WHY ENVIRONMENTAL SUSTAINABILITY CAN MOST PROBABLY NOT BE ATTAINED WITH GROWING PRODUCTION

Article written for the De-Growth Conference, Paris, April 2008, adapted for publication in Journal of Cleaner Production (submitted Dec. 2008, revised March 09, accepted April 09)

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Abstract

The concepts of welfare, economic growth, production, environmentally sustainable national income, environmental sustainability, environmental function and asymmetric entering are defined, because the confusion about these concepts hampers sound information. Based on these concepts the arguments are enumerated why it is plausible that environmental sustainability most probably cannot be attained with a growing production level (national income, NI) and why broad acceptance of a lower production level, meaning de-growth of production, will make attaining this goal much easier or at least possible. Some consequences of unsustainable development are provided and the alleged conflict between employment and environment is refuted. The conclusion is that our planet is threatened by a wrong belief in a wrongly formulated growth.

Keywords: Environmental function; Environmentally sustainable national income; Asymmetric entering; Environmental sustainability

1. The concepts of welfare, economic growth (and happiness)

The view now accepted by mainstream economic thought is that the problems of choice arising from scarcity together form a logical entity, irrespective of the end for which the scarce means are employed. This is referred to as the formal or indifferent concept of welfare, a term probably introduced by Rosenstein-Rodan [1]. It was Robbins [2] and Hennipman [3,4], who elaborated the formal concept of welfare and formulated its consequences for economic theory. For these authors, the subject matter of economics is demarcated by the criterion of scarcity. In Hennipman's view economic activity can serve all kinds of ends. The ends themselves are meta-economic and are not for economists to judge. They cannot be derived from economic theory, but must be taken as given, as data. Maximising or even just increasing national income should therefore not be considered a necessary end that can lay claim to logical priority over other ends such as labour conditions and safeguarding the environment. In the same vein, Robbins writes: "There are no economic ends as such; there are only economic problems involved in the achievement of ends".

Proceeding from the work of these authors, Hueting [5] posits the following. All economic activity is aimed at the satisfaction of wants, in other words at welfare, defined as the satisfaction of wants derived from our dealings with scarce means. Welfare is, besides on production, dependent on quite a few other factors such as income distribution and the state of the environment. Consequently the term 'economic growth' can mean nothing other than

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increase in welfare, defined as the satisfaction of wants derived from our dealings with scarce goods. Welfare is not a quantity that can be measured directly 'from outside'; it is a category of individual experience. For this reason the statistician focuses in practice on charting trends in factors that *can* be measured and that can plausibly be argued to influence welfare. These factors will not generally be strictly proportional to welfare but must at any rate satisfy the condition that they tend consistently in the same direction as the welfare they are indicating, positive or negative (or in other words: welfare is not proportional to, however monotonically increasing and decreasing with each of these factors, the other factors remaining equal). Some important welfare-influencing factors are: (1) the package of goods and services produced, (2) scarce environmental functions, (3) time, i.e. leisure time, (4) the distribution of scarce goods, i.e. income distribution, (5) the conditions under which scarce goods are acquired, i.e. labour conditions, (6) employment casu quo unemployment, (7) future security, to the extent that this depends on our dealings with scarce goods, and specifically the vital functions of the environment.

These factors often conflict with one another, although this is not always the case. For scarce goods it holds by definition, however, that more of one is less of another, for a good is scarce when something else has to be sacrificed in order to obtain it (sacrificed alternative, opportunity cost). Nowadays environmental functions have become scarce goods. All other things remaining equal (including the technological state of the art), more production therefore means less environment and vice versa. When (1) in a small or broad margin, preference is given to the environment over production, so when people are willing to sacrifice part of the production to obtain a safer environment, and (2) a government imposes controls on production processes and consumption habits that lead to a smaller volume of goods and services produced, then there will be an increase in the overall satisfaction of wants obtained by means of scarce goods. ***A decrease in production will then lead to greater welfare.*** It is therefore misleading to identify growth of national income with an increase in welfare, economic growth and economic success, as is still common practice even today. This terminology is fundamentally erroneous in its implications, to the detriment of the environment, and it should therefore be outlawed, in much the same way as discriminatory language against women.

For a long time there have been objections of a spiritual and religious nature about the pursuit of worldly and material possessions. Because this interferes with more essential properties of the human spirit. See Hueting [5]. Closely bound up with this criticism are the ideas of Marcuse [6], who states that man has lost his freedom through industrial capitalism and has become a slave of consumer goods imposed upon him, while his 'real needs' are not fulfilled. Easterlin [7] [8] does not discover (in inquiries) a connection between happiness and the growth of production. Layard [9], reviewing the literature on happiness, states that happiness is related to the activity level in different parts of the brains. Dependent on the country and the specific research it appears that after the 1960's or 1980's the level of happiness has not increased while the level of GDP increased substantially. Based on this research the following remarks can be made on the relationship between production (one of the factors influencing welfare) and happiness.

(1) Scarcity, which demarcates the economic discipline, and welfare are defined precisely (see above). The present author has not found an exact definition of happiness. (2) Happiness includes, apart from economic items such as income and employment, a series of items that are not submitted to a budget restriction and therefore do not force us into making a choice as in the case of scarce goods. Consequently, happiness falls outside the economic discipline. Layard [9] mentions love, friendship (both not for sale according to the saying), social relations, acknowledgement, creativity, marriage and personal freedom. (3) According to the spiritual and Marcusian criticism mentioned above, happiness and welfare can develop opposite to one another. (4) The results of the above-mentioned inquiries suggest that in a broad

margin produced goods are no longer scarce. This would mean that the reduction of National income (NI) that results from attaining environmental sustainability does not involve costs and will be easily accepted. In practice, however, the resistance to this is considerable. Hueting [10] gives arguments why it is plausible that the increase of production by itself contributes to welfare and refraining from it involves costs, although the existence of a macro variant of the law of diminishing utility is plausible too. (5) Starting from the 1960's or 1980's the level of happiness seems not to have been affected by NI growth. However, simultaneously the emission of greenhouse gases, the loss of biodiversity, the loss of landscape, droughts and floods increased considerably too, without affecting happiness. Nowhere in the literature is an explanation provided for this phenomenon, it is not even mentioned.

2. **The concepts of environmental sustainability, eSNI and environmental function**

Environmental sustainability is defined as the situation in which vital environmental functions are safeguarded for future generations. So the issue at stake is that the *possibilities* to use them remain available.

Environmentally sustainable national income (eSNI) is defined as the maximal attainable production level by which vital environmental functions remain available for future generations, based on the technology available at the time; see Hueting and De Boer [11]. The difference between NI and eSNI indicates the volume of production that is produced and consumed unsustainably.[2] Thus the eSNI provides information about the distance between the current and a sustainable situation. In combination with standard national income, the eSNI indicates whether we are approaching environmental sustainability or drifting farther away from it. Because of the precautionary principle, future technological progress is not anticipated in the calculation of eSNI. When constructing a time series of eSNIs, technological progress is measured after the event on the basis of the development of the distance between the eSNI and standard NI over the course of time. If the distance has decreased it can be estimated which part of the decrease has been caused by progress in environmental technology and which part by direct change to environmentally benign production and consumption (e.g. more biking).

The theory of and the necessary statistics for an eSNI have been worked on since the mid-1960's at the Department for Environmental Statistics of Statistics Netherlands, founded by the author. A first rough estimate of the SNI for the world in 1991 by Tinbergen and Hueting [12] arrives at about fifty percent of the production level of the world: the world income. The Institute of Environmental Studies estimate for The Netherlands in 2001 also arrived at about fifty percent of the production level or national income of The Netherlands; see Verbruggen et al. [13]. That corresponds with the production level in the early seventies. Estimates for the years 1990, 1995 and 2000 show that in the period 1990 - 2000 the distance between NI and eSNI increased by 10% or 13 billion euros; see Milieu en Natuur Plan Bureau [14]. So, although the period is relatively short, there seems to be a trend away from environmental sustainability.

In the theoretical basis for the calculation of sustainable national income, the environment is defined as the non-human-made physical surroundings, or elements thereof, on which humanity entirely depends, whether producing, consuming, breathing or recreating.

In our physical surroundings, a great number of possible uses can be distinguished, which are essential for production, consumption, breathing, et cetera, thus for human existence. These are called environmental functions, or in short: functions; see Hueting [5,15,16]. As long as the use of a function does not hamper the use of an other or the same

[2] The difference might be normalised by dividing it by NI in one certain year in order to arrive at indices.

function (by overuse), so as long as environmental functions are not scarce, an insufficiency of labour (that is: hands and brains, intellect or technology that increases traditional productivity) is the sole factor limiting production growth, as measured in standard NI. As soon as one use is at the expense of another, though, or threatens to be so in the future, a second limiting factor is introduced. The emergence of competition between functions marks a juncture at which functions start to fall short of meeting existing wants. Competing functions are by definition scarce and consequently economic goods. Indeed they are the most fundamental economic goods at the disposal of humanity. In the situation of severe competition between functions, which prevails today, labour not only reduces scarcity, thus causing a positive effect on our satisfaction of wants (welfare); but it also increases scarcity, thus causing a negative effect on welfare. The same holds for consumption.

The availability of functions, or, in terms of the System of National Accounts (SNA), their volume, decreases from 'infinite' (abundant with respect to existing wants) to finite, that is falling short with respect to existing wants. As a result, the shadow price of environmental functions rises, and with it their value, defined as price times quantity, from zero to an ever-higher positive value. *This rise in value reflects a rise in costs*. To determine the extent of the loss of function, in order to estimate the eSNI, we must know the value of the function. Since environmental functions are collective goods that are not traded on the market, supply and demand curves have to be constructed. Because, according to standard economic theory, determination of value is impossible without data on *both* preferences (demand) *and* opportunity costs (supply).

The estimated costs of measures necessary to restore functions, that rise progressively per unit of function restored, can be seen as a supply curve. We call this the cost-effectiveness curve or the elimination cost curve, because it refers to measures that eliminate the pressure on the environment. Except in the case of irreparable damage, this curve can always be constructed.

Preferences for environmental functions (demand), on the contrary, can only partially be determined, since these can be expressed only partially via the market, while willingness to pay techniques cannot yield reliable data precisely for vital functions; see Hueting [16]. Therefore, it is not possible to construct a complete demand curve. Expenditure on compensation for loss of function and restoration of physical damage resulting from loss of function, however, constitute revealed preferences for the availability of functions, so that some impression of these preferences can be obtained. One example is the additional measures for the production of drinking water as a result of the loss of the function 'drinking water' because of pollution (overuse of the function 'water as dumping ground for waste'). Another example is the restoration of damage caused by flooding due to excessively cutting forests etc. (overuse of the function 'provider of wood' etc.) that consequently are losing their function 'regulation of the water flow'.

Because individual preferences can be measured only partially, shadow prices for environmental functions, which are determined by the intersection of the first derivatives of the constructed curves for demand and supply (see Figure 1), cannot be determined. Consequently, these shadow prices – and the value of environmental functions - remain unknown. This means that the *correct prices for the human-made goods* that are produced and consumed at the expense of environmental functions remain *equally unknowable*.

However, to provide the necessary information, assumptions can be made about the relative preferences for environmental functions and produced goods. *One* of the possible assumptions is that the economic agents, individuals and institutions, have a dominant preference for an environmentally sustainable development. This assumption is legitimate since governments and institutions all over the world have stated support for environmental sustainability. Another possible assumption is that the economy is currently on an optimal path

that is described by the changes in the standard NI. So *both the SNI and the standard NI are fictitious* in the context of what is at issue in economic theory and statistics, namely to provide indicators of the effect of our actions on our welfare.

When assuming dominant preferences for sustainability, the unknown demand curves must be replaced by physical standards for sustainable use of the physical environment. The standards are scientifically determined and in this sense objective. They must, of course, be distinguished clearly from the subjective preferences for whether or not they should be attained. Examples are: the man-made rate of extinction of species should not exceed the rate at which new species come into being, for safeguarding the many functions of ecosystems; the emission of greenhouse gases has to be reduced by 70 to 80 % in order to let life support systems restore the climate; the rate of erosion of topsoil may not exceed the rate of formation of such soil due to weathering, for safeguarding the function: 'soil for raising crops'.

From an economic perspective, sustainability standards approximate demand curves that are vertical in the relevant area of a diagram that has the availability of functions measured in physical units on the *x*-axis and the demand for functions and their opportunity costs (the factor costs involved in attaining a certain degree of their availability) on the *y*-axis. The shadow price for environmental functions – and their value - based upon the assumed preferences for sustainability then follows from the intersection of the vertical line and the marginal cost-effectiveness curve. In this manner the distance to sustainability, denoted in physical units on the *x*-axis, is translated into monetary units. See Figure 1, which shows the relationship between economy and ecology. Of course, bridging the gap requires a transition period.

For a correct approximation, such calculations have been done with the aid of a general equilibrium model, which also generates the shadow prices for produced goods in a sustainable economy. From this, the level of sustainable national income follows. A model is used to trace the consequences of (1) the reactions to the change in price ratios (environment burdening activities become relatively more expensive, whereas environmentally benign activities become relatively cheaper) and (2) direct shifts to environmentally less burdening activities.

A recent overview of the development of eSNI is given by Colignatus [17]

3. **The phenomenon of asymmetric entering (asyms)**

According to standard economic theory, producing is adding value. National income (NI) equals the sum of the values added. So NI measures - the fluctuations in the level of - production. It does so according to its definition and according to the intention of the founders of its concept to get an indicator for one of the factors influencing welfare - and a tool for quite a few other purposes. See Tinbergen and Hueting [12]. (Nobelist Jan Tinbergen was one of the founders of the concept of NI and its quantification).

This value is added to the non-human-made physical surroundings. Consequently, environmental functions remain outside the measurement of standard NI. This is logical and easy to understand, because water, air, soil, plant and animal species and the life support systems of our planet are not produced by humans. So losses of functions, caused by production and consumption, are correctly not entered as costs. However, expenditures on measures for their restoration and compensation *are* entered as value added. This is asymmetric. These expenditures should be entered as intermediate, as they are costs.

This asymmetry is often defended by the remark that these expenditures contribute to welfare and generate income; see De Haan [18] and Heertje [19]. This is of course self-evident, counting from the moment at which the loss of environmental functions and the consequential adverse effects have already occurred. However, the production factors, used for the measures, do not add any value counting from the moment that the functions were still

available. With respect to that situation there is consequently no increase in (1) the quantity of final goods produced and (2) the availability of environmental functions. Opposite to the income earned with carrying into effect the measures there stays consequently no increase in production volume (= final goods produced) with respect to that situation. By entering these expenditures as final instead of intermediate, the growth of production is overestimated, thus obscuring what is happening with both environment and production.

Asyms (asymmetric entries into NI) can relate to events in the past, to events in the current financial year (e.g. oil spills) and, as prevention, to events expected in the future due to loss of function; that does not make any theoretical difference. It always boils down to undo or counteract the effects of production growth that should not contribute to the same growth. Asyms are clearly in conflict with the original intention of the founders of NI as a measure of fluctuations in the level of production; see Tinbergen and Hueting [12].

Hueting [5] comprehensively enumerates the shortcomings of NI (or GDP, gross domestic product). The term 'double counting' is used in imitation of Kuznets. However, because actual items are not entered twice, the present author later uses the term 'asymmetric entering'.

4. **Arguments why environmental sustainability can most probably not be attained with growing production and without broad acceptance of de-growth**

The official policy of all countries in the world is that standard NI - production - must increase in order to create scope for financing environmental conservation, and thus attain sustainability. The theoretical mistake of this reasoning is shown by Hueting [20]. Of course, the future cannot be predicted. But the *plausibility* of whether (a) the actual production level and (b) environmental sustainability will develop in the same direction, which is the consequence of the causal relation expressed in the political statements above, *can indeed be examined*. Developing in the same direction is a minimum prerequisite for assuming a causal relation. On the grounds of the data discussed below such development is extremely unlikely. The author feels the opposite is more plausible for the following seven reasons.

(1) Theoretically, the possibility cannot be excluded that growth of production and consumption can be combined with restoration and maintenance of environmental quality. However, such combination is highly uncertain and scarcely plausible. It would require technologies that simultaneously:

(i) are sufficiently clean,

(ii) do not deplete renewable natural resources,

(iii) find substitutes for non-renewable resources,

(iv) leave the soil intact,

(v) leave sufficient space for the survival of plant and animal species and

(vi) are cheaper in real terms than *current* available technologies, because if they are more expensive in real terms then growth will be reduced.

Meeting all these six conditions is scarcely conceivable for the whole spectrum of human activities. Especially simultaneously realising *both* (i) through (v) *and* (vi), which is a prerequisite for combining production growth and conservation of the environment, is extremely difficult. To give one example: as a rule, renewable energy is in market terms currently much more expensive than energy generated using fossil fuels. The costs of

implementing renewable energy throughout society are high, and this substantially lowers production growth. Internalising the costs of eliminating the emissions of burning fossil fuels will reduce the production level considerably. Anyhow, technologies necessary for the combination of production growth and full conservation of the functions of the environment are not yet available. Anticipating their future availability, that is stimulating NI growth in the expectation that e.g. clean, renewable, safe and cheaper energy, that does not damage vital environmental functions, will become available in the future, conflicts with the precautionary principle, and consequently with sustainability. Giving priority to research in e.g. such energy over production growth and to bringing such energy into practice, and then to wait and see whether or not production continues to grow, is a more prudent policy if one wants to arrive at environmental sustainability. At this moment less than one percent of energy consumption consists of such energy. As explained above and in Section 2, because of the precautionary principle no future technological progress is anticipated, which is, of course, certainly not the same as forecasting or not expecting such progress.

(2) An analysis of the basic source material of the Dutch national accounts shows that roughly one third of the activities making up standard NI (measured as labour volume) does not contribute to its growth. These activities include governance, the administration of justice and most cultural activities. Part of the services sector contributes moderately to the growth of NI, while the remaining one third contributes by far the largest part to the growth of production. Unfortunately, this latter third consists of activities associated with production and consumption that cause the greatest damage to the environment in terms of loss of nature and biodiversity (by use and fragmentation of space), pollution and depletion of resources. These activities include the oil and petrochemical industries, agriculture, public utilities, road construction and mining. These results are almost certainly valid for other industrialised countries and probably valid for developing countries; see Hueting [21] and Hueting *et al.* [22].

(3) The burden on the environment as represented in standard NI equals the product of the number of people and the volume of the activities per person. Reducing this burden by decreasing population lowers growth or leads to a lower production level. (Besides technical measures and direct shifts to environment-friendly activities, population policy belongs to the measures to arrive at a environmentally sustainable production level (eSNI)).

(4) Applying technical measures has a negative effect on growth of production because they enhance real prices: more labour is needed for the same product. The research for the estimates of eSNIs has shown that environmental sustainability cannot be attained solely by applying technology. In addition, direct shifts, such as from car to bicycle and public transport, and from meat to beans, also are necessary. From point (2) above it follows that these shifts also reduce growth or lead to a lower production level.

(5) A price rise resulting from internalising the costs of the measures which restore the environment means, like any price rise in real terms, a lowering of production growth. Depending on the situation, this decreases the production level. For a given technology, product costs will rise progressively as the yield (or effect) of environmental measures is increased. Of course, technological progress leads to higher yields. As production increases further, however, so must the yield of the measures increase in order to maintain the same state of the environment, while the fact of progressively rising costs with rising yields remains unaltered.

(6) An unknown part of the value added in standard NI consists of asyms and should therefore not be considered as a contribution to its volume, see above and Hueting [5]. This part will increase considerably because of the expenditures on (1) measures to eliminate the origin of the climate problem (caused by damaging the functions of life support systems due to production growth) by reducing the emission of greenhouse gases and on (2) measures to compensate the

effects of climate change, e.g. by building dikes and moving to higher elevations. In Section 7 it is concluded that a series of NIs minus asyms should be published alongside the standard NIs.

(7) A sustainable production level with available technology is about fifty percent lower than the current level, both for the world: see Tinbergen and Hueting [12] and for the Netherlands: see Verbruggen *et al.* [13]. From this it follows that eSNI has to grow more than twice as fast as NI in order to reduce the distance between NI and eSNI. This seems to be an almost impossible task for environmental technology, which is the only means for increasing eSNI. Of course, the distance between NI and eSNI in absolute figures is what matters because this reflects the volume of the measures and because future generations will be interested in the physical reality of their surroundings, not in percentages.

5. **Some consequences of unsustainable development**

There are several regions in developing countries today where desire for production in the short term over production that can be sustained in the long term already has led to production levels that are most probably much lower than sustainable levels. This should be a warning to change priority away from production growth and towards safeguarding the environment if one wants environmental sustainability. Thus deforestation has contributed to flooding, causing loss of harvests, houses and infrastructure, and to erosion leading to loss of soil; see UNEP [23]. Restoration of the damage constitutes costs and consequently a decrease in production. Deforestation has also caused reductions in local rainfall, thus contributing to drought; see Silveira and Sternberg [24]. Overgrazing and salination have led to decreases in agricultural yield; see UNEP [23]. Overfishing and dynamiting coral reefs have led to lower fish catches; see UNEP [23]. These developments have partly been caused by companies from rich countries.

To the extent that members of fish species are still present, catches are often well below the levels that would have been realised, had fishing remained at sustainable levels. The North Sea cod fishery is currently on the brink of collapse, and the current catch of cod is less than 20 % of what would have been possible, had fishing remained sustainable; see Nakken, et al. [25] and Parsons and Lear [26]. This exemplifies a more general problem. There is now convincing evidence that the current stock in the seas of large predatory fishes is about 10% of the pre-industrial level; see Myers and Worm [27]. That is raising prices sharply.

6. **No conflict exists between employment and environment**

The main stumbling block on the way to environmental sustainability is the alleged conflict between environment and employment. However, the production and consumption of the same amount of goods requires more labour with safeguarding the environment than is required without.. Therefore, there is, under the most logical conditions, no such conflict. On the contrary, the opposite holds true. The refutation of this alleged conflict can be found in Hueting [14].

7. **Conclusions and recommendations**

The arguments given above lead to the following conclusions and recommendations.

(1) Our planet is threatened by a wrong belief in a wrongly formulated growth.

(2) Environmental sustainability cannot not be attained with a growing production and without a broad acceptance of de-growth of production, that is NI without asyms.

(3) The NIs in all countries should be supplemented by a series of NIs without asyms and a series of eSNIs, alongside the standard NI.

8. Epilogue

Since completing this article, in March 2008, for the De-Growth Conference in Paris, the bank crisis has become more severe and now (March 2009) is influencing production and employment, mainly by cessation of credit and by reduction of demand. The editors have asked me to deepen the article by interweaving the consequences of this historical event in the text. The above text consists mainly of technical and quantitative arguments why environmental sustainability cannot be attained with increasing production. These arguments are not affected by a bank crisis. Therefore an epilogue seems a more appropriate way to reflect on the recent events.

Three statements seem to be important.

(1) Safeguarding the vital possible uses of the non-human physical surroundings – the scarce environmental functions – is infinitively more important than a bank crisis, irrespective of how serious its consequences may be. Because, human life, including production activities, depends on those functions. In case of irreparable damage of vital functions, production will collapse, regionally or globally, on land or in the oceans. In some regions this is happening already, as a result of droughts, flooding and overfishing (see Section 5). Production can be stagnated by a bank crisis, but never collapse. The demand for basic commodities and services will always remain intact, while labour and technology to meet this demand will always remain available. Sooner or later less urgent wants will be met by less necessary supply, so that the traditional growth path will be regained. That is, as long as threatening environmental losses are neglected.

(2) All produced goods, including capital goods, have been created by combining hands, brains (technology) and elements of our physical surroundings. So competing functions are evidently the most fundamental economic goods at our disposal. They fall outside the market and outside the measurement of national income. Therefore the market fundamentalism of most economists is in conflict with saving the basis of human existence. Consequently the current sad bank crisis has at least one positive side effect: it weakens this narrow view of the market mechanism and therefore could (hopefully) contribute to the acceptance of a lower production level (NI) that most probably will result from attaining environmental sustainability. The market can operate well only if it is supported by regulatory institutions. Thus environmental functions can be safeguarded within the market mechanism by raising levies on environment-depleting activities and to use the revenues for financing in market terms non-paying clean technology and in market terms non-paying alternatives for depletable resources (such as fossil fuels).

(3) Safeguarding environmental functions requires extra labour (see Section 6). So it should be self evident for governments that want environmental sustainability to subsidize in market terms non-paying clean technology and alternatives for depletable resources in order to simultaneously save the environment and combat unemployment caused by the bank crisis, in stead of subsidizing the car industry and road construction.

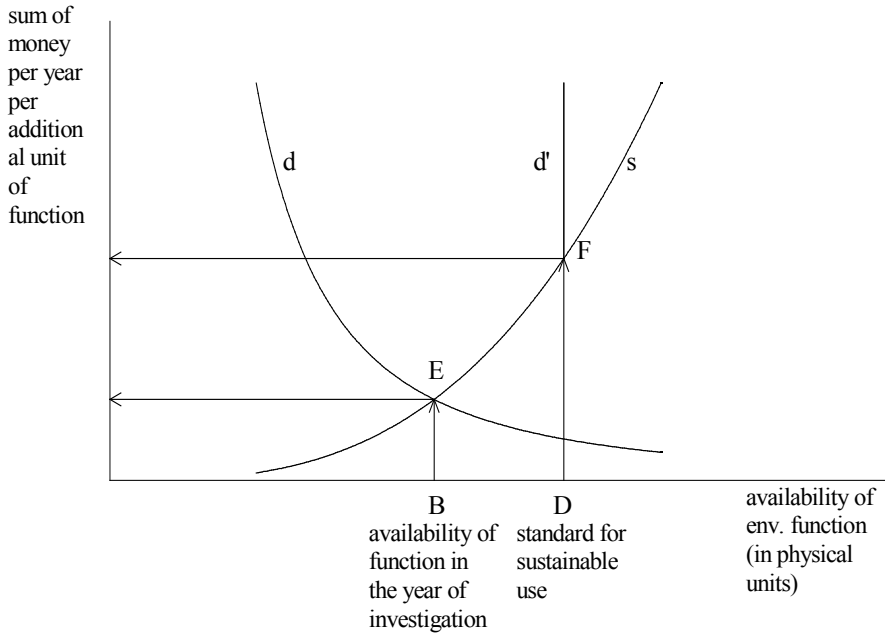

Figure 1, *taken from Hueting [5]. Translation of costs in physical units into costs in monetary units: s=supply curve or marginal elimination cost curve; d=incomplete demand curve or marginal benefit curve based on individual preferences revealed from expenditures on compensation of functions, and so on; d' = 'demand curve' based on assumed preferences for sustainability; BD = distance that must be bridged in order to arrive at sustainable use of environmental functions; area BEFD=total costs of the loss functions, expressed in money; the arrows indicate the way in which the loss of environmental functions recorded in physical units is translated into monetary units. The availability of the function (B) does not need to coincide with the level following from intersection point (E).*

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Most articles by the present author can be downloaded from www.sni-hueting.info

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Acknowledgement

The author thanks Dr. Robert Goodland, Ir. Bart de Boer, Thea Sigmond and three anonymous reviewers for their suggestions to make the text more clear for the reader, and Robert Goodland for checking the English.