the missive substitution of real transport by virtual transport has not yet occurred (Marvin 1976). One more point, related to the previous one, is that services are of course not completely isolated from the goods-producing sector. A large proportion of the service sector is a necessary and integrated part of goods-producing activities. This applies to transportation in particular. In fact, long-distance goods distribution can be organised and co-ordinated even more effectively in time and space via advanced telecommunication and information processing (Ellger and Scheiner 1997). Thus, overall, a crucial question is whether the more effective, network-type organisation of economic activity will result in positive or negative net environmental effects.

Generally speaking, policy level issues regarding the information society and the environment seem to have been separated from each other. For instance, Marien has concluded that researchers and promoters of the information society are not generally interested in sustainable development, and the same is valid vice versa (Marien 1994). Consistent with this, Marvin has noted that researchers and policy-makers in urban environment and telecommunication sectors inhabit distinct worlds with different ways of conceptualising cities (Marvin 1997). As a result, visions of a ‘sustainable city’ and an ‘informational city’ do not coincide.

What kind of factors, then, are there behind this policy failure? Why have "information society" and "sustainable development" been used as mutually exclusive notions? First of all, the policy problems seem to be based on the inconsistency of rationalities. Information society reasoning has mainly been justified by the economic technical rationality, whereas environmental policies still strongly relate back to conservation thinking and natural scientific rationality. Also, the integration of different policy areas is an issue of organisational authority and power and there are, in fact, no absolute reasons to assume that policy actors should have a strong interest in radically changing prevailing bureaucratic and socio-economic structures.

We must also note that the difficulties of narrow sector policies are the greater the profounder the socio-political strategies concerned. Finally, and importantly, those policy actors having interests in material production areas do certainly not give any support to the idea of any support to the "dematerialisation".

We can make the discussion more concrete with the example of Finland, because in this country there has appeared to be a lot of attention and investment[4] given to

[4] In1993, by a Finnish Government decision, the task to prepare a general information society strategy was given to the Ministry of Finance. In 1994. the Ministry of Transport and Communication and the Ministry of Education also began to prepare their own strategies. Then, in 1995, the Ministry of Finance published the influential programme, the ‘National Information Society Strategy’. It was immediately followed by a statement paper on measures approved by the Government. In this paper, each ministry was ordered to prepare a detailed action plan for the development of the

information society policies in recent years. According to the policies, "Finland aims to secure its position as a leading information society in the year 2000".[5] Our examination of Finnish information society policies leads us to conclude, though, that the ‘information society’ is under construction primarily on economic grounds. This is not to argue that other societal issues have been totally excluded. However, according to the main discourse of policies, in order to maintain the wellbeing of citizens, improving competitiveness and productivity is required from both the private and the public sector. Thus, other policy issue areas have clearly been subordinated to the activities of the national economy. This is illustrated, for instance, by the basic action lines proposed in the national strategy (Ministry of Finance 1995): (1) information technology and information networks should serve as tools in private and public sector renewal; (2) the information industry should become an important sector of economic activity; (3) professional expertise in information and communications technology should be maintained at a high overall level, with selected peaks; (4) everyone should have the opportunity and basic skills for using the services of the information society; and (5) Finland’s information infrastructure should perform efficiently in all aspects of life in comparison with other countries and be capable of providing high-quality services.

Regardless of the main trust laid in economic and technological change, information society policies have been legitimated by the notion of a comprehensive project: Finland’s national strategy is expected to have an impact on all aspects of administrative and private sectors, which ultimately reaches all the way back to the homes of individual citizens (Ministry of Finance 1995). The necessity for the country to be renewed has been regarded as the basis for such policies. The necessity in question is, in turn, seen as a result of the increasing competition of the global market, which is a concern of the state, small firms and citizens, in addition to international companies. Thus, from the perspective of national policies, the first Finnish steps towards the information society seem to have been primarily an economic project and secondarily a technological project, and to a lesser extent a social and a cultural project (compare Webster 1995).

With respect to environmental issues, Finnish information society policies have not expressed any remarkable foresight. Similarly, even if Finland has been classified as one of the European environmental policy ‘forerunners’ on the grounds of well-developed domestic policies (Andersen and Liefferink 1997), environmental policy-makers have not shown competence in utilising the information society framework in their programmes. Thus far, the main Finnish

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Finnish information society in the ministry’s area of competence. Furthermore, in 1996, a couple of policy groups, The National Committee for Information Society Issues and (on broad-based interest representation) The National Information Society Forum, were established. In 1997, the National Information Society Strategy was taken under revision process.

[5] Finnish Government. The Government position on measures for information strategy. The paper was approved at a Cabinet meeting on 18 January 1995.

information society strategy has simply been promoted by policy actors (such as the Ministries of Finance, Transport and Education) who have paid only marginal attention to environmental issues. To summarise, the examination of the Finnish policies thus far confirms the conclusion that information society issues and environmental issues have been separated from each other. There appear, however, to be signs of change: in the revised National Information Society Strategy of Finland (work in progress, still unpublished) sustainable development will be among the areas. Focus and its strategy will include a proposal for an action plan for the implementation of a sustainable information society.

Scenarios based on the concept of a sustainable information society

The frames of global environmental policies are conceptualised as complex political processes, which can result in different potential development paths and scenarios. The dominant framework of global environmental policy is based on the assumption that the market economy combined with economic growth is the driving force in the process of sustainable development (Luukkanen and Kaivo-oja 1999). On the other hand, it is clear that socio-economic policies and politics have substantial impact on the environment. Thus income policies will have to be redesigned to reduce intensive environmental decay. Ecological transparency, therefore and unfortunately, still is stuck in the socio-economic realities of a society.

In Figs. I and 2, which theoretically follow Karshenas (Karshenas 1992, Karshenas 1994), we illustrate the relationships between a stock of environmental amenities z on the vertical axis and the potential output per capita on the horizontal. Both variables are measured per capita, i.e., g = Q/N, where N is population and Q is the potential output in the spatial economy. Similarly. Z = Z/N, where Z is a stock environmental indicator appropriate to the society in question. By adding a socio-political equity dimension (the vertical axis downward) to Karshenas' framework, we can present a new, general framework for a sustainable information society (Kaivo-oja 1999). It must be noted that this theoretical scheme necessarily illustrates a very ideal process towards a sustainable information society.

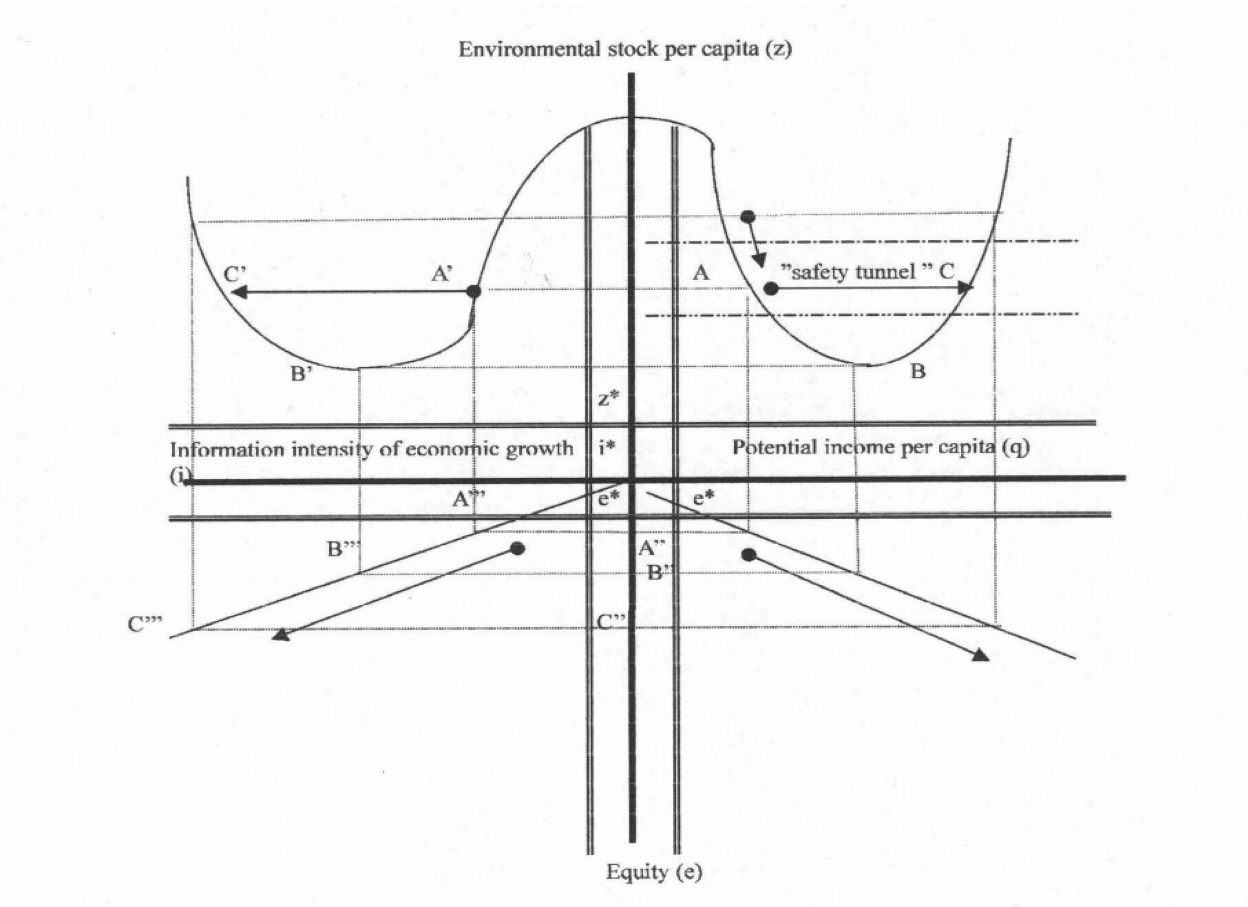

Figure 1. Development scenario A of sustainable information society: environmental risk alternative.

Fig. 1 presents a "Wealthy Country Scenario" of a sustainable information society, which may be possible in most developed societies. If we want to make a sustainable information society real, intensive learning and technological progress are needed in different sectors of society (Malaska and Kaivo-oja 1997). Mainstream economics tends to assume that a society chooses its path ABC (in Fig. 1) by maximising a discounted welfare function subject to known technical restrictions over time. This scenario leads to an ABC style resource use trajectory path. Mainstream economics also supposes that a dual solution to the optimisation problem provides a set of shadow prices, which can be used to guide resource allocation, and also the proper means of accounting for growth. However, there are evidently serious problems both on political and epistemological grounds with this approach. Politically, there is no reason to expect societal consensus on either environmental or economic issues. Class and income distribution conflicts in real economies may rule out such accord. The state itself may be autonomous, the creature of a conflict-ridden civil society, or something in between. Epistemologically, environmental decision-making is subject to fundamental uncertainty - meaningful probability distributions can hardly be made based on future events, which are unforeseeable given the present state of knowledge (Reckhow 1994, Taylor 1996).

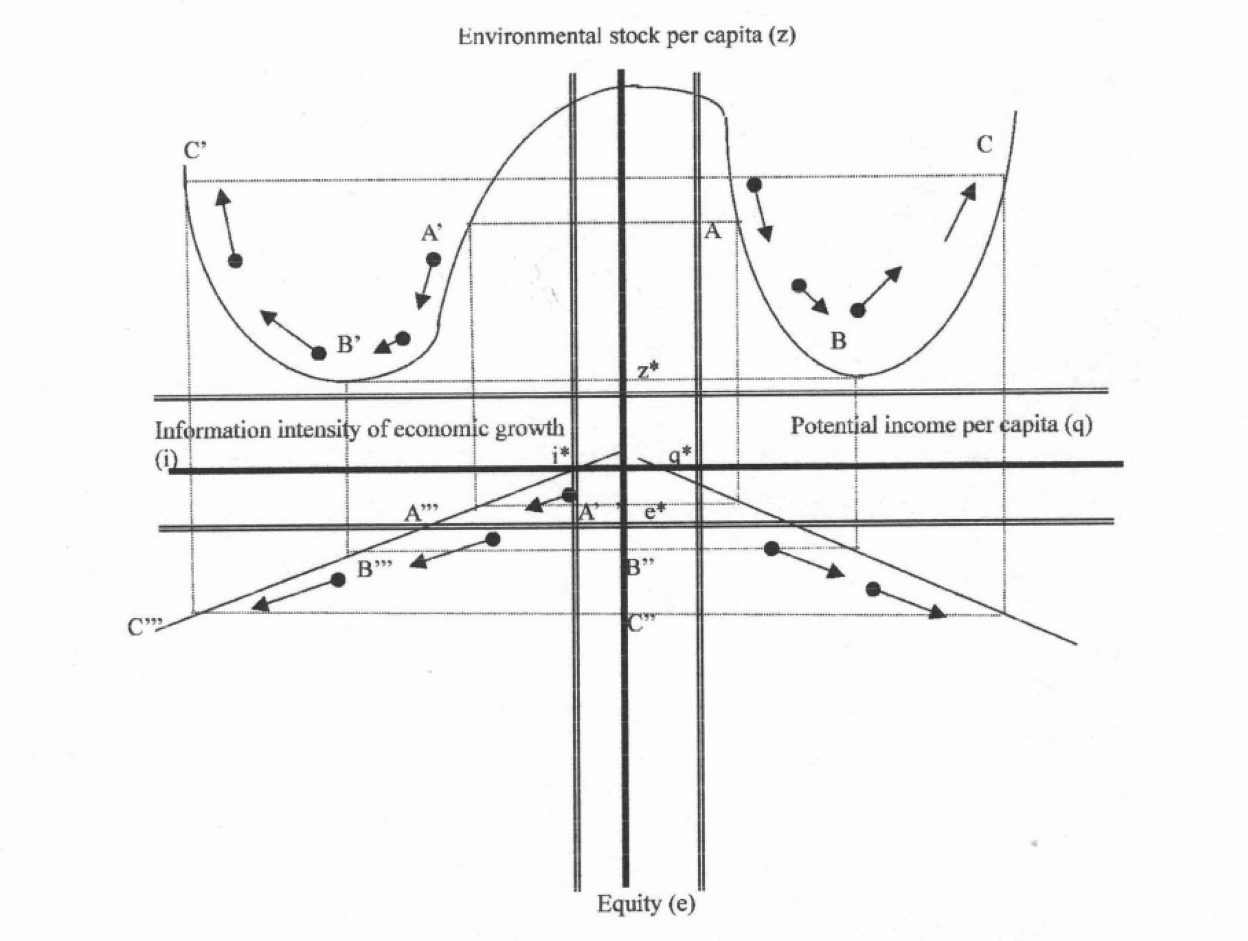

Figure 2. Development scenario B of sustainable information society: progressive technology development alternative without large environmental risks.

A non-deterministic view of the environmental Kuznets curve argument is illustrated in Fig. 2.[6] This "Less Developed Country Scenario" also requires very intensive technological progress, and it leads a society to the AC style resource use trajectory path. According to the logic of this scenario, the best possible and most available environmental technology should be used. The World Bank's economists regard this kind of scenario as a desirable, and even feasible,

[6] The environmental Kuznets curve describes the relationship between some pollutants and income as an inverted-U curve showing increasing levels of pollution for people living in lower income countries and declining levels of pollution for those living in higher per capita incomes. The relationship derives its name from the work of Kuznets, who postulated a similar association between income inequality arid income levels (Kuznets 1955). This hypothesis has been supported by some empirical studies (Shafik and Bandyopadhyay 1992, Selden and Song 1994, Grossman and Krueger 1995, Ekins 1997, Seppälä, Haukioja and Kaivo-oja 1998). See also a short summary of latest discussion in Rothman and de Bruyn (1998).

development path especially for developing countries. However, if this way is preferred, we must break away from the "historical determinism" of the environmental Kuznets curve hypothesis described in Fig. 1. As a consequence, according to the scenario in Fig. 2, a poor developing country does not need to find it obligatory to pass through the peak of environmental degradation at B in order to reach C. It says lower-income countries could learn from the experience of wealthier nations and adopt policies that permit them to "tunnel" through the curve along the path AC (Munasinghe 1995, 1996).

In reality, the actual development processes in different societies may diverge considerably from these ideal-type development paths. However, if we do not have a general impression of preferable development paths for societies, it may be impossible to reach them. The four-dimensional analysis, put forward above, combines environmental, human and socio-economic dimensions with information society issues and turns them into a coherent policy framework, which might help decision-makers increase the transparency of ecological and societal development. One can also see alternative scenarios as hypotheses of development processes and even empirically test whether societies really are developing towards the ideal of the sustainable information society (Ekins 1997).

The problem remains, as shown in Figs. 1 and 2, that there are "danger zones" in the environmental, economic, social and information arenas. These zones indicate unsustainable development conditions. Prudent national (or regional) planning would hold $q>q^*$ to avoid economic collapse and severe social conflicts, $z>z^*$ to preclude the possibility of environmental collapse, $e>e^*$ to preclude ultimate social inequality in a society and $i>i^*$ to preclude a lack of information intensity regarding economic growth. By increasing the ecological and socio-economic transparency of the information society we may avoid the processes leading to an unsustainable development.

Indicators as intensifiers of ecological transparency within the information society

Indicators for monitoring and measuring progress towards sustainable development are needed in order to assist decision-makers and policy-makers at all levels. In the past decades, economic and social indicators have normally been used. The construction of environmental and sustainability indicators is, however, a more recent exercise. It was added to the agenda when monitoring environmental conditions became a major concern of governments and international organisations during the 1990s.

A further challenge is to construct indicators for intensifying the ecological transparency of the information society. They could be called indicators of a sustainable information society. It is often easier to specify what is unsustainable than point out sustainable patterns (Fricker 1998). Consequently, such indicators, which reveal the unsustainable elements of an information society, are of value as well. Besides the recent extensive work on environmental indicators (OECD, World Bank, UNCSD, etc.),[7] a lot of statistics are available indicating the development of the information society in many countries. Such statistics are mainly based on data about the infrastructure and penetration levels of ICT (Parjo et al 1991).

The crucial question is how the information society could act as a successful framework for the ecological modernisation and restructuring of industrial economics. The environmental impact of economic activity can - at least in theory - be greatly diminished by using less environmentally damaging materials such as renewable energy; by improving the productivity of inputs through new technological and organisational processes (e.g., energy efficiency and 'clean' or low-pollution technologies); and by shifting the composition of output from products with high 'material intensity' (e.g., manufactured goods) to those of low intensity (e.g., services) (Jacobs 1997). Our hypothesis is that a compilation of indicators for a sustainable information society would help the ecological modernisation process utilise the power of the information age and thus improve our knowledge and lives.

The indicators of a sustainable information society would be tools for tracking environmental progress and gauging the environmental performance of the information society. The indicators are intended to simplify the communication process of the results of measurement for users. However, differences among countries may be considerable. Consequently, the establishment of reliable and internationally comparable data requires monitoring, analysis, treatment and checking on a continuous basis. It should also be borne in mind that indicators are only a tool for evaluation. Scientific and policy-oriented interpretation is needed for them to acquire their full meaning (OECD 1998). Linking the indicators more closely to established goals and commitments is therefore the ultimate challenge.

Besides monitoring the direction of development, the thorough analysis and interpretation of indicators is crucial from the risk aversion point of view. Environmental risk is usually defined in terms of damage to biological systems and, generally, to humans (e.g., toxins). A second type of environmental risk is concerned with impacts that degrade widely appreciated aesthetic properties (e.g., loss of visibility due to air pollution, the corrosion of buildings due to acid rain). The third type of environmental risk involves damage to important systems of the planet (e.g., biodiversity loss, global warming, ozone depletion).[8] Graedel and Allenby have argued that, according to many scientists and technologists, the

[7] The first noteworthy efforts to develop sustainability indicators began in the late 1980s, primarily by the Canadian and Dutch governments, as well as by the OECD (Allenby 1999, Parjo et al 1991).

[8] Risk comparability is a contentious issue. The Dutch National Environmental Policy Plan explicitly claims that these three categories of environmental risk cannot be considered interchangeable (Graedel and Allenby 1995).

general, public is unrealistically risk-averse and 'risk-illiterate' as well as unable to evaluate risk rationally (Graedel and Allenby 1995). With regard to the information society, however, it can be stated that the awareness of environmental risks connected to it is by and large weak. Instead, our awareness of potential socio-cultural risks such as infoglut, alienation or netsurfing addiction is strong. Hence ecological transparency would mean that the public obtains aggregated knowledge about the interaction of the information society and environmental issues.

Examples and proposals for indicators of a sustainable information society

There is much work done by various institutions such as OECD to produce environmental indicators. One of the most commonly used framework is OECD's Pressure-State-Response (PSR) mode. It enables environmental pressures, environmental conditions and societal responses to be classified into indicators. It is based on the philosophy that human activities exert pressures (pressure) on the environment and affect its quality and quantity of natural resources (state). Society in turn responds to such changes through environmental, general economic and sector policies, as well as through changes in awareness and behaviour (response). The PSR model highlights these links and helps decision-makers and the public perceive environmental and other issues as interconnected (OECD 1998). The lack of knowledge or indifference to the co-evolution of human systems and natural systems hinders their understanding of the overlapping dynamics involved (Fig. 3). Despite their intimate interplay, human and natural systems are usually perceived as separate.
Indicators of *environmental pressures* describe pressures from human activities exerted on the environment, including natural resources (Fig. 4). They are closely related to production and consumption patterns and often reflect emission or resource use intensities. Indicators of *environmental conditions* are concerned with the quality of the environment and the quality and quantity of natural resources. They are intended to give an overview of the situation as regards the environment and its development over time. Appropriate indicators of environmental conditions are, for example, concentrations of pollutants, excesses of critical loads, population exposure to certain levels of pollution, degraded environmental quality, the status of wildlife and of natural resource stocks. Indicators of *societal responses*, again, demonstrate the extent to which society responds to environmental concerns. They refer to individual and collective actions and reactions with the aims of: (1) to mitigate, adapt to, or prevent human-induced negative impacts on the environment; (2) to halt or reverse environmental damage already inflicted; and (3) to preserve and conserve nature and natural resources. Examples of indicators of societal responses are environmental expenditure, environment-related taxes and subsidies, price structures, the market share of environmentally friendly goods and services, pollution abatement rates and waste recycling rates.

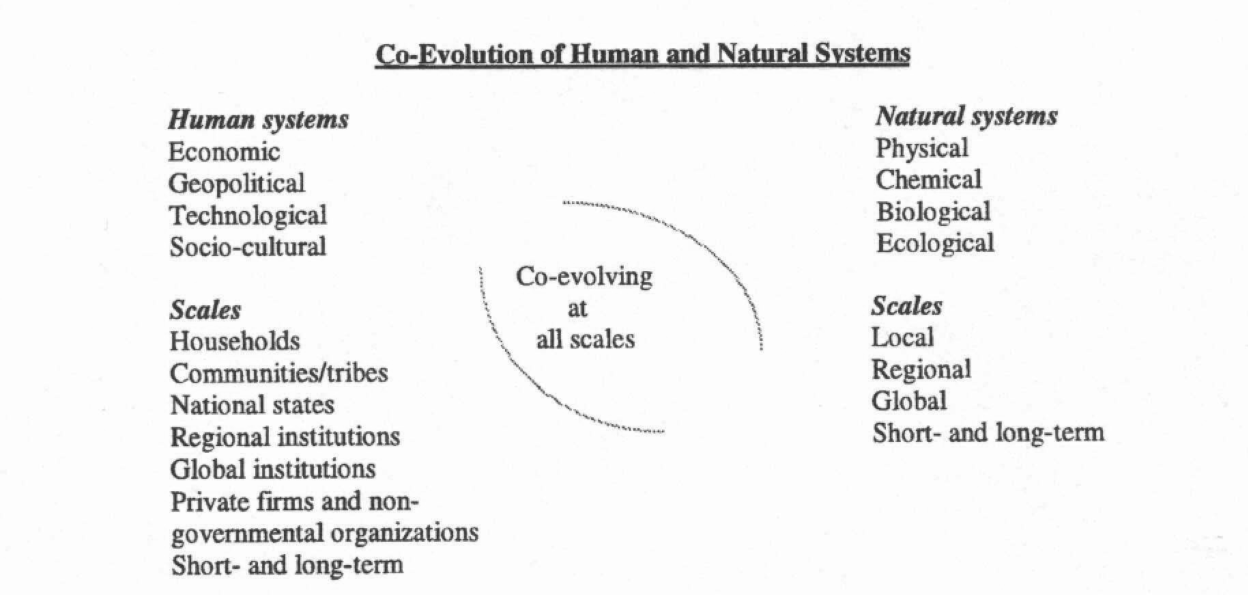

Figure 3. Co-evolution of human and natural systems is often neglected (adapted from Allenby (Allenby 1999, 48)

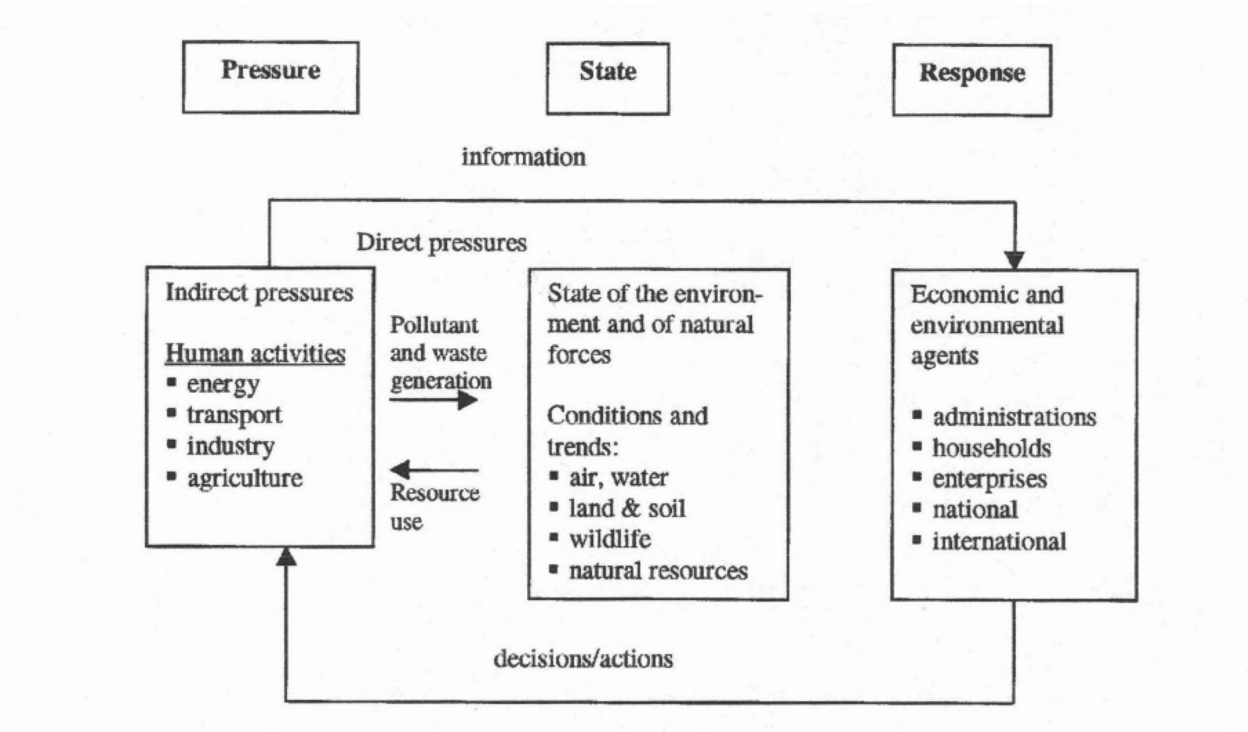

Figure 4. The pressure-state-response (PSR) model (OECD 1998, 108)

The indicators of the PRS model relate to some major environmental issues, mainly to either the use of the environment's sink capacity or to the use of the environment's source capacity. Indicators may also relate to sector trends and to such factors as economy-wide environmental expenditure and public opinion

(OECD 1998). Allenby has pointed out that there is a conceptual separation between the scientific-technological and the cultural-political dimensions of sustainable development (Allenby 1999). With the proposed indicator framework it might be possible to bridge that gap.

The PRS model can also be applied when presenting indicators of a sustainable information society (Table 1). Let us take one of the major environmental issues, air quality, into more detailed consideration. If the major issue is air quality, then an indirect pressure cause is, for example, road traffic, and the direct pressure causes are emissions of air pollutants such as SO_x, CO, CO_2 and NO_x emissions. The state indicators would be urban air quality trends and population exposure to air pollution - i.e., SO_x and NO_x, and concentrations of volatile organic compounds (VOCs). Examples of indicators of responses in a sustainable information society could accordingly (in response to the relevant pressure indicators) be those enabling a decrease in the use of cars via ICT. The information society provides tools in the form of telematics to enhance the flexibility of transport and reduce congestion-related pollution. On the other hand, as a rebound effect, smooth traffic flows are likely to attract more cars on to the roads. Therefore, a better response indicator in this context would be *the promotion of teleactivities to (at least partially) replace physical transport.*

Table 1. Proposal for a new indicators of a Sustainable Society (SIS)

Issue	Pressure	State	Response
Air quality	Road traffic (indirect); air pollutants such as SO_x and NO_x emissions (direct)	Urban air quality trends; population exposure to air pollution; VOC, NO_x and SO_x concentrations	Promotion of teleactivities (at least partially) replacing physical transport; the use of ICT for monitoring the environment and informing the citizens about its state
Climate change	CO_2 emissions, other greenhouse gas (GHG) emissions	Global atmospheric concentrations of GHGs and global mean temperatures	The same as above; energy intensity
Forest resources	Production of wood and wood products; trade in wood and wood products (indirect); intensity of use of forest resources (direct)	Area, volume and structure of forests; disturbed and deteriorated forests	Use of electronic products and services to replace the use of paper; frugality in the use (i.e., eco-intelligent use) of paper as related to ICT
Waste	Consumption levels and patterns; production levels and patterns (indirect); waste generation trends and intensities (direct)	Soil, groundwater quality	The use of ICT in promoting and applying waste recycling (all viable products); waste recycling rates for ICT products themselves (computer waste recycling rates)
Lifestyles	Lack of ecological transparency of information society (indirect); growth thinking and hedonistic worldview (direct)	Unsustainable lifestyles in housing, working, transport (wasting energy and raw materials, generating waste, lack of recycling, etc.)	Raising the eco-awareness through environmental education; information about eco-labelling

Within teleactivities various indicators depicting the penetration level of a given teleactivity could be constructed. For example, reference could be made to the percentage of a working population engaged in telework at least one full day per week. Clearly, the impacts of telework on transport are complex and difficult to disentangle (Marvin 1997, Heinonen and Weber 1998). However, if implemented consciously as a method for reducing transport, the net impact will be positive from the point of view of the environment.[9] In teleshopping the proportion of electronic commerce in retail sales could illustrate a reduction in trips to shops. However, the delivery of goods to the buyer would still remain a cause of traffic.

[9] Within a research project funded by the European Social Fund and the Finnish Ministry of Labour, a calculation model was developed to analyse telework potential on the basis of commuting distances. The model estimates the savings in time and emissions resulting from reduced commuting.

In many instances, though, the delivery of commodity services is now being and could be concentrated on certain collection points. With regard to intangible commodities, in some countries telebanking is fast becoming the primary mode of taking care of bank affairs. Visiting banks is consequently on the decrease, for instance in the Nordic countries. The present trend of the information society is to move away from bank tellers, just as the earlier move was away from bank offices to bank tellers. The proportion of electronic bank transactions as compared to all transactions might illustrate the situation as regards the use of transport. As for tele-education a relevant indicator might be the provision of distance learning curricula when compared with conventional educational in schools. In telemedicine the number of consultations or diagnoses through telecommunication, which is able to replace the physical transportation of patients, could indicate the improved use of natural resources through ICT.

Another indicator of responses in the issue of air quality could be *the use of ICT for monitoring the environment and informing citizens*. The transportation policy itself could also feature here as a response indicator. These indicators of responses are also appropriate when the major environmental issue is climate change. In this case the direct pressure indicators are CO_2 and other GHG emissions and the state indicators are global atmospheric concentrations of GHGs and global mean temperatures. Thus links between the related phenomena could be established for study and research. Energy intensity would be another response indicator here as this would, in particular, apply to products in the field of ICT. For instance, a modern energy-efficient laptop computer can ideally reduce electricity demand by 90-99% compared with an old-fashioned desktop computer with similar capabilities (von Weizsäcker, Lovins and Lovins 1998).

If the environmental issue is forest resources, indirect pressures are created by the production of wood and wood products, as well as the trade in wood and wood products. Direct pressures are imposed by the intensity of use of forest resources. The state indicators are area, the volume and structure of all forest types. Purely environmental indicators of responses would be the amount of protected forest area and the regeneration or the afforestation rate of harvested areas. However, an indicator of responses in a sustainable information society could be *the use of electronic products in the replacement of paper* (electronic archives, etc.). The use of paper in the information society is one of its most controversial topics. So far, the replacement of paper by ICT has proved to be theoretical only. Another response indicator is feasible here; i.e., eco-intelligent use of paper as related to ICT. For example, taking double-sided copies would cut the number of papers to be copied in half. Furthermore, the use of printers capable of printing double-sided print-outs would significantly reduce paper use.

One major environmental issue is waste where indirect pressures are created by consumption levels and patterns, as well as production levels and patterns. Direct pressures arise from waste generation trends and intensities. Therefore indicators of responses in a sustainable information society could be *the use of ICT in* *promoting and applying waste recycling (for all viable products); and waste recycling rates for ICT (computer waste recycling rates).* This is a pertinent issue because if we want to uncover the threads that connect the information society to sustainable development, considerable attention must be paid to lifestyles. The lack of ecological transparency within the information society could lead to unsustainable behaviour if efficiency is only used to allow us to consume more. However, raising ecological awareness through environmental education may be a response indicator that can reverse lifestyles, which waste energy and raw materials, and generate waste with no heed to recycling. Raising the needed awareness can find numerous solutions with the application of ICT. For instance, more environment education video games and television programmes could be developed to provide eco-feedback programmes for organisations, schools, households and citizens, and enable the evaluation and monitoring of their own patterns of daily behaviour.

When interpreting the concept of sustainable development broadly to include the social dimension, various indicators can also be constructed from this standpoint. For instance, in negative terms the increasing levels of inappropriate or illegal material on the Internet could prove dangerous to the health and life of individuals, institutions and communities. For the time being, due to overall resistance to control, the Internet is explicitly an open field to paedophiles, drug dealers, terrorists and information crackers. Consequently these new methods for crime have to tackled to protect bona fide users. A more pressing issue though is that in order to get ourselves on to socially sustainable trajectories in the information society, every effort should be made to resist 'information apartheid'. A frightening indicator of that phenomenon is the information poverty illustrated in the widening wealth gap between the information haves and information have-nots. A positive indicator in combating information poverty would be, for example, the number of free-of-charge Internet accesses for the public (generally in libraries). Overall, the policies and programmes of a socially sustainable information society must eventually include and combine basic characteristics from traditional civil society with the changes the information society is bringing. The problem is how to combine the basic human rights of traditional society with the rapid development of the information society. This is something which is not easy to resolve (Splichal, Calabrese and Sparks 1994, see also Jakubowicz 1994).

SIS (a sustainable information society) aims for a cyclical, constantly regenerating metabolism (minimising new inputs and maximising recycling) rather than a linear metabolism (Fig. 5). An eco-friendly society is based on the very idea of a cycle. The concept of waste has to be redefined as a resource. Following this logic, waste will thus be transformed back into a resource again to the maximum degree possible. In a sustainable information society the recovery rate of parts front office automation and ICT equipment has to be raised. The present ratio at which such parts can be recycled is still low, at between 5 and 30%. Japan, however, fosters plans to boost this ratio to 50% by 2000 (Nakajo

1998). In Japan, a new industrial paradigm is beginning to take shape where, at each stage of a product's life from manufacturing through use to waste management and recycling, the synergistic effect of institution and technology is taking place. Consequently the obtaining of considerable value from a small quantity of energy and resources signifies that the 'arterial' industries manufacturing products, on one hand, and the 'venous' industries processing and recycling the waste produced, on the other, would no longer exist as completely separate entities. The ecological transparency of the information society would ultimately enhance the dispersal of such synergistic approaches.

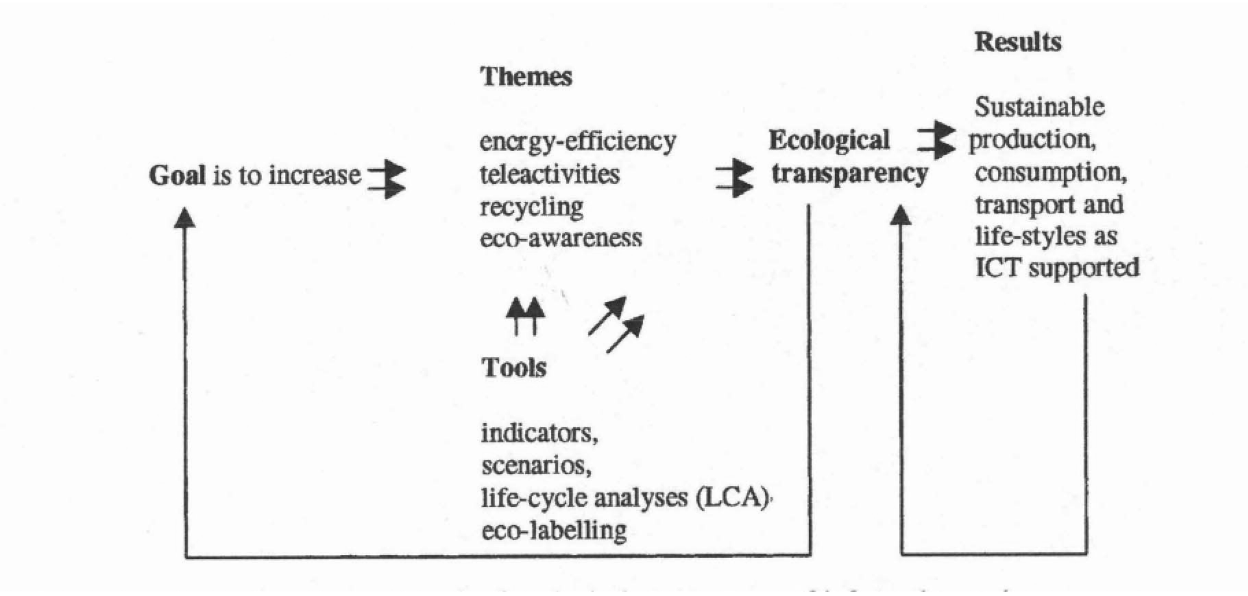

Figure 5. Framework of ecological transparency of information society.

Conclusions

A de-linking of pollution from economic growth and de-materialisation can probably be seen as the most important single characteristic of sustainable development. This paper has discussed the potential for successfully unifying and monitoring the positive factors of the information society and sustainable development. These necessary steps would include such things as the detailed life cycle analyses of ICT products, infrastructures and their applications. The indicators would provide a toolkit for policy-makers in the information society to help make strategies that can direct and evaluate development towards sustainable development. The planning for the information society would thus benefit the enhanced level of ecological transparency within the information society as presented via indicators.

Ex ante and ex post evaluations of the various consequences arising from the ecological transparency of the information society would be needed for better decision-making at local, regional, national and global levels.

The Fifth Framework Programme of the European Union largely replaces the terms "information and communication technologies" and "telematics" with the broader term: Information Society Technologies (IST). Accordingly, prerequisites should be created for evaluating the implications of the information society and for applying related information society technologies. Such approaches and activities can be termed Information Society Assessment (ISA). It would, however, evoke a more encompassing concept than conventional technology assessment (TA). ISA would tackle the problematique of the arising consequences of the information society from economic, socio-cultural, technological and ecological viewpoints. Ultimately then, the increasing ecological transparency of the information society as achieved through the construction and use of scenarios and indicators would provide a significant contribution to the environmental dimension of Information Society Assessment.

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THE CHALLENGES OF VISIONARY MANAGEMENT WITHIN A MULTILEVEL PLANNING ENVIRONMENT: HOW MURPHY'S LAWS MAY EMERGE IN GLOBAL SUSTAINABILITY POLICY

by

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Introduction

Many people in positions of high authority, whether in government, business, municipalities, or international organisations simply do not know what they are doing when they respond to change, forecasts and observed trends. Ignorance, malpractice, stupidity, or incompetence does not cause all this. The relationship of policies to interdependencies is too complex to be reliably analysed by scientific discussion and intuition. This is why the case method of management education has had limited success. It is intrinsically impossible to anticipate all the important outcomes (see e.g. Coates 1995, Modis 1998, 1).

One way to manage things wisely and promote sustainable development is to avoid potential problems, which can lead our human systems or ecological system down unsustainable development paths. This kind of management way can be also visionary.

It was Edward A. Murphy Jr., who noted that if anything can possibly go wrong, it will go wrong. He formulated Murphy's basic law in the following way: "*If there are two or more ways to do something, and one of those ways can result in a catastrophe, then someone will do it.*" Deceptive in its simplicity, this profound insight marked a turning point in our understanding of why things happen the way they do. Indelibly etching itself into the human psyche, this revelation ensured that never again would we look at the world in quite the same way. A fundamental pessimistic principle is: "*Anything that can go wrong, will.*"

Murphy's 13 classical pessimistic laws are the following (see e.g. Götz 1997):

1. Nothing is as easy as it looks.

2. Everything takes longer than you think.

3. Anything that can go wrong will go wrong.

4. If there is a possibility of several things going wrong, the one that will cause the most damage will be the one to go wrong. Corollary: If there is a worse time for something to go wrong, it will happen then.

5. If anything simply cannot go wrong, it will anyway.

6 If you perceive that there are four possible ways in which a procedure can go wrong, and circumvent these, then a fifth way, unprepared for, will promptly develop.

7. Left to themselves, things tend to go from bad to worse.

8. If everything seems to be going well, you have obviously overlooked something.

9. Nature always sides with the hidden flaw.

10. Mother nature is a bitch.

11. It is impossible to make anything foolproof, because fools are so ingenious.

11 Whenever you set out to do something, something else must be done first.

13. Every solution breeds new problems.

If we take Murphy's pessimistic laws seriously and accept them, there will never be signs of hope in global sustainability policy. There may not also be too much room for visionary management, if we take Murphy's pessimistic laws seriously. Indeed, we could stop discussion about sustainable development policy and visionary management, if we really believe in the pessimistic laws presented above. It is very interesting to observe that the same problem can be found in the context of strategic planning and management discussion. There has been a lot of pessimism, but also a lot of optimism in strategic planning and management discussions. The optimistic version of Murphy's basic law could be: "*Anything that can be a success story, will*." I think that intuitively we know that usually both overoptimistic and over pessimistic statements are incorrect. This can be the fundamental idea for the starting point of visionary management: Neglect over optimistic and pessimistic alternatives!

As Wilson (1998, 507) has noted there have been a lot of "on again/off again" affairs for most private companies, although the need for strategic planning has increased rather than decreased. The same observation holds for the global sustainable management arena, where both private and public sector organisations work. Actually, more than ever, we need strategic and visionary management tools in the promotion of sustainable development in both global and local arenas (see e.g. von Weisäcker 1994, Glenn and Gordon 1997).

Too much pessimism (="off again") or too much optimism (="on again") may cause more harm than a balanced strategy school discussion. Wilson (1998, 512) has noted that any strategy that aims to be sustainable over the long haul requires the harnessing of "opposite forces". Attention to one force while neglecting its opposite will, inevitably, lead to a deficiency and, ultimate disruption.

The basic idea of this paper is to connect the discussion of Murphy's laws, and especially the very pessimistic modes of thinking to the challenges of visionary leadership. I expect that both pessimistic and optimistic modes of thinking are important for the development of visionary leadership models (see discussion in Murphy 1998, Bloch 1999), but we do not need unproductive roller-coaster rides (see Wilson 1998). Many people who want to play safe in times of uncertainty adopt the ‘maxi-min’ principle of choosing the option whose worst consequence is better than the worst consequences of any other. This, while consistent with human rationality, is not dictated by it. The ‘maxi-max’ principle of choosing the option with the best consequence is equally consistent, as are intermediate principles that attach some weight both to the best and to the worst that could happen (see Arrow and Hurwicz 1971, 1-11). On the basis of this analytical result we can conclude that it may be very useful to pay special attention to the worst and to the best consequences of feasible options/scenarios. If we do this kind of analysis, we realise visionary management. This kind of balanced approach may provide solid base for visionary management. When we see the "dark side" of things, we can learn to also see "the sunny side" of things.

I also expect that pursuing a successful sustainable regional and social policy requires theoretical points of departure of a kind through which multilevel actions towards sustainability can be understood as part of the same whole process. This paper sets out (from the theoretical framework developed in futures research) to describe and analyse the challenges posed by a sustainable regional and social policy.

The essential point of departure in this framework is the visionary management model presented by Malaska and Holstius (1999a, 1999b), which will be expanded here to include planning and the implementation of action plans within a global multilevel planning environment.

Generally speaking, planning is about the search for the right course of action. In visionary management, it is not so easy to know what is the right course of action. Usually we have to focus on the management process. However, we also have to focus on creative thinking and strategic capability. We should also be ready for the next big thing (Wilson 1998, 512). That is why planning can be seen here as an attempt to gain control over the consequences of our action and to master the future in the present time. Planning can usually be seen as the process of preparing a set of collective decisions for future action (Sotarauta 1996, 131).

An essential assumption in assessing the opportunities offered by sustainable development from the futures research point of view is that some plausible, real paths of incidence in the regional and social policy are superior to others. From the point of view of humanity and the principle of sustainable development, reliable information can be obtained on different alternatives through scientific research. The problem therefore is how can we distinguish between different paths of development and choose the best sustainable development policy in each decision-making situation. This is not easy because most environmental problems are uncertain and possibly irreversible and complex. There is considerable support for the implementation of a “precautionary principle”. Such a principle implies the current safeguard of environmental resources against the potentially catastrophic outcomes at some decisions (see e.g. a scenario analysis of sustainable development alternatives in Kaivo-oja 1999 and Meister and Japp 1998).

The expression 'sustainable development' is here understood as an ideal description of a regional and social policy. This essentially involves safeguarding the quality of life for the next generations (intergenerational equity) in such a way that the aims of economic growth and ecological sustainability can be met simultaneously in a socially maximally equal society and ultimately in different regional communities. Other definitions of sustainable development and descriptions of development processes are here seen as leading to inferior processes of social development. The failure of an ideal sustainable regional and social policy can lead to the realisation of these watered-down scenarios, which create unsustainable development paths (see Kaivo-oja 1999).

In social or regional terms, failure here means: (1) Ecological environmental resources falling below a critical limit. (2) Income levels falling below the sufficient critical limit determined for satisfying basic needs. (3) Unbalanced social development in a society (or in one of its spheres). Inequality, which falls below the critical limit, usually means an imbalance in income distribution that induces unstable and violent social conditions. These watered-down versions of the process of sustainable development force one to compromise between ecological sustainability, economic well being or social equity, which are also, considered criteria for sustainable development (Kaivo-oja 1999).

The approach employed in the present paper emphasises the rationality of the goals set for concrete action. If we set out from the assumption that decision-makers in different societies regard the intention of creating a sustainable society as a rational goal and a foundation for the value rationality employed in this action. The four major critical elements, which make up the visionary management model are; (1) Vision, (2) Mission, (3) Action leading to the implementation of those and (4) The next steps (or projects and programmes) in the implementation phase. Of these, the vision is always connected with the setting of goals in the regional and social policy (politics). The mission, action and next steps produce the execution of this policy. These basic concepts can be used as a means for developing a general theoretical framework for pursuing a sustainable regional and environmental policy (Haila 1997, 15-21).

The normative goal of visionary management here is global sustainable development. The basic point of departure is an ideal sustainable regional development policy based on the long-term ecological sustainability of the earth. The fundamental topic examined here was derived from the generally accepted basic assumption that the present situation and the general development trend do not fully conform to the principle of sustainable development in global terms. According to present estimates, the regional and social policies of different countries and regions should make more deliberate attempts towards safeguarding sustainable development, which can also be regarded as the starting point of value-rational action (Commission on Sustainable Development 1997a, 1997b).

The problem in a regional and environmental policy is often the fact that the theoretical approaches offered by different sciences are differentiated and partial in nature. The approach employed in the present paper enables us to identify and specify problems that result from a lack of comprehensiveness. A more comprehensive approach would allow for combining multilevel planning. In a global environment the relevance and problems of multilevel planning do not disappear. On the contrary, planning and management problems connected to sustainability issues may increase within the global planning environment (Commission on Sustainable Development 1997a, 1997b).

The approach employed in the present paper combines multilevel planning with the model of visionary management developed by Malaska and Holstius (Malaska 1993, Malaska and Holstius 1999a, 1999b). The construction of multifield and multilevel frameworks of this kind is quite common in futures research on account of its interdisciplinary nature.

Outlining the strategy of global responsibility within the global multilevel planning environment

The purpose of futures research is to expand people's knowledge and awareness of environmental issues. It thereby supports and better informs people about their behaviour and choices. It does this by (1) extending the time perspective from the present to the future of our grand- children and beyond. (2) This expands our perspective of close relatives by linking our personal interests to the family, tribe, village, municipal, town, nation, ancestors and towards the origins of our culture. (3) We therefore recognise that the environment and nature in global terms function as a whole. These three fields together create a global conscious responsibility. It is apparent that a sustainable future-oriented regional and social policy should be based on this state in the above sense (Malaska 1993).

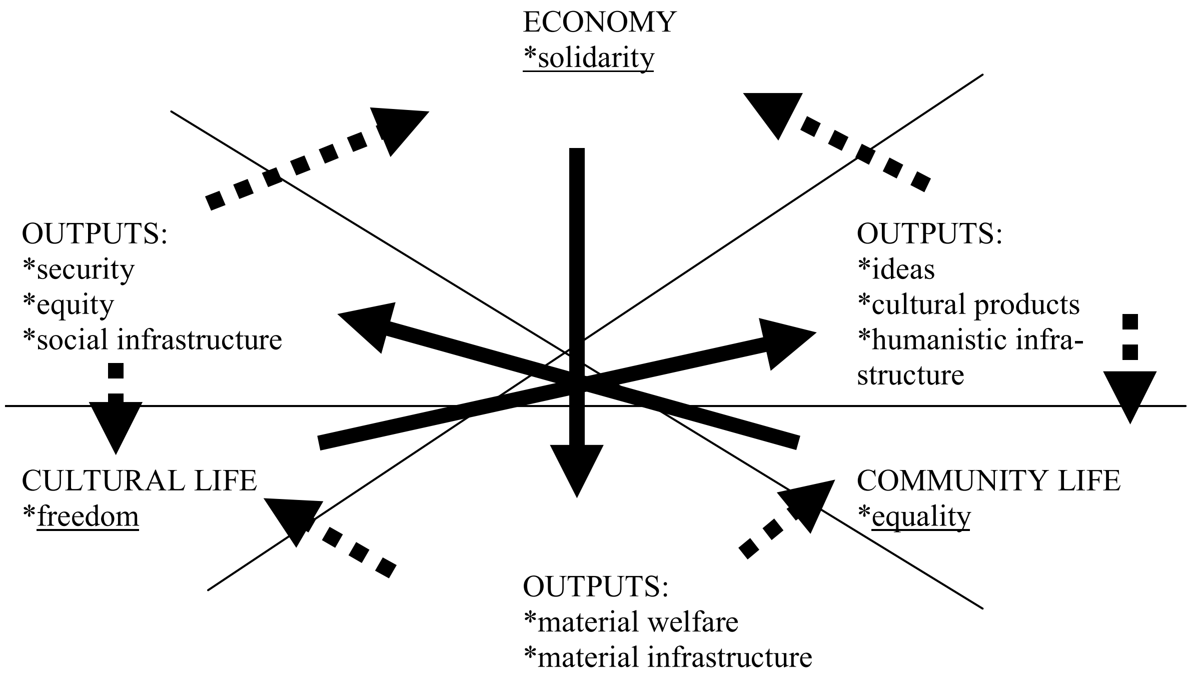
The nature of our global responsibility and its realisation in pursuing a regional and social policy are not dictated by any outside instance. This is rather for the actors themselves to determine when drawing up regional and social policy decisions, for they are required to indicate how participation which conforms to our global responsibility can be implemented, to inform other actors of it and to implement it. This whole composed of different types of co-ordinated function can be termed a communicative strategy for global responsibility, because information in communicative planning is a very crucial factor. At the same time, different social actors arc required to constantly present critical analyses of the definitions and investigations contributed by others. In this sense, it should be possible to reassess reflectively the action believed to be goal-rational and the content of this action in the light of new information (Malaska 1993).

It is not easy to implement the strategy of global responsibility in the world. If we follow the principle 'think globally, act locally', we should first describe at quite a general level the problem and solution-centred points of departure in the strategy of global responsibility, which are connected with the present state of the world. The background of this strategy can also be seen to comprise a general field of problems (problematique) which other strategies do not attempt to or cannot alleviate. The following exaggeration, for example, has been contributed: 'The existence of the mankind relies on a materially underdeveloped, risky technology, materialising itself socially in the form of unjustness and resting intellectually on nothing'. This assessment can be taken to generally describe a situation, which does not lead to an ideal process of sustainable development. The solution employed within the strategy of global responsibility (resolutique) has also been characterised in the following way; growing up as a human being lies in accepting the situation (problematique) as a challenge. And seeing in it the implementation of a choice which benefits all humanity from amongst the possible future alternatives. The belief of the optimist and the fear of the pessimist that we are living in the best possible world should thus be questioned' (Malaska 1993). Also this note emphasises the need for a more balanced approach.

The strategy of global responsibility can be organised by means of four concepts when using the model of visionary management, i.e. vision, mission, action and the present and future deeds of the next step. The vision of global responsibility has been characterised in the following way: 'A natural, sustainable technique of existence should be developed in order to generate material well-being, together with a functioning and legally just global community that enables all to participate in social action and co-operation. Preconditions should (also) be created, of a kind which will allow for the manifestation of creative and constructive spiritual and cultural phenomena, in order to diversify and enrich all aspects of life and deepen our ethical consciousness. Measures should (also) be taken ensure that these dissimilar, mutually supplementary levels and forces of materialisation merge into interaction that will benefit all of these'. This description may act as a general value-rational point of departure when discussing an ideal process of sustainable development (Malaska 1993).

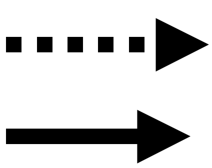
The problematique refers to the general problematisation of life, while the above vision describes the future desired alternative at a very general level. The qualitative and quantitative difference between the description of the present state and the future vision is called the mission. This in turn is a duty, which must be approved, and its measures committed to if a desired vision of global responsibility is to be accepted as the foundation of a regional and social policy. The co-ordinate system describing the present situation, vision and mission, is not confined to time but rather to a system, which presents the goal/objective level on one axis and capabilities and resources on the other. *Vision should preferably be more and qualitatively better than the present situation*. Yet it can only be achieved by developing capabilities and resources and through concrete deeds in particular, of a kind in which the existing resources and capabilities are utilised in an entirely new manner (Malaska 1993).

Figure 1. The semantics of global community policy interaction (Malaska 1993)



Legends to Figure 1:

The underlined words describe the driving force factors and the basic values of the functions.

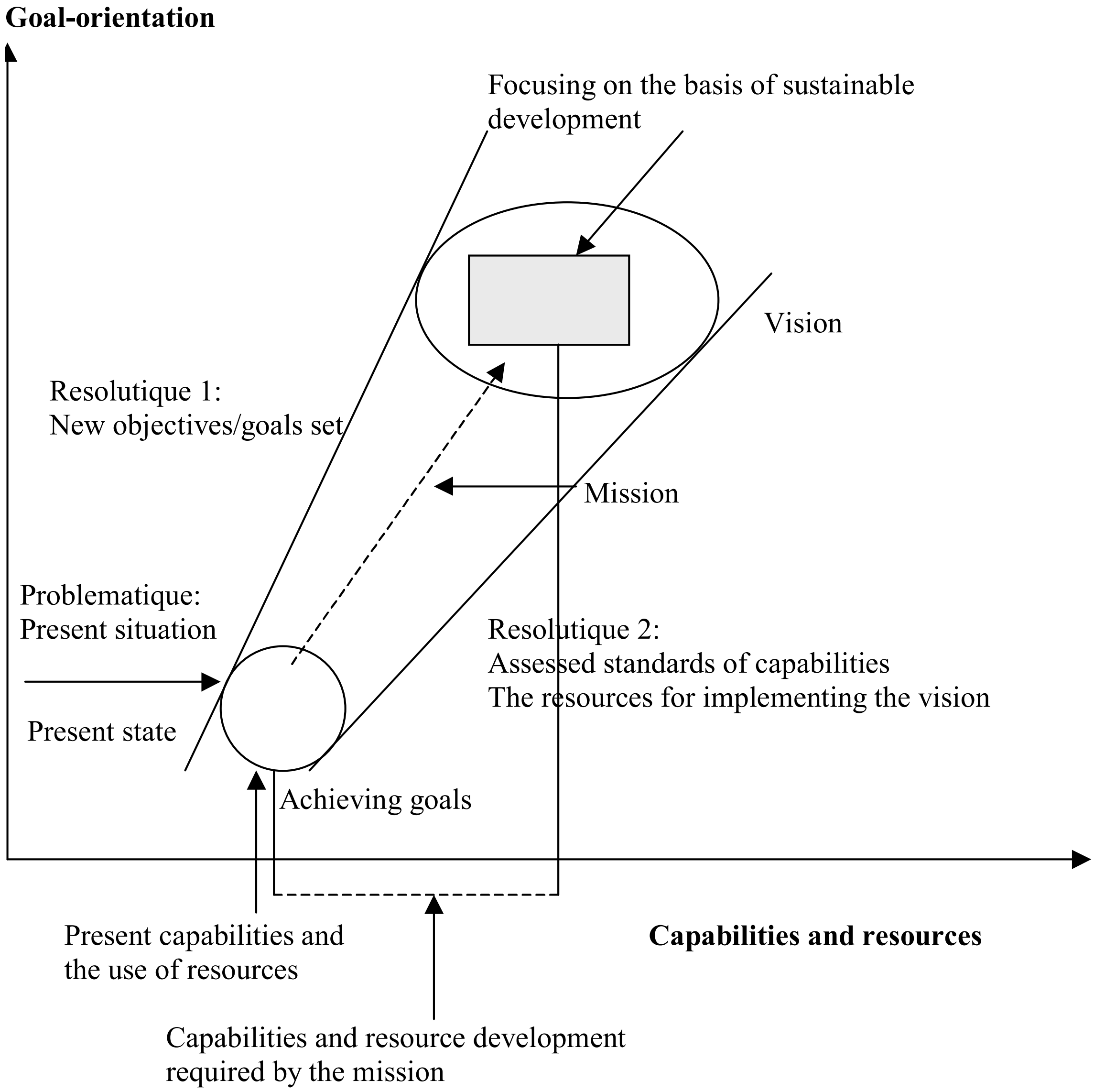


= interaction, exchange

= action

From the point of view of the strategy of global responsibility, the level of capabilities and the targeting, quality and scope of resources available globally at present unsuitable and insufficient for reaching the generally desirable goals. To reach the commitments determined in the mission and to do things through which the vision-related goals set can be reached, people have to develop their capabilities and resources. The horizontal axis in Figure 2 thus presents the superiority of human capabilities and resources over the earlier level (see Figure 2).

Figure 2. Syntax of vision, our present state and our mission



The need for goals and the deeds and capabilities required to achieve them determine the direction of the mission from the present time onwards. The mission thus comprises the goals and development direction to which one is committed. It involves the development of new resources and capabilities and the accomplishment of deeds. It should be borne in mind, however, that the vision of global responsibility is quite a general, holistic description of future. It also provides a broad description of the direction of the development task seen from the future point of view (i.e. the present seen from the future). It is thus justifiable to set out from the assumption that the social contents of both visions and missions are assessed continuously and critically in the light of the most recent information available. A mere declarative regional and environmental policy mainly aimed at compromises is not necessarily sufficient for use as a regional and social policy mission or vision at present. Thus a genuine value-rational commitment to global responsibility missions and visions is required. In a practical regional and social policy, different types of global vision and mission always have to be related to national and regional strategies, which in turn determine visions and missions at the regional level.

Beyond opportunistic and strategic management?

When we study the characteristics of a good decision we have to recognise that there are three main variants of decisions: opportunistic, strategic and visionary.

Visionary management and operation differs substantially from other management practises with which it coincides and occurs simultaneously. Management practises comprise opportunistic and strategic management, which, nevertheless, are parallel to and complement visionary management (Malaska and Holstius 1999a, 1999b).

Opportunistic management aims at producing the best possible result and output using the resources and capabilities available and by means of the resources and basic preconditions available at that particular moment. Almost all organisational management in the end has to involve an opportunistic quest for results. An optimum opportunistic management is the only management practise required for a longer term unless no appreciable changes take place in the external conditions of the future. If the prevailing conditions change radically in future, however, the actor himself has to change and alter his action so as to gain an optimum result. S/he can respond to an anticipated change in conditions through strategic management. The purpose of that is to retarget the resources and capabilities available to the actor, so as to gain a new optimum opportunistic management situation that will correspond to the change having occurred in the prevailing conditions. Strategic management thus involves the re-targeting of existing resources and its related planning and execution. This re-targeting often involves combining things and/or giving them up, major investments, new exchange, new information, reorganisation and a radical change in the principles of the organisation. The setting of all questions in visionary management begins from the development of entirely new forms of capabilities and resources. In visionary management, some of the resources obtained through opportunistic action and strategic acquisitions are used for the unproductive creation of strategic visionary capabilities and facilities during a period of a change in external conditions which extends longer into the future than the forecast. This provides social actors with a good, high-quality existence alternative even in the over-strategic time span (Malaska 1997, Malaska and Holstius 1999a, 1999b). Table 1 presents the types of decision-making:

The measures taken in a visionary sustainable regional and social policy span should ensure that the opportunistic and strategic action of different regional actors would lead to a sustainable result in the future. Successful opportunistic and strategic decision-making is thus a necessary part of visionary management, which may lead us to sustainable development (Malaska and Holstius 1999a, 1999b).

It can be proposed with regard to the above that it is impossible to draw up a sustainable regional and social policy in society without future-conscious visionary management practises. Thus mere opportunistic and strategic management practises in organisations are not a sufficient means for implementing an ideal process of sustainable development in the long run. For example, in Finland an extremely large number of regional and social policy practises are based either on opportunistic or strategic practises but not on visionary ones (see e.g. Sotarauta and Linnamaa 1998).

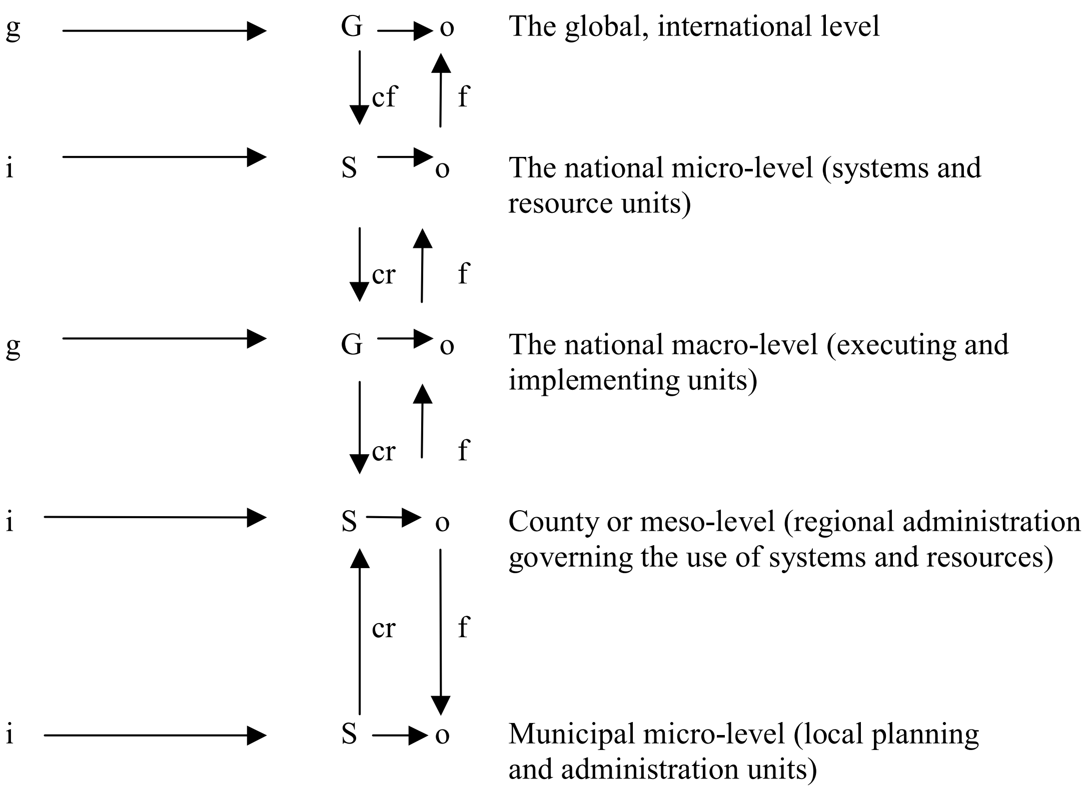
Table 1. Three forms of decision-making (a modified version of Malaska and Holstius 1999a)

Determinant of decision	**Opportunistic decision-making**	**Strategic decision-making**	**Visionary decision-making**
Situation	Known	Uncertain but predictable	Discontinuous & unpredictable, emergent
Purpose and objectives	Maximise profit and cash-flow in private sector organisation Maximise budget or personnel in public sector organisations	Adaptation, ROI, growth (of the organisation and resources) increasing power and public support	Excellence of performance, long-term survival, finding new options, quality of life, total quality thinking
Means and resources	Fixed	Reallocation of available and attainable resources	New skills, re-framing of business, envisioning, creating new capabilities needed for sustainable development
Management by	Control	Reallocation	Visionary renewal

The multilevel planning environment of sustainable development

At least four spheres of multilevel planning can be recognised in Finland's regional and social policy: the global level (international level), national macro level, provincial meso-scale level and local district level. Different areas today also endeavour to pursue regional co-operation other than that determined through sustainable development. Finland, for example, is engaged in Nordic co-operation, the European Union, United Nations' organisations, collaboration between industrialised OECD countries etc. At the provincial level, local councils also aim at pursuing district co-operation and nations at regional co-operation in the Baltic and the Barents Sea area, for example. Local councils, provinces and stales today also endeavour to pursue cross-border co-operation within the European Union. The intermediate forms of multilevel planning will not be examined here in any more detail (see e.g. Papunen 1986).

Figure 3. A model of multilevel planning and operation; pragmatic research code



The symbols in Figure 3 are:

G = a multi-objective unit (the goal-seeking unit)
S = a causal, intentional and strategic execution unit (system unit)
i = inputs, interaction (inputs)
o = outputs (outputs)
cf= control, objectives, resources etc. (co-ordination)
f = feedback e.g. on the extent to which the goals set can be achieved (feedback)
g = goals/objectives set

The System of multilevel planning can be theoretically organised in the following manner (see Figure 3, Papunen 1986, 64-66).

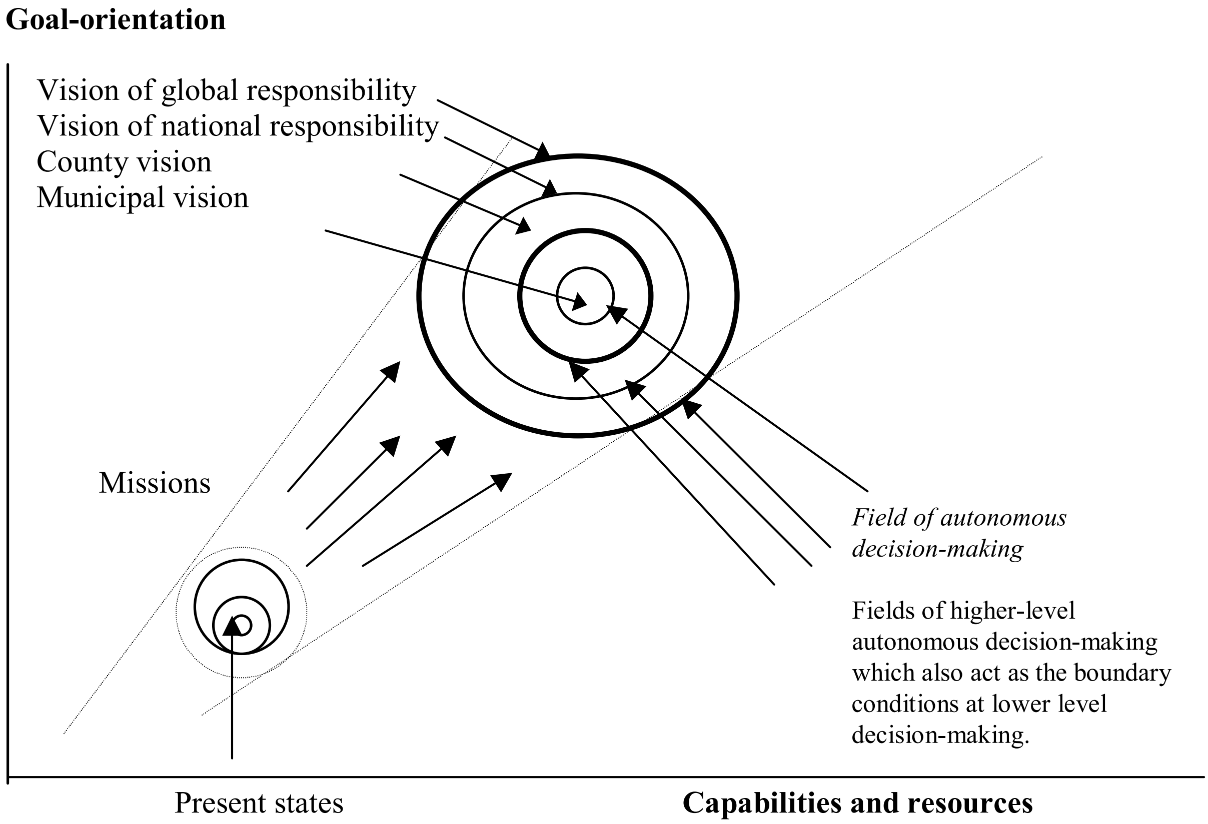
Figure 3 indicates that outlining the principle of global responsibility requires an understanding of the administrative policies and functions of different levels of regional planning. It is important that one should understand that each level always has autonomous functions of its own and ones derived from the functions of some other levels. The rationality of these functions requires taking into consideration their mutual correlation regardless of whether the functions are autonomous or derived from other levels. These contribute jointly to what kinds of practical result the regional and social policy practised will in the end lead in local communities. It is also important to recognise the importance of communicating information from one level of planning to another. Innes (1998) notes that information in communicative practice influences by becoming embedded in understandings, practices and institutions rather than by being used as evidence. Secondly, the process by which the information is produced and agreed on is crucial and must include substantial debate among key players and a social process to develop a shared meaning for the information. Thirdly, many types of information count, other than "objective" information.

Care should be taken when implementing the operative strategy of global responsibility in a regional or social policy that the missions and visions employed at different levels are combined to a sufficient degree. An ideal situation would apparently be the distribution of labour between the various levels of regional social policy planning in such a way that the necessary sub-tasks could be executed entirely independently and that doing so would also lead to the accomplishment of the overall duty. The perfect planned combination of the various functions or, alternatively, their complete separation is not rational either. The former easily leads to inflexibility and increased ineffectiveness in the form of risks, while the latter may result in the poor targeting of the existing resources and their ineffective use. Thus the policy selected in this way does play a role in pursuing a successful regional and environmental policy.

Visions, missions and projects of sustainable development: How can sustainable regional and social policy actions fail?

The ideal situation in regional and social policy planning is described in the framework of global responsibility in Figure 4. In an ideal case, all the visions and missions of the various spheres of multilevel planning are realised simultaneously. Together they may lead to the implementation of an ideal process of sustainable development though this is of course not always the case in practise.

Figure 4. Vision, present state and mission in an ideal situation in a multilevel planning environment.

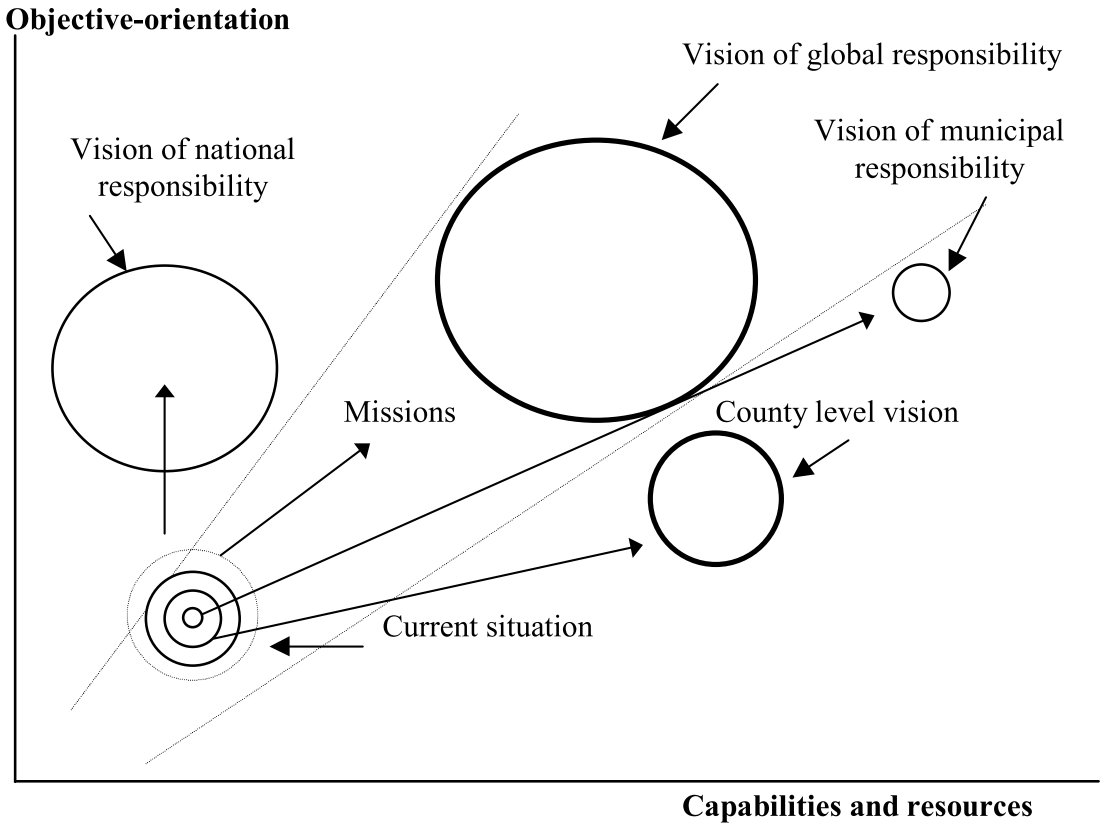


It is evidently difficult to contribute to an ideal situation in regional and social policy planning. Thus it is absolutely essential that one should think about how and why a sustainable global responsibility regional and social policy can fail. When these possibilities of failure are recognised, they can also be avoided. Recognising problems can lead to the development of better goal rationality in the regional and social policy employed.

It is important to think from the point of view of multilevel planning about the situations in which the ideal sustainable regional and social policy shown in Fig. 4 cannot be implemented. What risks of failure and ineffectiveness can be identified through it? The current section analyses the possibilities of failure in a sustainable regional and social policy within a multilevel planning environment.

Let us first examine situations where the visions of different levels of planning, which form a different entity, are differentiated. The visions are here assumed to be, in a way, false or defined in a contradictory manner. Cases of potential failure are described in Figure 5, of a kind where the visions are not mutually co-ordinated with regard to the vision of global responsibility. The situation yields different, contradictory answers to the basic question of what types of new capabilities, know-how and resources should be developed. Here, the actors on the various levels do not understand each other and disagreement is therefore bound to arise with respect to the relevant goals.

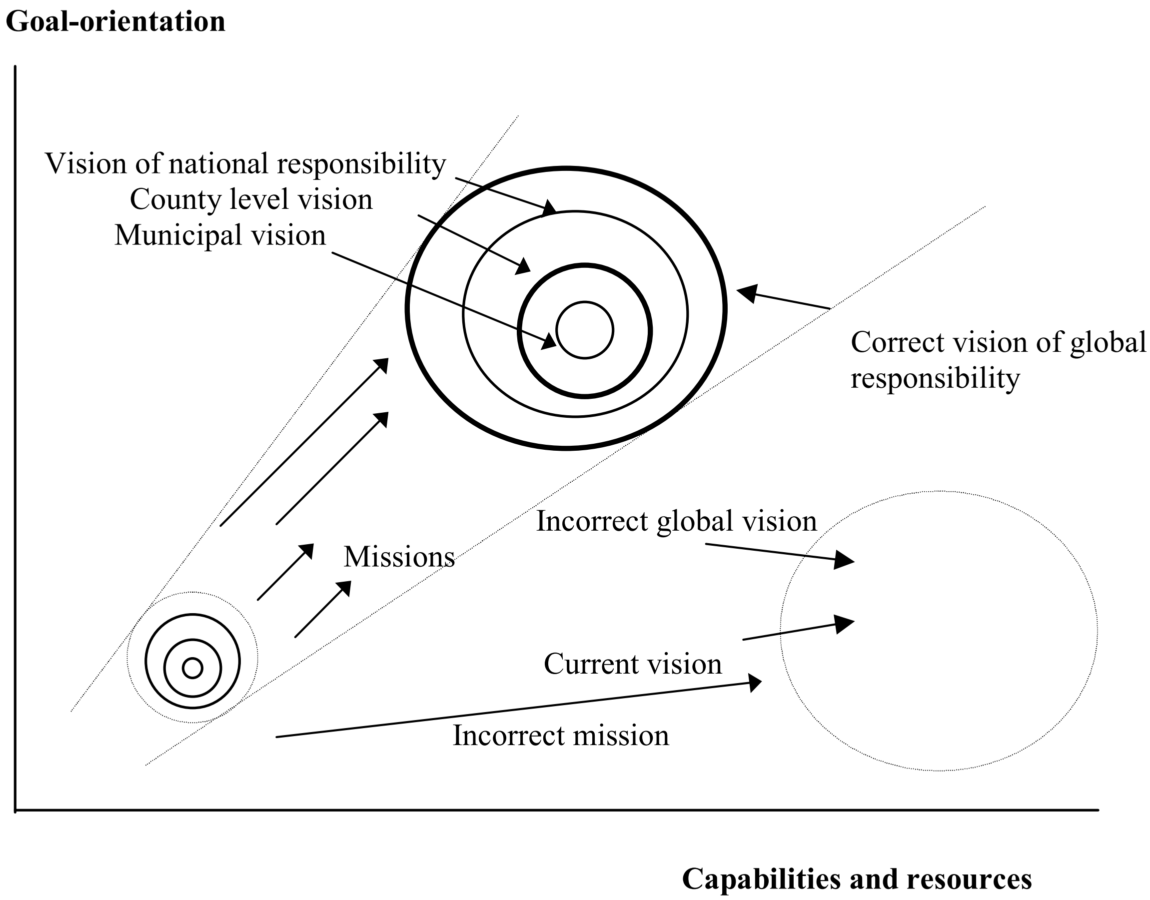
Figure 5. The visions and missions of uncoordinated regional spheres of planning within the multilevel planning environment.



Different types of situation are described in Figure 5 in which the national, provincial or district vision cannot be combined with the vision of global responsibility. Situations of this kind are in practise possible in regional and social policies. One feature typical of this problematic is the classic "free riding" problem. For example, a contradiction regarding the use of natural resources is built up intentionally by an interest sphere or group. In the case of free riding, the market may fall short of providing the efficient amount of the public good (for example, environmental assets). No automatic tendency exists for markets to reach the efficient allocation. In such a case, it is difficult to combine the interests of an actor and the common good. This plausible situation has been recognised in theoretical discussions regarding environmental protection and also in practise e.g. in the international climate change policy. A sustainable regional and social policy thus seems to require a view, which goes beyond individualised rationality

Egoistic rationality in turn alludes to free riding, which in turn leads to a collectively poor outcome. (see e.g. Marwell and Ames 1981).

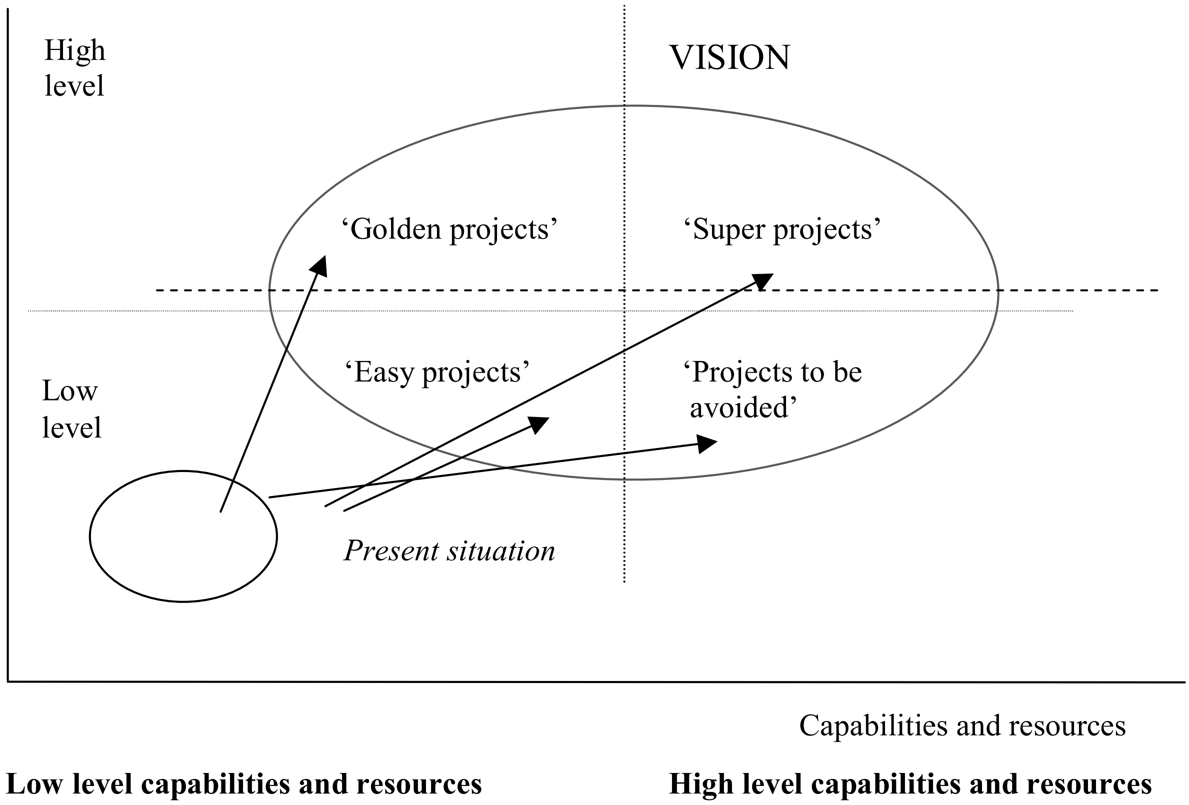
Figure 6. A vision of unacceptable global responsibility



It is of course also possible that the vision of global responsibility in itself is unacceptable and cannot be implemented at all. This kind of situation may arise from international policy actors, for example, not being able to engage them in a sufficiently critical discussion of the content of the global vision. The emphasis in the international environmental policy is often placed solely on visions that emphasise economic growth and not the questions of a just world or economic sustainability. These are often even left beyond the scope of environmental policy discussions altogether (see Luukkanen and Kaivo-oja 1999). This type of situation is shown in Figure 6.

Special problems are also involved in defining the actual vision of sustainability and critically assessing its content. Four alternative vision content types are indicated in Figure 7, the classification is based on itemising the content of the vision with regard to capabilities, resources and the goal-orientation of social action.

Figure 7. Itemising the content of vision with regard to goal-orientation, capabilities and resources.

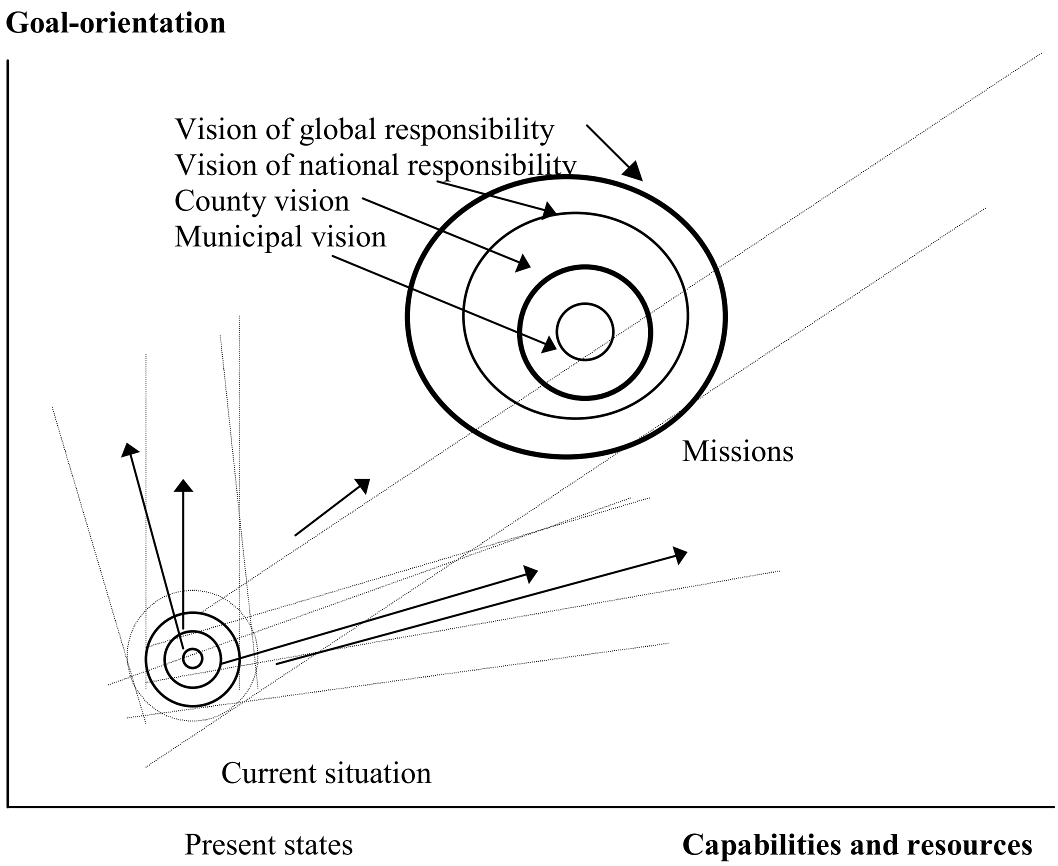


The itemisation shown in Figure 7 may be of use when organisations (both private and public sector organisations) critically assess their visions at different levels of regional and social planning. It is usually preferable when assessing visions to try to find future projects ("golden projects") of a kind which are sufficiently challenging but do not require too much risky, excessive expertise and resource inputs from the organisation. On the other hand, in implementing their visions in regional and social planning, organisations should avoid projects that require major capability and resource investments in the future but which yet only involve low-level goals ("projects to be avoided"). On the other hand, there are also so called "easy projects" in regional and social policy with low-level goals and minor expertise and resource requirements. Projects of this kind do not usually involve any major financial risks typical of "super projects". However, as the latter often entail extremely large financial risks in the form of capabilities and resources on account of the high-level goals involved. The problem in defining the vision may be that the organisations engaged in regional and social planning fail to specify the contents of their own vision sufficiently carefully as regards their goal-orientation or the required capabilities and resources.

Situations where the missions of the various regional and social policy planning levels are contradictory to each other create the cases of failure described in Figure 8.

Here the kind of missions are not mutually co-ordinated with regard to the vision of global responsibility nor to the other multilevel planning visions connected with it. Situations of this kind are in practise also possible in regional and social policy.

Figure 8. Missions differentiated from the missions of regional planning levels in the multi-level planning environment.

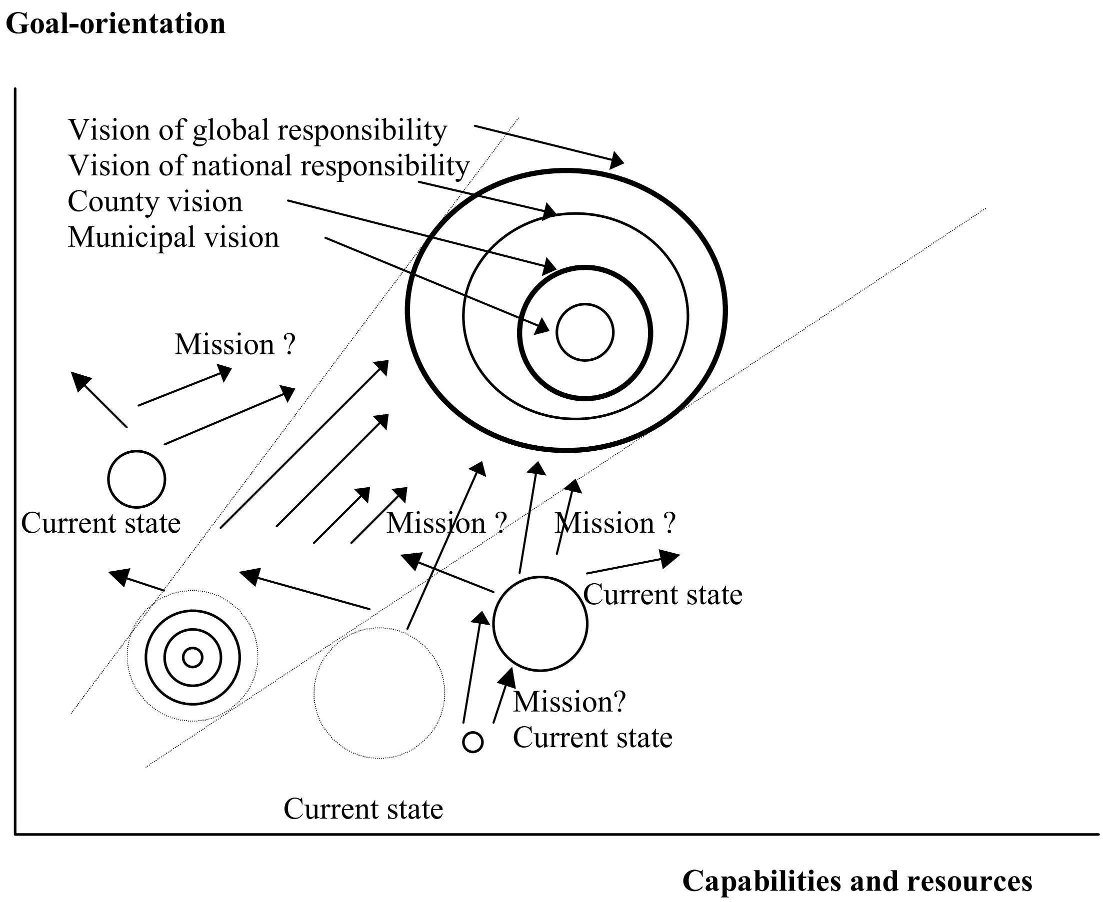


Dissimilar, contradictory answers can be obtained even in this situation to the basic questions of what types of new capabilities, know-how and resources should be developed. Contradiction may also arise from global-level action. Here, the actors engaged at the national, provincial and district level may understand each other but completely fail to understand the global level actors and their visions. In these situations, the vision is defined correctly when examined from the point of view of the principle of global responsibility though lower regional levels may fail to direct functional missions in the right direction.

Situations where evaluations of current positions and missions are defined incorrectly in relation to real-life situations are described in Figure 9.

A logical consequence of this kind of failure is that missions are biased in relation to visions. Thus failures in real-life mission analysis (for example in project evaluation) can lead to the misuse of resources and capabilities. Situations of this kind are in practise also possible in regional and social policy. In this case - the fundamental problem of planning - what kind of new capabilities and resources are needed can be answered, but the actual missions of multilevel agents are biased in relation to visions. A logical result is that missions and visions are not co-ordinated in relation to each other. In this case visions are ambiguous and the missions move in the wrong direction.

Figure 9. Incorrectly selected missions in regional planning levels within the multilevel planning environment.



Summary

In this article we have seen, on the basis of graphic demonstrations, that in the multilevel planning environment there are many potential possibilities for failure in sustainable development policy. On the basis of the analysis presented in this paper, potential cases for policy failures in the global multilevel planning environment are:

1. Visions of some regional planning level may be impossible to achieve due to being poorly defined or incorrect;

2. A mission may be incorrectly defined in relation to a vision on some regional planning level and thus an action (including projects and programmes) is not rational in relation to a vision;

3. Both a mission and a vision on some regional planning level can be simultaneously incorrectly defined;

4. The starting points of a mission can be incorrectly defined on some planning level and then the mission is misdirected and not goal-rational;

5. The operational actions of missions will not succeed if goals are not fulfilled in practice at a planning level.

In these cases visionary management does not work properly and Murphy's laws may emerge in different forms and contexts. However, it is possible to avoid these potentially emerging 'dead-end' situations. Thus, if we

1. define our visions carefully and critically focus on the actual substance of the sustainable development process criteria;

2. define our missions carefully and critically in relation to the right kind of vision;

3. critically define all possible visions and all possible missions within the different levels of multilevel environment;

4. analyse and define initial problem situations and the problematic position of a mission; and

5. begin actual operations according to the defined missions and the defined visions, we have an effective regional management process, which fulfils the criteria of visionary leadership model and culture.

The analysis presented in this paper tells us clearly that rational thinking is needed for a global sustainability policy and visionary management. However, procedural and communicative aspects of planning cannot be neglected. Planning of the global economy seems to be developing towards an increasing interplay between various actors operating on different levels. If we avoid these potential management failures and emerging 'dead-end' situations in sustainable development policy, a lot of progress in sustainability policies and strategies can be expected to occur - both in private and public sector organisations. Optimism and pessimism work together in reality, and therefore they should also work together in visionary management and planning. Optimism can lead to uncritical thinking and behaviour. While pessimism can lead to over-critical thinking and behaviour.

One can conclude on the basis of this article that a crucial part of environmental and regional planning activities should be co-ordination and information sharing between different planning levels. If planners in different planning organisations do not discuss global and local visions and missions then we can expect that serious policy failures will happen in sustainable development policy and planning. Especially in the global planning environment, it is very important to analyse what is really happening in different planning environments and what kind of visions planners and decision-makers present.

The actual contents of visions and missions should be critically discussed. The itemisation presented in this paper may be of use when organisations critically assess their visions of different levels a regional and social planning. The identification of 'golden projects', 'projects to be avoided', 'super projects' and 'easy projects' in the context of visionary leadership is a very important part of the successful planning and implementation process. It is usually problematic to find future projects of a kind which are sufficiently challenging but do not require too much risk, excessive capability and resource inputs from the planning organisation. On the other hand, in implementing their visions in regional and social planning, organisations should avoid projects that require the stretching of capabilities and resource investments in future but which only involve low-level goals. On the other hand, regional and social policy contains low-level goals and minor expertise and resource requirements. The problem in defining the vision may be that the organisations engaged in regional and social planning fail to specify the contents of their own vision sufficiently as regards their goal-orientation or the required capabilities and resources.

Communicative action while planning should not be forgotten in the global planning environment. This kind of communicative perspective represents a shift from a view widely held over at least 30 years, that the planner's role is mainly to deliver unbiased, professional advice and analysis to elected officials and the public, who in turn make decisions. In this view, information is a tool for policy makers to use to make decisions. The conventional planner's task is to "speak truth to power" rather than to give feedback to other planners and evaluate the missions and visions of other planning levels planners and decision-makers. The analysis presented in this paper powerfully demonstrates the potential for the serious planning and implementation failures of global sustainability policy if there is not enough information sharing concerning missions and visions at different regional planning levels.

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ALTERNATIVE SCENARIOS OF SOCIAL DEVELOPMENT: IS ANALYTICAL SUSTAINABILITY POLICY ANALYSIS POSSIBLE? HOW?

by

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Introduction

National and international economic policy is based on the conventional presumption that economic growth and economic liberalization of international trade are, in some sense, good for the environment. This notion has meant that economy-wide policy reforms designed to promote economic growth and liberalization have been encouraged with little regard to their environmental and socio-cultural consequences.

The optimistic international strategy has given nation states economic agents opportunities to legitimate very different activities in the name of sustainable development. It is fair to state that some of these practices may even be harmful with regard to welfare and the environment (see Jokinen *et al*., 1998).

The debate over the relationship between economic growth and environmental conditions has in the 1990s focused on the environmental Kuznets curve (EKC) hypothesis (Grossman and Krueger, 1995; Stern *et al*., 1996; Ekins, 1997). A central question in the debate has been whether pollution produced by industrial processes increases monotonically with economic growth or whether economies reach a ‘turning point’ at which emissions begin to drop because they can afford more efficient infrastructure and more stringent pollution controls (see e.g. Munasinghe, 1995, 1996; Ekins, 1997). In this article the EKC hypothesis is conceptualized in a wider scenario framework. In this article it will be demonstrated that the scenarios based on the existence of the EKC hypothesis give us a very limited future prospective of spatial sustainability problems. In this article, some theoretically motivated scenarios of societal sustainability will he presented. The approach to environmental policy is here clearly problem oriented. Some alternative scenarios of social development, which may be theoretically interesting, are presented here. The scenarios presented can give us alternative futures view to consider the relevance of different sustainability strategies in the social development planning and policy debates.

Alternative development scenarios of social sustainability

Theoretical assumptions of scenario analysis

Ravetz (1997) has pointed out that an appropriate response to the new challenges to science will require much more than new explicit goals and social organization. New leading questions will be appropriate. The traditional questions of "what/how?" for research and "how/why?" for the design fields will be supplemented by "what-if?" questions. The approach in this article is based on a question "what-if?". Thus, some scenarios are presented and then it is asked - on the basis of scenarios - what the real problems of social development policy really are, if scenario x happens in the future of a society. Scenarios presented and described are (i) the Deep Ecology Scenario, (ii) the Strong Sustainable Development Scenario, (iii) the Weak Sustainable Development Scenario, (iv) the Boomsday Scenario, (v) the Doomsday Scenario and (vi) the World Bank 'Policy Tunnel' scenario.

It is clear that economic policy can have substantial impacts on the environment. For example, access to credit can help the poor to avoid "intensive" degradation or "mining" of the environment. Income policies can be redesigned to reduce intensive decay when belt-tightening is needed. Theoretically, following Karshenas (1992, 1994), Figures 1-6 illustrate the relationships between a stock of environmental amenities z on the vertical axis and the potential output *per capita* on the horizontal. Both variables are measured *per capita*, i.e. $g = Q/N$, where N is population and Q is the potential output in the spatial economy. Similarly, $z = Z/N$, where Z is a stock environmental indicator appropriate to the society at hand. Here a socio-political equity dimension is linked to Karshenas' (1992, 1994) framework. By adding a socio-political equity dimension (the vertical axis downward) to Karshenas' framework a new theoretical framework can be presented for sustainability analysis. This new framework could be seen as a general framework of social sustainability analysis or analytical environmental policy. This kind of three-dimensional analysis combines environmental, economic and social dimensions in one coherent and analytical environmental policy framework. One can also see alternative scenarios as hypotheses of alternative development processes.

As shown in Figures 1-6, there are 'danger zones' in environmental, economic and social terms. These 'danger zones' indicate unsustainable development conditions in the society analysed. Prudent national planning would hold $q > q^*$ to avoid absolute immiserization and severe social conflicts, $z > z^*$ to preclude the possibility of environmental collapse arid $e > e^*$ to preclude ultimate social inequality in the society.

In Figures 1-6, it is also assumed that, if the environmental stock *level per capita* decreases in the society analysed, then this phenomena leads automatically to lower potential (equity-potential out *per capita*) indifference curves in equity-efficiency space.

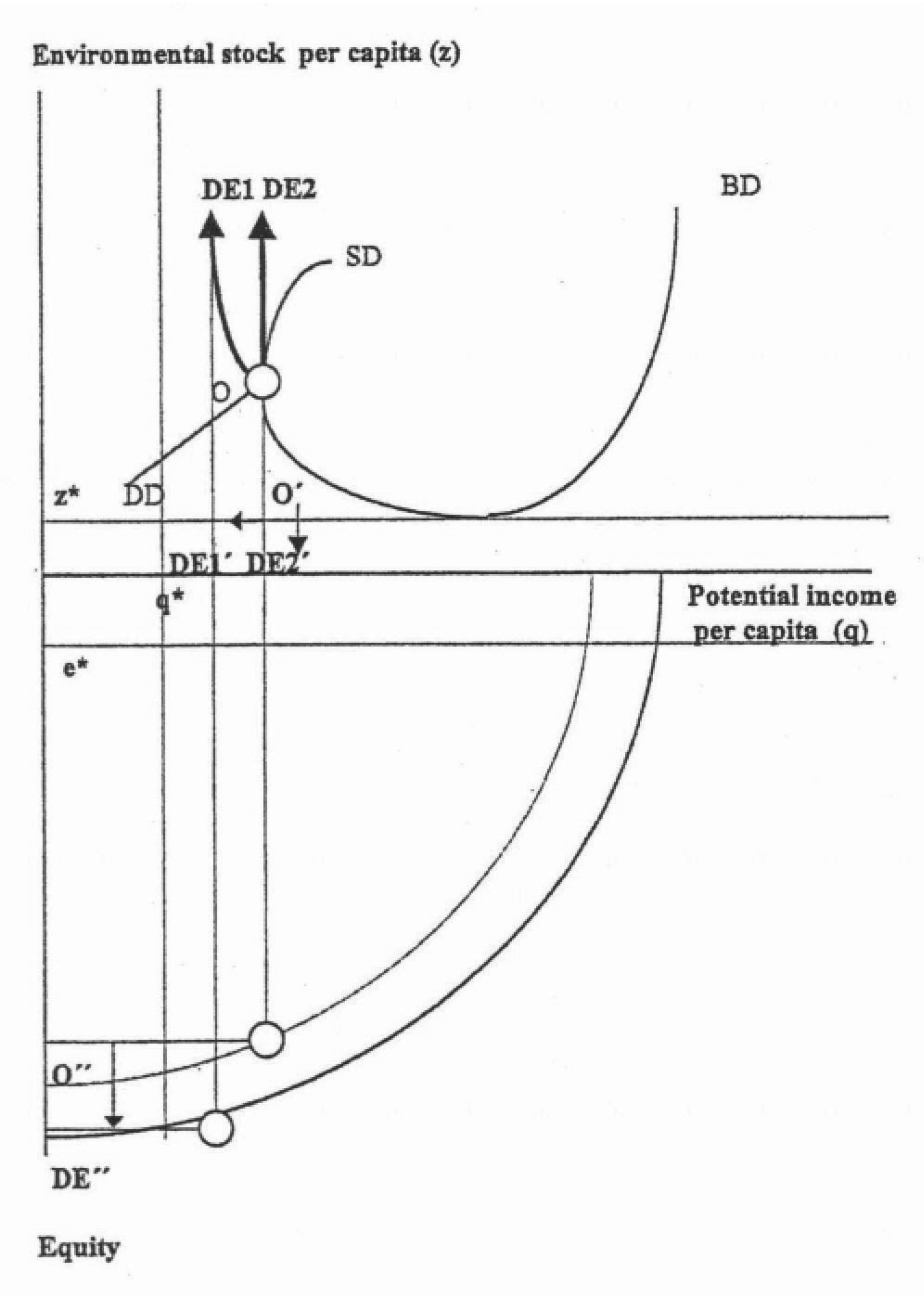

Figure 1. The Deep Ecology Scenario.

If we assume that potential output *per capita* indicates theoretically higher efficiency in the economy, we can also assume that there exists the same kind of relationship between efficiency (output *per capita*) and equity as presented by Stiglitz (1992, 250-251). Equity, in this context, refers to the re-distribution measures of income level. Efficiency, in this context refers to the quantitative amount of output and corresponding income level in the economy.

The Deep Ecology Scenario (the DE Scenario)

The Deep Ecology Scenario is described in Figure 1. The Deep Ecology Scenario is a thorough-going green strategy which would hold potential output *per capita* stable or even let it decline in order to permit environmental improvement along the trajectory running from O toward DE. Such a development path embodies the recommendations of gradualist deep ecologists for industrial societies (see e.g. Naess 1990). In the social domain of society, this DE scenario leads to a more equal society (DE1) or keeps equality stable (DE2), as can be seen in Figure 1.

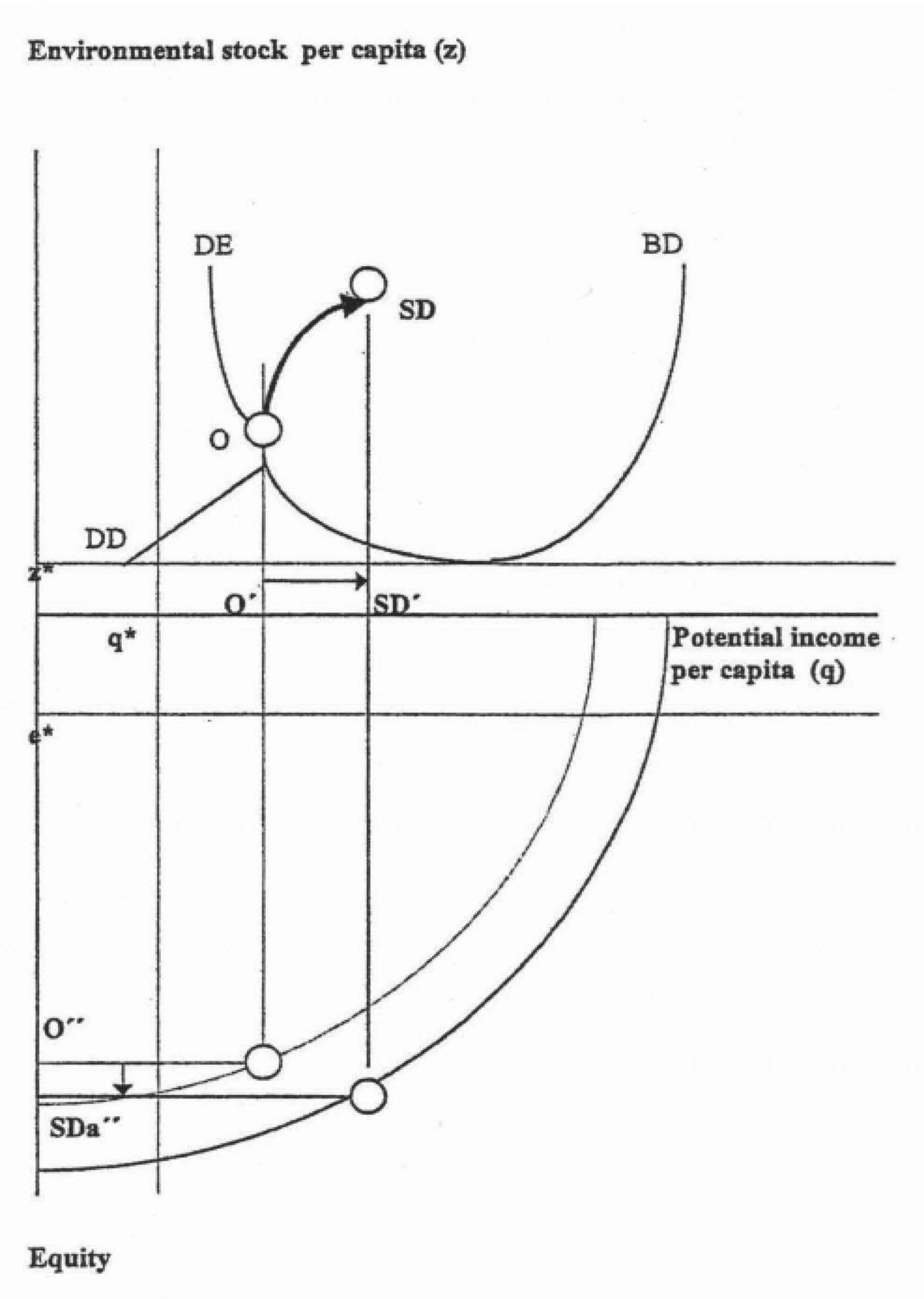

Figure 2. The Strong Sustainable Development Scenario (social welfare productivity of income growth *per capita* is positive).

The Weak and the Strong Sustainable Development Scenarios

Two alternative scenarios of sustainable development are described in Figures 2 and 3: one is a Strong Sustainable Development Scenario and the other is a weaker version of the Strong Sustainable Development Scenario. In both cases a trajectory runs from O to SD. In case A, all the criteria of environmental, economic and social sustainability are met, but in case B the criteria of social sustainability are not met because the level of equity decreases when output *per capita* increases in a society. The theoretical reason for the critical difference is that in the strong sustainable development process, the social welfare productivity of economic growth is positive (the Strong Sustainable Development Scenario), but in the other case it is negative (the Weak Sustainable Development Scenario)[1]. In the latter case, the growth of economic income *per capita* leads to deeper social inequality.

[1] See discussion concerning the social welfare productivity of the economic growth by Malaska and Kaivo-oja (1997).

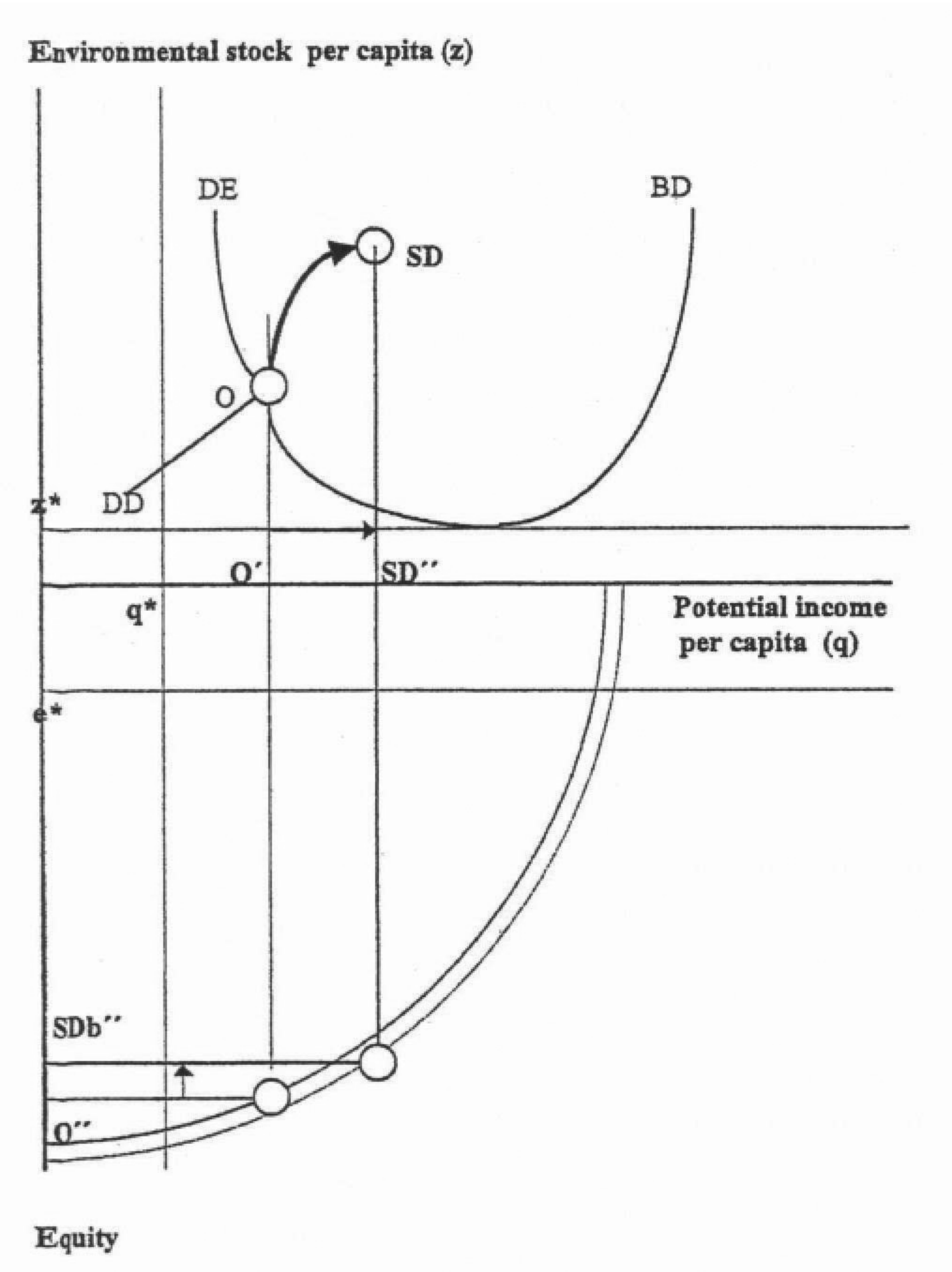

Figure 3. The Weak Sustainable Development Scenario (social welfare productivity of income growth *per capita* is negative).

Both versions of sustainable development seem possible in societies. Thus it is still very much an open question how much output growth, if any, especially in industrial countries, is possible without engendering utility-cancelling negative feedback.

The Boomsday Scenario (the BD Scenario)

Many mainstream economists assume that the 'society' chooses its path in Figure 4 by maximizing a discounted welfare function subject to known technical restrictions over time. The Boomsday Scenario leads to an O-to-BD style resource use trajectory path. Mainstream economists say also that a dual solution to the optimizing problem provides a set of shadow prices that can be used to guide resource allocation and also provide the proper means of accounting for growth. However, in the social sphere, this BD Scenario leads to increasing inequality in the society. In the environmental domain, the BD Scenario means considerable social risks, because one cannot know for sure that the coming "boomsday" are really leading to an ecological process where environmental stock *per capita* starts to increase (see Figure 2). For example, the changes in biodiversity may be irrevocable. This kind of fundamental ecological change may hinder the growth of environmental stock in spite of forecast economic growth. In spite of these 'small problems', many mainstream economists assume that this kind of scenario is a very realistic development path (see e.g. Munasinghe 1996). However, politically this kind of scenario is easy to accept by the name 'structural economic adjustment policy', for example in less developed countries. Thus, many mainstreamers think also that this kind of scenario is economically favourable in the future (see e.g. Solow 1993; see also wider discussion by Toman et al. 1995).

However, many authors for example in WIDER (see e.g. Taylor 1996, 221) see grave problems on both political and epistemological grounds with this approach. Politically, there is no reason to expect societal consensus on either environmental or economic questions. The degree of class and income distribution conflict in any real economy rules out such accord. The state itself may be autonomous, a creature of conflict ridden civil society or something in between. Epistemologically, environmental decision-making is subject to fundamental uncertainty - no meaningful probability distributions can be put on future events that are unforeseeable given the present state of knowledge. After this discussion it may be interesting to notice that if we compare the EKC hypothesis trajectory (see e.g. Munasinghe 1996) with the BD Scenario (Figure 4), we cannot avoid seeing the analogous characters of these trajectories. One could say that these approaches are analogous to each other.

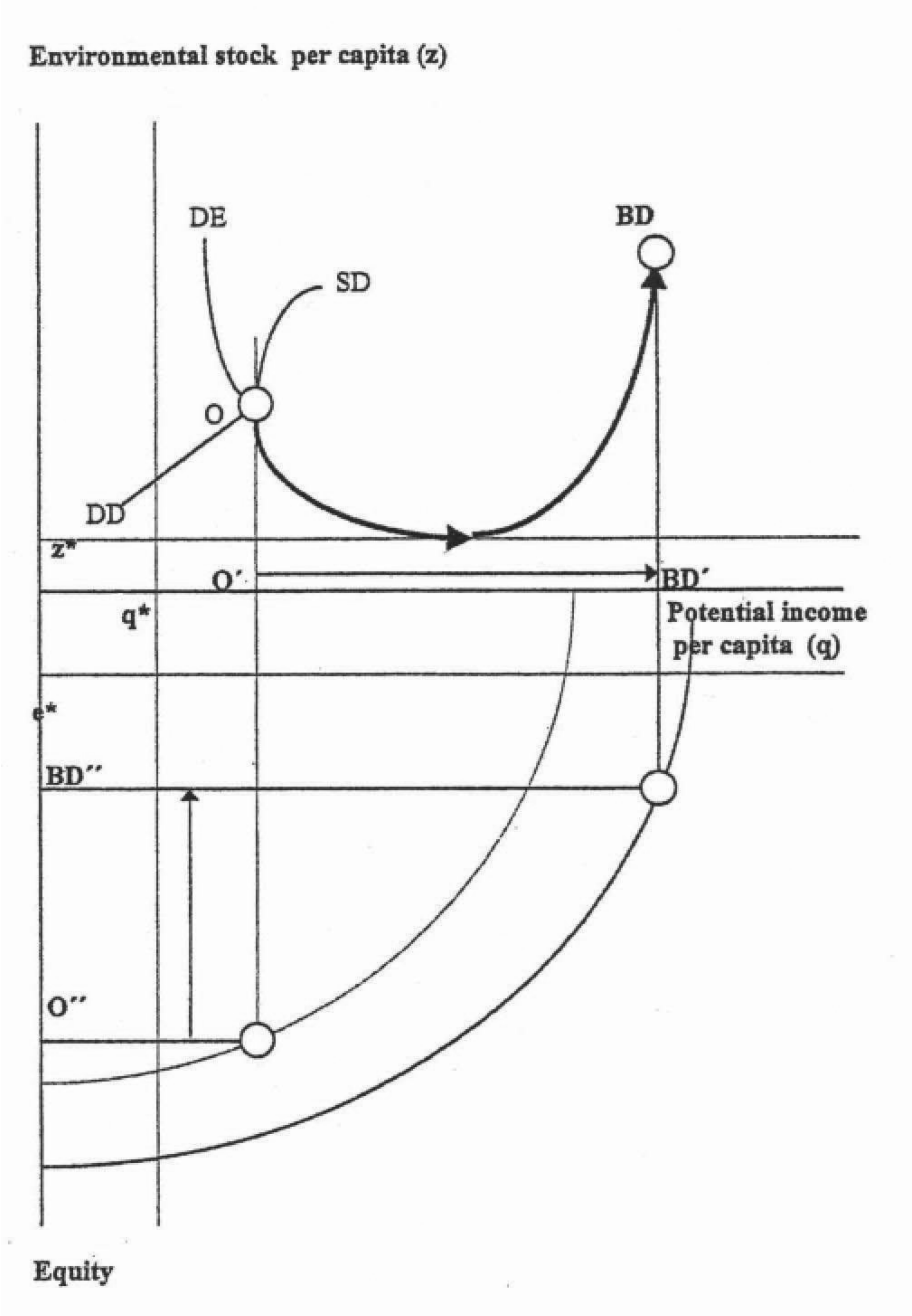

Figure 4. The Boomsday Scenario.

The Doomsday Scenario (the DD Scenario)

The Doomsday Scenario is outlined in Figure 5 with the trajectory running from O toward DD. The DD Scenario describes a societal process that leads to a very unsustainable society. The final output of this societal process is lower potential output level *per capita*, a decreased environmental stock *per capita* and increased inequality in a society. Naturally, the DD Scenario should be avoided in all the societies of the world. Unfortunately, this kind of scenario is realized locally already, for example in some countries of Africa and some regions of Russia.

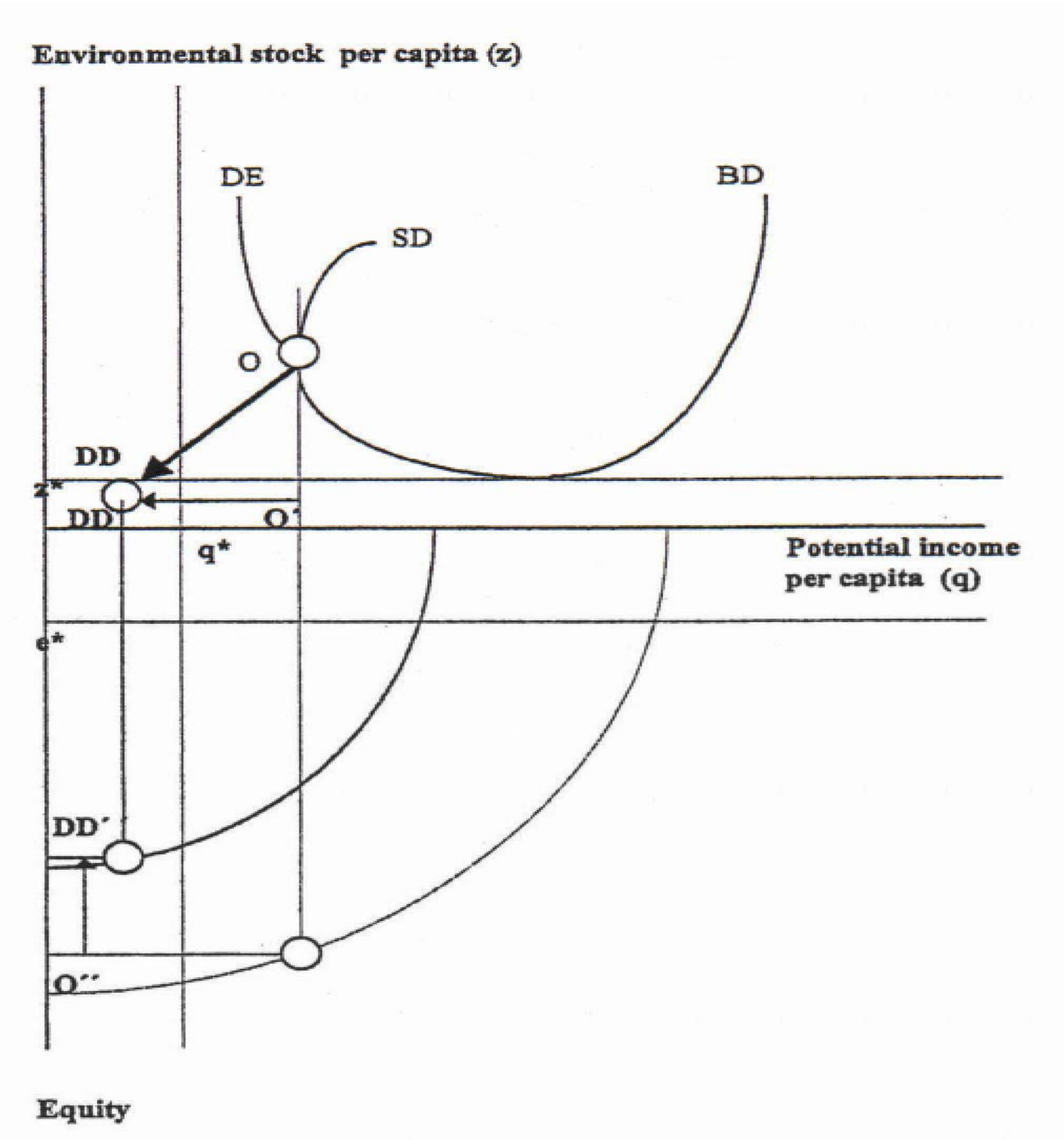

Figure 5. The Doomsday Scenario.

The World Bank 'Policy Tunnel' Scenario (The WBPT Scenario)

In Figure 6 the World Bank "Policy Tunnel" Scenario is presented. This scenario may be a relevant one for countries of lower income. The motivating idea of the World Band "Policy Tunnel" Scenario is that especially the lower-income countries could learn from the historical experience of wealthier nations and adopt well functioning spatial policies and new technologies that will permit them to 'tunnel' through the line along the path O toward WBPT in Figure 6 (see Munasinghe, 1996, 6).

By adopting the WBTV strategy the lower-income countries may avoid the ecological risks of the Boomsday Scenario. However, when we look more closely at Figure 6, we will find the fundamental socio-cultural problem of the WBFT Scenario. The problem is that this scenario potentially will lead to deeper social inequality in the society. In spite of this obvious problem, this kind of social policy consideration is not mentioned in the recent World Bank documents (Munasinghe, 1996).

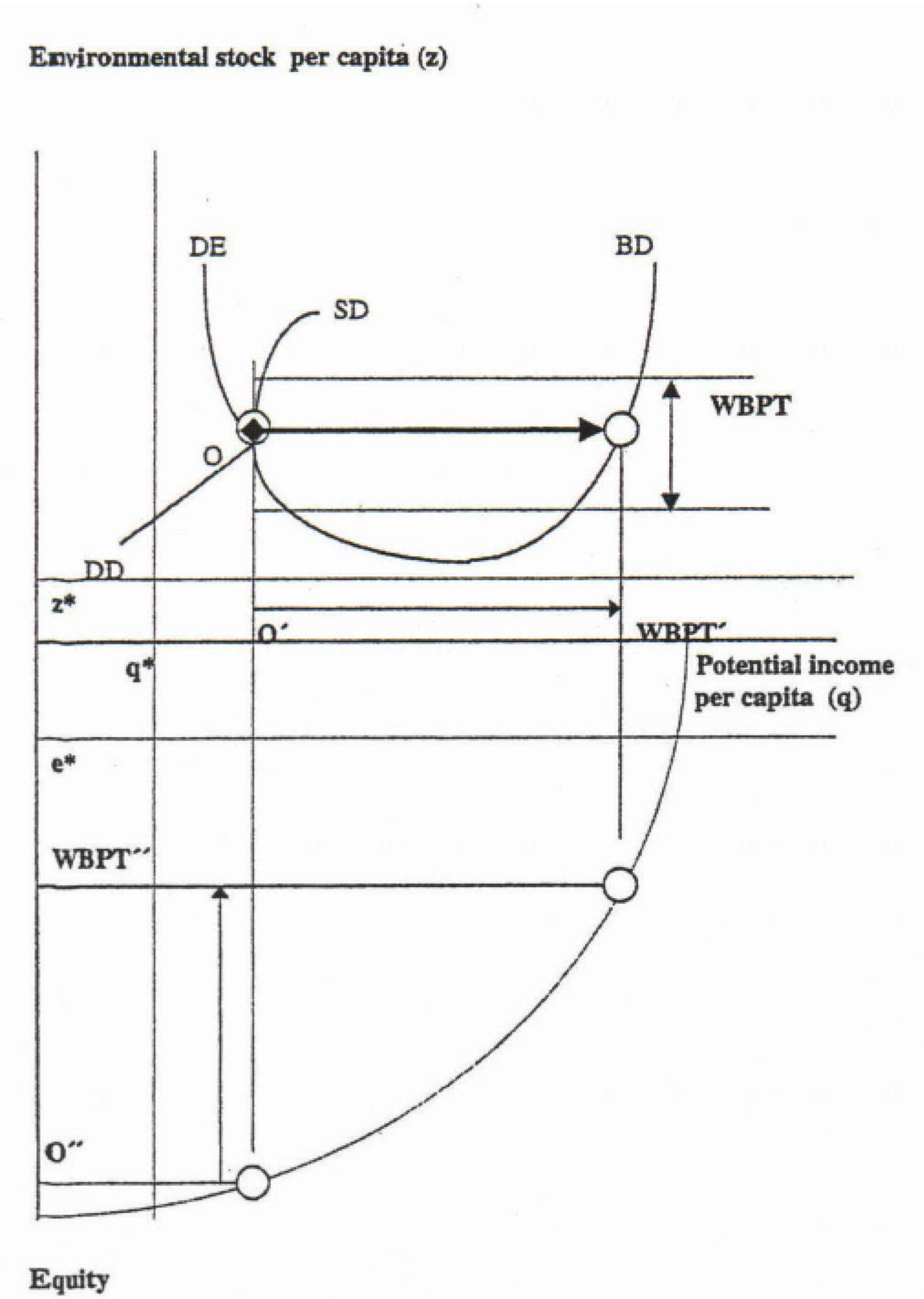

Figure 6. The World Bank 'Policy Tunnel' Scenario.

The positive aspect of the WBPT Scenario is that in the "policy tunnel" it is attempted to keep environmental sustainability (thus environmental stock *per capita*) constant by target-minded environmental policy measures and actions.

Above the very basic characteristics of different scenarios are outlined in three domains. It is obvious that especially debates about the desirability of the BD scenario are likely to be vigorous over the next few years. Especially in the lower-income countries, this kind of hot political debate will be difficult to avoid. All across the political spectrum, many mainstream economists would recommend the BD Scenario style of resource use (see Figure 4), but their greener counterparts will eventually be strongly opposed.

Situation based- framework and the basic guidelines of problem-oriented, analytical environmental policy

In this section we shall see a problem-oriented framework for environmental policy analysis on the basis of alternative scenarios presented above. This kind of framework can be used in environmental strategy analysis and in the positioning of sustainability problems of societies. If responsible political and economic leaders in the different societies want to formulate strategies on the basis of positioning their economy in critical policy domains, some kind of positioning framework may be useful. The idea of positioning is to view the economy’s strengths and weaknesses and then formulate a new working strategy of sustainable development policy. This kind of idea for strategic management is widely used in business life, when companies constitute new generic and competitive strategies (see e.g. Mintzberg and Quinn, 1996, p 82). Visionary leadership in sustainable development policy may be impossible if responsible political and economic leaders do not understand the current positions of their economies in environmental and development policy. The results of scenario analysis can be summarized (see Table 1).

It is important to understand that analytical scenarios can be used in the strategic conversation of sustainable development policy. Different scenarios "may lead" a society to new societal state and social conditions. The societal sustainability problems are always situation-based problems, not general problems. The next step is to present some general guidelines for environmental and development policies on the basis of alternative scenarios. In this section the strategic guidelines for sustainable development policy in the form of tables are presented.

In Table 2 the basic problematic in the DE Scenario is presented. In Table 3 the basic problematic in the SSDE Scenario is presented.

Table 1. Results of societal development in the alternative scenario cases.

Scenarios	Potential output *per capita*	Environmental stock *per capita*	Equity in social policy
Deep Ecology	decreases/or may be stable	increases	more equal society or may be stable
Strong Sustainable Development	increases	increases	more equal society
Weak Sustainable Development	increases	increases	more inequal society
Boomsday	increases	first decreases, after 'the turning point' increases.	more equal society
Doomsday	decreases	decreases	more inequal society
World Bank Policy Tunnel	increases	stable with some variations	more inequal society

Table 2. The DE Scenario.

Scenario	Potential output *per capita*	Environmental stock *per capita*	Equity in social policy
Deep Ecology	decreases or may be stable	increases	more equal society or may be stable
Critical environmental and development policy measures	responsible policy coordinators must be careful that the society is not led to a situation where $q<q^*$	environmental policy is in the control of policy makers: no big environmental problems	Responsible policy coordinators must be careful that strong equality policy (too high e) does not stop the economic growth

Table 3. The SSDE Scenario.

Scenario	Potential output *per capita*	Environmental stock *per capita*	Equity in social policy
Strong Sustainable Development	increases	increases	more equal society
Critical environmental and development policy measures	no big economic problems	no big environmental problems	responsible policy coordinators must take care that strong equality policy (too high e) does not stop the economic growth

In Table 4 the problematic in the WSDE Scenario is presented. In Table 5 the basic problematic in the BD Scenario is presented. In Table 6 the problematic in DD Scenario is presented. In Table 7 the problematic in the WBPT Scenario is presented.

From Tables 2-7 one can see that in different socio-economic situations the contents of critical sustainability policy measures are different ones, so there is no general sustainable development strategy that will be suitable for all societies. Thus problem-oriented and situation-based analyses are needed.

In reality, different societies may run along the trajectories of different scenarios. Indeed, all the presented scenarios may be problematic in some sense. From the perspective of environmental sustainability, the SSD Scenario, the WSD Scenario and the DE Scenario may be the best scenarios to follow.

In spite of these policy options of the future, the majority of economics in the world seem to follow the strategies based on the Boomsday Scenario. Many governments in the world think

Table 4. The WSDE Scenario.

Scenario	Potential output *per capita*	Environmental stock *per capita*	Equity in social policy
Weak Sustainable Development	increases	increases	more inequal society
Critical environmental and development policy measures	no big economic problems	no big environmental problems	responsible policy coordinators must take care that the social welfare productivity of economic growth is high enough

Table 5. The BD Scenario.

Scenario	Potential output *per capita*	Environmental stock *per capita*	Equity in social policy
Boomsday	increases	first decreases; after 'the turning point' increases	more equal society
Critical environmental and development policy measures	no big economic problems	responsible policy coordinators must be careful that the society is not led to a situation where $z<z^*$	responsible policy coordinators must be careful that the society is not led to a situation where $e<e^*$

Table 6. The DD Scenario.

Scenario	Potential output *per capita*	Environmental stock *per capita*	Equity in social policy
Doomsday Critical environmental and development policy measures	decreases the society is led to a situation where $q<q^*$. Policy measures which include aspects of economic crisis management are needed	decreases the society is led to a situation where $z<z^*$. Policy measures which include aspects of environmental crisis management are needed	more inequal society equity is not the main societal problem. All the members of the society suffer equally from the environmental and economic crisis. Responsible policy coordinators must be careful that the society is not led to a situation where $e<e^*$

Table 7. The WBPT Scenario.

Scenario	Potential output *per capita*	Environmental stock *per capita*	Equity in social policy
World Bank Policy Tunnel Critical environmental and development policy measures	Increases No big economic problems	Stable with some variations Responsible policy coordinators must be careful that the society is not led to a situation where $z<z^*$	More inequal society Responsible policy coordinators must be careful that the society is not led to a situation where $e<e^*$

still like the US President's Council of Advisors in 1971: "If it is agreed that economic output is a good thing it follows by definition that there is not enough of it" (*Economic Report to the President* 1971, 92).

On the basis of scenario analysis presented above in this article we can conclude that this kind of simple political statement is not universally valid in political and economic decision-making. We need strategies, which are analytically connected to the actual development problematic of the society.

Further reflections on the basis of scenarios and a summary

The literature on environmental economics has been enriched for about a decade by a theoretical branch that tries to integrate adequately ecological issues into economics. Hinterberger *et al*. have claimed that this branch of economics is known as "ecological economics", but "ecological economists are outside the main stream" and they "discuss mainly in their own journals and conferences and their concepts are not really relevant for environmental policy in practice - not yet" (Hinterberger *et al*. 1996, 1-2).

In the previous sections I have tried to transfer the discussion of economics and ecological economics a little closer to the practice of general social policy problems. Usually traditional environmental and resource economics map environmental problems only as a distorted allocation problem. If we analyse environmental problems from the "what-if?" perspective, we see that the problems of sustainability are complex ones. We cannot give universal sustainability policy advice to all societies. In practical policy-making we must also consider carefully values, because scenarios are not neutral or value-free policy options. For example, the dominant idea of development in the Western societies has been the idea of progress during the last 200 years. Progress in Western thinking has been related to economic growth, which has been chosen as the prime means for assessing human improvement (see Mannermaa 1988, 1993). It is important to understand that economic growth does always not lead sustainable development process in a society.

So the BD Scenario, the WBPT Scenario and both the Weak and the Strong SD Scenarios, which all include the idea of exponential growth-oriented progress, seem to dominate our futures thinking in most policy arenas. Usually the DE Scenario and the DD Scenario are marginalized in the political debates of Western countries, because these scenarios do not include the conventional idea of progress with the path of exponential economic growth. Most political statements deny that there exist various alternative development processes behind the environmental problems. However, all the alternative development processes are possible also in the future. If we do not understand the nature of these alternative development processes and paths, all the environmental policy measures and all the economic risk assessments may be misleading. Global strategies that are based on general, simple concepts of sustainable development can even be harmful for societies. If we are seriously biased in our environmental and economic policy analysis, we can give ‘right answers to wrong questions’. That is why it is very important to understand that alternative futures scenarios can be used as a positioning framework for potential strategies of sustainable development. It is very important to understand the actual preconditions of development in different societies.

"Sustainable development" has become one of the catchphrases of the 1990s, yet in its short existence it has frequently been damned with faint praise - for example, "moral convictions as a substitute for thought" (Redclift 1987, 2), "a good idea" which cannot sensibly be put into practice’ (O’Riordan 1988, 48) and ‘how to destroy the environment with compassion’ (Smith 1991, 135). In reality the concept of ‘sustainable development’ is difficult to define - let alone implement. However, Malaska has summarized the *principia ethica* of sustainable development as follows:

(i) to fight poverty and unequal economic standing of the developing countries;
(ii) to stop depletion of nature and destruction of environment;
(iii) to secure, that the future generations will enjoy the same possibilities of well being as we do and
(iv) in the general level sustainable development is aimed to be socially just and equal, ecologically and economically sustainable, politically and culturally free and innovative. (Malaska 1997, 13).

The scenario analysis presented here does not call these principles into question. We can conclude, that only a development process that satisfies the characteristics of the Strong Sustainable Development Scenario can fulfil all the principles of the *principia ethica* of sustainable development.

In this article, on the basis of theory-based scenario analysis, I have demonstrated why concept of sustainable development is very problematic, and why its proponents and advocates may interpret it in different ways. The important note according to this article to the conceptual sustainable development debate is that we need more rigorous theoretical and empirical analysis of potential sustainability. We must study which kind of development process we are taking part in. Also much more empirical research projects in the field of environmental indicators (including material flow indicators and biodiversity indicators) and environmental policy measures are needed in order to gain deeper understanding of sustainability problems in different social context. We cannot evaluate the nature of the development process without socio-economic and ecological indices. Theoretically, the framework presented here can be used as a general framework in the evaluations of sustainable development.

In this article it is shown that the scenarios (the BD Scenario and loosely the WBPT Scenario) that are based on the EKC hypothesis give us a very limited future perspective of spatial sustainability problems. The possibilities of the Deep Ecology Scenario, the Strong Sustainable Development Scenario, the Weak Sustainable Development Scenario and the Doomsday Scenario are forgotten, if we focus our analysis only on the potentialities offered by the Boomsday Scenario or the WBPT Scenario. These alternative, often "forgotten" development scenarios of societal development were assessed and discussed in detail.

The most important contribution of this article is that Karshenas' (1992, 1994) analysis is conceptualized in a new way. Especially, I included a socio-political equity dimension to Karshenas' former analysis with the help of Stiglitz (1992). On the basis of this new theoretical extension it was possible to analyse the most important aspects (environmental, efficiency and equity aspects) of alternative societal development paths.

On the basis of the scenario analysis presented in this article, it was possible to point out that sustainable development is not a conflict-free concept, because not all the criteria of sustainability (better environmental sustainability, better economic efficiency and greater social equity) can usually be guaranteed simultaneously in the general social policy. Global strategies that are based on general, too simple, concepts of sustainability can even be harmful for local communities. A more useful approach in environmental policy formation is analytical situation-based sustainability thinking, which is also theoretically well argued. The strategic guidelines of the new framework were presented in this article. The situation-based framework and new concepts presented in this article may help international development agencies and national and local governments in the formation of more analytical environmental policy strategies.

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SOCIAL AND ECOLOGICAL DESTRUCTION IN THE FIRST CLASS:

A PLAUSIBLE SOCIAL DEVELOPMENT SCENARIO

By

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Introduction

In this article, I shall present a social development scenario, which may be relevant in some societies. In a previous study of social development scenarios, I presented a set of scenarios: (1) the deep ecology scenario, (ii) the strong sustainable development scenario, (iii) the weak sustainable development scenario, (iv) the boomsday scenario, (v) the doomsday scenario and (vi) the World Bank "policy tunnel" scenario (Kaivo-oja 1999). Comments I received from the scientific community[1], there is a need to present a new scenario, which may be politically and strategically relevant in the formation of futures oriented sustainability strategies. I do not repeat the theoretical assumptions of the scenario framework presented before (see Karshenas 1992; Karhenas 1994; Kaivo-oja 1999, 141-142), but present another plausible social development scenario, which should be considered in the general sustainability discussion.

A plausible social development scenario

I call this new scenario *social and ecological destruction in the first class*. The social destruction in the first class is described in Figure 1 (SEDFC). In this scenario income *per capita* increases steadily, but inequality in society grows and environmental stock *per capita* goes down because output, and thus raises the potential incomes *per capita*. In this scenario society of mass consumption not succeed in limiting consumption to a sustainable level. In the long run, environmental stock *per capita* decreases below the sustainable level (z*).

[1] I would like to thank Dr Jyrki Luukkanen and Professor Riley E. Dunlap for their insightful comments.

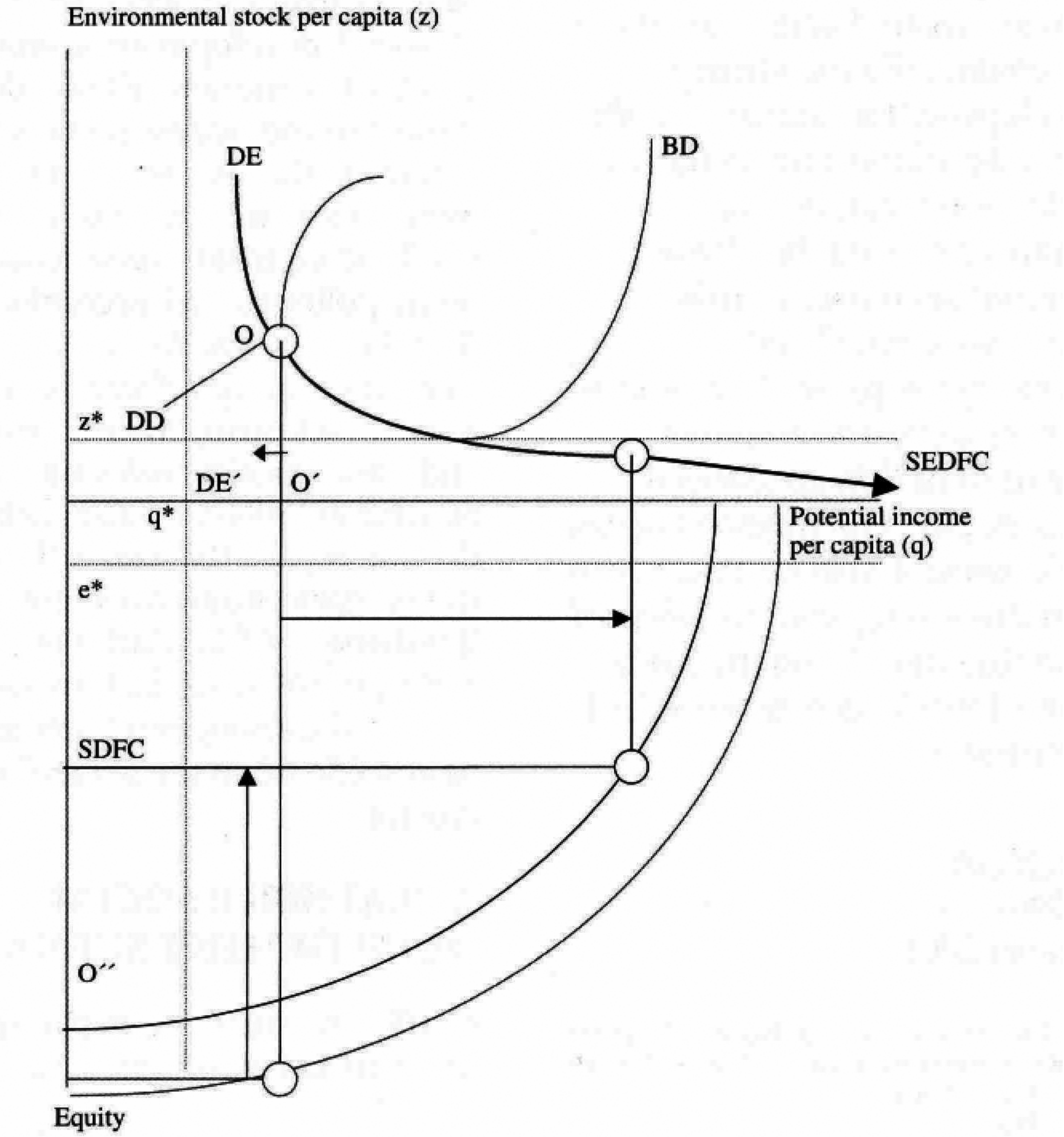

Figure 1. The social and ecological destruction in the first class scenario

Situation-based framework and the basic guidelines of problem-oriented, analytical environmental policy

In this section I present a problem-oriented framework for environmental policy analysis on the basis of the SEDFC scenario presented above. The basic characteristics of the scenario are presented in Table 1. Table 1 has a similar structure to the tables of the previous analysis (compare Kaivo-oja 1999, 145-147).

Table 1. Results of societal development in the social and ecological destruction in the first class scenario

Scenario	Potential output *per capita*	Environmental stock *per capita*	Equity in social policy
Social and ecological destruction in the first class	Increases	Decreases	Decreases

In Table 2, the basic societal problematic of SEDFC is presented in a nutshell.

Table 2. The SEDFC

Scenario	Potential output *per capita*	Environmental stock *per capita*	Equity in social policy
Social and ecological destruction in the first class	Increases	Decreases	Decreases
Critical environmental and development policy measures	No major economic problems	Major environmental problems. Responsible policy coordinators must be careful that the society is not led to a situation where $z < z^*$.	Responsible policy coordinators must take care that the social welfare productivity of economic growth is high enough.

In this section I have presented a problem-oriented framework for environmental policy analysis on the basis of an SEDFC scenario. The general framework presented in my previous paper (Kaivo-oja 1999) can be used in the environmental strategy analysis and in the positioning of sustainability problems. In reality, different economies may run along the trajectories of different scenarios. It is important to understand that analytical scenarios can be used in the strategy discussion of sustainable development policy. Also the SEDFC scenario should be discussed in the formation of proactive sustainability strategies. Different scenarios may lead a society to new societal conditions. The societal problems are situation based. As I have pointed out before, visionary leadership in sustainable development policy may be impossible, if the responsible political and economic leaders do not understand the current positions of their economies in environmental and development policy. There is no general sustainable development strategy that will be suitable for all the societies. Problem-oriented and situation-based analysis is always needed in the formation of spatial strategies (Kaivo-oja 1999).

Summary

This paper is a further self-reflection on my previous contribution (Kaivo-oja 1999). On the basis of the scenario framework it is possible to analyse the important aspects (environmental, efficiency and equity aspects) of alternative societal development paths. One highly relevant and plausible scenario was missing from my previous scenario analysis framework. This paper corrects this shortcoming, with a new scenario called "social and ecological destruction in the first class".

After this additional component the scenario framework covers the potential and plausible future development paths, as far I know. As a summary of discussion, I want to stress that this scenario should also be taken into consideration in the strategic discussion of potential sustainable development paths.

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ADVANCED SUSTAINABILITY ANALYSIS

By

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Glossary

Dematerialization of production: rationalization and technology development process leading to a decreasing trend of the total environmental stress on the supply side of economy.

Sustainable economic growth: economic growth utilizing advance of technology within constraints of non-increasing total environmental stress.

Sustainable technological development: rate of dematerialization sufficient to get the sustainable economic growth and real economic growth equal.

Gross rebound effect: excess of the real environmental stress to the calculated dematerialized environmental stress.

Structural shift of the economy: shift of employment of economy from a sector of economy to another leading to a decreasing trend of the total environmental stress.

Immaterialization of consumption: rationalization, life style and consumption development process leading to a decreasing trend of the total environmental stress on the demand or welfare side of economy.

Sustainable welfare growth: welfare growth utilizing advance of economic growth within constraints of non-increasing total environmental stress.

Welfare productivity of GDP: welfare produced per unit of economic growth as an input factor of welfare production.

SD: Sustainable development

CES: Constant elasticity of substitution

SMS: Safe Minimum Standards

TMR: Total Material Requirement

DMI: Direct Material Input

De-linking: De-linking means an ecological economic policy, which integrates environmental policy into economic policy in such a way that the general welfare of the society grows, but there will be simultaneously absolute reductions of environmental impacts. De-linking is often interpreted to mean more well-being through less consumption.

GDP: Gross Domestic Product

EKC: Environmental Kuznets Curve

TES: Total Environmental Stress, the first basic concept of the TES-approach to sustainable development

FFRC: Finland Futures Research Centre

MF: Material Flow, used as an indicator of TES in the empirical analysis

EF: Energy Flow, a variate operationalization of TES for empirical analyses

CO2: Carbon dioxide, a variate operationalization of TES for empirical analyses

WF: Welfare, the other basic concept of the TES-approach to sustainable development

POP: Population

MIPS: Material input per service unit

EMP: Employment

ISEW: Index of Sustainable Economic Welfare

HDI: Human Development Index

GPI: Genuine Progress Index

SE-gth: Sustainable economic growth rate

Dem-eff: Dematerialization effect on TES, supply side effect

Gth-eff: Economic growth effect on TES

Grbd-eff: Gross-rebound effect on TES

SW-gth: Sustainable welfare growth rate

Imm-eff: Immaterialization effect on TES, demand or welfare side effect

The Discourse on Sustainable Development

Roots of the Discourse

The roots of the discourse on sustainable development as an internationally recognized issue extend to the first UN Conference on the Human Environment in Stockholm in 1972 and to some earlier influential studies. The concept ”sustainable development” first became prominent in the World Conservation Strategy published by the World Conservation Union in 1980. It was thoroughly discussed and elaborated by the UN World Commission on Environment and Development in 1987 in the so-called Brundtland report ’Our Common Future’. And finally the global ethos of sustainable development was agreed on and confirmed by national governments at the UN World Conference on Environment and Development in Rio de Janeiro in 1992.

Sustainable Development (SD) is generally expressed by the Brundtland Report as an ethos that ”humanity has the ability to ensure that it meets the needs of the present without compromising the ability of the future generations to meet their own needs”. From the discussion followed it became evident that the meaning of SD is made up in three dimensions: economic, ecological and socio-cultural. In the ecological dimension, SD refers to the adaptation of economy and technology to the earth’s ecological constraints and environmental challenges. In the social dimension SD refers to giving attention in welfare creation to social equity and global solidarity rather than to the share-holders' profit issue. SD policies should give priority to those who live in poverty, and to achieving better equity both within generations (intragenerational equity) as well as across generations (intergenerational equity).

Provided with unlimited natural resources and with adequate accumulation of appropriate scientific knowledge we were easily able to meet the fundamental human needs of our generation without denying similar opportunities to succeeding generations. However, in a finite world such as ours where the human population is estimated to double while natural capital is depleted and degraded in increasing pace, we have to challenge the pace of knowledge accumulation. If not in synchrony with each other resources may become to constrain severely the task of meeting fundamental needs for all either periodically or spatially. Basically, the major options before humans are either a co-evolution with nature towards global sustainable society based on advancing human knowledge and wisdom, or a competitive fragmentation of societies and collapse of life support systems, - in the worst case - extinction of humankind. The choice is primarily an ethical and socio-cultural one, and only in the second place economic and technological in nature.

As long as the enduring solar radiation maintains adequate exergy flow and entropy exchange for the earth sustainable development will be a viable human alternative. The sustainability ethos may be regarded as a late-modern moral intention to keep the earth living and humankind capable of co-evolving with Nature. Nature has made us knowledgeable; we have a responsibility to make ourselves wise enough for co-evolution with her.

Sustainable development and economics

Mainstream views

Since the early days from the 1870s to 1970s the mainstream economists (with some notable exceptions) have appeared to believe that continuous economic growth as such could be sustained indefinitely, a claim which would make a special discourse on sustainability superfluous. Mainstream economists continued to argue that continuing economic growth as usual is both feasible and desirable, i.e. a growing economy does not run out of natural resources nor cause excessive environmental harms. Economic growth is considered not only to bring along overall improvement of life and equal opportunity for people, but also it is regarded necessary in order to finance improvements of the already deteriorated environment. What was called for, however, because of growing environmental awareness, is a more efficiently functioning price system and effective substitution. Such a system would be capable of accommodating economic activity while still preserving an acceptable level of ambient environmental quality. Economists claimed further that the economic valuation of environmental externalities would make the economy more efficient and accordingly also advance sustainability.

The inherent contradiction of these thoughts is, however, most evident, because the increasing efficiency does not necessarily imply improving intragenerational equity nor equity between present and future generations. On the other hand, economists also thought that resource exhaustion would always be countered sufficiently and in due time by new technology, e.g. by recycling and resource substitution. The technical development was also claimed to increase the quality of labor and capital and allow economic extraction of non-renewable resources to ever lower quality and maintenance of the quality of environment regardless of increasing amount of wastes, pollution and discharge emissions. There is, however, hardly any knowledge available about the technical development, which would be needed or adequate to meet the challenges claimed for. The optimistic view about continuing growth prevailed as the mainstream of economic thinking with the possible ‘Ricardian scarcity’ offset by omnipotent technological development and compensating market processes.

Ecocentric views

In the 1970s some ‘revisionists’ thinkers targeted to alter the ‘hard core’ of the conventional economic thinking in order to speed up the evolution of economies towards what they regarded relevant to a coming zero-growth society. Some others saw a challenge in trading the environmental constraints necessary for a growth economy with other goals of society. It lead to modified economic models but not radically different from the mainstream thinking.

From outside the circle of ‘hard core’ economists, ecocentrically oriented environmental economists threw serious doubts to the acceptability of the conventional growth paradigm, it’s strategies and objects. The influential Limits to Growth Report to the Club of Rome adopted the distinctively Malthusian position that the environmental protection policy and the promotion of economic growth objectives were incompatible, i.e. that no conventional economic growth objectives in the long-run - more than 100 years - were feasible. This line of thinking led to calls for a steady state or zero growth economy. The zero-growth argument was buttressed by socio-economic analyses, which sought to highlight the social and environmental costs of living in a ‘growth society’. Several lines of reasoning and empirical findings were marshalled to demonstrate that material growth, especially the GDP-measure, was not a proper or sole indicator of wellbeing and human development, but only one complementary dimension of it.

Several lines of 'social limits’ thinking may be mentioned here. One is the famous Easterlin’s paradox, which claims that material affluence and human happiness are not correlated. According to another, so called Hirsch’s concept of "positional goods", the enjoyment of a range of commodities is necessarily restricted to a small group of high income earners, contrary to the claim that all sections of society might one day participate in such a consumption ‘party’. And further, Scitovsky’s classical concept of "joyless economy" emphasizes the importance of human needs other than plain material affluence, and Giarini’s concepts of patrimony and limits to certainty introduce yet another unconventional frame of reference.

Ethos of sustainable development

The only dimension left unconquered by controversies in the discourse but commonly agreed on was the cultural one. Increasing cultural competence in the form of ethical awareness, accumulation of scientific knowledge and emerging new technologies has been commonly accepted as a sine qua non for sustainable development.

Meeting the needs of the present generation is an important part of the ethics and practice of sustainable development. This is not only an economic question but merely a question in the social dimension of sustainable development. To the developing countries it seems most important and challenging to fighting poverty and multifaceted deprivations and eradicating them within a reasonable time frame. Increasing poverty and diminishing solidarity among citizens is at present , however, also an acute but not properly prioritized trend running against sustainability ethos in many industrialized countries as well. The eradication of poverty requires e.g. abandoning social institutions maintaining unjust human conditions, and it calls for social development in terms of justice, equal opportunity and solidarity. Development of just and democratic local as well as global orders is one of the constitutional processes of sustainable development in the social dimension.

The second dimension of sustainability is inevitably ecological one, and this paper is primarily on meeting necessary conditions of ecological sustainability at the macro-economic account. Material affluence and poverty both contributes to ecological unsustainability at present. This vicious circle from poverty and affluence to ecological unsustainability must be better understood and, finally, broken through social, economic and technological renewal, effective global economic strategies, and practical civil society actions for sustainable development. Especially the ecological dimension of sustainability is vital to all nations in the same way, because it is really global in nature and approaching it is possible only by joint efforts.

The third constitutional dimension of sustainable development is to empower liberal and creative cultural opportunities of people that may generate kinds of scientific knowledge, technology, arts and humanistic values intrinsic to sustainable development.

Sustainable development as a whole may thus be seen as a dynamical interaction between the three processes mentioned above, i.e. ecological-economic, socio-political and cultural-spiritual processes of human reality. The following list presents the summary of the ethos of sustainable development.

- To fight poverty, multifaceted deprivations and unequal economic standing, especially in developing countries.

- To stop the depletion of nature and destruction of the environment, and to accept ecological sustainability as a quality standard in human affairs.

- To secure for future generations the same opportunities for wellbeing and the freedom of choice enjoyed by us.

Sustainable development is an interaction process in three dimensions, which provides a human future that, is socially just and equal, ecologically and economically sustainable, and politically and culturally free and innovative.

Sustainability approaches

Advancement of sustainable development is regarded as a direction of change, and it is important to be able to monitor if a proper direction is attained or maintained. In the literature there are many suggestions for how to monitor SD, and we will review the most important ones in what follows.

Hicks-Page-Hartwick-Solow approach

Early works in the neoclassical growth theory already incorporated natural resource constraints on the economic doctrine. In these economic models the idea of progress was defined to as the non-declining consumption of goods (and natural resources) over time. This approach may be regarded as a narrowing metaphor of SD, which substitutes the concept of SD with that of a constrained growth. As a consequence from the main concern was defined to be intergenerational efficiency rather than equal opportunity. It is well demonstrated by the Hartwick-Solow approach.

According to this approach a non-declining consumption through time is possible to obtain, even in the case of an economy that makes use only of non-renewable resources (such as oil) in its economic processes. Hartwick demonstrated that as long as the stock of capital did not decline over time, non-declining consumption was possible. In theoretical terms, the stock of capital could be held constant by reinvesting all Hotelling rents from non-renewable resource extraction in man-made capital. According to this rule, as the stock of oil (a type of natural capital) is depleted, the stock of man-made capital is built up to replace it. This result was very important for the development of new ideas of SD economics. The Hartwick-Solow approach is based on strong substitution assumptions between natural and human capital.

Criticism of the Hartwick rule runs along three lines. First, individuals derive diverse utility from Nature and do not view her merely as an input resource for production. If this is the case, non-declining consumption is not equivalent to non-declining welfare over time. Second, the Hartwick rule depends specifically on the particular aggregate production function, i.e. the Cobb-Douglas form. Hartwick was later able to restate his rule for a CES (constant elasticity of substitution) production function as well. This function has the property that the elasticity of substitution between natural resources and man-made capital is greater than one, which means that the limited supply of the natural resources is actually irrelevant. The third criticism against the Hartwick rule is that natural resources and man-made capital are not nearly as substitutable as the Hartwick-Solow approach suggests. Natural capital can be exploited by man, but cannot be created by man. According to the 'thermodynamic' school natural capital and man-made capital are in most cases complements rather than substitutes. For example, Christensen terms the various elements of the natural capital stock 'primary inputs' and man-made capital and labor the "agents of transformation". It seems that while substitution is possibly high within each of the factor groups, the substitution possibilities between the two groups are very low. Increasing output and gross domestic product in societies thus means increasing the use of both types of input in most cases, and the threat of unsustainability of economic growth is maintained.

London School approach

A different approach to solving the problem of the limited benefit from substitution to sustainability between natural capital (K_n) and man-made capital (K_m) is that of the London School Approach. According to the London School some substitution is possible between certain elements of K_n and K_m, while many other elements of K_n provide only non-substitutable services to the economy. For example, there are certain species, which must be preserved. The important strategic question here is: how much of K_n should be preserved? Three possible views are: (1) all of them at the existing level, (2) the level consistent with maintaining the critical elements of K_n, or (3) some amount in between these two. The crucial problem of this approach is that we must assume that we can measure the value of K_n at any point in time. In practice, it is also difficult to measure different elements of K_n in physical and monetary terms. With the help of material flow analysis, some aspects of K_n have been analyzed. Van Pelt has identified another problem with the constant natural capital stock concept. There are questions of spatial aggregation: within which geographic area should we hold stock constant? One solution would be to work with less aggregated data and analyze various elements of K_n separately. Yet another problem arises when Nature's intrinsic rate of change is taken into account. Human effect should be measured against the natural rate of change. Nature changes over all time scales. At least in some cases these rates are necessary for the persistence of life, because life is adapted to them and depends on them. What is the character of Nature when it is undisturbed by human influence, asks Botkin, and what are the effects of human beings on the changing non-human world?

Supposing that the aggregation problem for natural capital can somehow be overcome, the London School proposes a rule of how to prevent depletion of K_n below some prescribed fixed level. The rule is based on the discounted monetary valuation of environmental impacts or contributions, whether they are costs or benefits. In this fashion the whole of sustainable development is reduced to monetary economy and economics. However, the problem of sustainability of the given fixed level remains then unsolved.

Pearce and Atkinson have been attempting to develop indicators and measures of SD. The most widely accepted definition of SD, they claim, is economic and social development in per capita terms over time. There is a major problem one confronts at this point. It is if development is to be measured in narrow terms (such as GDP per capita) or in broad terms (such as measures of social and economic welfare, possibly including indices of human development, health and educational attainment etc.). Today most researchers would choose the broader criterion as the relevant measure. According to Pearce and Atkinson an additional essential condition for sustainability is that a nation's capital stock should not decline over time. The concept of capital used in their study is very broad; it includes physical, human and natural capital. It is worth of mentioning for further information, that a broad concept of capital was introduced also by Orio Giarini and called it patrimony in a report to the Club of Rome in 1978. The rule of so called constant stock of capital of Pearce and Atkinson has two variants, the rule of weak and of strong sustainability.

Weak sustainability is prevailing when the *total capital stock* – physical, human and natural – is not declining through time. An economy is sustainable when its savings exceed the depreciation on its man-made and natural capital. In this variant, development is sustainable even if one component (e.g. the natural capital) is declining, provided that the total capital stock is not falling. For this to be a meaningful criterion, it is necessary that different elements of capital stock can be substituted for one another. For example if a loss of a particular ecosystem is compensated by an increase in the stock of human knowledge. This means that the environmental and economic losses related with the ecosystem are more than outweighed by benefits in human capital, and that the overall system stability and resilience does not suffer in this substitution process.

The second variant, strong sustainability, affords environmental capital (or natural capital) a special place. SD is attainded, in a strong sense, if especially the nation's stock of environmental capital is non-decreasing. Pearce and Atkinson have pointed out that one may wish to modify this rule. Some parts of the capital stock is likely to be of particular importance, providing invaluable and nonsubstitutable environmental services to the economic process. If we call this critical natural capital, then the modified version of strong SD requires that development does not lead to a decline through time of the nation's stock of the critical natural capital.

It their studies Pearce and Atkinson evaluated their view of sustainability with some country data, and presented accordingly that e.g. Finland is a sustainable economy in the weak sense but not in the strong sense.

Safe Minimum Standard approach

Very closely linked to the non-declining natural capital stock approach is the safe minimum standards (SMS) approach identified primarily with Ciriacy-Wantrup and Bishop. SMS approach originates from decision making under uncertainty. Societies are deemed to be unsure about the future costs of current environmental degradation. In environmental policies, two classes of action may be taken: (1) to conserve environmental resources (such as wilderness areas) or (2) not to conserve them. The SMS rule is: prevent all reductions in natural capital stock below the safe minimum standard identified for each component of this stock unless social opportunity costs of doing so are 'unacceptably' high. According to the SMS approach deciding to conserve today is shown to be the risk-minimizing way to proceed.

There are at least three generic ignorances in the application of safe minimum standard approach. One is that the current generations are ignorant of the preferences of future generations, and accordingly it has a need to preserve options to cover uncertainty. Second is the uncertainty about the possible threshold of the ecological processes and about limits and collapsing properties and uncertainties related to the risk-taking behaviour of decision-makers. Thirdly there is an ignorance of the intrinsic value of species and natural phenomena.

The SMS approach contains the following problems: (1) difficulties in identifying critical SMS levels and (2) problems in defining 'unacceptable large' opportunity costs of preservation. And, at the borderline, it includes acceptance of a conduct known to be ecologically unsustainable, if the social situation so demands. The criteria selects the best decision of the smallest mistake, i.e. safe minimum standard is basically the same criterion as the minimax regret. The SMS approach shifts the burden of proof from those who wish to conserve to those who wish to develop. In practical terms, the safe minimum standard criterion rejects projects with catastrophic outcomes, e.g. any decisions which could lead to species extinction would be rejected, unless the social costs of doing so are "intolerably high". Because the meaning of "intolerably high" is not precise, that reservation is difficult to take into account, or, in each case, it may be left for the democratic political process to decide what it means.

Daly's Steady-state approach

In 1990, Herman Daly identified what he termed the 'operational principles' of SD. If these principles were followed, nations would move in the SD direction. The principles are as follows:

OP1: Set all harvest levels of renewable resources (fish, forest, game) at less than or equal to the population growth rate for some predetermined population size.

Daly emphasizes population policy in sustainability analysis and he sees that a steady-state population is a necessity. What holds for the population of human bodies must also hold for the populations of cars, buildings, livestocks, and for each and every form of physical wealth accumulated by humans. In an empty world the human population is complementary with the various populations of wealth. But in a full world they tend to become substitutes because they compete for the same space and maintenance throughput of low-entropy resources.

With the concept of density-dependent growth, Daly wants to emphasise that we cannot separate scale problems from allocation problems. According to Daly we cannot hide issues of scale and carrying capacity within the issue of improving allocation realisable through a better definition of property rights, as neo-classical economists often propose.

OP2: Establish for degradable pollutants assimilative capacities of the receiving ecosystems and maintain waste discharges below these levels. The discharge of cumulative pollutants should be set adequately close to zero.

OP3: Divide the financial receipts from non-renewable extraction into an income stream and investment stream. The latter part should be invested in renewable substitutes (for example biomass for oil) so that by the time a non-renewable resource reaches the end of its economic extraction, an identical level of consumption is available from the renewable substitute as the level available from the renewable resource at the start of the depletion programme. According to Daly, only the income stream can be available for consumption. The proportion of funds necessary to be diverted to the renewable substitute will depend on its growth rate, the rate of technical progress, the discount rate and the size of the renewable resource.

OP4: Minimize matter and energy throughput in societies. In the economy there must be some controls on macroeconomic scale. These controls must be quantitative and exercised for population and resource use.

Some critical authors have noted that it is not clear to what extent Daly's rules are actually operational. Much scientific uncertainty exists about the assimilative capacity of ecosystems for many pollutants. Also, the calculation of the investment stream for non-renewables would be difficult. In addition, the identification of the maximum or optimal scale of the world economy, and designing policies to ensure these scales are extremely difficult tasks.

The discussion of sustainability rules has shown that monetary valuations of the environment will not necessarily result in SD, and that there may be many other non-monetarized rules that better define sustainability over time. One of these is the total environmental stress approach of this paper.

World Bank approach

World Bank approach is quite similar to the conventional neoclassical approach. In World Bank, Pezzey has widely analyzed sustainability concepts, such as sustainable growth, sustainable development and sustainable resource use, in terms of the conventional neoclassical theory of economics, where sustainable means mainly the same as continuing or enduring economic growth. According to Pezzey's survey, the mainstream interpretations of sustainability require that the "quality of life" must not decline in the long-term future. Pezzey's neoclassical formalization of the core ethic is that utility (equivalent to quality of life measured most often with economic consumption) should not decline, although this may allow tradeoffs between various aspects of life that some think should be non-tradable.

According to the World Bank approach the definition of capital stock is the central issue in sustainability policy, because many definitions can be interpreted in terms of maintaining an economy's capital stock. This means judging how significant, essential or substitutable the various natural and man-made resource inputs to the economy's production processes are. Deriving sustainability conditions inevitably requires judgements about which natural and human resources are essential to production and to welfare, and about the extent these resources can be substituted for each other.

Pezzey argues that at different stages of economic growth different tradeoffs may be made between consumption and environmental quality. It means that environment is reducible to economic consumption and the SD approach is reduced to economic analysis. The main results of the neoclassical models imply that only inadequate technical development and open access to environmental resources may be the factors that cause non-sustainability, if non-renewable resource inputs are essential. Government intervention, in the form of resource conservation subsidies or depletion taxes can correct the open access problem and improve sustainability. On one hand, government subsidies for more use of resources aimed at encouraging development will harm sustainability. But on the other hand according to the neoclassical theory, advancing sustainability by slowing down resource depletion may lead to a lower level of consumption and utility.

The World Bank approach emphasizes property rights. Pezzey summarizes this point clearly: "Conventional environmental policies need not always mean making the polluter pay for externalities. More important is that property rights over the environment are first defined and enforced, if this is possible."

According to Pezzey a simple model with renewable resources shows that population growth can threaten sustainability and that poverty and environmental degradation can be interlinked. The link between poverty and environmental degradation establishes the case for development assistance. Pezzey notes that giving environmental property rights to the poor may both reduce poverty and improve the environment. This is true whether the poor are the polluters or the victims of pollution.

In the World Bank approach there are two levels of policy intervention: the system level and the project level. At the system level aggregate constraints (either regulatory or economic) must be imposed to control the depletion of whatever resources have been determined to be important for sustainability. Such constraints should drive up the price of such resources to whatever level is necessary to induce the required conservation efforts throughout the system. Such efforts are equivalent to intergenerational compensation investments. Pezzey agrees with some others that making sustainability operational at the project level is much harder, even conceptually.

Wuppertal approach

The analysis of the total material flows through the economic subsystems is of critical importance with regard to the discussion on the transformation of developed countries to so called service, information or knowledge societies. Today there is high agreement that a growth in GDP based on growth in the service sector is relatively less material intensive than an expansion of the manufacturing industrial sector. However, even if the services continue to grow more rapidly than manufacturing sector, this does not necessarily imply a decrease in total quantities of physical resources mobilised or a decrease in environmental impacts. In reality, absolute growth can therefore overcompensate the gains from sectoral shifs. The decisive indicator for sustainability is not the relative correlation between GDP and material use, but the absolute amount of appropriated natural capital. Therefore it is very important to measure what is the absolute amount of appropriated natural capital in economies.

The Wuppertal approach (developed in Wuppertal Institute for Climate, Environment and Energy) to sustainable development uses Total Materials Requirement (TMR) and Direct Material Input (DMI) concepts as indicators to the potential ecological impact of the economic processes. In this methodological approach material input (MI) comprises all materials, which are required for the production, usage and final deposit of a certain product. The MI of a product includes its so called "ecological rucksack", which can be defined as the amount of material, which has to be extracted from the environment in addition to the dead weight of the product itself. Relating this total material input to the Service Units, which are delivered by the analysed product allows to compare different products and production technologies with regard to their potential environment burden.

On the macroeconomic level, the TMR comprises the national and transnational (i.e. the global induced by imports) material extraction from the environment. It is the sum of the total material input and the hidden or indirect material flows, including deliberate landscape alterations. It is the total material requirement for a national economy, including all domestic and imported natural resources. The TMR gives the best overall estimate for the potential environmental impact associated with natural resource extraction and use. The Direct Material Input (DMI) is the flow of natural resource commodities that enter the industrial economy for further processing. Induced in this category are: (1) grains used by a food processor, (2) petroleum sent to a refinery, (3) metals used by a manufactures and (4) logs taken to a mill.

The main issue of the Wuppertal approach is on the ecological side, i.e. to what extent is the growth of the economy dependent on disturbances of the physical structure of Nature, and of withdrawal of material from the natural sites? The basic tenet is that, if ecological system is to be sustained and maintained supportive to human existence, an absolute reduction of material flows is necessary.

Since the citizens or governments will not voluntarily accept non-growing material well-being, de-linking the production of the income from exploitation of Nature of which well-being consists is necessary. If GDP is to grow, the de-linking will have to bridge an increasing gap in order to establish a sustainable path of development. If a factor 10 reduction of material input is necessary from an ecological point of view, it is obvious that it is impossible to rely on either pure efficiency or pure sufficiency strategies to reach the desired results. In the Wuppertal approach a requisite form of economic growth and its relation to material use is the main aspect studied. Even if the resource intensity decreases the absolute resource use may continue to grow due to increasing level of activity of human population. This may mean and actually it means that the cleaner production (reduction of environmental impact intensity) is not, as such, sufficient to fulfil sustainability condition.

Substitution processes between different natural resources in the production may give rise to a relation called Environmental Kuznets Curve (EKC). But this can be observed only with specific substances and it is not a general law of resource substitutability. From this point of view TMR and DMI do not suffer the drawbacks of usual measures. They are very little affected by shifts in the mix of materials used, but they do reflect growing efficiency or inefficiency of extraction and harvesting techniques and take into account used as well as hidden materials. The TMR is neither sensible to changes in the foreign trade pattern which may imply real changes in the environmental consequences of the production process considered as a whole, across the national boundaries.

In the Wuppertal approach the well being is expressed as a function of service, service intensity, material productivity, material input and environmental impact.

The Wuppertal approach has similarities with the TES-approach of FFRC in this paper more than the other approaches. One of the differences compared with the TES-approach of FFRC is that automation and employment issues and structural changes of the societies are not included.

Total environmental stress approach of FFRC

In next sections we will work out a general framework of advancing ecologically sustainable development. The ecological sustainability is defined on the basis of the total environmental stress (TES) caused by human affairs. It is postulated, that a decreasing TES is a necessary (albeit not sufficient) condition of advancing ecological sustainability. Environmental stress is generated not only when natural resources are taken from Nature and used in production and consumption, but also when wastes and pollution are discarded and thus returned to Nature, thereby depleting her space and interfering with her functions. To generate environmental stress is inescapable to human existence and progress, and there are many factors that lead to increasing stress. However, the sustainable development ethos is based on a firm conviction that some of stress is not inevitable but mainly a symptom of ignorance and a lack of better technology and wisdom of proper welfare. That part of the stress is avoidable, and to realize it by proper actions offers ways to sustainable development. Sustainable development is not an unattainable utopia.

The approaches reviewed see the sustainable development ethos mainly through the economic growth paradigm and as a constraint to the continuing growth. The TES Approach of the Finland Futures Research Centre (FFRC) regards sustainability in this paper basically as an ecological concept, much like the Wuppertal Approach with which it has a lot in common. But the Approach of FFRC analyses the issue of sustainability from more multiple perspectives than any other approaches.

The quantitative level of the TES may be indicated in various ways, e.g. with the total material flow (MF) or energy flow (EF) from Nature through the technosystem back to Nature or with the anthropogenic gas flow like CO_2 or a combination of several indicators. In the mathematical formulation of the theory, the material flow (MF) is used as an indicative measure of TES.

Conceptualization of advancing sustainability

A theoretical framework for advancing sustainability is worked out in this chapter. The theory is formulated as a set of two basic postulates of the necessary condition and four logical identities called the master equations of the theory. They relate the total environmental stress (TES) to basic indicators of economic, technological and social development. The explanatory power of the theory is demonstrated by new important concepts and formulas derived and with the empirical analyses conducted.

Indices for monitoring sustainability were developed already in the early 70s first by Malaska in a booklet "Prospects of Future of Technical Man" and Ehrlich and Holdren in their article "Impact of Population Growth". The indices had the well-known product form, I = PAT, i.e. environmental impact was understood as a multiplication of population, material intensity, and economic activity. The formula became popular among researchers again in the 90s. The framework developed in the Finland Futures Research Centre and presented in this article is a logical extension and generalization of the earlier thinking.

The postulates of advancing sustainability with total environmental stress and welfare

Decreasing TES with time is postulated as the first necessary condition for advancement of ecological sustainability. The other necessary condition of sustainability postulated is that of welfare growth. Whether the present state is sustainable or not is a question not addressed in the present paper, because answering that question needs a different kind of a theory. According to several scientists the use of raw materials already exceeds the sustainable level of consumption in industrialized countries. According to some other scientists there are countries which do not, as yet, exceed the sustainability level of material consumption while others do, but the global consumption level in the world is already too high. The theoretical frame of this paper is about change of a prevailing situation either towards sustainability or away from it.

The postulates of advancing sustainability of the prevailing state are given in (P1) and (P2):

P1. Without the total environmental stress (TES) decreasing sustainability is not advancing:

$$\mathbf{D}(\mathrm{TES}) < \mathbf{0} \tag{1}$$

P2. Without the welfare (WF) growing sustainability is not advancing:

$$\mathbf{D}(\mathrm{WF}) > \mathbf{0} \tag{2}$$

D(.) means an operator of change in-between an end year and the base year, i.e. $\mathbf{D}(X) = (X - X_o)$ with X as the end year value of a quantity, TES is for the total environmental stress and WF for the welfare.

The postulates define what is meant with advancing ecological sustainability. Economic, social or cultural decisions, which do not meet the conditions of the postulates are regarded as ecologically unsustainable, i.e. the ecological sustainability is not advancing with them. Hence, the decisions should decrease the total environmental stress (TES) and increase welfare (WEF). However, if the decisions or policies meet these conditions, it is not as yet sufficient for but only possible that sustainability advances with those decisions. It is a question of necessary but not succifient conditions of sustainability. The theory conceptually defines a domain, where the decisions possibly can advance sustainability and another domain where sustainable processes are impossible to occur.

The laws of thermodynamics determine what processes are possible. However, all the thermodynamically possible processes are not sustainable. From this perspective the demarcation line between the feasible region of sustainability advance and unfeasible region outside is analogue to the feasibility frame of thermodynamics of the material processes more generally. The ecologically sustainable domain of human development is only a sub-region within the thermodynamic feasibility frame.

The theoretical framework of identities

The logic of the analysis is built on four theoretical identities called the master equations of the theory. As identities they are logically tautologies and thus true of their intrinsic nature without any need for empirical or other verification. In the latter part of the article the explanatory power of the theory will be demonstrated empirically.

The four master equations are presented in the equation (3) to (6). The first equation relates the Material Flow (MF) as the chosen TES-indicator to the supply side of economy with a quantity called the material intensity of production, in the second equation the TES-indicator is related to employment and automation. The third equation relates employment of the materially intensive and less intensive sectors of the economy to the requirement of advancing sustainability. The fourth identity is of the demand side, i.e. welfare growth related to two new concepts called welfare productivity of GDP and material intensity of welfare. From each identity important new concepts of sustainable development are derived for use in policy formulations and empirical studies.

Production master equation

On the supply side, the master equation (3) relates the TES-indicator, i.e. the total material flow (MF), to population (POP), GDP production volume per capita (GDP/POP) and material intensity of production (MF/GDP) as follows:

$$MF \equiv POP \times \left(\frac{GDP}{POP} \right) \times \left(\frac{MF}{GDP} \right) \tag{3}$$

Here MF stands for the material flow through the economy, POP stands for population and GDP, the gross domestic product, stands for a measure of the total supply.

The identity (3) tells us that the total material flow depends on the population multiplied by GDP per capita and by material flow divided by GDP. All the estimates tell that the world population is growing indicating that the first multiplier on the right hand side of equation (3) is growing. The target of all the governments is to increase also the second multiplier, the GDP per capita. In order to decrease the environmental stress, indicated here by material flow MF, the last multiplier of the equation, material flow divided by GDP or material intensity of production, should decrease faster than the product of the first two multipliers.

Researchers have been familiar with the formula (3) since the 1970s, and it is similar to more recent statements of Paul and Anne Echrlich's and the familiar Wuppertal MIPS concept. Our approach, however, discusses the environmental impacts of economic and social activity in a larger frame and both from the supply side and demand side respectively.

Employment master equation

The employment master equation (4) relates the TES-indicator to employment (EMP), employment population ratio (EMP/POP), and to a quantity of (MF/EMP), i.e. the amount of material throughput per employed worker in production.

$$MF \equiv POP \times \left(\frac{EMP}{POP}\right) \times \left(\frac{MF}{EMP}\right) \tag{4}$$

The target of all the governments is to increase the employment of the economy or, in other words, to increase the second term in the Equation (4). Again, while the first term, population is increasing, if we want to decrease the environmental stress, indicated by MF, the third term in the equation, material throughput per employed worker should decrease. However, the automation of the production processes usually tends to increase the material flow that the workers can handle. Possibilities to solve this problem will be discussed in the following chapters.

In a more detailed conceptualization of the employment issue we should take into account working time, early retirements, part time employment etc.

Structural shift master equation

A structural shift of the economy means that the different sectors of the economy grow at different rates. The industrialisation was a structural shift, where the share of agricultural production of the total production decreased while the share of industrial production increased. The on-going change from the industrial economy to a service or network economy provides another demonstration of such a structural shift. With the master equation (5) it is possible to show that this kind of a shift also plays an important role in advancing ecological sustainability. The structural shift master equation is:

$$\frac{MF}{EMP} = \frac{MF_0}{EMP_0} x W_0 + \frac{MF_n}{EMP_n} x\left(1 - W_0\right) \tag{5}$$

and

$$W_0 = \frac{EMP_0}{EMP} \quad \text{and} \quad \left(1 - W_0\right) = \frac{EMP_n}{EMP} = W_n \tag{5a}$$

In Equation (5) the structural shift is related to the employment and material flows. For simplification, the economy is divided into two sectors: a materially intensive, heavy sector and a materially less intensive, light sector. In the equation W_o stands for a share of employment in the materially more intensive sector, and $(1\text{-}W_o)=W_n$ is then the complementary share of employment in the materially less intensive sector. Subscript o and n refers to the two complementary sectors of the economy. The theory assumes that the material throughput per worker (MF/EMP) of the materially intensive sector is much bigger than that of the other, or

$$\frac{MF_n}{EMP_n} << \frac{MF_o}{EMP_o} \tag{5b}$$

It is assumed that the change from industrial economy to service or network economy means that W_o is decreasing and W_n is increasing. With this type of structural shift it is possible to decrease the total material flow per employed worker (MF/EMP) is spite of the automation of production. Hence the structural shift of the economy provides one possibility to approach sustainability.

Welfare master equation

The GDP can be looked at from two sides of the national accounting balance: as a measure of the total supply and as a measure of the final demand. From the environmental point of view consumption and investments need not be separated. In what follows GDP is seen as a measure of the final demand.

The welfare master equation (6) relates the TES-indicator with welfare (WF) and a quantity of material intensity of welfare, i.e. with (MF/WF) ratio.

$$MF = \left(MF/WF\right) \times WF \tag{6}$$

Another identity relates the welfare to the economic growth (GDP) through a concept of welfare productivity of GDP (WF/GDP).

$$WF = \left(WF/GDP\right) \times GDP \tag{6a}$$

Here WF stands for welfare as postulated in (P1). The identity (6) tells us that if we want to increase welfare and decrease environmental stress (or MF) we have to decrease the material intensity of welfare, MF/WF. In the identity (6a) we assume that welfare can be measured independently from the economic growth. In recent years there have been many attempts to define and measure it (e.g. with

ISEW, HDI, GPI concepts), and numerous indicators are already available for this purpose. Then it becomes possible and sensible to talk about welfare as an end and the economic growth and GDP as a means for welfare. The new concept of (WF/GDP) gives then us a measure of how much welfare is get out of one unit of GDP, which we can define as the welfare productivity of GDP. The economic growth and GDP is no longer considered as the end but only a better or worse means to welfare, and the analysis informs us how to assess economic growth from the point of view of sustainability.

Theoretical views

From the eq. (1) to (6) several important new features of the ecologically sustainable development are derived. Some of the results challenge current aims of economic and technological development. It comes relevant even to speak about dilemmas between our present aims of development and our desires for sustainable development. The theory makes it possible to understand them and create some solutions for these dilemmas and to formulate policies for sustainable development.

Dematerialization of production

Dematerialization of production can be explained using Figure 1. Dematerialization of production means that in an economy it is possible to decrease material consumption in relation to economic production, i.e. decrease MF/GDP. In Figure 1 the straight lines starting from origo represent different levels of material consumption – GDP relations. If the economy moves along the same straight line starting from origo, the increase of GDP increases the material flow accordingly. Dematerialisation of production takes place when the economy shifts to another line, which is below the original one. A change from the initial state A to the state F represents such a dematerialisation process. The change from initial state A to state B is **not** a dematerialization process. Shaded area in Figure 1 represents a potential sustainability region in relation to initial state A indicating lower material consumption.

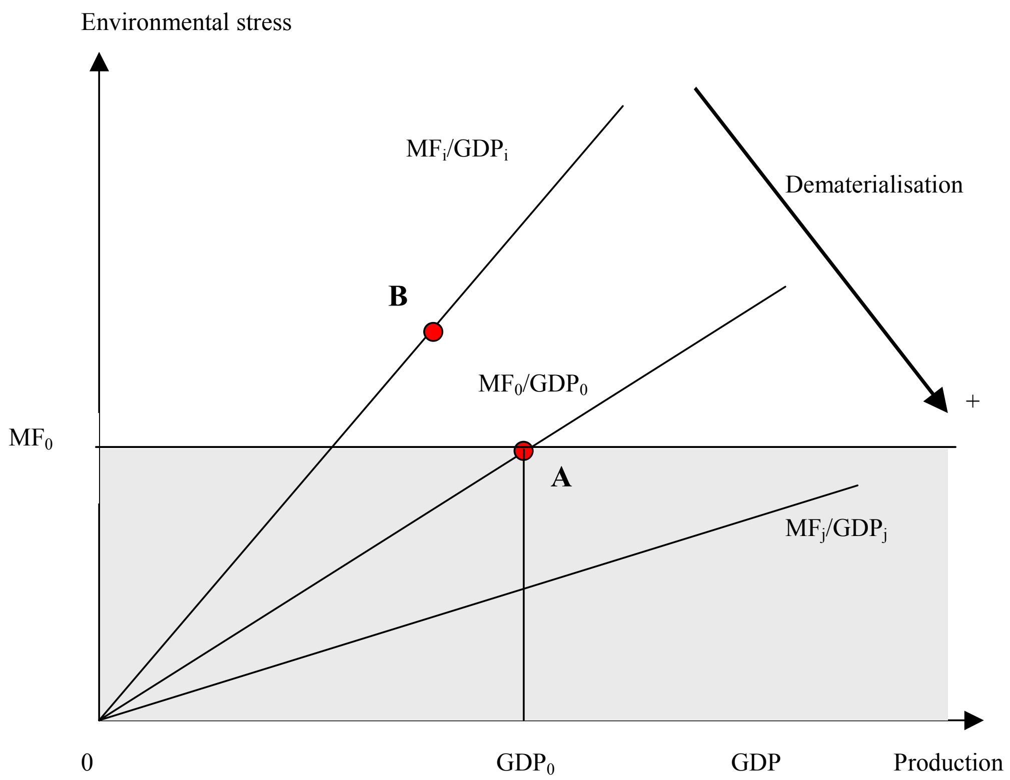


Figure 1. Graphical illustration of dematerialization of production and the shaded feasibility area of SD at the reference state A. The state B is on the unsustainability region while state F is on the sustainability region.

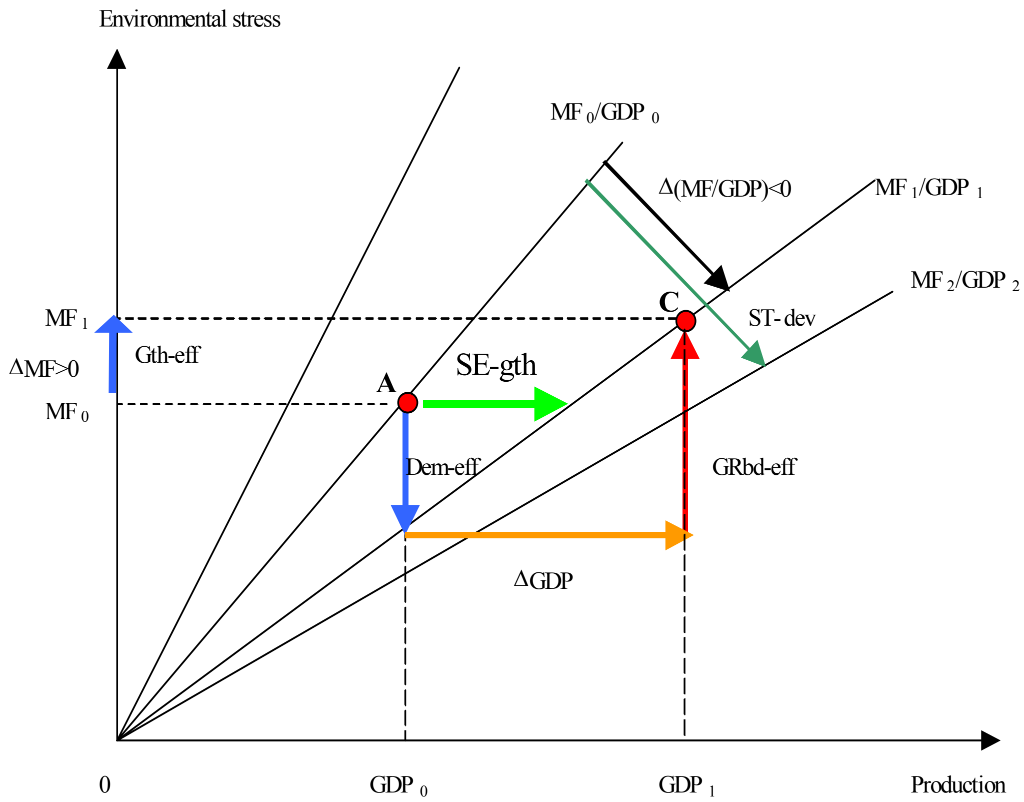
In Figure 2 a graphical illustration of the basic concepts of the theoretical framework of sustainability is presented. Point A represents the initial state. In the course from A to C the economic growth (□GDP) exceeds the sustainable economic growth (SE-gth). Sustainable economic growth indicates how much GDP can grow from initial state, at the certain level material intensity of production (MF/GDP), without increasing the material flow. It means the growth of GDP that should not increase the material flow. In this case, in the final state C, the material intensity of production $(MF/GDP)_1$ is lower than in the initial state A, meaning that dematerialization process has taken place. However, state C is not in the sustainability region, because material flow in state C is higher than the initial state A.

The material intensity of production $(MF/GDP)_1$ also determines dematerialization effect (Dem-eff). The Dem-effect tells us how much less material flow is needed to produce the same GDP. In this case the dematerialization of production is insufficient and Dem-eff inadequate to maintain sustainable development. Unsustainability is indicated by the positive values of Gth-eff. Growth effect indicates the actual amount of the growth of material consumption. If there had been no dematerialization effect the growth of material consumption would have been higher indicated in the Figure 2 by gross-rebound effect (GRbd-eff), which equals the sum of growth effect and dematerialization effect.

Figure 2. Graphical illustration of the basic concepts of the theoretical framework of sustainability.

Employment, automation and structural shift

At first sight the relation of the ecological sustainability to employment is opaque and obscure. The effect of automation may be assumed supportive to



sustainability, because of a more efficient use of natural resources it seems to offer. However, automation means that fewer workers can handle larger amounts of materials flows. Figure 3 presents a graphical illustration of automatisation. The straight lines of MF/EMP represent different levels of automation indicating the material flow each worker handles on the average. Change from initial state A to state E indicates increase of material consumption and decrease of employment. Figure 3 indicates that with the process of automation it is not possible to reach sustainability region from the initial state A.

The structural shift offers a solution to the employment and automation dilemma. It provides a way to decrease the ratio (MF/EMP) even with increasing employment and automation. The necessary condition for it is a multi sector economy where some sectors deviate from each other in their material intensity of supply. The material flow per employed worker in the dominant main industry is assumed to be much larger than in some other sector of the economy. If the less intensive sector is increasing its share of the total employment, the ratio

(MF/EMP) of the whole economy is to decrease. A shift of the employment from the materially more intensive sectors to a materially less intensive one becomes the solution of the sustainability dilemma of the previous chapter.

If the share of the “light” sectors of the economy, which do not cause large material flows, increases in the economy, it may be possible to decrease the MF/EMP relation and move from state A to state F. This is the case of sustainable structural shift indicating decreasing material flow and increasing employment.

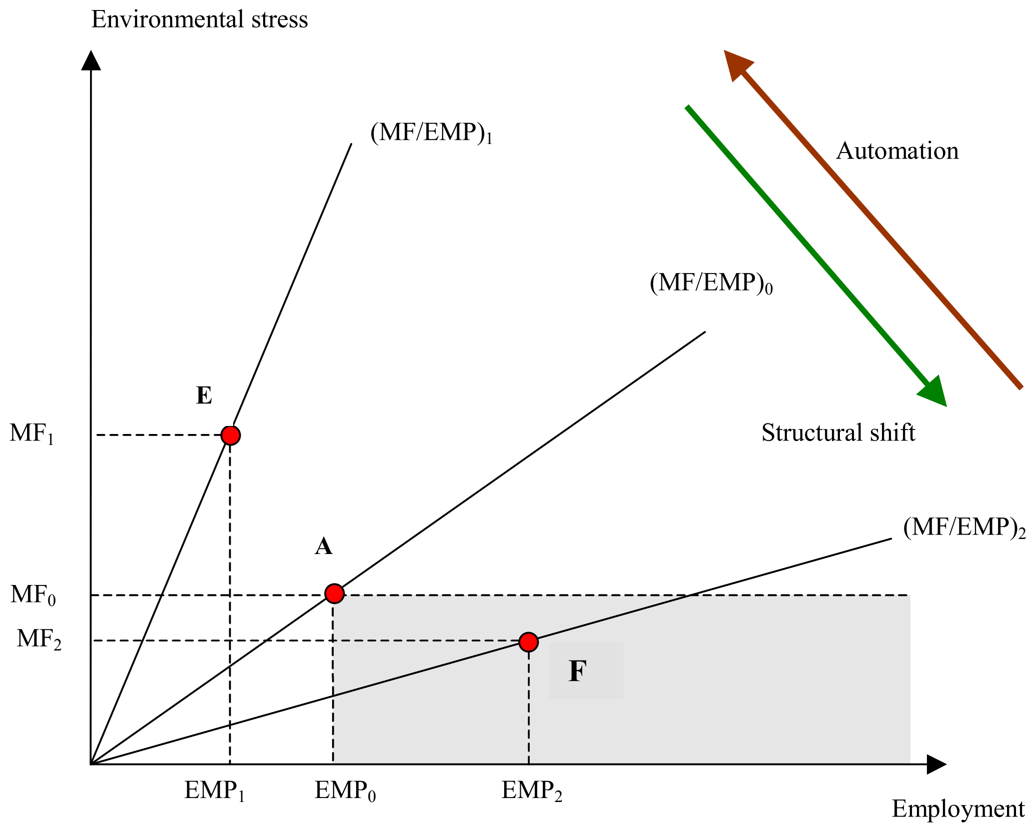


Figure 3. Graphical illustration of automatization and structural shift.

Immaterialization of consumption

The ultimate goal of human productive activity is not producing and consuming ever more material goods, but providing human welfare for which the material production is only as a means to the end. The environmental stress accounting must be extended to the final demand of welfare. In equation (6) a concept of the material intensity of welfare was presented and defined as the ratio between the material flow and the welfare provided, (MF/WF), on the demand side. The equation relates the TES with welfare production and its material intensity.

According to the postulate P2 the welfare is to be increasing. Equation (6) related welfare to the material flow in the following way:

$$MF = \left(MF/WF \right) \times WF \tag{6}$$

From the equation we can see that if WF increases and we want to decrease MF, the material intensity of welfare, (MF/WF) has to decrease. A process leading to a decreasing material intensity of welfare is named immaterialization of consumption.

Figure 4 illustrates immaterialization process. Change from initial state A to state B indicates immaterialization process because MF/WF decreases. However, state B is not in the sustainability region because the material flow increases. Hence the immaterialization of consumption has not been large enough.

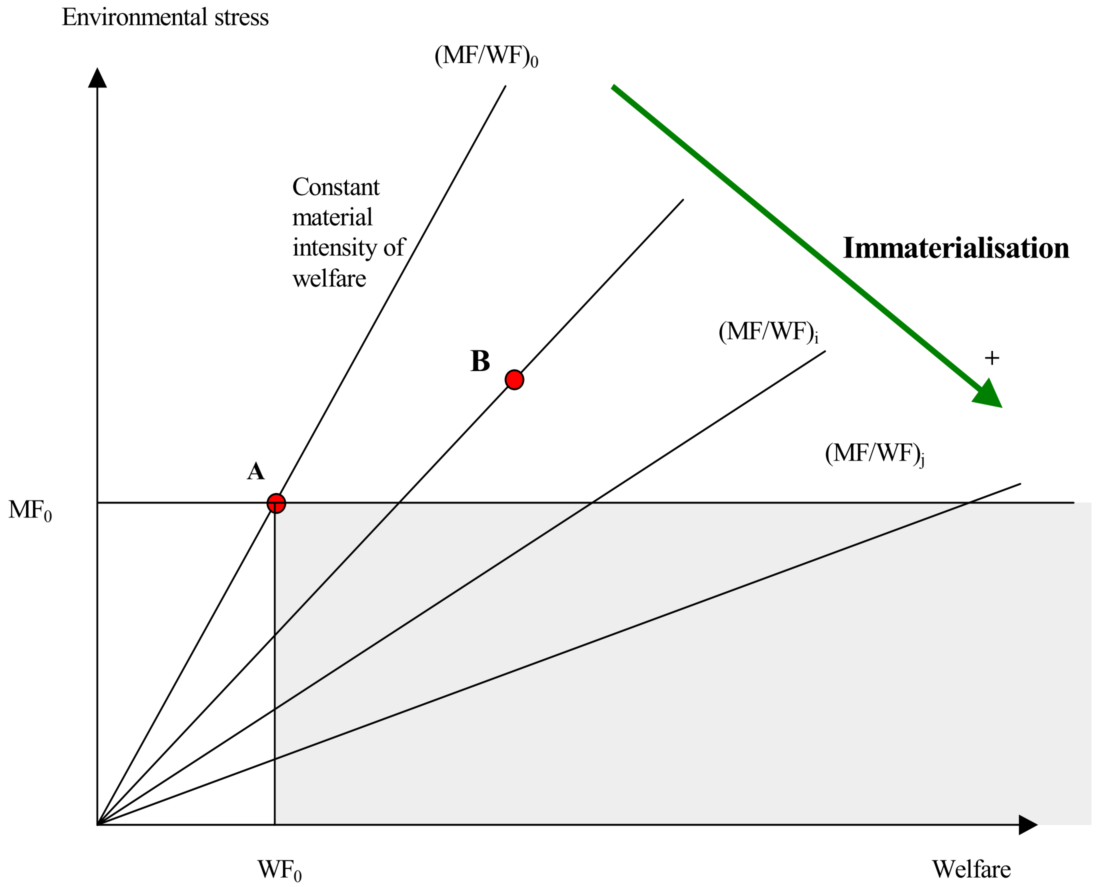


Figure 4. Graphical illustration of immaterialization of consumption and the shaded feasibility area of SD at the reference state A. The state B is on the unsustainability region.

In Figure 5 the basic concepts of immaterialization are illustrated. Change from state A to state D illustrates sustainable immaterialization process. The welfare intensity of material flow $(MF/WF)_1$ determines the highest possible sustainable welfare growth (SW-gth), where the material flow is not growing. $(MF/WF)_1$ also determines the immaterialization effect (Imm-eff) concerning the change from state A to state D indicating the potential decrease of material flow if the welfare had not grown.

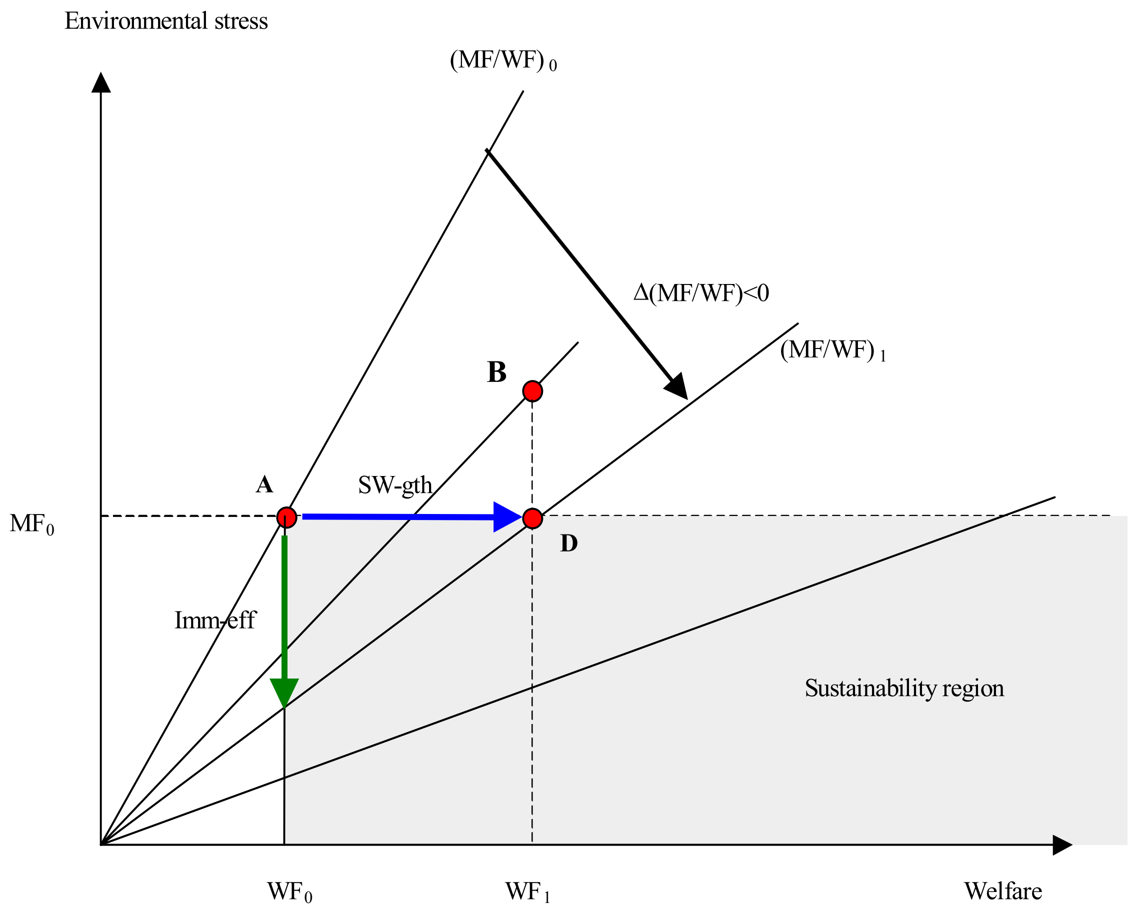


Figure 5. Graphical illustration of the basic concepts of the immaterialization of consumption, when Δ(MF/WF) is given. Sustainable growth of welfare at point A is SW-gth and immaterialization effect on TES is Imm-eff.

Welfare productivity of GDP

Increasing welfare is a necessary condition for sustainability as defined by the postulates. Welfare productivity of GDP is a relation of the welfare measure to the economic production (WF/GDP). It indicates that GDP is one factor of production of welfare and not vice versa. We do not use the concept of intensity because intensity refers to input/production type of relation instead of input/output type of relation. Figure 6 is a graphical illustration of the welfare productivity of GDP dimension of sustainability analyses.

Economic growth is not a necessary condition of sustainability per se, neither is it necessarily a preventing condition. A steady-state economy may be an alternative of sustainable development. In a steady-state economy, production neither grows nor declines.

The point B on the shaded area corresponds to the state B in Figure 1, Figure 4 and Figure 5 and accordingly it represents unsustainable course from A. The shaded area is a region of necessary but not sufficient condition of sustainability. Change from A to B indicates increase in welfare productivity of GDP and welfare, but decrease in GDP. However, change from A to B indicates increase of material flow according to Figs. 1, 4 and 5 indicating an unsustainable process.

Increase in economic production does not indicate increase of welfare productivity of GDP in an economy.

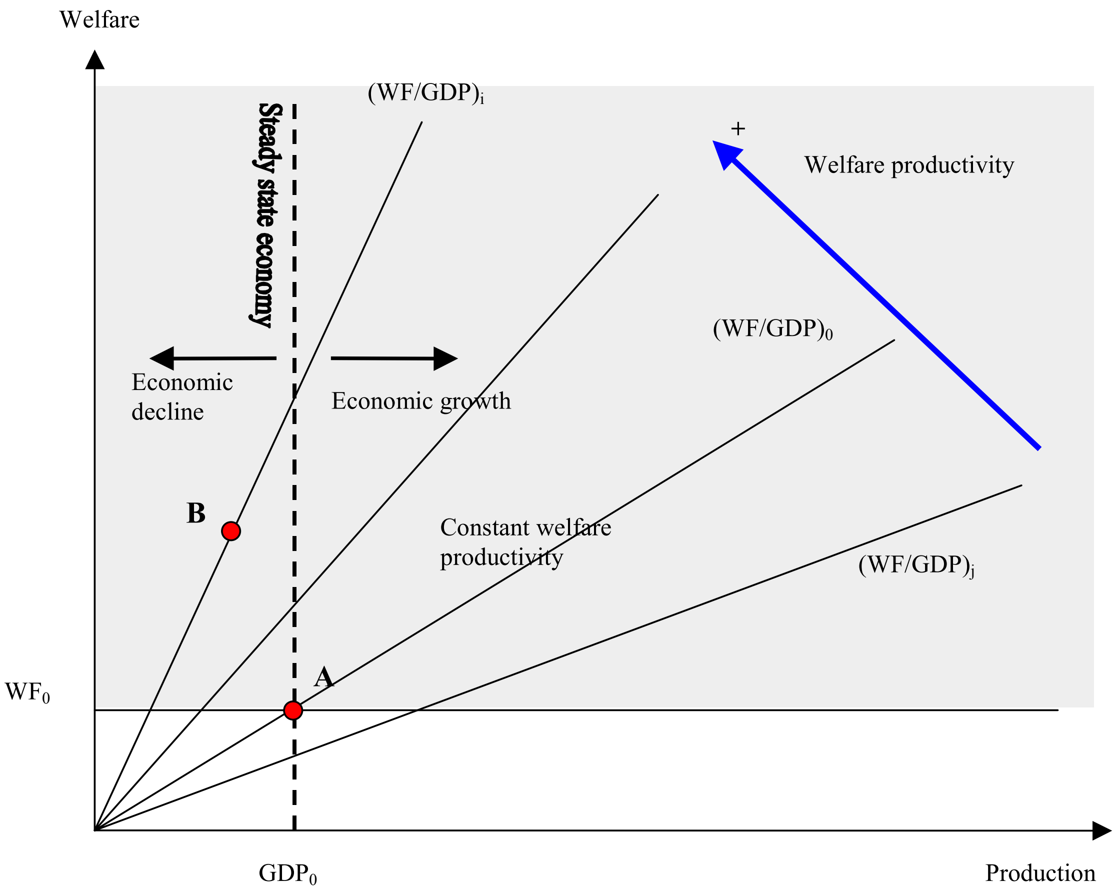


Figure 6. Graphical illustration of the welfare productivity of GDP dimension of sustainability analysis. Shaded area indicates a necessary but not a sufficient condition for sustainability.

Empirical analyses

In the empirical analyses, the total material flow (MF) is used to indicate the total environmental stress (TES). Another option would be to use a measure of the total energy for TES, because energy is inseparable from material processes whether it be extraction, production, consumption, or rejection and waste treatment – all material phenomena are associated with energy changes from higher to lower quality according to the entropy law. Electric energy data are used for illustration in one part of the study.

The aim of the empirical case analyses is to show how the theoretical formulas are applied. The second purpose is to demonstrate the explanatory power of the theory through numerical results. The case results will not be generally conclusive but explanatory in nature, only data from Finland as a case country are used. The sources of the data are Finland Yearbooks of Industrial Statistics in 1970-1997, Statistical Yearbooks of Finland in 1970-1997, Energy Statistics 1997 and material flow databases from Statistics Finland.

The results demonstrate possible advances or non-advances of the ecological sustainability in the case country during the observation period ranging from the 1960s to 1990s. The analyses can also be extended for writing scenarios on sustainability for the future and formulating sustainability policy; this, however, is not targeted by this study.

It is worth of repeating here that the results give only necessary conditions of advancing ecological sustainability. If any of the conditions postulated or derived is unmet, the ecological sustainability is not advancing. But on the other hand, if all the conditions are met, the advance of sustainability is not guaranteed, but it might require some other conditions to be fulfilled in addition. The necessary conditions of the analyses define a demarcation line between the regions where sustainability advance may be possible and where it is not possible to achieve.

TES data

Data of the total material flow (MF) as the chosen indicator for the total environmental stress (TES), is depicted in Figure 7. In the empirical study the quantitative values of the variables are expressed in the dimensionless numerical per-unit values with a given base-year value as the unit of measurement. For the total environmental stress the unit of measure is the value of the total material flow in 1960, i.e. unit of TES = 172.6 Mt/a in all the following figures.

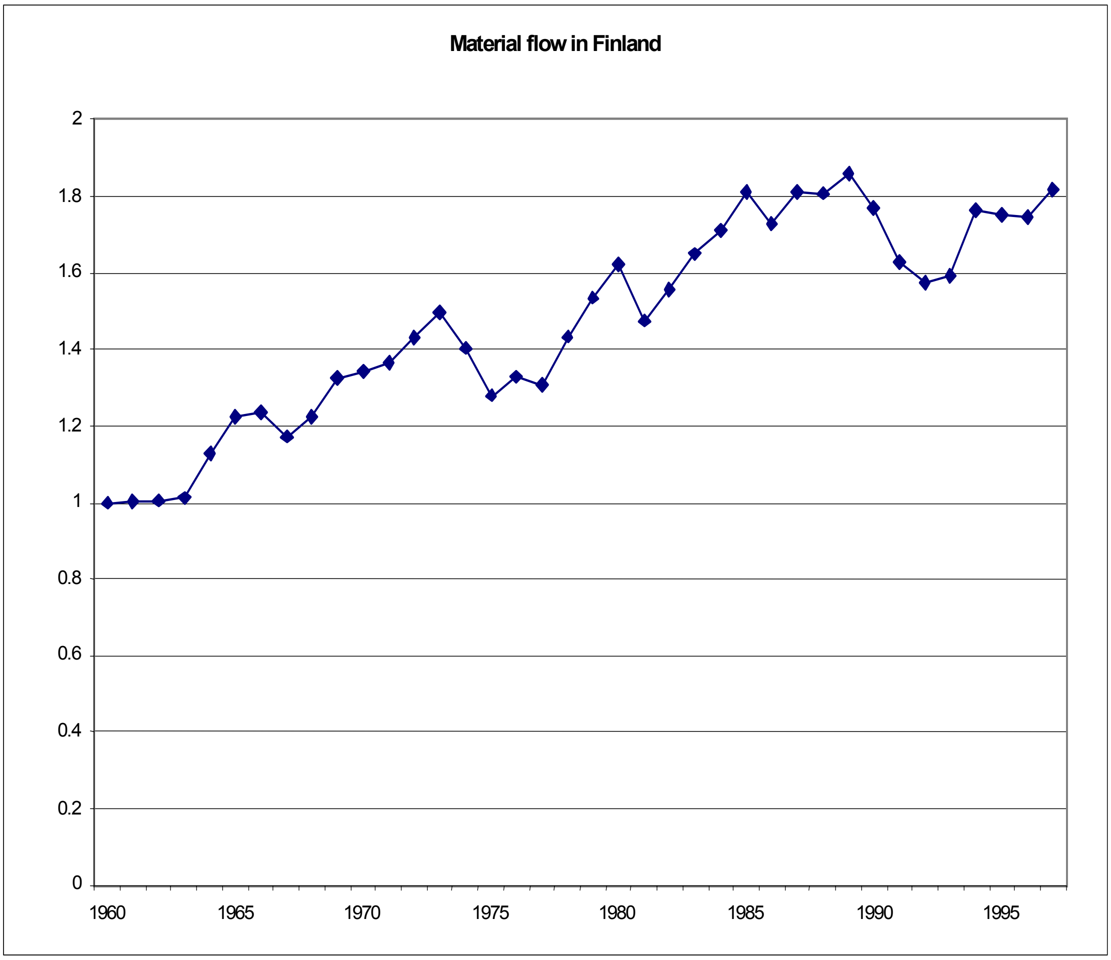


Figure 7. Data of the total material flow (MF) representing the total environmental stress (TES) in per-unit value (base year 1960, unit value = 172.6 Mt/a).

Per-capita figures of the direct material input, hidden material flow, and total material flow are depicted in Figure 8 in order to illustrate additional aspects of total environmental stress.

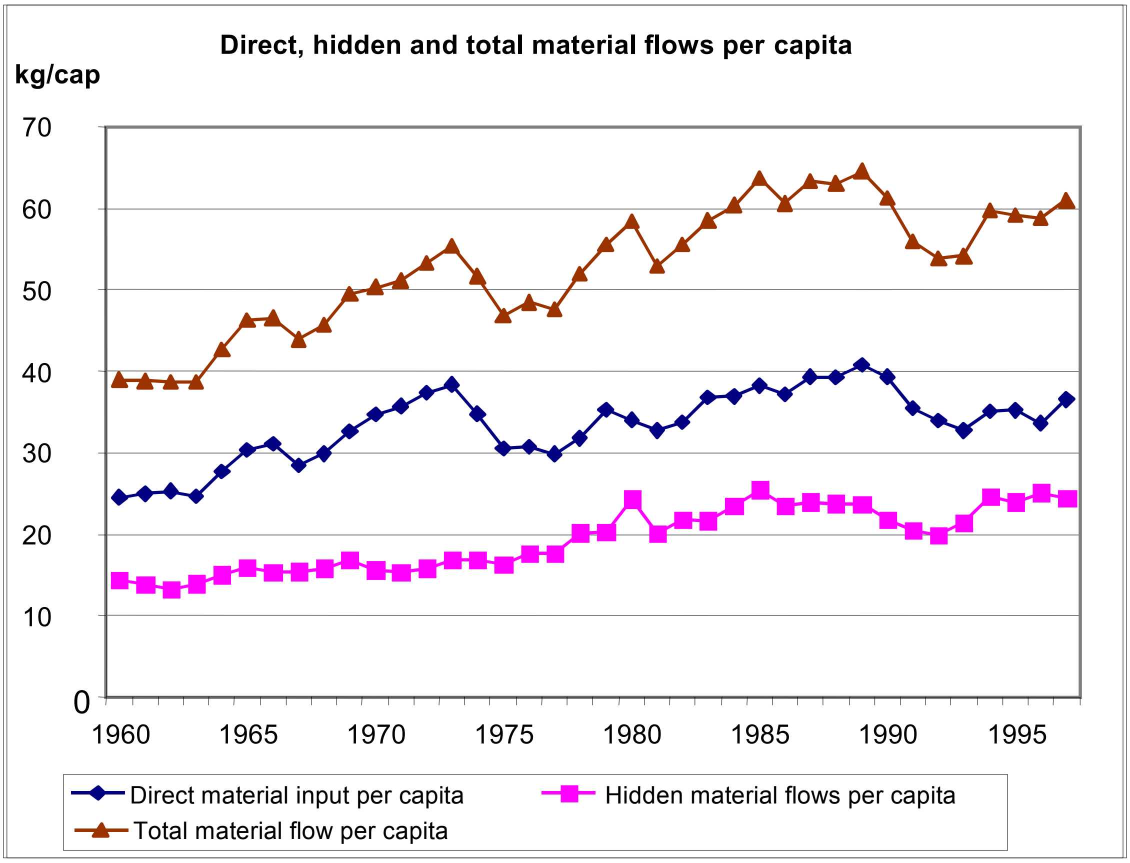


Figure 8. Per capita total material flow, direct material input, and hidden material flows in Finland from 1960 to 1997. Hidden material flows refer to the side flows and remains in the basic extraction of material (e.g. the unused stone material in mining).

As the Figure 7 and 8 show, environmental stress has increased during the period. Only the oil crises in the 1970s and the economic recession in the early 1990s had a decreasing effect on material flows. In the long run, the total material flow has been increasing at an average rate of 1.7 %/a (the direct material flow at 1.5 %/a and the hidden material flow at a faster rate, i.e. 2 %/a).

The empirical data above reveals directly according to the postulate P1 that the sustainability condition was not met by the Finnish economy from 1960 to 1997. A closer analysis gives a more complete picture of the sustainability situation and characters of deviation from a sustainable track.

Dematerialization and sustainable economic growth

The dematerialization of production is one of the key processes for advancing sustainability. Numerical estimates of the dematerialization, gross rebound and growth effects on the total environmental stress and the rate of sustainable economic growth can be calculated with the master equation (3). Data of GDP and MF/GDP required are provided in Figure 9 and Figure 10.

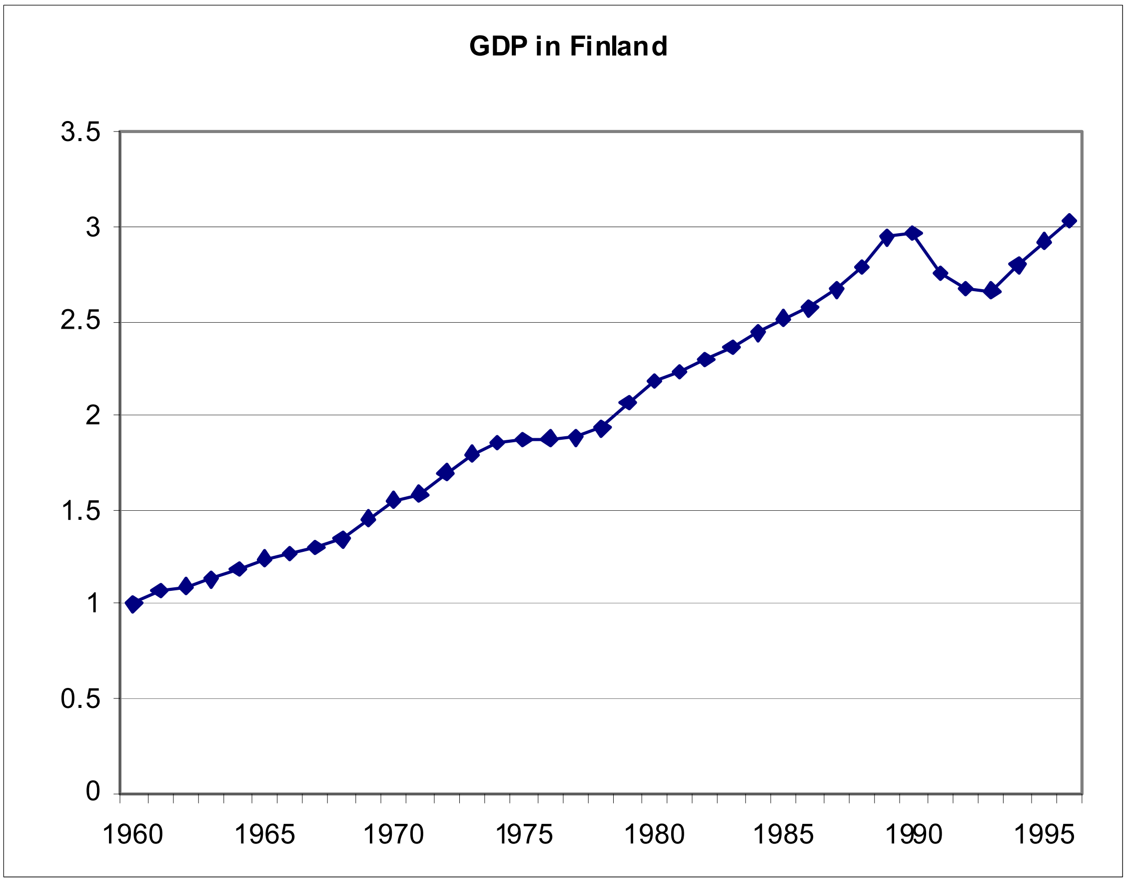


Figure 9. Data in per-unit value of the gross domestic product in Finland from 1960 to 1996 (base year 1960, unit value = $151.2*10^9$ FIM/a)

The GDP has been increasing almost monotonically since the 1960s with some recent exceptions in the 1990s. The theory offers a possibility to analyse, if continuous economic growth has been, at the same time, also advancing sustainability or has it taken place at the expense of sustainability and environment.

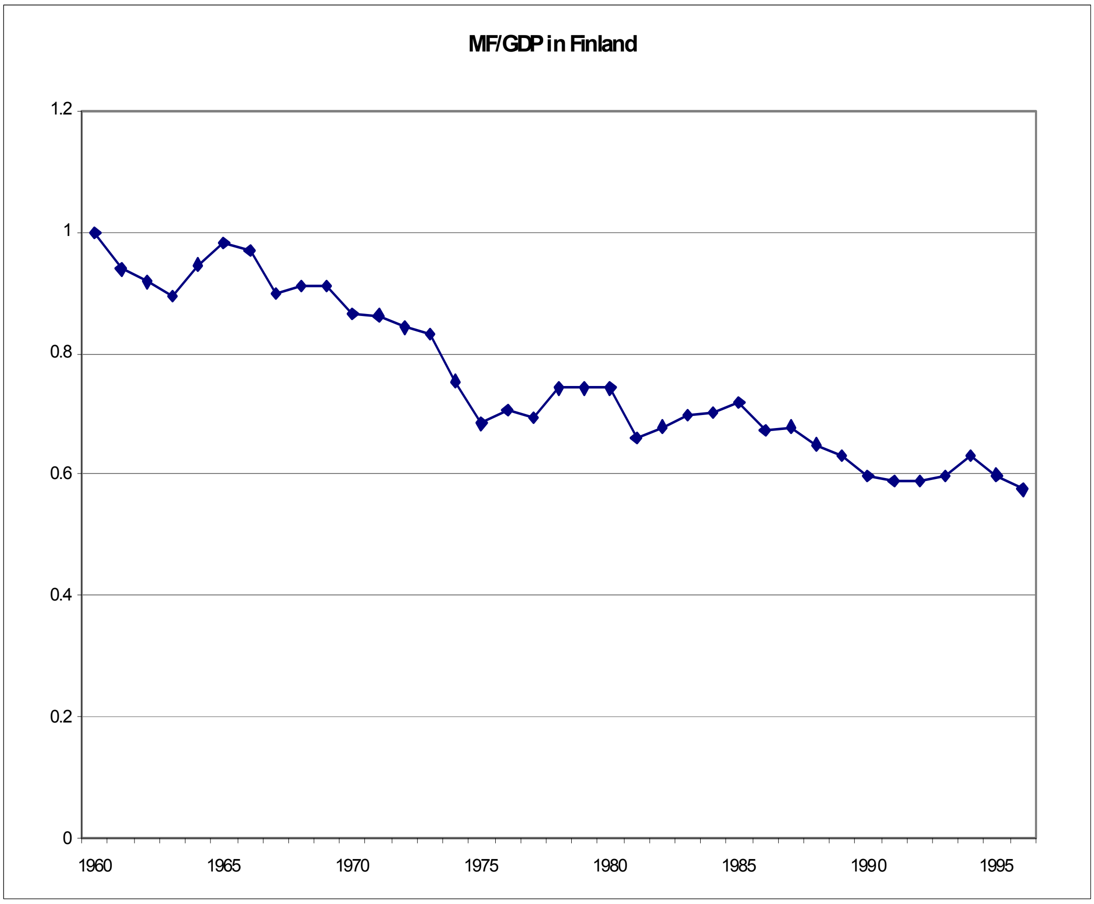


Figure 10. Data of the material intensity of GDP, (MF/GDP), in Finland from 1960 to 1996 (base year 1960, unit value = 1.14 kg/FIM)

The material-intensity figures in Figure 10 show that some dematerialization processes of production have been benefiting the Finnish economy since 1960.

The dematerialization process of the theory is conceptualized in the form of three different effects on total environmental stress: total dematerialization effect (Dem-effect), growth effect (Gth-effect), and gross rebound effect (GRbd-effect). The calculated empirical results of these effects are given in the figures 11, 12 and 13. The figures are cumulative values from the base year to the end year and in per-unit form with the unit of TES = 172.6 Mt/a of material flow.

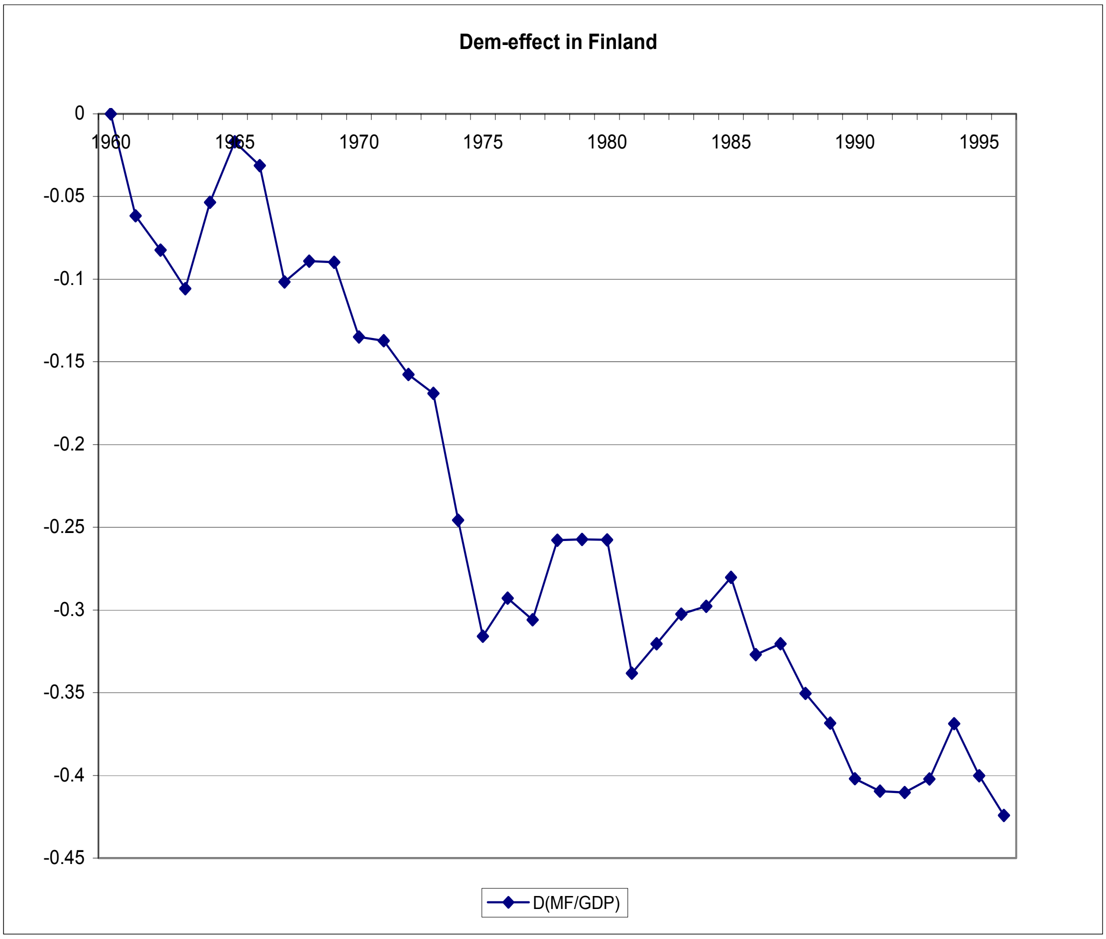


Figure 11. Cumulative total dematerialization effect on TES in Finland from 1960 to 1996 (base year 1960, unit value = 172.6 Mt/a). Positive values indicate contribution to deviation from sustainability, and negative values as in the figure some fulfilment of the necessary condition of sustainability.

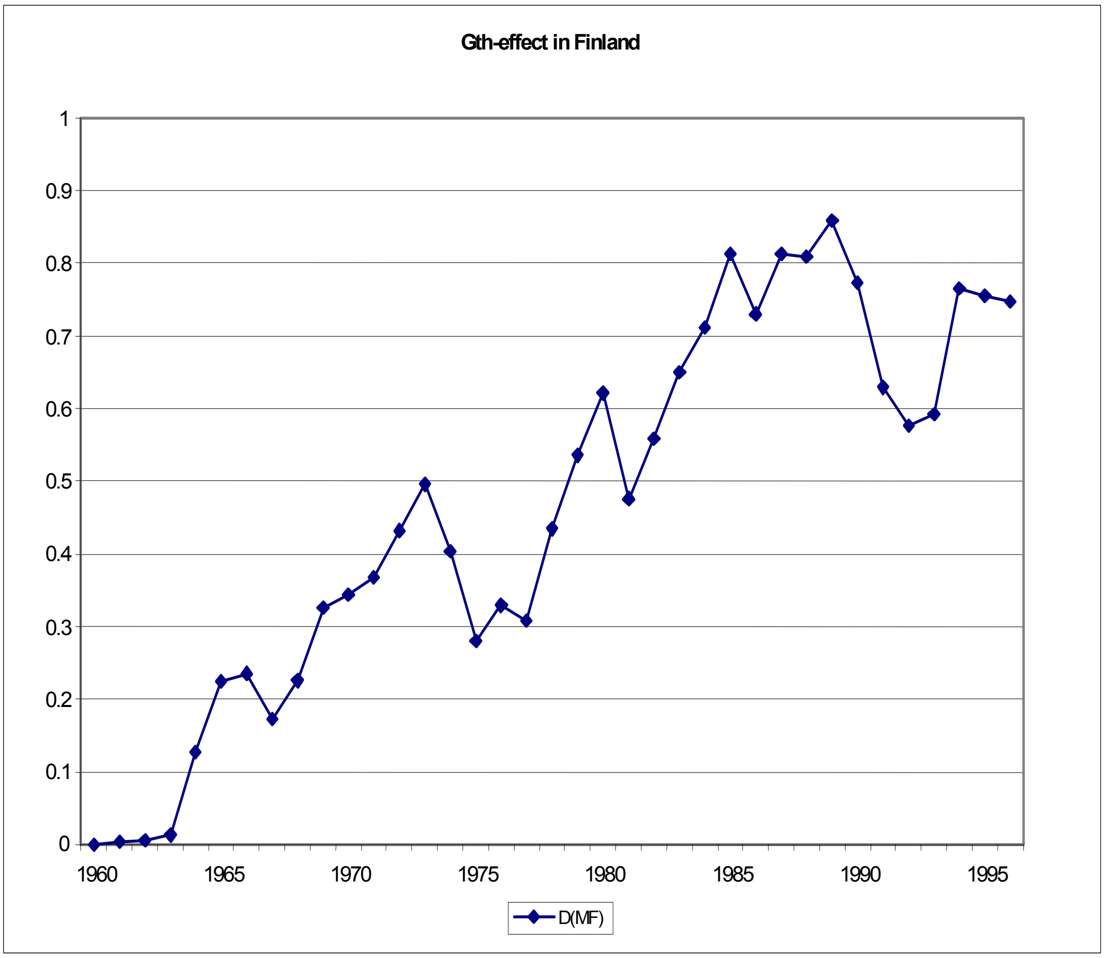


Figure 12. Cumulative growth effect on TES in Finland from 1960 to 1996 (base year 1960, unit value = 172.6 Mt/a). Positive values of the figure indicate some contribution to deviation from sustainability.

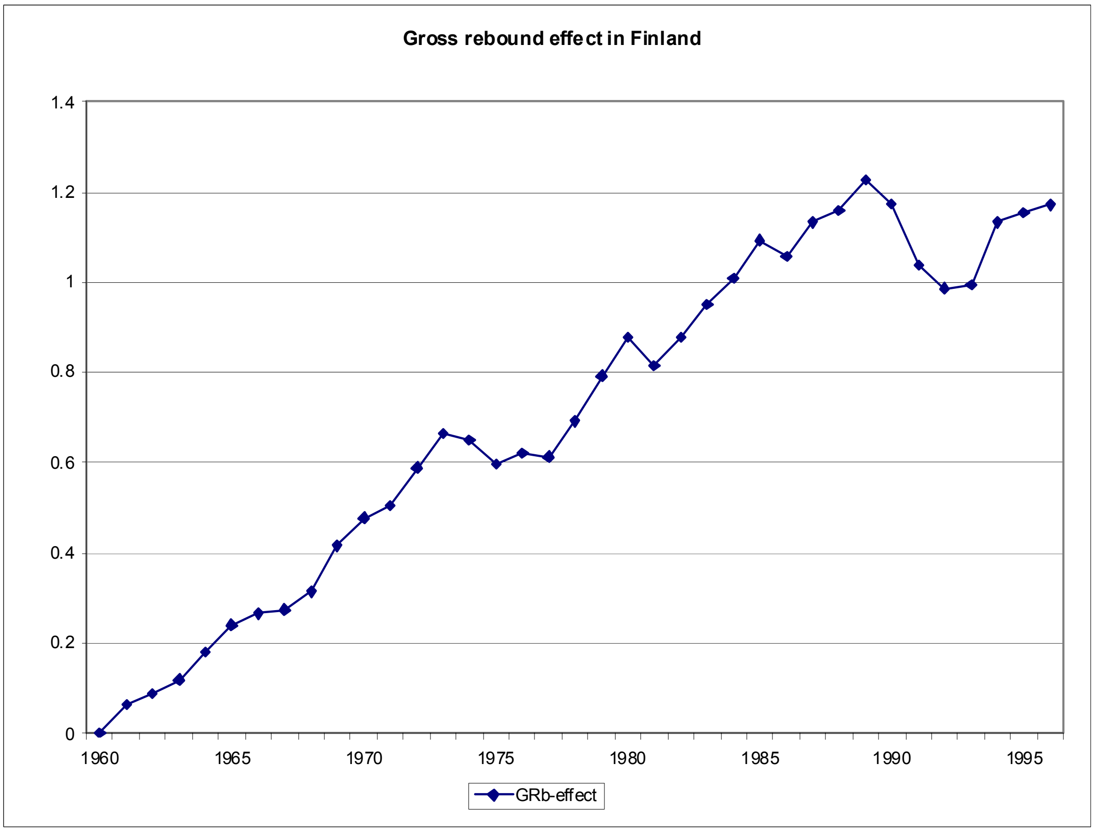


Figure 13. Cumulative gross rebound-effect on TES in Finland from 1960 to 1996 (base year 1960, unit value = 172.6 Mt/a). Positive values of the figure indicate some contribution to deviation from sustainability.

During the 36-year period, the dematerialization effect in Figure 11 has decreased the TES about 42 %. This corresponds to an average rate of improvement of material efficiency or development of technology of about 1.5 %/a from 1960 to 1996. Without this process of getting more from less in production, the increase in the use of material resources would have been considerably higher. The dematerialization process as a whole has, however, still been inadequate to compensate for the adverse contribution of economic growth and gross rebound to sustainability. This is observed from the strong positive growth effect in Figure 12 and from the counter-effect called gross-rebound in Figure 13, which advanced at an average growth rate of 2.2 %/a.

The sustainable economic growth concept provides a novel way to demonstrate whether the economic growth has also met the necessary condition of sustainability. According to the theory, the ecologically sustainable economic growth rate depends on the rate of change of the material intensity, i.e. rate of dematerialization, which can be seen in Figure 10. On the other hand, the material intensity of the economy indicates the quality level of production technology, and a decreasing intensity indicates technological development. This interpretation of the material intensity associates it and the dematerialization process as a whole with technological development.

The sustainable economic growth rate (SE-gth) and real growth rate in Finland from 1975 to 1996 are presented in Figure 14A.

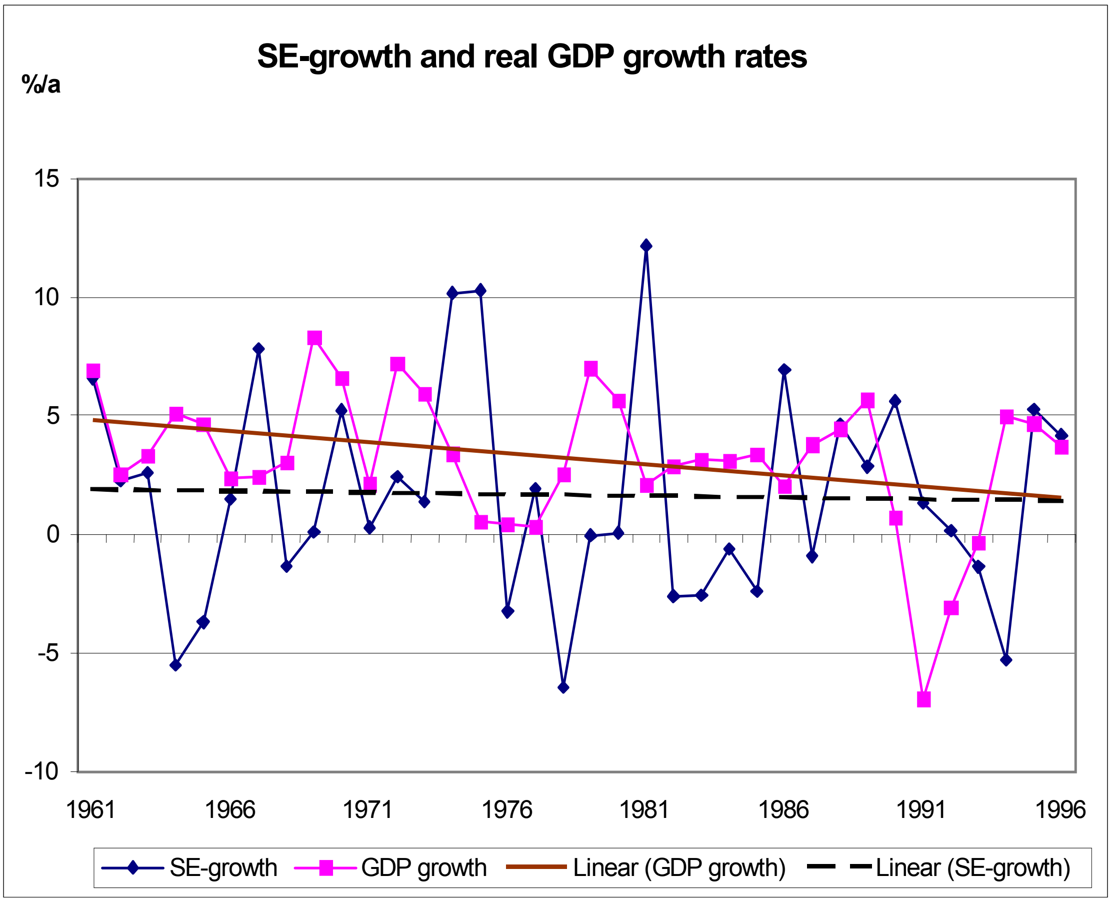


Figure 14A. The calculated annual sustainable economic growth rate and its linear trend in comparison with the observed real growth rate and its linear trend in Finland from 1960 to 1996. In the sustainability condition the real growth rate remains below the sustainable rate. This situation was met only in random occasion during the period.

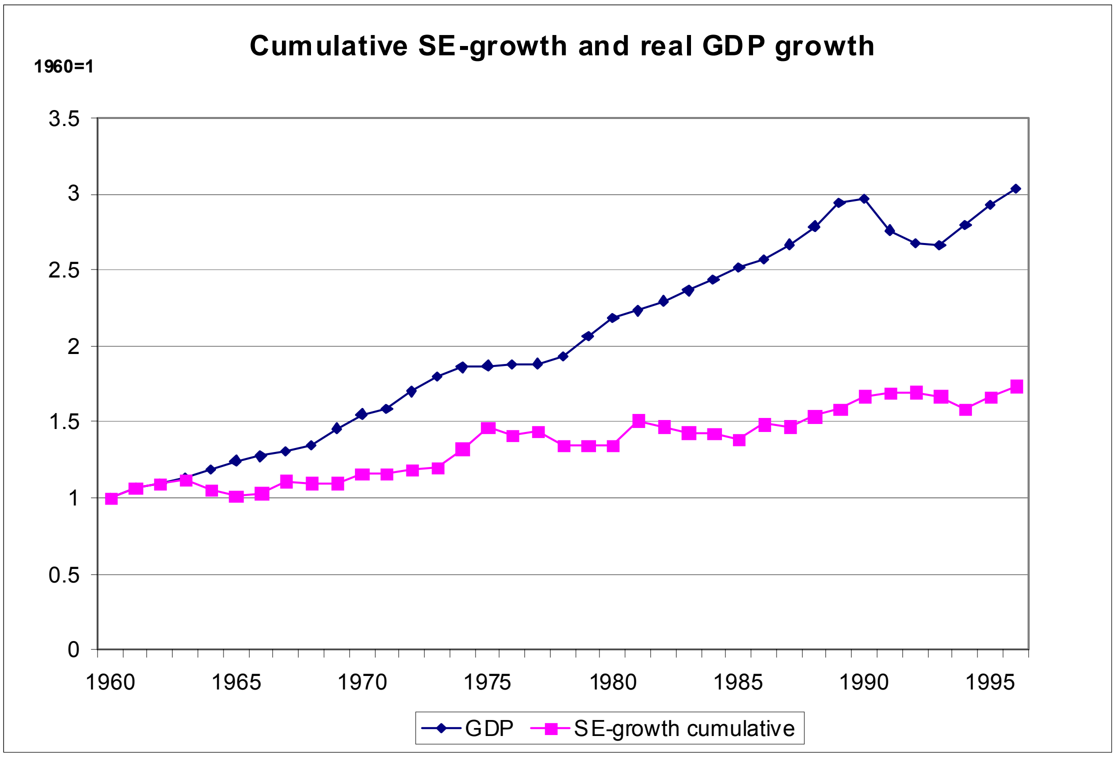


Figure 14B. The calculated cumulative sustainable economic growth in comparison with the observed real growth in Finland from 1960 to 1996 (base year 1960, unit = $151.2*10^9$ FIM/a). The difference between the curves demonstrates an increasing debt to sustainability and environment.

Comparing observed economic growth with calculated sustainable growth "potential" in Figure 14A, we observe that there are only few intervals where the sustainability condition is not violated, while for most of the period sustainability does not advance. The recession in the early 1990s contributed to ecological sustainability, but since then the trend has reversed itself. Most recently the growth has turned towards advancing sustainability again, and this time hopefully not only with slowing down the real growth but also by increasing the economy’s potential for sustainable growth especially by means of information and communication technology.

Welfare dilemma

The welfare dilemma of chapter 5.3 calls for a way to measure welfare independently of the GDP. There are numerous attempts, up to twenty known so far, to define and measure it in different ways. The UNDP's human development index (HDI), which is published annually in Human Development Reports, is one attaining increasing acceptance since the 1990. In this study HDI is used to analyse immaterialization processes, and the welfare productivity of GDP from 1960 to 1995 is determined accordingly. The use of HDI in measuring welfare has some special problems (e.g. the maximum value it can attain is 100) but in this paper we do not discuss this or other problems of welfare indices. The results of the empirical analysis (based on the Equation (4) of the theory) are presented in Figure 15 and Figure 16.

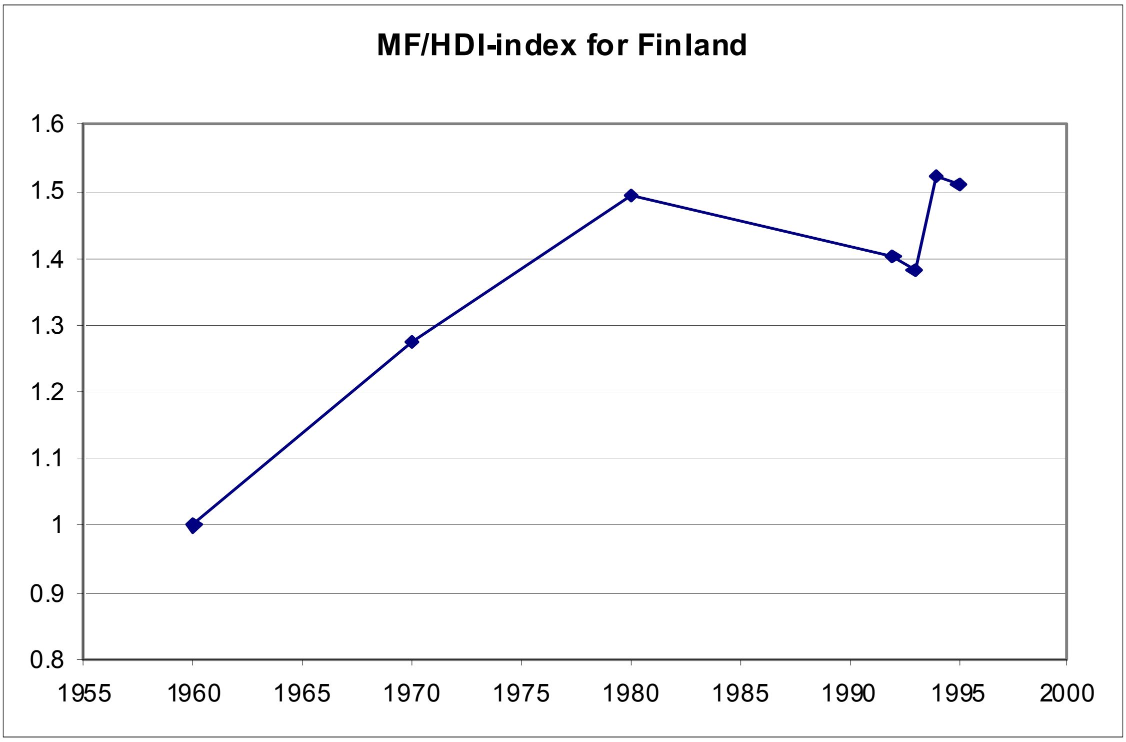


Figure 15. Data of the material intensity of welfare, i.e. the total material flow (MF) divided by the Human Development Index (HDI), in Finland from 1960 to 1995. (base year 1960, unit value = 212.8 Mt per HDI-unit)

Figure 15 shows that the material intensity of welfare has been increasing by the year 1980 but between 1980 and 1994 some temporary immaterialization process of consumption was in effect. The material intensity of welfare, measured by (MF/HDI), increased by about 50 % from 1960 to 1995. This reveals that sustainability was not advanced, but the eco-efficiency of welfare production in Finland decreased instead.

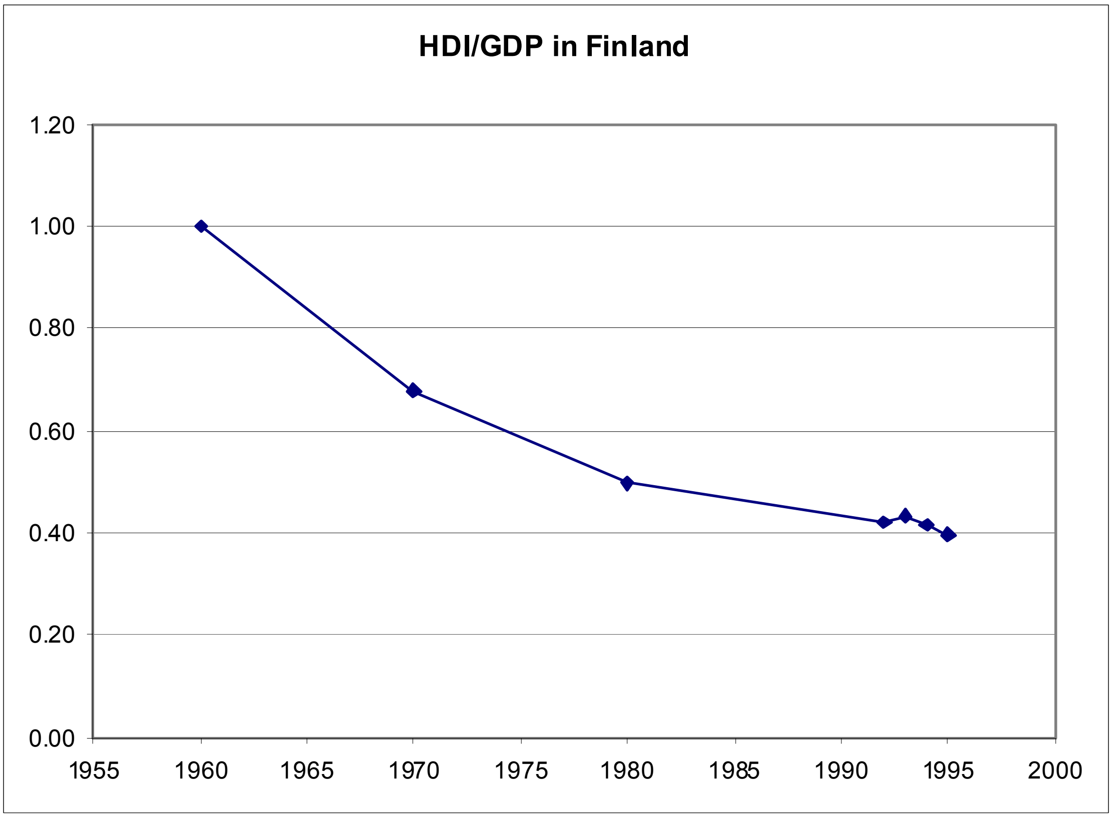


Figure 16. Data of the welfare productivity of GDP, which is measured by the HDI/GDP ratio (base year 1960, unit value = 5.35 HDI-unit/MFIM/a

In the official economic policies the GDP growth is regarded as the ultimate end of social activity. The sustainability analysis regards economic growth only as a better or worse means to an ultimate goal expressed by the welfare concept. It is thus only natural to inquire about the efficiency of the means to the end, i.e. about the efficiency of the economic growth policies adopted, and to give priority to the growth of welfare productivity of GDP instead of plain economic growth in policy formulation and strategies.

Figure 16 shows that the welfare productivity of GDP in Finland has decreased dramatically, about 60 %, since 1960. The economic growth has not been supporting welfare growth but has instead hindered it. It is believed that this dilemma is pertinent for present economic growth in all countries and for global growth as well. An increasing trend of welfare productivity of GDP is a necessary condition for advancing sustainable development. In Finland this condition has not been met. Sustainable development requires that governments and international economic actors substitute plain growth policies with welfare and welfare productivity of GDP policies.

It is interesting to notice that while some dematerialization has taken place in the Finnish economy the other determinants of decreasing material flow has not been met as implied by the positive growth effect and gross rebound effect. The theory is not about sufficient conditions, but only about necessary conditions for advancing ecological sustainability. Also, this theory is not a phenomenological theory capable of describing how to advance sustainability, but it provides the constraints and boundaries beyond which sustainability will certainly not been advanced.

Turning the welfare productivity of GDP from its present decreasing course shown in Figure 16 to increase would be the proper sustainable growth policy, and governments should make it a priority over plain economic growth. The course of the material intensity of welfare, as in Figure 15, determines the minimum reaction to welfare production in order to regain immaterialization of consumption (a decreasing course in Figure 16). The growth of welfare productivity of GDP required to counter-balance the realized increase of material intensity would have been according to data about 1.2 %/a on average in the observation time span. It has remained, however, unrealized. The analysis shows that economic growth can no longer be regarded as a sole and adequate measure of true sustainable development. If new measures in policy formulations are not taken, the result may be further decreases in welfare and worsening sustainability.

The theoretical analysis and the empirical demonstrations show that when material intensity is examined from two sides, i.e. from the production side and the consumption side of society, the social-economic dimensions of sustainability are more easily uncovered. The theory provides an inevitable basic conceptualization for sustainability discourse based on environmental, economic and social points of view. The explanatory possibilities it offers have not been taken into account sufficiently in contemporary sustainability discourse.

Employment and automation dilemma: The case of Finland

The role of automation and its social consequences has not adequately been discussed in the sustainability literature. The dematerialization of production in Figure 10 can, to some extent, be linked to automation. However, dematerialization does not explain all aspects of automation. A more thorough understanding is offered by the equation (5) of the theory, which relates automation and employment to the sustainability problematique. The employment data required for the empirical analyses are presented in Figure 17.

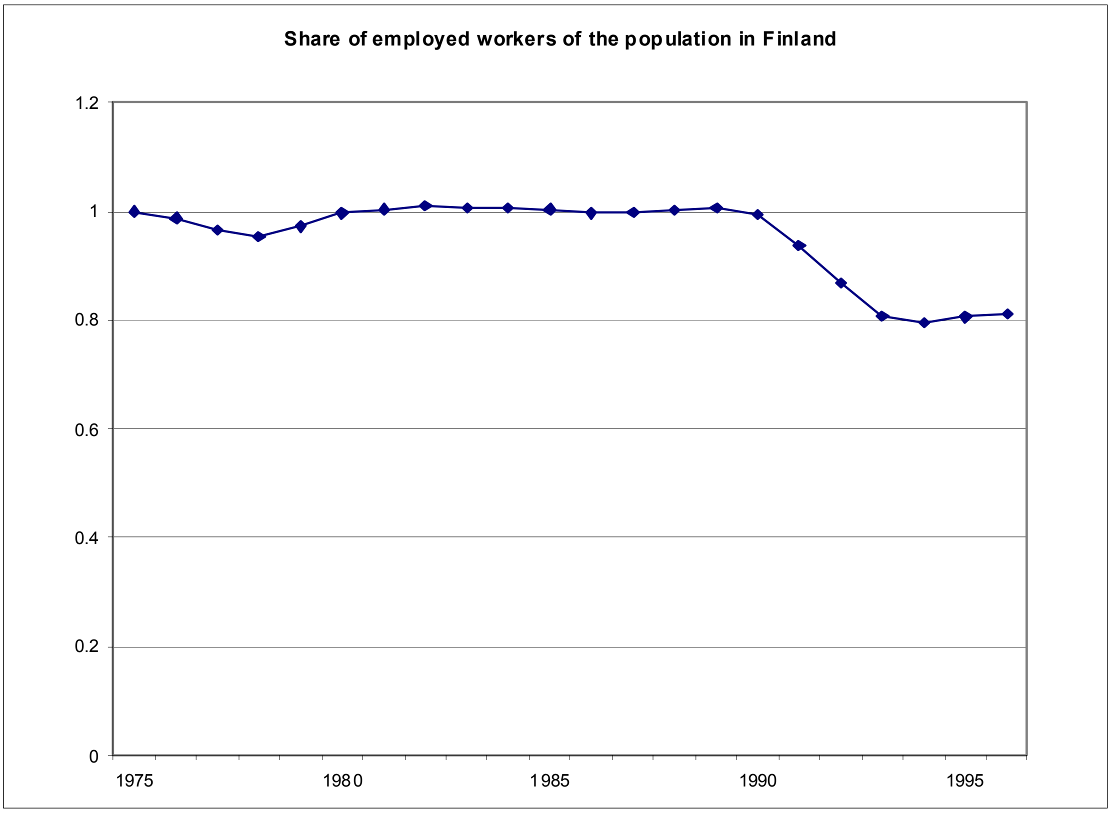


Figure 17. Data of the ratio of employed workers to the total population (EMP/POP) in Finland from 1975 to 1996 (base year 1975, unit value = 0.473 employed persons per capita)

The ratio of employed persons to the total population has been about 47 %, but during the economic recession in the 1990s it decreased below 40 %. This has resulted in high levels of unemployment. The unemployment problem has been incorporated in the development of environmental policies in two ways. Firstly, new fiscal measures have been planned through environmental taxes with the aim to reduce some other taxes and costs related to labor. This approach was thought to increase employment and to support labor-intensive technologies. Secondly, the severity of the unemployment situation has had an adverse and slowing down effect on making environmental solutions a priority over plain economic growth and export policies. These aims and policies are reflected in the empirical figures of the material throughput per worker as in Figure 18.

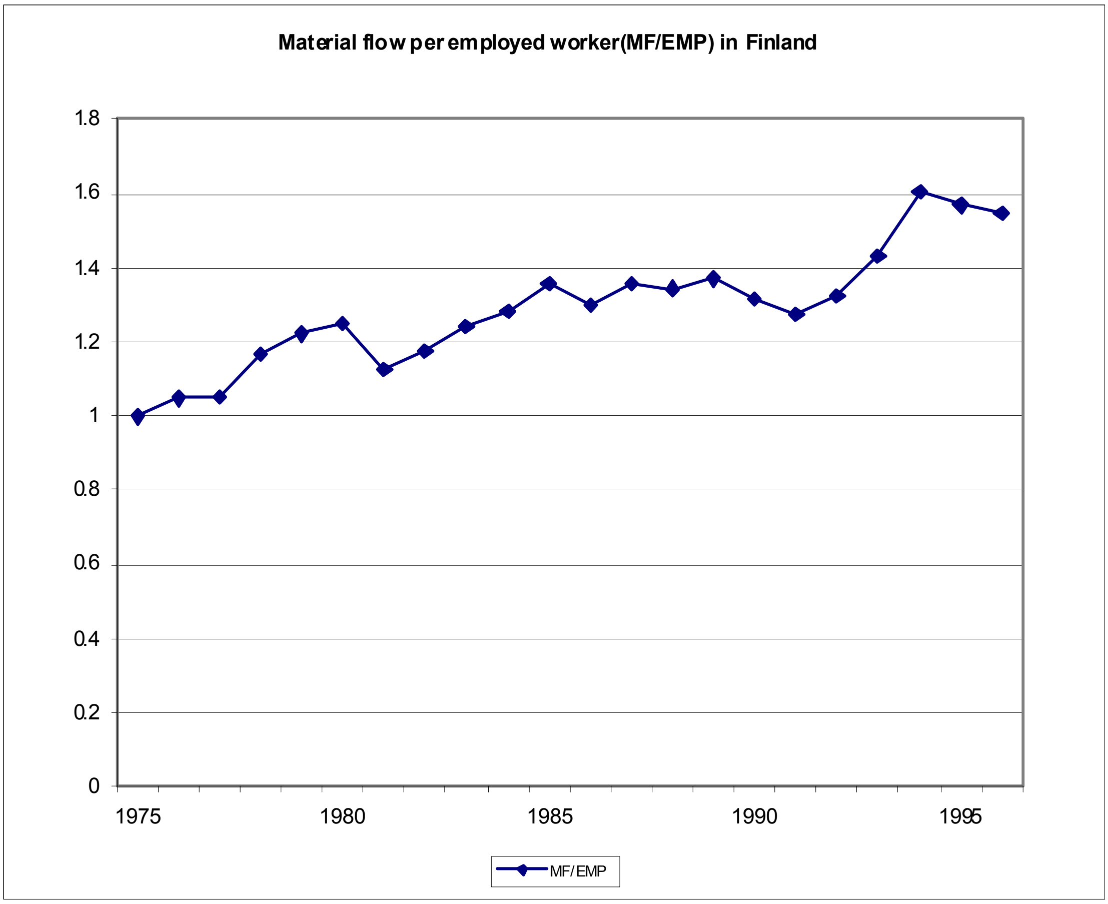


Figure 18. Data of the material flow per employed worker (MF/EMP) in Finland from 1975 to 1996 (base year 1975, unit value = 98.9 t/a/worker)

In Finland, the material flow per employed worker has increased about 60 % from 1975 to 1996. This reveals advancing automation of production presented in equation (6 a), i.e. one worker handles larger material flows with the help of automated machines. There is a trend-like increase in the figures, with variations up and down, until the end of the 1980s. Since 1990 the figures show a rapid increase, which is linked to the worsening unemployment during the same time. The turn reflects, however, a substantial labour productivity growth in the economy, i.e. getting more output from less labour in production.

To increase unemployment cannot be a sound policy to advance sustainability nor can be halting development of production automation. The empirical findings presented so far have only made the dilemma between these different goals visible. The theory can show a partial solution to the dilemma with a structural shift of the economy.

Structural shift as a sustainability: The case of Finland

In order to analyse the structural shift of the economy and its implications for sustainability, the sectoral data of material use are needed. Unfortunately, sectoral data of material use are not available. In the structural shift analysis the electricity consumption is used as the measure of TES. The economy is thought to consist of two sectors, one of high material intensity and the other of low intensity. The sectors approximately correspond to the industry and the service sector. Figure 19 provides data of the sector labour force shares (for the weight variables, W_o and $(1-W_o)$, in Eq. 6).

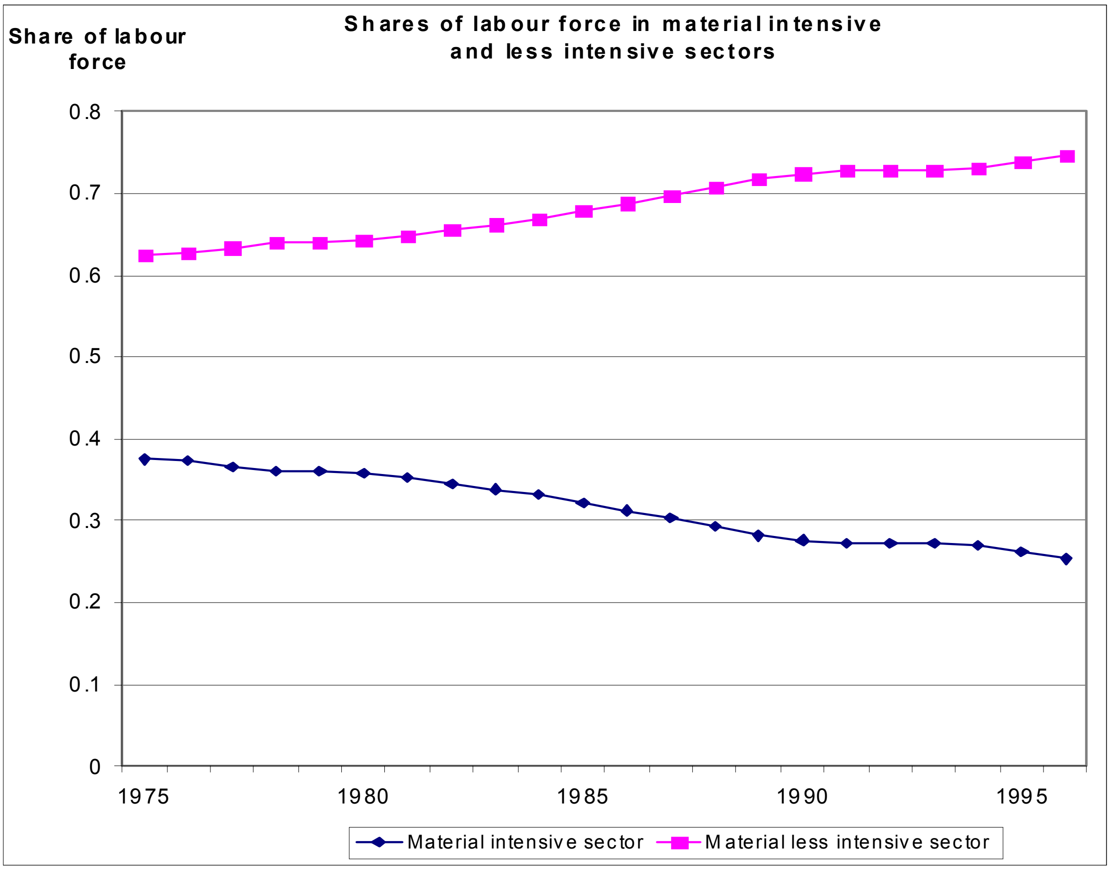


Figure 19. Rough data of labor-force share in the material-intensive sector (W_o) and in the less material-intensive ($1-W_o$) sector in Finland from 1975 to 1996. The material intensive and less intensive sectors are presented in Appendix 1.

The figures above indicate that a structural shift indeed took place in the Finnish economy between 1975 and 1996. Whether it has been strong enough to counter-balance the increase of total environmental stress from automation and employment is examined using the theory. The Figure 20 provides the data of the shift of employment from one sector to the other. The structural shift values needed to counter-balance the increase of the total environmental stress or material flow due to automation and employment dilemma are shown in Figure 20.

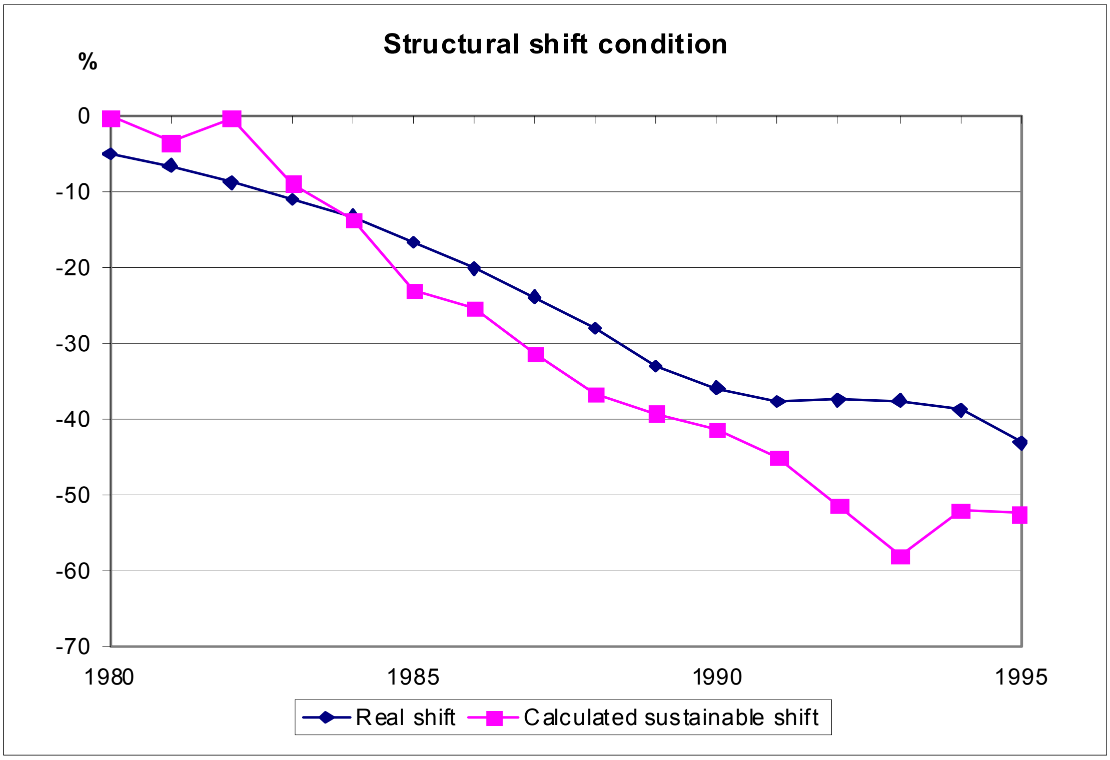


Figure 20. Data of the cumulative real structural shift in Finland from 1975 to 1997, and the sustainable shift (as per cent of the labor-force share of the materially-intensive sector for base year 1975). When the real shift is above the curve of the calculated sustainable shift, it implies deviation from sustainability.

The results indicate that the necessary condition of advancement of sustainability was realized in the Finnish economy during the early 1980s but not during the late 1980s and 1990s. The structural shift has been inadequate to compensate for the increase in total environmental stress caused by employment policy and automation advance.

Conclusions

New fundamental principles of sustainable development have been discussed in this paper. The sustainability approach presented is diachronic, statistical and macro-oriented, whereas synchronic issues concerning decomposition are not discussed. A new theoretical framework of necessary conditions for advancing sustainability is formulated by relating the total environmental stress to the indicators and variables of the economic, technological and social development. Empirical analyses of one country's data (Finland) were conducted to demonstrate the applicability of the theory. The explanatory power of the theory was demonstrated through important new concepts and formulas as well as through the empirical analyses using mainly the total material flow as a measure for total environmental stress.

Results show that the theory works well in evaluating the ecological sustainability of economic and social development. According to the theory the case country (Finland) has not given the advancement of sustainability a real priority among the objectives of the society, such as economic growth, automation or employment. Sustainability is, de facto, a global ethos, where each country has a joint role to play together with all others. The theory needs to be supplemented with a global decomposition theory enabling us to conduct synchronic analyses in addition to the diachronic analyses now available.

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[1] The number of references was limited to 12 key references by the Editor of the publication.

A SUSTAINABILITY EVALUATION FRAMEWORK AND ALTERNATIVE ANALYTICAL SCENARIOS OF NATIONAL ECONOMIES

by

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The total environmental stress approach

This paper concerns ecological sustainability, which, is defined by taking into account, the total environmental stress (TES) caused by human action. It is postulated, that decreasing TES is a necessary (albeit not sufficient) condition for advancing ecological sustainability. Environmental stress is generated not only when natural resources are taken from the environment and used in production and consumption, but also when wastes and pollution are discarded and thus returned to the environment. There is now widespread agreement, which formed the basis of the UNCED process, that most current economic development is not ecologically sustainable and that the unchecked consequences of this are likely to be unpleasant and perhaps catastrophic (Ekins 1996).

The TES Approach regards sustainability in this paper as basically an ecological concept, much like the Wuppertal Approach with which it has a lot in common. The quantitative level of TES may be indicated in various ways such as, the total material flow, (MF) or energy flow (EF) from the environment, through the material production system and back to the environment (see e.g. Malaska 1971, Spangenberg, 1995, Femia et al. 1999a, 1999b) and also, via anthropogenic gas flows such as CO_2. In the mathematical formulation of the theory, material flow (MF) is used as an indicative measure of TES. The methodology for measuring the material throughput (MF) has been studied by Hoffrén (1999a, 1999b) and Femia et al. (1999a, 1999b).

Conceptualising a sustaianable environment

A theoretical framework for advancing sustainability is presented in this chapter. The theory is formulated as a set of two basic postulates of the necessary condition, and four logical identities, called the master equations of the theory. They relate total environmental stress (TES) to the basic indicators of economic, technological and social development. The explanatory power of the theory is demonstrated by important new concepts and formulas presented in this paper and with the empirical analyses conducted. More detailed analyses can be found in Malaska et al. (1999), Kaivo-oja et al. (2001) and Hoffrén et al. (2001).

Decreasing TES over time is postulated as the first necessary condition for the advancement of ecological sustainability. The other necessary condition of sustainability postulated is the growth of welfare. Whether the present state is sustainable, or not, is not addressed in the present analysis, and it would need another kind of a theory. According to Spangenberg (1995) the use of raw materials already exceeds the sustainable level of consumption in industrialized countries. In contrast other researchers have found countries, which do not, as yet, exceed the sustainable levels of material consumption. However, global consumption is still too high (see e.g. Weizsäcker et al. 1997).

The theoretical frame of this paper is about change in the prevailing situation either towards sustainability or away from it.

The postulates for advancing towards sustainability from the present state are formulated in (P1) and (P2):

P1. Without a decrease in total environmental stress, sustainability will not occur:

$$\mathbf{D}(\mathrm{TES}) < \mathbf{0} \tag{1}$$

P2. Without a growth in welfare, sustainability will not occur:

$$\mathbf{D}(\mathrm{WF}) > \mathbf{0} \tag{2}$$

D(.) refers to the operator of change between an end year and the base year, i.e. $\mathbf{D}(X) = (X - X_o)$ with X as the end year value of a quantity, TES stands for total environmental stress and WF for welfare.

The postulates define what is meant by the creation of ecological sustainability. Economic, social or cultural decisions, which do not meet the conditions postulated, are regarded as ecologically unsustainable. Hence, all decisions should decrease total environmental stress (TES) and increase welfare (WF). However, if the decisions or policies meet these conditions, it is not as yet sufficient, but only possible that sustainability can occur with those decisions. Therefore, the question is of necessary but not sufficient conditions for sustainability. This theory conceptually defines a domain, where decisions possibly would create a sustainable environment and another domain where sustainable processes become impossible to maintain or create.

The logic of the analysis is built on theoretical identities called the master equations of the theory. The four master equations of the theory are presented in equations 3 to 6. The first equation relates the TES-indicator of MF to the supply side of an economy through a quantity called the material intensity of production. In the second equation the TES is related to employment and automation. The third equation relates TES to the materially intensive and less materially intensive sectors of the economy in the creation of ecological sustainability. The fourth identity refers to the demand side within welfare, and entails two new concepts called the welfare productivity of GDP and the material intensity of welfare. From each identity important new concepts of sustainable development are derived for use in policy formulations and empirical studies.

On the supply side, *production identity* relates the TES-indicator, i.e. the total material flow (MF), to population (POP), GDP production volume per capita (GDP/POP) and the material intensity of production (MF/GDP) as follows:

$$MF \equiv POP \times \left(\frac{GDP}{POP} \right) \times \left(\frac{MF}{GDP} \right) \tag{3}$$

Here MF stands for the material flow through the industrial production system, POP stands for population and GDP, the gross domestic product, stands for a measure of the total supply. The first identity states that the bigger the human population is, and the higher the level of economic supply per capita, the stronger the environmental stress is. Furthermore, the more materially intensive the economy is, the stronger the environmental stress effects are. Researchers have been familiar with this formula and approach since the 1970s (Malaska 1971, Commoner 1971, Malaska 1994). It was first formulated for the declaration to the first UN Conference on the Human Environment in Stockholm in 1972, by the world community of engineers (FEANI 1972, United Nations 1972). Similar statements have been presented by Paul and Anne Ehrlich and by Paul Ekins (Ehrlich et al 1970, Ekins 1991, Ekins 1996) and further elaborated and familiarized via the Wuppertal MIPS concept (see Femia et al. 1999a, 1999b). The TES approach discusses the environmental impacts of economic and social activity both from the supply side and the demand side respectively.

The second identity relates TES to *employment* (EMP), to the employment population ratio (EMP/POP), and to the quantity of (MF/EMP), i.e. the amount of material throughput per employed worker.

$$MF \equiv POP \times \left(\frac{EMP}{POP} \right) \times \left(\frac{MF}{EMP} \right) \tag{4}$$

The identity states that the higher the employment ratio, or the material throughput per worker, the higher the total environmental stress caused by production. And of course - ceteris paribus - the environmental stress is the higher the larger the population is.

A *structural shift* within the economy means that a more diversified and enriched mode of supply and demand emerges and substitutes the prevailing monolithic supply and demand profile of the economy. The on-going change from the industrial economy to a service economy provides a demonstration of such a structural shift. With the help of master equation (5) it is possible to show that this kind of shift can also play an important role in advancing ecological sustainability. The structural shift master equation is:

$$\frac{MF}{EMP} = \frac{MF_0}{EMP_0} x W_0 + \frac{MF_n}{EMP_n} x\left(1 - W_0\right)$$ (5) and

$$W_0 = \frac{EMP_0}{EMP} \quad \text{and} \quad \left(1 - W_0\right) = \frac{EMP_n}{EMP} = W_n \tag{5a}$$

In Equation (5) W_o stands for the share of the people employed in the materially more intensive sector related to the total number employed in the economy. In equation (5a)$(1\text{-}W_o)=W_n$ is the complementary share of the less materially intensive sector. Subscript o and n refer to the two different sectors of the economy. Subscript o stands for the sector, which declines in the profile, and subscript n refers to the sector, which increases its share in the profile. The theory assumes that the material throughput per worker (MF/EMP) of the former sector is much larger than that of the other;

$$\frac{MF_n}{EMP_n} << \frac{MF_o}{EMP_o} \tag{5b}$$

It is also assumed that the change from an industrial economy to a service or network economy means that W_0 decreases and W_n increases. With this type of structural shift it is possible to decrease the total material flow per employed worker (MF/EMP) in spite of the automation of production. Hence the structural shift of the economy provides one possible approach for creating sustainability.

The GDP measure can be understood by referring to two elements of the national accounting balance: The total supply and the final demand. From the environmental point of view, consumption and investments need not be separated. In what follows GDP is seen as a measure of final demand The *welfare identity* relates TES with welfare (WF) and the quantity of the material intensity of welfare, i.e. the (MF/WF) ratio.

$$MF = \left(MF/WF\right) \times WF \tag{6}$$

Another identity relates welfare to economic growth (GDP) through the concept of welfare productivity (WF/GDP).

$$WF = \left(WF/GDP\right) \times GDP \tag{6a}$$

Here WF stands for welfare as postulated in (P1). We assume that it can be measured independently of economic growth. In recent years there have been many attempts to define and measure it (e.g. via ISEW, HDI, GPI concepts), and numerous indicators are already available for this purpose (see e.g. Daly et al. 1989, Stockhammer et al. 1997). They make it possible to talk about the concept of (WF/GDP) as the welfare productivity of GDP. This allows us to discuss welfare as a desired end product and economic growth and GDP as a means for welfare. The new concept of (WF/GDP) provides a method for measuring how much welfare is derived from one unit of GDP, which we can define as the welfare productivity of GDP. Thus economic growth and GDP is no longer considered as the desired end goal but only as a better or worse means for welfare. The analysis therefore provides the means to assess economic growth from the point of view of sustainability.

The theoretical derivation

In the equations (1) to (6) several new considerations for ecologically sustainable development are derived. Some of them challenge current aims and concepts behind economic and technological development and create theoretical dilemmas. The aims and desires of sustainable development raised by the theory are therefore discussed in order to comprehend those dilemmas. Consequently the theory should allow for the improved formulation of sustainable development policies.

An analysis of the Production Dilemma

Starting with the supply master equation (3) we get the per-unit value formula (7) for the change of material flow as the TES:

$$\mathbf{D(}\mathrm{MF}\mathbf{)} = (\mathrm{MF/GDP})\mathbf{[}(\mathrm{GDP/POP})\mathbf{D(}\mathrm{POP}\mathbf{)} + \mathbf{D(}\mathrm{GDP/POP}\mathbf{)]} + \mathbf{D(}\mathrm{MF/GDP}\mathbf{)} \quad (7)$$

The quantity in the brackets [ ] of the formula (7) is the economic growth:

$$\mathbf{D(}\mathrm{GDP}\mathbf{)} = (\mathrm{GDP/POP})\mathbf{D(}\mathrm{POP}\mathbf{)} + \mathbf{D(}\mathrm{GDP/POP}\mathbf{)} \quad (7a)$$

Equation (7a) shows how the change of economic growth is comprised or divided between the population growth effect and the economic growth effect per capita. In this paper only an analysis of total economic growth is made and the population growth problem is not taken into explicit analysis. It is evident that the world's population will continue to grow for the foreseeable future, i.e. $\mathbf{D(}\mathrm{POP}\mathbf{)} > 0$ and that continuing economic growth per capita will also remain a dominant objective in every economy in the foreseeable future meaning that $\mathbf{D(}\mathrm{GDP/POP}\mathbf{)} > 0$, thus, the necessary condition for advancing ecological sustainability, i.e. $\mathbf{D(}\mathrm{MF}\mathbf{)} < 0$, can only be met by forcing the last term of (7) to decrease in order to counter-act the sum effect of the two other terms. This condition means decreasing the material intensity of production, in other words obtaining more production output from less use of natural resources. This is here called the *dematerialization of production* (see Fig. 1). The dematerialization process of production or the supply side of the economy stated above is defined in mathematical form in (8):

$$\mathbf{D(}\mathrm{MF/GDP}\mathbf{)} < 0 \quad (8)$$

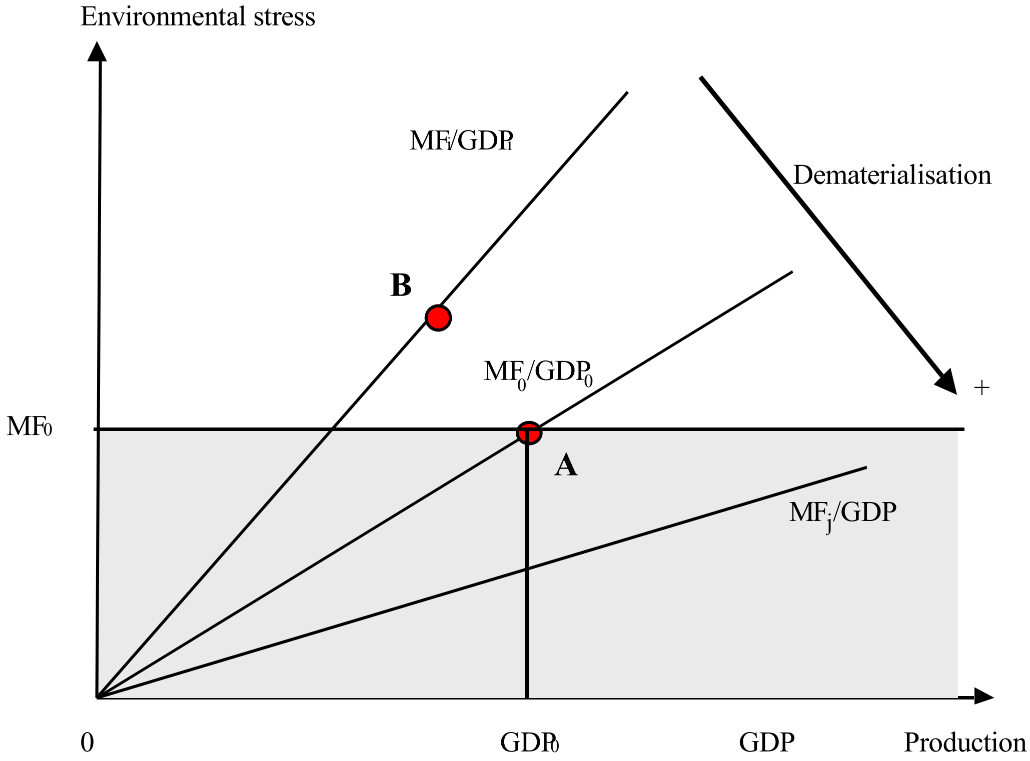

Figure 1. Graphical illustration of dematerialization of production and the shaded feasibility area of Sustainable Development at the reference state A. The state B is on the un-sustainability region.

The quantitative change in total environmental stress due to dematerialization is called the dematerialization effect (Dem-effect) and is defined in an empirically measurable way in (8a):

Dem-effect = **D(**MF/GDP**)** (8a)

When ecological sustainability improves the Dem-effect shows negative values. However, the total use of natural resources, and thus the total environmental stress caused by production, has increased in many countries from the 1970s to 90s despite dematerialization processes occurring (Hoffrén 1999b). It appears that there are other processes going on at the same time as dematerialization, that counter-balance the dematerialization effect. One of them is fast economic growth itself with its excessive contribution to total environmental stress. This is here called the growth effect, or Gth-effect for short. The growth effect is defined as the total change of TES, or in quantitative terms:

Gth -effect = **D(**MF**)** (9)

The simultaneous occurrence of the dematerialization effect and the growth effect generates a complementary third theoretical term, which is called the gross rebound effect and (here termed the GRbd-effect). It represents the change of the TES in excess of the dematerialization effect. The dematerialization process may give birth to counter-acting rebound effects. Some other researchers use the term rebound differently to include it as an intrinsic part of the excess of the change, which can be attributed to specific and known counter-acting causes. The term Gross rebound is aimed at recognizing the difference of definitions. From equations (7), (8) and (9) we get a definition of the gross rebound effect in (10):

GRbd-effect = Gth-effect - Dem-effect (10)

In an empirically measurable form we get

GRbd-effect = = **D(**MF**) - D(**MF/GDP**)** (10a)

Under sustainable conditions economic growth is inevitably both possible and desirable. The more effective the dematerialization process is the faster the economic growth may be without causing a deviation from a sustainable development track. Sustainable economic growth is defined as the maximum growth permissible which does not lead to a positive growth effect, i.e. as the condition of **D(**MF**)** = 0 in equation (9). From there we get the definition of sustainable economic growth (SE-growth) in (11).

SE-growth = - **D(**MF/GDP**)** / (MF/GDP) (11)

The above equation asserts that under sustainable conditions cumulative economic growth between the base year and the end year cannot exceed the relative improvement of the material intensity during that time, or if annual figures are used, the economic growth rate cannot exceed the rate of dematerialization of production. From another point of view the change in the material intensity of production may be interpreted as an implication of technological development. Decreasing intensity is possible only through technological development and thus these two factors are causally related to each other. With this interpretation in mind equation (11) shows that the faster the technological development is, the faster economic growth can be and yet still be acceptable within the regime of sustainability. If the growth effect is positive, it indicates that the real growth rate is unsustainable. In such cases a sustainable economic policy would call for either the slowing down of the economic growth rate or the acceleration of the pace of technological development. If the economic growth rate is a fixed and inflexible target, the pace of technological development - sustainable technological development - becomes of primary interest in maintaining sustainability. The definition linking sustainable technological development (ST-dev.) to the targeted economic growth **D(**GDP**)** is given in equation (11a):

ST-dev. = (MF/GDP)**D(**GDP**)** (11a)

The defined terms are depicted in Fig. 2.

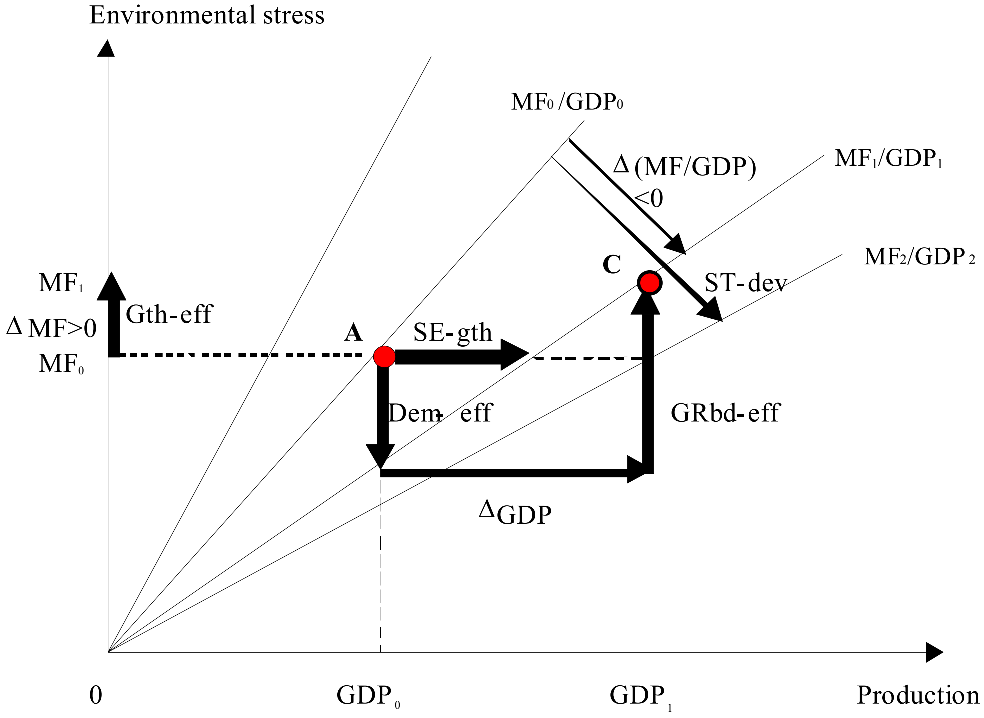

Figure 2. Graphical illustration of the basic concepts of the theoretical framework of sustainability. In the course from A to C the economic growth (□GDP) exceeds the sustainable economic growth (SE-gth) and dematerialization of production is insufficient and Dem-eff inadequate to maintain sustainable development. Unsustainability is indicated by the positive values of Gth-eff.

The Employment and Automation Dilemma

At first sight the relationship of ecological sustainability to employment is opaque and obscure. The effect of automation may be assumed supportive to sustainability, because of its more efficient use of natural resources. But the identity relation of the total environmental stress with employment in (5) reveals new aspects of the issue. Redefining **D(**MF**)** in employment form we get:

$$\mathbf{D}(\mathrm{MF})=(\mathrm{MF/EMP})(\mathrm{EMP/POP})\mathbf{D}(\mathrm{POP})+(\mathrm{MF/EMP})\mathbf{D}(\mathrm{EMP/POP})+\mathbf{D}(\mathrm{MF/EMP}) \quad (12)$$

The growth of population, **D(**POP**)**>0, will remain an unavoidable fact for a long time to come. And maintaining the employment level of population as high as possible is an uncompromising policy of any government, i.e. **D(**EMP/POP**)**>0. The only factor in the right hand side of the equation that might bring a decreasing effect to environmental stress is the material flow handled per employed worker or **D(**MF/EMP**)**<0. This then becomes a key factor in creating a sustainable environment. However, present economic development automates production and moves in the opposite direction. The quantity of (MF/EMP) is related to automation so that the ratio increases with increasing automation. The very process of automation means that a smaller number of workers will manage and handle larger and larger volumes of material flow due to more and more efficient production systems and machines. Accordingly, the consequence is, that total environmental stress will increase if employment increases. For the change in the ratio (MF/EMP) we use the above:

$$\mathbf{D(}\mathrm{MF/EMP}\mathbf{)}\,/(\mathrm{MF/EMP}) < -\,[(\mathrm{EMP/POP})\mathbf{D(}\mathrm{POP}\mathbf{)}+\mathbf{D(}\mathrm{EMP/POP}\mathbf{)}] \qquad (12a)$$

In the above equation the value of the right hand side is negative, but advancements in automation keep the left side positive. This is a sustainability dilemma in mathematical form and does not have a direct solution. One has to turn to an analysis of the structural shifts in an economy for a solution.

Structural Shifts in an Economy as a Sustainability Solution

Structural shifts offer a solution to the employment and automation dilemma. They provide a way to decrease the (MF/EMP) ratio even with increasing employment and automation. The necessary condition for this is a multisector economy where some sectors deviate from each other in their material intensity of supply. The material flow per employed worker in the dominant industry is assumed to be much larger than in other sectors of the economy. If the less materially intensive sector increases its share of total employment, the (MF/EMP) ratio to the whole economy will decrease. A shift in employment from the materially intensive sectors to those less materially intensive thus allows for the solution of the sustainability dilemma of the previous chapter. Firstly, equation (5) must be looked at again. In that equation the ratio (MF_o/EMP_o) increases in the dominant industry sector (denoted by the subscript o) as automation increases, i.e. the condition $\mathbf{D(}MF_o/EMP_o\mathbf{)} > \mathbf{0}$ holds. On the other hand there is a chance to shift the total employment share from that sector to a less materially intense sector, as in; $\mathbf{D(}W_o\mathbf{)} < \mathbf{0}$. The change in the ratio of the whole economy **D(**MF/EMP**)** is then from (5)

$$\mathbf{D(}\mathrm{MF/EMP}\mathbf{)} = (MF_o/EMP_o)\mathrm{x}\mathbf{D(}W_o\mathbf{)} + W_o\mathrm{x}\mathbf{D(}MF_o/EMP_o\mathbf{)} - (MF_n/EMP_n)\mathrm{x}\mathbf{D(}W_o\mathbf{)} \qquad (13)$$

The structural shift value $\mathbf{D(}W_o\mathbf{)}$, which would be adequate to counterbalance the automation advance would then follow from the condition of **D(**MF/EMP**)** < 0:

$$\mathbf{D(}W_o\mathbf{)} < \frac{\mathbf{D(}MF_o/EMP_o\mathbf{)}}{MF_o/EMP_o - MF_n/EMP_n} \qquad (14)$$

This formula gives the sufficient minimum structural shift in terms of the relative change in the prevailing industry's share of employment $\mathbf{D}(W_o)/W_o$. The greater the difference between the intensive and the less intensive sectors, the smaller the shift that is capable of balancing an assumed advance in automation, and vice versa. The equation (14) shows that the shift from an industrial to a service economy is in accordance with an ecologically sustainable ethos. The effects of automation and the structural shift are depicted in Fig. 3.

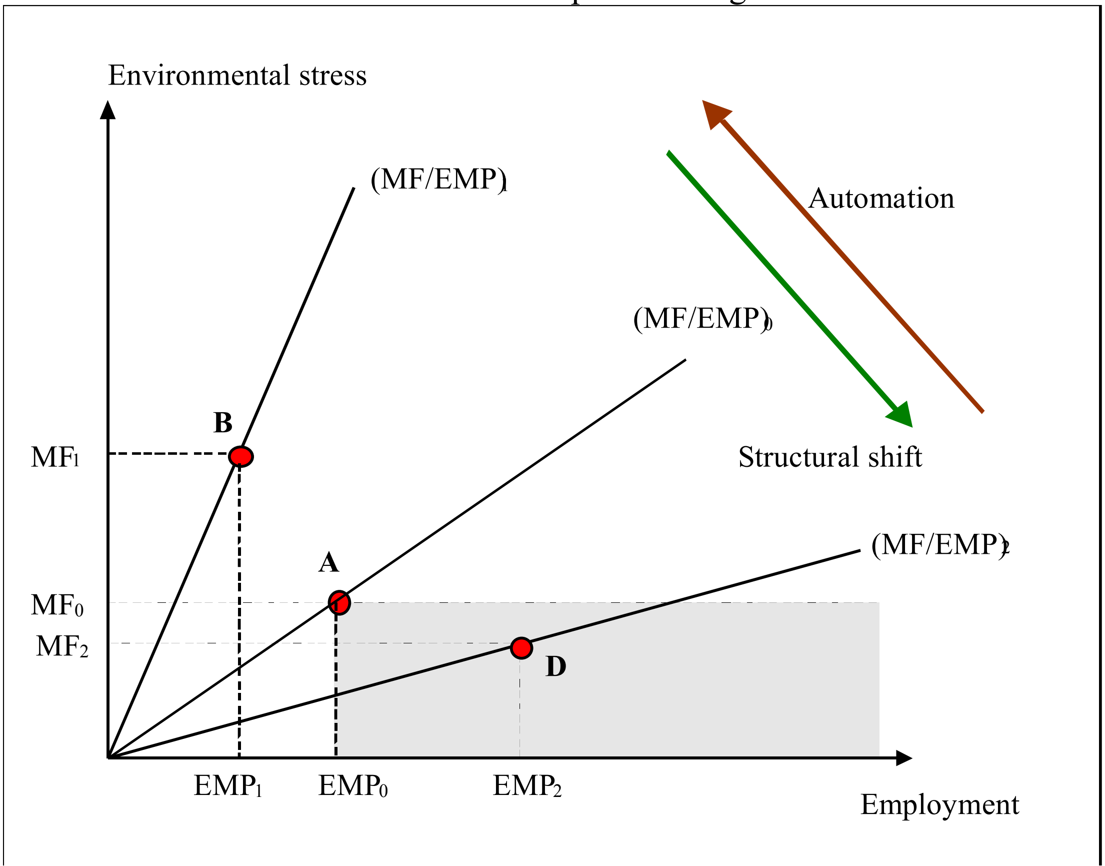

Figure 3. Graphical illustration of the basic concepts of the automation and structural shift. With the automation the material flow per employed worker increases while structural shift to service economy can decrease the average material flow per employed worker.

The Immaterialisation of Consumption

The ultimate goal of human productive activity is here defined as not the production and consumption of ever more material goods, but as providing human welfare for which material production is only as a means to an end. Thus environmental stress accounting must be extended to meet the demands of welfare. In equation (6) a concept of the material intensity of welfare was presented and defined as the ratio between the material flow and the welfare provided, (MF/WF), on the demand side. The equation relates TES with welfare production and its material intensity. Via a difference operation we get the following condition of advancing sustainability:

$$\mathbf{D}(MF) = (MF/WF)\mathbf{D}(WF) + \mathbf{D}(MF/WF) < 0 \qquad (15)$$

According to the postulate P2 welfare should increase. From this it follows that a decrease in the material intensity of welfare, i.e. **D(**MF/WF**)** < 0, is a sine qua non to the advancement of sustainability. The process leading to a decrease in the material intensity of welfare is named immaterialisation of consumption (see Fig. 4).

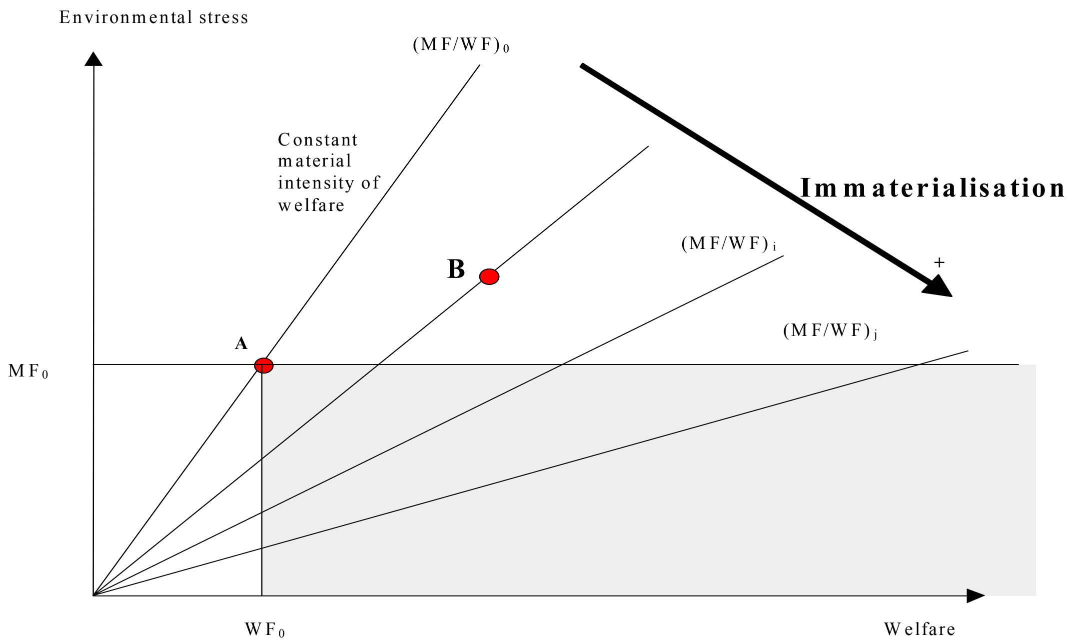

Figure 4. Graphical illustration of immaterialisation of consumption and the shaded feasibility area of Sustainable Development at the reference state A. The state B is on the unsustainability region.

In a way analogous with the dematerialization effect it is now possible to define the immaterialisation effect on the demand side. This requires a fictive decrease of TES in the base year due to the change in the material intensity of welfare, i.e. Imm-effect = **D(**MF/WF**)** in the per unit value of TES. And respectively it is possible to define an indicator for the concept of the sustainable welfare growth as; the maximum growth of welfare given the pace of immaterialisation, i.e. SW-growth = **- D(**MF/WF**)/ (**MF/WF**).** The concepts are depicted in Fig. 5.

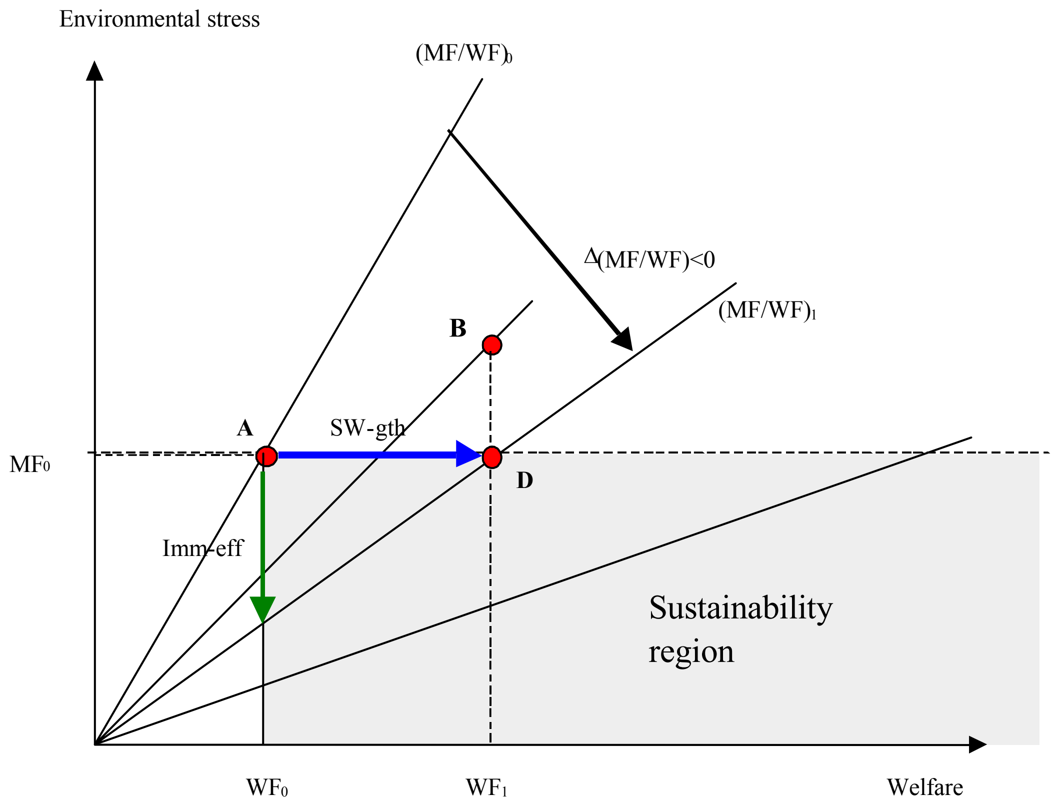

Figure 5. Graphical illustration of the basic concepts of the immaterialization of consumption, when □(MF/WF) is given. Sustainable growth of welfare at point A is SW-gth and immaterization effect on TES is Imm-eff.

Welfare Productivity

From the welfare identity in equation (6a) and the postulate P2 a necessary condition for the creation of advancing sustainability is derived for equation (15a)

$$\mathbf{D}(WF) = (WF/GDP)\,\mathbf{D}(GDP) + \mathbf{D}(WF/GDP) > 0 \qquad (15a)$$

The sustainability conditions of equations (15) and (15a) define a feasible area of sustainability for economic growth and welfare productivity (see Fig. 6).

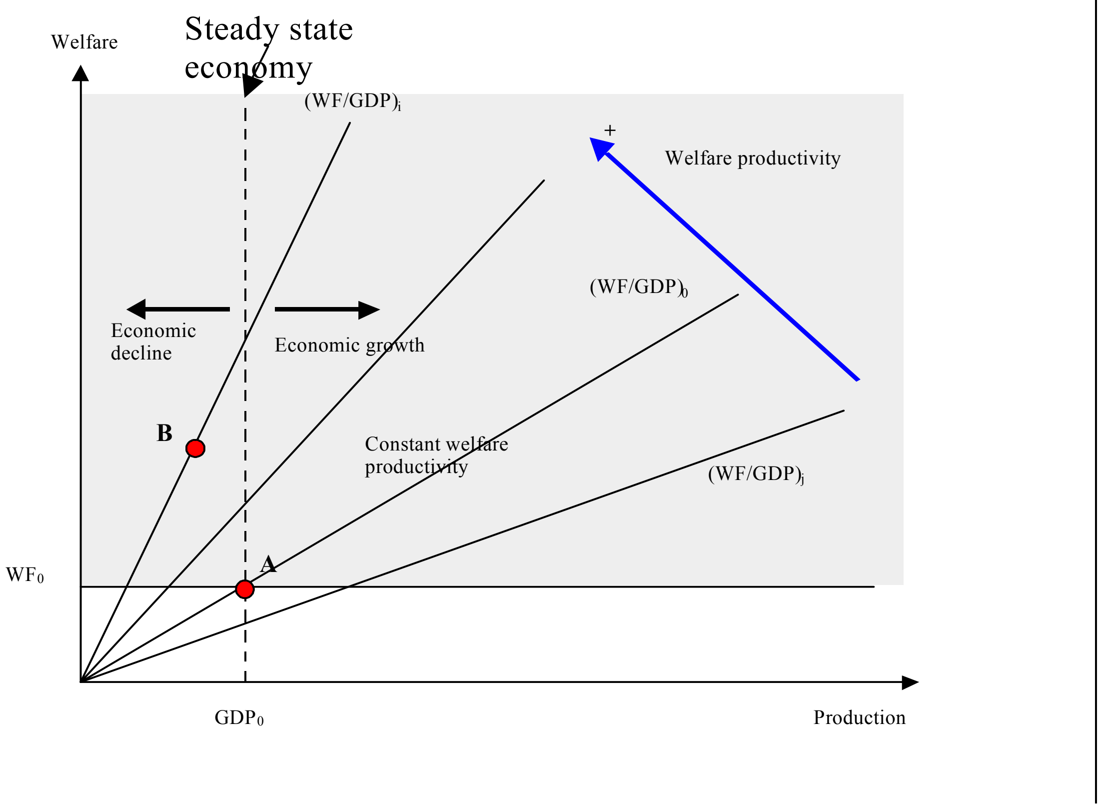

Figure 6. Graphical illustration of the welfare intensity dimension of sustainability analysis. Economic growth is not a necessary condition of sustainable development nor is it a preventing condition. A steady-state economy may well be an alternative to sustainable development. The point B on the shaded area corresponds to the state B in Figure 1, Figure 4 and Figure 5 and accordingly it represents unsustainable course from A. The shaded area is a region of necessary but not sufficient condition of sustainable development.

In general there are three different feasible sub-areas of sustainability. In one sub-area sustainable conditions are maintained via strong growth in welfare productivity and even with negative economic growth. In the second area high economic growth dominates, and the third sub-area is characterized by variability between economic growth and welfare productivity growth rates. The actual choice of these values determines the pace of decrease for the material productivity of welfare, i.e. the pace of the immaterialisation of consumption.

A Scenario framework

Alternative Scenarios

On the basis of the previous theoretical analyses we can present a three-dimensional scenario framework. The dimensions are: welfare, production and environmental stress. In Figure 7 we present the welfare – production space. In the framework four different development paths are begun from the base year of the analysis. They are; (A1) economic production growth with increasing welfare, (A2) economic production growth with decreasing welfare, (A3) economic production decline with decreasing welfare and (A4) economic production decline with increasing welfare. Only development path A1 fulfils the necessary condition for sustainable development. All other development paths are more or less unsustainable, A4 being the least sustainable.

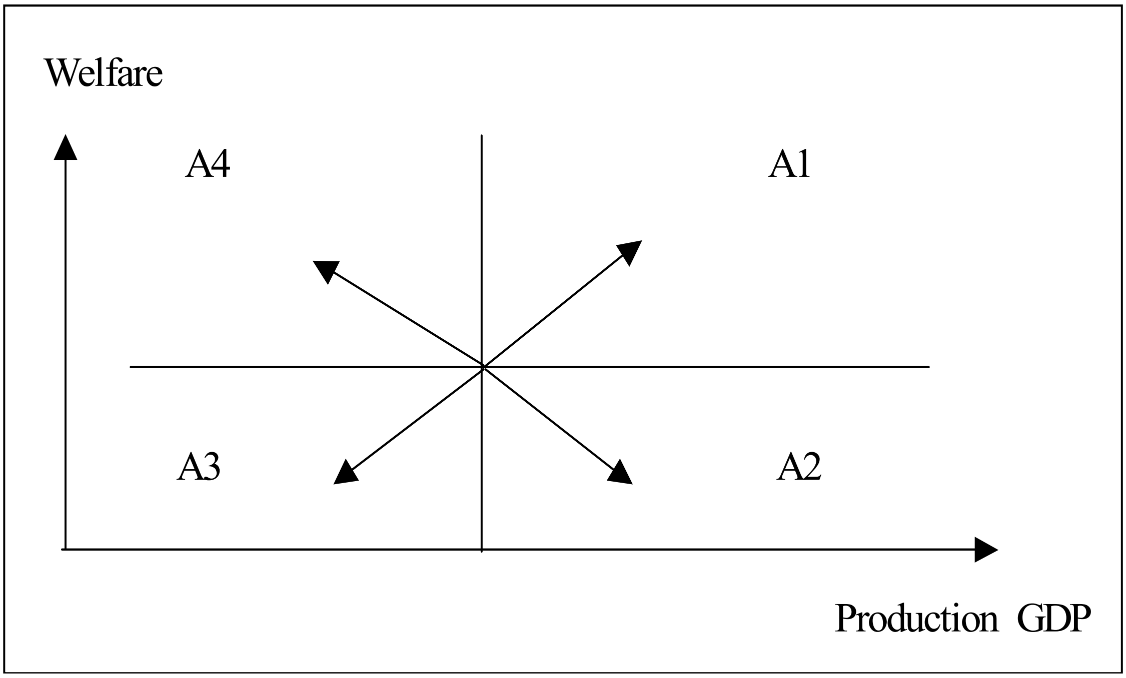

Figure 7. Welfare – production space indicating possible development path directions.

In Figure 8 we present the environmental stress – production space. In the framework there are four different development paths: (B1) economic production growth with increasing environmental stress, (B2) economic production growth with decreasing environmental stress, (B3) economic production decline with decreasing environmental stress and (B4) economic production decline with increasing environmental stress. Only development path B2 fulfils the necessary condition for sustainable development. All other development paths are more or less unsustainable, B3 being the least sustainable.

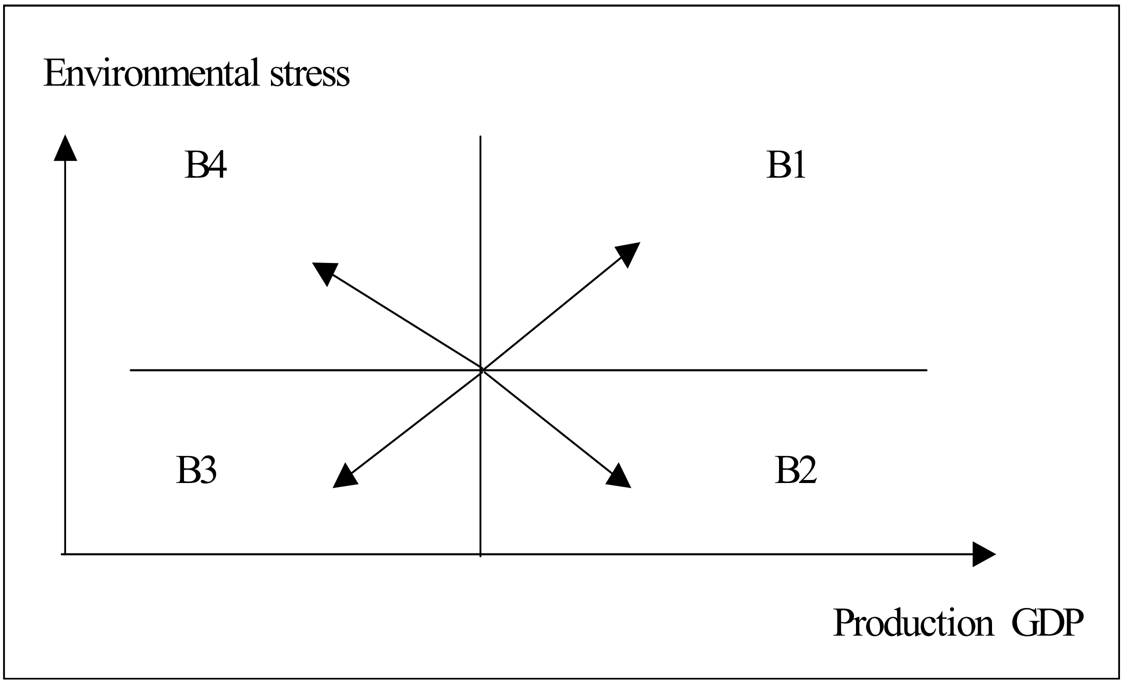

Figure 8. Environmental stress – production space indicating possible development path directions.

In Figure 9 we present the environmental stress – welfare space. In the framework there are four different development paths: (C1) welfare growth with increasing environmental stress, (C2) a decrease in welfare with increasing environmental stress, (C3) welfare decline with decreasing environmental stress and (C4) welfare growth with decreasing environmental stress. Only development path C4 fulfils the necessary condition for sustainable development. All other development paths are more or less unsustainable, C2 being the least sustainable.

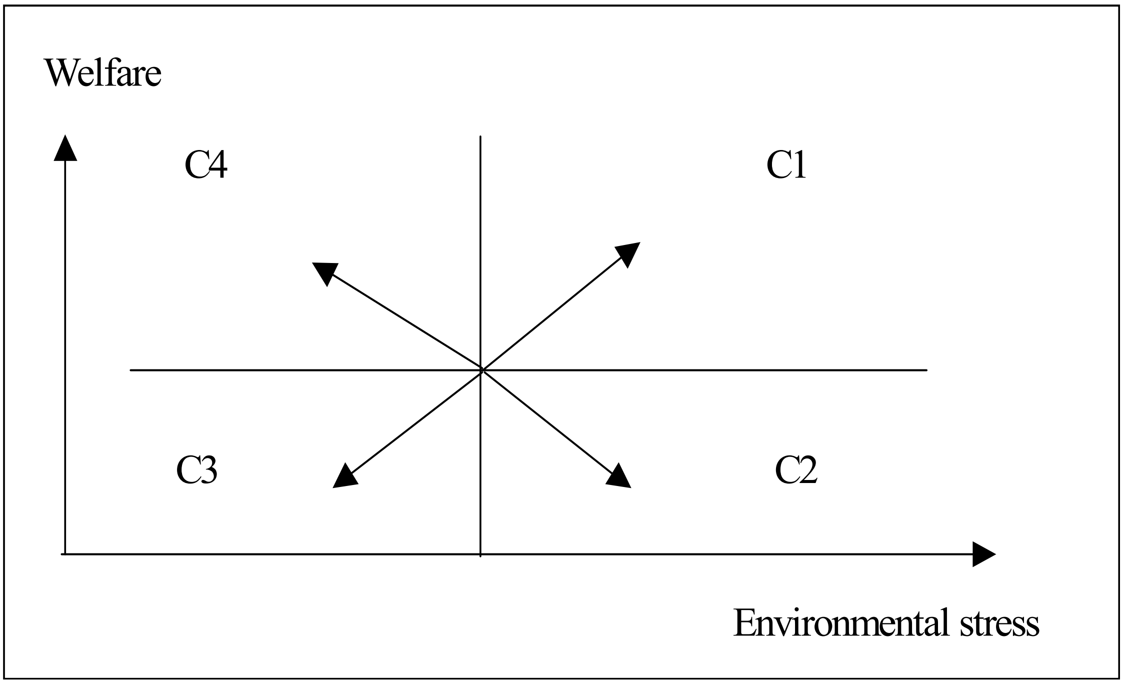

Figure 9. Welfare – environmental stress space indicating possible development path directions.

On the basis of previous analyses we can present a summary of all possible scenarios. A summary is presented in Table 1.

Table 1. Alternative scenarios according to the Total Environmental Stress (TES) approach.

Scenario groups		**Symbols**	**Title of a scenario**
Increasing growth and increasing welfare	Increasing TES	1 $A_1B_1C_1$	”To Eco-destruction in the First Class”
	Decreasing TES	2 $A_1B_2C_4$	Strong Sustainable Development
Increasing growth and decreasing welfare	Increasing TES	3 $A_2B_1C_2$	Destructive Growth
	Decreasing TES	4 $A_2B_2C_3$	Social Misery with Growth and Nature
Decreasing growth and increasing welfare	Increasing TES	5 $A_4B_4C_1$	Happiness in polluted ”Stoneage”
	Decreasing TES	6 $A_4B_3C_4$	Deep Ecology
Decreasing growth and decreasing welfare	Increasing TES	7 $A_3B_4C_2$	Doomsday
	Decreasing TES	8 $A_3B_3C_3$	Hard life with the Nature

Conditions for Sustainability

The three critical conditions of sustainability can be distinguished as:
D(TES) < 0. This condition is fulfilled in scenarios 2, 4, 6 and 8.
D(WF) > 0. This condition is fulfilled in scenarios 1, 2, 5 and 6.
D(GDP) > 0. This condition is fulfilled in scenarios 1, 2, 3, and 4.

We can apply these conditions in two alternative ways: Temporarily and via indefinite time perspectives. We can identify four critical combinations for attaining sustainability conditions:

D(TES) < 0 AND D(WF) > 0. Ecological and social sustainability. These conditions are fulfilled in scenarios 2 and 6.
D(TES) < 0 AND D(GDP) > 0. Ecological and economic sustainability. These conditions are fulfilled in scenarios 2 and 4.
D(WF) > 0 AND D(GDP) > 0. Social and economic sustainability. These conditions are fulfilled in scenarios 1 and 2.
D(TES) < 0 AND D(WF) > 0 AND D(GDP) > 0. Ecological, social and economic sustainability. These strong sustainability conditions are fulfilled only in scenario 2.

In an empirical sustainability evaluation we can use these alternative conditions for measuring sustainability. The measurement of the different sustainable dimensions of an economy can be made by defining their class of sustainability (ecological, social and economic sustainability). Their sustainable criteria can then be used in macro-economic sustainability analyses. In addition an analytical scenario evaluation can be made based on the general framework presented.

An empirical case: Finland

In this chapter we shall present a demonstration of the TES scenario approach. Finland is used for this a case study example and in the empirical analysis, total material flow is used to indicate the total environmental stress. Another option would have been to use a measure of the total energy use, as energy is inseparable from material processes, whether it is used for extraction, production, consumption, or rejection and waste treatment. All those material phenomena are associated with energy-flow changes from higher to lower qualities, according to the law of entropy. A third, and better, way would be to use a combination of different environmental indicators that give a more comprehensive estimate of the total environmental stress. However, only material flows are used as indicators in order to demonstrate the method.

The use of welfare in sustainability analyses calls for it to be measured independently of GDP. Numerous attempts to define and measure it have been made. The UNDP's Human Development Index (HDI) has gained increasing acceptance since 1990 (see UNDP 1990-1998). In this study it is used to analyse immaterialisation processes, and the welfare productivity of GDP from 1960 to 1995 is determined accordingly. The use of HDI in measuring welfare has some special problems (e.g. the maximum value it can attain is 100) but in this paper we do not discuss this or other problems of welfare indices. It would be useful to make a comparative analysis based on different welfare indexes (ISEW, Gini-coefficients etc.), but in this paper we limit our analyses to the use of HDI. The sources of the data are the Finnish Yearbooks of Industrial Statistics from 1970-1997 (Statistics Finland 1970-1997a), the Statistical Yearbooks of Finland from 1970-1997 (Statistics Finland 1970-1997b), Energy Statistics 1997 (Statistics Finland 1997) and material flow databases from Statistics Finland (Hoffrén 1999a, 1999b).

In Fig. 10 the development of the Finnish economy from 1960 to 1995 is presented in the GDP – MF space. On the basis of Fig. 10 a B1 type of development path is identified.

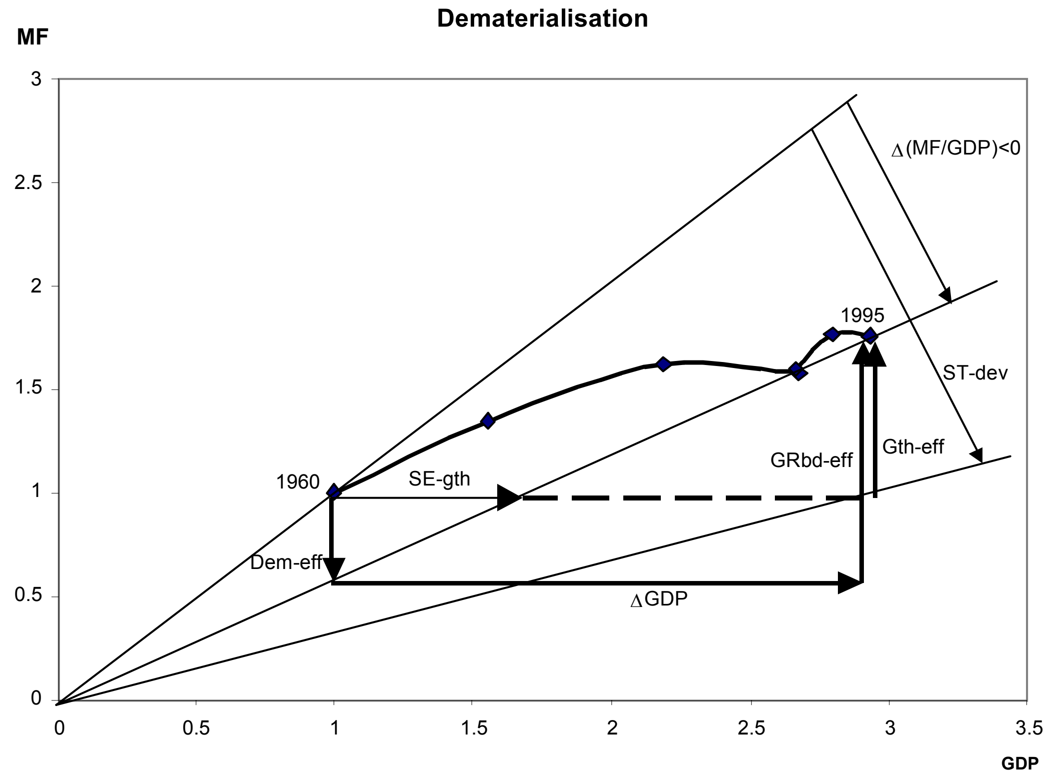

Figure 10. GDP – MF space of the Finnish economy from 1960 to 1995.

In Fig. 11 the development of the Finnish economy from 1960 to 1995 is presented in the HDI – MF space. On the basis of Fig. 11 a C1 type of development path can be identified.

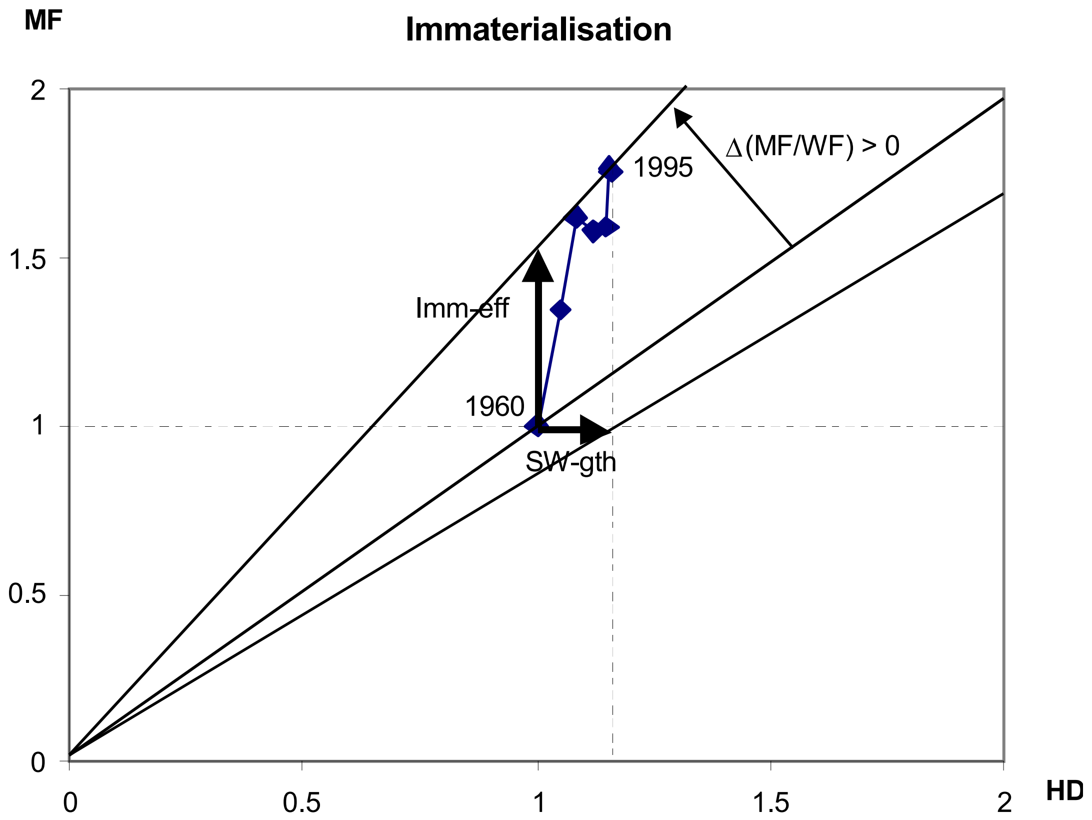

Figure 11. MF – HDI space of the Finnish economy from 1960 to 1995.

In Fig. 12 the development of the Finnish economy from 1960 to 1995 is presented in the GDP – HDI space. On the basis of Fig. 12 an A1 type of development path can be identified.

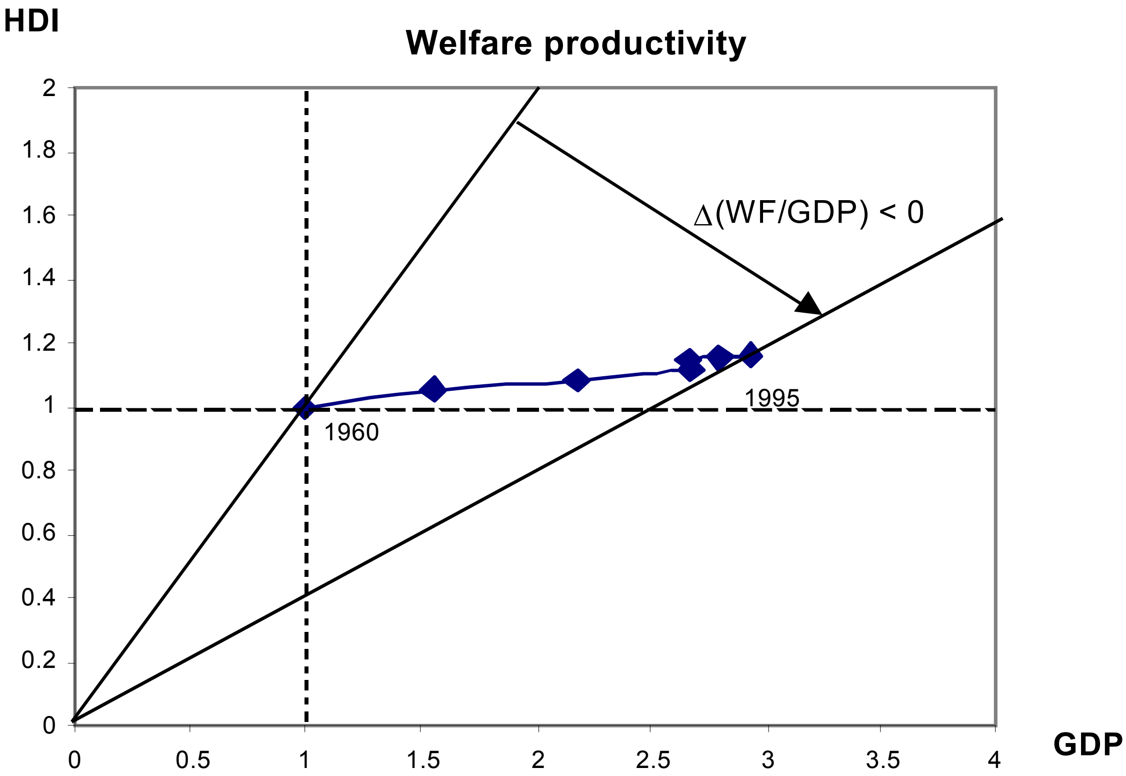

Figure 12. GDP – HDI space of the Finnish economy from 1960 to 1995.

On the basis of Figs. 10-12 a conclusion can be made that the Finnish economy has developed according to the; ”To Eco-destruction in the First Class” -scenario.

Summary

New fundamental principles of sustainable development have been discussed in this article. The sustainable approach presented in this article is diachronic, statistical and macro-oriented, whereas synchronic issues concerning decomposition are not discussed. A new theoretical framework of the necessary conditions for sustainable development has been formulated by relating total environmental stress to indicators and variables of economic, technological and social development. An empirical analysis of Finnish data was conducted to demonstrate the applicability of the theory and the general scenario approach. We wish to emphasise that in future analyses wider sets of economic, technological, social and ecological indicators should be used. It would also be important to make comparative country analyses and other regional comparisons on the basis of the methodology presented in this article. If data is available, the methodology can be used for sustainability analyses at different levels, from local to international.

The results clearly show that the theory works well in evaluating ecological and other dimensions of sustainable development. Our empirical demonstration shows that the theoretical framework can be used in a macroeconomic sustainability evaluation. In this paper 8 alternative scenarios were identified on the basis of the theoretical framework. The analyses, based on the chosen indicators, indicate that the economy of Finland has followed the scenario path; "To Eco-destruction in the First Class". In future studies comparative analyses of different national economies and regions should be carried out to test the applicability of the framework for sustainability planning. It would be especially interesting to connect the presented theoretical framework to the ongoing de-linking debate and set the empirical analysis within a larger scale.

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DECOMPOSITION ANALYSIS OF FINNISH MATERIAL FLOWS: 1960-1996

By

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Introduction

Many researchers argue that the impact of the explosively intensifying exploitation of natural resources on the environment already exceeds the sustainable production of many environmental systems today (see, for example, Brown et al. 1998). According to van Dieren (l995, l00), natural capital is basically our natural environment, and it is defined as the stock of environmentally provided assets such as soil, atmosphere, forests, water, and wetlands that provide a flow of useful goods or services. Natural capital also includes the sinks for wastes (assimilation service). In its conventional sense, sustainability means maintaining the environmental assets, or at lease not depleting them. Overexploitation of natural capital has resulted in undesirable environmental impacts. Materials accounting systems are a means by which the stocks and appropriate flows of natural resources can be combined into a single overall picture describing their interaction. Such systems can be used to analyze changes in the natural capital. A number of articles have studied materials flows in national economies and in the world economy (see, for example, Spencer 1972; Spencer 1980; Malenbaum 1978; Rogich 1993; Wernick 1994; Wernick and Ausubel 1995, 1997; Wernick et al. 1997; Hammond et al. 1995; Ruth and Harrington 1997; Adriaanse et al. 1997; Bringezu 1997; Cleveland and Ruth 1999; Matthews 2000). In this article, we have analyzed materials flows using a decomposition model – a method applied earlier mainly in energy studies. With the decomposition model, it is possible to distinguish the causes of the changes in materials flows: the effect of economic growth or activity effect, the effect of technological or production system change or intensity effect, and the effect of the structural change of the economy or structural effect.

The practical applications of materials accounting provide many new insights into the physical basis of a society. The benefits are numerous. Before proceeding to the actual analysis, however, it is vital to keep in mind the uncertainties and problems that relate to the practical application of these methods. From the biological viewpoint, the use of a small amount of some highly toxic substance in the economy may have a greater impact than the use of a much larger amount of a relatively harmless one. As a result, the summation of various material tonnages into a single measure provides a very rough picture of the state of the environment. It can easily be accused of being unscientific because different materials have different environmental problems. For example, many environmental scientists feel uncomfortable about summing the mass of different materials. No universally accepted weighting system exists for balancing out the environmental effects of different materials. Yet, without this kind of simplifying hypothesis, the opportunity for making macroscale analyses and international comparisons on materials use will he lost. Keeping these shortcomings in mind, we can compile and use aggregated materials measures in this analysis. In fact, materials accounting systems provide the only estimates of changes in materials use that have been produced in a consistent and reliable way. Thus, these estimates are the most reliable for the analysis of the structure of the materials use of an economy.

Although the ratio of the materials consumed by an economy to the quantity of its out-put has improved slightly in the past few years, the consumption of natural resources has nonetheless continued to increase in absolute terms. The shift to the exploitation of poorer ore and mineral deposits, in particular, will mean sharp rises in the amounts of materials that are excavated in ore mining, and in the associated environmental impacts, the so-called ecological rucksack, for each unit of ore produced (Schmidt-Bleek 1994; Ayres and Ayres 1996). At the same time, the energy input required for such exploitation will grow in proportion to the amount of excavated material.

We have used a decomposition model to analyze the materials consumption of an economy. Due to lack of data, previous efforts to analyze materials flows have failed to explore factors affecting the interaction between economic activities and natural resources. Index decomposition methodology was first used in the late 1970s to study the impact of changes in a product mix on industrial energy demand. A recent survey classifies more than one hundred energy decomposition studies based on the application area (e.g., energy and CO_2 emissions), aggregate index number framework, and decomposition scheme (Ang and Zhang 2000). We have not encountered any previous application of decomposition analysis to materials use. Decomposition analysis makes it possible to distinguish the different factors that influence the total amounts, as well as the Structure, of materials use. These effects are the so-called activity, intensity, and structural effects of an economy on materials use. Knowledge of the effects can be utilized to analyze the performance of an economy in relation to its use of material resources. The activity effect describes the impact of economic growth of the economy as a whole on materials consumption, whereas the structural effect indicates the impact caused by a structural change in an economy, that is, a shift in the relative amount of economic activity across sectors (e.g., if the electronics industry grows and the food processing industry shrinks). The intensity effect relates to the efficiency of materials use in the production of economic output. This effect captures the quantity of materials used to produce a given level of economic output. The inclusion of the efficiency analysis in materials flow analyses provides insight into a new dimension in the functioning of an economy. This type of approach has not been presented before.

The decomposition model can be utilized to analyze aspects of the environmental sustainability of a society as a whole as well as factors that contribute to it. That is the aim of this study. Furthermore, in the future, we can use this very same technique to compare the functioning of different national economies and sectoral performances. Possible inefficiencies can be identified through the decomposition model and political actions can be targeted at improving the efficiency of materials use in an economy.

In this study, we use Finnish data to perform the decomposition analysis and to evaluate the potential use of the method in macrolevel sustainability evaluations. In many countries, there are no data available on materials flows. This severely constrains analyses as well as the development and testing of new methods for analyzing the material bases of industrialized economies. In Finland, however, a suitable database on materials flows at the national level has been compiled recently, enabling us to use decomposition analysis. In the 1990s, Statistics Finland worked to develop energy and environmental accounting systems, in particular. By international standards, materials flow accounting is advanced in Finland. This offers new possibilities new developing advanced empirical methods, such as decomposition analysis, that can be used in evaluating sustainability.

We start by providing a brief summary of the structure of the Finnish economy. We then discuss natural resource use in Finland and describe physical resource use in the framework developed by the Wuppertal Institute. This provides the context for the description and application of decomposition analysis to Finnish materials flows. We propose a series of metrics derived from decomposition analysis - dematerialization, immaterialization, and the rebound effect - and apply them to the Finnish data. We conclude by considering the implications of our findings.

Structure of the Finnish economy

In this analysis, total materials consumption is considered to consist of the uptake into the production processes at the economy of ores, minerals, limestone, peat, stone material (gravel, sand, and rocky materials), wood, fossil fuels, cultivated resources produced in agriculture and market gardening, forest by-products (berries, mushrooms, and game), and fisheries output (the catch from professional and recreational fishing). The estimates do not include the consumption of air and water, for which no reliable statistics are available. Nor do the estimates include secondary materials (i.e., materials that are processed from primary materials into useful intermediate goods such as metal plates) or tertiary materials (that is, the next step in the product chain consisting of materials in machinery and equipment).

Today, the Finnish economy, particularly some sectors of export industries that sustain national affluence, is strongly based on the exploitation of natural resources and fossil fuels. Looking back in history, we note that a structural change took place in Finland from an agricultural to an industrial economy after World War II. Figure 1 depicts changes in the shares of GDP of the different sectors of the economy from 1860 to the present day.

The post-war reconstruction and industrialization of the 1940s and 1950s were based especially on the forestry and engineering industries, (e .g., metals processing and manufacturing) and were made possible by the availability of natural resources, cheap hydroelectric power, and a relatively well-educated labor force. The economic backbone of the nation was built around industries exploiting the forest resources and cheap energy, such as the pulp and paper industry, basic metals industry, and the engineering sector. This in turn enabled the later construction of an affluent society. Even though the structure of Finnish industry has diversified since the 1960s and 1970s and the importance of the electronics sector increased during the 1990s, the forestry and basic metals industries are still widely regarded as the backbone of the country's economy. The proportion of the gross national product accounted for by industry began to rise again in the 1990s as a result of policies favourable to industrialization, whereas the proportions accounted for by services, construction, and agriculture have fallen (see Figure 2).

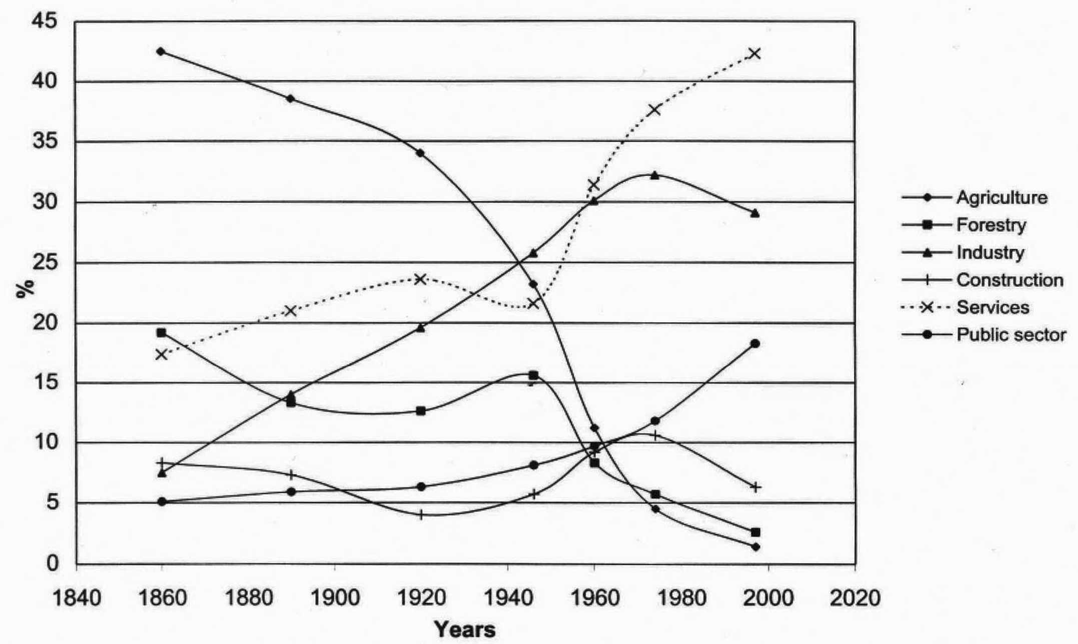

Figure 1 GDP shares of sectors in Finland in the years 1860–1997. Sources: Hjerppe 1988, Hjerppe 1996, OSF, National Accounts 1992–1997, Tables.

Throughout history, Finland's economically most important natural resource has been her forests. In the eighteenth and nineteenth centuries, however, these were exploited in a manner that almost completely wiped out forests in the near vicinity of settlements. Since the 1920s, the use and care of the forests has been based on the idea of sustainable timber production. In the 1950s and 1960s, however, the harvest required for reconstruction exceeded annual growth, which meant that there was an interim fall in timber reserves. Since 1970, the growth in the timber stock has clearly exceeded harvest. Even the total drain, including both fellings and natural wastage (the material content of trees that died of natural causes), is now clearly below the annual volume of growth. Exploitation of timber resources has not endangered the stocks, so in this respect the Finnish forestry industry has met the criteria for sustainable development. The rate of timber exploitation, however, continued at record levels in the mid-1990s at the same time as forest growth slackened off so that the gap between growth and total drain is rapidly narrowing (see Figure 3). Even though the large-scale exploitation of timber resources is quantifiably sustainable, the Organisation for Economic Cooperation and Development (OECD), for example, has pointed out that this is the main reason for loss of biodiversity in Finnish ecosystems (OECD 1997; Hoffrén 1999a).

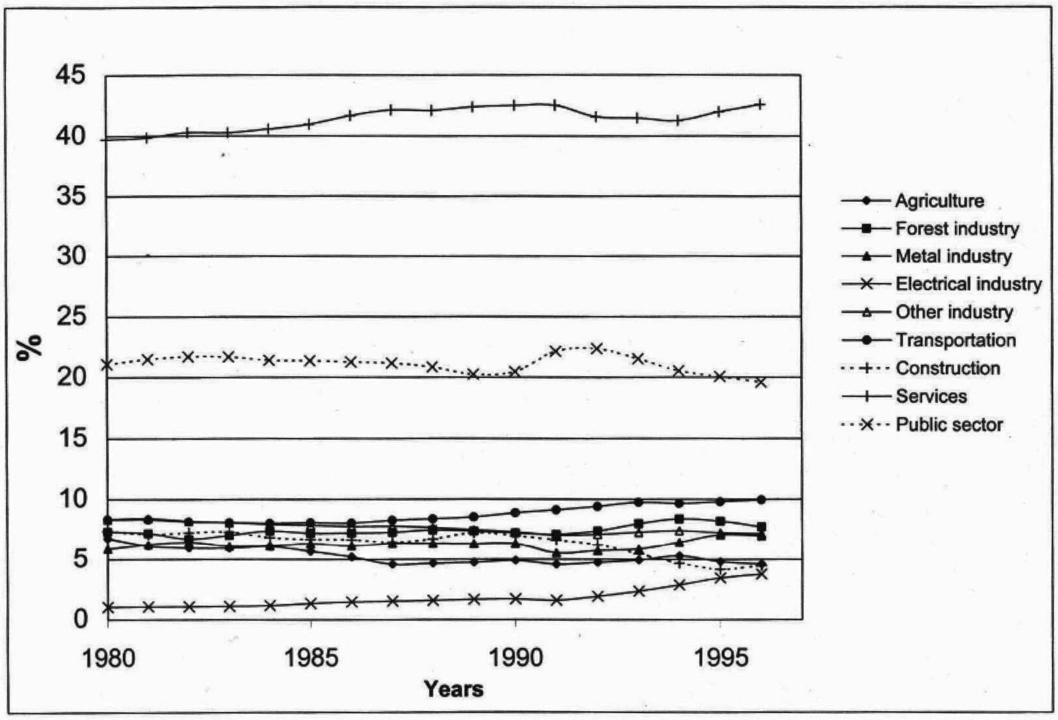

Figure 2 GDP shares of different sectors in Finnish economy during 1980–1996. Source: OSF, National Accounts 1980–1996, Tables.

Finland's environmental legislation and administration concentrate on reducing the volume of undesirable emissions and waste from the economy and on preventing disruption in landscapes. Current legislation does not seek to steer the economy toward thrifty use of natural resources, with the possible exception of fossil fuels. The actual prices of natural resources seldom cover all of the external costs associated with their exploitation and use.

In practice, Finnish legislation encourages and favours the consumption of natural resources. The Mining Act, for example, allows ore exploration to take place on private land without the owner's permission and even allows trees to be felled for this purpose. Claims may also be staked on another's land and such procedures as test excavations and draining may be performed there. Exploitation of natural resources is largely based on various licensing procedures. The principal laws are the Extractable Land Resources Act and the Mining Act, together with the Water Act and the Nature Conservation Act (Hoffrén 1999a).

The Data on Natural Resource Consumption

Changes in the overall consumption of natural resources in Finland have been investigated by such researchers as Pekka Mäkelä of the Centre for Economic Planning (1985), Urho Laine of the State Economic Research Centre (1994), and Jukka Hoffrén of Statistics Finland (1997 and 1999). The work for Mäkelä's Finland 2000 report involved the monitoring of natural resource use in relation to the gross national product and the calculation of what is known as material intensity over the period 1960-1980, together with predicted use in the year 2000. One particular area of emphasis has been the availability of metals and minerals and the market outlook. Laine's work involved monitoring the overall materials consumption in Finland, partly on the basis of Mäkelä's data, over the period 1960-1991 in an effort to estimate future use of materials. Hoffrén's study endeavors, in relation to research into natural resource charges, to assess the consumption of natural resources more comprehensively than earlier studies and presents the latest available data for the years 1991 to 1996.

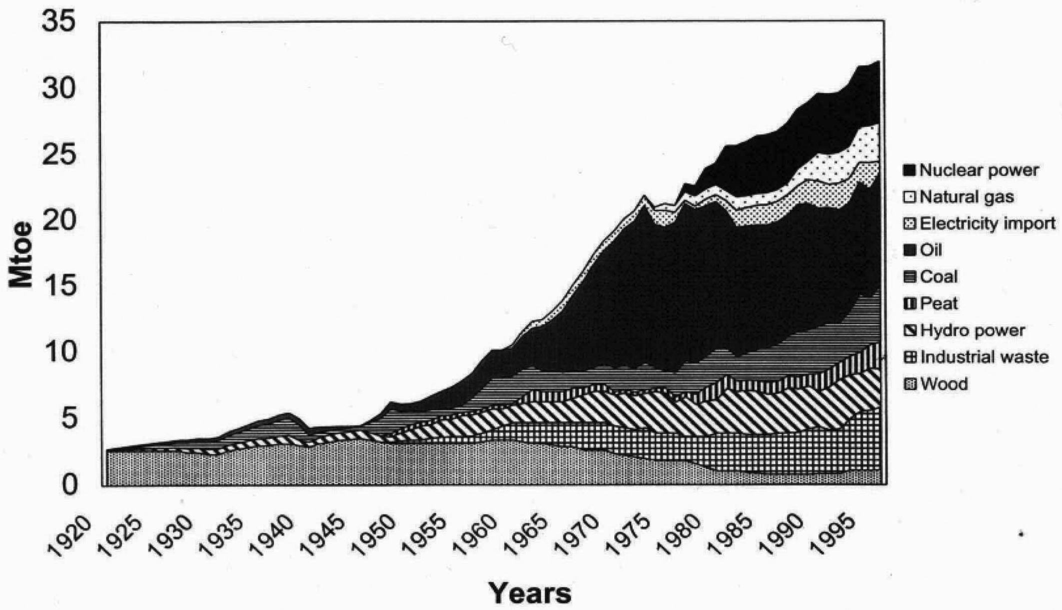

Figure 3 Various energy sources in Finland 1920–1996 (million tons of oil equivalent).

For this analysis, Hoffrén's data (Hoffrén 1999b) on the direct use of the most important natural resources have been checked and updated. Even though these data are not fully comprehensive, they include the largest material classes by weight and thereby provide a fairly reliable picture of the trends in the direct use of materials. The input into economic production processes of metal ores, minerals, limestone, peat, gravel, timber, fish, and cultivated crops are all treated as materials consumption. These figures specifically represent the consumption of primary materials, natural resources, and biomass that are exploited in producing the commodities and services required for affluence.

Consumption of natural resources

Excludind air and water, an estimated total of 187.6 million tons[1] of primary materials were consumed in Finland in 1997. Non-renewable natural resources, including peat, made up 114.4 million tons and renewable natural resources 59.9 million tons of this. Stone materials accounted for 36.5 percent of the direct total consumption of natural resources, whereas domestic ores, minerals, and limestone made up 9.2 percent and fossil fuels 8.6 percent. Timber materials accounted for 29.4 percent, and 6.7 percent consisted of cultivated crops. The remaining 8 percent consisted of peat, fish, market garden products, game, forest by-products, and imported metals. The consumption of different materials over the period 1960-1997 is illustrated in Figure 4.

Compared to Finland's level of industrial production, reserves of metal ore are relatively small and known ore reserves are rapidly being exhausted. In the beginning of the year 2000, only six of Finland's ore mines were still operating. The quantities of materials extracted from Finnish mines have fallen rapidly. Ore mine production in 1980 was still 10.5 million tons, but by 1997 this had fallen to 3.47 million tons. The most important mined materials were chromium, zinc, nickel, copper, and gold.

Gravel formations cover 4.5 percent of Finland's total surface area; that is, some 3.7 million acres. A shortage of certain types of extractable resources exists, including the highest quality gravel used in construction. The quantities of Finland's sand and gravel reserves vary regionally.

The forests are regarded as Finland's most important natural resource. Thanks to the application of forest management, the standing stock of Finnish forests has increased considerably over the past decades. Since 1960, the timber stocks have risen from about l,400 million solid cubic meters to more than 1,900 million solid cubic meters. Growth arising from the largely young age structure of the Finnish forests and from efficient forestry will continue for at least the next15 to 20 years. The timber harvest has also increased considerably during this time because of growing demand for raw materials by a modern pulp and paper industry. A record total of 59.1 million cubic meters of timber were harvested in 1997 for industrial and other purposes (Hoffrén 1998, 1999a).

[1] Unless otherwise noted, ton refers to metric ton. One metric ton = 1,102 short tons or 1 mega-gram (Mg).

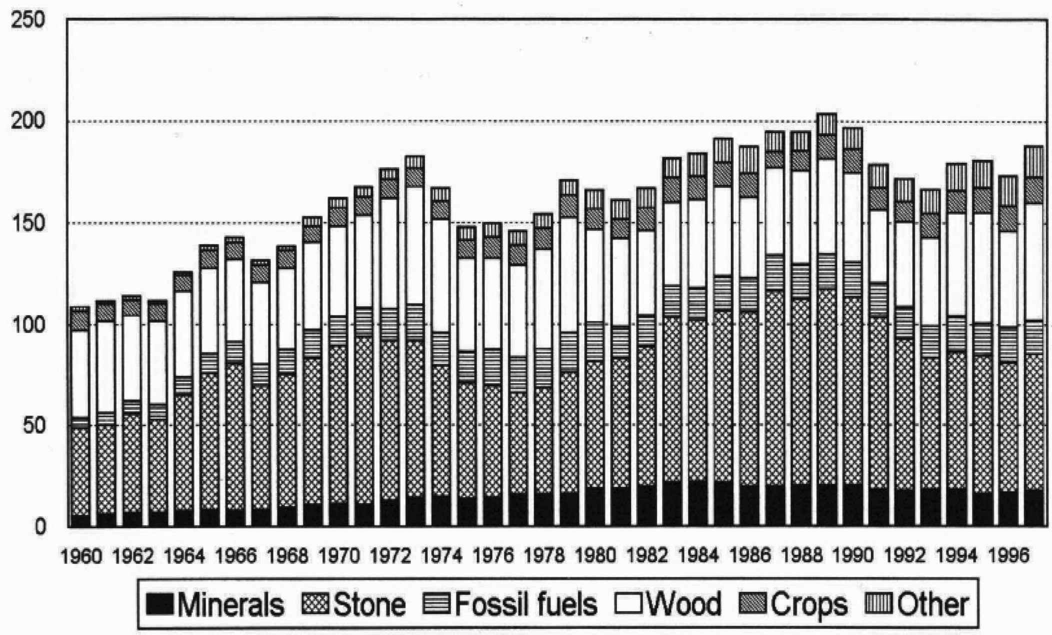

Figure 4 Consumption of various materials over the period 1960–1997 (million tons). Source: Hoffrén 1999b.

Hidden flows involved in natural resources consumption

The Wuppertal Institute and others have developed a widely used framework for materials flow accounting that not only tracks the direct consumption of natural resources, but also calculates other materials flows associated with the exploitation of natural resources (see Adriaanse et al. 1997; Bringezu et al. 1998). It is possible in Finland to provide fairly reliable estimates for both direct consumption and the associated hidden flows. For example, with respect to Finnish domestic mining and quarrying operations, the estimates are not only of the amounts of usable stone but also of other stone that is excavated but not used. Of the material excavated, 49 percent was ore or usable stone in 1997 and the remaining 51 percent was mining slag. Only 22 percent of the material excavated in the mining and quarrying of ore was usable. The proportions of usable material in limestone excavation and in mineral excavation were 24 percent and 69 percent, respectively. The amounts of usable stone and other stone extracted from Finnish mines over the period 1980-1997 are shown in Figure 5.

In the period between 1980 and 1997, the proportion of known hidden flows of timber materials was 41-47 percent of the total timber consumption. In mining and quarrying, the proportions of hidden flows varied between 58 and 68 percent. The relative proportions of the hidden flows of timber remained roughly stable over the monitoring period. The proportions of hidden flows in domestic mining and quarrying, on the other hand, grew from 58 percent in 1980 to 67 percent by 1997. The proportion of bidden flows in the total material requirement (TMR) for the economy as a whole varied between 55 and 76 percent in the united States, Germany, Japan, and the Netherlands. In another study, the “ecological rucksack" of the Finnish economy was calculated to have varied between 42 percent in 1970 and 57 percent in 1997 (Suomen ympäristö 2000). Thus the development has been quite similar to the one in other industrialized countries (Hoffrén 1999a, 1999b). Figure 6 shows Finland's real GDP (at 1990 prices) and Hoffrén's estimate of changes in the use of materials for the period 1960-1998.

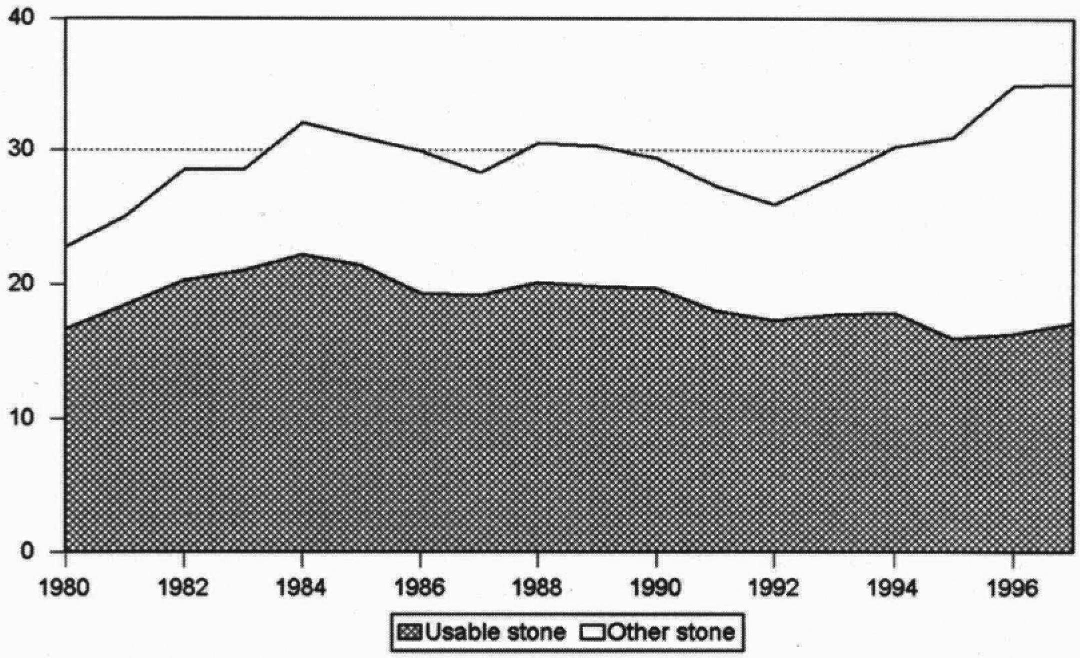

Figure 5 Amounts of usable stone and other stone extracted from Finnish mines 1980–1997 (million tons). Source: Hoffrén 1999a.

Figure 6 indicates that the development of economic production was intensive in Finland at the very end of the 1980s and during the 1990s. That is, it has been possible to produce greater amounts of wealth from smaller amounts of material. It is estimated that the total direct consumption of natural resources per unit of GDP has fallen from the 1980 level of 0.41 kilograms per Finnish markka[2] to 0.33 kilograms per Finnish markka by 1997. The total direct domestic consumption of natural resources per capita, on the other hand, has remained roughly stable, varying between 31 and 40 tons over the course of monitoring period and standing at 35 tons per person in 1997. In the investigation conducted under the direction of the Wuppertal Institute (Adriaanse et al. 1997; Bringezu et al. 1998), direct use of materials was estimated according to the material content of products based on industrial statistics (Hoffrén 1999a). Calculated in this manner, the direct material input (DMI) for the United States was 20, for Germany, 22, for Japan, 17, and for the Netherlands, 38 tons per person. Allowing for the fact that this estimate of Finland's direct domestic consumption of natural resources includes many of the materials flows that are classified by the Wuppertal Institute as hidden flows, and that no allowance has been made in the Finnish figures for the effects of foreign trade, the adjusted Finnish DM1

[2] In January 2001, one Finnish markka (FIM) was about US $ .16 and .17 EUR.

figure is in the same order of magnitude as that of Germany, the United States, the Netherlands, and Japan.

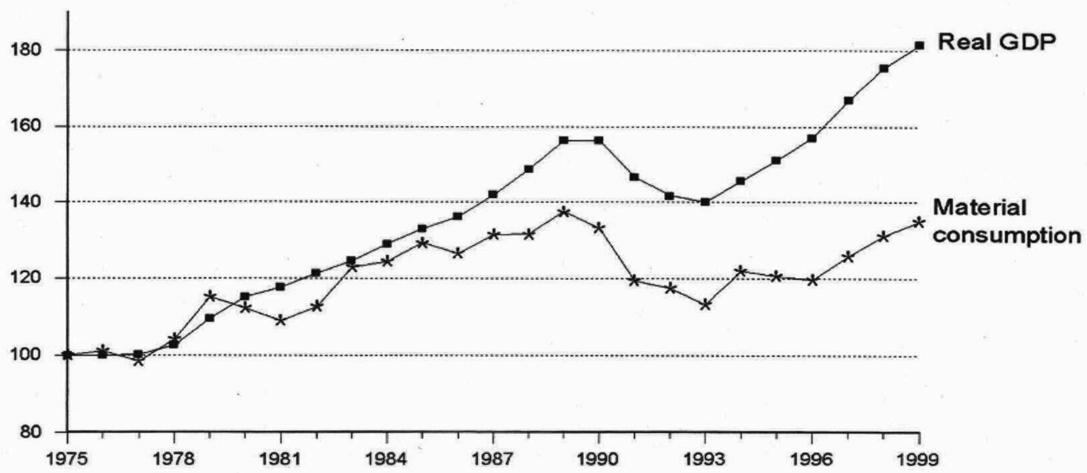

Figure 6 An estimate of changes in Finland's real GDP and direct use of materials (1960 = 100). Source: Hoffrén 1999b.

Figure 7 presents the factor index of materials use in Finland. The factor index describes how much the efficiency of materials use has increased by calculating GDP per quantity of materials used, that is, the inverse of the intensity of materials use. In Finland, achieving Factor 1.75 has taken 36 years, from 1960 to 1996. On the basis of this historical evidence, achieving Factor 4 or Factor 10 in 50 years is a significant challenge for Finland (see von Weizsäcker, Lovins, and Lovins 1997).

Decomposing materials use of an economy

Historically, Finnish environmental policy has paid very little attention to the efficiency of the materials use of the economy. In fact, only as a result of the decomposition model are we now able to identify actual inefficiencies for possible policy actions. Thus, we have used the decomposition model to analyze the various effects of changes in the economy and technology on the level of materials consumption. The decomposition analysis itself says nothing about sustainability because it is unable to quantify and to determine the sustainable level of any activities. However, supposing that increased materials efficiency can in general terms be interpreted as a more sustainable direction of development, we can conclude that the decomposition analysis also facilitates the analysis of sustainability of a national economy and its sectoral performance. In this analysis, we use the general term "sustainability" to refer to the environmental dimensions of sustainability. The lack of sustainability is a matter of damage to environmental systems caused by human activities that is related at the aggregate level to the magnitude of natural resources and environmental assets used.

The operationalization of the material productivity ratio P(M, Q) is defined by equation (1):

$$P(M,Q) = \frac{\textit{economic}\ \text{output}}{\text{material input}} = \frac{Q}{M} \tag{1}$$

The materials intensity of different sectors (i) can be defined as the inverse of the previous equation:

$$I_i = \frac{M_i}{Q_i} \tag{2}$$

Materials intensity can be decomposed in relation to the structure of an economy. In this case, the materials intensity will be:

$$I = \frac{M}{Q} = \sum_i I_i \frac{Q_i}{Q} = \sum_i I_i s_i \tag{3}$$

where the summation is taken over all sectors and

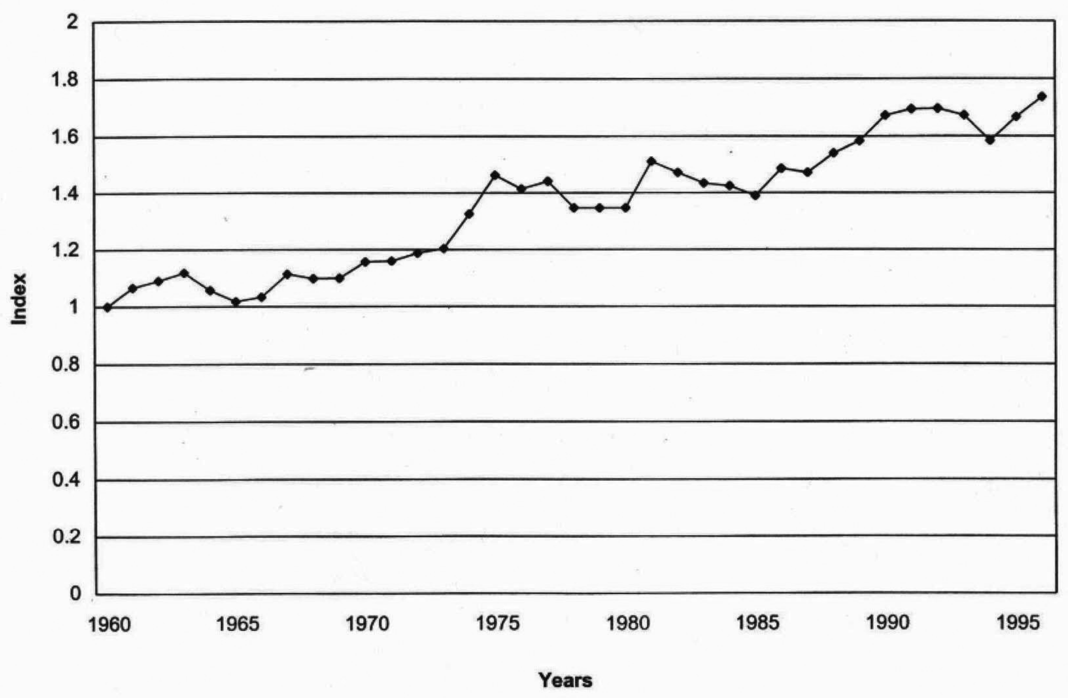

Figure 7 Factor Index (GDP/MF of materials use in Finnish economy in the years 1960–1996. Source: Hoffrén 1999b.

$$I_i = \frac{M_i}{Q_i} \tag{4}$$

is the sectoral materials intensity, and

$$s_i = \frac{Q_i}{Q} \tag{5}$$

is a structural factor of the economy, that is, the share of the total production represented by sector i. Changes in the materials consumption of the different primary material consuming sectors of the economy are presented in Figure 8.

When examining changes in the materials consumption of the different sectors of the economy, we notice that some have grown substantially while others have shown steady or no growth at alt. Materials consumption has grown substantially from 1960 to 1997 in electricity, gas and water supply (mainly fuels), pulp and paper production (wood), civil engineering (gravel), and mining and quarrying. Materials consumption has remained quite steady with no less than 15 percent growth in the wood and wood products sector (wood), transport (transport fuels), agriculture, basic metals production (ore and mining slag), and building complete constructions sectors.

Decomposition analysis

The aim of the decomposition analysis is to model the changes in the use of production factors. The intensity ratio is the main measure of efficiency in the analysis. The explanatory variables are: activity level of the economy, sectoral efficiency, and structural shift (see Figure 9).

Several methods and indices have been developed for use with decomposition analysis. Examples of these are the factor isolation method (Hankinson and Rhys 1983), combination method (Reitler, Rudolph, and Schaefer 1987) simple index method (Howarth 1991), Laspeyres and Paasche indices (Doblin 1988; Howarth and Schipper 1992), divisia index (Liu, Ang, and Ong 1991; Ang and Lee 1994; Park 1992; Boyd et al. 1988; Reitler et al. 1987), and difference method (e.g., Hankinson and Rhys 1983; Park 1992; Reitler et al. 1987). These methods have been used in the analysis of the energy sector.

Sun (1996, 47-61) has developed a difference method, which, unlike the other methods, no residual term. The materials model can be developed from this Complete Decomposition Model in the following way:

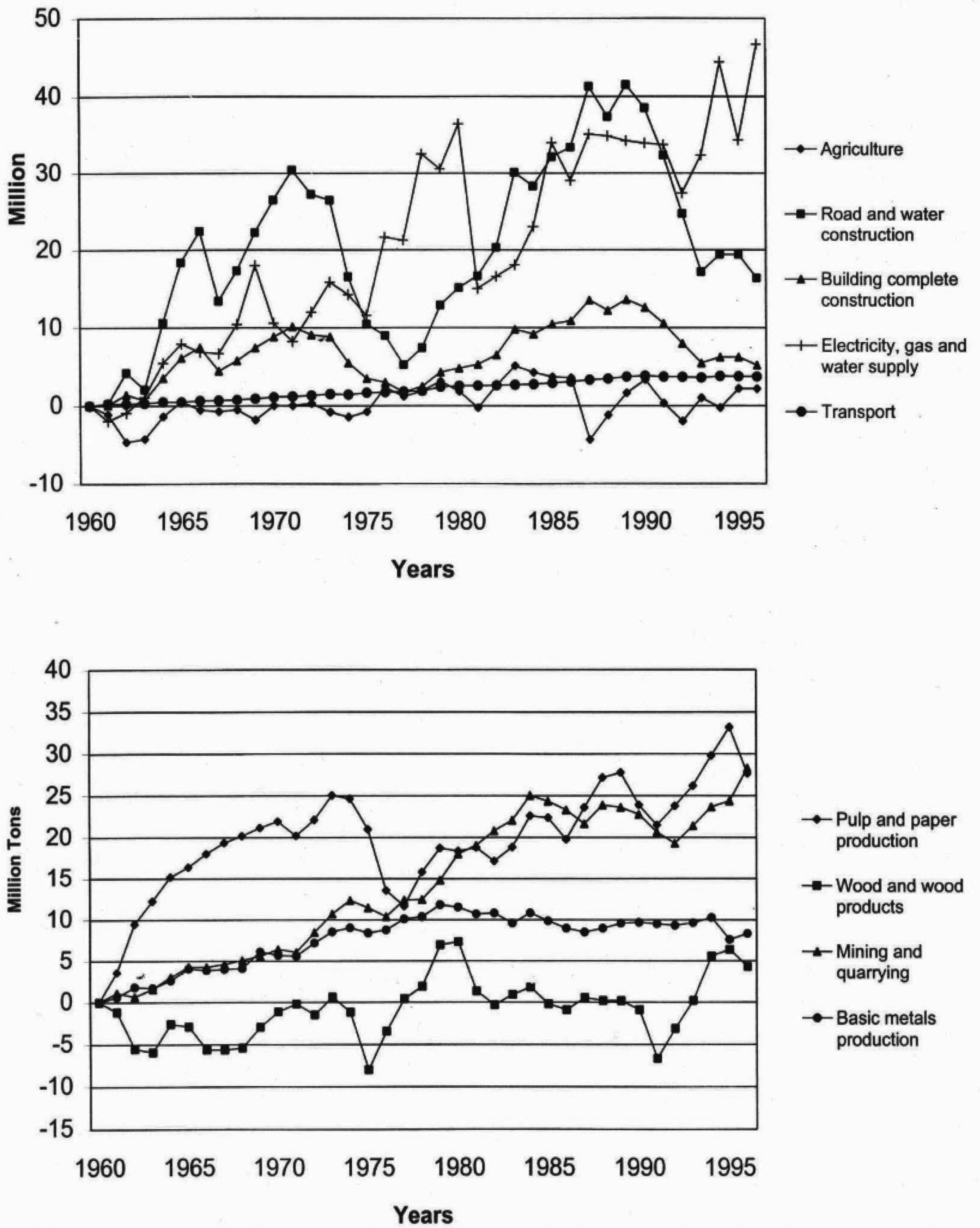

Figure 8 Changes in materials consumption in various sectors of the Finnish economy.

$$\Delta M = M^t - M^0 \tag{6}$$

$$Q_{effect} = \Delta Q \sum_i I_i^0 s_i^0 + \frac{1}{2} \Delta Q \sum_i (I_i^0 \Delta s_i + \Delta s_i^0 \Delta I_i) + \frac{1}{3} \Delta Q \sum_i \Delta I_i \Delta s_i$$

$$I_{effect} = Q^0 \sum_i s_i^0 \Delta I_i + \frac{1}{2} \sum_i \Delta I_i (s_i^0 \Delta Q + Q^0 \Delta s_i) + \frac{1}{3} \Delta Q \sum_i \Delta I_i \Delta s_i$$

(7)

$$S_{effect} = Q^0 \sum_i I_i^0 \Delta s_i + \frac{1}{2} \sum_i \Delta s_i (I_i^0 \Delta Q + Q^0 \Delta I_i) + \frac{1}{3} \Delta Q \sum_i \Delta I_i \Delta s_i$$

This model produces exact decomposition, so that

$$\Delta M = Q_{effect} + I_{effect} + S_{effect} \quad (8)$$

Q_{effect} is the activity effect that describes the effect of the total economic growth on the sectoral materials use. It does not directly depend on the sector's own production.

I_{effect} is the intensity effect that describes the impact of changes in technologies and production systems on the sectoral materials consumption. S_{effect} is the structural effect that describes the impact of changes in the sectoral share of total production on materials consumption.

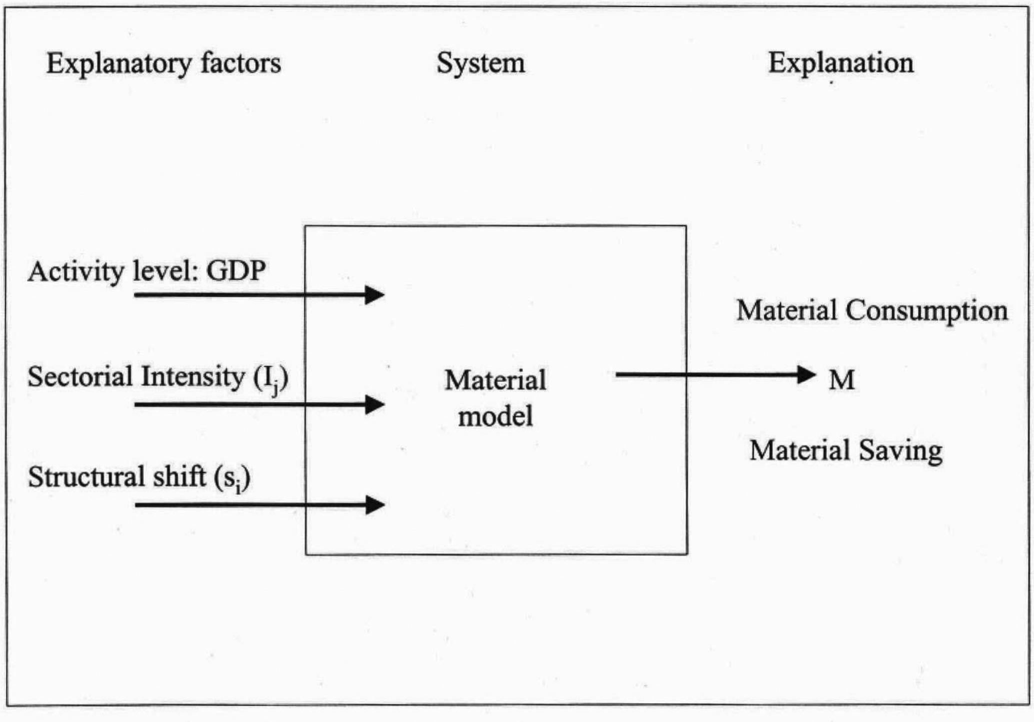

Figure 9 Factor decomposition model.

For example, if (1) the production of an economy grows, (2) there are no changes in technology in sector A, and (3) the share of the total production of sector A decreases, then the activity effect of the sector is positive, its intensity effect is zero, and its structural effect is negative. Even if the production of sector A decreases in absolute terms, its activity effect is positive if the total production grows. Activity effect describes the effect of changes in total production without the impacts from structural and technological factors.

Results of the decomposition analysis

In our practical application, the activity effect, intensity effect, and structural effect were analyzed using the decomposition analysis. An analysis of the results of the activity effect revealed that growth had been the most extensive in the civil engineering, electricity, gas and water supply, pulp and paper production, agriculture, and wood and wood products sectors. In these sectors, economic growth was mostly based on material resources. Economic growth had been least based on materials in the transport, basic metals production, mining and quarrying, and building complete constructions sectors. The development of the activity effect is presented in Figure 10.

An analysis of the intensity effect, which describes the effects of technological changes and changes in production systems on materials use, showed that materials intensity had decreased most in the electricity, gas and water supply, pulp and paper production, wood and wood products sectors, and in the 1990s also in the basic metals sector (see Figure 11). In these sectors, technological changes or changes in production systems had facilitated a decrease in the materials needed for a certain economic output; that is, the economic effectiveness of materials use has increased. In civil engineering and in mining and quarrying sectors, the intensity effect has been positive, which means that increasing amounts of material have been needed to achieve the same amount of economic output and the effectiveness of materials use has de creased in these sectors. The development of the intensity effect is presented in Figure 11.

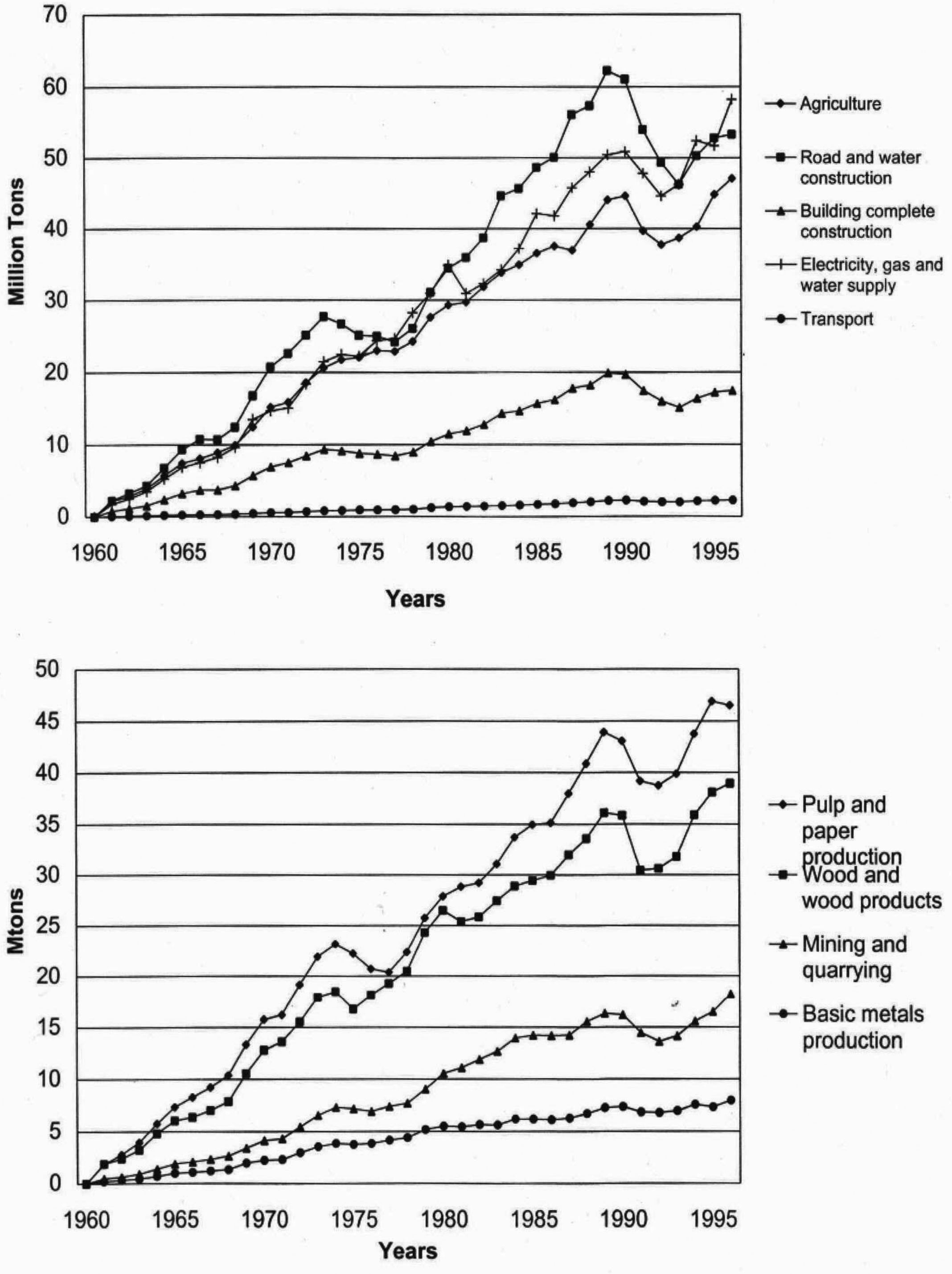

Figure 10 Activity effect on materials consumption in various sectors of the Finnish economy.

The economic development of various sectors in terms of the value added produced (the change in their share of the total output) is called structural change. The biggest reduction in materials use due to structural change occurred in civil engineering and agriculture. By comparison, structural change increased materials use in the electricity, gas and water supply, pulp and paper production, basic metals, and mining and quarrying sectors. The development of the structural effect is presented in Figure 12.

Over the thirty-six-year period under consideration (1960-1996), the analysis indicates that there was a net increase of 143 million tons in the materials input of the Finnish economy. Our decomposition analysis indicates that this increase can be attributed to an increase of 290 million tons arising from the activity effect. This increase is reduced by 92 million tons due to the intensity effect and 55 million tons due to the structural effect.

Sustainability evaluation

The environmental sustainability of an economic system is difficult to express in a quantitative way. We can, however, draw some conclusions about the general direction of the development of the system. If we use the materials consumption of a society as a crude measure of the environmental stress it causes, we can conclude that lowering materials consumption represents a way of decreasing environmental stress. This is the approach of the Wuppertal Institute in their materials flow analysis (MFA) (Schmidt-Bleek 1996; von Weizsäcker et al. 1997). in this respect, we argue that decreasing the materials flow of an economy is a necessary (but not sufficient) condition of sustainability.

We propose a group of metrics in order to relate the decomposition analysis to matters of sustainability (see Malaska et al. 1999). Various factors shaping sustainable materials use, such as dematerialization of production, immaterialization of consumption, and rebound effect, can also be distinguished with this model. The equation for materials sustainability (Ms) can be presented in the following matrix form (see Malaska et. al. 1999):

$$Ms = \begin{pmatrix} M_{De} \\ M_{Sa} \\ M_{Re} \end{pmatrix} = \begin{pmatrix} -1 & 0 & 0 \\ -1 & -1 & 0 \\ 0 & +1 & +1 \end{pmatrix} \begin{pmatrix} I_{effect} \\ S_{effect} \\ Q_{effect} \end{pmatrix} \tag{9}$$

where

M_{De} is dematerialization
M_{Sa} is immaterialization (material saving)
M_{Re} is material rebound effect

Dematerialization is the negative of the intensity effect and, as shown in Figure 11, has taken place in the electricity, gas and water supply, pulp and paper production, wood products, and, to some extent, in the basic metals and civil engineering sectors. Dematerialization indicates the reduction of materials use in production due to technological changes or changes in production systems.

Immaterialization describes the effects from technological progress and structural changes of an economy. Immaterialization, or material saving, indicates the total reduction of materials use if the overall economic activity remains unchanged. If the effectiveness of production technology increases, immaterialization takes place. If the share of a sector of the total production volume decreases, this will also increase immaterialization. Whereas the concept of dematerialization refers to the diminishing use of natural resources in an economy caused by the increase in the efficiency of material use, immaterialization also takes into account the structural shift, such as the shift toward the use of services instead of material commodities. The immaterialization process in different sectors is shown in Figure 13.

According to Figure 13, it seems that immaterialization, or material saving, has taken place in most sectors. Only the mining and quarrying, basic metals sectors, and, to some extent, the transport sector have not been able to save materials in their operations. In these sectors, the positive developments have largely been overcome by the increases in the scale of their operations.

The material rebound effect captures the development that takes place if technological change is excluded. It is the calculation of a sector's response in terms of materials consumption to the development of the value added plus the structural effect. The material rebound effect reflects the indirect effect of technological development on material use insofar as technological development has increased economic growth, but also caused a structural shift in the economy. The rebound effect is thus equal to the total change minus the change caused by technological development. The concept of the rebound effect has also been defined in other ways. Often, it is seen as the consequence of technological saving (of, for example, material), which leaves consumers more money to increase consumption. The development of the rebound effect is presented in Figure 14.

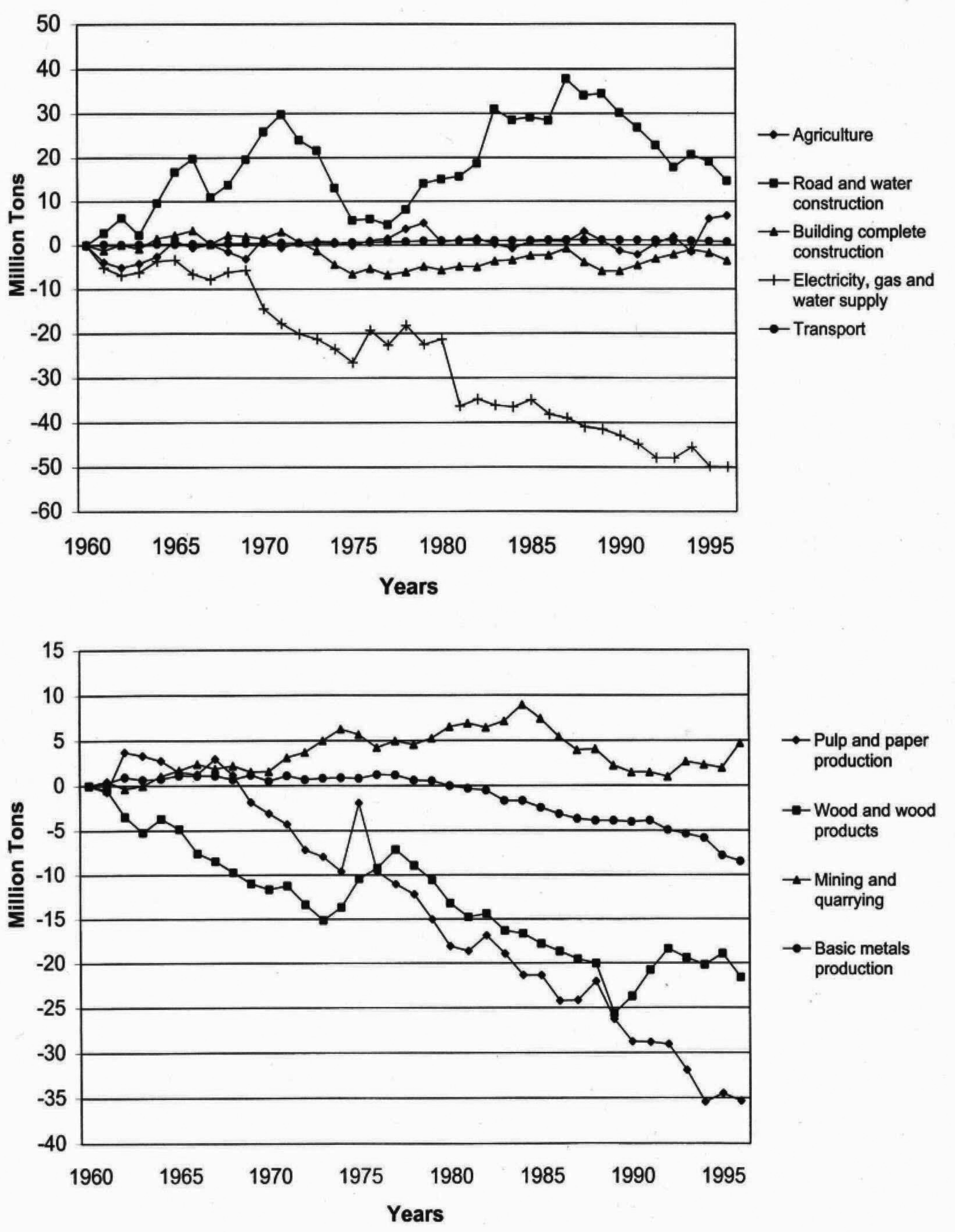

Figure 11 Intensity effect on materials consumption in various sectors of the Finnish economy.

The rebound effect has been positive in most sectors (apart from agriculture), which implies that economic growth is increasing the materials use of an economy. To be able to decrease materials consumption, the dematerialization effect should be greater than the rebound effect.

On the road to a sustainable information society?

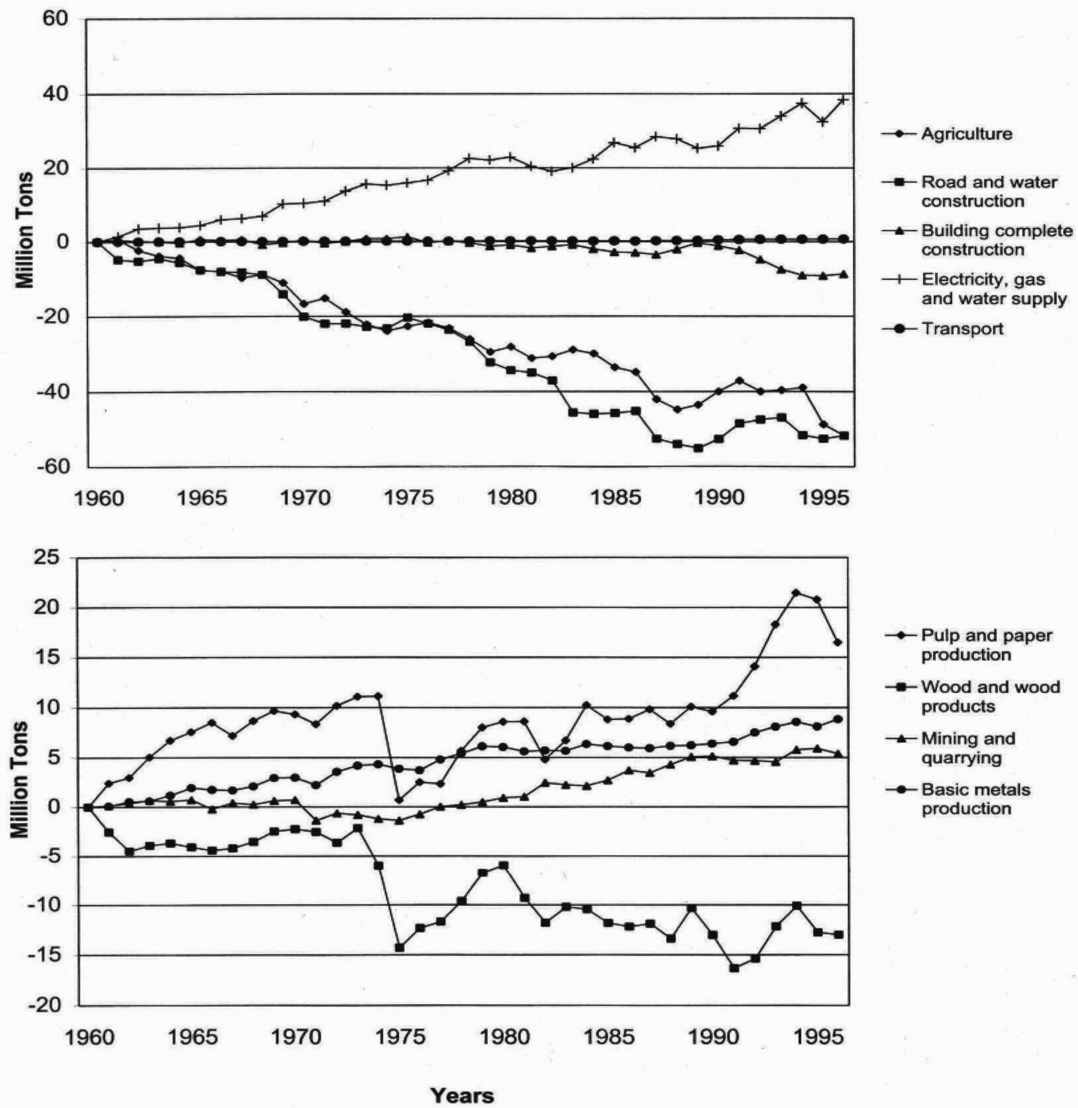

Figure 12 Structural effect on materials consumption in various sectors of the Finnish economy.

In this article we have presented empirical results concerning the materials flows in Finland during the years 1960-1996. In the MFA, we have used the decomposition method, which provides a useful tool for sectoral sustainability evaluation at the macro level. We have presented here the activity, intensity, and structural effects that have taken place in different primary materials consuming sectors of the economy. In addition, we have also presented the dematerialization, immaterialization, and rebound effects resulting from the previous effects. On the basis of our analysis, we can draw some conclusions about the sustainability of the national economy in Finland.

Many social scientists have suggested that societal development is advancing to a novel stage of the “information society.” The crucial material qualifiers of this “new society” are ambiguous, however. Many experts and scientists say that there is potential for reducing the stress on the environment. In practice, the emergence of information technologies and service can lead to dematerialization in production and immaterialization in consumption. On the other hand, risks are present: Any positive environmental effects may be overcome by the rebound effects caused by the extensive economic growth made possible by development of areas such as information technology. Past research has concluded that theoretical and empirical studies are needed in order to examine the complex and contradictory relationships between the information society and environmental issues (Jokinen et al. 1998). The study presented here provides some empirical findings with which to address these questions.

We consider the most essential findings of the study to be the following:

1. Materials consumption: According to our empirical study, economic development in Finland has caused the highest growth of materials use in the building of infrastructures such as roads, waterways, structures for supplying electricity, gas and water, and in the production of pulp and paper products. The least growth has taken place in the transport and basic metals sectors. It seems clear that the most materials-intensive sectors are those that provide the infrastructure and the related maintenance services. Over the years, their use of non-renewable resources has become quite steady, so that their material intensities have diminished. The results of the study suggest that planning of infrastructures could be an essential factor in the efficient management of materials flows.

2. Activity effect: The total growth of the Finnish economy is the main explanation for the activity, effect in different sectors. The activity effect is the greatest in the sectors in which the total materials flows are the highest: civil engineering, electricity production, agriculture, and pulp and paper production.

3. Intensity effect and the dematerialization process: The intensity effect describes the effects of technological development and changes in production systems on materials use. The intensity effect tells us how producers have succeeded in decreasing materials flows while producing more value added to the economy. In this sense, the most successful sectors are electricity production, pulp and paper production, and the wood and wood products industry. In electricity production, the introduction of nuclear energy at the beginning of the 1980s has decreased the fuel materials flow. It seems that the export-oriented sectors have increased eco-efficiency in their production or produced more value added with the same material input. In civil engineering, and in mining and quarrying, the reason for poor eco-efficiency performance is a decrease of easily accessible stocks.

4. Structural effect: The structural effect is the result of differences in the economic performances of different sectors. The decrease of the share of the

total value added of agriculture and civil engineering and, to some extent, the wood and wood products industry has decreased the materials consumption resulting from them. On the other hand, the increase of the share of GDP of electricity production and pulp and paper production has increased materials consumption.

5. Immaterialization process: Immaterialization describes the combined effect of technological progress and structural change on the economy. In agriculture and civil engineering, immaterialization occurs because of the structural changes that have considerably decreased the relative production volumes of these sectors. In the wood and wood products industry, immaterialization can be attributed both to structural change and to increased eco-efficiency. On a smaller scale, the same kind of process has taken place in building construction. In electricity production and in pulp and paper production, the reason for immaterialization is increased eco-efficiency. Immaterialization has not taken place in mining and quarrying or in basic metals production.

6. Rebound effect: The material rebound effect calculates the materials use that takes place if technological development is excluded from the accounting. It is a sector's response in terms of materials consumption to the development of the value added plus the structural effect. An important finding of this study is that the rebound effects can be found in almost all sectors of the economy. The largest rebound effects were found in electricity production and in pulp and paper production. The large rebound effects in these sectors are caused by high activity and structural effects, which result from rapid growth of a strong, export-oriented sector (pulp and paper) and its subcontracting utilities (electricity production for export industries).

7. Factor index: The factor index describes how much the total eco-efficiency of materials use has increased. In Finland, Factor 1.75 has been achieved in 36 years from 1960 to 1996. On the basis of this historical evidence, the goal of reaching Factor 4 or Factor 10 in 50 years is a significant challenge for Finland.

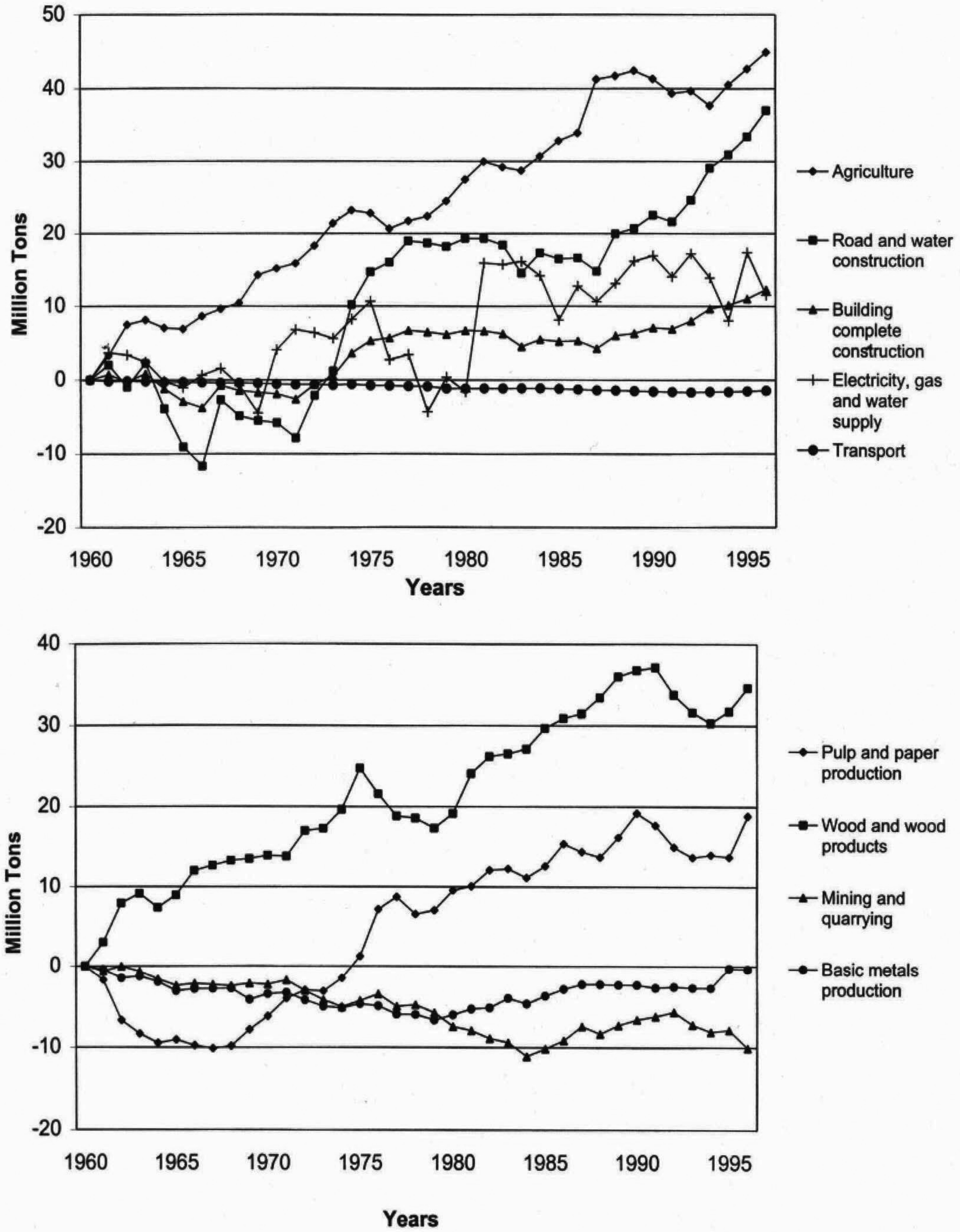

Figure 13 Immaterialization or material saving in various sectors of the Finnish economy.

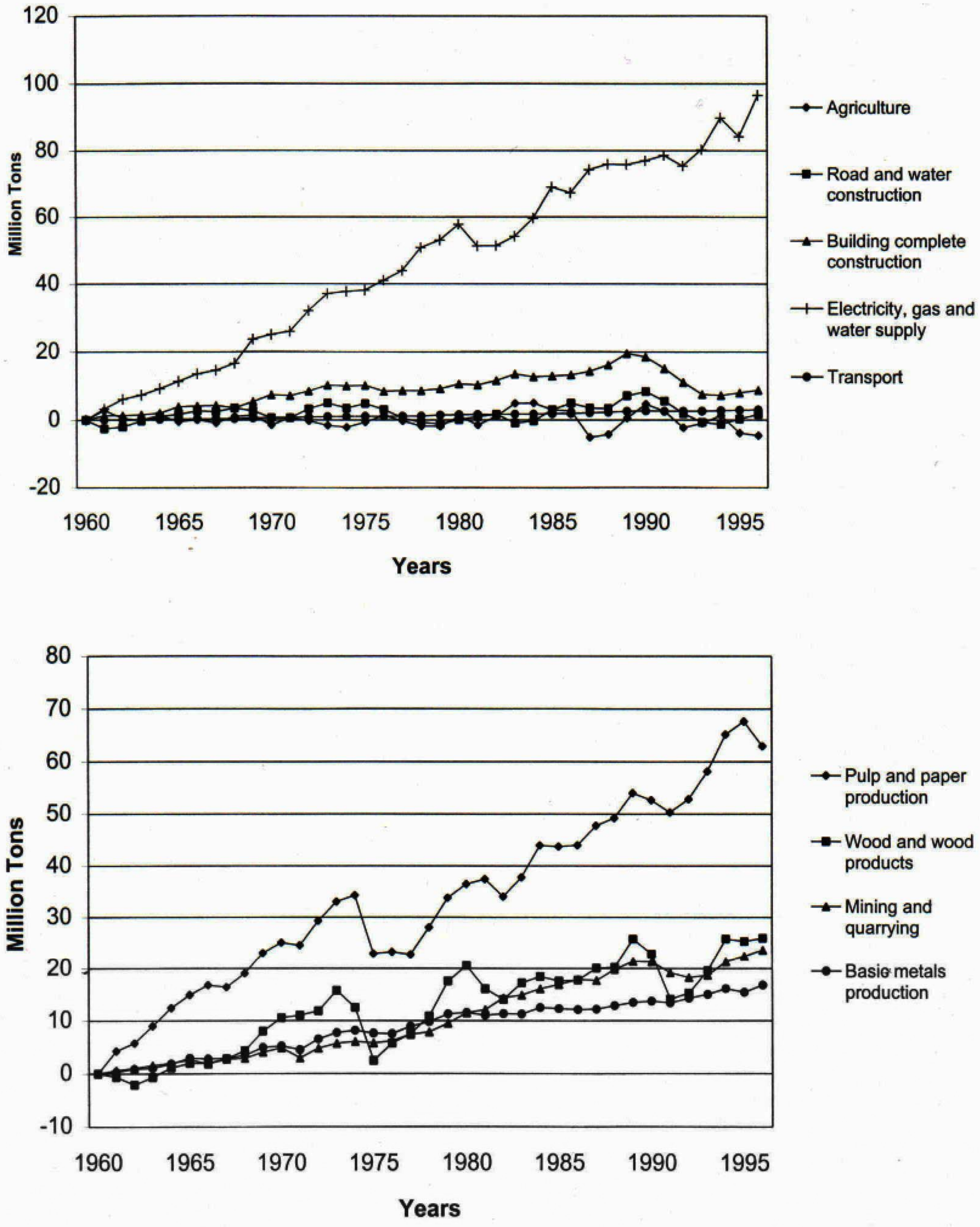

Figure 14 Rebound effect on materials consumption in various sectors of the Finnish economy.

The decomposition approach has turned out to be a useful means of analyzing the development of the materials basis of an economy. To our knowledge, this is the first time the decomposition technique has been used at the national level to analyze the development of the materials base of an economy in practice. Our aim is to develop more new methods and techniques that can be used to measure the eco-efficiency of natural resource use - the quantity of materials used to generate a given level of societal wellbeing. To develop the analysis further, better materials flow data are needed, especially data on the secondary and tertiary materials consumption. Such data would assist in the implementation of sustainable development in industrialized countries by quantifying the scope of the possibilities for specific production processes and production techniques. Our hope is that these empirical research results can and will serve in environmental analyses and planning in support of environmental policy. Our follow-up study aims to produce an early warning system for unsustainable processes by providing updated trend and cycle analyses from time series data and from a scenario model to be constructed.

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THE EUROPEAN UNION BALANCING BETWEEN CO_2 REDUCTION COMMITMENTS AND GROWTH POLICIES: DECOMPOSITION ANALYSES

By

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Introduction

According to the Kyoto Protocol, EU member states have to reduce GHG emissions together by eight per cent from the 1990 level during the first commitment period 2008-2012. The commitment was shared between 15 EU member states according to the Burden Sharing Agreement as contained in the Council Conclusions of 16 June 1998. The development of the EU's common energy policy (CEP) has taken place in the context of a growing global concern about the whole range of political and economic issues related to the sector. Two of the first three treaties were concerned with the integration of energy policy across Europe. Despite the existence of these treaties (European Coal and Steel Community (ECSC) Treaty 1951 and European Atomic Energy Community (Euratom) Treaty 1958) there have been continuous conflicts between the role of the member states and that of the EU. The reality has been that the member states have been dominant, largely because of their ownership of parts of energy sector and their control over fiscal policy. The security of energy supplies has been central to national industrial policy, and has been seen as a strategic issue. However, the EU's single market has become more important, so has the development of the internal energy market (IEM). (Barnes and Barnes 1999).

There exist several possibilities to reduce the CO_2 emissions of a country, the most habitual ones from macroeconomic perspective being: (i) reduction of economic output (GDP), (ii) reduction of the energy intensity of the economic production or (iii) reduction of the CO_2 intensity of the energy production (see e.g. Ehrlich and Holdren 1971, Kaya 1989, Malaska 1971 of the original ideas of decomposing environmental impacts). The first option, which is related to the activity and structural effects of the decomposition analysis explained in the following chapter, is usually not interesting for the policymakers. So the key question in the analysis of EU's single market is how energy and CO_2 intensities are developing among EU15- countries. This article describes some important trends among EU15-countries and in Norway, which is not EU member country.

In this study we shall make a comparative analysis of energy utilisation and CO_2 emissions in the European Union member countries. Our analysis is based on decomposition methods, which have been used in recent energy sector analyses. For example, Ang (Ang 1995a, 1995b, 1, 2), Ang and Zhang (Ang and Zhang 1999), Sun (Sun 1998 2000), and Sun and Malaska (Sun and Malaska 1998) have used the decomposition method to compare energy-related CO_2 emission levels between countries and regions. Nordic, country level sectoral analyses have been carried out by e.g. Schipper et al (Schipper, Howarth and Geller 1992, Schipper, Howarth, Andersson and Price 1993, Schipper, Johnson, Howarth, Andersson, Andersson and Price 1993, Schipper, Perälä, Johnson, Khrushch, Ting and Unander 1995). Similar methodology with this article was utilised in the studies of Luukkanen and Kaivo-oja (Luukkanen and Kaivo-oja 2001, Luukkanen and Kaivo-oja 2002, Kaivo-oja and Luukkanen 2002) for energy system analysis and Hoffrén et al (2001) for material flow analysis. In this study, we continue this research tradition of using the complete decomposition model, but we shall also provide dynamic analyses of the significant changes in the energy sectors and CO_2 emissions of EU-15 economies. A scenario approach linked with decomposition analysis is presented in Kaivo-oja et al (2001).

This article is organised in the following way: In section 2, we present general development trends in EU-15 countries and in Norway. In section 3, we present the methodology and models of the article. In section 4, we report the results of the comparative analyses. In section 5, we summarise the results and draw conclusions.

Data and general development trends in EU-15 countries

The data used for the analyses was taken from IEA statistics (IEA 1999, IEA 2000). Figures 1 and 3 plot the Total Primary Energy Supply (TPES) and the CO_2 emissions from fossil-fuel combustion in the EU from 1960 to 1998. The GDP data was compiled for the individual countries at market prices, in local currency and at annual rates. The data has been scaled up or down to 1990 price levels and then converted to US dollars using the yearly average based on 1990 exchange rates. All the presented data is macro economic, country level data. The analysis here is restricted to macroeconomic scales and sectoral or engineering bottom-up analyses are not presented in the article. Basic sectoral economic data for the countries is presented, but the reason for not presenting sectoral decomposition analysis is the lack of sufficient data for all the sectors of EU countries. Decomposition of industrial CO_2 emissions has been carried out by Liaskas et al. (2000).

The decomposition results are given in relative terms: all the figures are compared to the levels of 1990, which is the base year for the Kyoto Protocol. This type of comparison provides information about the development of the energy systems in the different countries in relation to the Kyoto target. The aim is not to evaluate the differences between the countries, because the targets of the Kyoto Protocol are national.

Total primary energy supply has increased in EU-15 in 30 years two and a half fold as can be seen in Figure 1. The fast growth of the sixties has slowed down after the energy crises in 1973 and 1979 and in the nineties the average growth rate has been about one per cent per year. But if we look at the energy intensity of the European economies we can find out that it has been declining after the first oil crisis in 1973 (Fig. 2). Decreasing energy intensity means that less primary energy is used to produce one US dollar of economic output. Decreasing energy intensity means increasing energy efficiency. One way of lowering the CO_2 emissions is to increase energy efficiency – if less energy is needed to produce the required economic welfare fewer emissions will be released.

The decreasing energy intensity can be a result of two different types of development. If the energy technology improves, less primary energy is needed to fulfil the desired tasks. With the increasing efficiency of e.g. a power plant it is possible to produce the same amount of electricity with less coal or gas. Secondly, if the structure of the economy changes to a less "heavy" direction, less energy is needed to produce same amount of economic output. In many European economies the shift from heavy industry dominated economy to service and ICT dominated economy has already taken place or is gradually taking place. This type of de-coupling of energy from economic growth has taken place in the European economy after the oil crises in the seventies.

The final energy demand grows faster than primary energy demand if the conversion efficiency in power generation improves. The increase in the share of electricity in the final demand, however, increases the primary energy demand compared with direct fuel use in final energy because of the low conversion efficiency of thermal condensing power plants. On the other hand, the increased use of electricity in the final energy consumption usually increases the use efficiency due to e.g. better control possibilities compensating part of the loss of efficiency in the total energy conversion chain. In this article we do not carry out analysis of final energy demand because it would enlarge the empirical analysis too extensive for a single paper.

From the point of view of CO_2 emissions the picture is also complicated. The increase of electricity share in the final energy demand tends to increase the emissions, but fuel switch to less carbon intensive or carbon free fuels (such as renewable sources or nuclear power) decreases the CO_2 intensity of the economy.

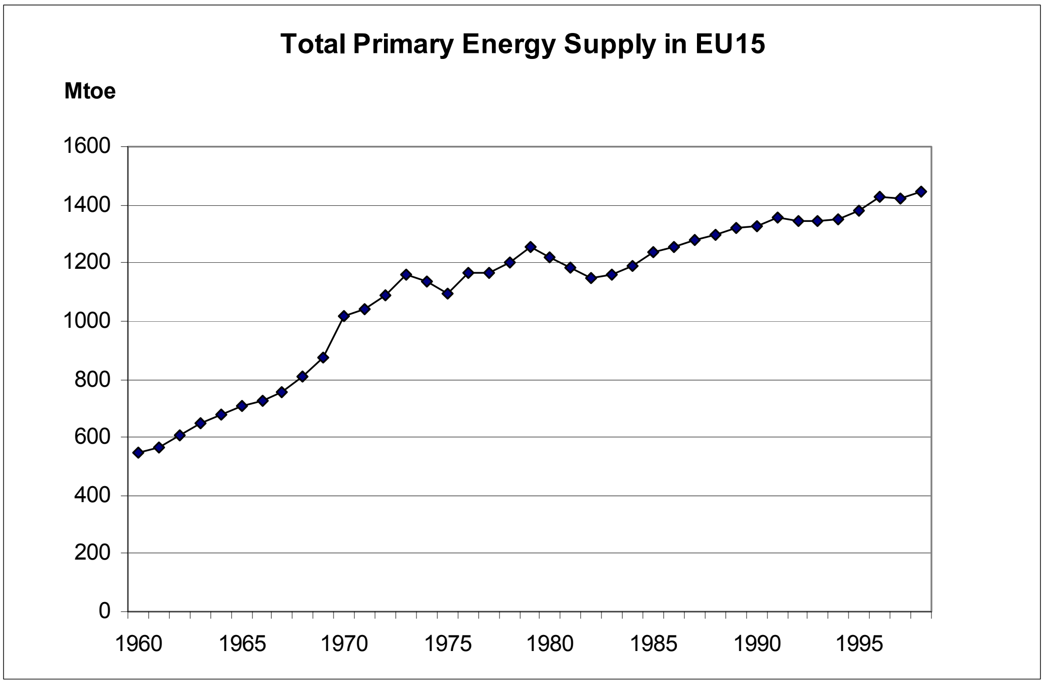


Figure 1. Total primary energy supply (TPES) in EU15 countries from 1960 to 1998 (IEA 1999 and IEA 2000)

Table 1. Average growth rate percentage of TPES in EU-15

Table 1. Average growth rate percentage of TPES in EU15				
1960-97	1960-70	1970-80	1980-90	1990-98
2.6	6.4	1.8	0.9	1.0

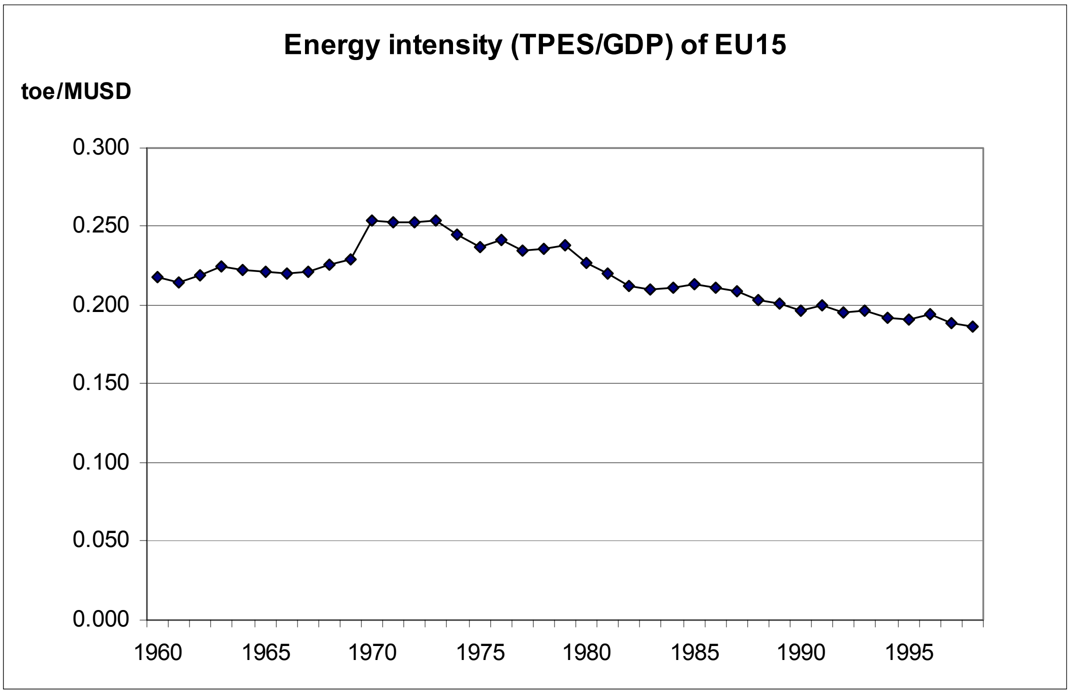


Figure 2. Energy intensity of EU15 measured as total primary energy supply divided by value added of economic output (tons of oil equivalent / million US dollars in 1990 value) (Data source IEA 1999 and IEA 2000)

Figure 3 illustrates the total CO_2 emissions in EU15. After the oil crises in the 70's the emission amount has stabilized. This is due to two reasons. First, the energy intensity of the economies has decreased, as was shown in Fig. 2, and second, the CO_2 intensity of energy use has decreased as can be seen in Figure 4. The reason for the decreasing CO_2 intensity of energy use is fuel shift towards less carbon intensive fuels. Such a change takes place e.g. when coal based electricity production is replaced by hydro, nuclear, wind, biomass or gas based production. The general national level fuel switching in relation to carbon intensity can be measured by the difference of the percentage changes of the intensity effect of CO_2 emissions and the intensity effect of energy use (more details of the concepts in the following chapters). In the following text fuel switching refers to this national level change in the intensity effects. Decreasing fuel switch curve indicates decreasing carbonisation of the energy production system. Figure 6 shows that the fuel switching in EU-15 has been a continuous process towards less carbon intensive production.

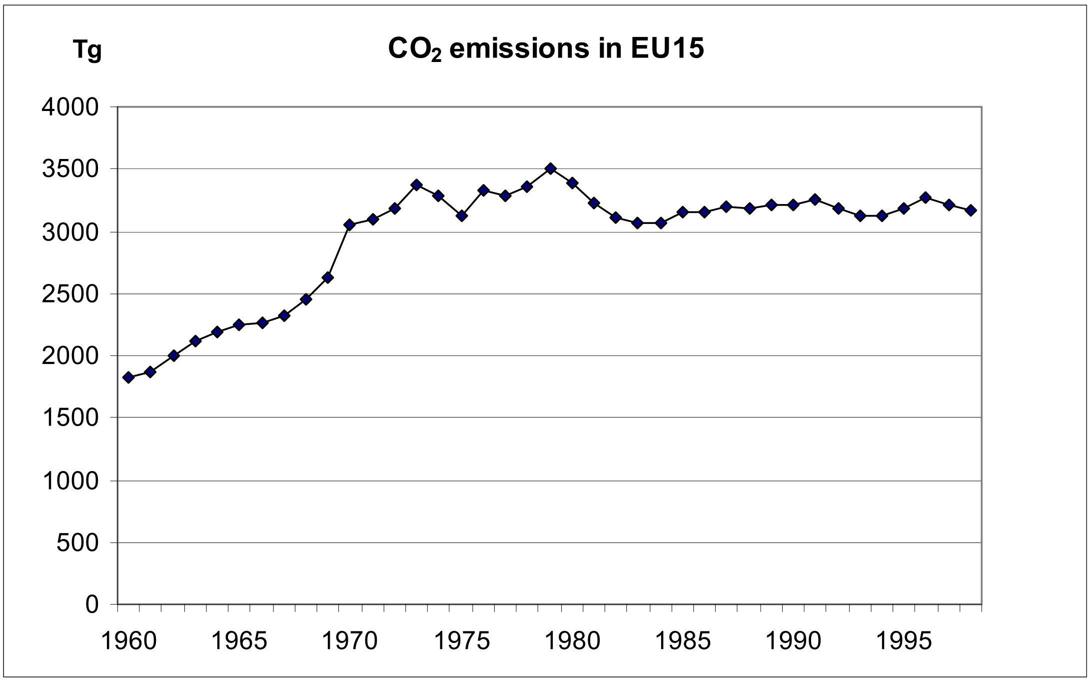


Figure 3. Total CO_2 emissions in EU15 countries in teragrams (Tg = Mton) (Data source IEA 1999 and IEA 2000)

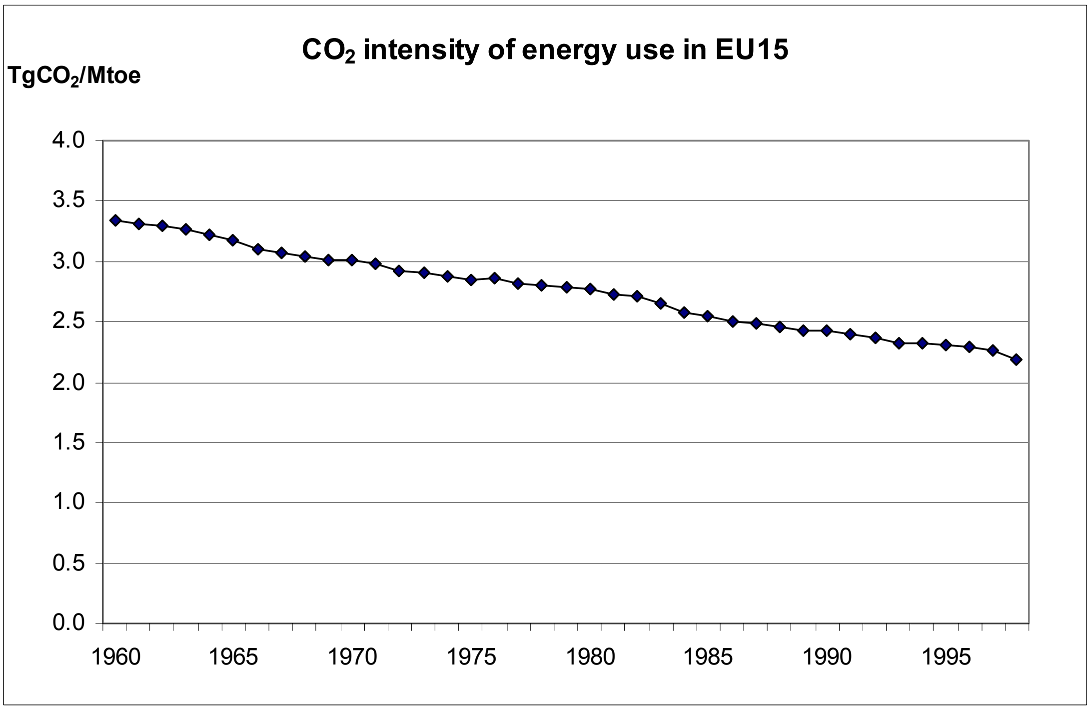


Figure 4. CO_2 intensity of total primary energy supply in EU15 (teragrams of CO_2 / Mtoe) (Data source IEA 1999 and IEA 2000)

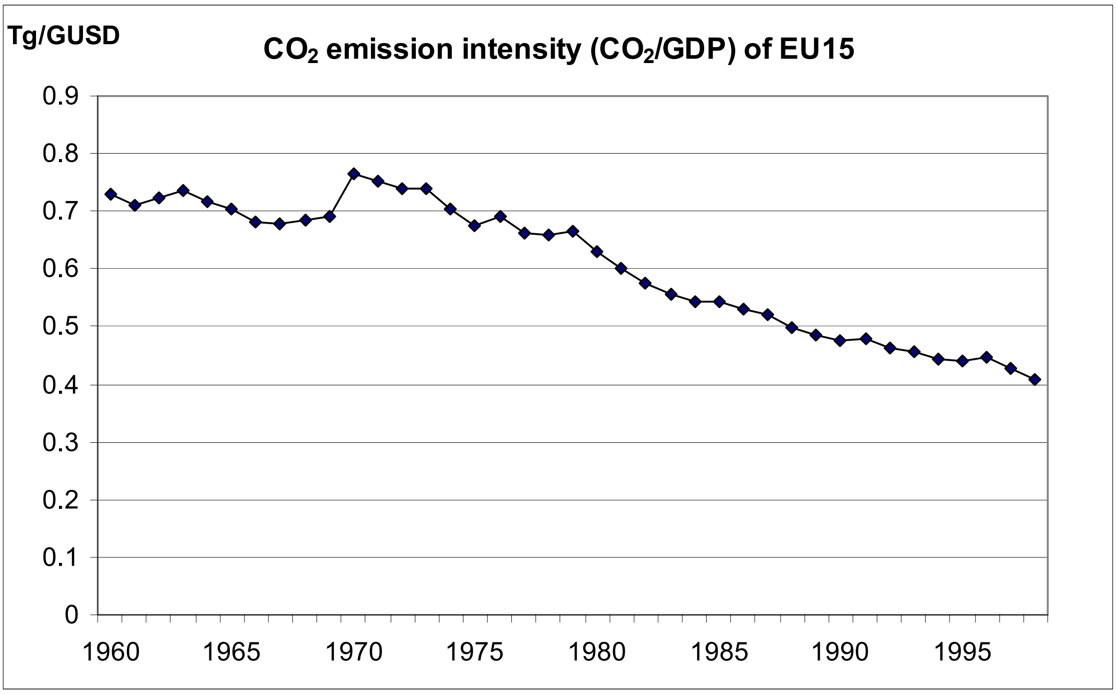


Figure 5. CO_2 emission intensity of the economy of EU15 countries (teragrams of CO_2 / Giga (10^9) US dollars in 1990 price) (Data source IEA 1999 and IEA 2000)

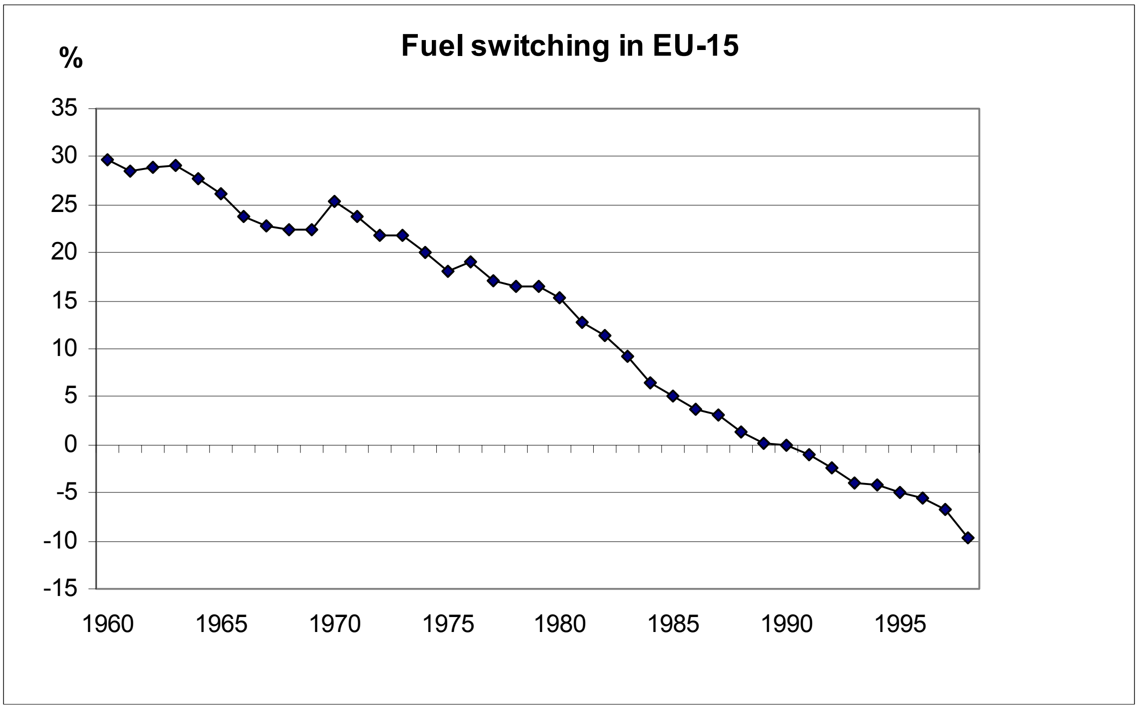


Figure 6. Fuel switching in relation to carbon intensity in EU-15 countries as a percentage change compared to 1990 level. Decreasing curve indicates decreasing carbonisation of the energy production system. The fuel switching is calculated as the difference between the percentage changes of the intensity effect of CO_2 emissions and the intensity effect of energy use.

Decomposition method in the study

The operationalisation of the productivity ratio of energy P(E,Q) can be defined as:

$$P(E,Q) = \frac{\text{economic outcome}}{\text{energy input}} = \frac{Q}{E} \tag{1}$$

The intensity of energy consumption can be defined, in different sectors (i), as inverse to the previous formula:

$$eI_i = \frac{E_i}{Q_i} \tag{2}$$

where eI_i is the energy intensity in sector i, E_i is energy use in sector i and Q_i is the value added of sector i.

To decompose the energy use of an economy we can use the following equations.

$$E = Q \times \frac{E}{Q} = Q \times \sum_i eI_i \frac{Q_i}{Q} = Q \times \sum_i eI_i s_i \tag{3}$$

where the sum is taken from all sectors and

$$s_i = \frac{Q_i}{Q} \tag{4}$$

is a structural factor of the economy, i.e., the share of sector i production of the total production.

In a similar manner we can decompose the CO_2 emissions P:

$$P = Q \times \frac{P}{Q} = Q \times \sum_i pI_i \frac{Q_i}{Q} = Q \times \sum_i pI_i s_i \tag{5}$$

where

$$pI_i = \frac{P_i}{Q_i} \tag{6}$$

is the sectoral CO_2 intensity.

In Eqs. (3) and (5) the energy use and the CO_2 emission are thus decomposed in relation to the structure of economy.

The aim of this decomposition analysis is to model the changes in energy consumption and emission production. The explanatory variables are: the activity level in the economy, sectoral intensity, and structural shift.

Several methods and indexes have been developed for the purposes of decomposition analysis and they have mainly been used to analyse the energy sector.

Sun (1996) has developed a difference method, which has no residual term unlike other methods. From this Complete Decomposition Model, we have developed the dynamic energy model in the following way:

$$\Delta E = E^t - E^0 \tag{7}$$

$$\begin{aligned}
EQ_{effect}{}^{t} &= (Q^t - Q^0)\sum_i eI_i^0 s_i^0 + \tfrac{1}{2}(Q^t - Q^0)\sum_i (eI_i^0(s_i{}^t - s_i{}^0) + s_i^0(eI_i{}^t - eI_i{}^0)) \\
&+ \tfrac{1}{3}(Q^t - Q^0)\sum_i (eI_i{}^t - eI_i{}^0)(s_i{}^t - s_i{}^0) \\
EI_{effect}{}^{t} &= Q^0\sum_i s_i^0(eI_i{}^t - eI_i{}^0) + \tfrac{1}{2}\sum_i (eI_i{}^t - eI_i{}^0)[\, s_i^0(Q^t - Q^0) + Q^0(s_i{}^t - s_i{}^0)\,] \\
&+ \tfrac{1}{3}(Q^t - Q^0)\sum_i (eI_i{}^t - eI_i{}^0)(s_i{}^t - s_i{}^0) \\
ES_{effect}{}^{t} &= Q^0\sum_i eI_i^0(s_i{}^t - s_i{}^0) + \tfrac{1}{2}\sum_i (s_i{}^t - s_i{}^0)[\, eI_i^0(Q^t - Q^0) + Q^0(eI_i{}^t - eI_i{}^0)\,] \\
&+ \tfrac{1}{3}(Q^t - Q^0)\sum_i (eI_i{}^t - eI_i{}^0)(s_i{}^t - s_i{}^0)
\end{aligned} \tag{8}$$

where superscript *0* refers to the base year value and *t* refers to the values of the comparison year varying from n_1 to n_n, in this case from 1960 to 1998.

This model produces an exact decomposition so that:

$$\Delta E = EQ_{effect} + EI_{effect} + ES_{effect}\,. \tag{9}$$

The Q_{effect} is the activity effect that describes the effect of total economic growth on sectoral energy use. Increasing economic output increases the activity effect. The I_{effect} is the intensity effect, which reveals the impact of the technological change and the change in production systems on sectoral energy consumption. If the increase in economic output is larger than the increase in the energy input the intensity effect decreases. The S_{effect} is the structural effect, which reveals the impact of change in the sectoral share of total production on energy consumption. If the share of one sector in the total economic output increases its structural effect increases. In the empirical analysis of this article the structural effect refers to the changes in the share of the different countries in the total EU economy.

In a similar way we can develop equations for the decomposition of CO_2 emissions:

$$
\begin{aligned}
PQ_{effect}{}^{t} &= (Q^t - Q^0)\sum_i pI_i^0 s_i^0 + \tfrac{1}{2}(Q^t - Q^0)\sum_i pI_i^0 (s_i{}^t - s_i{}^0) + s_i^0 (pI_i{}^t - pI_i{}^0)) \\
&+ \tfrac{1}{3}(Q^t - Q^0)\sum_i (pI_i{}^t - pI_i{}^0)(s_i{}^t - s_i{}^0) \\
PI_{effect}{}^{t} &= Q^0 \sum_i s_i^0 (pI_i{}^t - pI_i{}^0) + \tfrac{1}{2}\sum_i (pI_i{}^t - pI_i{}^0)[\ s_i^0 (Q^t - Q^0) + Q^0 (s_i{}^t - s_i{}^0)\ ] \\
&+ \tfrac{1}{3}(Q^t - Q^0)\sum_i (pI_i{}^t - pI_i{}^0)(s_i{}^t - s_i{}^0) \\
PS_{effect}{}^{t} &= Q^0 \sum_i pI_i^0 (s_i{}^t - s_i{}^0) + \tfrac{1}{2}\sum_i (s_i{}^t - s_i{}^0)[\ pI_i^0 (Q^t - Q^0) + Q^0 (pI_i{}^t - pI_i{}^0)\ ] \\
&+ \tfrac{1}{3}(Q^t - Q^0)\sum_i (pI_i{}^t - pI_i{}^0)(s_i{}^t - s_i{}^0)
\end{aligned}
\tag{10}
$$

To analyse the dynamics of the change we have used Eqs. (8) and (10) to calculate the differences in the long-run time-series data from 1960 to 1998 compared to the reference year 1990, which has been chosen as it is the base year for the Kyoto Protocol (UNFCCC 1998).

In this analysis of the EU and the Nordic countries, the sixteen individual countries refer to the different sectors (*i*) of the equations.

An example of the decomposition analysis for the CO_2 emissions for the France is presented in Fig. 7. In this figure the CO_2 emissions are decomposed in the three components (Q, I and S effects), which sum up to the total emissions. It is interesting to notice that the increase in CO_2 emissions in France up to the first oil crisis in 1973 has been almost entirely caused by the increasing economic activity. The improving efficiency in relation to CO_2 emissions after 1973, indicated by decreasing intensity effect, has been the main cause for decreasing emissions. This development has been mainly the result of the introduction of nuclear energy in France. The structural effect (in the EU context) has not had a remarkable effect on emissions in France.

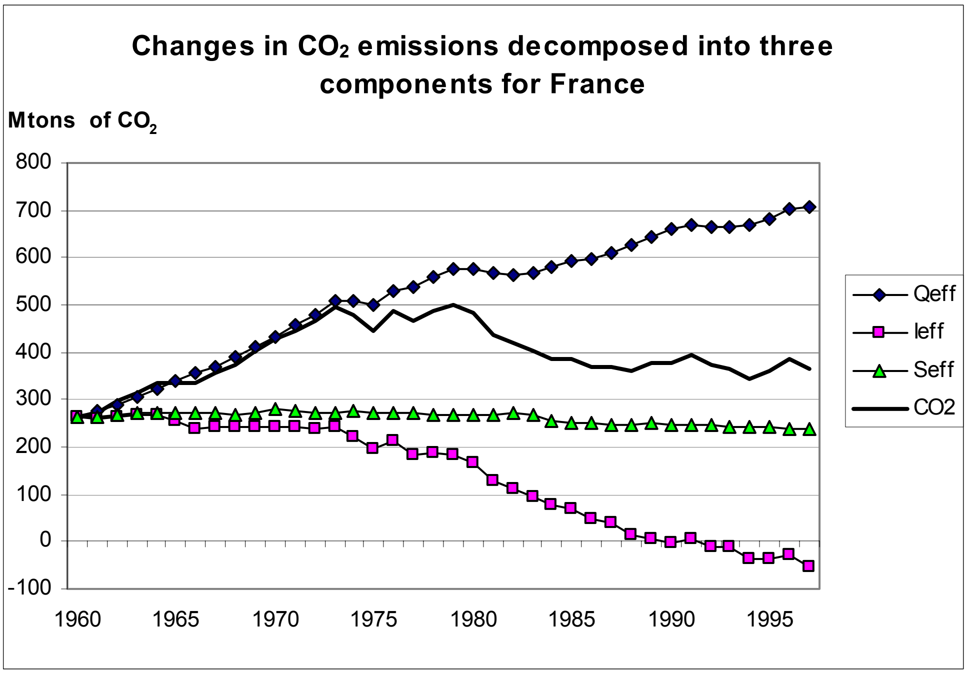


Figure 7. An example of decomposing the CO_2 emissions of the UK in the three components, activity effect, intensity effect and structural effect, which sum up to the total emissions

In this article we have not included the final energy demand in the analysis to reduce the complication of the model. The refined Laspeyres type of decomposition formulae, which is used in this analysis and is suitable only for additive decomposition, becomes very complicated, when the number of factors exceed three (see Ang and Zhang 2000).

The results of the empirical analyses are organised in the following way. First the detailed country level analyses are presented in Chapter 4 (large EU countries. Germany, France, Italy and UK), Chapter 5 (Nordic countries, Denmark, Finland, Norway and Sweden), Chapter 6 (Cohesion countries, Greece, Ireland, Portugal and Spain) and Chapter 7 (Other EU countries, Austria, Belgium, Luxembourg, and the Netherlands). The detailed country level results are synthesised and the main features are collected in table format and visualised by graphs in Chapter 8. The conclusions are drawn in Chapter 9.

Country level analyses of energy and CO_2 intensity: Large EU countries

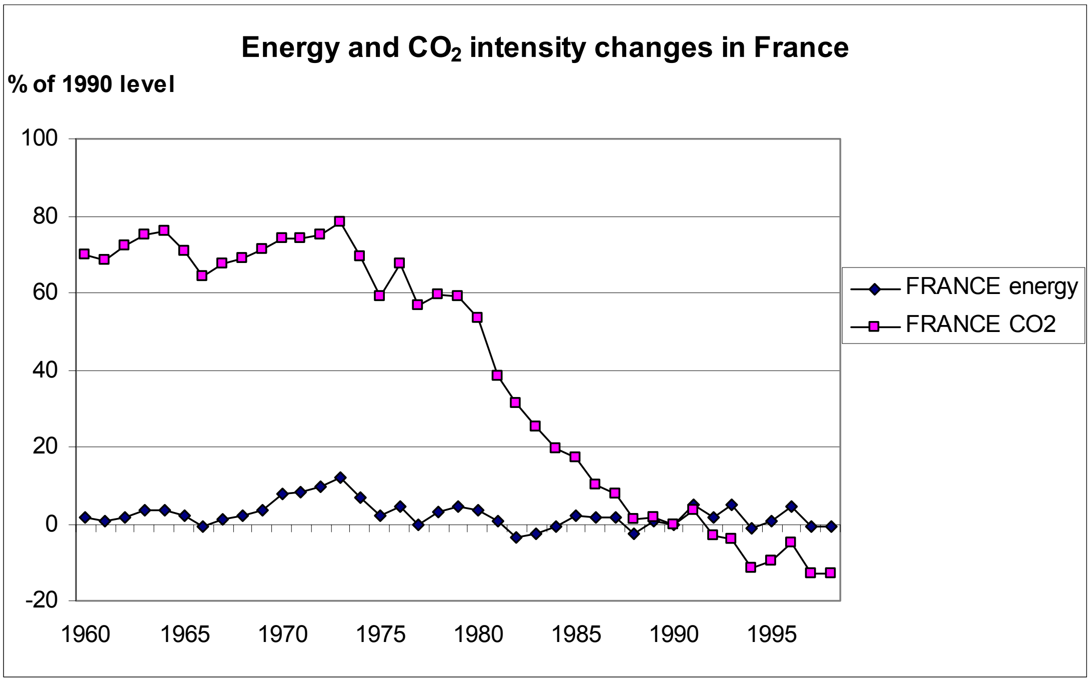
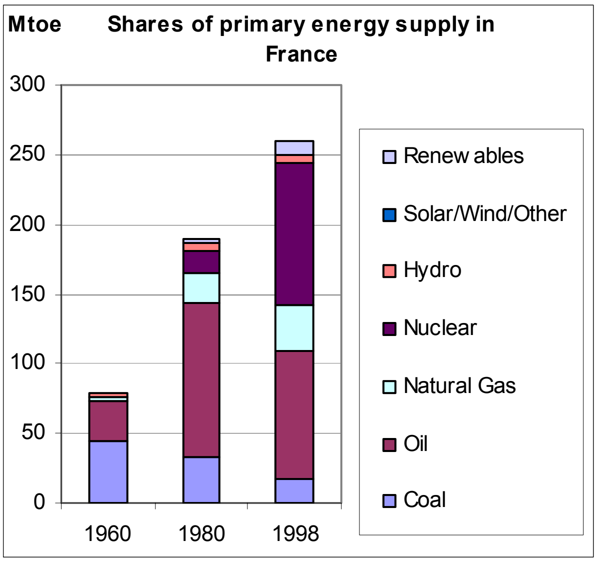


Figure 8. Energy and CO_2 intensity effect changes in France



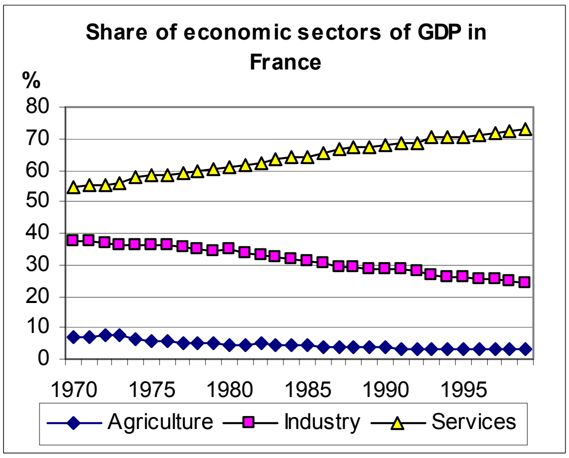


Figure 9. Shares of primary energy supply and economic sectors of GDP in France

France is an interesting case, when we analyse energy production trends among EU countries. Figure 8 illustrates the dynamic changes in energy and CO_2 intensity effects in France. The intensity effect of energy use does not have any clear increasing or decreasing trend during the analysed time period. This means that the total energy efficiency in France has not improved. The French macroeconomic production structure has remained as inefficient in relation to energy use as it was in the sixties.

The changes in the intensity effect of CO_2 compared with energy intensity effect indicate that there has been a remarkable fuel switch in France. The carbon intensity remained quite stable to the year 1974, but after the turning point there has been a steady downward sloping trend till the year 1997. The decreasing trend is caused mainly by heavy nuclear power investments in seventies and eighties. In the case of France it is interesting to note the total energy efficiency has not improved, which may be due to heavy reliance on nuclear power and the related lack of incentives on the energy conservation. The French economy has gone through a structural change towards service economy, but this has not affected the energy intensity of the economy.

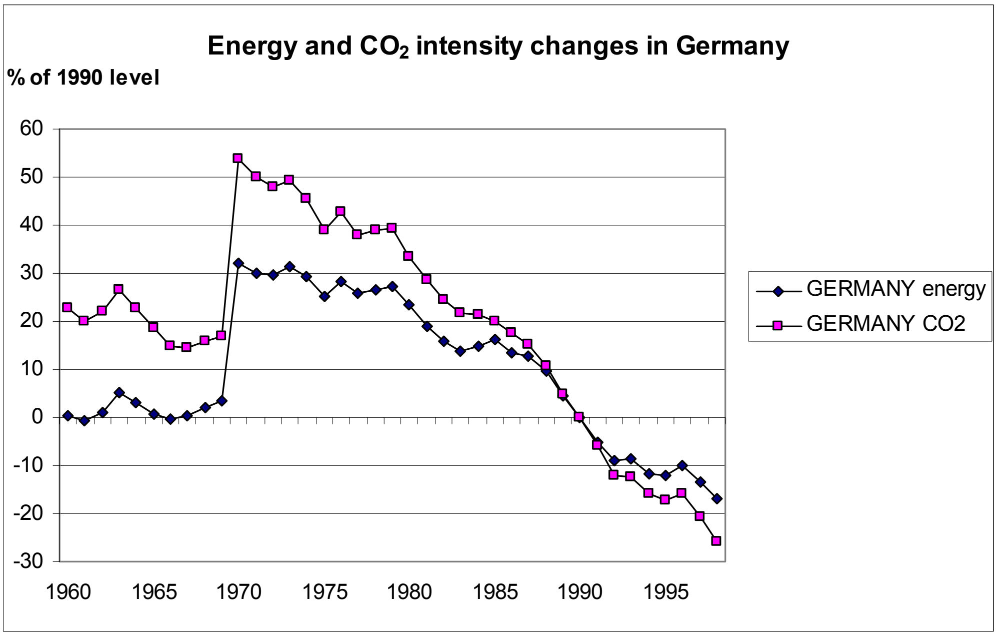
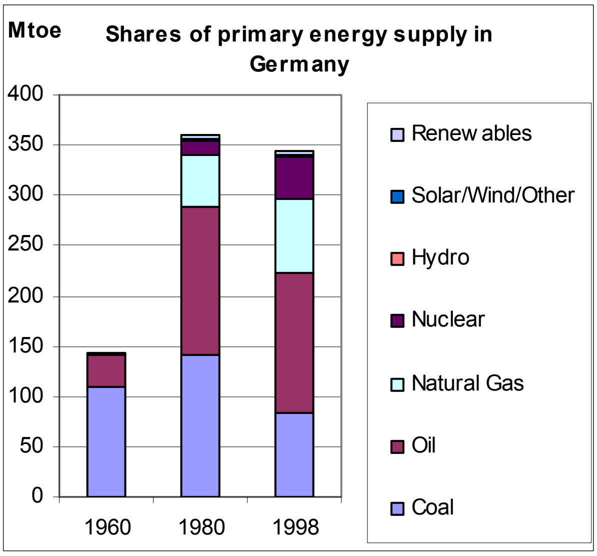


Figure 10. Energy and CO_2 intensity effect changes in Germany



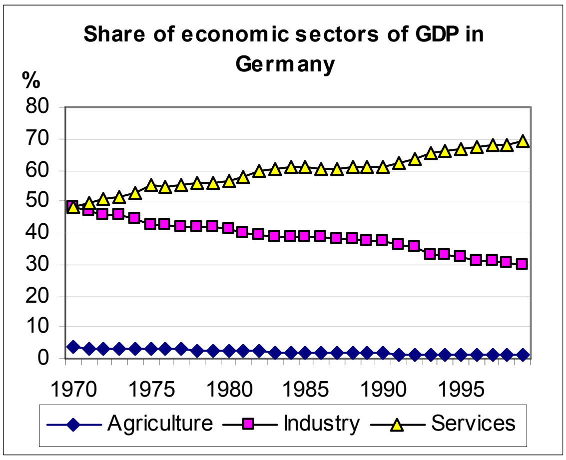


Figure 11. Shares of primary energy supply and economic sectors of GDP in Germany

It looks that during the years 1969-1970 intensity of Germany's economy changed drastically towards more inefficient direction, but this is due to the changes in statistics. The statistics before 1970 include only Western Germany while the new federal states have been added in the IEA statistics for 1970-1998. The changes in the intensity effect of CO_2 compared with energy intensity effect indicate that there have been remarkable fuel switches in Germany as shown in Fig. 10. From 1960 to 1973 the energy intensity has remained at approximately the same level, while CO_2 intensity has decreased to some extent indicating slight fuel switch towards less carbon intensive energy production in Germany. After oil crisis 1973 the energy intensity has decreased considerably and the introduction of nuclear power plants has caused remarkable fuel switch decreasing the CO_2 intensity even faster up to the year 1988. During the years 1988-1991 there was not a remarkable fuel switch. In the 1990s the fuel switch has been mainly from coal to gas and the restructuring in the economy in the new federal states has improved the energy efficiency remarkably. It is interesting to notice the large structural change of the economy from industry-oriented production to service dominated system.

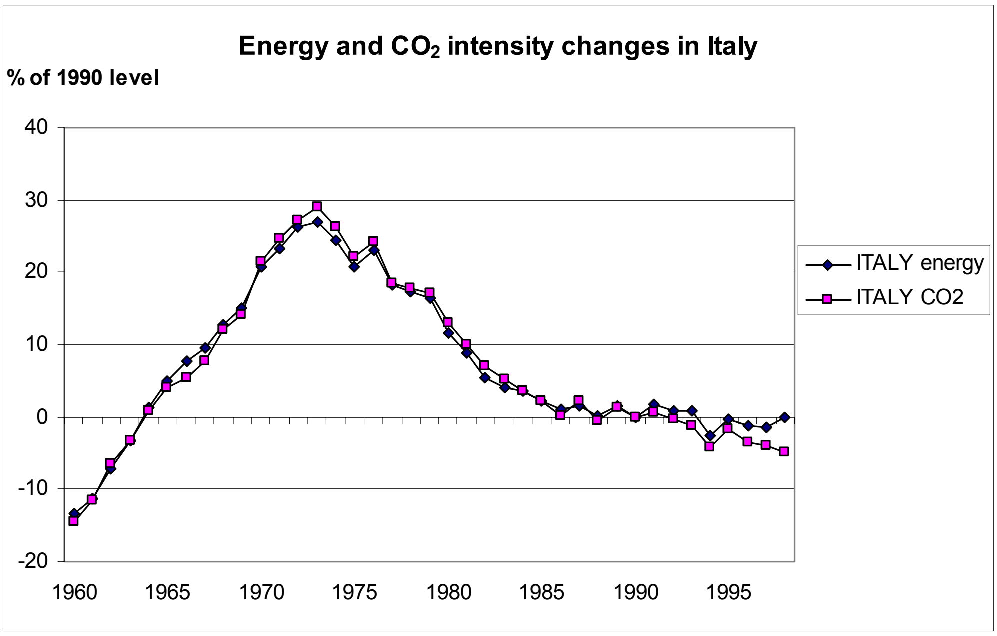
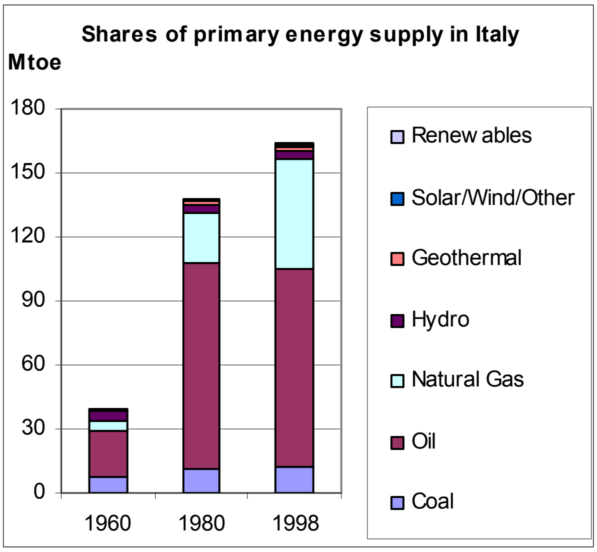


Figure 12. Energy and CO_2 intensity effect changes in Italy



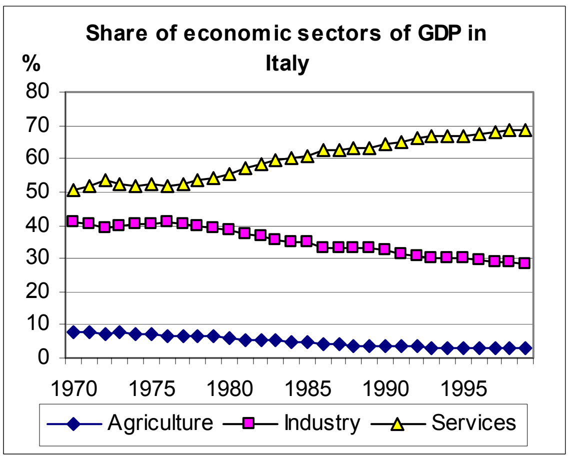


Figure 13. Shares of primary energy supply and economic sectors of GDP in Italy

In Figure 12 the dynamic changes in the energy and CO_2 intensity effects in Italy are compared. In the 60's the intensity effects have been increasing considerably, but after the turning point in 1973 there has been a considerable change towards decreasing energy and CO_2 intensity effects. The results indicate that there have not been remarkable fuel switches in Italy, but increasing energy efficiency has caused the decreases in CO_2 intensity. Only a very small fuel switch towards less carbon intensive energy production can be observed after the year 1990. This is caused mainly by the increased share of natural gas.

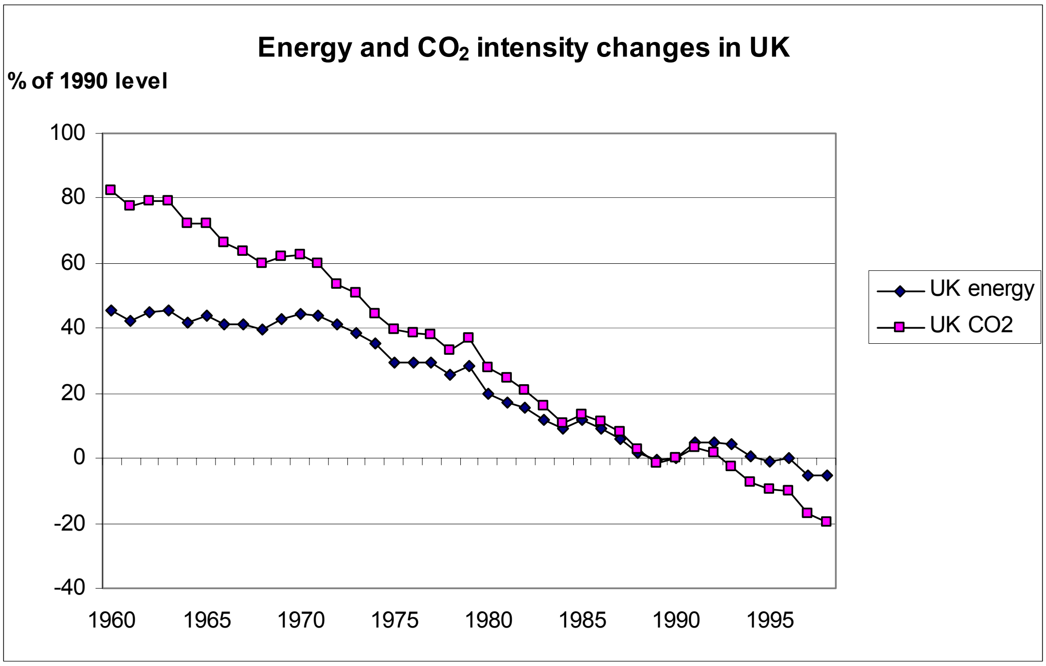


Figure 14. Energy and CO_2 intensity effect changes in the United Kingdom

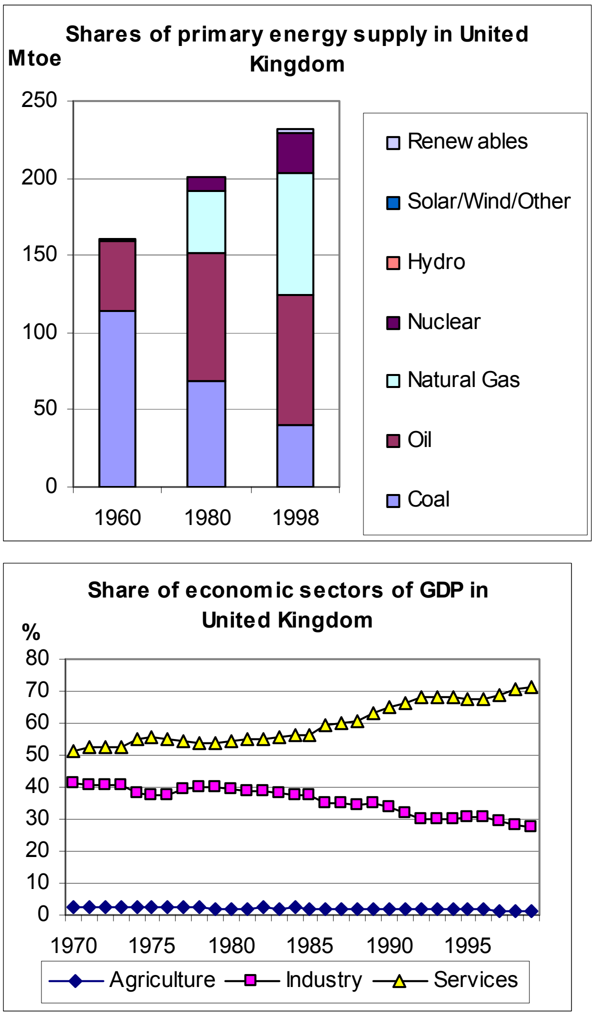


Figure 15. Shares of primary energy supply and economic sectors of GDP in the United Kingdom

Figure 14 illustrates the dynamic changes in energy and CO_2 intensity effects in the UK. The intensity effect of energy use has slightly decreased till the year 1989 indicated by a slow downward sloping trend. The intensity effect on CO_2 has decreased still faster indicating that there has been a fuel switch towards less carbon intensive energy production in the UK, an increased use of nuclear energy and a switch from coal to gas. In the case of the UK the start of oil and gas production in the North Sea has not increased the energy intensity effect, which means that the introduction of a major domestic energy source does not automatically lead to wasteful use of energy or lead to heavier production structure.

Figure 16 summarises the fuel switching that has taken place in the large EU countries. The fuel switching at national level is indicated by the difference of the percentage changes of the intensity effect of CO_2 emissions and the intensity effect of energy use. Decreasing curves indicate decreasing carbonisation of the energy production system.

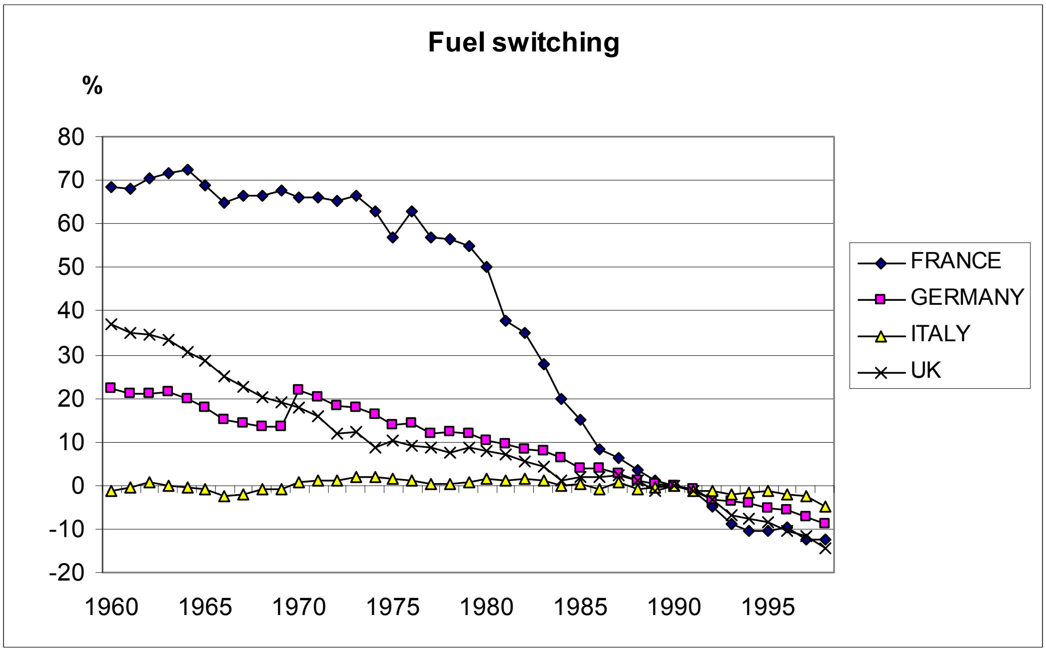


Figure 16. Fuel switching in France, Germany, Italy and the UK

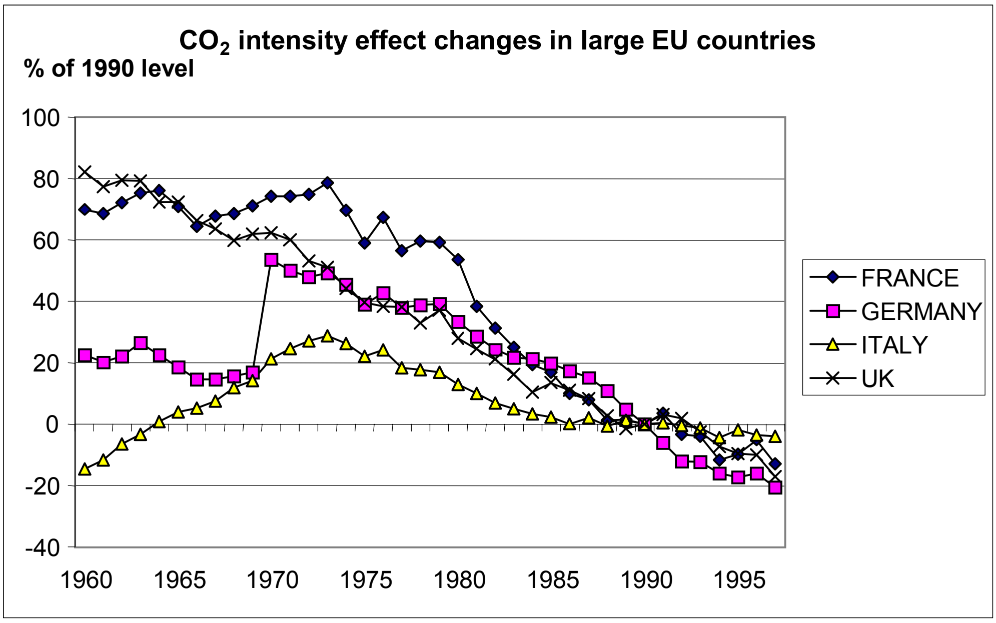


Figure 17. CO_2 intensity effect changes in the large EU member countries (% of 1990 level)

Country level analyses of energy and CO_2 intensity: Nordic countries

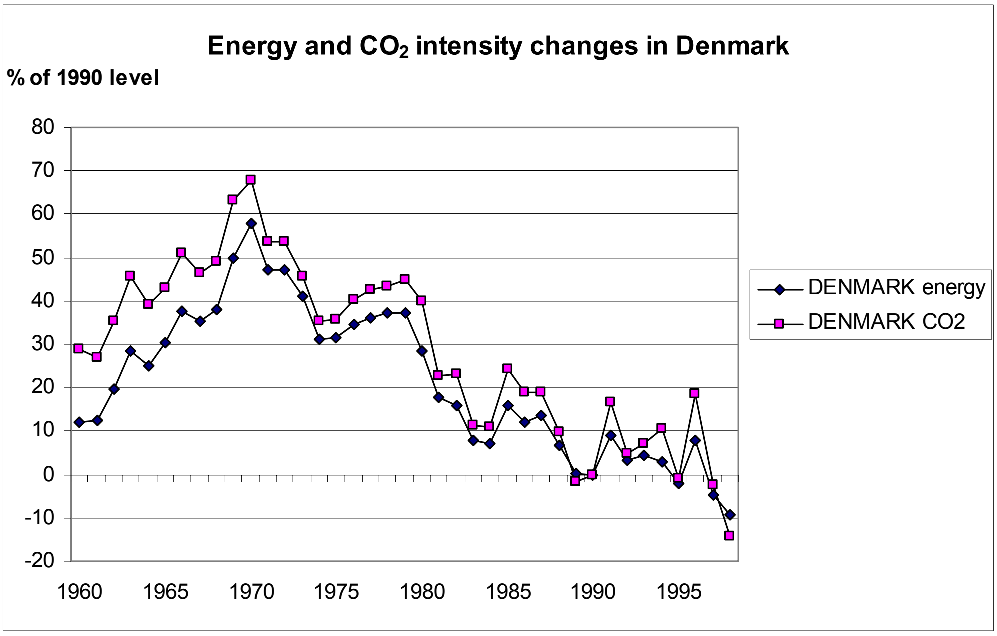
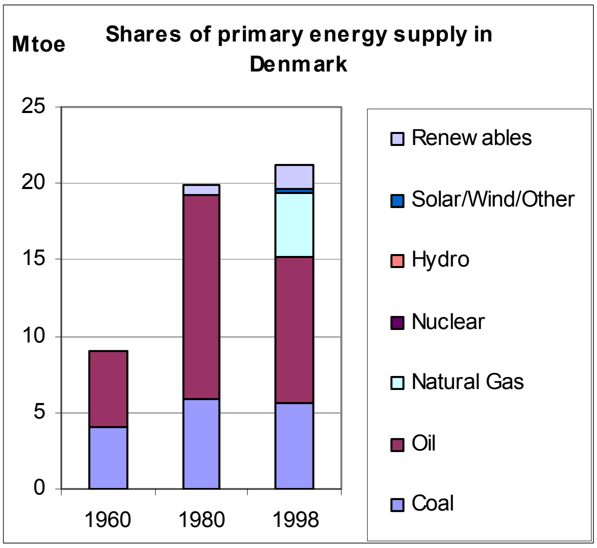


Figure 18. Energy and CO_2 intensity effect changes in Denmark



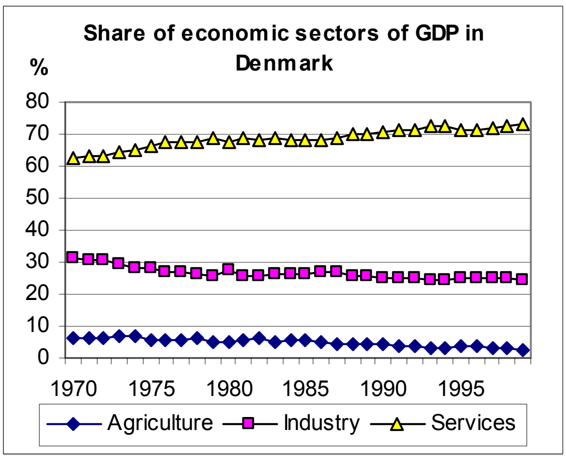


Figure 19. Shares of primary energy supply and economic sectors of GDP in Denmark

In Figure 18 the dynamic changes in the energy and CO_2 intensity effects in Denmark are compared. In the 60's the intensity effects have been increasing considerably, but after the turning point in 1970 there has been a considerable change towards decreasing energy and CO_2 intensity effects. The results indicate that there has been some fuel switch towards increased use of natural gas, but increasing energy efficiency has mainly caused the decreases in CO_2 emissions. The Danish economy has been very service intensive already in the 70s.

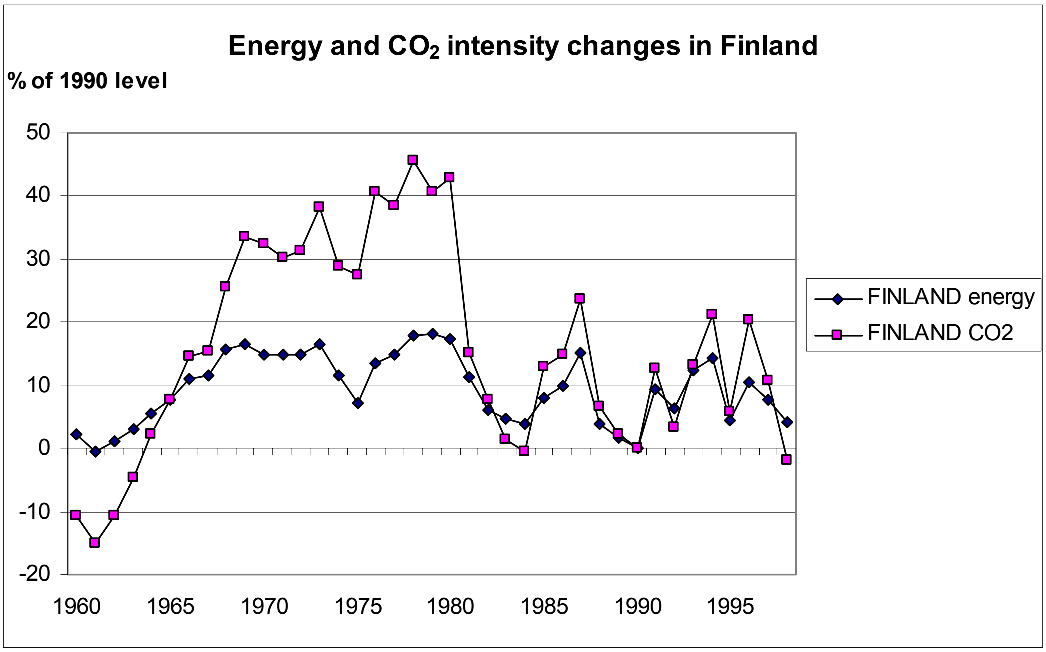


Figure 20. Energy and CO_2 intensity effect changes in Finland

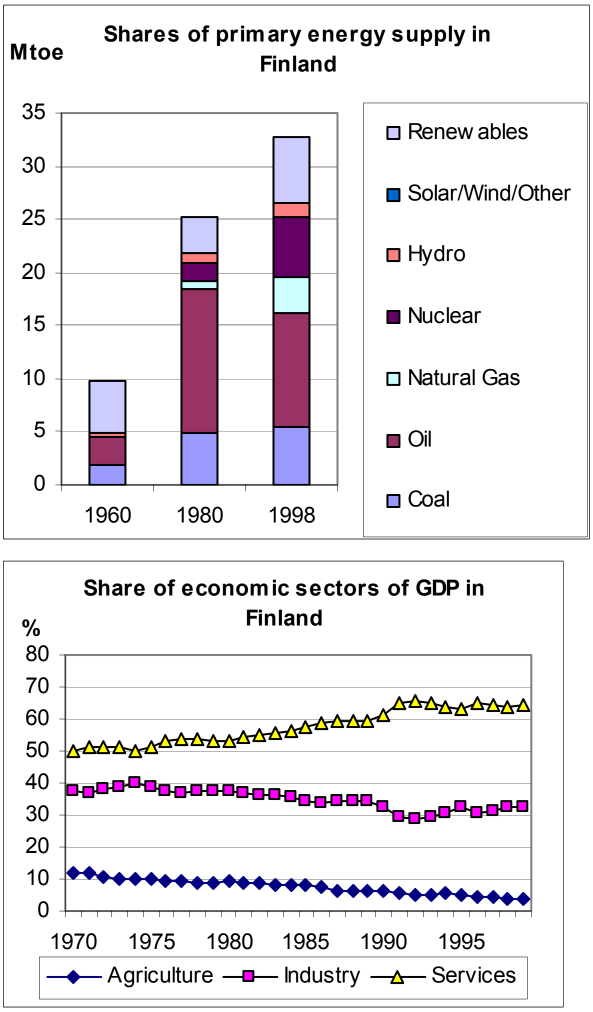


Figure 21. Shares of primary energy supply and economic sectors of GDP in Finland

In Figure 20 the dynamic changes in the energy and CO_2 intensity effects in Finland are compared. The intensity effect of energy use does not have any clear increasing or decreasing trend during the analysed time period. This indicates that there have not been any significant improvements in the total energy efficiency in Finland. In the year 1960 a little bit less amount of energy was used to produce one FIM of GDP than in the year 1998. This means that there has not been a change towards less energy intensive production mode. In the 90s the tendency in the economy has been re-industrialisation, which has been one reason for the non-improving energy efficiency.

The changes in the intensity effect of CO_2 compared with energy intensity effect indicate that there have been remarkable fuel switches in Finland. In the 1960s there has been fuel switch towards carbon intensive energy production. In practice woodfuel was replaced by oil and coal. In late 70's and early 80's the introduction of four nuclear power plants caused remarkable fuel switch towards less CO_2 intensive energy production. After 1982 there has not been any considerable fuel switch in Finland. The large fluctuations in energy and CO_2 intensity effects are mainly caused by changes in hydropower production in the connected Nordic electricity utilities sector. The fluctuations are similar to those in Denmark, which indicates that the domestic coal based condensing power production adapts to changes in hydropower supply. Fluctuations in energy intensities are due to hydropower fluctuations because of the difference in the efficiency of condensing coal fired power production and hydro production.

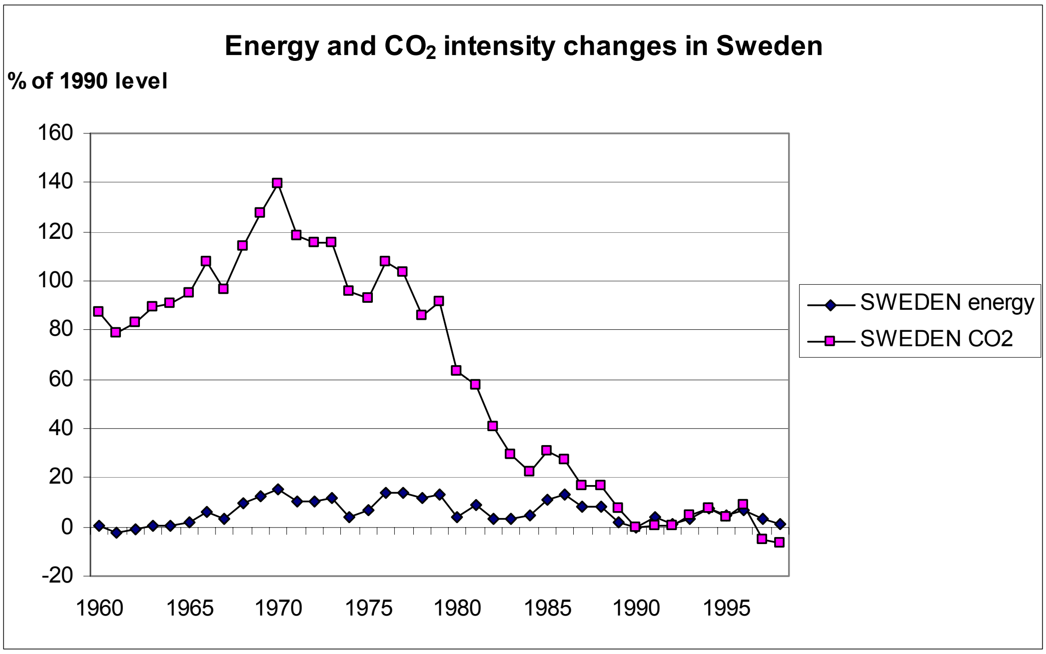
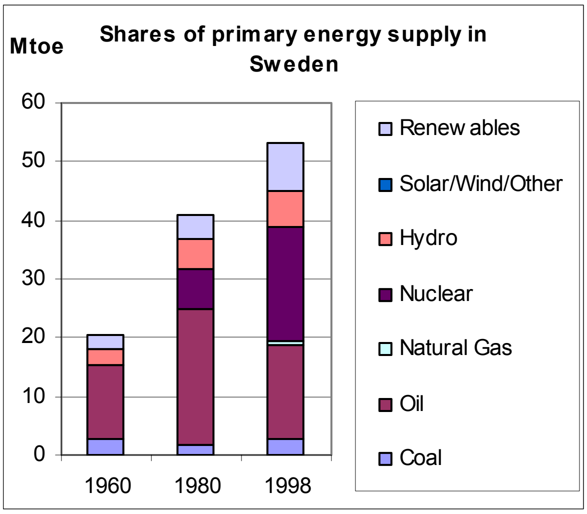


Figure 22. Energy and CO_2 intensity effect changes in Sweden



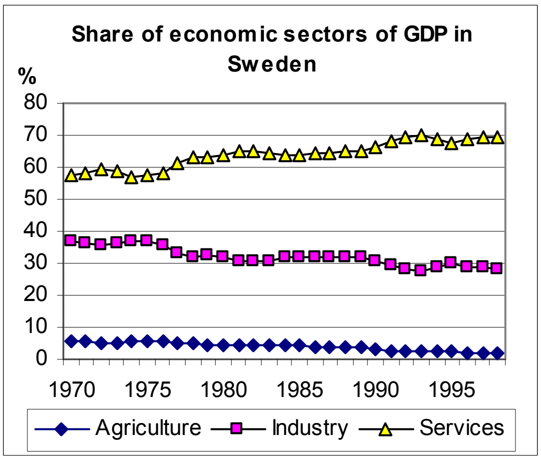


Figure 23. Shares of primary energy supply and economic sectors of GDP in Sweden

Figure 22 illustrates the dynamic changes in energy and CO_2 intensity effects in Sweden. The intensity effect of energy use is quite similar to the Finnish case and it does not have any clear increasing or decreasing trend during the analysed period. The total energy efficiency in Sweden has not improved. The Swedish production structure has remained as inefficient in relation to energy use as it was in the sixties.

The changes in the intensity effect of CO_2 compared with energy intensity effect indicate that there have been remarkable fuel switches in Sweden. The carbon intensity increased in the sixties, but after the turning point in 1970 there has been steady downward sloping trend till the year 1990. The decreasing trend is caused by hydro and nuclear power investments in seventies and eighties. After 1990 the downward sloping trend has broken and there has not been considerable increase in CO_2 efficiency. The effects of hydro production fluctuations on the intensity effect are much smaller than in Finland and Denmark indicating that they have caused mainly changes in electricity export and import and not in fossil based production. Swedish electricity production is, to a very large extent, based on hydro and nuclear production and only few percentages is based on thermal production (Schipper, Johnson, Howarth, Anderson, Anderson and Price 1993).

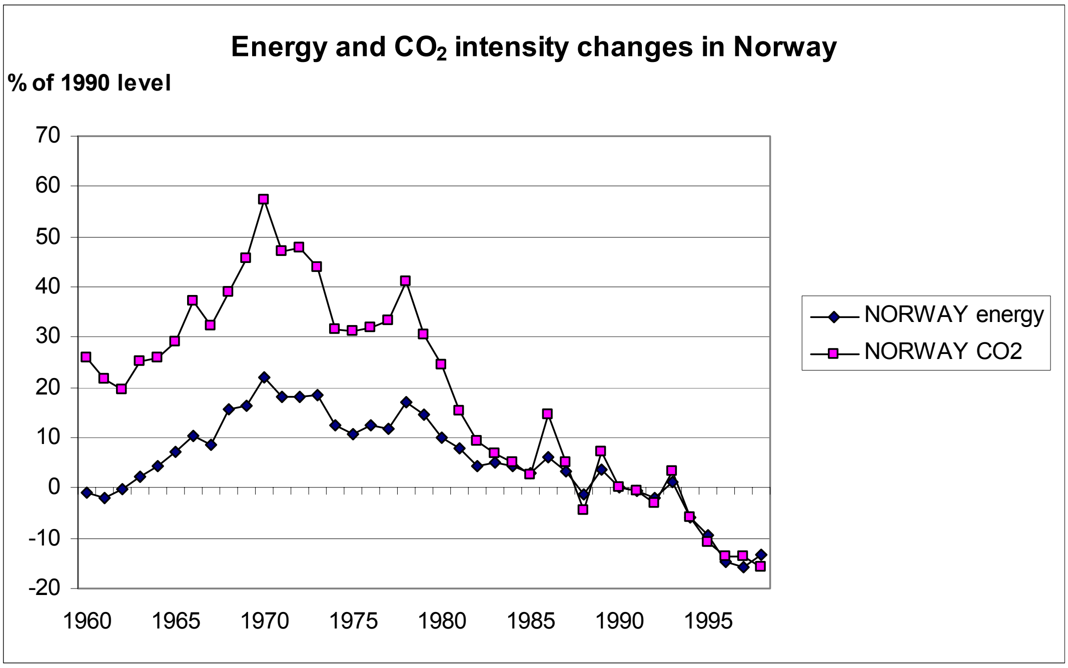
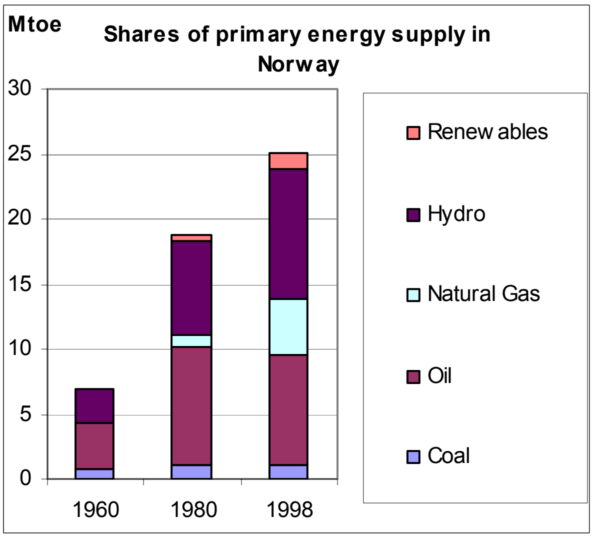


Figure 24. Energy and CO_2 intensity effect changes in Norway



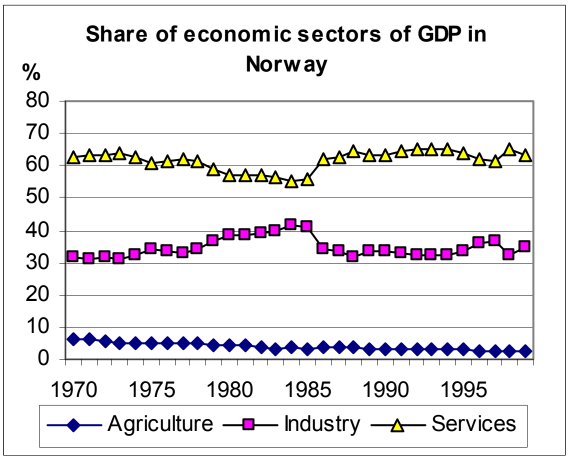


Figure 25. Shares of primary energy supply and economic sectors of GDP in Norway

Figure 24 illustrates the dynamic changes in energy and CO_2 intensity effects in Norway. The intensity effect of energy use has slightly increased during the sixties after which there has been a slow downward sloping trend.

The sharper downward sloping trend in the intensity effect of CO_2 compared with energy intensity effect indicates that the hydro based electricity has increased its share in the total energy production. The hundred-percentage reliance on hydropower in electricity production is a remarkable feature in the Norwegian case. The effects of hydro production fluctuations in Norway on the intensity effect are much smaller than in Finland and Denmark indicating that they have caused mainly changes in electricity export and import. The structural changes in the Norwegian economy are quite different from many EU countries. The importance of oil and gas production is indicated by the large share of the industrial sector. The sharp oil price decrease in 1985 can be seen in the sectoral shares of the economy.

Figure 26 summarises the fuel switching that has taken place in the Nordic countries. The fuel switching is indicated by the difference of the percentage changes of the intensity effect of CO_2 emissions and the intensity effect of energy use. Decreasing curves indicate decreasing carbonisation of the energy production system.

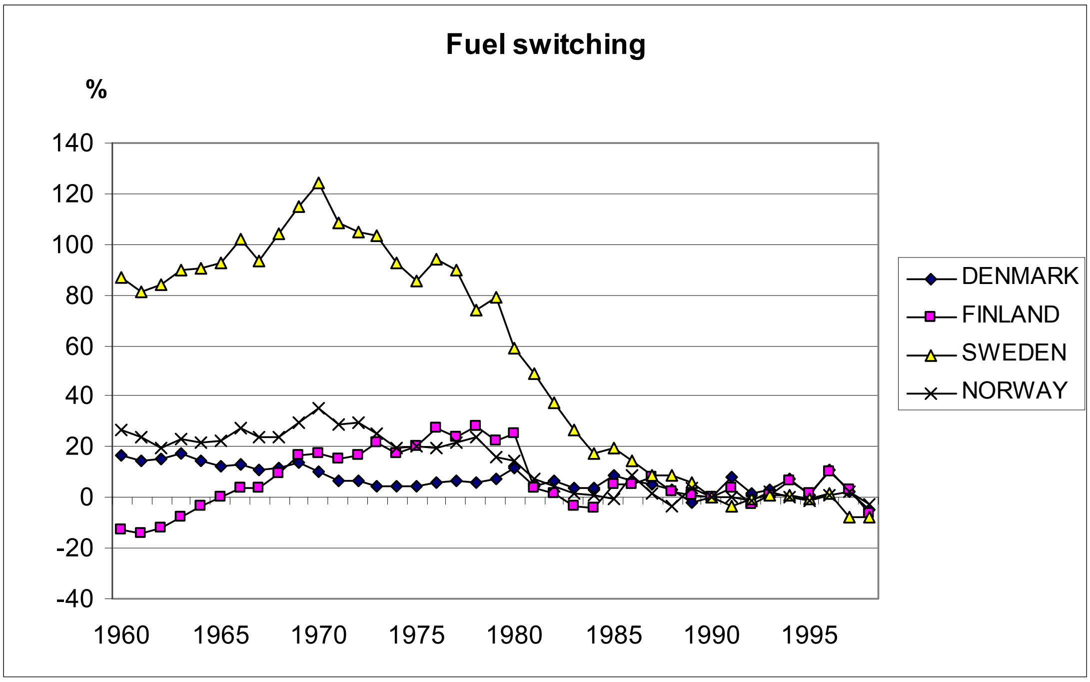


Figure 26. Fuel switching in Denmark, Finland, Sweden and Norway

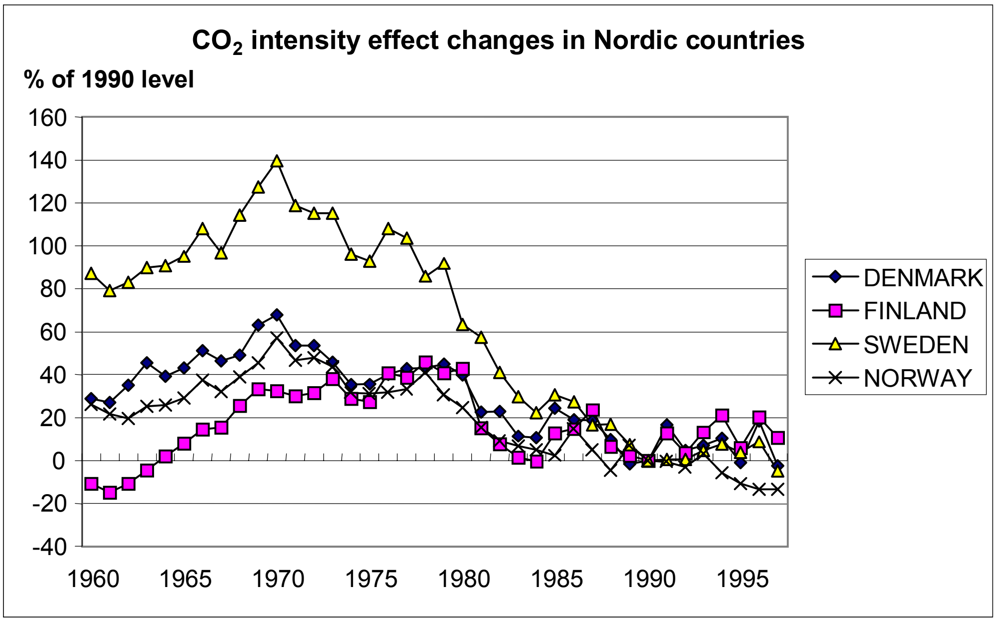


Figure 27. CO_2 intensity effect changes in the Nordic countries (% of the 1990 level)

It is obvious that the Nordic energy system reveals a large degree of flexibility for meeting international CO_2 commitments. Hydro and wind power, increased use of bio fuels, end use conservation and efficiency measures, increased power production from combined heat and power units but also increased reliance on natural gas, are all factors that may play an important part in reducing CO_2 emissions in the future.

6. Country level analyses of energy and CO_2 intensity: Cohesion countries in European Union

Both energy and CO_2 intensity effects have been growing considerably in Greece (see Fig. 28). This indicates that more energy is used and more emissions are released to produce same amount of GDP. From the sixties to the nineties there is no indication of fuel switch. The energy production in Greece has been almost totally based on coal and oil leading to carbon intensive structure of the economy. In the late nineties one can observe a slight change towards less carbon intensive energy use. The share of agricultural production is still quite large in Greece.

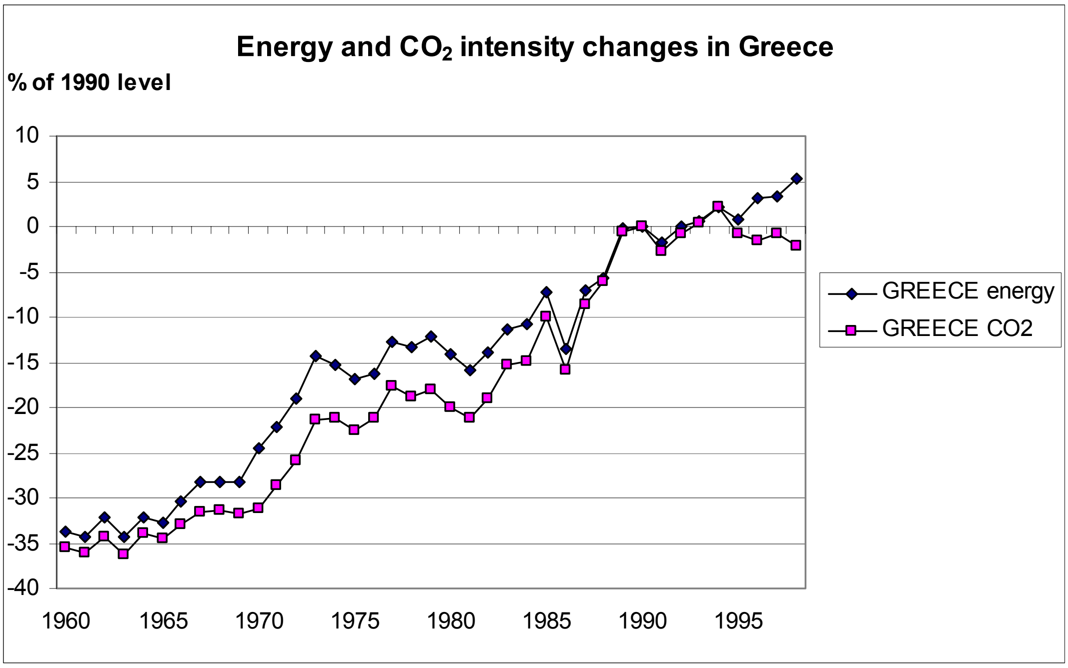


Figure 28. Energy and CO_2 intensity effect changes in Greece

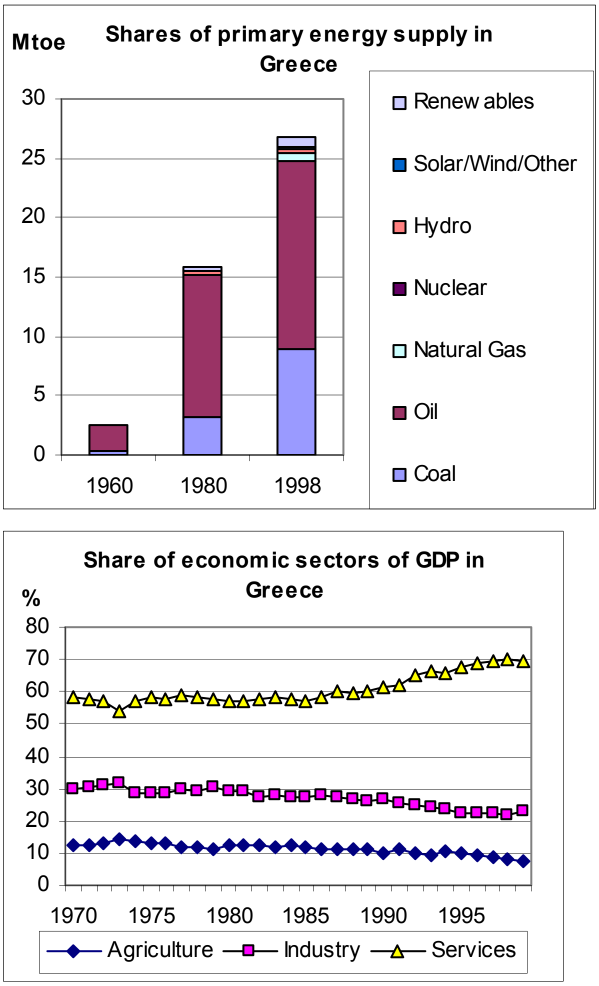


Figure 29. Shares of primary energy supply and economic sectors of GDP in Greece

One can see in Fig. 30 that energy and CO_2 intensity effects in Ireland have been decreasing considerably, especially in the nineties. This is related to the structural change in Irish economy. Especially chemical industry and computers and instrument engineering have increased their share in the GDP producing larger economic output with less energy input. The increasing CO_2 efficiency in Ireland is mainly due to the increasing energy efficiency – there seems to be no larger fuel shift although in the late nineties natural gas has increased its share.

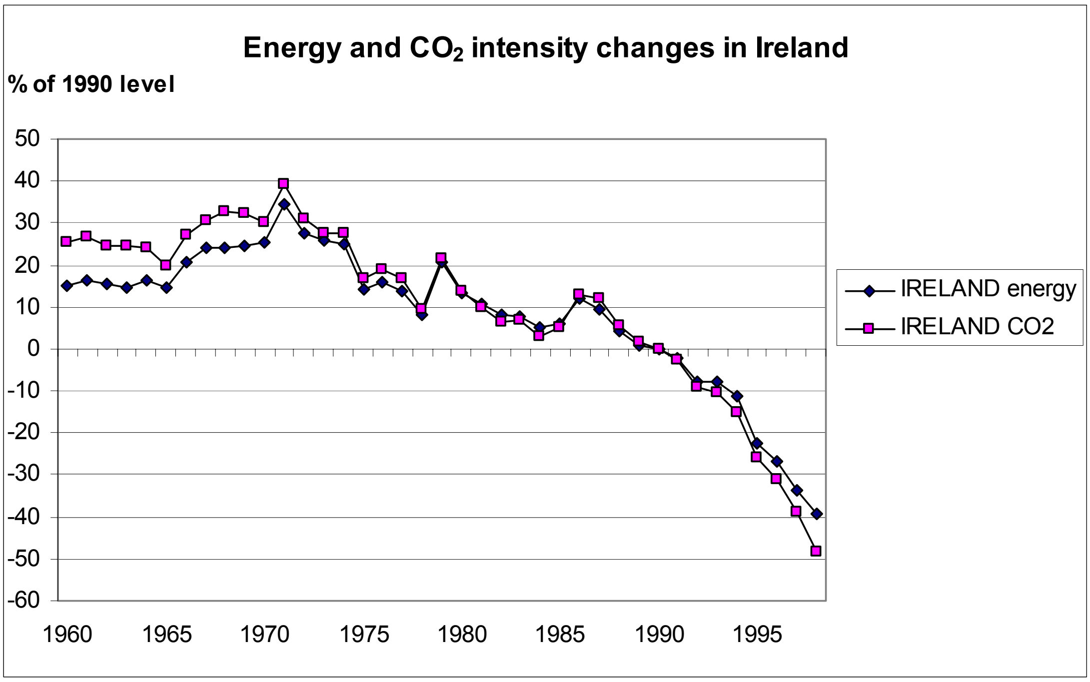
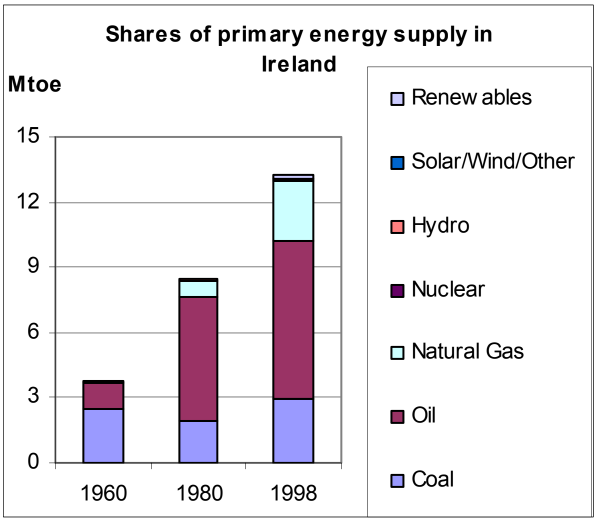


Figure 30. Energy and CO_2 intensity effect changes in Ireland



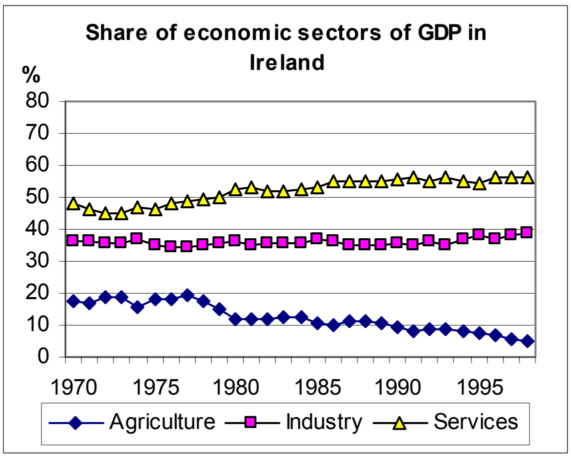


Figure 31. Shares of primary energy supply and economic sectors of GDP in Ireland

In Portugal the energy and CO_2 intensity effects have been increasing hand in hand. This indicates that there have not been any major fuel switches in Portugal and the economy is developing in a more energy intensive direction. Start of oil refinery industry in the 1980s and especially the fast growth of road transport fuel consumption in the 1990s are the main reasons for the increasing energy intensity of the Portuguese economy. Decreasing share of agriculture in GDP is also one reason affecting the development.

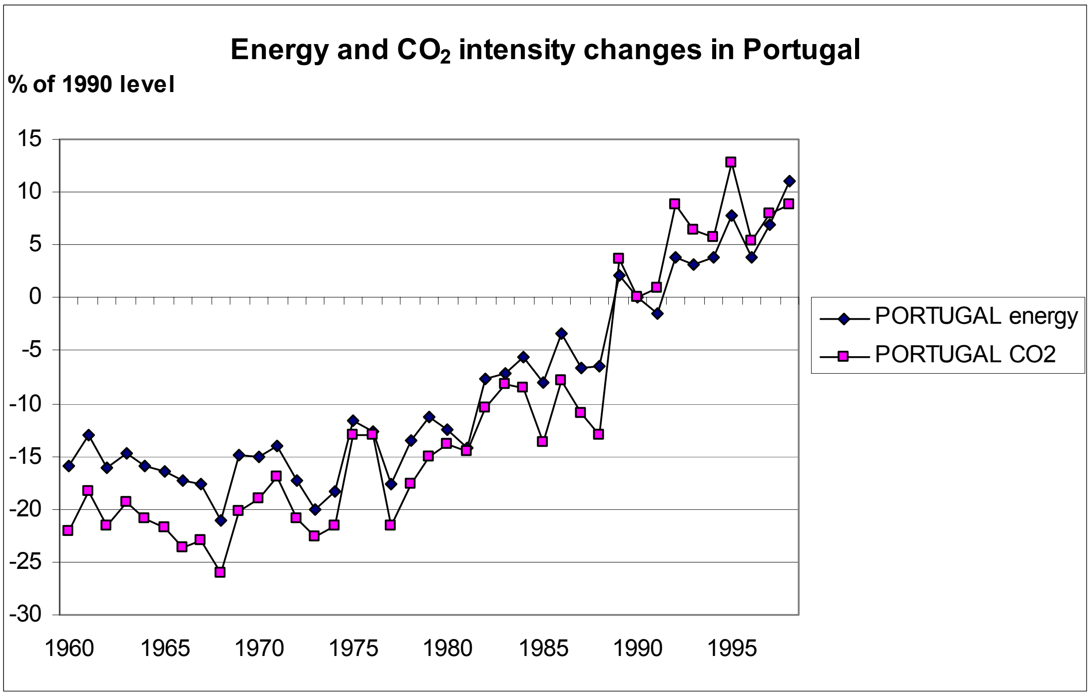


Figure 32. Energy and CO_2 intensity effect changes in Portugal

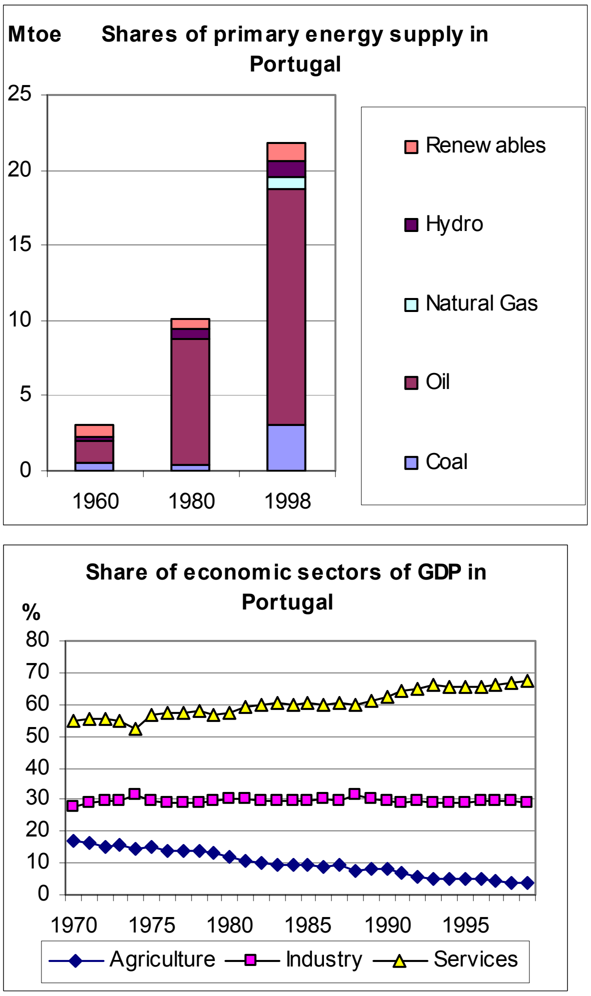


Figure 33. Shares of primary energy supply and economic sectors of GDP in Portugal

In Spain the shapes of the development of energy and CO_2 intensity effects have been similar up to 1980 indicating no fuel switches. From 1980 to 1988 the CO_2 efficiency has improved considerably due to the introduction of nuclear power. After 1988 the CO_2 efficiency has again started slightly to decrease along with the energy efficiency (see Fig. 34).

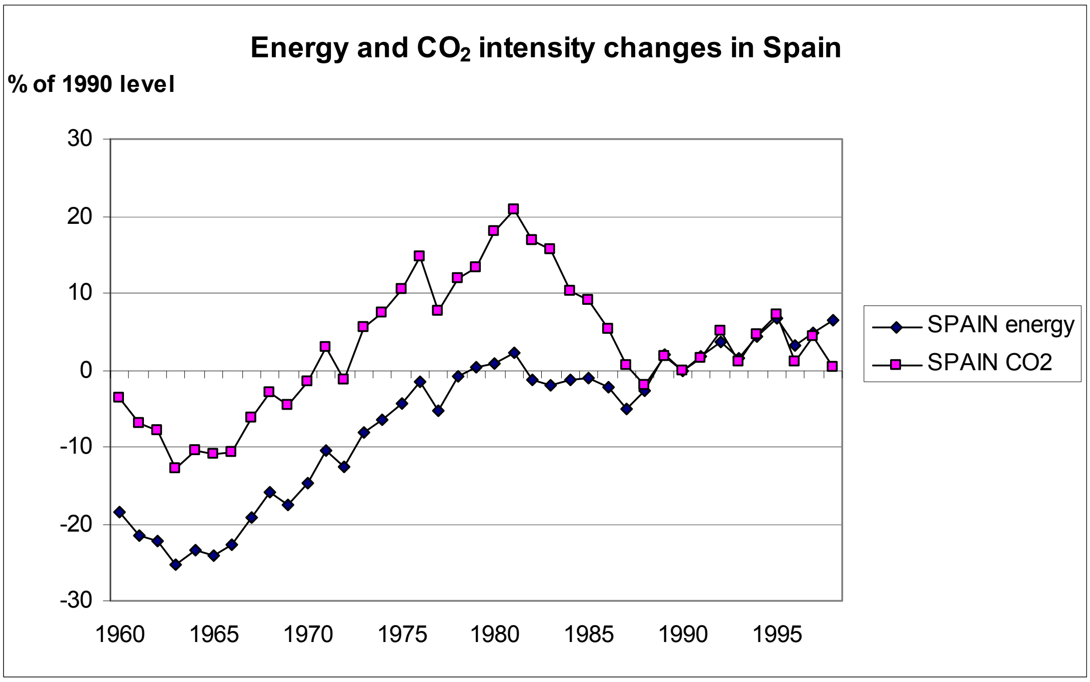
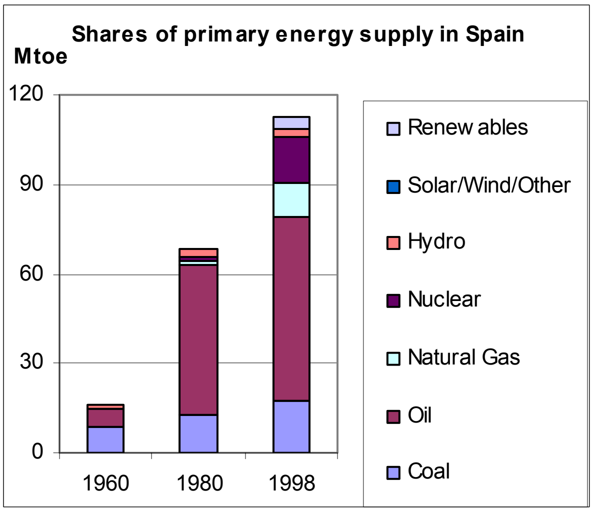


Figure 34. Energy and CO_2 intensity effect changes in Spain



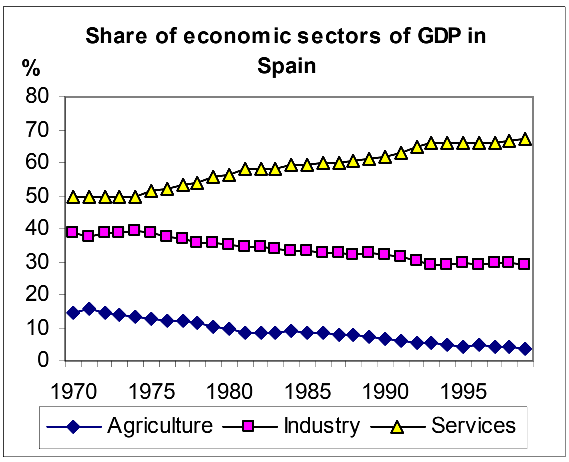


Figure 35. Shares of primary energy supply and economic sectors of GDP in Spain

Figure 36 summarises the fuel switching that has taken place in the EU cohesion countries. The fuel switching is indicated by the difference of the percentage changes of the intensity effect of CO_2 emissions and the intensity effect of energy use. Decreasing curves indicate decreasing carbonisation of the energy production system.

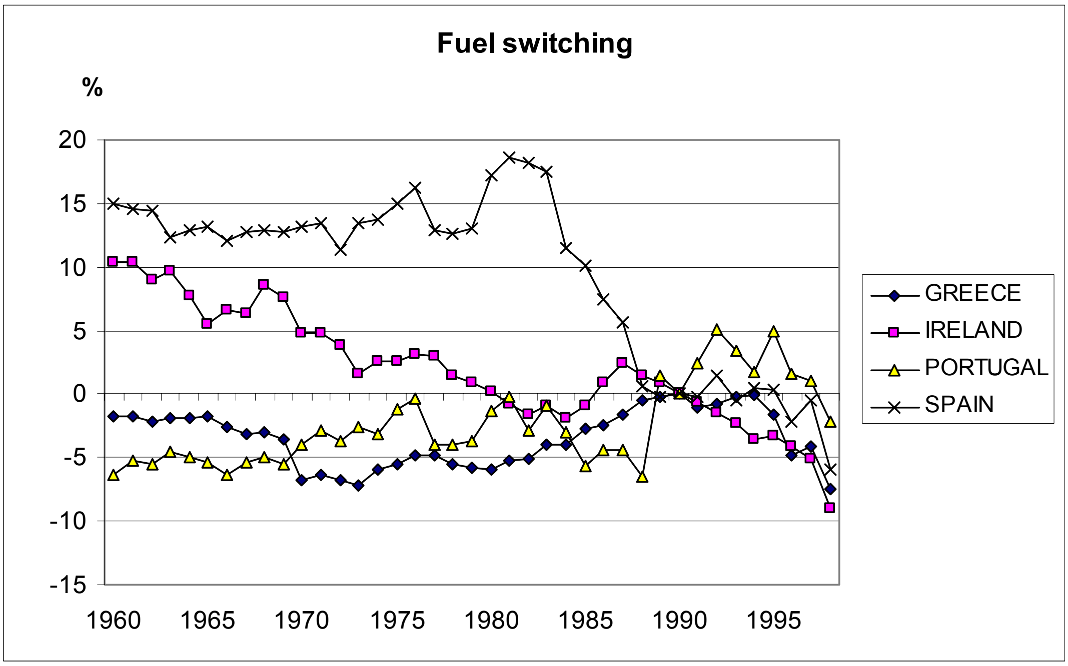


Figure 36. Fuel switching in Greece, Ireland, Portugal and Spain

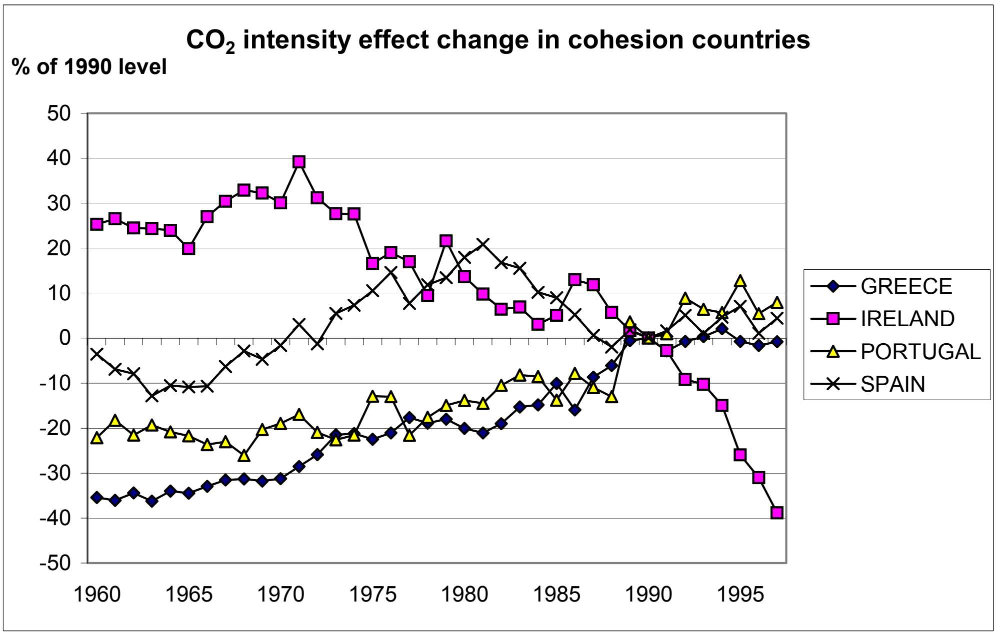


Figure 37. CO_2 intensity effect changes in the cohesion countries (% of the 1990 level)

Country level analyses of energy and CO_2 intensity: Other EU countries

In Austria the energy and CO2 efficiencies have increased considerably after the first energy crisis in 1973. The increasing natural gas consumption and hydro production have contributed to the fuel switch to less carbon intensive energy mix. (Fig. 38).

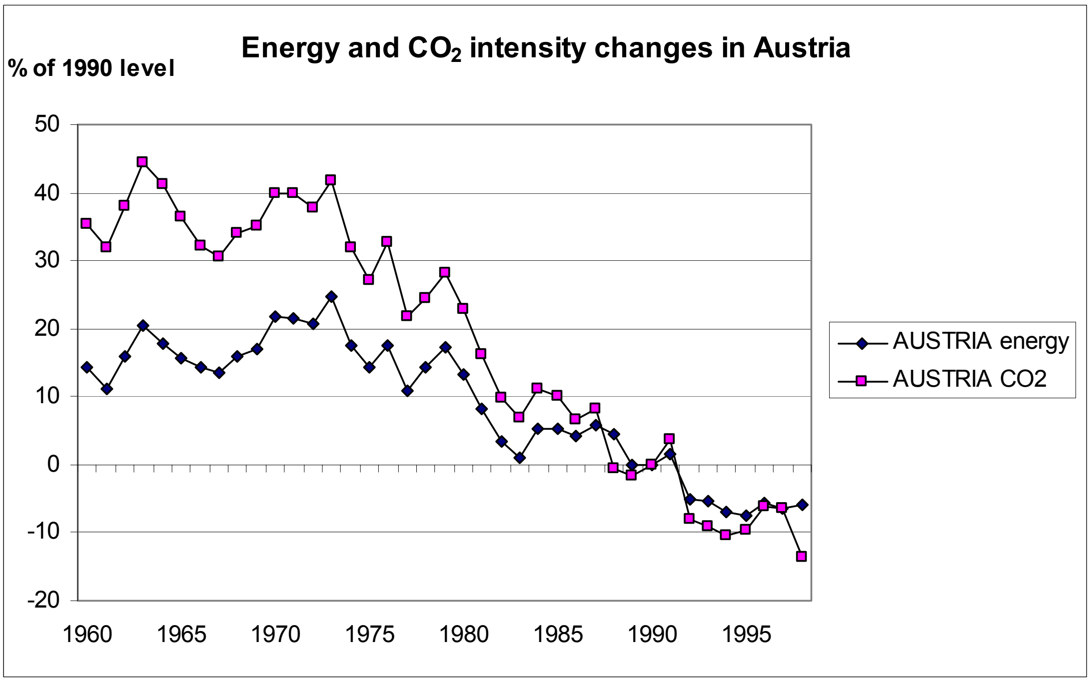
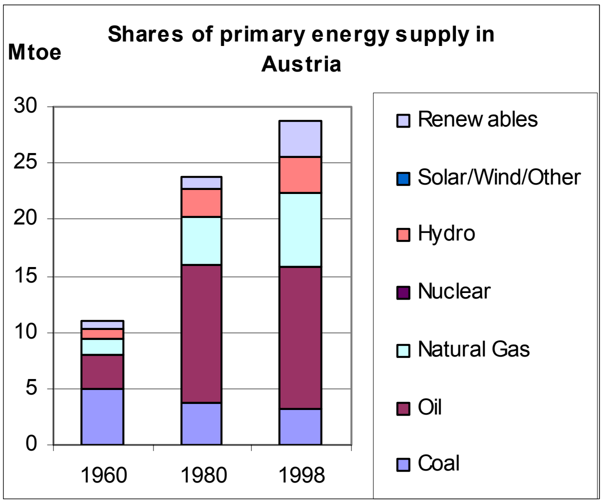


Figure 38. Energy and CO_2 intensity effect changes in Austria



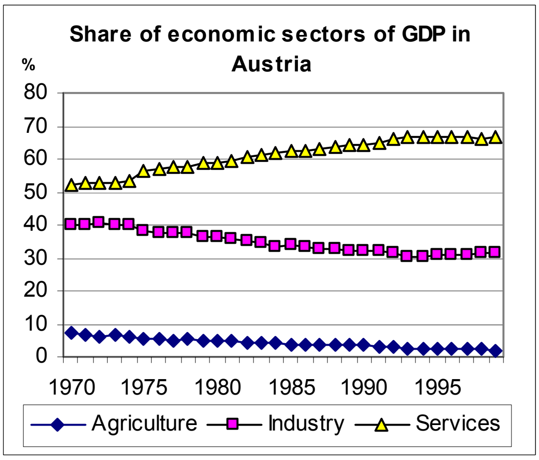


Figure 39. Shares of primary energy supply and economic sectors of GDP in Austria

In Belgium there has been a slight increase in the energy efficiency after the first energy crisis 1973 but the positive development has ended in the beginning of the 80s after the introduction of nuclear power. The improvement in the CO_2 efficiency has been remarkable after 1970. The introduction of nuclear power is the main reason, but also the energy efficiency has improved. The structural change in the economy has been considerable in Belgium. (Fig. 40).

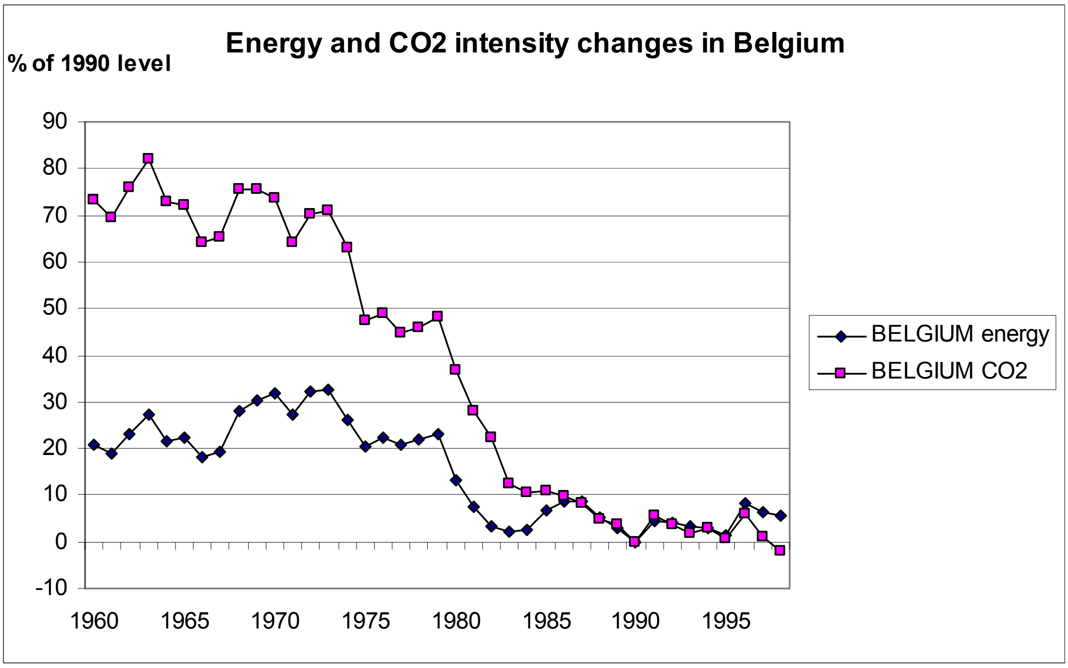
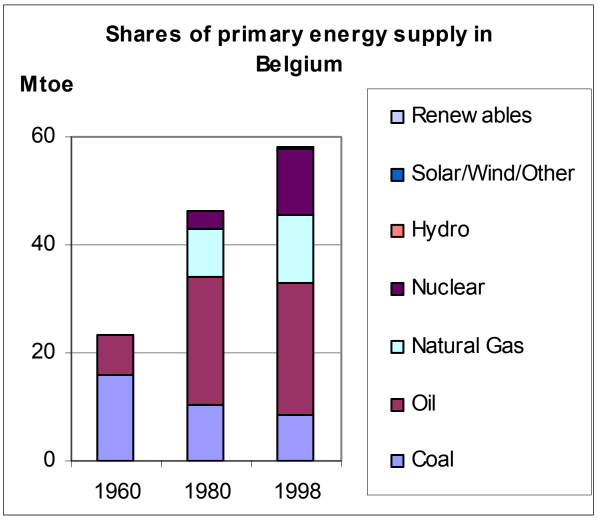


Figure 40. Energy and CO_2 intensity effect changes in Belgium



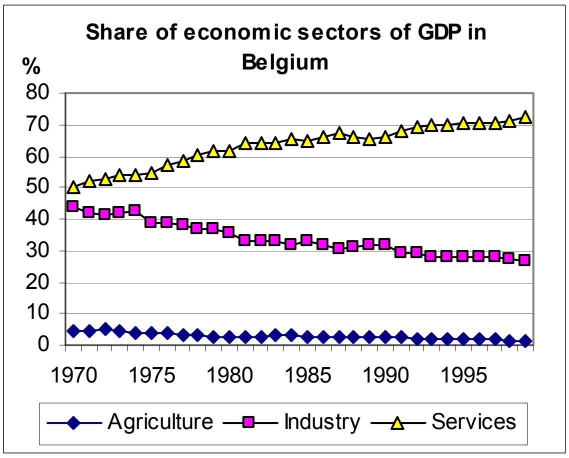


Figure 41. Shares of primary energy supply and economic sectors of GDP in Belgium

Luxembourg shows a remarkable increase in both energy and CO_2 efficiency. There has been a large shift from coal to petroleum products and to some extent to natural gas. The total energy consumption has decreased while the economy has been growing. The change is caused by the large structural shift in the economy from industry dominated production to service economy. (Fig. 42).

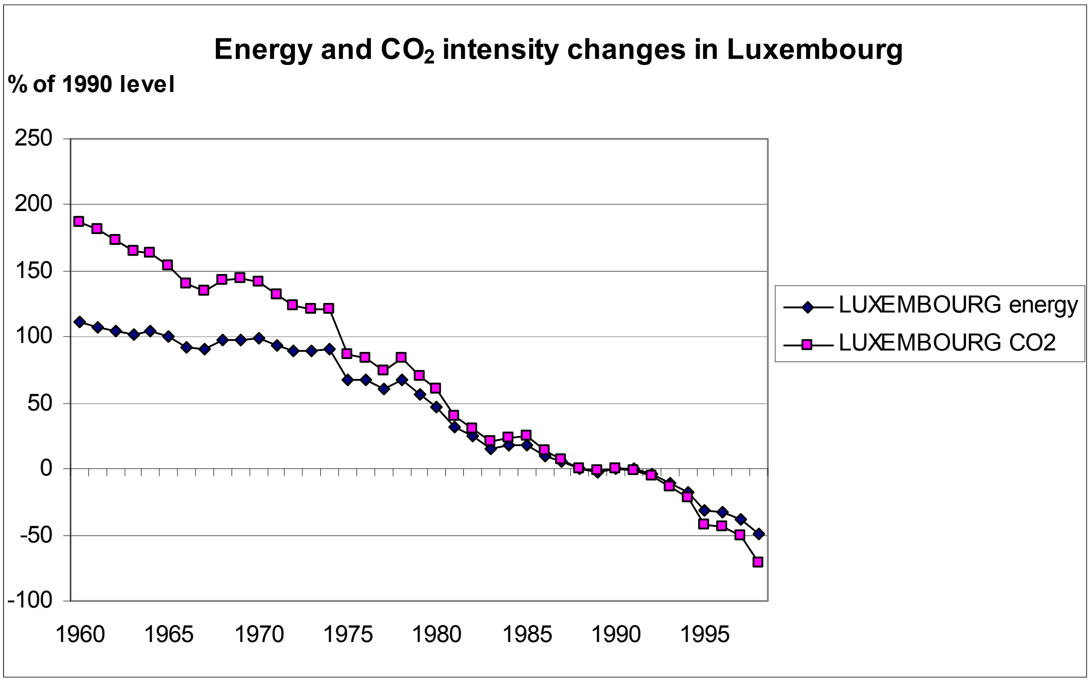
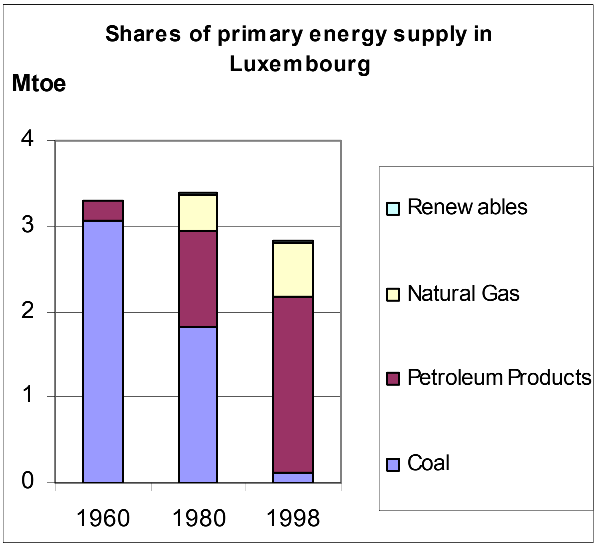


Figure 42. Energy and CO_2 intensity effect changes in Luxembourg



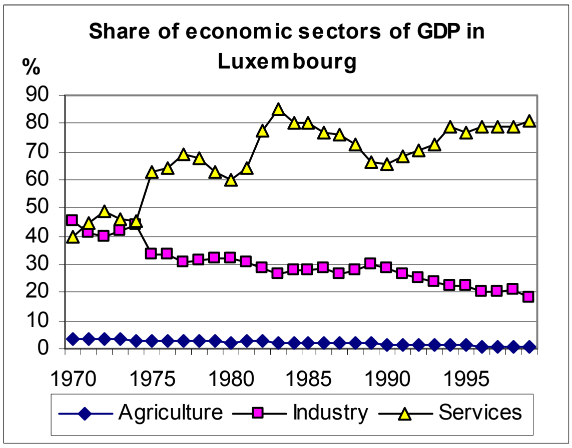


Figure 43. Shares of primary energy supply and economic sectors of GDP in Luxembourg

The first oil crisis in 1973 has been a turning point in the energy economy in the Netherlands. The development towards more carbon intensive economy ended and after the second oil crisis in 1979 there was a considerable increase in energy efficiency. After the first oil crisis there have not been any major fuel switches and the increased CO_2 efficiency has been due to the improving energy efficiency (Fig. 44).

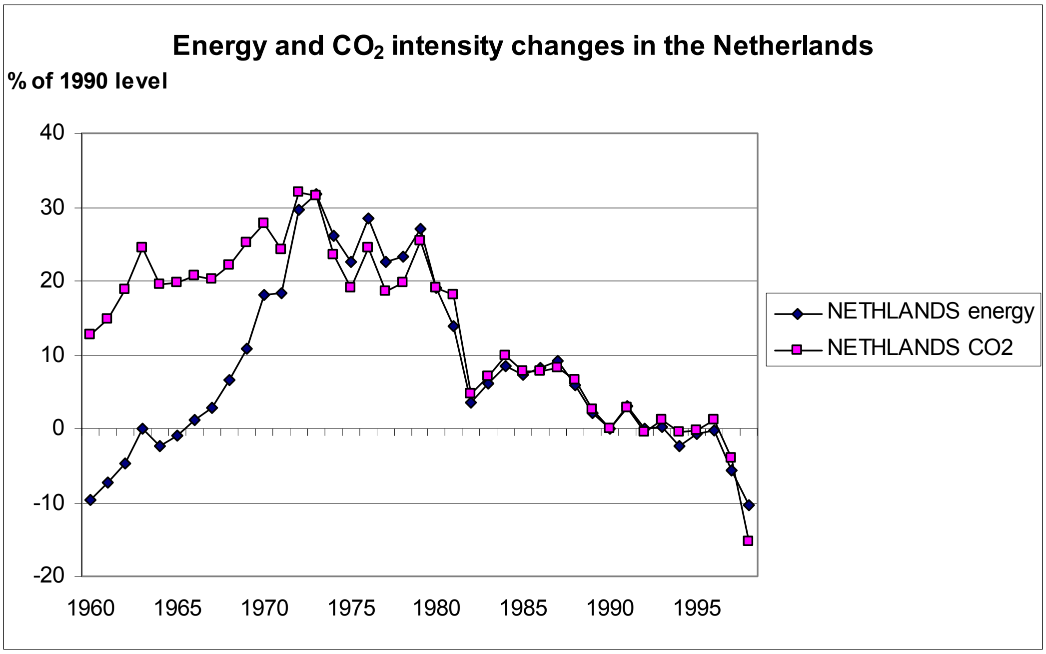
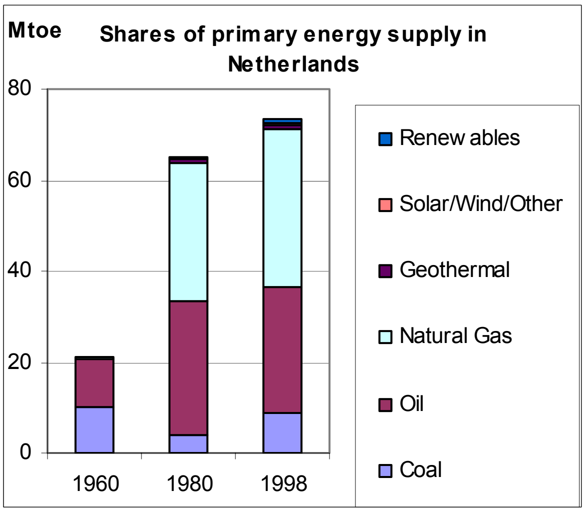


Figure 44. Energy and CO_2 intensity effect changes in the Netherlands



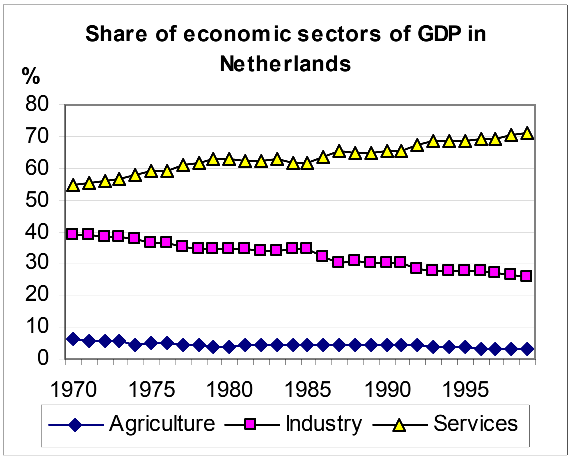


Figure 45. Shares of primary energy supply and economic sectors of GDP in the Netherlands

Figure 46 summarizes the fuel switching that has taken place in Austria, Belgium, Luxembourg and the Netherlands. In the figure 45 the fuel switching is indicated by the difference of the percentage changes of the intensity effect of CO_2 emissions and the intensity effect of energy use. Decreasing curves indicate decreasing carbonisation of the energy production system.

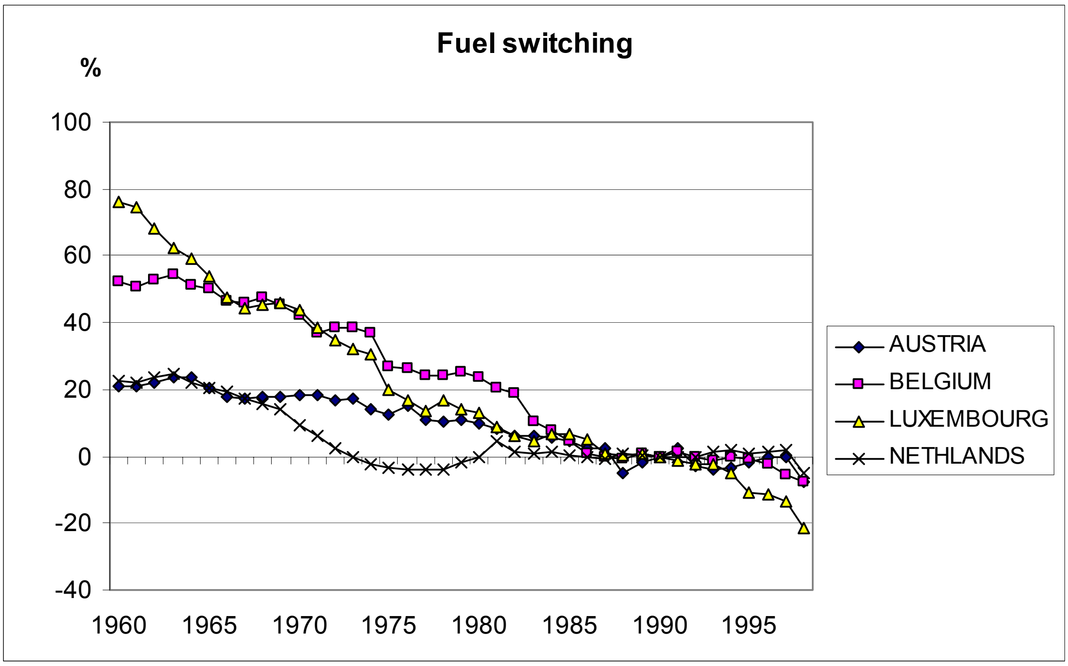


Figure 46. Fuel switching in Austria, Belgium, Luxembourg and the Netherlands

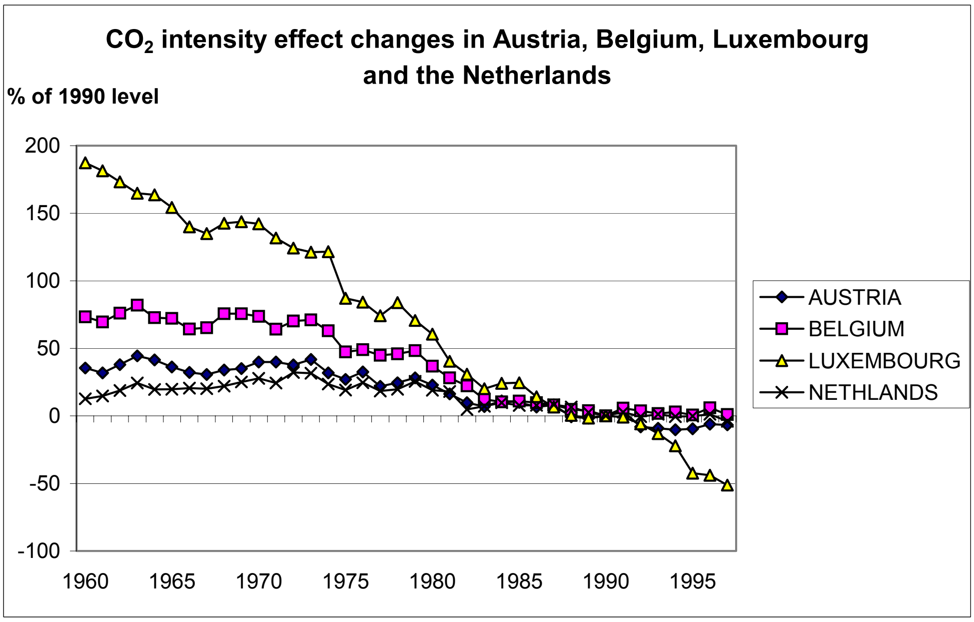


Figure 47. CO_2 intensity effect changes in other EU countries (% of the 1990 level)

Results and discussions

There are basically three different possibilities for the reduction of CO_2 emissions of a country; (i) reduction of energy use, (ii) fuel switch to less carbon intensive fuels or (iii) efficiency improvement of the energy system. The efficiency improvement depends on (i) the socio-cultural development of the society, (ii) economic and structural development and (iii) technological development. Within the economic development especially the role of industrial development and its structure in the globalised economy (e.g. shift of heavy and polluting industry to developing countries and increase of ICT sector) in relation to the development of other sectors (e.g. service sector and tourism) is essential.

In this study we have carried out a comparative study of all the three factors for EU-15 countries and Norway. The research period 1960-1998 has been divided into two periods, from 1960 to 1973 and from 1973 to 1998 because the first oil crisis changed the energy sector development considerably. The most significant results of the study are summarised in Table 2.

The results of the Table 2 have been visualised in Figs 48, 49 and 50.

Figure 48 depicts the annual change in primary energy consumption. The oil crises in the 1970's had a remarkable effect on the energy consumption increase. The average annual energy use increase has decreased from 6.5 per cent before the first oil crisis down to less than 1.5 per cent. There are, however, large variations between the different EU countries. The larger growth in energy consumption in the cohesion countries has been, to some extent, accepted as "the price" the EU has to pay to modernise the production structure and to industrialise the countries. We can, however, ask whether the industrialising strategy based on increased energy consumption is the best available option or could there be other possibilities based on e.g. post-industrial information society development, which would be less energy intensive.

Table 2. Annual primary energy consumption increase, fuel switching and energy efficiency improvement in the EU-15 countries and Norway.

Countries	**Annual primary energy consumption increase**		**Fuel switching**		**Energy efficiency improvement**	
	1960-1973	**1974-1998**	**1960-1973**	**1974-1998**	**1960-1973**	**1974-1998**
Austria	**5,4**	**1,1**	**0**	+ +	**-**	+ + +
Belgium	**5,4**	**0,9**	+	+ + +	**-**	+ +
Denmark	**6,2**	**0,2**	+	+	**- -**	+ + +
Finland	**6,2**	**1,8**	**- - -**	+ +	**-**	**0**
France	**6,3**	**1,5**	**0**	+ + +	**0**	**0**
Germany	**6,9**	**0,1**	+	+ +	**0**	+ + +
Greece	**13,0**	**3,2**	**0**	**0**	**- -**	**- -**
Ireland	**5,1**	**2,5**	+	+	**-**	+ + +
Italy	**9,5**	**1,1**	**0**	**0**	**- - -**	+ +
Luxembourg	**2,4**	**-1,2**	+ + +	+ + +	+ + +	+ + +
Netherlands	**8,7**	**0,7**	+ +	**0**	**- - -**	+ + +
Norway	**6,1**	**2,1**	**0**	+ + +	**-**	+ +
Portugal	**7,0**	**4,5**	**0**	**0**	**0**	**- - -**
Spain	**9,5**	**3,1**	**0**	+ +	**-**	**-**
Sweden	**5,1**	**1,2**	**- -**	+ + +	**0**	**0**
United Kingdom	**2,5**	**0,2**	+ + +	+ +	**0**	+ + +

\+ = fuel switching to less carbon intensive fuels or improved energy efficiency
\- = fuel switching to more carbon intensive fuels or decreased energy efficiency
0 means no remarkable change (less than 5%)
\+ or **-** means small percentage change (from 5% to 15%)
\+ + or **- -** means medium percentage change (from15% to 25%)
\+ + + or **- - -** means large percentage change (over 25%)

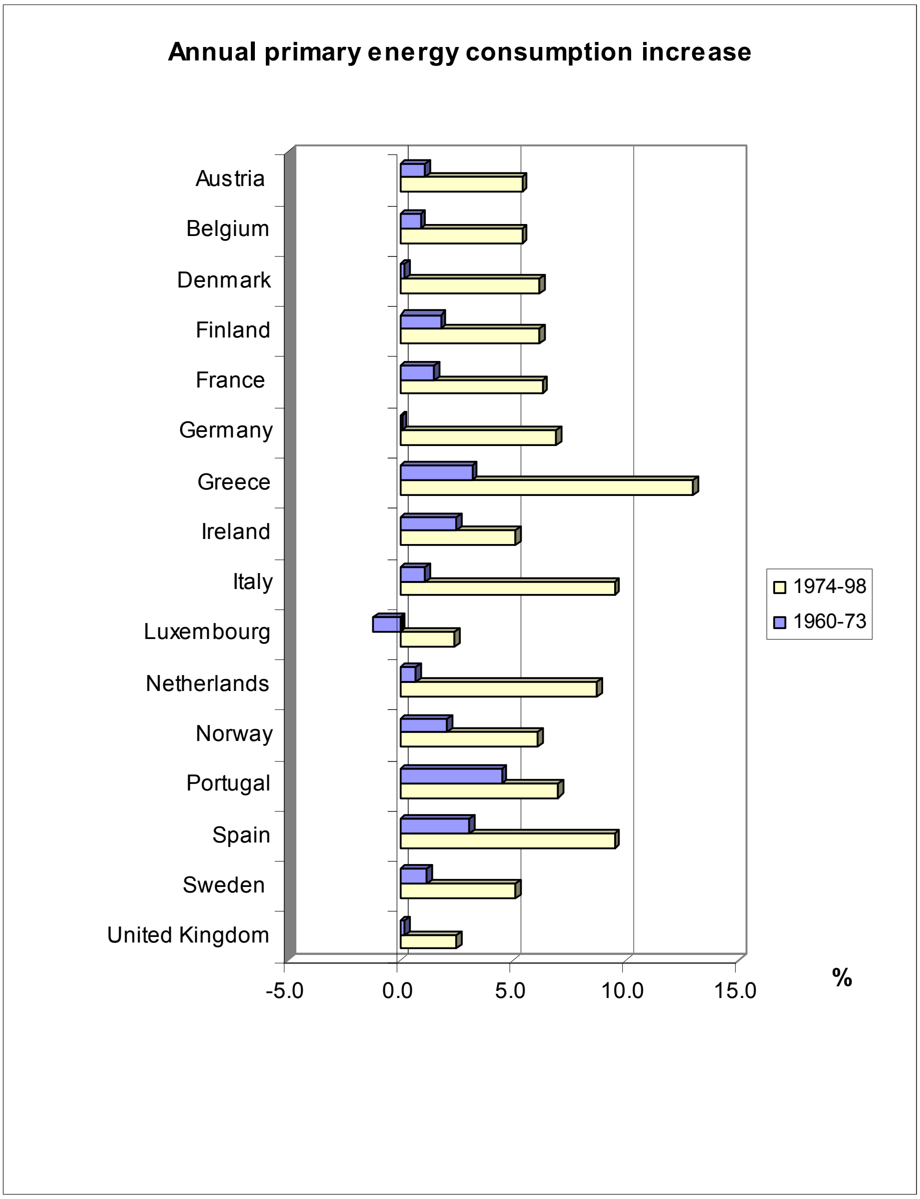


Figure 48. Changes in average annual primary energy supply (TPES) in EU-15 countries for the time periods of 1960-73 and 1974-98.

Figures 49 and 50 plot the countries in the decarbonisation/energy efficiency space for the two time periods. According to the figures the general trend of development has lead towards decarbonisation, i.e. the fossil carbon intensity of the primary energy supply has decreased, and towards increased energy efficiency. Again in these figures we can see that the Mediterranean cohesion countries have not been able to improve their energy efficiency due to the structural changes that are taking place in these countries.

It is also interesting to notice that France, Sweden and Finland have not improved their energy efficiency. These three countries have relied to a large extent on nuclear power in their supply and energy intensive industrial development in their economy. Countries with heavy reliance on nuclear power, but decisions to reduce the reliance (such as Germany, UK and Belgium) have improved their energy efficiency considerable. Generally, the decarbonisation process has been most successful in the countries relying on nuclear power and hydro power.

In countries relying mainly on fossil energy sources, such as Italy, Ireland, Denmark and the Netherlands, the decarbonisation process has not proceeded during the research period, but the efficiency improvement has been able to control the CO_2 emission growth. Switch to renewable energy sources would be the main target in these countries to reach the Kyoto targets in the future.

Performance 1960-1973

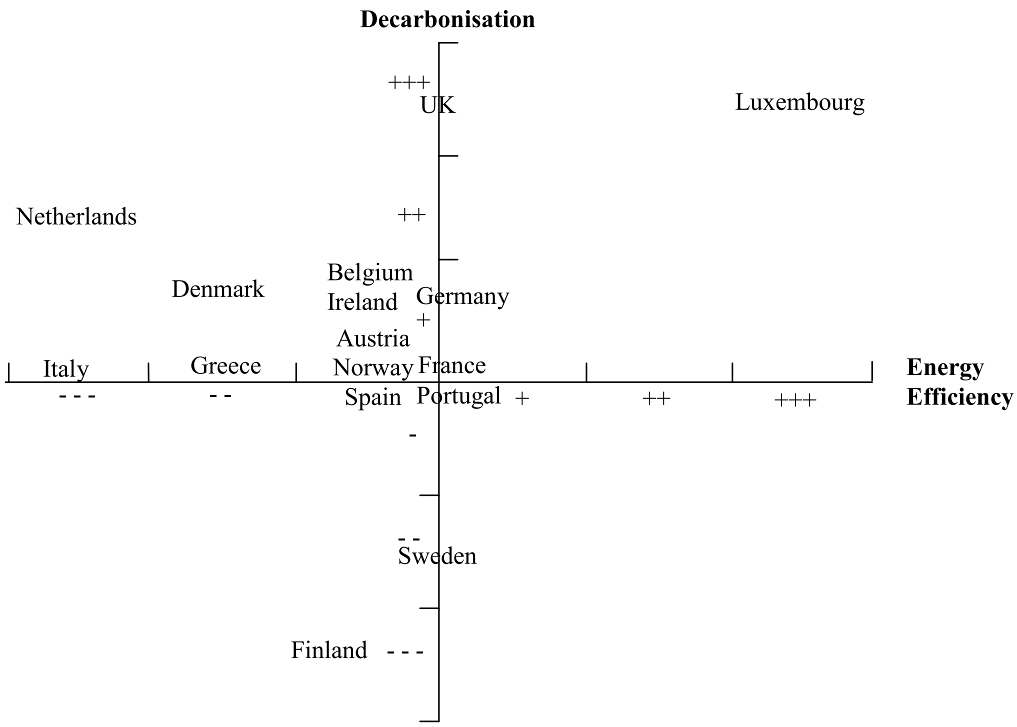


Figure 49. Performance of the EU-15 countries in relation to decarbonisation of energy supply and changes in energy efficiency during 1960-1973.

Performance 1974-1998

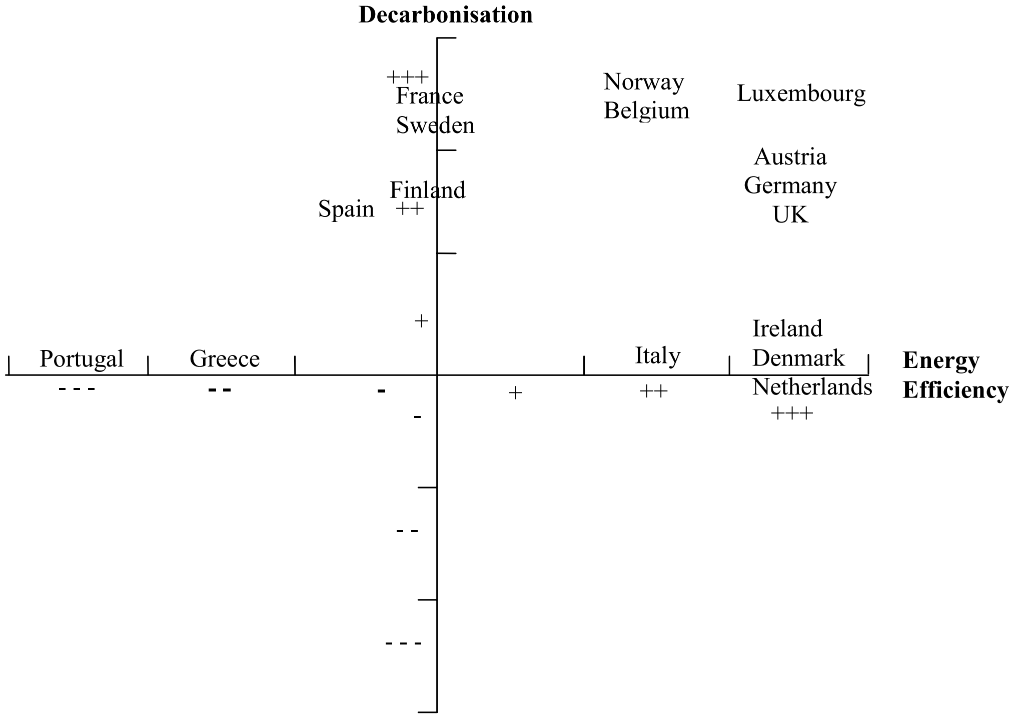


Figure 50. Performance of the EU-15 countries in relation to decarbonisation of energy supply and changes in energy efficiency during 1974-1998.

Conclusions

The results show that there exist quite different trends in the European Union energy sector development and there is room for energy policy harmonisation in the EU. On the one hand we must remember that the EU countries are in different phases of their economic and industrial development, which is one reason for the observed trends. On the other hand, we can ask whether the industrialisation process is the best option for the cohesion countries, especially if we take into account the environmental aspects, or could the Irish way of development, relying heavily on post-industrial information society development, offer better options also the Mediterranean countries.

With the introduction of new member countries the variations and differences still increase. The accession process will raise new challenges for the harmonisation of the energy and climate policy. The acceptability of different policy instruments varies among EU countries and different stakeholder groups and the decision making of the economically important issues is problematic (see discussions in Hacker and Pelchen 1999 and Vehmas et al 1999). The climate policy of EU has been based on the burden sharing within the EU bubble, but in the future the accession process will certainly have an effect on the policy formulations.

The results of the study indicate that only some EU countries have been able to follow the sustainable energy development path. Only Luxembourg, Norway, Belgium, Austria, Germany and the UK have been able to improve energy efficiency and decarbonise the energy system at the same time after the oil crises. A critical question in the future EU energy and climate policy is the interaction with the economic development policy. The structure of economic development is the main determinant for the development of the energy intensity of the society. In this respect several options are available and the EU policy planning has to evaluate the results of the different development paths.

So far the EU climate policy has been quite successful and the decision to allow the growth of emissions for the Mediterranean cohesion countries is a distinct choice to carry the burden elsewhere. Whether the present EU countries will carry the burden of the new member countries and how large space for environmentally unsustainable development will be allowed for them is an important question for the future policy formulation.

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ENERGY AND CO_2 EFFICIENCY DYNAMICS IN THE WORLD REGIONS

By

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Introduction

The target of this paper is to analyse the efficiency development in the global world economy. The analysed world regions are: Latin America, USA, Africa, the Middle East, China, the rest of Asia and Europe.

Our analysis is based on decomposition methods, which have been used in recent energy sector analyses. For example, Ang (1995a), (1995b), Ang and Zhang (1999, 2000), Sun (1998, 2000), and Sun and Malaska (1998) have used the decomposition method to compare energy-related CO_2 emission levels between countries and regions. Country level sectoral analyses have been carried out by e.g. Schipper et al (1992, 1993a, 1993b, 1995). Similar methodology with this article was utilised in the studies of Luukkanen and Kaivo-oja (2002a, 2002b), which analysed the Nordic energy systems and ASEAN energy system.

In this study, we continue this research tradition of using the complete decomposition model, but we shall also provide dynamic analyses of the significant changes in the energy sectors and CO_2 emissions of the world regions.

Data and general development trends in the world regions

The data used for the analyses was taken from IEA statistics (IEA 2001). Figures 2 and 3 plot the Total Primary Energy Supply (TPES) and the CO_2 emissions from fossil-fuel combustion in the world economy regions in the study from 1971 to 1999. The GDP data was compiled for the individual countries at market prices, in local currency and at annual rates. The data has been scaled up or down to 1995 price levels and then converted to US dollars using the yearly average based on 1995 exchange rates. All the presented data is macro economic, country level data. The analysis here is restricted to a macroeconomic scale and sectoral or engineering bottom-up analyses are not presented.

The decomposition results are given in relative terms: all the figures are compared to the levels of 1990, which is the base year for the Kyoto Protocol. This type of comparison provides information about the development of the energy systems in the different countries in relation to the Kyoto target. The aim is not to evaluate the differences between the countries, because the targets of the Kyoto Protocol are national.

In section we present some basic economic and energy system trends of the analysed world regions. Figure 1 tells clearly that European Union and US to growing extent dominate world economy. Other regions of the world economy are economically not as strong as EU and US are. The gap between these two post-industrial regions between other regions (the Middle East, Africa, Latin America, Asia and China) is widening. During the years 1971-1999 the growth of GDP has been in the US economy almost 5 000 billion dollars and in the EU about 4500 billion dollars. In the years 1971-1999 in other world regions China has gained almost 1 000 billion dollars growth of GDP, the rest of Asia almost 1 300 billion dollars growth of GDP and Latin America almost 900 billions dollars growth of GDP. The growth of GDP in the years 1971-1999 have been about 280 billion dollars in Africa and191 billion dollars in the Middle East.

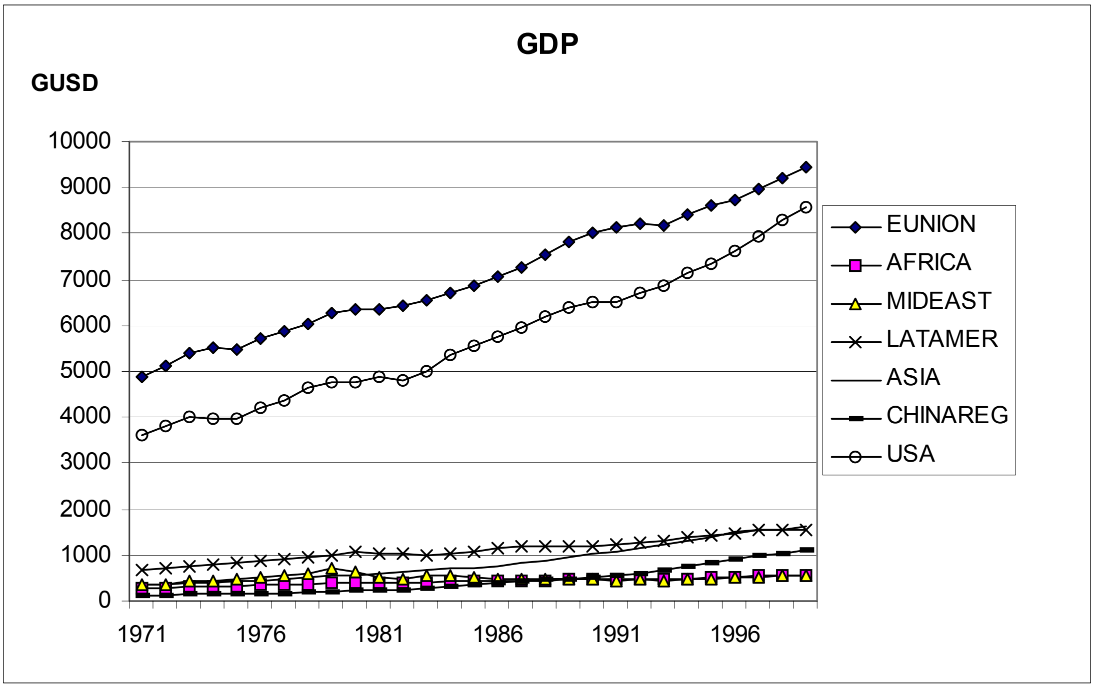

Figure 1. GDP of world regions (million US dollars in 1995 value) (Data source IEA 2001).

The economic activity is the main driver for energy use, but also energy intensity of economies is an important driving factor. When we compare the total primary energy supply (TPES) of US economy and EU economy in relation to other word regions economies like China, Asia, Latin America and Africa (see Fig. 2) we can postulate that the difference in the magnitude is much smaller than in the economic production.

In Table 1 we have reported numerical figures of changes in energy use in the world regions. Largest energy consumption increases has taken place in Asia (724 Mtoe), China (713 Mtoe) and in US economy (677 Mtoe). In Africa, Latin America and the Middle East increases have been less than 300 Mtoe (Africa 290 Mtoe, the Middle East 293 Mtoe and Latin America 244 Mtoe). European Union has increased its energy consumption only by 402 Mtoe in the years 1971-1999. (see Table 2.1 and Fig 2.2).

Table 1. Changes in energy use in the world regions in 1971-1999

	Changes in 1971-1999 (Mtoe)	**Growth (%)**
European Union	402	39
Africa	290	145
Middle East	293	581
Latin America	244	121
Asia	724	203
China	713	181
USA	677	42

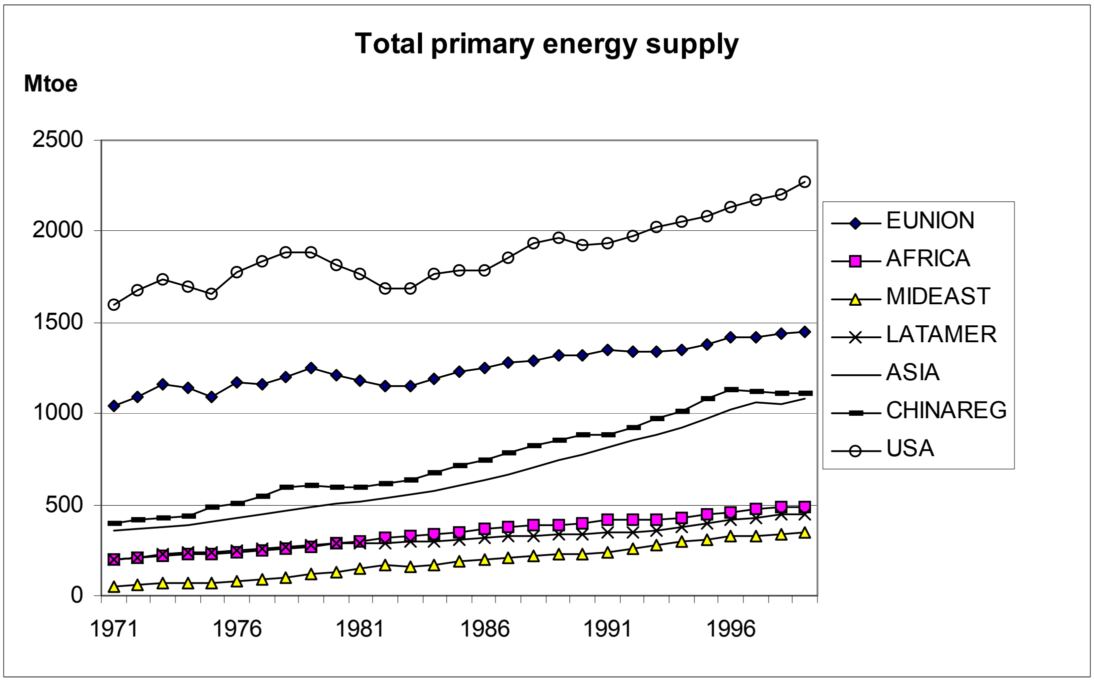

Figure 2. Total primary energy supply (TPES) in the world regions from 1971 to 1999 (Data source IEA 2001).

These increasing energy consumption trends are also reflected in CO_2 emissions. On the basis of Figure 3 we make two interesting observation. Firstly, one interesting observation concerning the CO_2 emission trends is that China has reached the level of European Union in late 1990s. Secondly, the gap in CO_2 emissions trends between US economy and EU economy has widened during the years 1971-1999. (see Fig. 3).

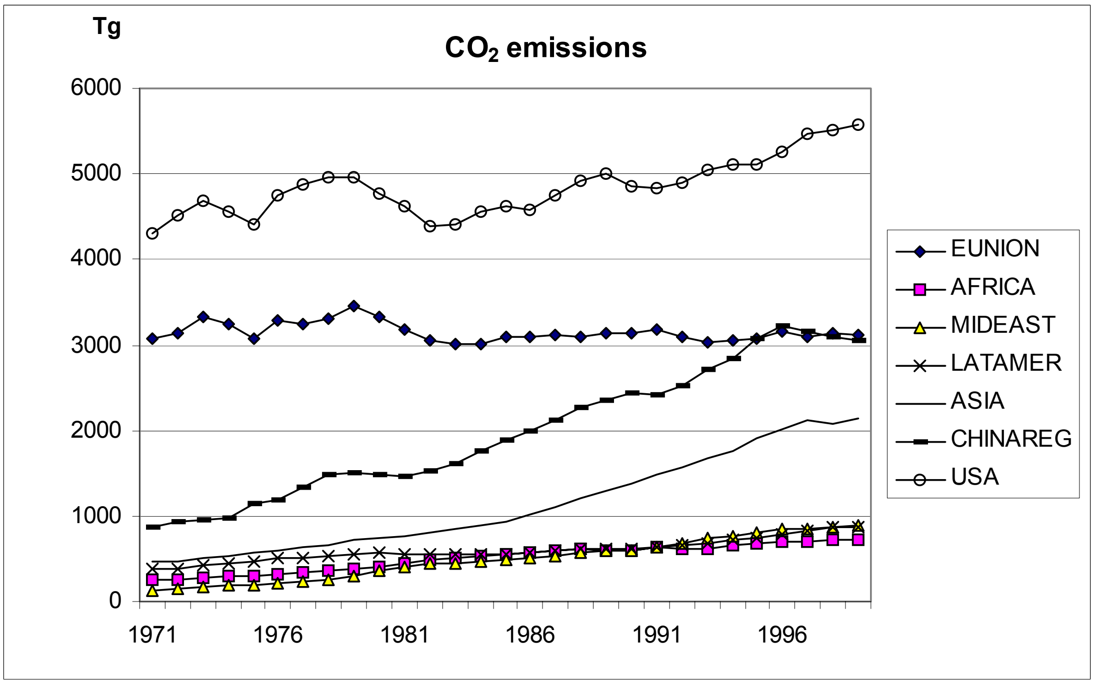

Figure 3. Total CO_2 emissions in the world regions in teragrams (Tg = Mton) (Data source IEA 2001).

Decomposition method in the study

The operationalisation of the productivity ratio of energy P(E,Q) can be defined as:

$$P(E,Q) = \frac{\text{economic outcome}}{\text{energy input}} = \frac{Q}{E} \tag{1}$$

The intensity of energy consumption can be defined, in different sectors (i), as inverse to the previous formula:

$$eI_i = \frac{E_i}{Q_i} \tag{2}$$

where eI_i is the energy intensity in sector i, E_i is energy use in sector i and Q_i is the value added of sector i.

To decompose the energy use of an economy we can use the following equations.

$$E = Q \times \frac{E}{Q} = Q \times \sum_i eI_i \frac{Q_i}{Q} = Q \times \sum_i eI_i s_i \tag{3}$$

where the sum is taken from all sectors and

$$s_i = \frac{Q_i}{Q} \tag{4}$$

is a structural factor of the economy, i.e., the share of sector i production of the total production.

In a similar manner we can decompose the CO_2 emissions P:

$$P = Q \times \frac{P}{Q} = Q \times \sum_i pI_i \frac{Q_i}{Q} = Q \times \sum_i pI_i s_i \tag{5}$$

where

$$pI_i = \frac{P_i}{Q_i} \tag{6}$$

is the sectoral CO_2 intensity.

In Eqs. (3) and (5) the energy use and the CO_2 emission are thus decomposed in relation to the structure of economy.

The aim of this decomposition analysis is to model the changes in energy consumption and emission production. The explanatory variables are: the activity level in the economy, sectoral intensity, and structural shift.

Several methods and indexes have been developed for the purposes of decomposition analysis and they have mainly been used to analyse the energy sector.

Sun (1996) has developed a difference method, which has no residual term unlike other methods. From this Complete Decomposition Model, we have developed the dynamic energy model in the following way:

$$\Delta E = E^t - E^0 \tag{7}$$

$$\begin{aligned}
EQ_{effect}{}^t &= (Q^t - Q^0)\sum_i eI_i^0 s_i^0 + \tfrac{1}{2}(Q^t - Q^0)\sum_i (eI_i^0(s_i{}^t - s_i{}^0) + s_i^0(eI_i{}^t - eI_i{}^0)) \\
&+ \tfrac{1}{3}(Q^t - Q^0)\sum_i (eI_i{}^t - eI_i{}^0)(s_i{}^t - s_i{}^0) \\
EI_{effect}{}^t &= Q^0 \sum_i s_i^0 (eI_i{}^t - eI_i{}^0) + \tfrac{1}{2}\sum_i (eI_i{}^t - eI_i{}^0)[\ s_i^0(Q^t - Q^0) + Q^0(s_i{}^t - s_i{}^0)\ ] \\
&+ \tfrac{1}{3}(Q^t - Q^0)\sum_i (eI_i{}^t - eI_i{}^0)(s_i{}^t - s_i{}^0) \\
ES_{effect}{}^t &= Q^0 \sum_i eI_i^0 (s_i{}^t - s_i{}^0) + \tfrac{1}{2}\sum_i (s_i{}^t - s_i{}^0)[\ eI_i^0(Q^t - Q^0) + Q^0(eI_i{}^t - eI_i{}^0)\ ] \\
&+ \tfrac{1}{3}(Q^t - Q^0)\sum_i (eI_i{}^t - eI_i{}^0)(s_i{}^t - s_i{}^0)
\end{aligned} \tag{8}$$

where superscript *0* refers to the base year value and *t* refers to the values of the comparison year varying from n_1 to n_n, in this case from 1971 to 1999.

This model produces an exact decomposition so that:

$$\Delta E = EQ_{effect} + EI_{effect} + ES_{effect}\,. \tag{9}$$

The Q_{effect} is the activity effect that describes the effect of total economic growth on sectoral energy use. The I_{effect} is the intensity effect, which reveals the impact of the technological change and the change in production systems on sectoral energy consumption. The S_{effect} is the structural effect, which reveals the impact of change in the sectoral share of total production on energy consumption.

In a similar way we can develop equations for the decomposition of CO_2 emissions:

$$\begin{aligned}
&PQ_{effect}{}^{t} = (Q^t - Q^0)\sum_i pI_i^0 s_i^0 + \tfrac{1}{2}(Q^t - Q^0)\sum_i pI_i^0(s_i{}^t - s_i{}^0) + s_i^0(pI_i{}^t - pI_i{}^0)) \\
&+\tfrac{1}{3}(Q^t - Q^0)\sum_i (pI_i{}^t - pI_i{}^0)(s_i{}^t - s_i{}^0) \\
&PI_{effect}{}^{t} = Q^0\sum_i s_i^0(pI_i{}^t - pI_i{}^0) + \tfrac{1}{2}\sum_i (pI_i{}^t - pI_i{}^0)[\ s_i^0(Q^t - Q^0) + Q^0(s_i{}^t - s_i{}^0)\ ] \\
&+\tfrac{1}{3}(Q^t - Q^0)\sum_i (pI_i{}^t - pI_i{}^0)(s_i{}^t - s_i{}^0) \\
&PS_{effect}{}^{t} = Q^0\sum_i pI_i^0(s_i{}^t - s_i{}^0) + \tfrac{1}{2}\sum_i (s_i{}^t - s_i{}^0)[\ pI_i^0(Q^t - Q^0) + Q^0(pI_i{}^t - pI_i{}^0)\ ] \\
&+\tfrac{1}{3}(Q^t - Q^0)\sum_i (pI_i{}^t - pI_i{}^0)(s_i{}^t - s_i{}^0)
\end{aligned} \tag{10}$$

To analyse the dynamics of the change we have used Eqs. (8) and (10) to calculate the differences in the long-run time-series data from 1971 to 1999 compared to the reference year 1990, which has been chosen as it is the base year for the Kyoto Protocol (UNFCCC 1998).

In this analysis of the world regions, each country group (EU, US, Africa, the Middle East, Latin America, Asia and China) refer to the different sectors (*i*) of the equations.

Analyses of energy and CO_2 changes in the world regions

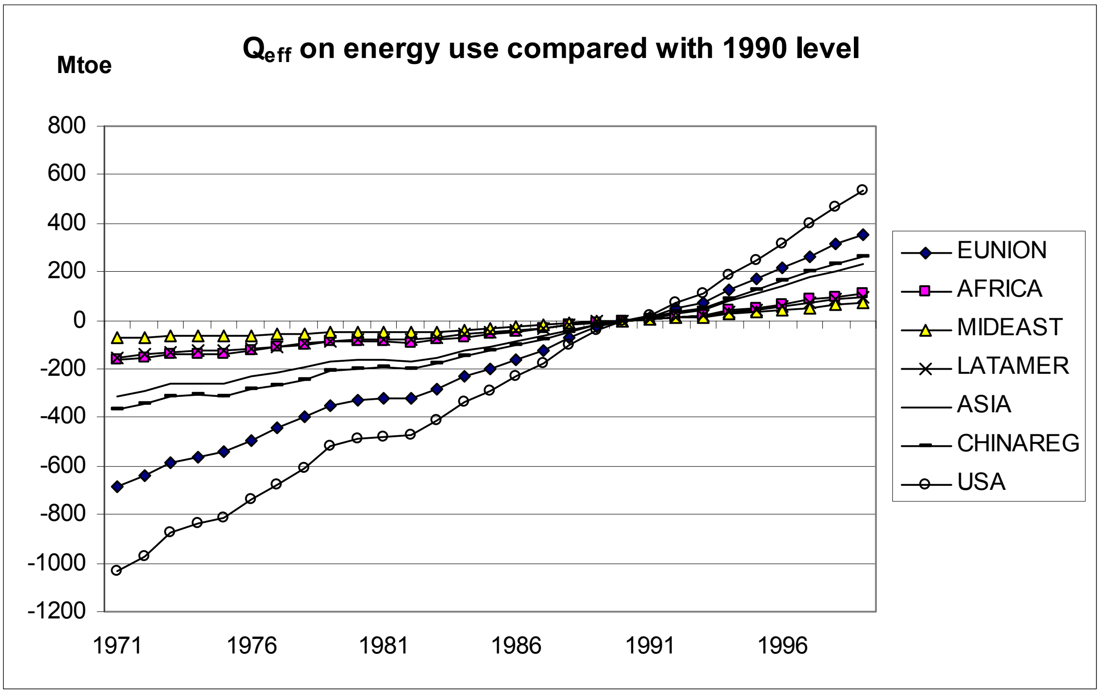

Figure 4. The activity effects on energy consumption (EQ_{effect}) for the world regions in absolute values (Mtoe) when compared to their 1990 levels

Figure 4 illustrates activity effect (EQeffect) on energy use in the world regions. We have reported numerical indicators of change in Table 2. Largest activity effects in absolute terms can be observed in US economy and EU economy. In Asia and China one can observe quite remarkable activity effects. The considerable larger economic growth in the US economy and European Union has resulted in larger growth in the energy consumption. (see Fig. 4 and Table 2).

Table 2 Changes in energy use in the years 1971-1999 in the world regions due to the activity effect

	Change 1971-1990 (Mtoe)	**Change 1990-1999 (Mtoe)**	**Change (%) in 1971-1990**	**Change (%) in 1990-1999**
European Union	686	354	52	27
Africa	164	113	41	28
Middle East	73	71	32	32
Latin America	151	99	45	29
Asia	314	235	40	30
China	369	266	42	30
USA	1033	534	54	28

The structural changes have not had considerable effect on energy consumption in the US economy, European Union and in Africa. Structural changes have had quite remarkable effects on energy consumption in China, Asia and the Middle East. In Table 3 numerical indicators of changes in the years 1971-1999 are reported. Structural changes have had decreasing impacts on energy consumption in EU, Africa and the Middle East, but increasing impacts of energy use in Latin America, Asia, China and the US economy. Table 3 and Fig. 5 verify these interesting observations.

Table 3. Changes in energy use in the years 1971-1999 in the world regions due to structural effects

	Change 1971-1990 (Mtoe)	**Change 1990-1999 (Mtoe)**	**Change (%) in 1971-1990**	**Change (%) in 1990-1999**
European Union	-94	-126	-7	-10
Africa	-23	-28	-6	-7
Middle East	-44	-24	-19	-11
Latin America	4	9	1	3
Asia	282	192	36	25
China	506	558	57	63
USA	42	44	2	2

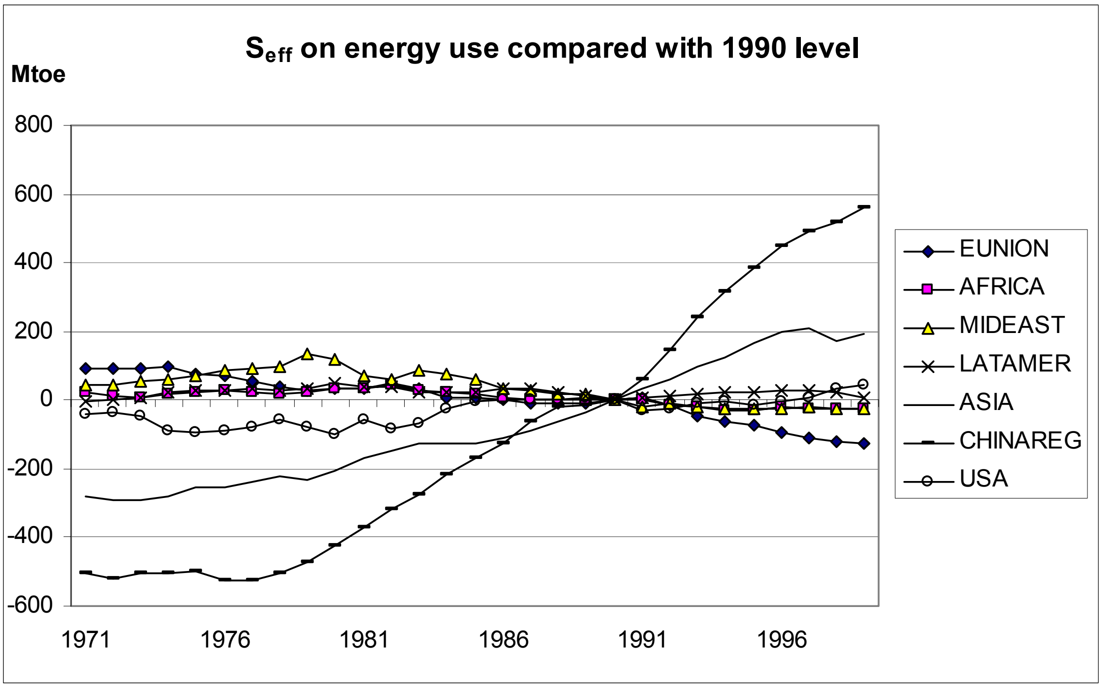

Figure 5. The structural effects on energy consumption (ES_{effect}) for the world regions in absolute values (Mtoe) when compared to their 1990 levels

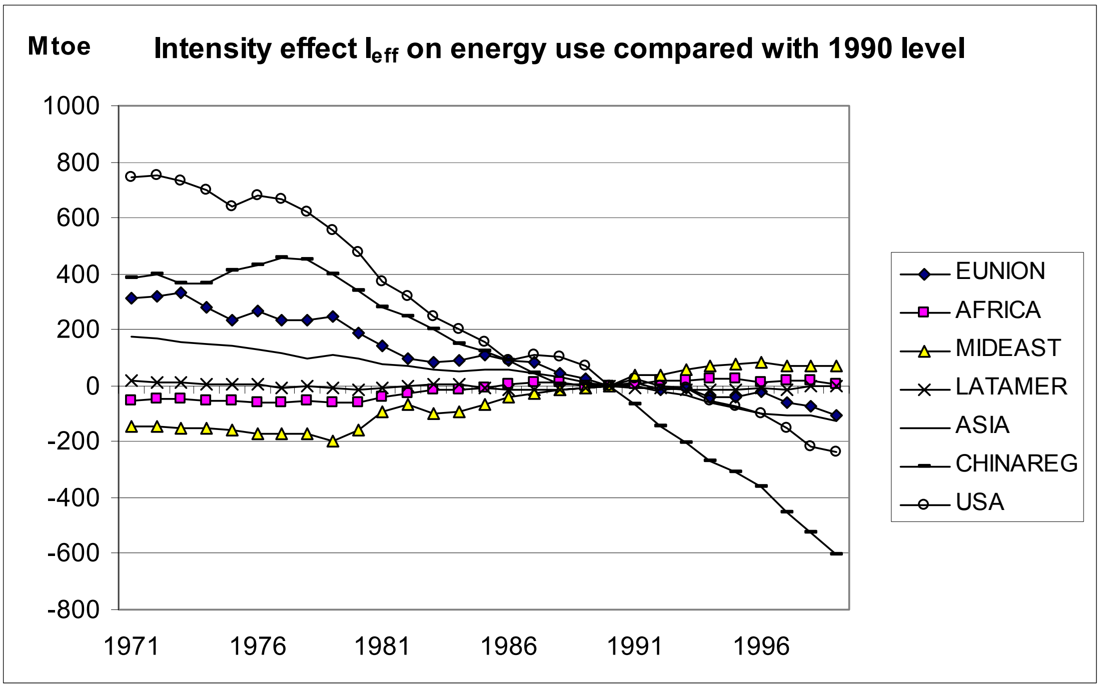

Figure 6. The intensity effects on energy consumption (EI_{effect}) for the world regions when compared to their 1990 levels

The energy intensity has changed remarkably in the world regions during the research period. In European Union the intensity effect has decreased energy consumption by 311 Mtoe from 1971 to 1990 or 24 % of the 1990 level. In the 1990s the reduction has been smaller, only 106 Mtoe or 8 % of 1990 level.

In the US economy the intensity effect has decreased energy consumption by 743 Mtoe from 1971 to 1990 or 39 % of the 1990 level. In the 1990s the reduction has been a little bit smaller, 234 Mtoe or 12 % of 1990 level. In China the intensity effect has decreased energy consumption by 385 Mtoe from 1971 to 1990 or 44 % of the 1990 level. In the 1990s the reduction has been greater, 601 Mtoe or 68 % of 1990 level. In the other Asia region the intensity effect has decreased energy use by 174 Mtoe form 1971 to 1990 or 22 % of the 1990 level. In the 1990s the reduction has been a little bit smaller, 125 Mtoe or 16 % of 1990 level.

In Latin America the intensity effect on energy use has been small. The intensity effect has decreased energy consumption only by 20 Mtoe from 1971 to 1990 or 6 % of the 1990 level. In the 1990s no reduction has taken place.

In Africa and the Middle East the intensity effects have increased energy use. In Africa, the intensity effect has increased energy use by 56 Mtoe from 1971 to 1990 or 14 % of the 1990 level. In the 1990s the increase has been a smaller, 8 Mtoe or 2 % of 1990 level. In the Middle East, the intensity effect has remarkably increased energy use by 146 Mtoe from 1971 to 1990 or 65 % of the 1990 level. In the 1990s the increase has been a smaller, 71 Mtoe or 31 % of 1990 level (see Fig. 6 and Table 4). On the basis of these observations we have to ask why the development has been different in Africa and the Middle East. In the Middle East the reason for increasing intensity effect can be found from the increasing oil based industrialisation. In Africa the shift from non-commercial renewable energy sources, of which the statistics are usually not reliable, to commercial forms of fossil energy is one of the reasons behind the observed development path. (see e.g. Kartha and Larson 2000).

Table 4. Changes in energy use in the years 1971-1999 in the world regions due to the intensity effect

	Change 1971-1990 (Mtoe)	**Change 1990-1999 (Mtoe)**	**Change (%) in 1971-1990**	**Change (%) in 1990-1999**
European Union	-311	-106	-24	-8
Africa	56	8	14	2
Middle East	146	71	65	31
Latin America	-20	0	-6	0
Asia	-174	-125	-22	-16
China	-385	-601	-44	-68
USA	-743	-234	-39	-12

The economic growth contributed to a large increase in CO_2 emissions. In Table 5 we reported activity effect changes on CO_2 emission in the years 1971-1999 in the world regions.

One can observe largest activity effect in the US economy, European Union and China. Asia has the fourth largest activity effects, while Latin America, the Middle East and Africa are having considerable lower activity effects on CO_2 emissions. The US economy and European Union are having biggest problems with their activity effects on CO_2 emissions (see Table 5 and Fig 5).

Table 5. Changes in CO_2 emission in the years 1971-1999 in the world regions due to activity effects.

	Change 1971-1990 (Mton)	**Change 1990-1999 (Mton)**	**Change (%) in 1971-1990**	**Change (%) in 1990-1999**
European Union	1848	801	59	26
Africa	226	169	7	5
Middle East	187	185	6	6
Latin America	278	187	9	6
Asia	481	440	15	14
China	901	731	29	23
USA	2714	1331	87	42

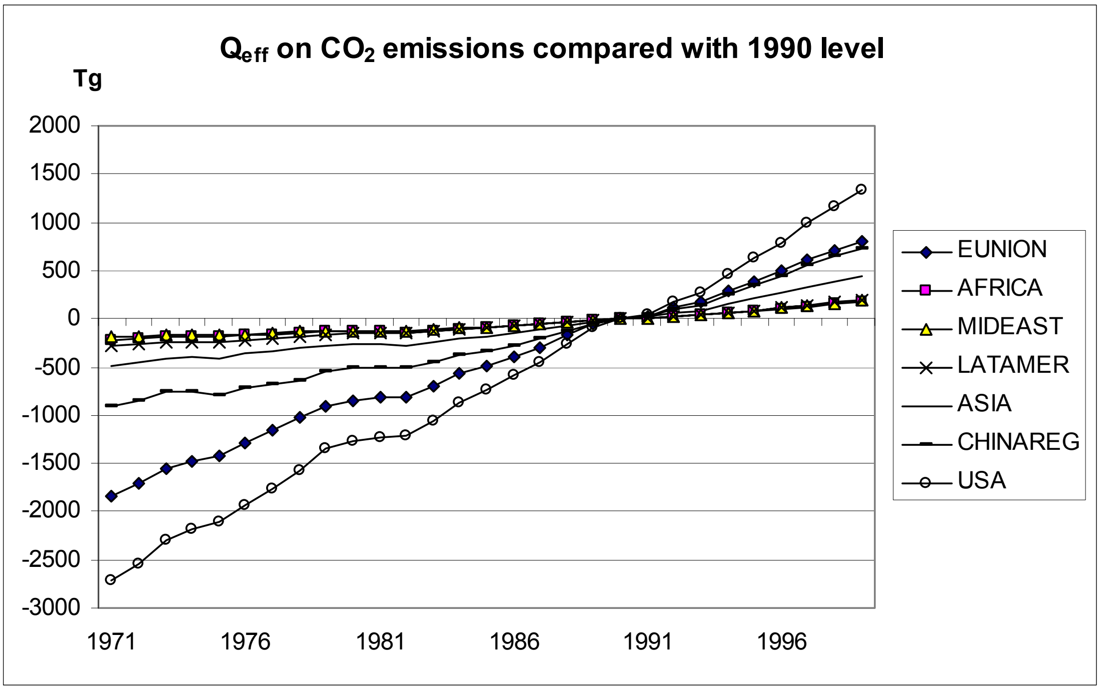

Figure 7. The activity effects on CO_2 emissions (PQ_{effect}) for the world regions in absolute values (Tg) when compared to their 1990 levels

The structural effect on CO_2 emissions is quite similar to structural effect on energy use (compare Fig. 8 with Fig. 6). China and Asian region seem to have the most problematic trend concerning structural effects on CO_2 emissions. Table 6 summarises the changes of CO_2 emissions that have taken place due to the structural effect.

Table 6. Changes in CO_2 emissions in the years 1971-1999 in the world regions due to structural effects

	Change 1971-1990 (Mton)	**Change 1990-1999 (Mton)**	**Change (%) in 1971-1990**	**Change (%) in 1990-1999**
European Union	-250	-285	-8	-9
Africa	-32	-42	-1	-1
Middle East	-113	-62	-4	-2
Latin America	7	18	0	1
Asia	433	358	14	11
China	1230	1537	39	49
USA	111	109	4	3

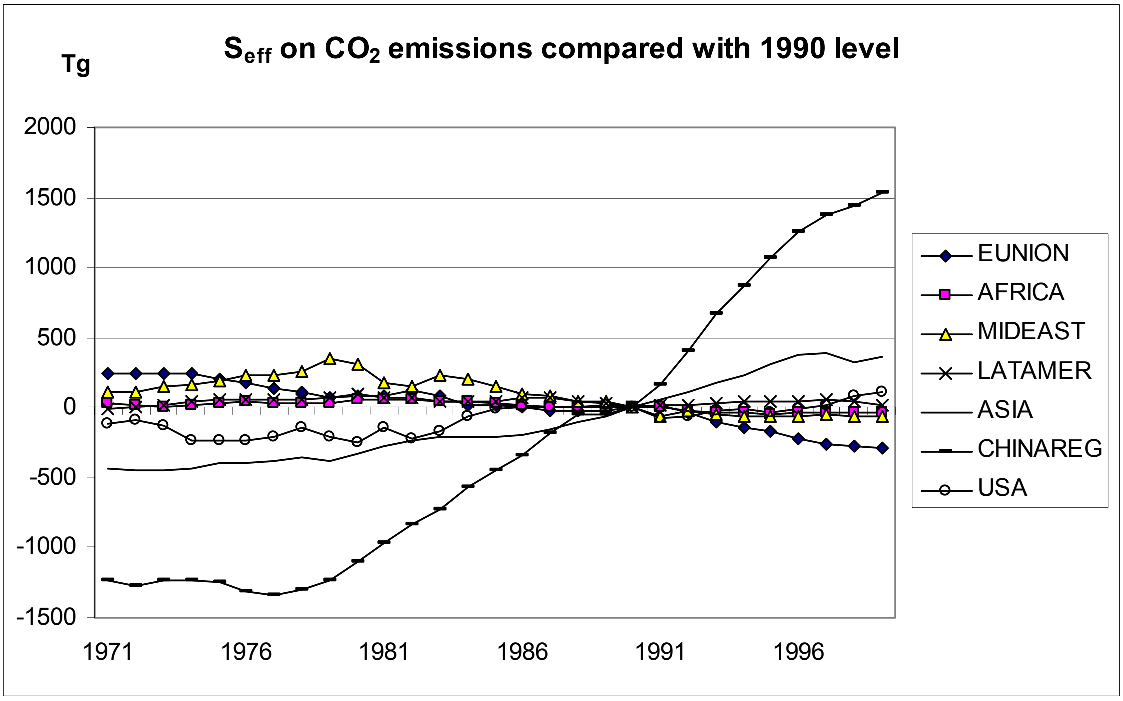

Figure 8. The structrural effects on CO_2 emissions (PS_{effect}) for the world regions in absolute values (Tg) when compared to their 1990 levels.

During the research period the following changes in CO_2 emissions due to the intensity effect have taken place (see Table 9 and Fig. 7). CO_2 intensity of China, European Union and the US economy has improved considerably. In Africa and the Middle East the development phase has increased the CO_2 intensity. Changes in Latin America have been small in magnitude. There was a successful period in 1971-1990, when some improvements were made, but a repercussion took place in 1990-1999. Table 9 summarises the changes of CO_2 emissions that have taken place due to the intensity effect.

Table 7. Changes in CO_2 emissions in 1971-1999 in the world regions due to intensity effect.

	Change 1971-1990 (Mton)	**Change 1990-1999 (Mton)**	**Change (%) in 1971-1990**	**Change (%) in 1990-1999**
European Union	-1530	-544	-49	-17
Africa	162	3	27	1
Middle East	381	179	65	31
Latin America	-35	37	-6	6
Asia	-5	-48	0	-3
China	-573	-1646	-24	-68
USA	-2285	-701	-47	-14

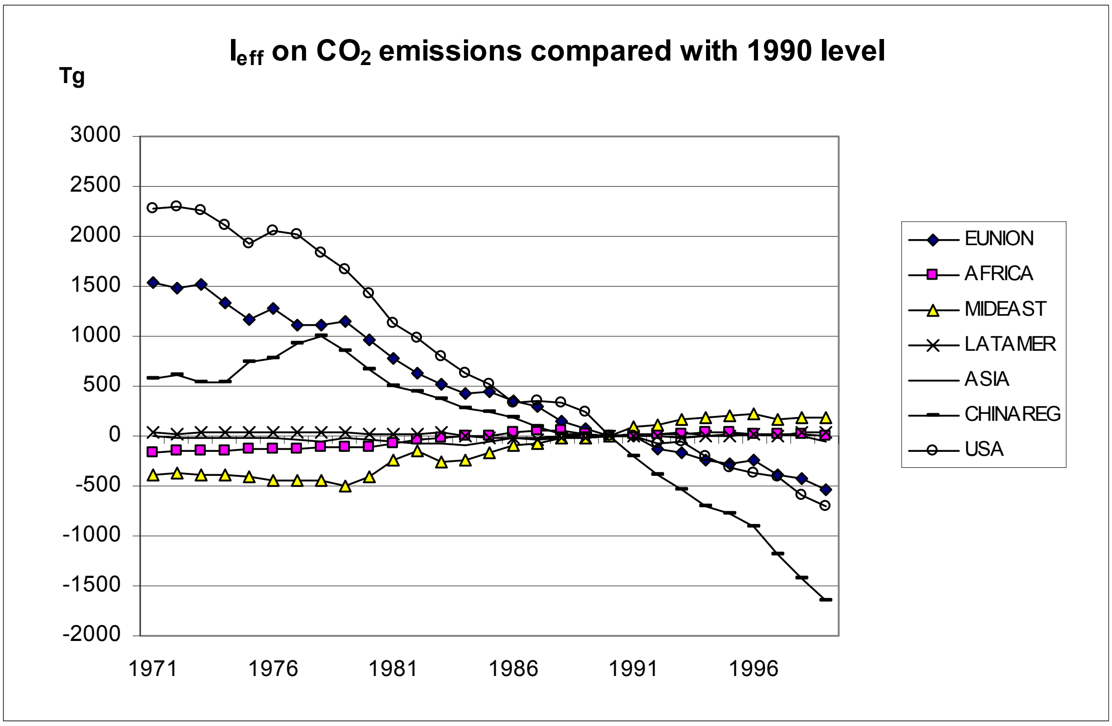

Figure 9. The intensity effects on CO_2 emissions (PI_{effect}) for the world regions in absolute values (Tg) when compared to their 1990 levels.

5. Regional analyses of energy and CO_2 intensities

Comparison of percentage changes in the intensity effects on energy and CO_2 emissions gives information of reasons behind the changes in CO_2 emissions. In EU the CO_2 intensity has decreased faster than the energy intensity indicating that part of the CO_2 emission reductions are caused by fuel switching to less carbon intensive energy production. Improved energy efficiency caused part of decrease in CO_2 emissions. (see Fig. 10)

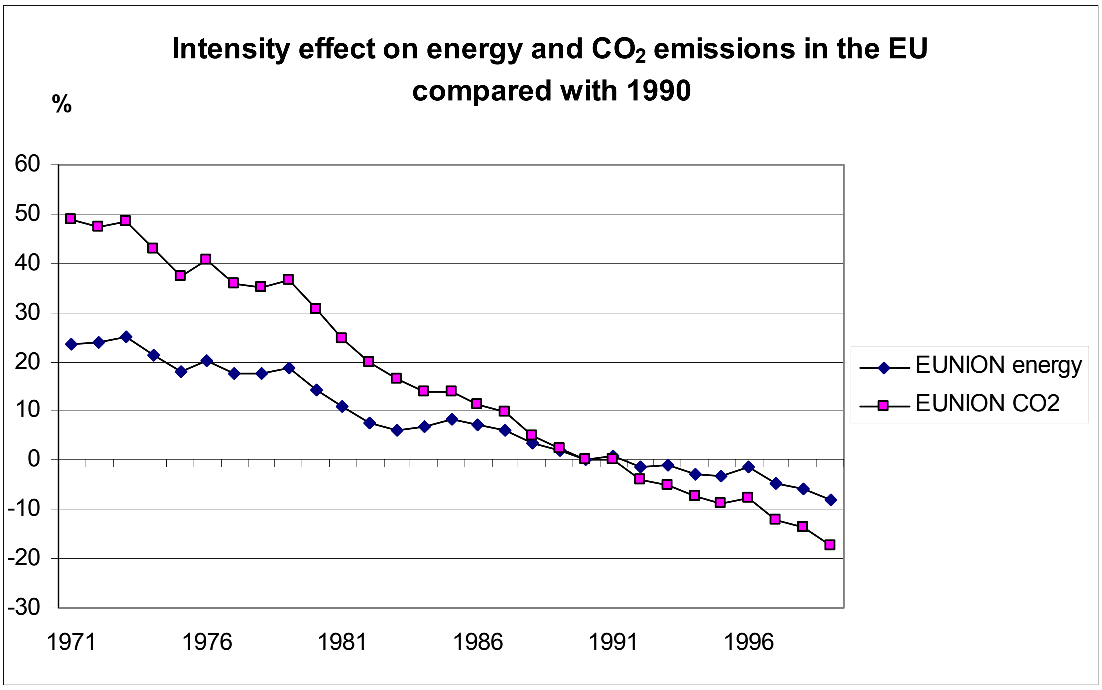

Figure 10. The intensity effects on energy use (EI_{effect}) and on CO_2 emissions (PI_{effect}) for European Union in percentage changes (%) when compared to their 1990 levels

Figure 11 reveals that there has been almost no fuel switching in the Middle East region. The increase in CO_2 emissions has been caused by increased use of fossil energy sources utilising the domestic oil and gas resources (see e.g. IEA 2001).

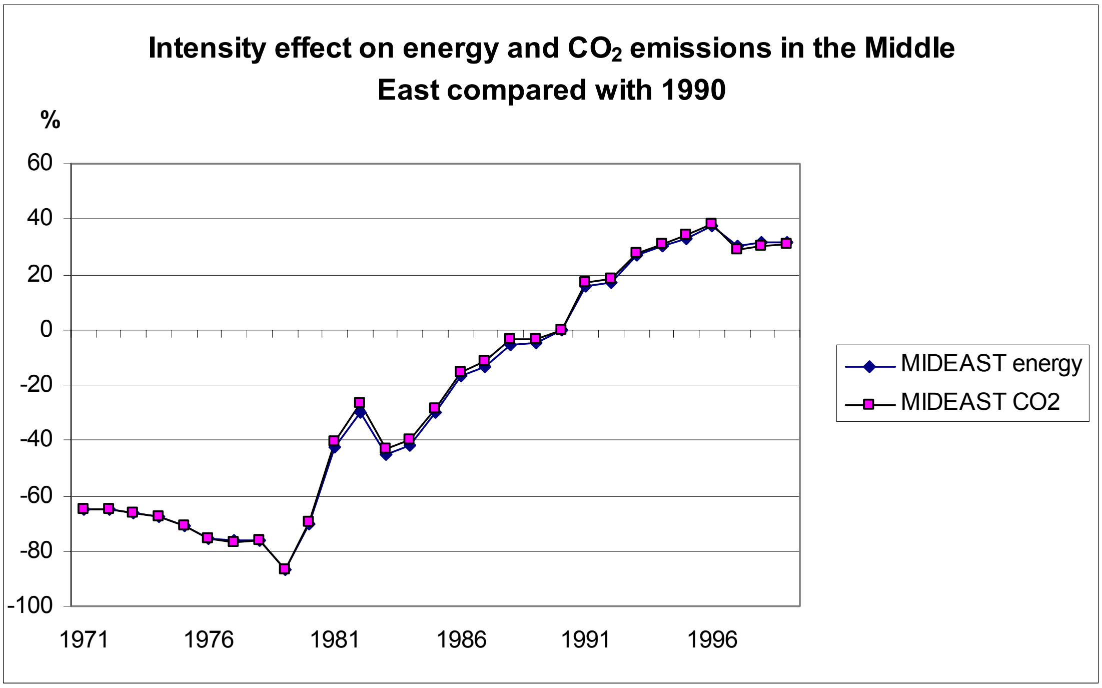

Figure 11. The intensity effects on energy use (EI_{effect}) and on CO_2 emissions (PI_{effect}) for the Middle East in percentage changes (%) when compared to their 1990 levels

Figure 12 reveals that in Latin America energy intensity has decreased faster than CO_2 intensity in the years 1971-1982. In the years 1993-1994 there was not much fuel switching, but after year 1994 Latin America returned back to earlier trend, according to which the CO_2 intensity is increasing faster than energy intensity. Thus Latin America is having fuel-switching process to more carbon intensive energy production. The changes in the intensity effects have been quite small in Latin America.

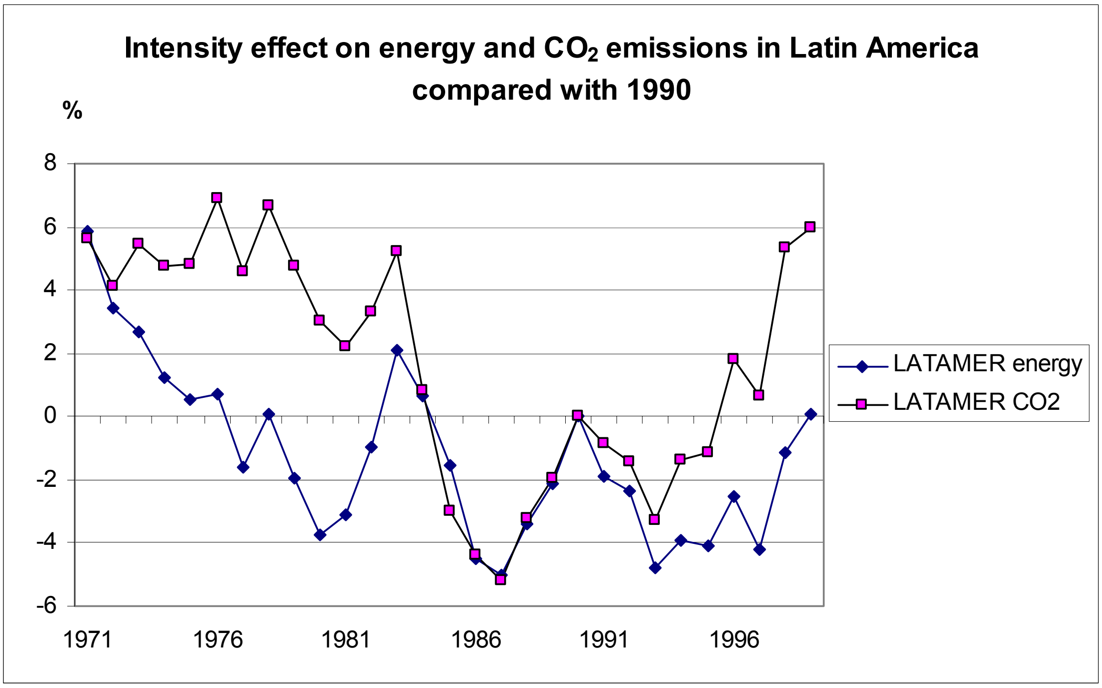

Figure 12. The intensity effects on energy use (EI_{effect}) and on CO_2 emissions (PI_{effect}) for Latin America in percentage changes (%) when compared to their 1990 levels

Figure 13 reveals that there has been considerable fuel switch towards more carbon intensive energy use in Africa in the 1970s, but after that almost no fuel switching has taken place. Both energy and CO_2 intensity increased rapidly in the 1980s but the speed of changes has been quite small in the 1990s.

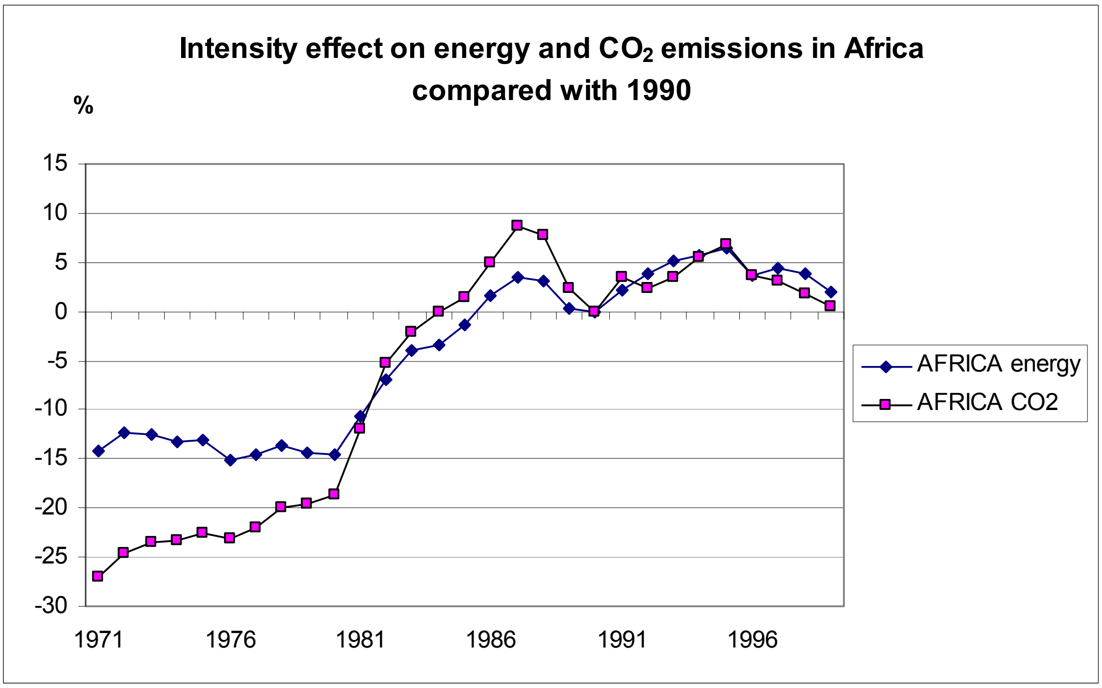

Figure 13. The intensity effects on energy use (EI_{effect}) and on CO_2 emissions (PI_{effect}) for Africa in percentage changes (%) when compared to their 1990 levels

In Asia the energy intensity has decreased quite fast, but the CO_2 intensity has remained almost constant during the whole research period. This indicates that there has been a constant fuel switch towards more carbon intensive energy production, but the improved energy intensity has kept the CO_2 intensity constant resulting in a situation, where the CO_2 emissions have grown hand in hand with the economic growth.

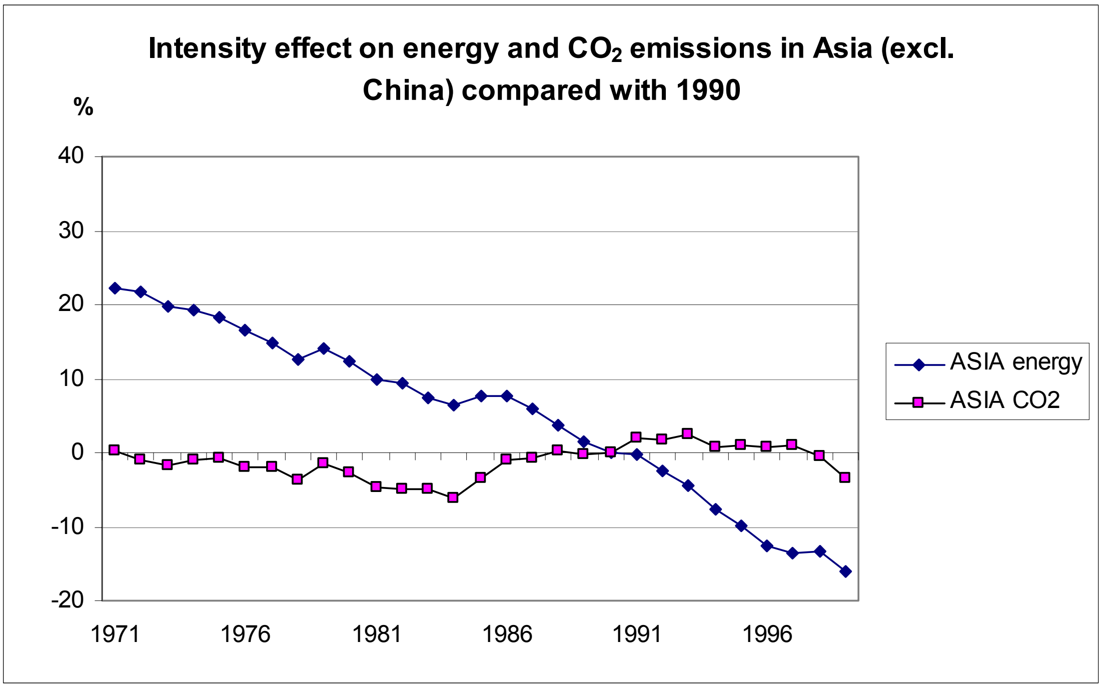

Figure 14. The intensity effects on energy use (EI_{effect}) and on CO_2 emissions (PI_{effect}) for Asia (excluding China) in percentage (%) changes when compared to their 1990 levels

Figure 15 illustrates the observations of the economy of China. In China both intensity effect on energy and CO_2 emissions have downward sloping trends after late 1970s. In China there has been a considerable fuel switch towards more carbon intensive energy system before 1990, but after that both intensity effects have decreased hand in hand. There has been speculation that the data of Chinese economy is not very reliable and the growth of GDP has been overestimated (see e.g. Ayres 1998, Zhang 1998). This can be one reason behind the curves in Fig. 15.

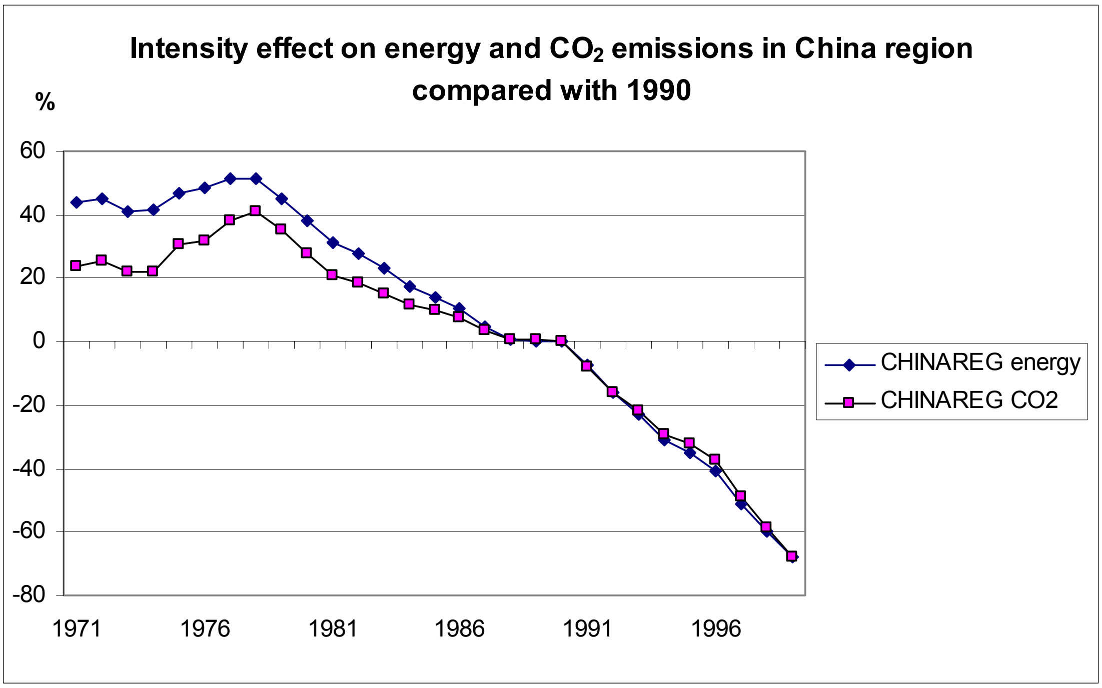

Figure 15. The intensity effects on energy use (EI_{effect}) and on CO_2 emissions (PI_{effect}) for China in percentage changes (%) when compared to their 1990 levels

Figure 16 illustrates the observations of the economy of the US economy. In the U.S.A. both intensity effect on energy and CO_2 emissions are decreasing and having downward trends. There has been continuous slow decarbonisation process in US energy system up to the 1990s, but after that the decrease in CO_2 intensity has been caused by the decrease in energy intensity.

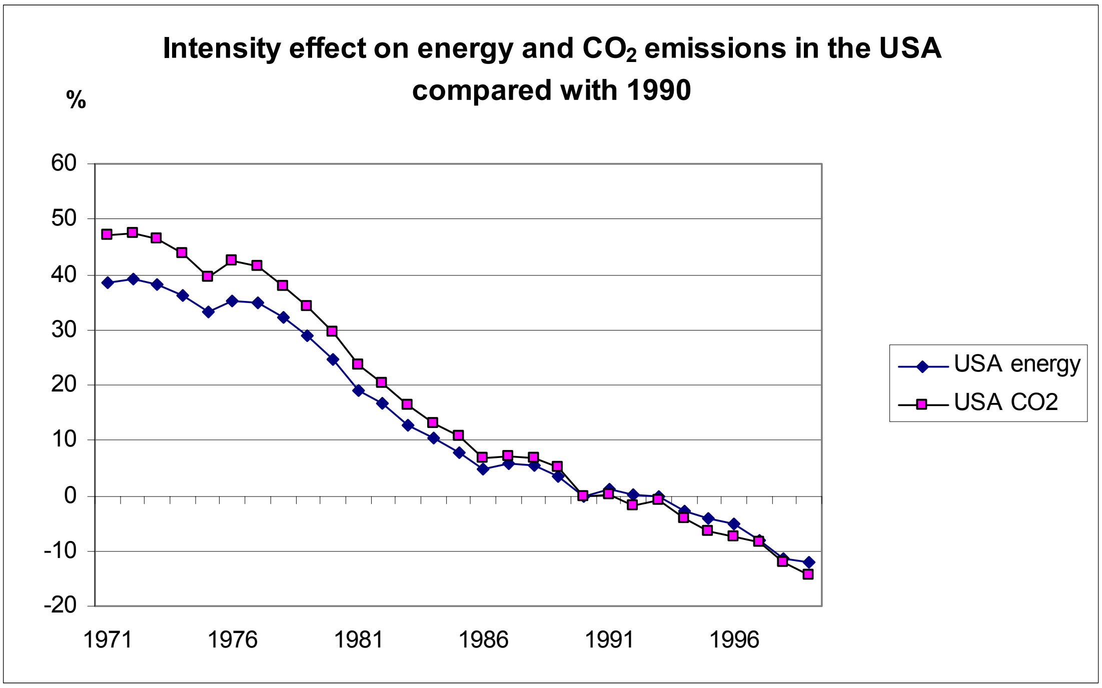

Figure 16. The intensity effects on energy use (EI_{effect}) and on CO_2 emissions (PI_{effect}) for the U.S.A. in percentage changes (%) when compared to their 1990 levels

Figure 17 illustrates the observations we made about fuel switching above. Decreasing trends towards less carbon intensive energy production systems can be observed in the European Union and the United States. Increasing trends towards more carbon intensive energy production systems can be observed in Asia, China and Africa (before the 1990s). In Latin America and the Middle East the fuel switching has been considerably slow. In the Africa, the Middle East, Latin America, Asia and China two counteracting processes have taken place: there has been switch from traditional renewable fuels to fossil fuels (especially in developing countries) and at the same time switch from coal to gas.

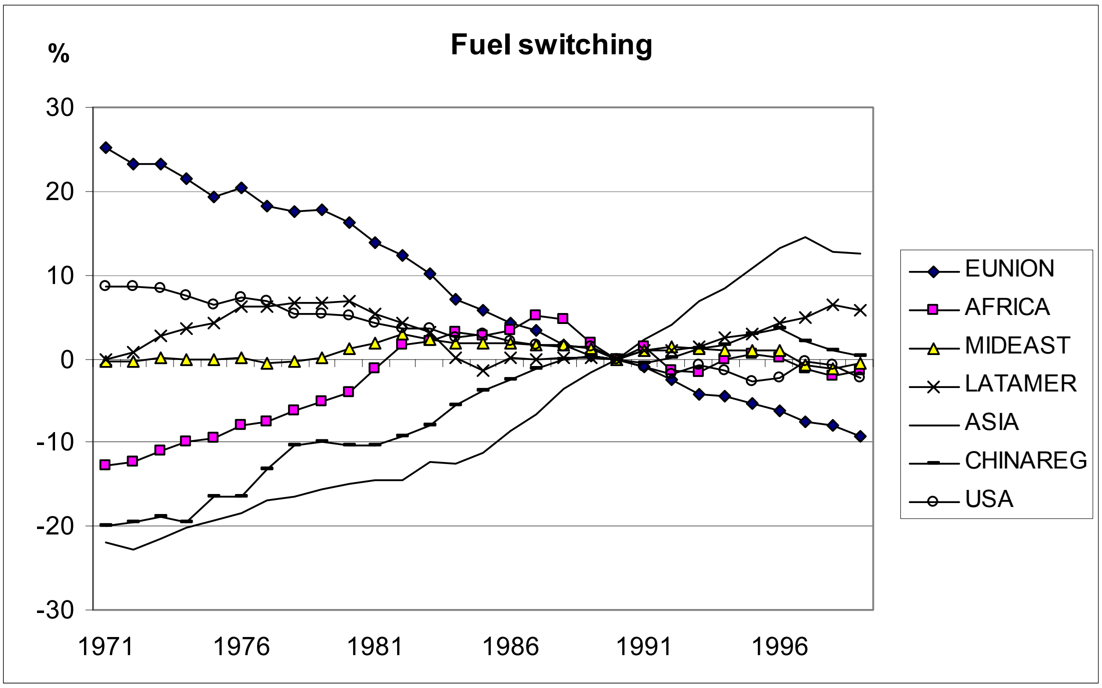

Figure 17. Trends in fuel switching in world regions in the years 1971-1999 (percentage changes)

Summary

This article provides wide-ranging empirical application of decomposition methodology in the spatial context of global economy. All major regions of the world economy were analysed empirically in this study using dynamic decomposition method. Basically there are two different ways to reduce CO_2 emissions in the world economy; firstly, by increasing the energy efficiency of the economy; secondly, by fuel switching to less carbon intensive energy production. This study reveals what kinds of processes have taken place in different world regions (compare e.g. Nakicenovic and Grübler 2000). The U.S.A. and European Union have implemented both of these strategies, but still the fast economic growth has outweighed the effects of the activities in the U.S.A. Developing regions like Africa, the Middle East, Latin America, Asia and China failed to carry out considerable fuel switching but in the 1990s the fast improvement in the energy efficiency has had considerable decreasing effects on the CO_2 emission growth.

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ENVIRONMENTAL KUZNETS CURVE HYPOTHESIS TESTS FOR DIRECT MATERIAL FLOWS IN FIVE INDUSTRIAL COUNTRIES

By

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Introduction

It is generally recognised that economic growth and the state of the environment are related. However, evidence on the nature and strength of the relationship are controversial. There are few alternative theories about the relationship, which do not unambiguously describe how the environment and economies co-evolve in reality. Because of this ambiguity an empirical analysis is needed in order to reach a deeper understanding of real-world development. The purpose of this paper is to examine how direct material flows and economic growth are related in some industrialised countries: Germany, Japan, the USA, the Netherlands and Finland. The framework for the analysis is the so-called Environmental Kuznets Curve hypothesis (EKC).

Roughly speaking, there are two contradictory views about the co-evolution of the environment and the economy. Firstly, it is argued that, economic growth unavoidably degrades the state of the environment, since the growth of economic activity always requires the intensified material use of natural resources and the environment. On the other hand, it is often argued that economic growth is needed in order to create wealth and technological progress so that we can afford to the better environment, and the means to sustain it. The optimistic growth view argues that individuals prefer environmentally friendly goods as their incomes rise. Consequently, people demand more environmental goods and services, which politicians and firms have to take into account in their decision-making processes. Thus, politicians take public action that should be beneficial to the environment, while firms try to attract customers with "green" products and production methods. As the latest technology enables corrective action, the empirical analysis should reveal the progress of indicators for environmental stress as compared to economic growth.

The environmental Kuznets curve hypothesis and its economic relevance

The EKC hypothesis

The EKC hypothesis states that economic growth degrades the environment at low-income levels, but as incomes rise, harmful environmental impacts decrease (see also Kuznets, 1955). According to the theory, the environment is initially exploited to a great extent in order to create economic growth. When an economy becomes developed enough, the environment becomes more valued, and technical progress makes it possible to create wealth with less environmental stress. This means that one should be able to find a level of income after which the negative environmental impacts of economic activity will decline.

The EKC is a special case of the general Income-Emission Relation (IER). Before the early nineties the IER was said to be more or less linear: higher incomes meant more production and consumption, and it was presumed emissions would rise. This relation caused considerable concern as rich countries showed high growth rates and environmental pressures increased. Figure 1 represents a stylised view of the EKC hypothesis. The resource degradation or pollution is shown as initially increasing and then eventually declining. The EKC is also known as an inverse U-curve.

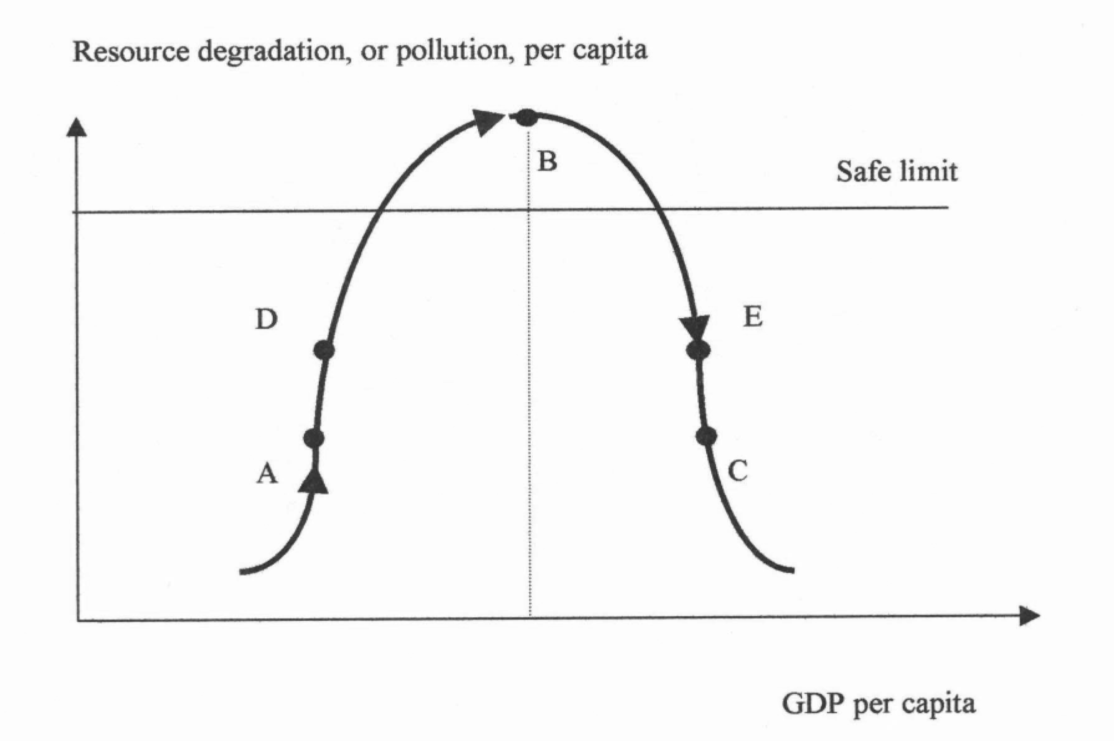

Figure 1. Environmental Kuznets Curve

We may expect that developing countries are located on the left-hand side of the EKC curve (for instance, point A or D). On the other hand, we should expect that rich industrialised countries lie on the right hand side of the EKC (e.g. point E or C). The development of an immaterially oriented information society might provide a complementary explanation for the social behaviour behind the environmental Kuznets curve (see Jokinen et al. 1998).

Economic theory has shown that standard assumptions concerning the marginal values of consumption, pollution, and abatement costs may lead to the inverted U –shape relationship (Hettige et al. 1997, 1, see also Munasinghe 1995, Munasinghe 1996). Thus, theory can provide critical pre-conditions for successful environmental policy making. Of course, actual turnaround points depend on the relative magnitudes of the underlying parameters. On a general level, structural changes in the economy and effective environmental policy are important factors behind pollution abatement. Some authors have claimed that if the EKC hypothesis holds, economic growth is not at all a threat to global sustainability, and there are no environmental limits to growth (see for example the discussion in Stern et al. 1996, 1151). We can call this an extreme interpretation of the EKC. This means that environmental policy is not needed because economic growth leads to a better environment in the long run. This, of course, means that the EKC phenomena should be strong and wide enough, so that critical life supporting systems survive.

However, so far the EKC relationship has only been observed for certain substances, which could also be due to substitution processes among different natural resources. If the ecological system is to be sustained, some reduction of material flows may be necessary (Femia et al. 1999, 3, 17). That is why the EKC hypothesis has to be tested also with aggregated direct material flow data. Direct material flows consist of ores, minerals, limestone, peat, stone material, wood, fossil fuels, cultivated resources produced in agriculture and market gardening, forest by-products and fisheries output.

Arguments for the EKC hypothesis are as follows (Ekins 1997):

(a) Due to competition, firms continuously search for cost reduction in their activities. As a consequence, more efficient uses of inputs may also cause less pollution.

(b) The stages of economic development may be identified as follows: from subsistence economy to agricultural society, from agricultural society to industrial society, and from industrial society to service society and to information society. In this last stage environmental stress should have been considerably lessened by more efficient and new kinds of production methods. It is argued that the development process is independent of the policies practised in the economy. Rather, the stages of development depend on capital formation and the accumulation of human capital in an economy. This is a crucial argument behind the extreme interpretation of the EKC hypothesis.

(c) When environmental problems become so severe that they are real threats to human health and cultural values, environmental protection including new environmental laws, prohibitions and sanctions are to a large extent demanded by the people.

(d) At low income levels, consumers prefer commodities which are inexpensive but often environmentally unfriendly. As soon as incomes reach a higher level, the demand for environmentally friendly goods increases considerably. This means that the government and the market must respond to the new wants and needs of consumers.

Ekins (1997) has also presented the EKC hypothesis counter-arguments:

(a) Market agents make their purchase decisions according to the price information in the market. Often environmental resources are under-priced even though they have social value. This means that environmental resources are used uneconomically, that is, they are extracted in excess of what is environmentally sustainable. If this is the case, it is optimal for an individual economic agent to use environmental resources in excess, even though the use of resources is not optimal for the whole economy. Resultingly, resources are often exploited beyond a safe limit (see Fig. 1). For instance, biodiversity may be lost if environmental goods are not priced according to their full social value.

(b) Economic development in general may indicate that the use of the environment decreases in relation to economic growth. However, in absolute terms, the state of the environment may still degrade.

(c) Environmental policy is just one sector of the political arena. It is not guaranteed that an efficient environmental policy will be practised.

(d) Especially, in developing countries some environmental problems are real threats to health. The existence of environmental degradation does not mean that people were not willing to pay for a better environment. Instead, the limiting factor is budget constraints. Increasing demand for a better environment due to a rising income may also be harmful to the environment. For example, “eco-tourism” affects the original flora and fauna of holiday destinations. It is also questionable whether all the environmental requirements of the people and environmental campaigners are favourable to the environment. Very often, environmental cost-benefit analyses are based on local conditions and evaluations, and they may underestimate the interests of the poor and future generations, and the complexities of ecosystems.

The EKC research

The EKC hypothesis analysis was introduced by Grossman and Krueger (1992), and Shafik and Bandyopadhyay, (1992). Since then EKC-literature has expanded (Panayotou 1993, Holtz-Eakin and Selden 1995, Selden and Song 1994, Tucker, 1995, Suri and Chapman 1998, Dijkgraaf and Volleberg 1998, Stern, 1998, de Bruyn et al. 1998, Rock 2000 and others).[1]

Typically, in EKC research a quadratic or cubic function is analysed in reduced form in order to test the inverted-U shape of the EKC. In the basic setting a selected environmental indicator is explained by per capita GDP. In some studies additional explanatory variables are also included in the models: investment shares, electricity tariffs, per capita debt, political rights, civil liberties, and trade indicators among others (Agras and Chapman 1999, 268-269). Typical research problems are the following:

[1] Comprehensive surveys are presented by Stern, et al. (1996), Ekins (1997), and Stern (1998). Some unresolved issues behind the EKC-analysis are highlighted in Rothman and de Bruyn (1998).

Does pollution follow the Kuznets curve; first rising and then falling as income increases?
At what income level does the turning point occur, if there is any?
Do all pollutants follow the same trajectory?
Is pollution reduction in industrialised economies primarily due to structural change, or to regulation? (Hettige et al. 1997, 1)

Grossman and Krueger (1995) analysed the relationship between per capita income and various environmental indicators. They estimated a reduced form of regression model. Their study covers four types of indicators: urban air pollution, the state of the oxygen in river basins, the fecal contamination of river basins, and contamination of river basins by heavy metals. They used panel data from Global Environmental Monitoring System (GEMS) covering both developed and developing countries in the years 1985-88. They found no evidence that environmental quality deteriorates steadily with economic growth. Rather, for most indicators, economic growth brings an initial phase of deterioration followed by a subsequent phase of improvement. The turning points for the different pollutants vary, but in most cases they are reached before a country reaches a per capita income of $ 8000. However, their study does not strongly support the EKC hypothesis either, since other forms for the relationship were also recognised in their study. Ekins (1997) reported various EKC studies and evaluated their results. On the basis of Ekins' study it is possible to calculate (crude) critical threshold levels for air media, water media and land media. On the aggregate level the recognised turning points are; for air media $ 10 824 on average[2] (range $ 3 000 - 35 400), for water media $6 443 (range $ 1 400 - 11 400) and for deforestation $3 051 (range $ 823 - 5 420).

Although turning points can be recognised for some environmental media, the EKC hypothesis cannot be generalised as a scientific fact at the global level (see Stern et al. 1996). This critical condition also holds for developed countries. Ekins (1997) has concluded that there are no deterministic forces that save or destroy the quality of the environment. Economic growth does not have an intrinsic mechanism, which automatically degrades or improves the environment. This means that we need an active environmental policy. Thus, we cannot be sure whether sustainable development is achieved or endangered through rising per capita GDP.

Even though, the EKC hypothesis is valid in some countries, we cannot conclude that there will not be any social or economic problems for their environmental resource management. This is because the EKC analysis is typically executed with environmental indicators only, and it does not include an analysis that takes into account an ecological carrying capacity or sustainability. Some economists like de Bruyn, van den Bergh and Opschoor (1998) claim that the EKC hypothesis can be used for testing sustainable growth, which is defined as the

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[2] An extreme value of one study (over 8 million $) is omitted.

rate of economic growth that does not lead to growth in emissions. They maintain that a sustainable growth rate can be calculated for each type of emission and country, based on estimated parameter values (de Bruyn et al. 1998, 171-172). This approach has one deficiency, because emissions are indicators only, one can not assess, with this framework, whether or not emissions are optimal for sustainable growth. A deviation from the optimal sustainable growth path means that there may be too much, or too little emissions. This is clear, if different emissions and economic activities are interlinked so that some of them are substitutes or complements. If that is the case, it is impossible to conclude that growth or decrease in some emissions indicates unsustainable or sustainable growth. In addition, ecological carrying capacities are crucial factors behind ecological sustainability.

Even so, it is apparent that searching for empirical evidence of the existence, or non-existence of the EKC, is extremely important in providing background knowledge for the implementation of successful economic policies. If the EKC hypothesis does not hold the conclusion must be that there exist serious market or government failures and, consequently, harmful external problems in an economy. The EKC analysis can be seen as a basic empirical test for the proper functioning of an economy containing environmental goods. In this sense testing the EKC hypothesis can provide empirical information about the need for a more effective environmental policy. By considering selected five industrial countries we expect that the empirical evidence should support the EKC hypothesis, because they are among the most developed industrial countries. For the available data we apply time series regression models where the explanatory variable is GDP per capita and the dependent variables are direct material flows (also measured per capita). The purpose is to analyze whether the EKC hypothesis holds for direct material flows in these countries. In short, we analyse, if a pattern of economic growth can be observed that is consistent with a materials' consumption scenario, as regards the EKC hypothesis (see e.g. Ayres 1998, 5, de Groot 1999).

The model and data

The model

In our study the basic form of an EKC model in statistical form is the following third order (or cubic) polynomial:

$$\ln DMF_t = \alpha + \beta_1 \ln GDPCAP_t + \beta_2(\ln GDPCAP_t)^2 + \beta_3(\ln GDPCAP_t)^3 + \varepsilon_t, \quad (1)$$

where

$\ln DMF_t$ is the direct material flow per capita in logarithmic form;
$\ln GDPCAP_t$ is the real gross domestic product per capita in logarithmic form;

α is a regression constant, and β_1, β_2 and β_3 are regression coefficients to be estimated; ε_t is error term; t is time, t=1975, …, 1994.

We can get this long run equilibrium function for direct material flows from autoregressive distributed lag (ADL) model as follows. In general an ADL model takes the form:

$$\ln DMF_t = \tau + \tau_1 \ln DMF_{t-1} + \varphi_1 \ln GDPCAP_t + \gamma_1 \ln GDPCAP_{t-1} + \varphi_2(\ln GDPCAP_t)^2 + \gamma_2(\ln GDPCAP_{t-1})^2 + \varphi_3(\ln GDPCAP_t)^3 + \gamma_3(\ln GDPCAP_{t-1})^3 + \varepsilon_t \qquad (2)$$

where it is assumed ε_t's are independent and identically distributed with zero mean and variance σ^2, and $|\tau_1| < 1$. In the long run we may assume that variables' deviations from their equilibrium values will diminish. Then we may write:

$\ln DMF_t = \ln DMF_{t-1}$, and $(\ln GDPCAP_t)^i = (\ln GDPCAP_{t-1})^i$, i=1,2,3. After rearranging we get the function (1) where long run response parameters are defined to be:

$\alpha = \tau/(1-\tau_1)$, $\beta_1 = (\varphi_1+\gamma_1)/(1-\tau_1)$, $\beta_2 = (\varphi_2+\gamma_2)/(1-\tau_1)$, and $\beta_3 = (\varphi_3+\gamma_3)/(1-\tau_1)$.

The polynomial model allows us to determine the number of turning points of the direct material flow as a function of GDP (as well as the turning points themselves). The cubic form allows at most two turning points, which is sufficient for us, as our main interest is to study the existence of one turning point.

If $\beta_3 \neq 0$, there would be (at most) two turning points for the material flow curve. On the other hand, if $\beta_3=0$ and $\beta_2 \neq 0$, the material flow curve will have one turning point. The sign of β_2 determines if that point is a maximum ($\beta_2 <0$) or a minimum ($\beta_2 >0$). The case of an existing maximum point would be supportive to the EKC hypothesis. The testing is based on statistical regression analysis. The case of an existing maximum point would be supportive to the EKC hypothesis. This implies that to test the EKC hypothesis a one sided hypothesis test H_0: $\beta_2 \geq 0$ against H_1: $\beta_2 <0$ must be performed. At the same time the existence of more than one turning point is checked by testing the hypothesis H_0: $\beta_3=0$ against H_1: $\beta_3 \neq 0$.

Model specifications for individual countries were defined in two stages. Firstly, the relationship between direct material flow per capita and GDP per capita was determined by stepwise regression analysis. Secondly, the time series models were estimated by corrective autoregression procedures using Prais-Winsten and Cochrane-Orcutt methods to correct autocorrelation problems. The regression models reached in this way are reported below for each country under consideration.

Data sources

The direct material flow data was collected from Hoffrén (Hoffrén 1999, 52) and Adriaanse et al. (Adriaanse et al. 1997). Real GDP per capita (in 1985 international prices) data from 1975-1992 was collected from Penn World Tables (Summers-Heston data) and the rest of the data for - i.e. years 1993 and 1994 - is based on the authors' own calculations.

Empirical test results

General views

In Figure 2 direct material flows for Germany, Japan, the United States, the Netherlands and Finland between the years 1975-1994 are presented.

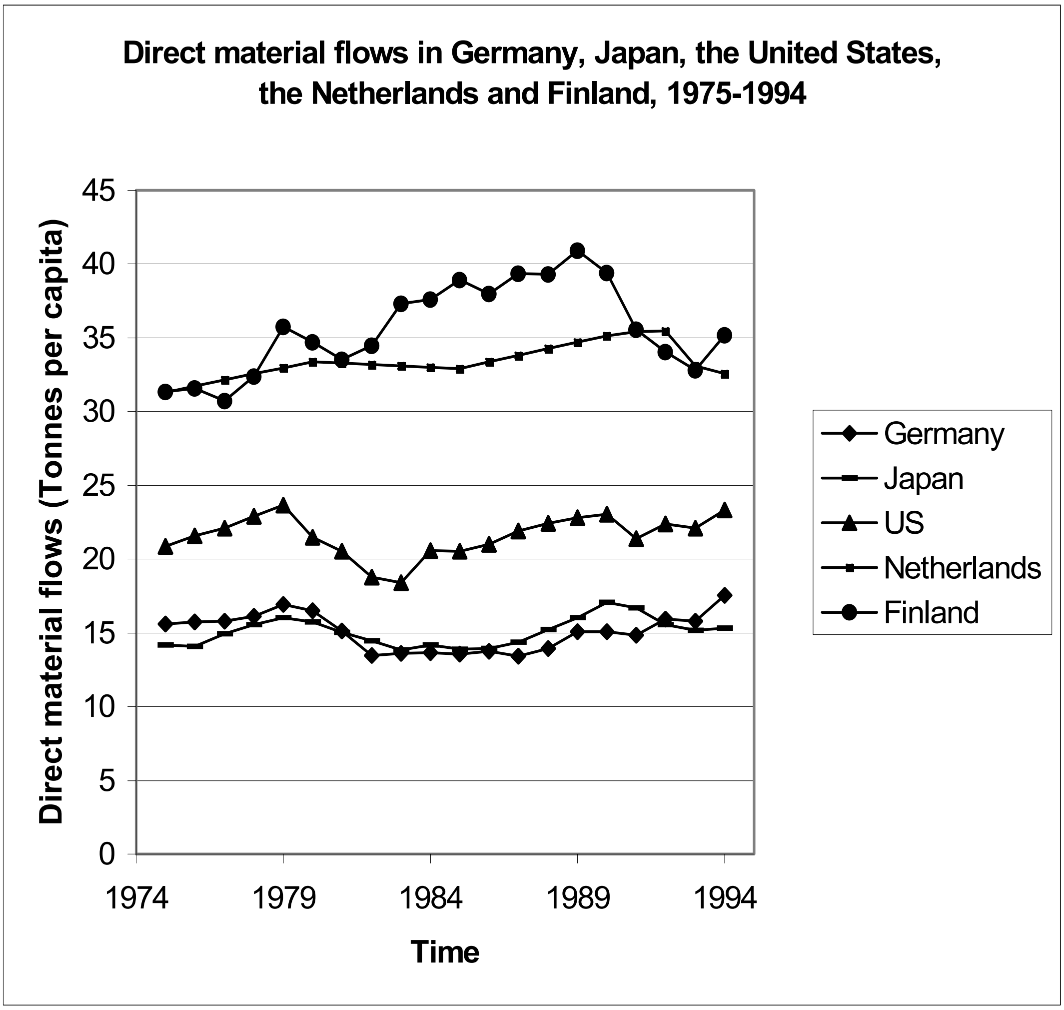

Figure 2. Direct material flows for Germany, Japan, the United States, the Netherlands and Finland, from 1975-1994

One can see that during the whole period Finland and the Netherlands have the highest direct material flows per capita whereas the USA, Japan and Germany have significantly lower levels. Next the results of the regression analysis for each of the countries involved are presented.

Germany's EKC curve ?

In Figure 3 the direct material flows (DMF) and GDP per capita are presented as an index time series for Germany.

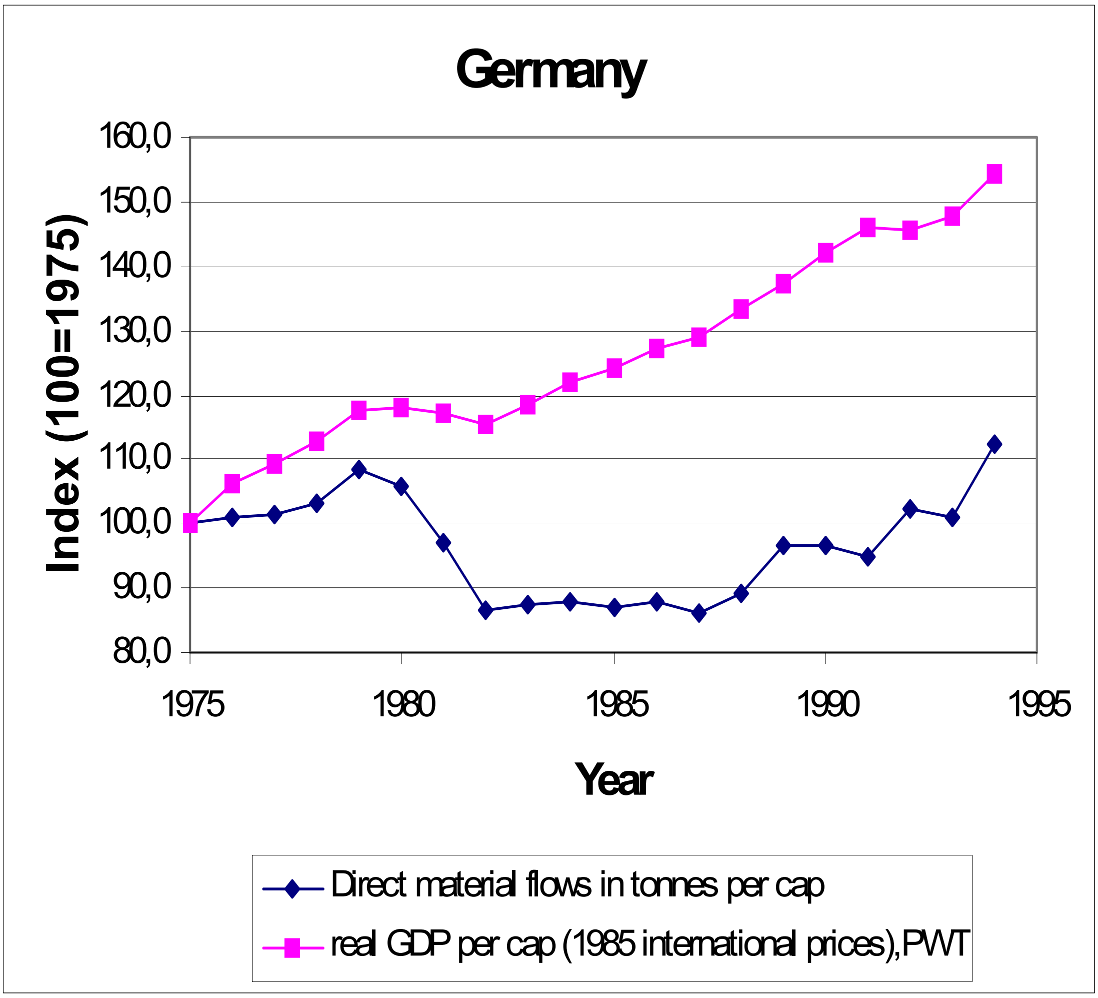

Figure 3. Germany: index series of GDP per capita and direct material flows per capita

Figure 4 presents a scatter diagram of German GDP per capita and the direct material flows per capita.

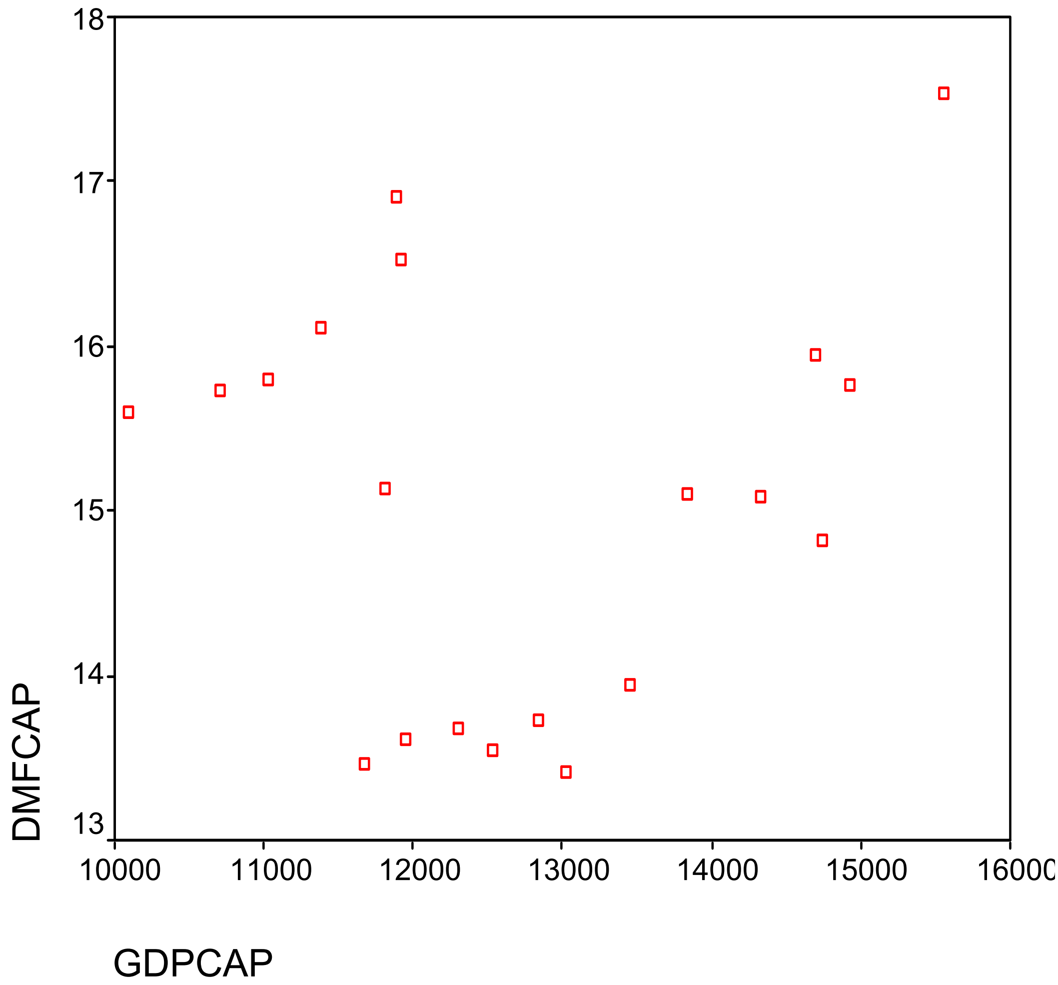

Figure 4. Germany's scatter diagram: GDP per capita and the direct material flows per capita

When running the regression it can be seen that the 1st and 3rd order terms are not statistically significant. After using Cochrane-Orcutt method and statistical diagnostics, we end up with the following quadratic regression model:

$$\ln DMF_t = a + b_2(\ln GDPCAP_t)^2, \quad (3)$$

where the regression model is estimated as follows:

	Coefficient	Standard error	t	Significance
b_2	0,099	0,024	4,13	0,0008
a	-6,409	2,218	-2,89	0,011

R-Squared	0,517
Standard Error	0,038
Durbin-Watson	1,290

The significances reported are, as commonly, based on two-way tests. For the one-way EKC hypothesis H_0: $\beta_2 \geq 0$ against H_1: $\beta_2 < 0$, the statistical significance is 1- 0,0008/2=0,9996. Thus the null hypothesis of no EKC is not rejected.

So no statistical support for the Environmental Kuznets Curve hypothesis was found when the German data was analysed. The data implies strongly the opposite. Statistically the model is quite good but the problem of autocorrelated error terms did not disappear totally, as the Durbin-Watson test statistic shows. It is quite clear from the results and Figure 2 that for the material flow curve there exists a minimum rather than a maximum level during the period under consideration. The DMF curve seems to be a U type and therefore it can be considered to be an inverse EKC-type.

Japan's EKC curve?

In Figure 5 the index time series of Japanese data is presented.

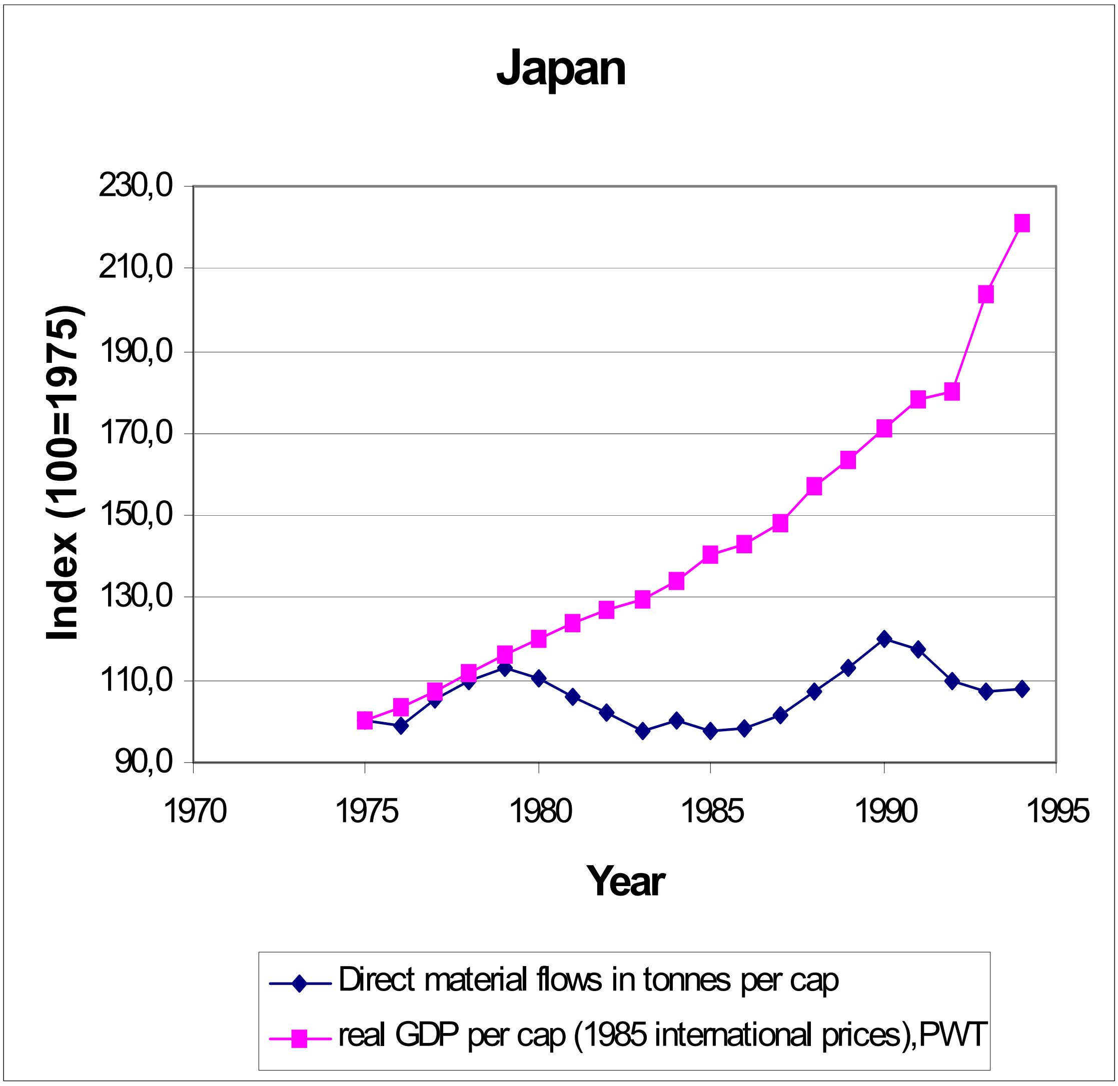

Figure 5. Japan: index series of GDP per capita and direct material flows per capita

Figure 6 presents a scatter diagram for Japanese GDP per capita data and the direct material flows per capita.

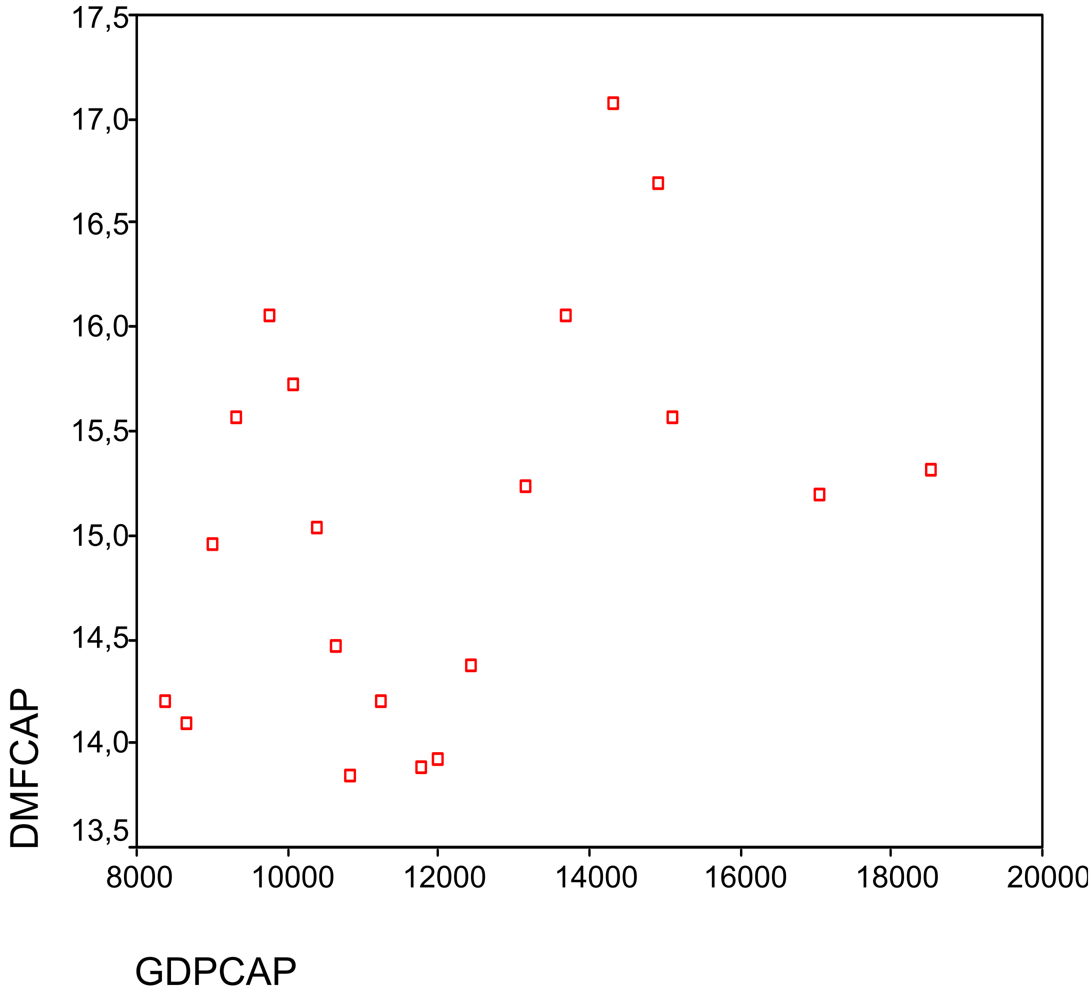

Figure 6. Japan's scatter diagram: GDP per capita and the direct material flows per capita

The 1st order term is not statistically significant. After using the Cochrane-Orcutt method, the following model and statistics were found:

$$\ln DMF_t = a + b_2(\ln GDPCAP_t)^2 + b_3\ln(\ln GDPCAP_t)^3, \tag{4}$$

	Coefficient	Standard error	t	Significance
b_2	2,224	1,173	1,90	0,077
b_3	-0,152	0,080	-1,89	0,078
a	-67,68	37,01	-1,83	0,087

R-Squared	0,198
Standard Error	0,038
Durbin-Watson	1,019

Based on the regression model empirical evidence supporting the EKC - hypothesis in the Japanese case cannot be found. The no-EKC hypothesis is retained at significance level 0,962. Again there is the problem of autocorrelation; in addition the coefficient of determination R^2 of the model is quite low; therefore caution is advised concerning the scientific implications of this model. From Figure 6 it seems evident that the material flow curve has three turning points, which would imply that a 4^{th} degree polynomial model would be more appropriate. However, this was not used, as our concern in this study was to test the EKC hypothesis.

The USA's EKC curve ?

The EKC hypothesis was also tested with US data. Figure 7 presents the index time series for the US data.

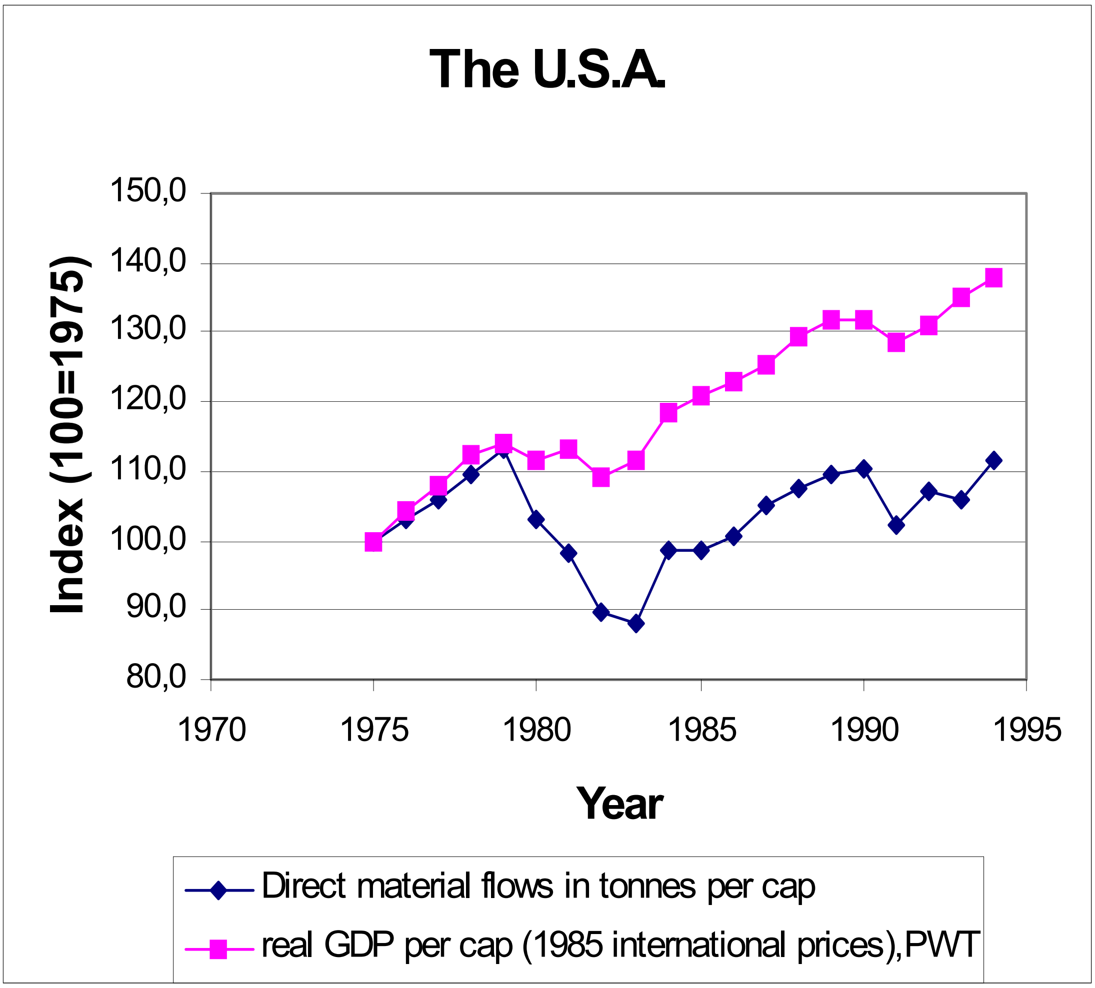

Figure 7. The USA: index series of GDP per capita and direct material flows per capita

Figure 8 presents a scatter diagram of the USA's per capita GDP data and direct material flows per capita.

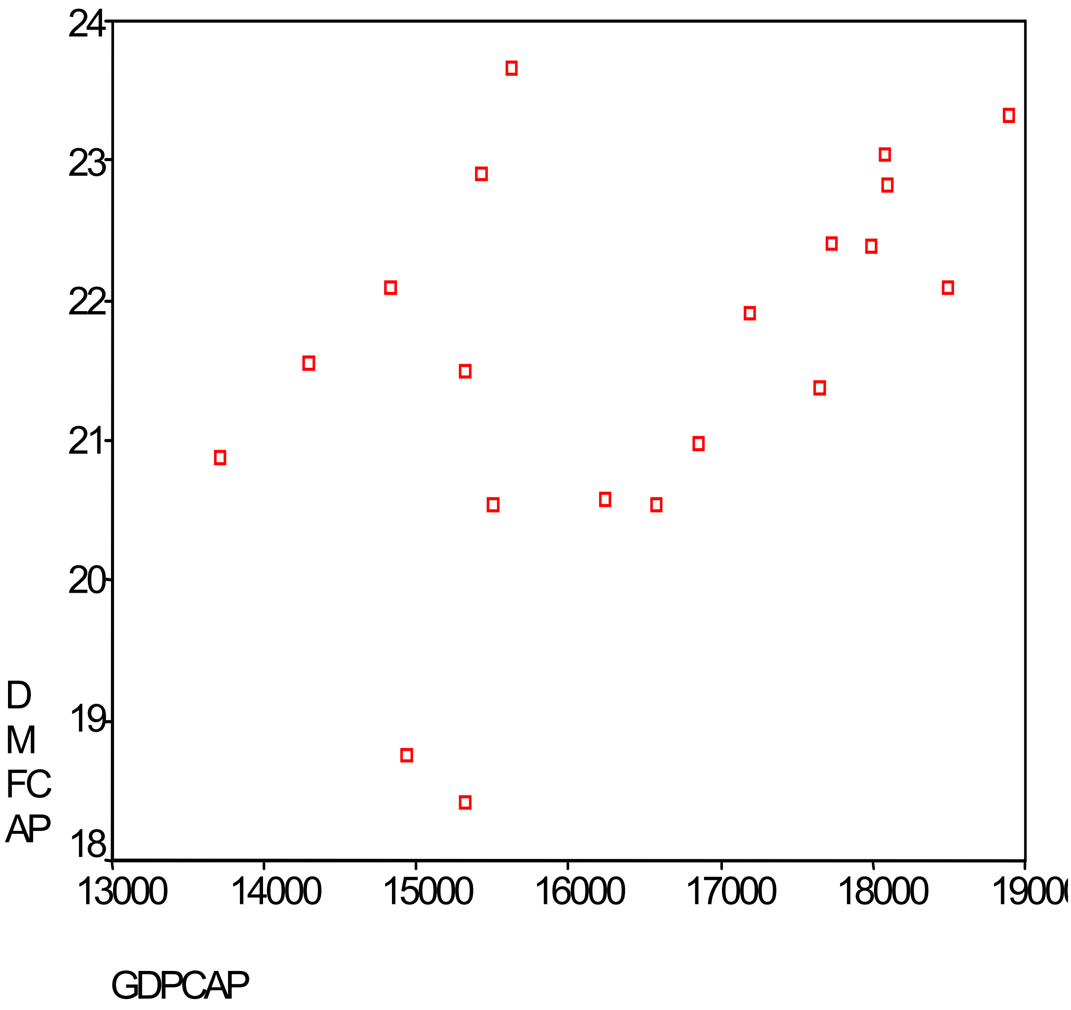

Figure 8. The USA's scatter diagram: GDP per capita and direct material flows per capita

The 1st and 3rd order terms are not statistically significant. After using the Cochrane-Orcutt method, the following model and statistics were found:

$$\ln DMF_t = a + b_2(\ln GDPCAP_t)^2, \quad (5)$$

	Coefficient	Standard error	t	Significance
b_2	0,010	0,015	6,81	<0,000004
a	-6,590	1,428	-4,61	0,00029

R-Squared	0,744
Standard Error	0,027
Durbin-Watson	1,242

Again, no statistical support for the EKC hypothesis was found, when the USA's data was analysed. The significance of the EKC test is 0,99999, which strongly supports a positive relationship between the DMF and GDP. The DMF curve resembles a U type, similar to the German case. Statistically the model fits quite well but there are some autocorrelation problems. The EKC hypothesis is not accepted.

The Netherlands' EKC curve?

We also tested the EKC hypothesis for the Netherlands' data. Figure 9 presents the index time series for the Netherlands' data.

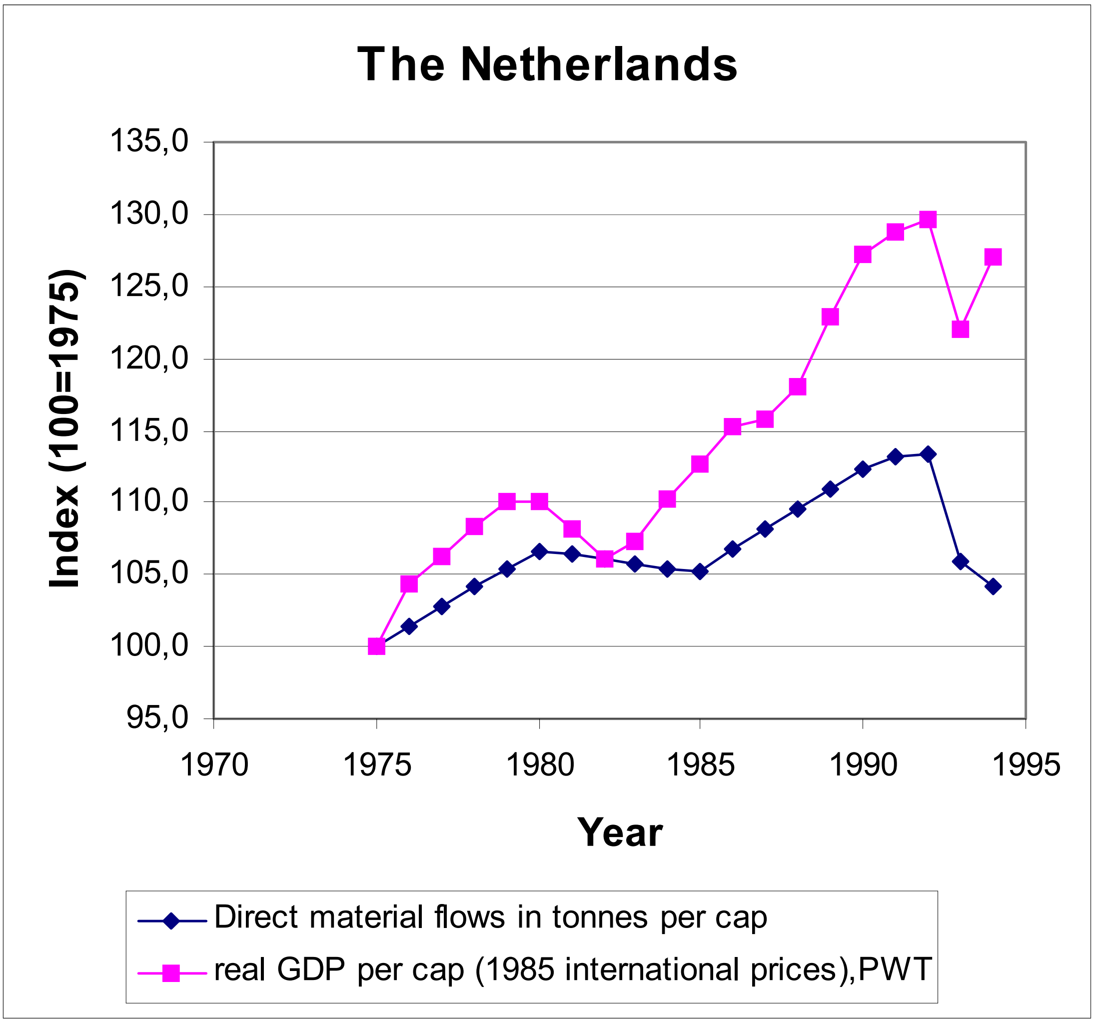

Figure 9. The Netherlands: index series of GDP per capita and direct material flows per capita

Figure 10 presents a scatter diagram of the Netherlands' GDP per capita data and direct material flows per capita data.

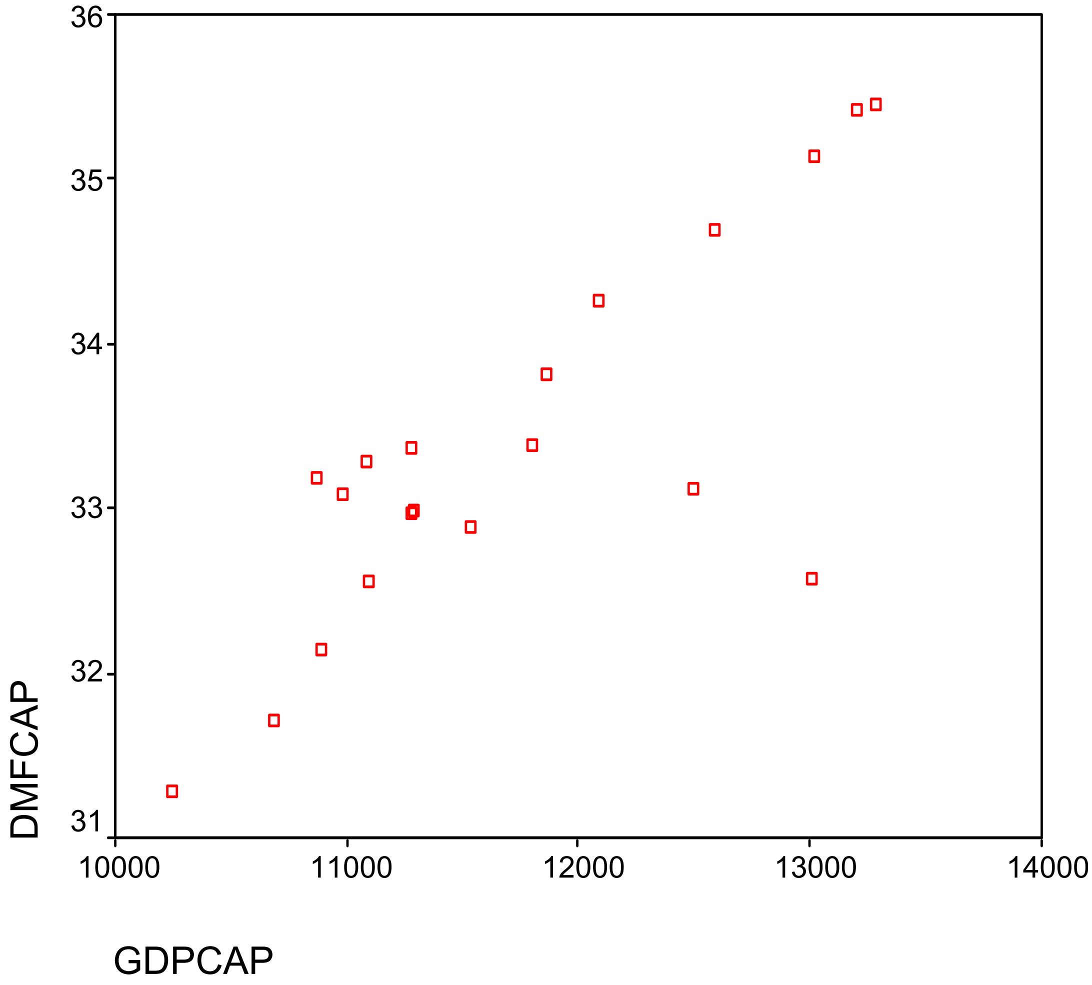

Figure 10. The Netherlands' scatter diagram: GDP per capita and direct material flows per capita

The 1st and 3rd order terms are not statistically significant. After using the Cochrane-Orcutt method, the following model and statistics were found:

$$\ln DMF_t = a + b_2(\ln GDPCAP_t)^2 , \qquad (6)$$

	Coefficient	Standard error	t	Significance
b_2	0,151	0,006	2,67	0,01690
a	2,178	0,501	4,35	0,0005

R-Squared	0,308
Standard Error	0,017
Durbin-Watson	0,644

There is a serious autocorrelation problem, and Prais-Winsten and Cochrane-Orcutt procedures do not give any remedial. Ignoring this the significance of the EKC hypothesis is 0,9985. If the autocorrelation problem of the model is neglected it can be said that the EKC hypothesis does not gain empirical support from the Netherlands' case either. The positive relationship between the GDP and DMF per capita can also be seen from Figure 10.

Finland's EKC curve ?

The EKC hypothesis was tested for Finnish data as well. Figure 11 presents index time series for the Finnish data.

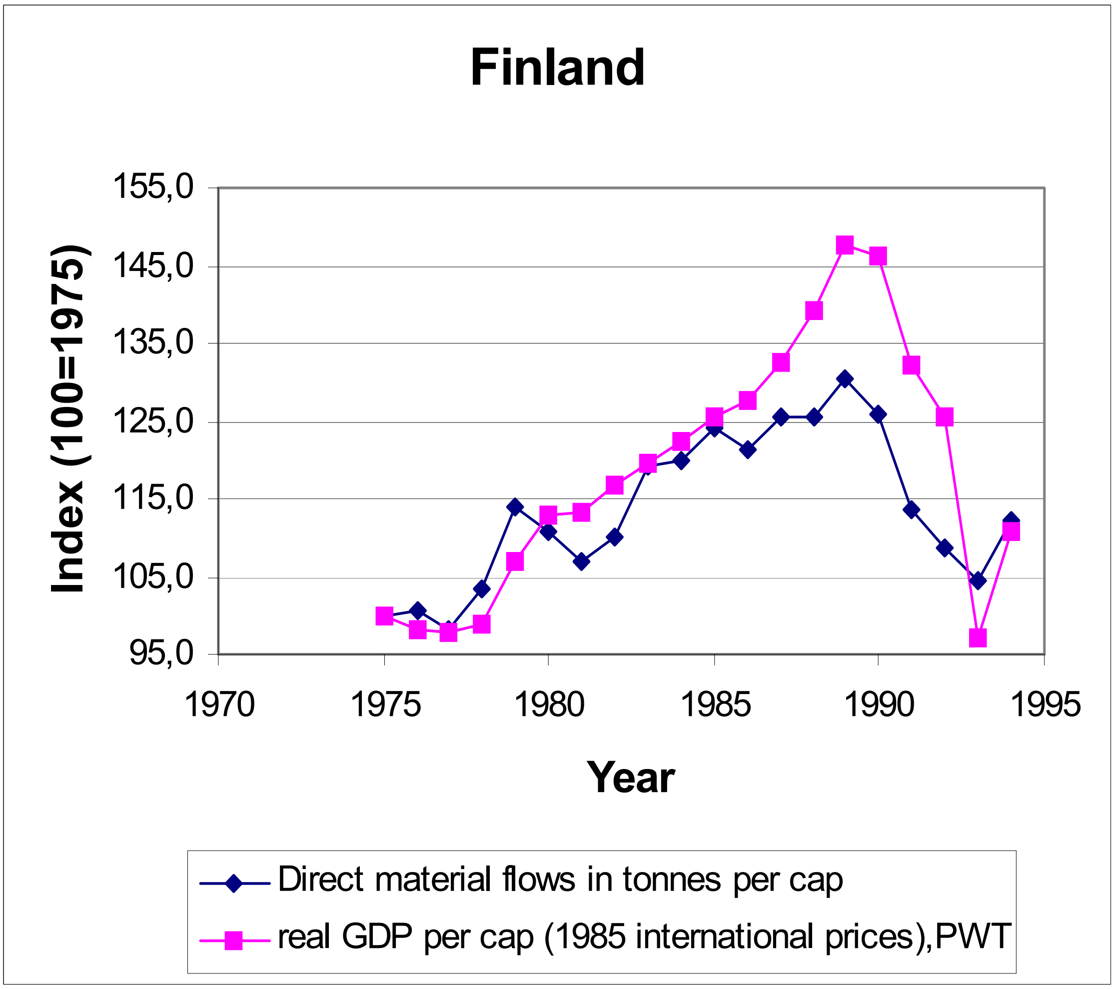

Figure 11. Finland: index series of GDP per capita and direct material flows per capita

Figure 12 presents a scatter diagram for Finland's GDP per capita data and direct material flows per capita.

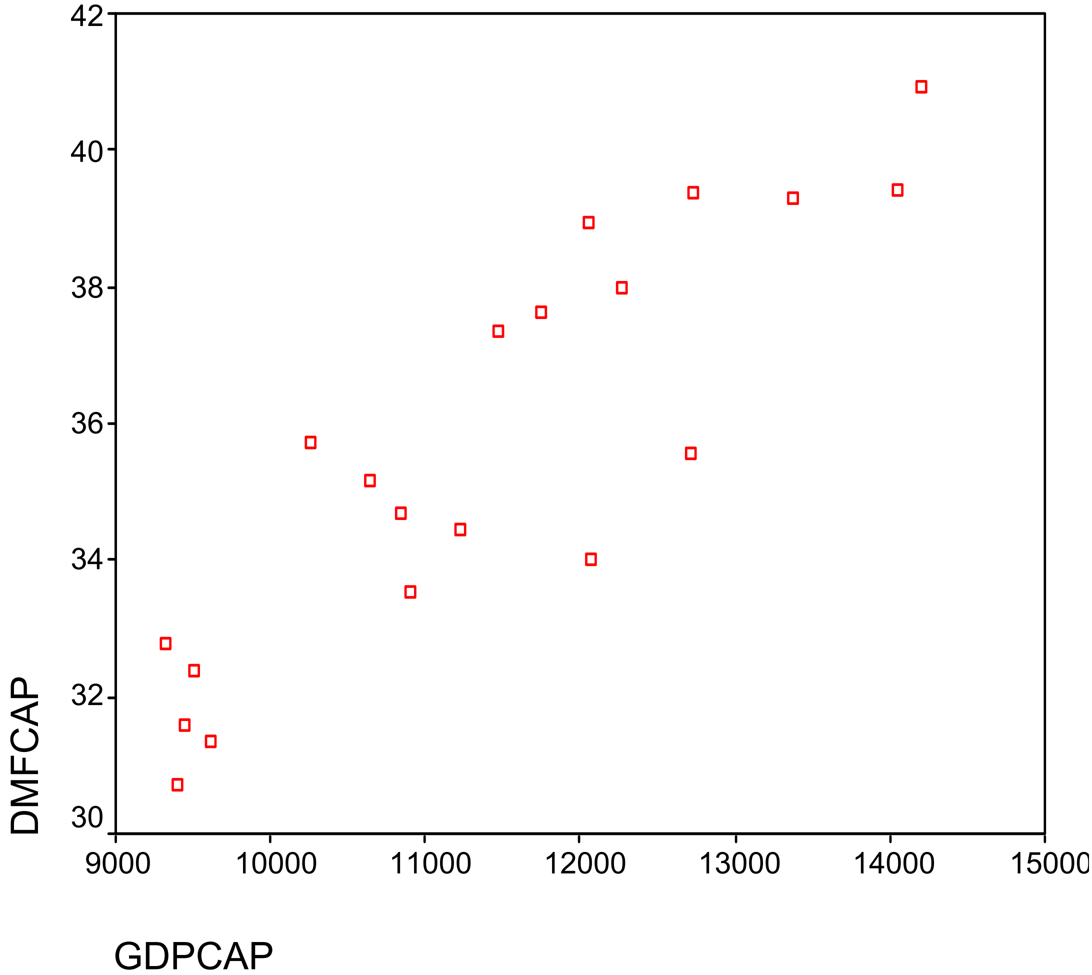

Figure 12. Finland's scatter diagram: GDP per capita and direct material flows per capita

The 1st and 3rd order terms are not statistically significant. After using the Prais-Winsten method, the following model and statistics were found:

$$\ln DMF_t = a + b_2(\ln GDPCAP_t)^2 , \qquad (7)$$

	Coefficient	Standard error	t	Significance
b_2	0,028	0,005	5,69	0,00003
a	1,136	0,427	2,66	0,017

R-Squared	0,656
Standard Error	0,038
Durbin-Watson	1,653

Again in Finland's case statistical support for the EKC hypothesis was not found. The significance for the EKC test is 0,99998. Therefore the EKC hypothesis for the Finnish data must be rejected. Statistically the model fits well; in this case there were no autocorrelation problems. The positive relationship between per capita GDP and DMF per capita can be seen quite clearly from Figure 12.

Summary

This study analyses the Environmental Kuznets Curve hypothesis with material use data for the USA, Germany, Japan, the Netherlands and Finland. The literature on this issue has developed rapidly over the last few years. There has been a long discussion concerning the relevance of the EKC hypothesis, which claims that as countries become wealthier environmental stress will begin to decline at a certain income level. However, the EKC hypothesis has not been widely tested with direct material flow data. In this paper, we have presented an attempt to test the EKC hypothesis via direct material flows. The results of the empirical hypothesis tests conducted here indicate that the EKC hypothesis does not hold for industrialised countries such as Germany, Japan, the USA, the Netherlands and Finland. This is the main result of the paper.

However, there are some limits in the time series data that make it somewhat difficult to totally deny the EKC hypothesis. If a longer time series analysis could have been made, the inverted U-curve might be identified. On the basis of our analysis, we conclude that in sustainability analyses and policy making it seems there will be significant future challenges for the management of material flows. This conclusion can be derived from the fact that none of the countries under investigation showed an inverted U-curve.

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