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INTRODUCTION TO THE THEORY OF eSNI, A MACRO INDICATOR FOR SUSTAINABLE DEVELOPMENT.

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Environmentally sustainable national income (eSNI) is defined as the maximal attainable production level by which vital environmental functions remain available for ever, 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.

The theory of and the necessary statistics for an eSNI has been worked on since the mid sixties. A first rough estimate of the eSNI for the world in 1991 by Tinbergen and Hueting arrives at fifty percent of the production level of the world: the world income [1)] . 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 percent of the production level or national income of The Netherlands [2)] . That 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 1990-2000 the distance between NI and eSNI increased by thirteen billion euro.

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 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. Producing is defined, in accordance with standard economic theory, as the adding of value. *This value is added to the elements of our physical surroundings (the environment), so the non-human-made physical surroundings falls outside the standard NI.* This is logical, for water, air, soil, plant and animal species and the life support systems of our planet are not produced by humans.

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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. As long as the use of a function does not hamper the use of an other 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 NI. As soon as one use of a function is at the expense of another or the same function (by excessive use), 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 the most fundamental economic goods humanity disposes of. In a 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 it 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. 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 as well as on opportunity costs, determination of value is impossible.

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, 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 [3)]. Their expression via the market and budget mechanism is blocked by so called blockages or barriers [3)]. Therefore, it is not possible to construct a complete demand curve. Expenditure on compensation of 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. Examples are the additional measures for the production of drinking water as a result of the loss of the function ‘drinking water’ because of pollution, or the restoration of damage caused by flooding due to forests losing their ‘hydrological regulation’ function.

According to key authors like Tinbergen, Kuznets and Hicks, who pioneered and developed the practical implementation of the concept of NI in the nineteen-thirties, changes in the level of NI are explicitly intended as *one* of the indicators for the development of welfare. This is the way such changes in the level are understood by the public, the media and governments. This is logical, because all economic action is aimed at the satisfaction of wants, so at the increase of welfare. In the nineteen-thirties, however, the environment did not play a role in economics. That is different today. Safeguarding the vital functions of our physical surroundings – that include humanity’s life support systems – has become the most important economic issue confronting mankind. As stated above, scarce environmental functions are the most fundamental economic goods at mankind’s disposal, because we are entirely dependent on them. However, as stated above, their loss is for logical reasons not recorded in the standard NI. Unfortunately we have to deal with the situation in which a process that is accompanied by the destruction of the most fundamental economic goods is called economic growth and is identified with economic success. Continuation of this process receives the highest priority in the policy of all countries in the world. Therefore, publication of ‘green’ NI’s, especially eSNI, that is NI’s corrected for environmental losses, alongside the standard NI’s, is urgent, because it provides essential information for society and policy-making. This was the firm conviction of Tinbergen, that is documented in his papers [1)], while it is implied in the work of Kuznets and Hicks.

Apart from this, indicators such as income distribution combined with a poverty index, unemployment and labour conditions should be given equal attention as standard NI in the decision making process.

Because individual preferences can be measured only partially, shadow prices for environmental functions, which are indispensable for this correction and which are determined by the intersection of the first derivatives of the constructed curves for demand and supply, cannot be determined. Consequently, these shadow prices 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. This means that there are as many shadow prices for environmental functions and produced goods as reasonable assumptions can be made - and consequently as many green NI’s. Each of these assumptions is associated with the optimal path of the economy that follows from it. That is the path on which the annually available package of economic goods, both human-made goods and environmental functions, perfectly reflects the assumed preferences. *One* of the possible assumptions is that the economic agents, individuals and institutions, have a dominant preference for an environmentally sustainable development, as is the case with eSNI; this is the path denoted by *s* in Figure 2. This assumption is legitimate since governments and institutions all over the world have stated support for this. A second possible assumption is that the economy is currently on an optimal path that is characterised by the changes in the standard NI: path *b* in Figure 2. A third possibility is that path *b* is attained because expression of preferences for sustainability is blocked (see above). 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 [4)] .

When assuming absolute preferences for sustainability, the unknown demand curves must be replaced by physical standards for sustainable use of the environment. The standards are scientifically estimated using environmental models and are in this sense objective. They must, of course, be distinguished clearly from the subjective preferences for whether or not they should be attained. 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 for environmental functions 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 [4)]. In principle, this monetary distance is equal to the distance between the national income figures belonging to the current path *b* and the sustainable path *s* in Figure 2. This is the distance to sustainability the country in question has to bridge in terms of the required opportunity costs, c.q. factor costs. 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, with robust changes in the price ratio's between environment burdening and less burdening products. From this, the level of sustainable national income follows.

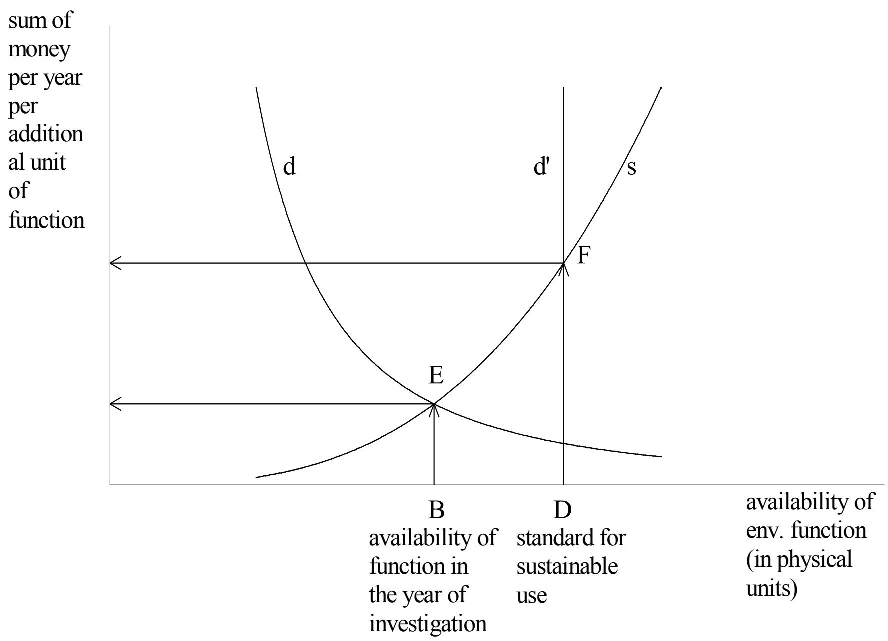

Figure 1. *Translation of costs in physical units into costs in monetary units: s=supply curve or marginal elimination cost curve; d=incomplete demand curve or marginal benefit curve based on individual preferences (revealed from expenditures on compensation of functions, and so on; d'='demand curve'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

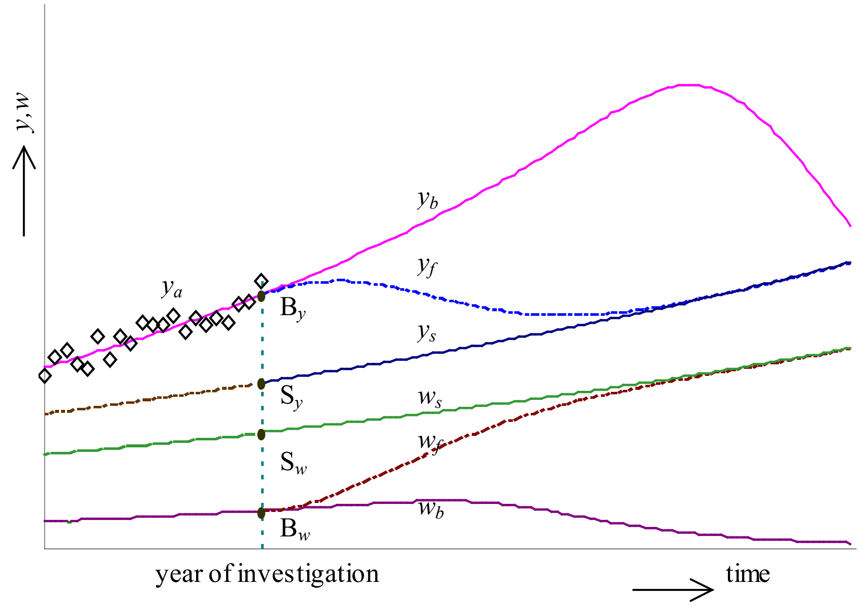

Figure 2. *Actual standard national income observations (y_A, fictitious example) compared with the net national income (y) and a welfare indicator (w) on three optimal paths, calculated with a dynamic environmental economic model. The blocked path (index b) approximates the actual path (index a) by assuming incomplete expression of preferences for the environment. These preferences are assumed to be completely expressed on the unfeasible unblocked path (index s) and the feasible unblocked path (index f). The points B_y and B_W indicate the levels of national income y and the welfare measure w on the blocked path b in the year of investigation; S_y and S_W are the corresponding points on the unfeasible unblocked path s.*

The actual economic development path *a* displayed in Figure 2 is calculated in the System of National Accounts over a series of years. It can be approximated by path *b* using the models just mentioned. Far extrapolation may indicate a collapse of production and therefore income and welfare, because the environmental functions which are vital for production are depleted. This collapse is the characteristic of an unsustainable development.

Sustainable economic development paths have in common that environmental functions do not decline in future due to their use for production and consumption, because this use is limited. Two kinds of sustainable paths exist.

Suppose the state of the production, consumption and the environment in the first year of calculation is chosen such that income is lower than standard national income, but, while it may increase in the future, it will never decline "as far as the models used can see". Then a 'sustainable balanced growth path' is found. If, moreover, the initial state is chosen such that national income is maximal in each year, this income is the eSNI and the path is called *the* sustainable path here, path *s* in Figure 2. The path is infeasible in that it cannot be reached directly. This is the path calculated with the method discussed here.

A sustainable transition path *f* departs from a state of production, consumption and the environment that is chosen as close as possible to the actual state without loosing sustainability, that is, without lowering the availability of environmental functions below their sustainable levels. Income will drop first when gradually more and more measures are taken to reach the sustainable equilibrium, with sustainable use of the environment. A sustainable transition path may be realistic, i.e. feasible. Calculation of the transition path is not part of the eSNI research, but its existence is important, because it shows that reaching sustainability is feasible and may take some time.

This transition time follows from the delay times between changes in the use of the environment (such as emissions) and their effects on the environmental function levels appearing in models used to estimate the sustainability standards for the use of the environment. These standards are input to a general equilibrium model of the national economy dedicated to the calculation of sustainable national income. In this model and its outcomes is the environmentally sustainable national income the central goal variable.

The foundation Promotion of research on eSNI (FSNI) is planning to set up eSNI estimates in other countries, including developing countries. However, unfortunately up to now no funding could be found. The former ministers of the environment in Indonesia and The Netherlands, Emil Salim and Jan Pronk, are members of the board of this foundation. If somebody in the audience is interested, please get in touch with me.

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