Environmentally Sustainable National Income: Indispensable Information for Attaining Environmental Sustainability

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ABSTRACT

Environmental functions are defined as the possible uses of the non-human-made physical surroundings on which humanity is entirely dependent. Competing functions are by definition economic goods, indeed the most fundamental humanity disposes of. Environmental sustainability is defined as the dynamic equilibrium by which vital environmental functions remain available for future generations. Environmentally sustainable national income (eSNI) is defined as the maximum attainable production level by which vital environmental functions remain available for future generations. Thus the eSNI provides information about the distance between the current and a sustainable situation. In combination with the standard national income (NI), the eSNI indicates whether the part of the production that is not based on sustainable use of the environment is increasing or decreasing in the course of time. Calculation of the eSNI involves the use of environmental models and a static general economic equilibrium model. It is shown that asymmetric entries are obscuring what is happening with both environment and production and that there is no conflict between employment and safeguarding the environment.

KEYWORDS

Environmental function, economic growth, sustainability, employment, asymmetric entries

JEL codes: O4, P44, Q01, Q2, Q3, Q4, Q5

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1. ENVIRONMENTAL SUSTAINABILITY

The notion of environmental sustainability has a long intellectual history, going back to the concept of a 'stationary' or 'steady state' economy employed by nineteenth-century economists. This concept denotes a state of dynamic equilibrium between production and natural resources. J.S. Mill (1876) wrote that he sincerely hoped people would be content to be stationary, for the sake of posterity, long before necessity compels them to it. This pronouncement can be interpreted as being based on considerations of intergenerational equity. In the context of sustainable national income this means investigating under which conditions the *possibilities* for using our non-human-made physical surroundings can be passed on to future generations undamaged.[1] In the twentieth century the notion of sustainability has been extended to encompass other aspects of the environmental issue, such as the relationship with the living world (nature) and pollution (IUCN, 1980).

In the process, the principle of preferences for intergenerational equity has always remained a core element of the concept. This implied a state of dynamic equilibrium with the available natural resources and with the living world, and abatement of pollution, to the extent of its significance for future generations. Uncompensated exportation of anthropogenic environmental risks to future generations was rejected as inadmissible. To establish an appropriate maximum environmental burden to meet these preferences was seen as a task for natural scientists. In other words, sustainability was taken to mean that the environmental capital – defined as the possible uses, or functions, of the environment and natural resources – provided by nature and capable of being scientifically established, should remain intact (Kapp, 1950; Daly, 1973; Hueting, 1974; Goodland, 1995).

Using Boulding's terminology, this implies a dynamic equilibrium, in which (*ceteris paribus*) the functions of environment and natural resources remain available (Boulding, 1991). Measures taken to allow for the permanent availability of functions should be derived from scientifically based presuppositions. Whether these measures are sufficient can of course only be evaluated after the event, again using natural science. So in this view environmental sustainability is an objective concept to the extent that natural science is objective. Whether or not individuals and institutions want to attain environmental sustainability depends on their preferences, which are evidently subjective.[2] The equilibrium is dynamic because both geological processes and human activities are continuously changing the state of our planet.

In the report *Our Common Future*, also known as the Brundtland report, the concept of sustainability was clearly linked to the issue of intergenerational

1. So no normative pronouncement is made as to whether or not this should be accompanied by production growth.
2. Because they reflect the feelings of subjects

equity (Brundtland,1987). In Our Common Future this was phrased as follows: 'Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs'. Many countries have by now subscribed to sustainable development as defined in the Brundtland report. However, the report is, according to Hueting (1990), a matter of conflicting goals, because it is pleading for both sustainability and production growth; see Section 6.

2. THE CONCEPT OF ENVIRONMENTAL FUNCTIONS

In the theoretical basis for the calculation of environmentally sustainable national income (eSNI), the environment is defined as the non-human-made physical surroundings: water, air, soil, plant and animal species and the life support functions (including ecosystems) of our planet, on which humanity is entirely dependent, whether producing, consuming, breathing or recreating. It is true that our observable surroundings are largely human-built. However, houses, roads, machines and farm crops are the result of two complementary factors: labour, that is technology, and elements of the physical surroundings as here intended.

The possible uses, or functions, of our physical surroundings (the environment), on which all human life depends, have come into being largely via processes proceeding at a geological or evolutionary pace. For the life support systems it is unfeasible ever completely to be replaced by technology, as is shown by Goodland (1995). It is thanks to these life support systems, which are under threat of disruption, that indispensable (or vital) environmental functions remain available.

Life support systems are understood to mean the processes that maintain the conditions necessary for life on earth. This comes down to maintaining equilibria within narrow margins. The processes may be of a biological or physico-chemical nature, or a combination thereof. Examples of biological processes include the carbon and nutrient cycles, involving the extraction of such substances as carbon dioxide, water and minerals from the abiotic environment during creation of biomass, and the return of these substances to the abiotic environment during decomposition of the biomass. Examples of physico-chemical processes include the water cycle and regulation of the thickness of the stratospheric ozone layer. These examples show that there is interaction between the processes, whereby equilibrium may be disturbed. The water cycle, for example, may be disturbed by large-scale deforestation. Climate change is a disturbance of the carbon cycle.

In our physical surroundings, a great number of possible uses can be distinguished, which are essential for production, consumption, breathing, *et cetera*, and thus for human existence. These are called environmental functions, or, in short, functions (Hueting 1969, 1974). Environmental functions are clearly collective goods. As long as the use of a function does not hamper the use of another or the same function, so as long as environmental functions are not scarce, an insufficiency of labour – that is, intellect or technology – is the sole factor limiting production growth, as measured in standard national income (NI). As soon, however, as one use of a function is at the expense of another or the same function (by excessive use), or threatens to be so in the future, a second limiting factor is introduced. This competition of functions leads to partial or complete loss of function. An example of excessive use of one and the same function, leading to its loss, is overfishing resulting in decreased availability of the function 'water to accommodate fish species'; then the catch of some species decreases or species become extinct.

A distinction is made between three kinds of competition of functions: spatial, quantitative and qualitative (Hueting, 1974). When spatial and quantitative competition occurs, the amount of space and the amount of matter respectively are deficient in respect to the existing or future needs for them. In qualitative competition, overburdening the function 'waste dumping medium' by chemical, physical or biological agents has caused partial or total loss of other possible uses of the environment, such as the function 'drinking water' or 'air for physiological functioning of humans, plants and animals (breathing)'.

Worldwide severe competition exists between use of space for production of food, production of bio fuels, natural ecosystems and the survival of species, road building, building of houses, traffic and possibilities for children to play and discover their surroundings. In many regions of the world the quantity of ground and surface water is insufficient to meet the needs of the population for watering agricultural crops, supplying industrial processes, providing drinking water and ensuring the survival of species. Qualitative competition includes pollution, disturbance of ecosystem by exotics and phenomena such as climate change.

When using the concept of function, the only thing that matters in the context of sustainability is that vital functions remain available. As for renewable resources, functions remain available as long as their regenerative capacity remains intact. Regeneration in relation to current use of 'non-renewable' resources such as crude oil and copper that are formed by slow geological processes is close to zero. Regeneration then takes the form of developing substitutes. The possibilities for this are hopeful (Brown *et al.*, 1998; Reijnders, 1996). So, economically speaking, there seems to be no essential difference between the two.

3. VALUATION OF ENVIRONMENT AND PRODUCTION – AN IMPOSSIBILITY LEADING TO ASSUMPTIONS

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 the most fundamental economic goods humanity disposes of. In the situation of severe competition between functions in which we live today, labour is not only reducing scarcity, and thus causing a positive effect on our satisfaction of wants, or welfare; but is also increasing scarcity, thus causing a negative effect on welfare. The same holds for consumption. So today production not only adds value (*viz*. goods for consumption) but also nullifies value (by damaging environmental functions).

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, 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. Without data on *both* preferences (demand) *and* opportunity costs (supply), determination of value is impossible. For, if a good is not wanted or if its acquisition requires no sacrifice, the economic value of that good equals zero and no problem of choice arises. It then is obviously not scarce, has by definition no economic aspect and falls consequently outside economics.

The estimated costs of measures necessary to restore functions, that rise progressively per unit of function restored, can be seen as a supply curve, because the measures supply the function. 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, the elimination costs can always be estimated, so this curve can always be constructed. The measures include technical measures, direct shifts to environmentally benign production and consumption, development of alternatives for depletable resources such as oil and copper, and family planning. The necessary pace of substitution of non-renewables is dealt with in Hueting and De Boer (2001).

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. Hueting (1989, 1992) and Hueting and De Boer (2001) mention quite a few reasons for this statement. Thus much of the damage resulting from the loss of functions will take place in the future. No financial damage or compensation expenditures, as revealed preferences, can therefore arise in the present. Choosing a discount rate boils down to making an assumption about preferences and therefore does not resolve the problem (Hueting, 1991). Another example is that we cannot base ourselves on observed individual behaviour, given the working of the prisoners' dilemma.

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. Furthermore Hueting (1987), referring to the ecological risks by production growth, postulates: 'Man derives part of the meaning of existence from the company of others. These others include in any case his children and grandchildren. The prospect of a safer future is therefore a normal human need, and dimming of this prospect has a negative effect on welfare.' *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 eSNI 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. This holds true apart from the fact that measuring NI has smaller uncertainty margins than measuring eSNI.

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 as to 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, in order to safeguard the many functions of ecosystems; the emission of greenhouse gases has to be reduced by 70 to 80 per cent 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, to safeguard 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 on the *y*-axis. The shadow price

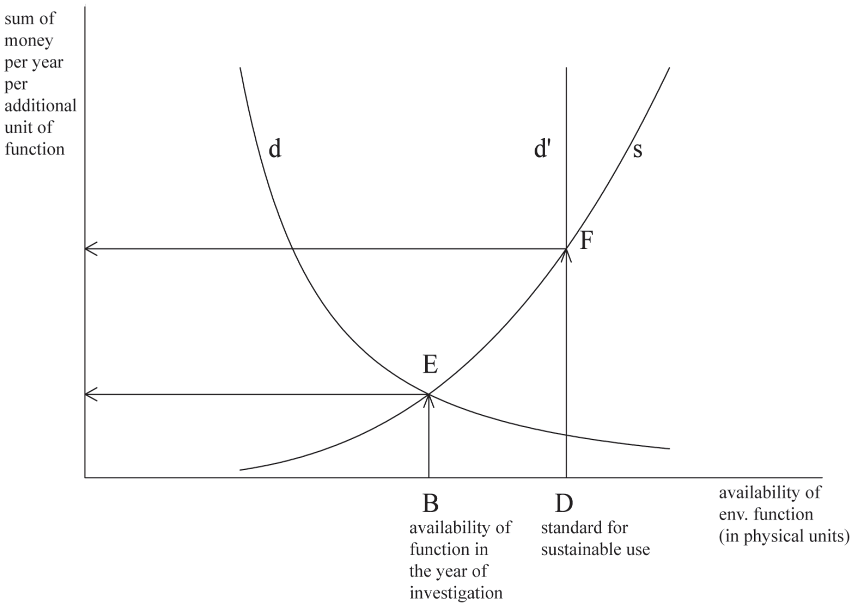

Figure 1. Taken from Hueting (1974). Translation of costs in physical units into costs in monetary units: s=supply curve or marginal elimination cost curve; d=incomplete demand curve or marginal benefit curve based on individual preferences revealed from expenditures on compensation of functions, and 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).

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, taken from Hueting (1974), which shows the relationship between economy and ecology. Of course, bridging the gap requires a transition period.

The greater the distance between the present economy and the desired more environmentally benign economy that has to be bridged, the higher the costs of the required set of elimination measures are, as Figure 1 shows. These measures, consisting of technical means to reduce the use of the environment, direct shifts to less environment-damaging products and, if necessary, birth control, are interacting with deliveries of all products, including services. So, when bringing these measures into practice, the interdependences between the producers, consumers and the environment make all commodity flows and prices change.

4. THE CONCEPT OF ENVIRONMENTALLY SUSTAINABLE NATIONAL INCOME

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. Thus the eSNI provides information about the distance between the current and a sustainable situation. The length of the period to bridge this distance, that is the transition period towards a sustainable situation, is limited only by the condition that vital environmental functions must not be damaged irreversibly. In combination with the standard national income (NI), the eSNI indicates whether or not the part of the production that is not based on sustainable use of the environment, is becoming smaller or greater. Because of the precautionary principle, future technological progress is not anticipated in the calculation of eSNI. When constructing a time series of eSNI's, 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. When this distance increases, society is drifting farther away from environmental sustainability, if this distance decreases, society is approaching environmental sustainability.

Theoretically, the eSNI depends on all interacting processes mentioned in Section 3. The processes can be described by an interconnected environmental-economic equilibrium model. In this model, the behaviour of each producer is explained by a production function which yields the supply of products by that specific producer. Likewise, the behaviour of each consumer is explained by a welfare function which yields the satisfaction of his needs derived from the use of goods and environmental functions by that consumer. The reactions of the environment to the use made of its functions, including the effects on the availabilities of these functions, are explained by dedicated sub-models. The theoretical model as a whole explains the changes of stock and flow variables in the economy and the environment in their mutual dependence, so the model is dynamic. It has time-dependent solutions, which form paths in the space of variables vs. time. These and some other complications not mentioned here make clear that this theoretical approach is unfeasible. Simplifying assumptions in the calculation of eSNI were therefore unavoidable.

5. CALCULATION OF ESNI

The theory of and the necessary statistics for an eSNI have been worked on since the mid sixties. A first rough estimate of the eSNI for the world by Tinbergen and Hueting (1991) arrives at roughly 50 per cent of the production level of the world: the world income. Estimates for The Netherlands by a cooperation of Statistics Netherlands, the Institute of Environmental Studies and the Netherlands Environmental Assessment Agency also arrived at about fifty per cent of the production level or national income of The Netherlands (Verbruggen *et al*., 2001). This corresponds with the production level in the early seventies. In view of the smaller size of the population, the consumption per capita was by that time substantially higher than fifty percent of the current level. In the period 1990–2005 the distance between NI and eSNI increased by thirteen billion euro or ten per cent.

In a recent literature review on the economics of climate change, Stern *et al.* (2006) rated the costs of mitigation of climate change to be only one per cent of gross national income as an average over 50 years, much lower than the eSNI figures indicate. This is disturbing, because climate change and the connected depletion of fossil fuels have the largest elimination costs of all environmental problems. One cause of this difference is the risky high stabilisation level of 3°C average global warming used by Stern *et al.*, where the eSNI is based on the ecologically more realistic limit of 1.5°C. This, combined with the steep rise of the elimination cost curve, explains a great part of the difference. The second important cause is the use of the truncating time horizon of 2050, thus neglecting the high costs that are expected to occur after that year. This implies that the authors effectively use a much higher discount rate for elimination costs than the near-zero rate they mention. The third cause is allowing for technological progress, which makes these costs drop in the course of time. The latter two assumptions do not occur in eSNI estimation, because it yields a comparative static *ex-post* national income figure, in which discounting future income has no meaning. The advantage of this approach is that it avoids ignoring the risk that the race between rising emissions and technological progress is lost by the latter, which is in conflict with the precautionary principle that is the essence of environmental sustainability.

The methodology of the present calculation was proposed by Hueting *et al*. (1992) and was developed further into a model approach published by Verbruggen *et al.* (2001) and Hueting and De Boer (2001). The calculations have been done with aid of a dedicated set of models, co-operating sequentially instead of interactively. The case of sustainable development offers a possibility to make this simplification without making large errors. The necessary condition for sustainability is that environmental functions are maintained for future generations, at the lowest levels of availability that enable the physical elements of the environment, which are the carriers of the functions, to remain supporting these levels. This is assumed to be dependent on three conditions.

The first condition is that the extinction of biological species at the global level may not be accelerated by human influence. The second condition is that any changes in the state of the environment may have only a minor, acceptable impact on human health. The third condition is that vital environmental functions must be present all over the world, that is, within the reach of human use. These three conditions impose bounds on the acceptable variation in the state of the environment, however imprecise. One may think for instance of maximum allowable pollutant concentrations, minimal ozone column, maximum global warming *et cetera*.

These boundaries to the state of the environment are used as inputs in models of environmental problems such as excessive use of natural resources, loss of biodiversity by fragmentation of space, climate change, acidification, eutrophication, dispersion of harmful substances and droughts. Iteration with each model yields limits to the use of the environment by production and consumption activities. These limits or standards for the sustainable use of the physical environment are actually approximations of its use on the sustainable path.

The limits are inputs to a dedicated static general equilibrium model of the country's economy. The dynamics of production and consumption, caused by changes in capital stocks and so on are neglected. Again, this assumption seems acceptable for the approximation of the permanent sustainable development path. The data of the cost of the measures to attain and maintain vital functions, that rise progressively per unit of function restored (expressed in physical units, see Figure 1), are estimated in the way exposed in Section 3. The model yields an approximation of the eSNI.

The model traces 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. The change in price ratios can be elucidated as follows.

It follows from research into the basic source material of the National Accounts by Hueting (1981) and Hueting *et al.* (1992) that the bulk of national income growth is generated by industries that cause the greatest losses of environmental functions, both in production and in consumption. The increase in productivity in these industries, measured in terms of goods produced, is much greater than elsewhere in the economy, so the real prices of these products decrease strongly, and, with them, the price ratio between environmentally burdening and less burdening products. As a result, any shift to environmentally friendly products has a negative impact on the volume of national income (Hueting *et al*. 1992). When, as in the simulation of environmentally sustainable income, the cost for attaining environmental sustainability are internalised in the prices of environment burdening products, the real prices of the latter increase, as does the price ratio between environmentally burdening and friendly products. The latter price ratios reflect the situation in an environmentally sustainable situation. *Attaining environmental sustainability without a (drastic) change in price ratios is unfeasible*.

A recent overview of the development of eSNI is given by Colignatus (2008).

6. THE FALLACY OF THE POLITICAL STATEMENT THAT PRODUCTION MUST GROW TO FINANCE SAFEGUARDING THE ENVIRONMENT

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 attaining sustainability. The theoretical mistake of this reasoning is shown by Hueting (1996). Of course, the future cannot be predicted. But the *plausibility* of the statement can be examined. On the grounds of the data discussed below the statement seems 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 a 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. In particular, simultaneously realising both (i) through (v) *and* (vi), which is a prerequisite for combining production growth and conservation of the environment, is extremely difficult. Anyhow, technologies necessary for the combination of production growth and full conservation of the functions of the environment are not yet available. Anticipating the future availability of such technologies conflicts with the precautionary principle, and consequently with sustainability, which is, of course, certainly not the same as forecasting or not expecting technological 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) do 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 (Hueting, 1981; Hueting *et al.*, 1992).

(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.

(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 asymmetric entering (see Section 7) and should therefore not be considered as a contribution to its volume (Hueting, 1974). 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 (2) measures to compensate the effects of climate change, e.g. by building dikes and moving to higher elevations.

(7) A sustainable production level with available technology is about 50 per cent lower than the current level, both for the world (see Tinbergen and Hueting, 1991) and for the Netherlands (see Verbruggen *et al.*, 2001). 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.

7. ASYMMETRIC ENTRIES (ASYMS) IN NATIONAL INCOME

Producing is defined, in accordance with standard economic theory, as the adding of value. National income 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 (Tinbergen and Hueting, 1991; Nobelist Jan Tinbergen was one of the founders of the concept of NI and its quantification).

As mentioned just now, producing is adding value. *This value is added to the non-human-made physical surroundings.* Consequently, environmental functions (the most fundamental economic goods at humanity's disposal) 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 (De Haan, 2004; Heertje, 2006). 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 undoing or counteracting 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 (Tinbergen and Hueting, 1991).

8. THE FALLACY OF A CONFLICT BETWEEN ENVIRONMENT AND EMPLOYMENT

The main stumbling block on the way to environmental sustainability is the alleged conflict between environment and employment. The refutation of this alleged conflict can be found in Hueting (1996). Environmental functions are scarce goods which require the use of production factors for their restoration, preservation and substitution. Of these, labour is the most important. In the Netherlands more than 80 per cent of net Domestic Product is labour income. Capital goods are manufactured by labour, using elements of our physical surrounding. The production and consumption of the same amount of goods requires more labour with safeguarding the environment than is required without. Hueting (1996) shows that with direct shifts to environmentally benign activities attaining a certain goal requires more labour. Therefore, there is, under the most logical conditions, no such conflict. On the contrary, the opposite holds true. These logical conditions are: (1) income has to be reduced in proportion to the costs of the measures required to conserve the environment, (2) these or similar measures must be taken to the same degree simultaneously by other firms involved, in all countries.

The absurdity of the alleged conflict becomes evident when we trace its consequences. If conservation were to be achieved at the expense of employment, then 'clean' production and consumption should require less time than the 'dirty' production and consumption. Because labour is the dominant cost factor (see above), clean production would then be cheaper. From this it follows that there would be no environmental problem! The market would force producing and consuming without burdening the environment. The environmental problem can be conceived as a process involving the steady substitution of time, or working hours, through depletion of the environment.

Openly admitting the above obvious fact and creating the logical conditions under which the problems of unemployment and the environment would neutralise one another would lead to a structural drop in (traditional) labour productivity. This certainly checks the growth of production or leads to a lower production level and consequently to a step in the direction of environmental sustainability.

9. COMPARISONS

The handbook of Integrated Environmental and Economic Accounting (SEEA) deals with a number of methods to adapt standard national income to environmental losses (United Nations *et al*., 2003). Paragraph 199 of Section 10 reads:

> Much of the initiative to look for an alternative path for the economy rather than a different measure of the existing economy came from the work of Hueting in the late 1960's and early 1970's. He introduced the concept of environmental function referred to throughout this manual, explaining how pressure on functions leads to scarcity or competition for these functions. As with any economic good or service, this scarcity gives rise to an economic value due to the opportunity costs involved in their use or appropriation. The concern is then to define aggregate indicators to characterise a sustainable economy which ensures the maintenance of key environmental functions in perpetuity. Such an economy may be described as a 'greened' version of the existing economy where typically an increase in national income is secured at the expense of worsening environmental degradation. Interest then focusses not on the new aggregates themselves but in the gap between the existing economy and the greened version.

The SEEA describes quite a few ways to adapt NI for environmental losses. These welfare indicators have the same theoretical foundation and the same structure. They can be distinguished as combinations of the following categories.

- 'Damage adjusted', 'depletion adjusted' and 'environmentally adjusted' national incomes on the one hand vs. 'greened economy' national incomes on the other indicate welfare in the actual and environmentally more benign development, respectively.
- Ex post and ex ante indicators focus on years in the past and the future, respectively.

eSNI's are ex post 'greened economy' estimates that show, in combination with NI's, whether or not the gap with environmental sustainability becomes smaller. Ex ante 'greened economy' estimates focus on prognoses for the transition path to environmental sustainability (see Figure 10.2 of the report). Both types of 'greened economy' national incomes are promoted by the GREENSTAMP project (Brouwer and O'Connor eds., 1997). Maintenance costing and Net pricing yield ex post environmentally adjusted national income estimates.

Despite their common base, most indicators have little similarity with SNI. For instance, a damage adjusted NDP cannot be compared with SNI, because attaining environmental sustainability eventually yields negligible damage costs, but requires all kinds of elimination measures. Calculating eSNI involves the calculation of the costs of these measures. Damage costs are by no means the same as elimination costs as can easily be seen in Figure 10.1 of the report, in which the benefits equal the avoided damage costs. More or less comparable with SNI are the depletion and the environmentally adjusted Net Domestic Product (dpNDP c.q. eaNDP).

DpNDP is not an environmental sustainability indicator for two reasons. First, it does not take environmental degradation into account. Second, it does not use physical sustainability standards, as it does not intend to describe national income at sustainable resource use. The latter is a prerequisite for determining environmental sustainability, as explained above.

EaNDP also does not use physical standards. As for environmental degradation, eaNDP uses maintenance or avoidance costs (M) for adaptation of NI, as far as these costs are not already accounted for in the NI. There are two versions for M. (a) M consists of the costs necessary to bring about the situation in the beginning of the accounting period. If at this date the situation is not sustainable (which is very likely) eaNDP is also for this reason not an environmental sustainability indicator. (b) M consists of the costs to attain some desired situation, e.g. sustainability. In that case M 'suffers a major conceptual weakness in that it assumes that a new set of prices or production changes can be introduced without consequences for the rest of the economy', as the SEEA report rightly states in paragraph 239 of Section 10.

Another proposed economic indicator for sustainability is genuine savings (GS), which we discuss below. The GS approach is actively promoted by the World Bank.

Pearce *at al*. (2001) have defined genuine savings *Sg* as the savings term of a version of environmentally adjusted net national income (eaNNP) which includes adjustments for damages, compensation and depletion. $EaNNP = C + S_g + X - M$, analogous to gross savings S in the definition equation of gross national product ($GNP = C + S + X - M$) and analogous to net savings S_n ($= S - \mathrm{d}K/\mathrm{d}t$) in net national product ($NNP = C + S_n + X - M$). In these expressions, C = consumption, S = gross saving, X = export, M = import and $\mathrm{d}K/\mathrm{d}t$ = depreciation of produced assets. Consequently, $S_g = S - \mathrm{d}K/\mathrm{d}t - r(R - G) - p(E - A)$, where r = unit resource rent (defined as the difference between the price obtained for a unit of extracted or harvested resource and its marginal costs of extraction or harvesting); R = resource extraction or harvest; G = natural growth rate of the resource (zero for non-renewables); p = marginal social damages from pollution; E = emissions; A = natural assimilation (i.e. dissipation) of pollutants; $r(R - G)$ and $p\ (E - A)$ are respectively the value of depreciation on natural resources and the value of net pollution damage.

We agree with Pearce *et al*. that the genuine savings approach can provide some kind of (weak) signal *vis-à-vis* sustainability. The eSNI and the GS approaches can supplement one another, but only under additional conditions.

As Pearce *et al.* rightly assert, welfare depends on total stocks of produced, natural and human assets. Produced capital, however, is a combination of labour (technology) and elements from our physical surroundings (the environment). In the final count, we are dependent on only two factors: human and environmental assets (Hueting and De Boer, 2001). The *sine qua non* of *environmentally* sustainable development is a production level that guarantees preservation of vital environmental functions with available technology (Hueting and de Boer, 2001). From this there follow already three conditions for calculation of the 'genuine savings' indicator, and for versions of the related eaNNP for that matter.

(1) Any increases in human assets must be used exclusively for environmental protection and/or for growth of production that does not (further) damage the environment. This condition is hard to satisfy, because (a) expenditures on environmental protection check production growth (Hueting, 1974; Hueting and De Boer, 2001) and (b) it is precisely the most environmentally damaging sectors of the economy that account for the bulk of production growth (see on the latter point Hueting, 1981 and Hueting *et al.*, 1992). In implementing condition (1), due heed should be paid to the essential difference, explained in the above quoted literature, between (i) an increase in the size of a sector (expansion) in terms of deflated value added and (ii) that sector's contribution to an increase in production volume resulting from increase in labour productivity, as measured in standard NI (more explanation in Hueting, 1974, p. 170, footnote 2, English edition; Hueting *et al.*, 1992, Appendix 3).

(2) Likewise, increases in stocks of produced assets must be exclusively for the purpose of environmental protection or 'clean' growth. Again, it is a condition that is not easy to satisfy, for the reasons just given under 1(a) and 1(b). According to Pearce *et al.* (2001) investments in infrastructure contribute positively to genuine savings. From the perspective of environmental sustainability, however, their contribution is negative. The fragmentation of the landscape caused by roads and other infrastructure and the consequent loss of habitat and isolation of gene pools are substantially accelerating the rate at which plant and animal species are becoming extinct, which in turn negatively affects life support systems (Hueting and De Boer, 2001).

Certainly in the industrialised countries and in tropical rainforests, infrastructure should be demolished rather than constructed if the goal of environmental sustainability is to be realised.

(3) Resource revenues must be invested in environmental protection or ‘clean’ growth; see (1) and (2).

Further:

(4) Consumption *C* in the genuine savings formula is taken from standard NI statistics. So *C* contains expenditures on elimination of and compensation for loss of environmental functions, financed by government and private households (Hueting, 1974; Hueting and De Boer, 2001). These so called asymmetric entries must be deducted from *C* in conformity with the welfare theory underlying the national income indicators adjusted for environmental losses, presented by the authors and many others.

(5) The condition $S_g \geq 0$ must hold for all t to warrant (weak) sustainability, that is for a long time series, not just for a single year or single accounting period, as in the formula presented by Pearce *et al*. (2001).

(6) Only in the case of non-renewable resources may technology be substituted for nature, as argued in Hueting and Reijnders (1998) and Hueting and De Boer (2001).

As long as these six conditions remain unsatisfied, the genuine savings method certainly cannot serve as an indicator for environmentally sustainable development.

10. CONCLUSION

The information for society and policy makers about the development of production and environment would be greatly improved by supplementing the series of national income (c.q. GDP) by a series of national income minus asymmetric entries and a series of environmentally sustainable national income.

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