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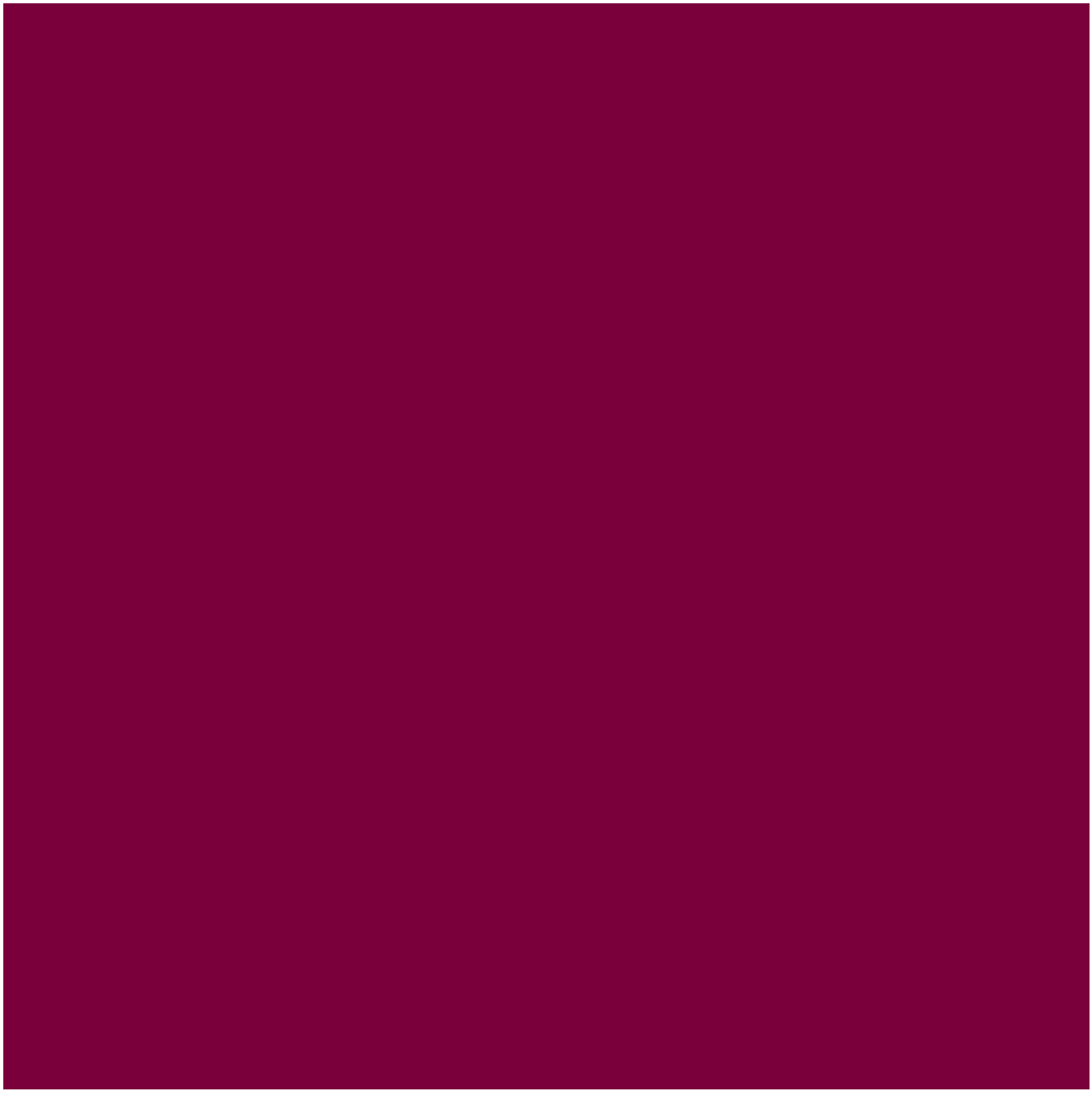
Thomas Sterner

Growth and the Environment



Growth and the Environment

**Written for Sida by Thomas Sterner,
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Growth and the Environment

It is far too easy for simplified perceptions to grow into truths.

The idea that economic growth in the traditional sense of the term – as measured by GNP – is the ultimate and complete solution to the problems of poverty and development is one of these obsolete, mistaken truths.

Continued growth, combined with a rapid increase in population and unchanged production and consumption patterns, increases pressure on the biosphere. We have found that many people – including economists – do not understand the costs of environmental degradation. The national accounts, our way of calculating growth, do not include these costs. Therefore, actual economic growth in both rich and poor countries is smaller than what is generally believed. Growth and development are not the same thing. The type of growth is of crucial importance.

One weakness of the economic models is that they are unable to include the ecological services provided by nature and the ecosystems which may be impossible to replace if they are destroyed. The ecosystems are characterised by complex functions and relationships – it is difficult for us to know in advance when effects on an ecosystem lead to serious, and sometimes irreparable, damage.

We must therefore pay careful attention to the costs of growth. The solution to the problems is not necessarily more growth of the traditional type. We need a form of development which takes place within the framework laid down by nature, and not at the expense of nature and the environment. We must ask ourselves what is sustainable in the long-term. This is also Sida's mission: to contribute to development that is really sustainable. A poor fisherman's family undoubtedly needs more food on the table and an increase in income, but at the same time we must learn that longer nets and faster boats do not necessarily provide more – on the contrary they can lead to the depletion of fish resources and to greater poverty.

We thus need an in-depth understanding and discussion of economic growth.

We have asked Thomas Sterner, a leading environmental economist in Sweden, to reflect on the relationships between growth and the environment.

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Contents

1 Summary

Economic growth is of great importance for poor countries and, not least, for the poorest people in these countries. Growth literally means that their incomes increase, and that they can therefore afford better food, water, clothes, housing and, in the long term, better health and education. This naturally presumes that the growth is genuine– that available resources really grow rather than depreciating so that they can provide for more consumption.

If "growth" is a result of irresponsible exploitation, for example where cotton is cultivated on unsuitable land with the aid of irrigation and spraying, the effect can be that a fertile and humid climate is transformed into a chemical desert, as is the case around the Aral Sea. In a case of this type, there is certainly "growth" in one sector (cotton) during a certain period of time but other sectors on which many poor people depend are devastated and, in the long run, even the cultivation of cotton is threatened. It is this type of situation that debaters refer to when they speak of a conflict between growth and the environment. We prefer to say there was no growth at all. If a correct value is placed on the negative effects and reasonable consideration is given to the future, the amount available for consumption does not increase, it diminishes.

The definition of sustainable development is, in fact, the amount for consumption that is made available in a sustainable way. It is important to understand the significance of the dimension of time as well as the importance of the distribution of production and particularly the poorest people's share of production. It is not sustainable if the incomes of a small group increase while those of others sink below the hunger line. It is not sustainable if natural resources are destroyed that are more valuable than, for example, the raw materials that are extracted.

It is very popular in certain circles to speak about Kuznets curves for environmental factors. The basic idea is that development inevitably leads initially to pollution, which can be remedied later when incomes have risen substantially and thereby permit action to be taken. It is naturally possible to find examples where certain types of pollution have increased and then diminished, but this is far from a law of nature: other patterns can also be found.

The reasoning behind Kuznets curves is not only erroneous, it can also be misleading. It encourages the attitude that nothing needs to be done, which is extremely unfortunate in all those cases where irreversible damage is done, or where quite simply it would have been better to prevent damage to the environment from the outset rather than remedying the damage after the event. It is reasonable to assume that one of the few advantages of late industrialisation is that sustainable technologies can be selected immediately. It is not necessary to slavishly copy all the mistakes made by the industrialised countries in previous eras.

2 Introduction

Growth and the environment have two things in common. They are two "catchwords" in the debate and they are both highly diverse and complex concepts. It is difficult to describe the relationship between them briefly and exhaustively. We have nevertheless made an attempt to do so since these two words represent two important directions in the development debate. On the one hand, growth is necessary to enable the income of poor people to increase to a lowest acceptable level and, on the other, consideration of the environment is necessary to enable us all to lead a good life in the long-term. Since both of these objectives are so important, it is natural to wonder whether there can be conflicts between them. Is consideration of the environment a luxury which stands in the way of projects which are needed to provide a livelihood for the poor? Is combating poverty more important? Do environmental projects take away resources from projects which could have given a greater yield in terms of money and job opportunities for the poor people?

Isn't consideration of the environment a luxury and combating poverty much more important?

Naturally it is easy to find examples where industrial development in relatively unspoiled countryside has caused considerable change and even harm to the environment but has been both justified and desirable in order to provide employment and incomes. But there are also many examples where this type of industrial investment is economically unprofitable since no consideration has been given to the interaction between ecosystems and society (for example unsuccessful dams which have become inefficient since they have silted up and, in addition, spread disease and led to other problems). There are also many examples of how environmental degradation affects the poorest people most severely of all (see Sida's publication "The Environment and Poverty"[1]). It is important to understand that growth does not just consist of the most common products, growth can also mean cleaner beaches which attract ecotourists prepared to spend a lot of money, or restored wetlands which provide a better water supply and thereby lower medical costs. Above all, growth today shall not be achieved at the expense of the natural

[1] Segnestam, M. & Sterner, T., (2001), "The Environment and Poverty", Sida's Environment Policy Division.

resources that the poorest people are dependent on for their livelihoods, or at the expense of resources that are essential for future development.

In the debate on the environment and growth some "optimists" demand more growth to enable investments to be made in the environment, while "environmental fundamentalists" want to stop all growth in order to save the environment. Both standpoints are far too simplistic. One objection to the first is that the environment is not a luxury product which can be purchased when one can afford it, and one objection to the second standpoint is that all growth is not bad for the environment. Consider for instance the sectors which are growing are composting, national parks, ecotourism, culture...

Economic growth is a change in income exactly as speed is a change in position. If a certain goal – say Paris is to be reached, the main thing is not to drive quickly but to drive in the right direction! Likewise it is not the rate of growth which is most important but the direction of the growth. In other words it is clear that if society chooses to focus on the right composition of sectors and uses suitable technology, high rates of growth can also take the environment into consideration and thereby be sustainable. There does not need to be a conflict between growth and environment but there can be: growth does not automatically lead to improvement from the environmental point of view. The composition of goods produced in the economy is not determined by planners in a ministry of planning but by demand on the market. When peoples' incomes increase they will eat more meat and drive more cars. These types of preferences or consumer habits can, especially with the wrong technology, result in severe strains on the environment but this still does not mean that growth in general is incompatible with the environment. It simply means that suitable policy instruments must be used.

For the poorest people growth is naturally an overall objective that should guide all development cooperation, but the growth must be sustainable. To ascertain whether it is sustainable, it is important to measure income and growth with the right indicators which include all resources and everything else of importance for economic welfare and growth. There is no single definitive analysis of "the relationship between growth and the environment". Useful analyses must be based on concrete cases. This review takes up certain questions of principle:

- What determines growth, and what are the roles of natural resources and environmental factors?
- What are the roles of substitution and technical progress? Is sustainable development possible in the long-term?
- What is the relationship in practice between different types of natural resources and environmental factors on the one hand and growth or income on the other?
- Is it possible to find measures of growth which take all aspects into consideration, including long-term sustainability?
- How are the poorest people affected?
- Is it possible to combine demands for higher incomes and a good environment?

3 Growth: Underlying factors

There are many economic models which explain growth. In general this is a technical area which is difficult to understand but, to put it simply, we can say that the first traditional models focused a great deal on savings. Production and income can be divided into three categories, private consumption, public consumption and savings or investments. In the short-term it doesn't matter if a consignment of iron rods is used for *consumption*, say for the manufacture of simple furniture, for *investments* in factory buildings or for *public consumption* (for example statues). In a slightly longer perspective it is of great importance since it is investments alone which provide an increase in the stock of capital and it is this (together with labour) which is used to produce the goods and income of tomorrow.

The idea that production in the economy can be regarded as a function of, among other things, labour and capital and that the latter is built up by investments is the simplest conceivable model[2] but it nevertheless illustrates much of the emphasis on savings and capital in conventional thinking in both classic and Marxist economics which has formed the basis of development planning in many countries.

The strategic issue in all theses models was how to increase capital. A little reflection (or empirical studies) shows among other things that the rich save a larger proportion of their income than the poor. This stylised fact justified the unequal distribution of income. When there is an uneven distribution of incomes, savings increase, investments increase and thereby the entire productive capacity of society increases. But under certain circumstances the growth soon gives the poorest people a greatly improved standard and thereby contributes to further justify the uneven distribution of income[3]. In "planned" economies (which had no rich people with savings) the need for capital accumulation was used as a reason to oppress the masses, to force them to work hard, and to pay them very little. In countries such as the Soviet Union, and later Algeria and many others, investments were deliberately made in a distorted economic structure which contained almost exclusively heavy industries.
The exclusive production of cement and steel in a closed economy "guarantees" that the proportion of investments in the economy is high since the products can hardly be used for consumption to any great extent.

[2] In this text we have chosen to avoid equations. However, this is an area which is normally analysed with highly formalised models. Interested readers are referred to the appendix at the end of this publication.

[3] This is related to the so-called "trickle-down" effect.

Many empirical studies have been performed in order to understand what determines growth in different countries. Sometimes growth is found to be lower than expected, based on the amount of capital and labour. This may happen if capital has become obsolete (factories which have been built but which lack spare parts, or factories whose products are not in demand). It is more common in the rich countries that growth is higher than would be explained by the increase in capital and the number of workers. The typical result is that there is a large "residual" which indicates that there must be other factors in addition to labour and capital which explain production and thereby growth[4]. The factors that are usually mentioned are the following[5]: raw materials, energy, education, natural capital, technical development, organisation, and social institutions (see, for example, articles by Solow).

The most obvious categories of productive factors which are omitted are perhaps energy and raw materials but, even when they are included, there is usually still a residual item. Another important aspect which was often omitted in the earliest studies refers to the skills or educational levels of the labour force. This shows that we should not regard education as public consumption (as in the national accounts) but as the investment it rightly is. Another type of factor which is particularly relevant in this context is the "natural" capital which the ecosystem represents. It was obvious for a long time to the early economists that land was an important production factor, but land is actually a complex of factors: nutrition slope, precipitation, and many other factors which all contribute to the production results we see in the agricultural and forestry sectors.

Technological development is also a very important factor even if it is hard to measure. Instead it has the character of a "residual" – everything which cannot be explained by the measurable factors is "technical development". When it comes to providing guidance for policy making, this is of limited value. The conclusion is of course that technical development is desirable but the question remains as to whether it occurs automatically or whether it is possible to promote it. Some researchers have continued to look for factors which promote "technical development" and growth and there is an increasing focus on the institutions and organisation of society[6]. It is not just a question of the amount of education, health care and other inputs provided by society, but how good these are and whether they reach the right persons: how they are distributed. How much does the structure of society promote or obstruct the exchange of ideas and technology? Is entrepreneurship encouraged? Are there incentives for education and productive work?

In, for example, World Bank Institute (1999), it is shown that important factors which explain the rate of growth[7] include openness of

[4] This residual is often lacking in poor countries – or it is even negative, which shows the relationship, in these countries, between inadequate institutions, infrastructure, education etc, and a lack of economic growth.

[5] In one study Levine and Renelt (1991) found more than 50 factors correlated to growth.

[6] One important school perceives development not as exogenous but as an endogenous factor. In the so-called "endogenous growth theory", it is emphasised that technical development depends on other economic variables that determine the environment for the emergence and development of innovations. An important writer that initiated this research was Arrow who emphasised "learning by doing".

[7] Statistics on education, health care and other expenditure usually consist (at best) of physical measures – the numbers educated, numbers treated etc. Data on the breakdown of these services by different social groups is very complicated to collect, politically sensitive and methodologically complex. It therefore took a long time before the first databases were established which permit certain simple comparisons and analyses.

countries to the world market, freedom from corruption, and the *distribution* of factors such as land and natural resources, as well as education. The importance of availability of education is particularly interesting. The same probably applies to many other public services such as access to health care and to certain resources such as safe water. The relationships are complicated but one interpretation which can be drawn is that "talent" is randomly distributed among the population and that a combination of talent and the opportunity to develop is necessary for a person to be really productive. A broad education which reaches all people through primary schooling and then makes it possible (through free education, scholarships, etc) for the talented to continue, is thus able to better exploit the "reservoir of talent" which is to be found among the poor, women, minorities, people living in rural areas and others who are not educated in the traditional school system and who cannot afford private schools.

The importance of distribution and of turning talent to account is a factor which indicates that an increase in equality should have positive effects on future rates of growth and that there are at least two factors which indicate that this factor is more important in the deregulated world of today than the ability to generate capital through savings (which, as mentioned above, is easier in an unequal society). Firstly, the world of today is much more knowledge-intensive. And secondly, the importance of domestic savings has decreased. If a country, for example Cambodia, is to develop, it is not necessary today to generate all savings locally for investments. There is an extremely active and highly mobile international capital market and experience shows that capital moves to places where the conditions are right. The "right" conditions can conceivably include access to a well-educated labour force and a good environment, both ecological and socio-economically, i.e. freedom from both smog and corruption. When the environment is so run down that many poor people cannot obtain sufficient protein from over-exploited coastal areas and do not have access to safe water or clean air and adequate health care, it is also a question, in addition to direct human suffering, of the loss of a productive labour force which could have attracted investments. On the other hand, one should naturally not have an excessively naïve opinion of international investments. There can naturally be companies which are attracted by the possibility of plundering natural resources, of bribing those in power and of employing a fairly destitute labour force which does not make demands. However, the choice of focus is of great importance for the long-term sustainability of growth.

Conflicts or the absence of conflicts is an additional, extremely important factor that is intimately associated with other social institutions such as transparency and democracy. In certain cases there are also close links to natural resources since the struggle for resources, for example water, leads to conflicts and, in the absence of institutions for mediation, the conflicts lead to military confrontation, refugee problems and a lack of development which, in turn, exacerbate the conflicts.

4 Substitution, technical development and *long-term* growth

In the section above we have drawn a simplified picture of the factors that explain growth. One fundamental question is whether growth can continue indefinitely. Ecologists feel instinctively that *nothing* can grow forever in a limited space, for example the globe. Man has already taken over half of the planet's biomass production for his own needs[8].
This shows that the limits are not just hypothetical future limits and that we are already using a large part of our "living space". Some research groups such as the Rome Club[9] consider that we have already exceeded the population and (average) consumption levels which the planet can bear[10]. However, other researchers are extremely critical of this analysis and are of the opinion that the "Malthusians"[11] misunderstand the difference between growth in the physical and the economic sense and that there is a great potential for further economic growth through substitution and technical development.

Physical growth is naturally not possible in a limited space. We cannot continue to increase our consumption of water by 5% per year in all eternity. However, in principle this does not mean we cannot have economic growth, i.e. growth in the value of production. If a consultant or a musician does better and better work each year (with the consumption of insignificant material resources), the value of production can increase in all eternity[12]. Even the value of water and wastewater services can grow even if the amount of water does not increase. Through better technology, a certain amount of water can provide greater benefits (showers or toilets which use less water). The invoice from the water company can be easier to understand and pay (e.g. by electronic means).

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[8] According to Vitousek et al (1986) humanity had taken over some 40% of the photosynthetic production of terrestrial systems by the 1980s. Photosynthesis is the (only) process on earth which converts solar energy to chemical energy such as sugar or cellulose. This is done by green plants and certain algae and the chemical energy they store provides food for all other forms of life such as animals, fungi and bacteria. (There is no "other" food for us humans and we need to leave food for wildlife, and we want to have certain plants as trees in our parks!)

[9] The Rome club is a global think-tank which became famous for the report "The Limits to Growth", by Dennis L Meadows et al (1972), which predicted that some of the earth's resources would be exhausted and that we would have great problems with famine and pollution (see further http://www.clubofrome.org).

[10] Donella H Meadows et al (1972)

[11] Somewhat derogatory term for "growth pessimists". Malthus was an important economist 200 years ago when economists were known for this "growth pessimism" which states that population grows more rapidly than production and therefore that we will always live in misery. The leading economists of today are much more optimistic about growth.

[12] "Eternity" is strictly speaking not the right concept. Our solar system (and therefore the Earth) has a finite life cycle but, since it is expected to be "very long" measured in human terms, eternity is used a little carelessly here to describe the hopefully very long time in which there could be life on Earth.

The quality of service can be improved by reducing risks for pollution and breakdowns, by quality controls of water and more efficient purification of wastewater etc.

In other words, economic growth can take place in principle without an increase in the consumption of natural resources or greater pressure on ecosystems. Whether or not this can take place in practice is dependent on the possibilities for substitution or technical development. Knowledge is the only resource which, as far as we know, has no boundaries. To give a brief summary of this debate it can be said that it is a question of how *indispensable* and *irreplaceable* the natural ecosystems are. The necessary criteria can be formulated mathematically[13] but empirically it is difficult to reach a definite conclusion.

Previously there was a certain amount of interest in whether supplies of oil and minerals would peter out and, for example, the Rome Club's first report predicted that this would be the case for a number of important minerals etc[14]. This has not happened at all. Instead the usual market mechanisms have ensured that any scarce resources are used economically. When a metal has become more attractive (for example due to new uses), its price has risen which has led to efforts to find new deposits or substitutes, or to efforts to make current uses more efficient.

Where scarce mineral resources are concerned, we can assume that the owners control supplies. If they see that demand may increase in the future they have an interest in holding back supplies and forcing up the price. This is most often referred to as Hotelling's theory and can be illustrated by figure 1 in which the price (or actually scarcity rent) rises exponentially. This leads to a corresponding reduction in use and thus even a finite resource can last for ever in the sense that supply meets demand since demand decreases due to the high price. This implies that a number of users will find substitutes and the high prices also make it profitable to search for and exploit somewhat inferior deposits, which can also lead to the resource having a longer life.

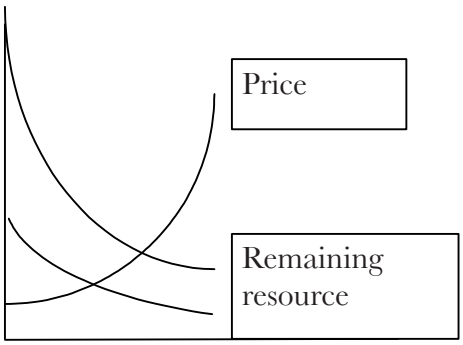


Figure 1 Hotelling's theory on rising prices and economical use as a result of scarcity

The fact that the "growth optimists" have been "right" in the matter of finite resources which can last forever is extremely important (and we should all be relieved that this mechanism exists). However, this does not automatically mean that the same optimists are right where more subtle

[13] See appendix at the end of this publication.

[14] According to this "static" index, reserves of lead would come to an end in 1998 and mercury in 1985. As we know, this did not happen and now we are worried that there is too much lead and mercury in the environment! (Meadows, D.H. (1972). See table 4 page 56)

environmental problems and entire ecosystems are concerned. The ecological reason is that certain functions are difficult to replace (see below) and the economic reason for this is that the relevant ecosystems often lack the protection of ownership. Since no one owns the atmosphere or the oceans there is no owner to take care of the scarcity rent and thus resources can easily be overexploited as in Hardin's famous article "The Tragedy of the Commons" (1968)[15].

Ironically enough, it is therefore often the so-called renewable resources which are more under threat than the so-called finite resources[16]. These renewable resources provide vital conditions fo r life, for example the composition of the atmosphere and systemic services such as water and nutrient recycling. It is often the case that the natural ecosystems are very efficient when compared to other systems, even in purely economic terms.

It is clear that large parts of our civilisation are built on the substitution of natural systems. Our agriculture has replaced natural ecosystems with great success (at least from our point of view). It is at least conceivable that aquaculture will have corresponding success in replacing species of "wild" fish which are being depleted due to global over-exploitation, but there are already suspicions that this will have a number of potentially serious side effects. It is not certain that this type of substitution is always successful and researchers are finding an increasing number of examples where the natural ecosystems are performing services for humanity (such as water and wastewater treatment, climate control etc) which would be extremely costly if possible at all to perform in an artificial way. Gren (1995) has found that Swedish wetlands can, in certain cases, be much cheaper and more efficient than treatment plants. New York State has purchased considerable areas of land and forests in Upstate NY as a cheaper way of protecting water quality than the more conventional engineering solutions in treatment plants etc[17]. In recent years, in an ever-increasing number of places, commercial transactions have been used under which, for example, towns make payments to communities that protect ecosystems which protect water sources or other important ecosystem resources, see Pagiola (2002). The major systems have a special position since it is not possible to learn by a process of trial and error. For example, replacing the ozone layer or climate systems by something else must hopefully be regarded as pure science fiction[18].

New York has reduced its costs for safe water by protecting water sources. If the forests had been felled or the ground polluted, this would not have been possible.

[15] "The Tragedy of the Common". In actual fact the tragedy which takes place when everyone contributes to the over-exploitation of natural resources is not typical for commons but only applies in situations when no one has control, so-called "open access".

[16] However, this is not to say that oil resources cannot constitute a problem at all.

[17] The City of New York started an extensive, long-term process in 1989 to protect its water sources and their catchment areas. The programme included purchases of land, environmental projects, sewage treatment and environmental agreements with other landowners. In total several billions were invested (at least SEK 2 billion in land purchases alone), but these investments have permitted New York to avoid the considerably more expensive investments in water purification, filtration etc which the environmental protection authorities would otherwise have demanded. As a side effect, New York has acquired an area for hiking and recreation. Source: City of New York, Dept of Environmental Protection

[18] It can be added that the possibilities of finding substitutes must diminish if we face restrictions at the same time. If we have a shortage of water we might desalinate seawater. But if we have restrictions on energy at the same time, this is more difficult.

5 Relationship between environment, natural resources and economic growth

Today it is popular to summarise the relationship between environmental pollution and economic growth with the aid of a so-called Kuznets curve (see figure 2) where the relationship has the form of an inverted "u". In simple terms (really) poor countries are unpolluted and rich in resources but, in order to develop, they must put up with a great deal of environmental pollution and resource degradation. When they have become really prosperous they can then reduce pollution and become clean once again.

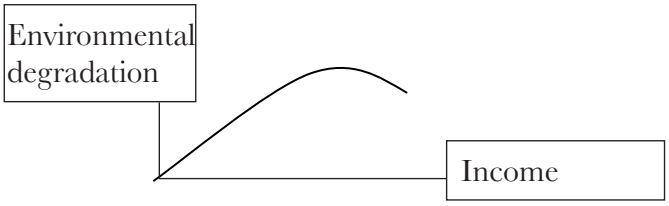


Figure 2 An environmental Kuznets curve

The ideas are largely taken from Kuznets' work in which he demonstrated this type of development for the distribution of income which would first deteriorate (become more unequal) and then improve. In theoretical terms the environmental Kuznets curve has been justified by the following factors:

- Increasing "income elasticity for the environment", i.e. it is only when people are well fed that they start to "care for" the environment.
- Relative prices. In a poor country the environment is usually very clean and this clean environment does not become valuable until it becomes scarce. Poor countries can become "pollution havens".
- Changes in the sectoral composition at different stages of economic growth (agriculture in developing countries, heavy industry in middle-income countries, knowledge and service industries in the richest countries).
- Demographic changes (the population increases, then becomes stable or starts to decrease)
- Provision of more education and other institutional factors which make it easier to obtain support for environmental policies and which are consequences of increases in income.

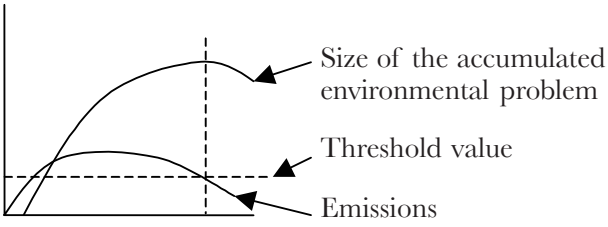
Apart from the somewhat hair-raising way of speaking of the environment as a simple product, the Kuznets curves do not rest on very solid theory but might be a way of summarizing empirical observations.

A relatively large number of empirical studies have been carried out which find all possible forms of relationships between GNP on the one side and different types of emissions, environmental conditions or natural resource assets on the other[19]. There are certainly examples which have the "inverted u" of figure 2 (often at the local level, for example certain indicators of air pollution in cities), but there are also many other types of relationships. For example, the amount of bacteria in drinking water is something which improves (i.e. is reduced) with an increase in GNP, or emissions of carbon dioxide which appears to grow with an increase in GNP (see figures in appendix).

If the Kuznets curve is a poor empirical model, it is even worse if it is interpreted normatively, i.e. that it is necessary to destroy ecosystems, fell virgin forests and experience industrial and urban smog in order to be sure that one is really on the right road. Naturally a poor environment cannot be an indicator of economic growth and it is not possible in general to rely on a decrease in environmental pollution when the magic threshold on the Kuznets curve is passed[20]. A misunderstanding of this type would be extremely misleading since in actual fact it is most often considerably more expensive to clean environments which have been polluted than to take preventive action when making the initial investment. Some damage can also prove to be irreversible: when, for example, forests in certain areas are felled with the aid of large-scale clear-felling, the local micro climate and soil are changed so much that new forest cannot take root (or has great difficulties in doing so).

[19] International Journal of Ecological Economics (1998), Journal of Environment and Development Economics (1997).

[20] The curve often shows emissions. If these accumulate, the environment continues to deteriorate even after the curve turns downwards. It is necessary that emissions fall below the absorption capacity of the ecosystems to enable the environment to start to recover. If the environmental problem is acute and fairly easy to solve it is better to invest in solving it. Otherwise productive investments that increase incomes can be preferred. It would then be possible to use the increase in income later to solve the environmental problems.



6 Measuring income and growth

To assess a country's development we attach great importance to "growth" in the economy but unfortunately we do not possess a really good indicator. A discussion of measurement problems can clarify the role played by natural resources and a clean environment. How is it possible to measure growth in order to take all aspects into consideration, including long-term sustainability?

The answer is that use must be made of the right indicator to measure the concept of *income:*

Hicks (1935) is often said to be the economist who provided the best definition of income: "The maximum value which [a man] can consume during a week, and still expect to be as well off at the end of the week as he was at the beginning."

What needs to be observed here is the close link between income and the concepts of periods of time and wealth. If a person earns SEK 5,000 in a week and spends it without anything else changing, it can be regarded as a measure of income. But if, instead, a person sells an inherited stamp collection for SEK 5,000 and then spends the proceeds, the person does not fulfil the criterion of having the same amount of wealth at the end of the period as at its beginning. In actual fact the sale is not *income* but merely a *"substitution"* of wealth from a collector's piece into cash. If a person buys shares or puts the money in the bank, he has, in principle, the same asset at the end of the period but he does not have anything to spend. The same applies to a person who owns a property which he either lets or lives in himself. It must (see Hicks' definition above) be in the same condition at the end of the period as in the beginning.
The costs of repairs and maintenance (or so-called depreciation) must be deducted from the gross income to give the true (net) income.

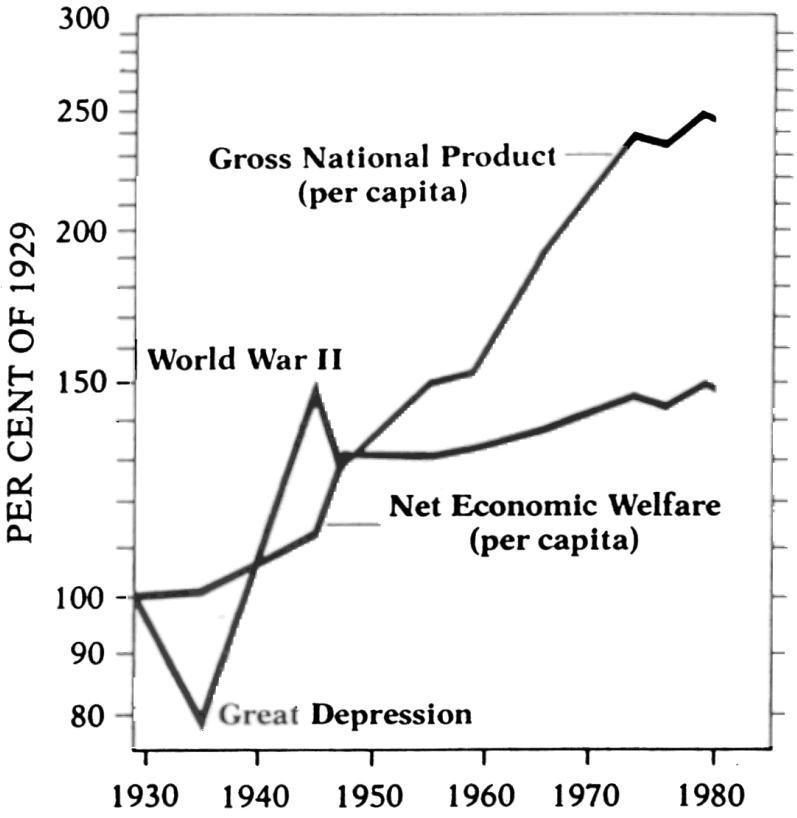
Where countries are concerned, the income concept is naturally more complex but the principle is the same. The concept of Gross National Product can never be an indicator of income since it is a *gross* indicator. First of all we must deduct the cost of wear and tear or depreciation of roads, houses, factories etc in order to obtain a *Net* National Product. The *next* step is to make corrections which take into account the wear and tear of natural resources, the damage caused by environmental pollution etc (and a number of other corrections)[21]. It is only when we have done

[21] See formulae in the appendix.

this that we obtain a real indicator of income and are able to measure whether this income is increasing rapidly or not (growth). This indicator of income has sustainability and consideration of the environment built into it since it already takes wealth into consideration or requires that wealth (including natural wealth) is left intact.

The reader may wonder why we do not use the net national product indicator more often. This is due to the fact that we do not know its size exactly! It is natural for companies to deduct depreciation but they use standardised rules for their depreciation (with the aim of calculating profit which in turn forms the basis of taxation and dividends). It would be desirable to have exact figures in the national accounts but these are not available[22]. In other words the main problem is that the exact amount of this depreciation or wear and tear is not known. In order to understand the problem, let us consider the depreciation of a calculator. Depreciation depends, among other things, on how long the machine will last. This can be difficult to know, but it is even more difficult to calculate its economic life. Think of all the mechanical machines which became obsolete with the advent of computers and pocket calculators!

The problems relating to environmental degradation and natural resources are, in practice, much greater but the principle is the same. If a country owns oil reserves which are extracted and sold, the total amount obtained from the sale shall not be regarded as income (the part which is payment for extraction and distribution is income but not the realised scarcity interest).



Figur 3 Net Economic Welfare grows slower than GNP Källa: Nordhaus & Tobin (1972)

[22] The fact that it is difficult to measure (net) income correctly is, however, no excuse for not trying! Even variables which are possibly regarded as "commonplace", such as inflation and unemployment, are actually extremely difficult to define and measure exactly.

There are a number of studies which attempt to calculate real national income. One of the earliest was Nordhaus (1972) (see figure 3) which showed that the USA's real income was not only much smaller than GNP but (and this was much more interesting) that the increase was much smaller and in actual fact had almost come to a standstill. This type of study is extremely demanding and encounters a number of theoretical and practical problems. Therefore, relatively few complete studies have been made. Somewhat more common are studies which focus on "correcting" GNP to take into account a number of obvious shortcomings such as a resource index for extraction in oil exporting countries. One early example of this type was Repetto (1992) who analysed Indonesia.

For a number of years the World Bank[23] has attempted to provide a comprehensive picture of the economic situation in a large number of countries. World Bank (1997) provides calculations of total wealth and changes in wealth or genuine savings. The (normal) savings are obtained from the national accounts but are supplemented by including depreciation of physical capital, important fossil and mineral resources and certain other natural resources. Education is also included in order to underline that it is an investment and not consumption. These indicators are continuously updated and information is available on the World Bank's database at www.worldbank.org/environmentaleconomics (Green Accounting).

Naturally many things are still lacking (for instance the costs of regular environmental degradation) but, in principle, these are the best international comparable data on genuine savings. When savings are defined in this way, it can be said that, as long as savings are negative, the country's true income will decrease which means that development is unsustainable. On the other hand, it is not equally certain that development is sustainable if savings are positive. This assessment must depend on the size of the negative effects (not included) in respect of degradation of the environment and natural resources. For example, the reduction in a child's ability to learn and to be productive due to the lead content in petrol is not included. If, due to an increase in acid rain, the cars in the country are subjected to more corrosion and need to be replaced more rapidly, this is also depreciation which should be included but we are not able to do this at the present time.

Figure 4 shows developments in Ecuador where GNP and official domestic savings increased over a number of years but genuine savings were actually negative: the economy was actually based on the unsustainable over-exploitation of natural resources, principally oil.

The table on genuine savings[24] shows corresponding figures for a larger number of countries. Note that all countries have much lower real savings than indicated by the figure for official savings. Despite the fact that education is included as an investment (which raises the figures), the wear and tear of environmental and natural resources is so great that total "genuine" savings are often negative, which will result in unsustainable development if it is allowed to continue for a long period of time. Many countries show positive genuine savings but this provides no guarantee that development is sustainable! It has not been possible to put a value in these tables on the many environmental problems and examples natural

[23] With support from Sida.

[24] The table on genuine savings is in the appendix. A web-site address is also provided where you can obtain more information.

resource depletion, for example soil erosion, over-fishing, deterioration of eco-system services, and loss of species and biological diversity. Thus, it is necessary to make further studies of each country. For those countries that already have negative figures, it can be said with some degree of certainty that the situation is *not* sustainable! In view of the considerable population growth in many developing countries, unsustainable development will be further accelerated since future generations will have fewer resources to share for their livelihoods.

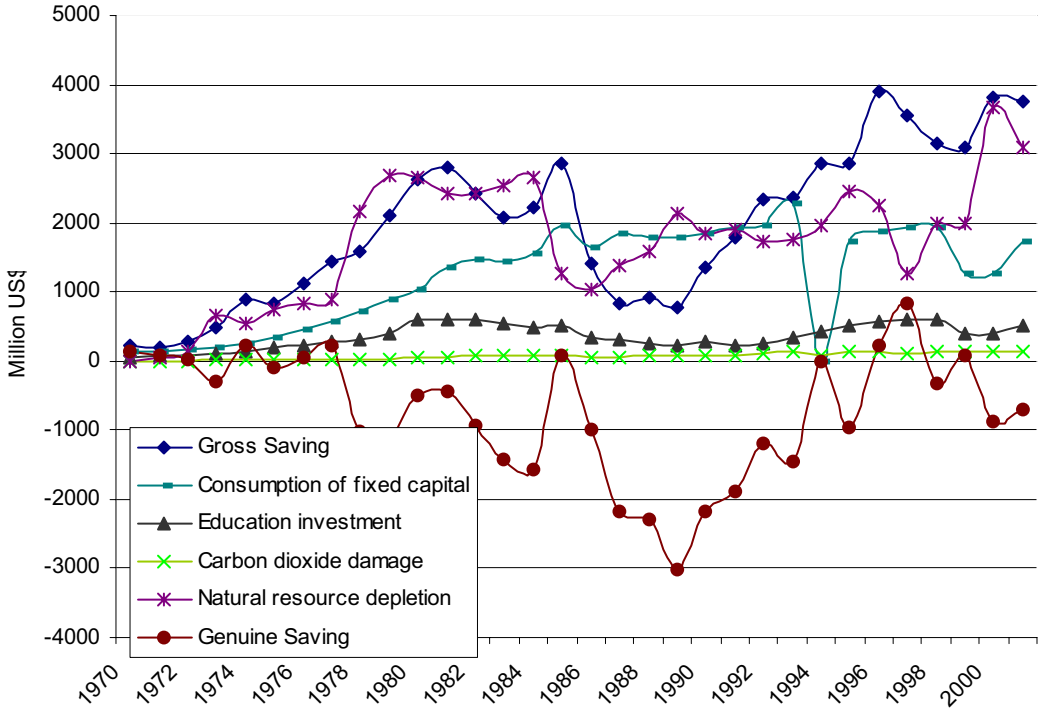


Figure 4: Official and genuine savings in Ecuador 1970–2001
Source: World Bank, World Development Indicators, Genuine Savings data 2003

In recent years Genuine Savings has been used as an environmental indicator in the country strategy process at Sida. Figure 5 is an example that has been used for Zambia. It shows that the traditional savings indicators overestimate actual national savings which naturally should take the depreciation of natural resources into account.

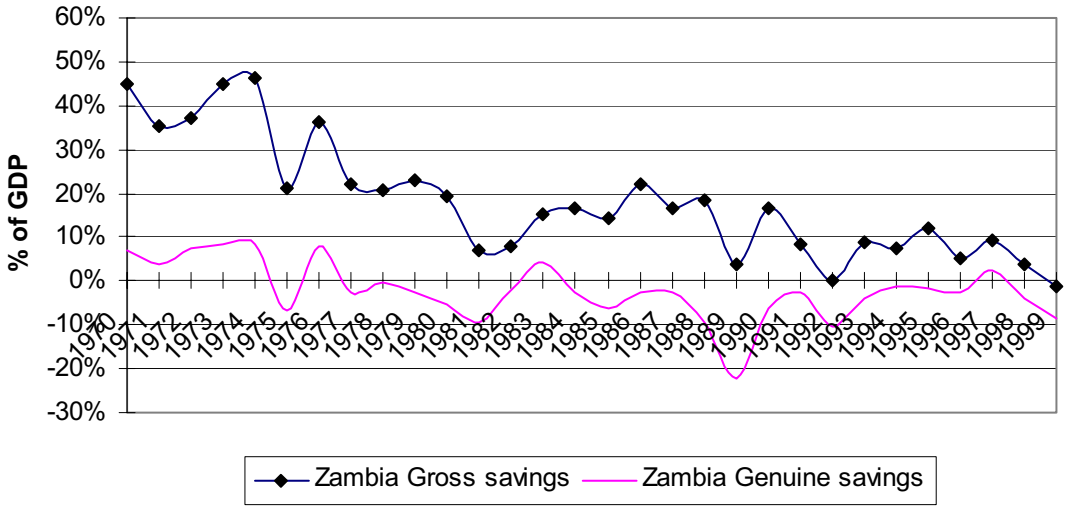


Figure 5: Zambia: gross saving and genuine saving 1970–1999
Source: World Bank, World Development Indicators, Genuine Savings data 2003

7 Poverty and the environment

Sida has analysed relationships between poverty and the environment in a separate publication[25]. There, emphasis is placed on the importance of environmental and natural resource issues to help poor people to break the vicious circle of their poverty. One difficult but necessary starting point is the understanding that the number of poor people in the world has never increased as rapidly as in recent decades. At the same time, the depletion of many of the natural resources that we are all dependent on has never taken place at such a rapid pace as today.

One of the central conclusions is that, to a greater degree than the well-to-do, poor people are directly dependent on renewable natural resources for their livelihoods. The fact that poverty in the world has not diminished to a great extent but, on the contrary, is in danger of increasing, is largely due to environmental degradation and natural resource depletion. The increase in the use of natural resources and energy gives rise to local and global pollution that threatens production and health. For many substances, the ability of nature to deal with pollution has been exceeded. Poor countries and poor people are seriously affected by pollution and often lack the resources to take proper care of substances that put pressure on the environment.

Consequently the challenge is twofold – to successfully combat poverty and to successfully restore the productivity of depleted ecosystems. The two sides of the challenge are closely connected: in order to be sustainable, our strategy to combat poverty must also take aspects of the environment and natural resources into account: successful environmental work benefits the poor in particular. To a greater extent than the well-to-do, poor people and countries are obliged to make their livelihoods in ways that directly and immediately deplete natural resources and thereby long-term productivity (which does not mean that poor people are responsible for the most serious environmental effects in total). The underlying causes of this must be tackled and handled better. In order to be effective and to have permanent effects, a poverty programme must also take issues of sustainability into consideration.

Poverty is increasingly becoming an urban problem as people migrate from rural areas, since it is impossible to make a living there, to the towns in the hope of having a better life. We must ensure that all environmental

[25] Segnestam, M and Sterner, T., (2001), "The Environment and Poverty", Sida's Environment Policy Division. This section is based directly on the conclusions in that publication.

programmes to reduce the pollution of water, air and food in the towns benefit the poor since they are particularly exposed to the problems of pollution arising from uncontrolled urbanisation and industrialisation. Urbanisation leads to a massive transport of nutrients from rural areas to the towns. These nutrients must be restored to the rural areas in order to complete the ecocycle. In rural areas, restoring natural resources is an active method to combat poverty. If there are greater prospects of making a living, through the creation of job opportunities and the re-establishment of productive capacity, there will be less pressure to move to the towns.

Today, conflicts and wars constitute one of the greatest threats to development and a direct threat to life and security. The understanding that it is necessary to restore depleted natural resources, and then to work thereafter to ensure that natural resources are used sustainably, can have the effect of preventing conflicts, since it forces groups and individuals to cooperate in order to achieve a common goal that they are all dependent on. The risk of conflicts arising as a result of lack of resources and of more people becoming environmental refugees needs to taken with the utmost gravity.

Today there are considerable shortcomings where sustainable use of natural resources and consideration of the environment are concerned. At the same time, there is a great asset – the productive capacity of those who are being involuntarily held back in poverty. Combining the urgent need of poverty reduction with the absolute requirement of using natural resources and the environment in a sustainable manner is both possible and necessary. It requires considerable national and international contributions in the form of knowledge, capital and development of institutions, but is an investment that both industrial countries and developing countries will benefit from.

8 Policy instruments to combine growth with a good environment: thereby making growth sustainable

There are no rigid laws of the Kuznets type that predict the development of different ecosystems when the economy grows. We have discussed the principles that relate environment and growth and have shown that these complex relationships can have many different forms. It is possible, although very difficult, to include environmental degradation (or improvements) in an indicator of sustainable income. The major problem is economical use of resources of the type that have no owner, or where ownership is uncertain and poorly protected. This is often the case with common lands that can be of extremely great importance for the poorest groups who do not have the power to defend the resources that traditionally they have been able to use.

The conclusion is that we have to use policy instruments and that sometimes fairly strict controls can be needed! We can take the greenhouse effect or overgrazing as examples. When income increases, the demand for cars, petrol and meat also increases. Petrol comes from oil, and is certainly a finite resource but, as we have pointed out above, a resource which has owners who ensure that they are paid. Oxygen is used in the combustion process and this is a "free" resource. There would be a problem if there was less of it, but there is so much that it fetches no rent. But in the combustion process carbon dioxide (and other gases) are also formed, and the ability of the atmosphere to assimilate carbon dioxide is a "resource" which does not have an owner or a price. Therefore it is overexploited and we have problems with the greenhouse effect. Does this not mean that growth must be stopped?

Not at all! The demand for petrol is determined by both income and price. If we grow richer we use more petrol but if the price increases (through taxes or through the use of other interventions) demand can be limited. This is shown not least by the example of Europe. In Europe petrol is two or three times more expensive than in the USA with the result that the use of petrol per person is approximately half that of the USA! If only USA, Canada, Australia and some of the oil-exporting developing countries that have very low fuel prices domestically were to have similar fuel taxes as those in Europe, a considerable part of the greenhouse problem would be solved! However, it would be preferable if all these countries (and Europe as well) had the same high carbon dioxide taxes for industrial and other energy use also.

If the price of the emissions of carbon dioxide is included in the price of petrol[26], consumption and emissions can be kept in check in spite of continued growth. The same applies to the consumption of meat. If the increase in meat consumption leads to overgrazing of sensitive but badly managed public lands, ownership rights (possibly collective rights) must be created which lead to limitations on grazing[27]. If grazing takes place on government-owned land, perhaps the government can charge a fee. Regardless of the method used, the result will be more expensive meat and thus less consumption.

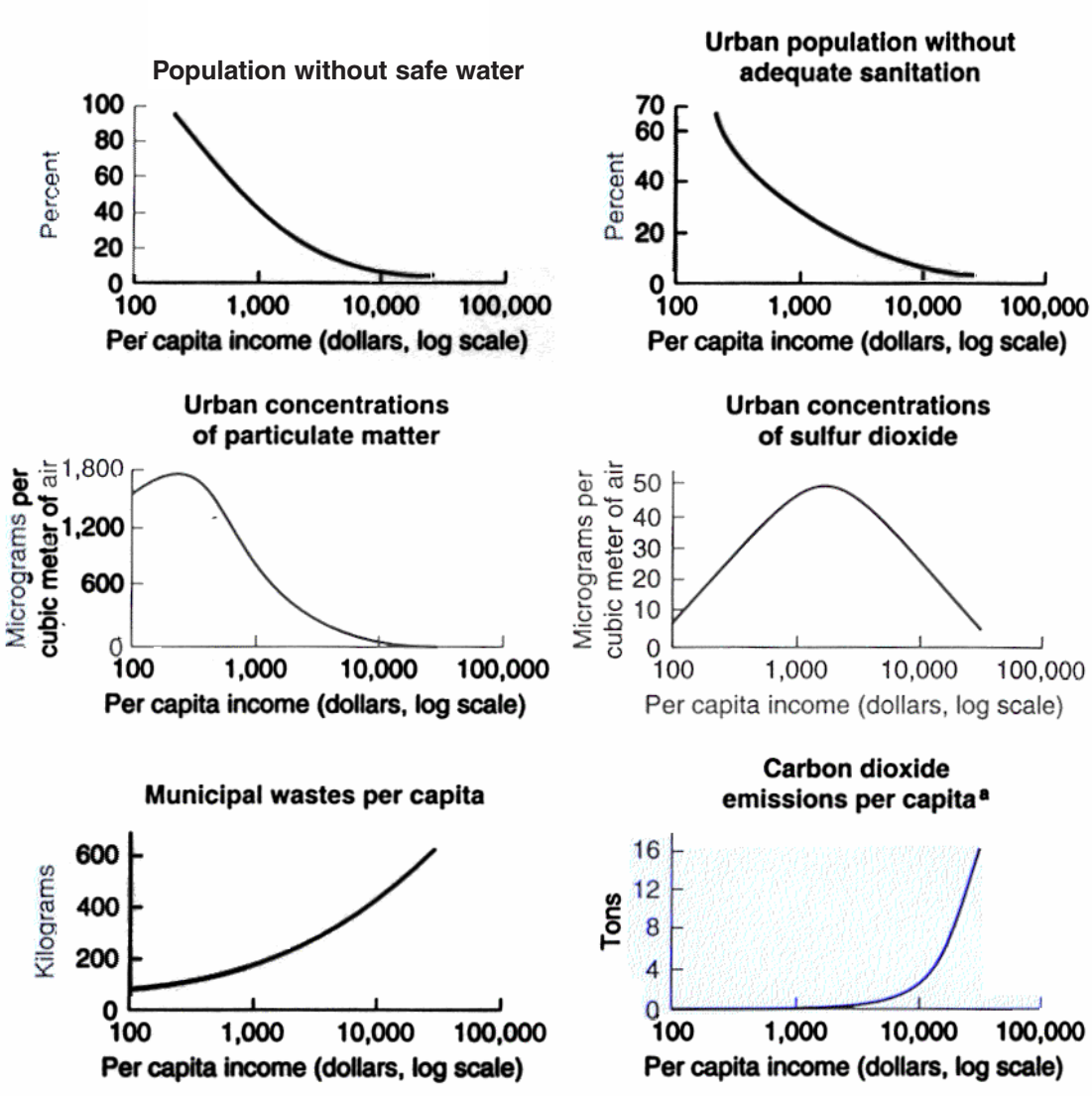
However, the formulation of policy instruments is an extensive and complex discipline. For example, overgrazing by herds that are too large for the land is often not only an expression of a large demand for meat but also of the absence of banks and insurance schemes for poor people in rural areas. Therefore, they build up their savings in one of the few, relatively permanent "products" on offer, namely cattle. In such cases the correct policy instrument is not necessarily a tax on cattle or grazing quotas, but rather support for small-scale banking systems similar to that of Grameen Bank in Bangladesh. In the selection and formulation of policy instruments, it is important to understand both the ecological and technical potential and the socio-economic and political conditions. In addition to efficiency, it is also important to take a number of other criteria into consideration, for example the distribution of costs and advantages that are created by different policy instruments. For further information, see Sterner (2002), a book on policy instruments that has been supported by, among others, Sida and the World Bank.

[26] For formal models, see appendix.

[27] Note that there can also be many other reasons for large herds and overgrazing. It can, for example, be a question of a lack of banking and credit systems in rural areas which force people to keep all their "savings" in livestock. In this case it would not be ownership rights or taxes but promotion of savings banks.

Different "Kuznets-curves"

In the text there was a discussion on the so-called Kuznets curve for the relationship between environmental degradation and income. We maintained that the empirical relationship can have different forms. This can be illustrated by the following curves where it is possible to see that some environmental problems, such as availability of safe water, seem to be automatically "remedied" with the aid of income while others, such as amounts of waste or emissions of carbon dioxide, increase with income, and only a few such as concentrations of sulphur dioxide follow a pattern which is similar to the classic "inverted u" form of *the* Kuznets curve. As we mentioned in the text, emissions of sulphur dioxide can be influenced to a very great extent by various forms of control.



Note: **Estimates are based on cross-country regression analysis of data from the 1980s.**
[a] Emissions are from fossil fuels.
Source: **World Bank (1992).**

Table showing genuine savings

Comparisons between genuine savings and official savings USD million) taken from the national accounts of 2003 of a sample of countries.

Country	Official savings	Genuine savings
Angola	2750	-534
Argentina	33383	2729
Bangladesh	9681	6291
Bolivia	726	-266
Burkina Faso	286	125
Burundi	37	-65
Chad	72	-11
Colombia	11767	276
Congo, Rep.	851	-344
Costa Rica	2379	2164
Ecuador	3742	-690
Ethiopia	863	-119
Guatemala	2136	4
India	108569	59919
Indonesia	32978	6327
Iran	39865	-5540
Kazakhstan	4259	-4316
Kenya	1185	924
Malawi	-35	-111
Malaysia	31028	14710
Mali	237	93
Mauritania	255	-7
Niger	52	-120
Peru	8947	3509
Saudi Arabia	52045	-33866
South Africa	15241	3831
Sudan	851	-81
Tanzania	801	275
Togo	61	-42
Uganda	765	98
Ukraine	9135	-1026
United States	1756248	945578
Uzbekistan	2083	-4114
Venezuela	27619	-5409
Vietnam	10684	6031

Source: World Bank www.worldbank.org/environmentaleconomics (Green Accounting).
Here it is possible to download data for all countries from 1970 onwards (up to 2001) and to obtain an exact description of how the corrections to savings have been made.

Models

Two very simple formalised models relating to the text are presented below.

1. Firstly an economic model relating to sections B, C and E in the text.

The simplest economic model which is discussed in the text can have the form of
(1)–(3) below

$$Y = C + G + I. \qquad (1)$$

Where income Y is equal to the sum of consumption, C + investments (or savings) I + public consumption G. Investments minus depreciation D give an increase in the stock of capital K:

$$\Delta K = I\ D \qquad (2)$$

GNP in this simple model is defined as Y while NNP is defined as Y-D. It is the stock of capital which (together with the labour force) is used to produce income:

$$Y = f(K,L) \qquad (3)$$

A more complete production function can have the following appearance:

$$Y = f(K_t,K_n,R,g(L,U),S,T) \qquad (4)$$

where capital can be manufactured or natural K_t, K_n, in which resources and energy are included as R, in which labour includes both the number of workers and their education in a function of its own g(L,U) and where social institutions S and technical development T are also included.

In this type of model it is possible to deduce mathematically the conditions for "sustainability" (which, for example, can be defined in the form that income or income per capita does not decrease). In a simple but informative analysis Dasgupta and Heal show that even without technical development the function (which is assumed to be Constant Elasticity of Substitution) $Y = f(K_t,K_n)$ to be sustainable in this sense as long as substitution elasticity E>1 (If E=1 the function will be Cobb-Douglas and then sustainability depends on whether the output elasticity for manufactured capital is higher than for natural capital.)

2. Model of demand for petrol (section F)

A simple model of demand for petrol is $Q = Y^a P^b$ and according to most studies the elasticities are approximately 1 and −0.8, (see Sterner & Dahl 1991, Sterner, Dahl & Franzén 1992). If, for example, incomes increase by 20% and we want emission to decrease by 30% it is necessary to increase the price by 96% since this is the solution to the equation $P = (0.7/1.2)^{-1/0.8}$.

Contacts: Environmental Economics Unit

The Environmental Economics Unit at Gothenburg University was established in 1991 and consists today of 25 doctoral students and a dozen researchers, and is led by Professor Thomas Sterner. The Unit works with research into environmental economics in Sweden and developing countries. An important part of the work relates to development and the environment. The Unit has cooperated with Sida from the time it was established. Cooperation has focused on two components (i) capacity building in environmental economics in developing countries, and (ii) capacity building at Sida to facilitate environmentally sound development projects. In order to do this, a strong Swedish resource base has been created in the field of environmental economics.

The Unit gives a number of courses in environmental economics at both undergraduate and post-graduate level in which Swedish and invited guest students from the Third World participate. Moreover there is both a postgraduate programme and a master's programme in environmental economics Short tailor-made courses and seminars as well as advisory services are offered to Sida staff.

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Web-site: http://www.handels.gu.se/econ/EEU

See also the World Bank's web-site for "green national accounts": http://Inweb18.worldbank.org/ESSD/envex.nsf/44ByDocName/EnvironmentalEconomicsandIndicators.

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