# 2.1. Meeting needs, consuming resources

## 1. Economic activity and the environment: links and limits.

It has been estimated that it took the whole of human history to grow to the EUR 60 billion scale of the world economy of 1900 (Speth, 1989). The world economy now grows by this amount about every two years (Goodland, 1991), and is currently at EUR 39 trillion (1998).

It is the speed and scale of this economic development which presents a threat to the integrity of the environmental support system that underpins economic activity (Box 2.1.1), and it is this which has changed most significantly over the last few decades.

Ecological services, unlike man-made technologies, are largely free, but their value can depreciate, and may disappear with over-use, as in the case of energy and materials taken from the environment, converted into useful products, then returned to the environment as waste and emissions. Such 'economic metabolism', if it exceeds the resilience of the environment, could cause shortages of both resources and ecological services.

However, managing the exploitation of the *sources* of energy and materials from nature, such as metals, minerals and forests, is much easier than managing the ecological *services* of nature, such as climate regulation, nutrient recycling, waste assimilation, and radiation protection from the ozone layer.

Shortages of materials can be overcome by improvements in efficiency, or via alternative products, such as plastics from biomass waste. Furthermore, the deposits of metals and fossil fuels are usually owned by someone, so that control over their use, via price and other means, is possible. Scarcity, and its associated price rises, stimulates invention, and man-made capital can sometimes replace natural materials from nature.

Ecological services are more difficult to deal with. It is not possible to replace the ozone layer (see Chapter 3.2) or the climate regulatory systems with man-made capital, and their efficient functioning can fail once thresholds of 'load' are passed. Such ecological services are not owned by anyone, nor do

**Box 2.1.1. Economies depend on the environment**

The planet is an integrated system of energy and material flows which involves the circulation of carbon, chlorine, nitrogen, sulphur, water and other key elements between the environmental compartments of air, water, soil and vegetation. The sun is the initial driving force behind such activity. This environmental system not only sustains individual life via air, food and drink but also enables us to collectively organise food, clothing and shelter in an economic sub-system through the provision of:

-Sources of energy and materials
-Sinks for waste and pollution
-Services such as water flow regulation; and
-Space for people, nature and aesthetics.

**Economies and the environment: key links** Figure 2.1.1


Economic Activity depends on:
'Sources' of Energy and Materials
'Sinks' for Waste
'Services' such as Water Flow Regulation
'Space' for People, Nature & Aesthetics

**Source**: EEA

These four basic 'life support' functions of the environment are essential to any economy, but whilst the products of nature such as food and drinking water are vital, the more hidden, but essential, ecological services are often ignored, or under-valued. For example, rivers and wetlands not only provide fish, water and facilities for recreation but scientific advances show that their servicing functions include holding and circulating water, producing oxygen, storing carbon dioxide, helping to regulate climate, and filtering pollution.

they usually have prices, so preserving them via market mechanisms is not so easy.

It is therefore concern about the current systems of economic activity overwhelming the *sinks* and destroying the *services* from the environment, rather than possible shortages of energy or materials, that have moved scientists, politicians and others to suggest that radical change in the way that we meet our needs is required (Box 2.1.2).

## 2. Natural and man-made resources: substitutes or complements?

Both the rate at which natural resources can be safely exploited, and the particular use of the resulting income stream for re-investment in replacement stocks, depends on whether it is possible to replace the functions of natural capital with those from man-made capital. If such substitution is possible, 'sustainability' can be achieved by leaving a constant stock of some combination of man-made and natural capital for future generations – this is the 'weak sustainability' view (Peskin, 1991). If substitution is not possible, as is the case with such ecological services as radiation protection from the ozone layer, or climate regulation, then natural capital must be preserved- the 'strong sustainability view' (Opschoor, 1992).

There may be cases where losses of small amounts of natural capital, such as wetlands or forests, could in theory be 'compensated' with the creation of similar resources, but despite many attempts, particularly in the USA, there have been few examples of the successful recreation of complex ecosystems such as wetlands (NRC, 1992).

There are clearly economic as well as physical limits to the replacement of free ecological services by engineered systems powered by fossil fuels. For example:

- replacing the functions of a forest requires replacements for wood products and the construction of erosion control works, air pollution control technology, water purification plants, flood control works, air conditioning plants and recreational facilities, all of which make large demands on taxes, as well as the consumption of other natural resources, with the loss of their ecological functions, such as soil (see Chapter 3.6);
- the functions of soil include food and timber production; storing twice as much carbon as the atmosphere; and

**Box 2.1.2. Living beyond our means?**

'The future of our planet is in the balance…The present pattern of human activity, accentuated by population growth, should make even the most optimistic about future scientific progress pause and reconsider the wisdom of ignoring these threats to our planet. Unrestrained resource consumption for energy production and other uses, especially if the developing world strives to achieve living standards based on the same level of consumption as the developed, could lead to catastrophic outcomes for the global environment.' (Royal Society/National Academy of Sciences, 1992).

Two crises are nudging humanity towards the 'outer limits' of what earth can stand.

First are the pollution and waste that exceed the planet's sink capacities to absorb and convert them. Use of fossil fuels is emitting gases that change the ecosystem – annual carbon dioxide ($CO_2$) emissions have quadrupled over the past 50 years. Global warming is a serious problem, threatening to play havoc with harvests, permanently flood large areas, increase the frequency of storms and droughts, accelerate the extinction of some species, spread infectious diseases – and possibly cause sudden and savage flips in the world's climates. And although material resources may not be running out, waste is mounting, both toxic and non-toxic. In industrial countries, per capita waste generation has increased almost threefold in the past 20 years.

Second is the growing deterioration of renewable resources – water, soil, forests, fish, biodiversity:

- twenty countries already suffer from water stress, having less than 1 000 cubic metres per capita a year, and water's global availability has dropped from 17 000 cubic metres per capita in 1950 to 7 000 today;

- a sixth of the world's land area – nearly 2 billion hectares – is now degraded as a result of over-grazing and poor farming practices;

- the world's forests – which bind soil and prevent erosion, regulate water supplies and help govern the climate – are shrinking. Since 1970, the wooded area per 1 000 inhabitants has fallen from 11.4 square kilometres to 7.3;

- fish stocks are declining, with about a quarter currently depleted or in danger of depletion and another 44% being fished at their biological limit.

**Source**: United Nations Development Programme (UNDP), 1998

providing home to the micro-organisms which are responsible for the creation of the oxygen-rich biosphere that permits life, as well as contributing to the maintenance of soil quality, the recycling of nutrients, and the breakdown of pollution (European Commission, 1997);
- it may be possible to replace, or even lose some of the millions of species in the world without too much cost, but it is very difficult to guess which species may have 'keystone ' functions that may be highly critical for ecosystem functioning, particularly under changing environmental conditions which are themselves difficult to predict (Frost *et al*, 1995). Genetic variability is therefore an insurance against the unforeseen (European Commission,1998a). A rich array of plant species, for example, ensures that when drought or other environmental stress causes some species loss, other species, with different tolerances, can compensate. Given the lack of knowledge about how ecosystems function, the present level of biodiversity may be the best proxy that scientists have for a 'safe' level of biodiversity (Baskin, 1997).

Research funded by European Commission (DG XI) is underway into the identification of critical natural capital and its management (Ekins, 1998). Adequate supplies of natural capital are also needed to maintain the value of man-made capital, e.g. saw mills without logs, or fishing boats without fish rapidly lose their value.

## 3. Resources: stocks, flows, accounts and impacts

Before the beginning of the Industrial Revolution, around 1750, economic activity was mainly powered by the use of flows of energy from the renewable resources of sun, wind, wood and water. After the invention of the steam engine, energy supplies moved to the exploitation of non-renewable stocks of fossil fuels, such as coal, then later oil and gas (Table 2.1.1).

For non-energy products too, there has been a similar shift towards using stocks of non-renewable resources, such as metals and minerals, rather than the flows of renewable resources, such as biomass. Non-renewable resources now account for about 70-75% of total material flows in industrialised countries compared to about 50% at the beginning of this century (Jackson, 1996; Schuster, 1997).

**Main environmental re-sources: stocks and flows** — Table 2.1.1.

| Stocks ('Non-Renewable') | Flows ('Renewable') |
|---|---|
| Fossil fuels | *Permanently renewable:* |
| - recyclable - oil for plastics | Sunlight |
| - non-recyclable - oil for fuel | Winds |
| Metals | Tides |
| Minerals | *Conditionally renewable* |
| Land | Inland Water |
| Sea | Air |
| Space | Soil |
| | Biodiversity |
| | Biomass. |

**Source**: EEA, adapted from RMNO, 1994

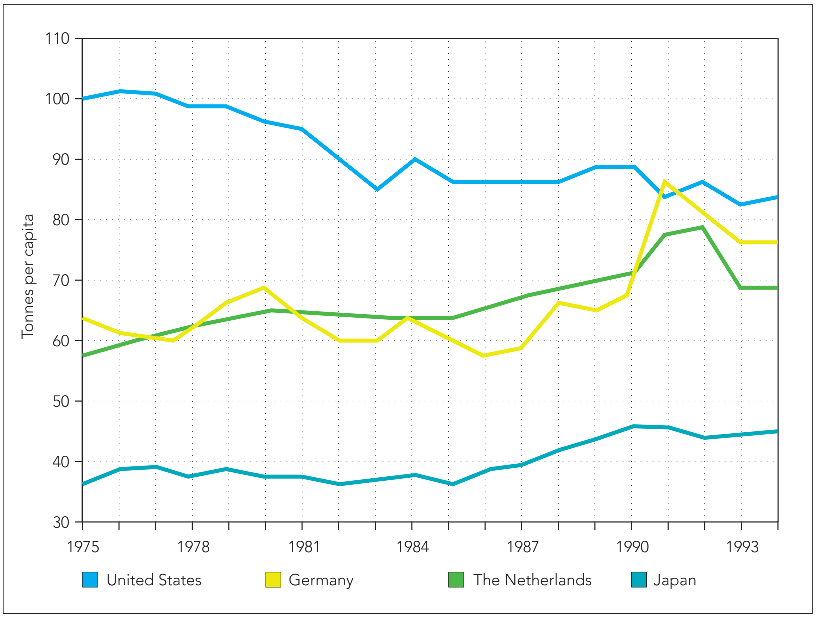
Data on total material flows in the EU is lacking, but indicative figures are available for Germany and The Netherlands, and on a comparable basis for the USA and Japan (Figure 2.1.2).

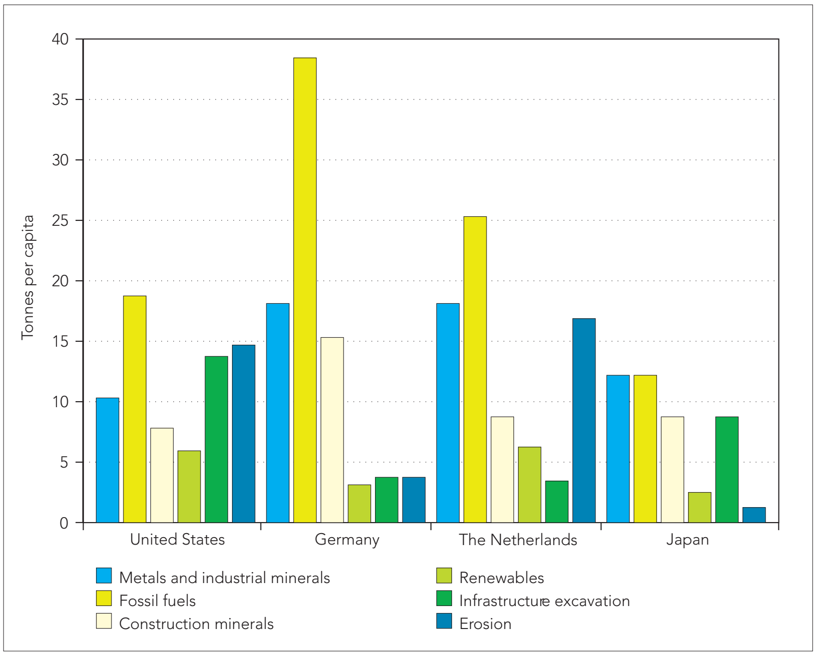
Germany, the Netherlands and the USA consume about 80 tons of materials per person per year (excluding air and water), with Japan consuming about half that. These total material requirements of current economic activity have been relatively stable over the last 20 years, despite efficiency improvements. They consist mainly of fossil fuels, mining and construction materials. Between a quarter and a half of these material flows include over-burden from mining, waste from logging etc. That do not enter normal accounting systems and which are therefore 'hidden' from the market. They are also hidden from the direct experience of the consumers, in that large amounts of materials are imported. Between one and two-thirds of these material flows are imported into Germany and the Netherlands respectively, representing part of the 'ecological footprint' of their economic activity on the rest of the world.

Stocks of non-renewable resources such as fossil fuels and metals are by definition finite but from a human perspective the stock is dynamic because the boundaries between the categories of resources that are 'known' and exploited move under changing market, technological and geological conditions (Figure 2.1.3).

How much of the stocks of such resources are used depends on whether the resource can be recycled (as with metals; and fossil fuels used as materials), or not (as with fossil

Figure 2.1.2 **Total material requirements: annual flows and main constituents**




**Source**: Adriaanse et al., 1997

fuels used as energy). Exploitation of resources also depends on the environmental impact of their use with available supplies sometimes being unused where environmental impacts would be unacceptably high, as with some mineral deposits.

The rate of exploitation of renewable resources must not exceed their rate of renewal if the stock is not to decline, but this principle is often ignored (Box 2.1.3).

***3.1. Accounting for nature.***

The market currently uses price and accounting signals which encourage the overuse of the environment. Firstly, current methods of accounting for the use of national resources via production, consumption and investment, and the associated indicator, the GNP, overestimate real growth of income because they fail to properly account for both the depletion of natural capital and for damage from pollution and associated 'defensive ' expenditures, such as the health service costs of air pollution, or the clean up of chemical spills. The consumption of natural capital is treated as income, which economists (Hicks, 1946; Repetto *et al.*, 1989) and business leaders agree is unsound. Both ecological damage to other countries (see Chapter 3.4), and the loss of global welfare from the destruction of tropical rain forests and other critical natural capital (see Chapter 3.11) need to be properly accounted for if optimal global well-being is to be achieved. However, accounting for the hidden subsidies from natural capital is not easy, particularly when the value of, say, biological diversity is more than the sum of its parts (Box 2.1.4).

In order to measure progress more accurately, several proposals to environmentally

**Box 2.1.3. Fisheries: living off the capital or the interest of nature?**

One way to picture the use of renewable resources is to imagine a fish biomass as being like money in a bank savings account. The money might earn 5% interest a year. If at the end of each year, 5% of the initial account were consumed, the balance of money in the account would remain the same. If more than 5% were consumed, the account would get progressively smaller and if less than 5% were consumed, the account would get bigger. Clearly, the account remains the same size only if the removal rate equals the interest rate.

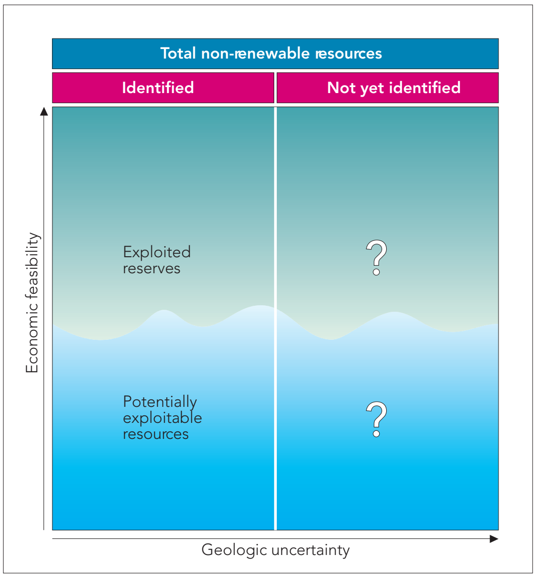
This is approximately what happens with fish populations when they are harvested. In fisheries, as in banking, it is important to distinguish between capital and interest. It is always possible to fish harder to get a higher harvest rate. However, this leads to diminished capital and hence potentially to reduced future income. Many of the world's fish stocks are being over-fished; e.g. the seven countries of the North Atlantic Salmon Conservation organisation agreed in June 1998 to a moratorium on commercial salmon fishing (EEA, 1998a).

'The bottom line is that the human species is living more off the planet's capital and less off the interest … this is bad business … many of our attempts to make progress are simply unsustainable….fundamental change is needed.' (Schmidtheiney/BCSD, 1992).

**Box 2.1.4.**

'How should the American oyster population of the Chesapeake Bay be valued? Is its value what it brings to market as seafood annually? Or is it the value from the current population filtering a volume of water equal to the entire bay once a year? Or is it the value before pollution and degradation, when it filtered that same enormous volume once a week? Our economies are riddled with such beneficial subsidies from nature, for which there is no current accounting. Similarly, our economies are riddled with subsidies and incentives that lead to environmental degradation.' (Lovejoy, 1995).

**Stocks of non-renewable resources are not static** Figure 2.1.3




**Source**: EEA

adjust national accounts and associated indicators have been made, such as the Index of Sustainable Economic Welfare (Jackson *et al.*, 1997; Box 2.1.5), and the 'genuine savings' indicator, but much further work is needed before environmentally-adjusted accounts and indicators are agreed and used. (Bouwer and Leipert, 1998)

Secondly, market prices do not include the full costs of environmental damage which, for transport for example, have been estimated at 4% of the EU's GNP in accidents, congestion and pollution costs. Environmental costs need to be 'internalised' into market prices, via taxes, etc. if overall welfare is to be optimised (European Commission, 1998) (see Chapter 4.1).

### *3.2. Impacts of human activity*

In pre-industrial economic activity, the flows of carbon between the different compartments of the environment were in balance, but once the burning of fossil fuels began, the previously 'locked in' carbon was released (Figure 2.1.5).

In a relatively short space of time, this accumulated as carbon dioxide in the atmosphere, where it and other greenhouse gases contribute to global warming (see Chapter 3.1). There have been large variations in levels of greenhouse gases such as carbon dioxide and methane before now. Some of them have led to rapid changes in global temperature, such as an increase of about 7°C in the Arctic during a 50-year period some 10 700 years ago, according to

**Box 2.1.5. Measuring real progress?**

The Index of Sustainable Economic Welfare (ISEW) was originally pioneered for the United States (Daly and Cobb, 1989) and further developed in the UK (Jackson *et al.*, 1997). It starts with the GNP and then adjusts this figure for inequalities in the distribution of incomes using non-monetarised contributions to welfare from services provided by household labour; certain defensive expenditures against pollution; changes in the capital base, e.g. the human capital stock; and the loss of future ecological services as a result of the depletion of natural resources, the loss of habitats and the accumulation of environmental pollution.

ISEWs have been computed for the UK, Sweden and Germany, as well as the USA. They all show a similar pattern, i.e. a lower growth rate than GDP up to about the mid 1970s, then a decline, resulting in a measure of welfare in 1996 that is little higher than that in the 1950s.

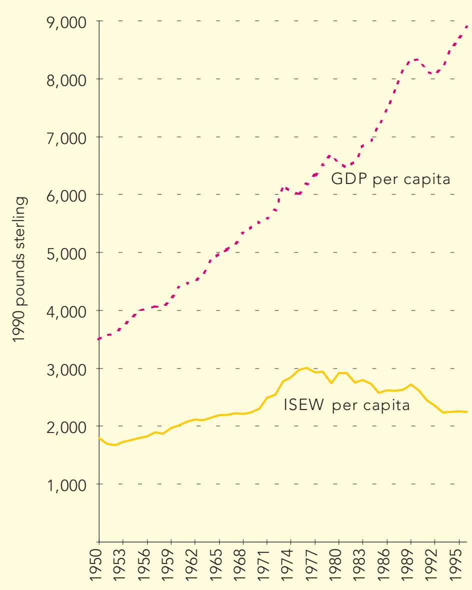
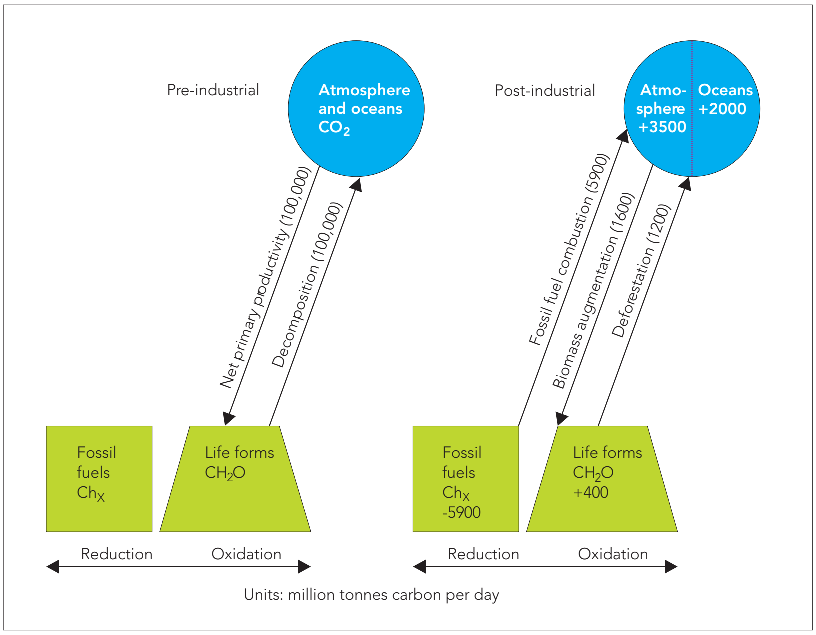



Figure 2.1.4
**Development of ISEW and GDP in UK 1950-1996**

**Source**: Jackson *et al.*, 1997

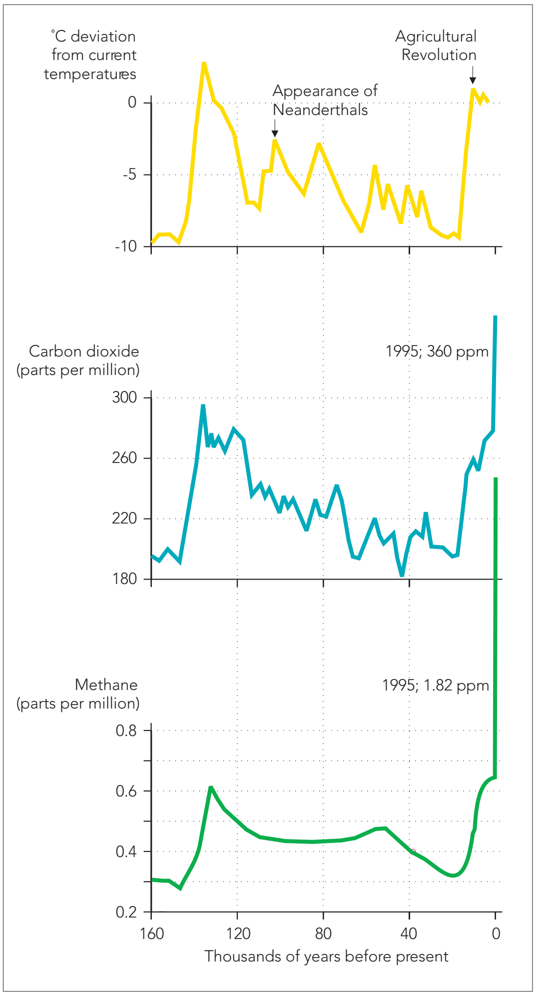
Figure 2.1.5 **Pre- and post-industrial carbon flows**




**Source**: Ayres, 1994

Figure 2.1.6 **Variations in some greenhouse gas concentrations and global temperature**

**Source**: Houghton, 1994 (updated with 1995-figures)




ice core evidence (Houghton, 1994). However, whilst it took nature about one million years to lay down the fossil fuels, their exploitation over the last 250 years has led to relatively rapid rises in carbon dioxide and methane concentrations in the atmosphere (Figure 2.1.6).

A similar change has occurred with the nitrogen cycle, with human additions of 150 million metric tons of nitrogen a year (90 from fertiliser, 40 from leguminous crops and 20 from fossil fuel combustion), providing an approximate doubling of the pre-industrial rate of nitrogen fixation (Ayres *et al.*, 1994). The speed of increase is again significant. Half of the one billion extra tons of global nitrogen added to nature from fertilisers during the period 1920-1985 accumulated during the period 1975-85 (Smil, 1991). While a more fertile world can have some benefits, the rate of increase of additional nitrogen from human activity seems to be too high for benign assimilation, leading to eutrophication, and contributing to acidification and photochemical smog. However, whilst the carbon cycle has received much attention from businesses and politicians, leading to energy efficiency gains etc., relatively little attention has so far been paid to the disturbances of the nitrogen cycle caused by fertilisers and fossil fuels.

Other human disturbances to the 'grand cycles' of nature, such as the sulphur and chlorine cycles, have led to problems of acidification and ozone layer damage (see Chapters 3.2 and 3.4). Although the human additions to natural stocks and flows can often be very small, they can be large enough to disturb the system. For example, the human-induced addition to the flow of fixed 'new' nitrogen every year is only about 1 part in 30 million of the stock of nitrogen in the atmosphere – but as nearly all of the atmosphere stock is bio-unavailable, all life depends on this trickle of fixed nitrogen, and doubling its flow may have significant impacts (Ayres, 1994).

Clearly, the use of resources to meet human needs requires a radical change in the efficiency with which they are exploited.

## 4. Eco-efficiency: getting more from less

Meeting needs with less use of natural and man-made resources but with more use of people has become an environmental and economic imperative (Box 2.1.6). 'Eco-

**Box 2.1.6. 'Less nature, more people?'**

'The serious economic and social problems the Community currently faces are the result of some fundamental inefficiencies: an 'under-use' of the quality and quantity of the labour force, combined with an 'over-use' of natural and environmental resources… The basic challenge of a new economic development model is to reverse the present negative relationship between environmental conditions and the quality of life in general, on the one hand, and economic prosperity, on the other hand.'

**Source**: European Commission, 1993

efficiency' aims at de-coupling resource use and pollutant release from economic activity and is becoming an object of environmental policy (OECD,1998; EEA, 1998b).

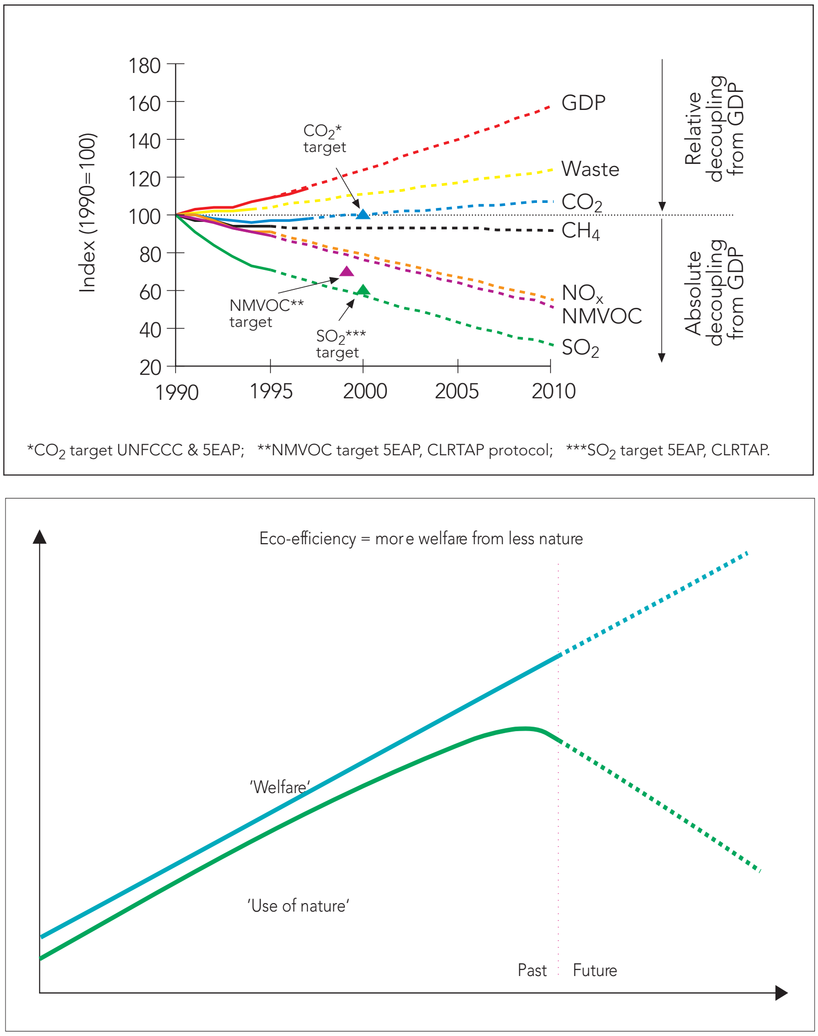
The Agenda 21 up-date (UN, 1997), in its paragraph on integration, notes the need to improve the efficiency of resource use; to consider a ten-fold improvement in resource productivity in industrialised countries; and, to promote measures favouring eco-efficiency. This will require breaking the links between use of nature, as measured by environmental indicators, and economic development, as measured by output indicators, such as GDP, or passenger-kilometres in transport for example. Both 'use of nature' and 'welfare' indicators need improving in order to better reflect reality and human needs, but some current trends in eco-efficiency can be gauged from using existing information.

Improved eco-efficiency is not a sufficient condition for sustainable development, as absolute reductions in the use of nature, and associated environmental pressures, may be necessary to get within the earth's (and human) carrying capacities, so that both relative and absolute de-linking between the use of nature and economic growth will be necessary.

Figure 2.1.7 summarises progress with the de-linking of some environmental indicators from economic growth in the EU in the first half of the 1990s, with outlooks to 2010.

The case of Austria, which was the first country to adopt the Factor 10 target in its national environmental plan, illustrates the difference between relative eco-efficiency gains and the continued rise in the absolute use of resources from economic growth (Figure 2.1.8).

**Relative and absolute de-linking: current developments and future directions** Figure 2.1.7



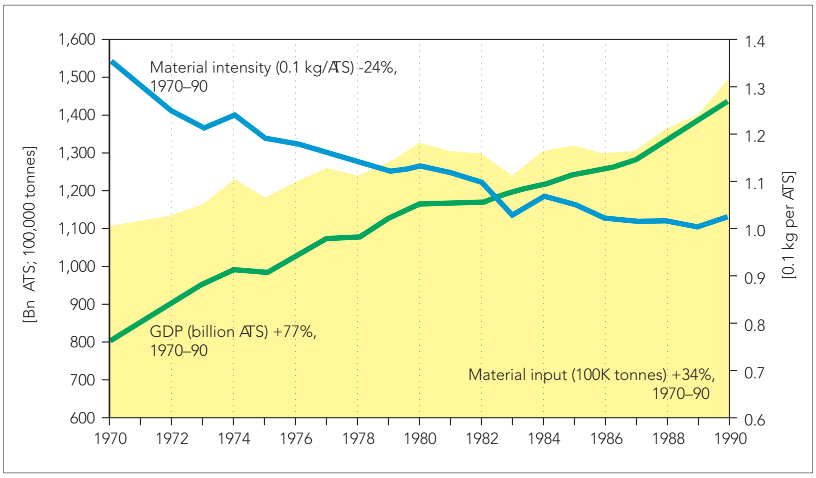

**Source**: EEA

There are two broad ways to enhance eco-efficiency:

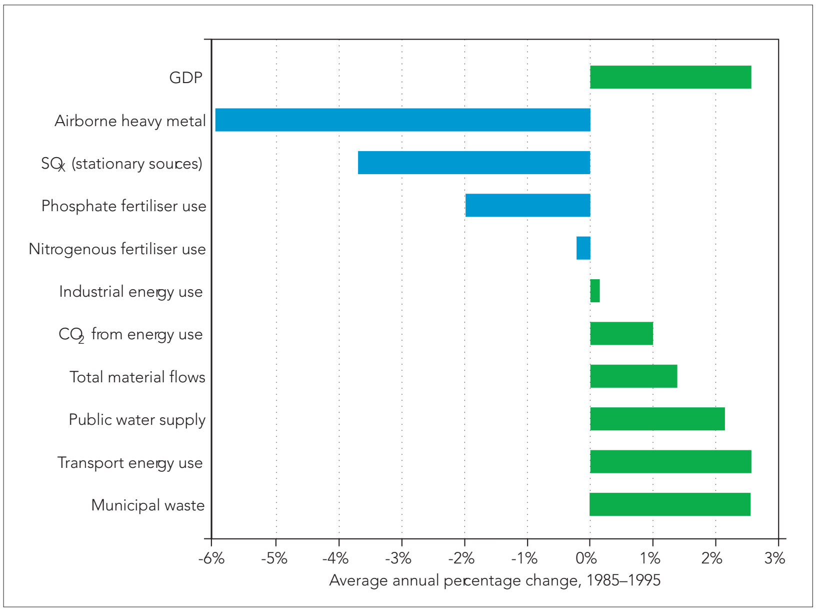
- via the more elegant and equitable use of resources, through innovation in the use of resources and labour; and
- via a focus on meeting human needs more from labour-intensive services than from capital-intensive products.

There is considerable potential for initiatives by firms and communities to improve eco-efficiency using current technologies. For example, manufacturers have found profitable ways to reduce their use of materials, energy and water per unit of production by 10-40% (OECD, 1998) and initiatives in the services sector, local governments and households achieve similar savings. Firms have also demonstrated technologies that cut the use or emission of toxic substances by 90% or more, although these technologies are not always put into place (OECD, 1998; Weizsäcker *et al.*,

**Figure 2.1.8** Eco-efficiency and material flows in Austria




**Source:** Schuster,1997




**Source:** OECD, 1998

1997). A few firms have taken initiatives to reduce environmental impacts during and after the use of products, for example by recovering used equipment and re-using durable components (see Chapter 3.7). Initiatives that address impacts over the full life-cycle offer the greatest potential for reducing pollution and resource use economy-wide, but few firms have developed comprehensive strategies for achieving this. Business organisations such as the World Business Council for Sustainable Development (WBCSD) are encouraging reductions in the intensity of energy and materials use via the promotion of eco-efficiency (Box 2.1.7). 'Demand-side management' in the energy, water, transport and parts of the chemicals sector is beginning to shift the focus from consuming products to using services, with associated eco-efficiency and employment gains.

Industrial ecology has been slowly emerging as an approach to eco-efficiency and sustainability since the early 1970s (Erkman, 1997). It includes the promotion of regional recycling networks (or industrial ecosystems) such as the Industrial Symbiosis networks in Kalundborg, Denmark, parts of the Ruhr, Germany, and Styria, Austria, which already involve using the outputs of substantial quantities of waste from some companies as inputs for other companies. For example, of the estimated 3.8m tonnes of non-construction waste generated each year in Styria, about 1.5m is now used as production inputs to iron manufacturing, construction materials, paper and cement plants within the recycling network (Schwarz and Steininger, 1997).

Eco-industrial parks (Lowe, 1997) are being developed, mainly in the USA and Japan, where the principles of industrial symbiosis and 'zero emissions' (Pauli, 1997) are being designed into the development plans of the parks. Although there are thermo-dynamic, energy and economic limits to recycling, the current high ratio of wastes to useful products indicates that there is considerable scope for the more efficient use of resources.

The search for innovative chemical processes which facilitate less toxic and resource-intensive chemical production (Box 2.1.8) is being stimulated by 'Green chemistry' networks in Germany, Italy, the UK, Japan, and the USA (Anastas and Breen, 1997; Tundo and Breen, 1999; Royal Society of Chemistry, 1999). As the US Academy of Engineering has pointed out, 'design should not merely meet environmental regulations: environmental elegance should be part of the culture of engineering education.' (Jackson, 1996). Those companies and countries that first succeed in emulating nature's elegance in resource use will provide a great service to the environment and human society (EEA/UNEP, 1998).

In general, the focus on eco-efficiency will lead to the development of circular, rather than linear economies, where wastes become inputs rather than outputs.

The OECD has identified several ways in which governments could encourage eco-efficiency initiatives by firms and communities, such as: tax and subsidy reform; regulations; promoting 'extended producer responsibility'; and supporting the development of standard monitoring and reporting procedures.

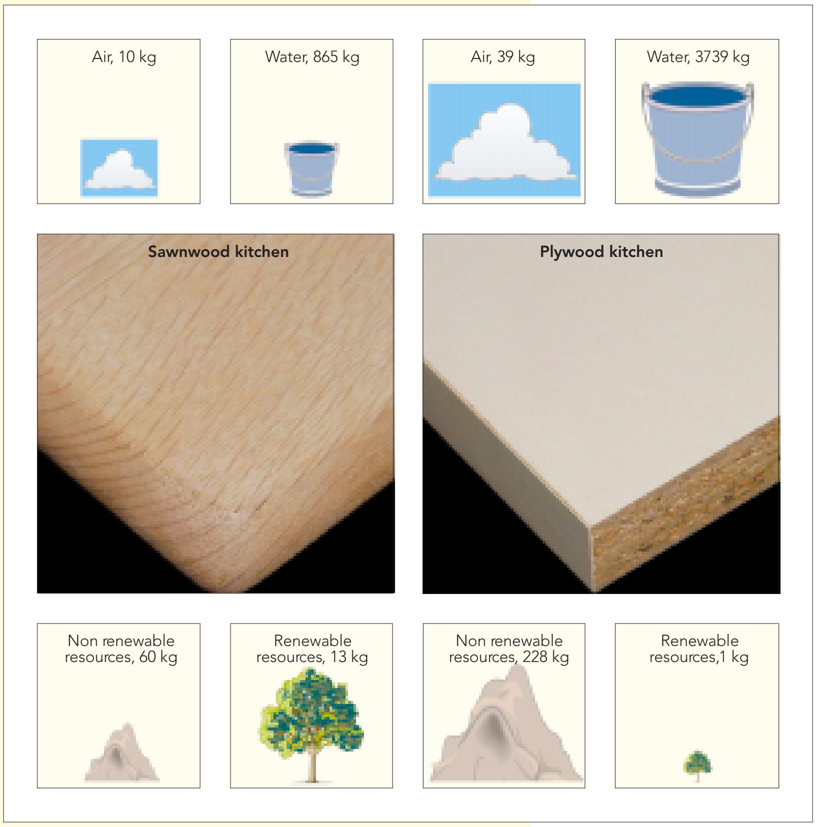
**Box 2.1.7. Eco-efficiency criteria of the World Business Council for Sustainable Development**

1. minimise the material intensity of goods and services;
2. minimise the energy intensity of goods and services;
3. minimise toxic dispersion;
4. enhance material recyclability;
5. maximise the use of renewable resources;
6. extend product durability;
7. increase the service intensity of goods and services.

**Source**: WBCSD/EPE, 1999

The materials intensity of two different types of kitchen illustrate the application of some of these criteria (Figure 2.1.9)

**Materials intensities: kitchens example** Figure 2.1.9




**Source**: Liedtke et al., 1994

## 5. Equity and sustainable development

'It took Britain half the resources of the planet to achieve its prosperity: how many planets will a country like India require?' (Mahatma Gandhi, when asked if, after independence, India would attain British standards of living).

It has long been recognised that the rest of the world could not achieve northern standards of living by using the same resource consuming methods. 'It will be impossible for the habits of comfort prevailing in western Europe to spread themselves over the whole world and maintain themselves for many hundred years.' (Marshall, 1920). The present global shares of resources are very unequal (Box 2.1.9) and have become more so in the last 40 years (UNDP, 1998).

Both poverty and affluence can destroy resources and damage ecological functions, but whereas both cause local and regional damage, only affluence causes widespread global damage. 'Sustainable Development'

**Box 2.1.8. Green chemistry: key objectives**

- Clean synthesis (e.g. new routes to important chemical intermediates including heterocycles).
- Enhanced atom utilisation (e.g. more efficient methods of bromination).
- Replacement of stoichiometric reagents (e.g. catalytic oxidations using air as the only consumable source of oxygen).
- New solvents and reaction media (e.g. use of supercritical fluids and reactions in ionic liquids).
- Water-based processes and products (e.g. organic reactions in high-temperature water).
- Replacements for hazardous reagents (e.g. the use of solid acids as replacements for traditional corrosive acids).
- Intensive processing (e.g. the use of spinning disc reactors).
- Novel separation technologies (e.g. the use of novel biphasic systems such as those involving a fluorous phase);
- Alternative feedstocks (e.g. the use of plant-derived products as raw materials for the chemical industry).
- New safer chemicals and materials (e.g. new natural product-derived pesticides).
- Waste minimisation and reduction (e.g. applying the principles of atom utilisation and the use of selective catalysts).

**Source**: 'Green Chemistry', Vol. 1, No. 1, Feb. 1999, University of York

**Box 2.1.9 Global inequity**

- Developed economies with only 20% of the world's population, consume 80% of its resources whilst sharing less of the world's increasing wealth with the 80% of the population in less 'developed' countries than 30 years ago; despite consuming large proportions of resources from developing countries, such as:

  - 45% of all meat and fish; the poorest 20% of the world's population consume 5%;

  - 58% of total energy, the poorest 20% of the world's population consume less than 4%.

- Consumption per capita has increased steadily in industrial countries (about 2.3% annually) over the past 25 years. The average African household today consumes 20% less than it did 25 years ago. The poorest 20% of the world's people and more have been left out of the consumption explosion.

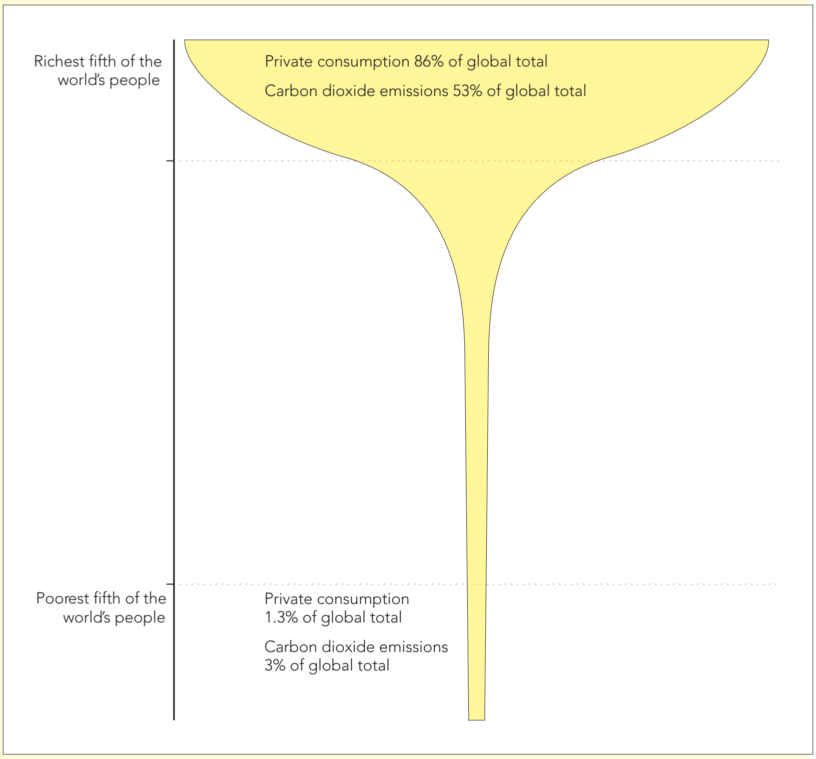
- Deforestation is concentrated in developing countries. Over the last two decades, Latin America and the Caribbean have lost 7 million hectares of tropical forest; Asia and Sub-Saharan Africa 4 million hectares each. Most of it has taken place to meet the demand for wood and paper, which has doubled and quintupled respectively since 1950. But over half the wood and nearly three-quarters of the paper is used in industrial countries.

**Source**: UNDP, 1998

The combined wealth of the world's richest 225 people is $1 trillion, whilst the combined annual income of the world's poorest 2.5 billion people is also $1 trillion (Worldwatch Institute, 1999).

Current global shares of consumption and carbon dioxide are shown in figure 2.1.10.

Figure 2.1.10 **Fair global shares?**




**Source**: EEA, based on UNEP, 1992 and 1998

therefore embraces equity and social considerations as well as economic and environmental issues.Trade issues are also important. For example, improving the overall efficiency of resource use by internalising full environmental costs into market prices can penalise the 'pioneer' countries who adopt full cost pricing first, if 'free trade' prevails. International agreements are therefore being proposed to help achieve optimal global welfare (Box 2.1.10).

Achieving well-being depends on achieving the optimal balance between the three pillars of sustainability, the economic, the social and the environmental (Box 2.1.10; Figure 2.1.11).

## 6. Monitoring progress towards more welfare from less nature

Monitoring progress in using less nature to meet human needs requires measures of accounting and reporting that relate *welfare* to the *use of nature*. In practice, this involves measuring the eco-intensity of production and consumption via efficiency indicators, which are one of four main types of indicators (EEA, 1999). New reporting systems, such as the Transport and Environment Reporting Mechanism (TERM) currently being developed at EU level, are trying to use a wider range of indicators to capture both eco-intensity ratios, such as energy use and pollutants per billion kilometres of output, and performance against target values, such as air quality standards.

Many firms have also developed indicators and targets for reducing their intensity of material use, energy consumption and toxic emissions per unit of production (Box 2.1.11). They monitor progress towards these targets and release the results in their annual environmental reports. Few have yet developed quantitative indicators or targets for concepts such as 'service intensity' (i.e. the quality of the service they provide to their customers), or for reducing impacts over the life-cycle of their products and services.

At the level of the economy there is a need to focus on key indicators for resource use and associated impacts: nine have been proposed by the EEA (Box 2.1.12) and similar ones are being developed by countries such as Germany, Sweden, the Netherlands and the UK. They will be further developed and described in the regular indicator reports from the EEA, Eurostat, the European Commission and Member States expected in 1999. In some cases, they will be linked to targets for the use of nature which are either linked to output, such as the 'Factor 4' eco-efficiency target, which assumes a doubling of welfare from a halving of resource use (Weizsäcker *et al.*, 1997), or the target of 'Factor 10', which aims at the absolute reduction of the global use of nature, 'over one generation' by one half, and its more equitable distribution across the world. This will involve a ten-fold reduction in absolute resource use in industrialised countries (Carnoules Declaration of the Factor 10 Club, 1997).

Some Member States have referred to overall resource-use targets, such as Germany ('Increasing raw materials productivity 2.5-fold by 2020 compared to 1990') and Austria and Sweden (Factor 10), but there is as yet little development of such targets at economic sector level (EEA, in press).

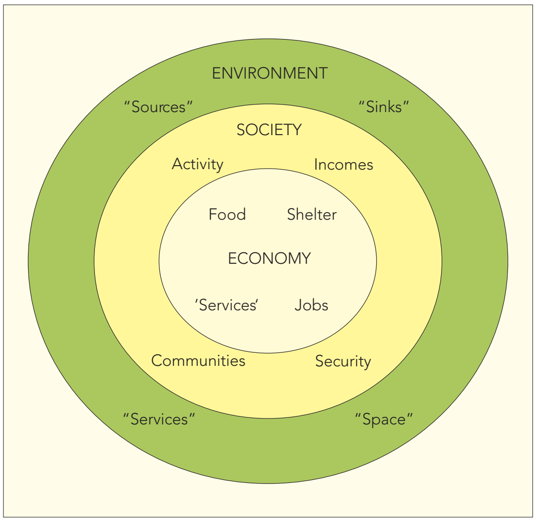
Progress towards less use of nature will require greater integration of economic and environmental activity in sectors, such as through the internalisation of external environmental costs into market prices (see Chapters 2.2 and 4.1).

**Box 2.1.10. International commodity related environmental agreements?**

The 'internalisation' of environmental costs into market prices can help improve economic efficiency and welfare, but this approach is not usually available to developing countries, who are usually 'price takers', with no influence on world prices for their products. Where natural capital in developing countries provides global ecological services (e.g. tropical rain forests), or when full cost pricing for traded commodities is the objective, then International Commodity Related Environmental Agreements (ICREA) have been proposed. These involve import taxes in developed countries which provide earmarked funds for developing countries to use on environmental projects. Such taxes on 'northern' consumption represent full cost pricing payments for the externalities of ecological damage and services. As the trend in commodity prices has been in favour of 'northern' consumers since 1970 (whilst interest on Third World debt payments has also risen), such moves towards 'fair and efficient pricing' of commodities could contribute to sustainability at global level.

**Source**: Kox and Linnemann, 1994

**The three pillars of sustainability: Economy, society and environment** — Figure 2.1.11




**Source**: EEA

**Box 2.1.11. Corporate reporting on eco-efficiency**

The WBCSD's working group 'eco-efficiency metrics & reporting' recommends using the following ratio as a general equation to measure and report eco-efficiency:

- eco-efficiency = unit of value provided per unit of environmental burden

The following cross-comparable indicators have been considered by the WBCSD working group:

| Environmental Indicators | Value Indicators |
|---|---|
| - Total Amount of Energy Use | - Mass or Number of Product |
| - Total Amount of Materials Use | - Number of Employees |
| - Greenhouse Gas Emissions | - Sales/Turnover |
| - Ozone Depleting Substances Emissions | - Gross Margin |
| - $SO_2$ and $NO_x$ Emissions | - Value Added |

**Source**: WBCSD: Executive Brief, January 1999

**Box 2.1.12. Nine possible key indicators for resource use and associated impacts**

| *Inputs (resource use):* | *Outputs (impacts/ pollution)* |
|---|---|
| - material input | - emission of greenhouse gases |
| - energy use | - emission of acidifying substances |
| - land-use | - emission of ozone-depleting substances |
| - water consumption | - generation of (hazardous) waste |
| | - hazardous chemicals |

**References**

Adriaanse, A.; Bringezu, S.; Hammond, A.; Moriguchi, Y.; Rodenburg, E.; Rogich, D.; Schütz, H., 1997. *Resource Flows: The Material Basis of Industrial Economies.* World Resources Institute. Washington D.C.

Anastas, P.T. and Breen, J.J, 1997. *Design for the environment and green chemistry: the heart and soul of industrial ecology.* In Journal of Cleaner Production, Vol.5 n 1-2, Oxford.

Ayres, R.U, Schlesinger, W.H. and Socolow, R.H., 1994. *Human Impacts on the carbon and nitrogen cycles.* In 'Industrial ecology and global change', R. Socolow, C. Andrews, F. Berkhout and V. Thomas (eds), Cambridge University Press.

Baskin, Y., 1997. *The Work of nature: How the diversity of life sustains us*, Island Press, Washington.

Brouwer, R. and Leipert, C., 1998. *The role of environmental protection expenditures in a system of integrated economic and environmental accounting, theory, practice and future prospects.* CSERGE, working paper GIC98/01 Norwich.

Daly, H. and Cobb, J., 1989. *For the Common Good - Redirecting the Economy towards Community, the Environment and Sustainable Development.* - Beacon Press, Boston.

Ekins, P., 1998. *Making sustainability operational: critical natural capital and the implications of the strong sustainability criterion*; project no PL9702076, 06XII, technical annex, Mimed, Dept. of Environmental Social Sciences, Keele University, Keele.

Erkman, S., 1997. *Industrial ecology: a historical view.* In Journal of Cleaner Production, Vol.5 n 1-2, Oxford.

European Commission, 1993. *White Paper on Growth, Competitiveness, and Employment* (COM(93)700 final), European Commission, Brussels, 5 December 1993

European Commission, 1997. *Functional Implications of Biodiversity in Soils*, Ecosystems Research Report 24, Brussels.

European Commission, 1998a. *Understanding Biodiversity.* Ecosystems Research report no 25, Brussels.

European Commission, 1998b. *Towards fair and efficient pricing of Transport.* Brussels.

EEA, 1998a. *Technical report on Fisheries situation in EU.* Prepared for the EEA by Pope, J. European Environment Agency. Copenhagen.

EEA, 1998b. *Background Paper for eco-efficiency workshop, 'Making Sustaiability Accountable'*, October 1998, Copenhagen.

EEA/UNEP, 1998. *Chemicals in Europe: Low doses, high stakes*? Copenhagen, Geneva.

EEA, 1999. *A Typology of Indicators.* (in press). Copenhagen.

EEA, (in press). *Progress with integration: a contribution to the Global Assessment of the Fifth Environmental Action Programme.* Copenhagen.

Frost, T.M. , Carpenter S.R., Ives, A.R., Kratz, T.K., 1995. *Species compensation and complementarity in ecosystem function.* In Jones C.G. and Lawton J.H. (eds), 'Linking species and ecosystems', pp 224-239. Chapman and Hall, London

Goodland, R., 1991. *The case that the world has reached its limits.* In 'Environmentally Sustainable Economic Development: building on Brundtland'. UNESCO, Paris.

Hicks, J.R., 1939. *Value and Capital.* Second edition, 1946. Oxford University Press, Oxford.

Houghton, J., 1994. *Global Warming: the Complete Briefing*, Lion Publishing, Illinois.

Hueting, R., 1980. *New scarcity and economic growth.* New York, Oxford University Press.

Jackson T., 1996. *Material Concerns: pollution, profit and quality of life.* Routledge, London.

Jackson, T.; Marks, N.; Ralls, J.; Stymne, S., 1997. *Sustainable Economic Welfare in the UK 1950-1996.* New Economics Foundation, London.

Kox H.L.M. and Linnemann, H., 1994. *International commodity-related agreements as instruments for promoting sustainable production of primary export commodities.* In 'Sustainable Resources Management and Resources Use: Policy questions and Research Needs', RMNO, The Netherlands.

Lazarus, O.S., 1991. *Save our Soils.* In 'Our Planet', vol. 2, no. 4, New York.

Liedtke C., Orbach T. and Rohn H., 1994. *Towards a Sustainable Company: Resource Management at the Kambium furniture Workshop.* Included in Conaccount conference proceedings, Wuppertal.

Lovejoy, T.E., 1995. *Will expectedly the top blow off?* Bioscience, Science and biodiversity policy Supplement: S-3-6, Washington.

Lowe, E.A., 1997. *Creating by-product resource exchanges: strategies for eco-industrial parks.* In Journal of Cleaner Production, Vol. 5 n 1-2, Oxford.

Marshall, A., 1920. *Principles of Economics.* Macmillan, London.

NRC, 1992. *Restoration of Aquatic ecosystems: Science, Technology and public Policy.* National Research Centre, National Academy Press, Washington D.C.

OECD, 1998. *Eco-efficiency.* Organisation for Economic and Co-operation Development, Paris.

Opschoor, J.B.,1992. *Economy, environment and sustainable development.* Wolters Noodrhoff Groningen.

Pauli, G., 1997. *Zero emissions: the ultimate goal of cleaner production.* In Journal of Cleaner Production, Vol.5 n 1-2, Oxford.

Peskin H.M., 1991. *Alternative environmental and resource accounting approaches*, in Robert Costanza, ed. Ecological Economics: 'The science and management of sustainability', New York, Columbia University Press.

Repetto R., Magrath W., Wells M., Beer C., Rossini F., 1989. *Wasting assets: natural resources in the national income accounts.* Washington, D.C.: World Resources Institute.

RMNO, 1994. *Sustainable Resource Management and Resource Use: Policy Questions and Research Needs.* RMNO, The Netherlands, 1994.

RS/NAS, 1992. *Population Growth, Resource Consumption and a Sustainable World.* Royal Society, London/US National Academy of Sciences, Washington, 1992.

Royal Society of Chemistry, Green Chemistry Network, Clean Technology Centre, University of York, York.

Schmidheiney/BCSO, 1992. *Changing course; a global perspective on development and the environment*, Business Council for Sustainable Development, Geneva.

Schuster M., 1997. *Translating Material Flow Analysis into Environmental Policy in Austria*. In Analysis for action : Support for Policy towards Sustainability by Material Flow Accounting, Proceedings of the Conaccount conference, Wuppertal.

Schwarz E.J. and Steininger K.W, 1997. *Implementing nature's lesson: the industrial recycling network enhancing regional development*. In Journal of Cleaner Production, Vol.5 n 1-2, Oxford.

Smil V., 1991. *Nitrogen and phosphorus*, in The Earth as transformed by human action (B.L. Turner, H.W.C. Clark, J.F. Richards, J.T. Mathews and W.B. Meyer, eds), Cambridge University Press, UK, 423-436.

Speth, J.G., 1989. *A luddite recants: technological innovation and the environment.* In The Amicus Journal (Spring). Washington.

Tundo P. and Breen J.J., 1999. *Venice: a center for green chemistry on the continent*. In Today's chemist at work, Vol.8 n° 2, American Chemical Society Publisher.

UN, 1997. *Overall review and appraisal of the implementation of Agenda 21 (Earth Summit +5)* – New York, 21-23 June 1997.

United Nations Development Programme (UNDP), 1992 and 1998. *Human Development Report 1992* and *1998*. Consumption for Human Development. New York (http://www.undp.org/hdro/98.htm).

Weizsäcker, E. v., Lovins A. B., Hunter L., 1997. *Factor Four - Doubling Wealth - Halving Resource Use*. The new report to the Club of Rome. Earthscan Publications Ltd, London.

Worldwatch Institute, 1999. 'Worldwatch', January, World Watch Institute, Washington.

WBCSD/EPE, 1999. *European eco-efficiency initiatives; a road map for business strategy and government action.* From World Business Council for Sustainable Development, Geneva, and European Partners for the Environment, Brussels