

# Towards a Typology of 'Environmentally Adjusted' National Sustainability Indicators Key Concepts and their Policy Applications

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*The paper is intended to provide guidance about the construction and exploitation of 'adjusted aggregate' concepts for maximum policy usefulness. It tries to provide some structure for appraising the variety of work over the past 20 years around the world, and it seeks in this regard to be reasonably wide ranging and conceptually rigorous. Inevitably it is far from comprehensive in its references to individual theoretical and statistical studies. However, a selection of cross-references to key works where fuller discussions of the methodological issues involved and the heritage of research, both theoretical and applied, may be found. For example, detailed discussion of the core distinction (in Section II of the paper) between the AICCAN and the geGDP indicator concepts, may be found in the Cahier du C3ED No.00–05, "Natural Capital, The Greened National Product, and the Monetisation Frontier" (Faucheux & O'Connor, 2000). The selected examples (in Section III of the paper) of inter-country 'environmental load displacement' have been extracted from the scattered literature by my colleague Roldan Muradian (see Muradian & O'Connor, 2001), and detailed literature review papers on this subject are forthcoming.*

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# Abstract

The practice of estimating 'environmentally adjusted' macro-economic aggregates should, this paper argues, not only be rooted in appropriate economic theories, but should also aim to ensure the potential of the 'adjusted' aggregates to offer aid to policy makers (i.e., to provide answers to questions posed). This is the 'bottom line' against which to measure the concepts, practice and informational power of 'adjusted' aggregates.

The paper is structured as follows. A general introduction (**Section I**) provides a simple structural perspective on sustainable development is exploited, portraying a national economy as a set of production and consumption sectors that is interdependent with (i) natural processes, (ii) communal and social infrastructures, and (iii) other national economies. This structural perspective facilitates our presentation of the several distinct 'adjustment' concepts that are put to work in the development of aggregate indicators on the basis of integrated economic and environmental accounts for a nation.

In a first main cut (**Section II**) we make a classification of two broad families of 'environmentally-adjusted GDP' for a national economy, based on two complementary adjustment concepts. The first type of adjustment centres on accounting conventions, through a *change in the system boundary*, an enlargement of the scope of national accounting to include specified categories of environmental assets. This is the basis for construction of an 'Aggregate Indicator of the Change, during the Current year, in the economic Assets of the Nation' (AICCAN for short). The second indicator type is based on hypotheses of *adjustment of the economy itself*, that is, an 'adjusted economy' with a new pattern of production processes, levels of production and consumption activity, technologies employed, etc., which respects specified environmental performance standards. We call the corresponding indicators 'greened economy GDP' (geGDP for short).

To highlight the complementarity of these two measurement concepts, the notion of the 'Monetisation Frontier' is introduced. This is the line that separates between two zones of natural wealth — on the one side the resources and assets that are valued *from the point of view of their potential conversion into commercially priced goods and services* (trees into wood products, for example), on the other side the assets that are valued *from the point of view of their roles as in situ services as sites, scenery, scientific interest and ecological life-support in complement to human economic activity*.

In a second main cut (**Section III**) we outline, with examples, the ways that adjustments to national aggregate indicators and adjustments may be proposed for taking account of openness to the rest of the world. In effect, the 'Monetisation Frontier' concept and the AICCAN/geGDP distinctions are maintained, while further classifications are introduced for making the distinction between 'costs borne' and 'costs caused' by a nation. This field is, however, much less 'mature' in theoretical and statistical terms than is the core of national accounting practice. Although a careful typology of the between-nation adjustment concepts is attempted, and a variety of selected examples are presented of different types of 'inter-country environmental load displacement' indicator concepts and empirical results that can be found in the published literature, this Section nonetheless has more the character of a research agenda than a definitive typology.

The conclusions of the paper (**Section IV**) make an overall appraisal of the pertinence of the different indicator concepts in macro-economic and environmental policy contexts. It is emphasised how the **AICCAN** and '**geGDP**' families — whether formulated for a nation's 'domestic' accounts or further adjusted for taking account of inter-country load displacement — respectively address different roles of natural capital. Each indicator type refers to a distinct 'object' and each estimation procedure, including the inter-country dimensions, has distinctive difficulties of reliable quantification and uncertainties. Each indicator concept is therefore adapted to certain policy questions and not to others. They should be used in the domains for which (i) their scientific credibility is good and (ii) the

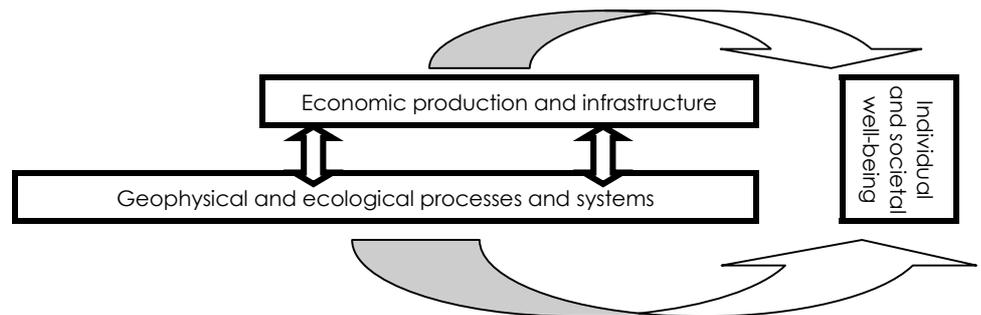
pertinence of their message for society is clear. To conclude, suggestions are made as to the respective places, and limitations, of the respective indicator concepts in the orientation and evaluation of sustainability policies. Where their domains of respective applicability overlap, the complementarity of the different indicator concepts should be exploited.

# Section I

## Introduction

### I.1 Sustainable Development and Adjusted Aggregates

Policy objectives of sustainable development refer not just to sustaining produced wealth, human health and money income flows but also to the maintenance and renewal of important 'environmental functions'. Ecosystems provide a variety of material flows, services and supports for economic activity. The 'environmental capital' and the ecological 'goods and services' that flow from this capital (natural resources, amenities, waste reception, life support functions) are complementary to economic capital stocks and the produced goods and services as sources of human well-being (Faucheux & O'Connor, eds., 1998; Faucheux & O'Connor, 1999; Brouwer, O'Connor & Radermacher, 1999).



\* The diagram comes from the **EVE Policy Brief No.3, 'Natural Capital'** (O'Connor, 2000). As outlined by the United Nations Operational Manual on *Integrated Environmental and Economic Accounting* (Alfieri & Bartelmus, eds., 2000, p.27 and p.41), "the SEEA extends the concept of capital to cover not only human-made capital but also non-produced natural capital. [...] Capital formation is correspondingly changed into a broader concept of 'capital accumulation'," hence the notion of 'environmentally adjusted net capital formation' and, conversely, the problem of natural capital 'depreciation'. The emphasis is shifted to

Sustainable development may, in this view, be defined as a process of economic and ecological resource management aiming at the joint delivery of economic and ecological benefits and services. This is the context in which extensions of the established SNA (system of national accounts) are sought, beyond the domains of economic assets and priced transactions of goods and services, to include environmental assets and the flows across the economy-environment interface that are concomitant with economic activity but which may alter the quality and quantity of environmental assets and, hence, present and future levels of human well-being.\*

The term greened national accounts refers thus to national accounting systems extended to include information on the state of the environment and on interactions (e.g., 'pressures') between economy and environment. The environmental and interface accounts will include some stock and flow information categories expressed in monetary value terms, and others in non-monetary units of measure. It is crucial to define clearly the respective roles of monetary and non-monetary information.

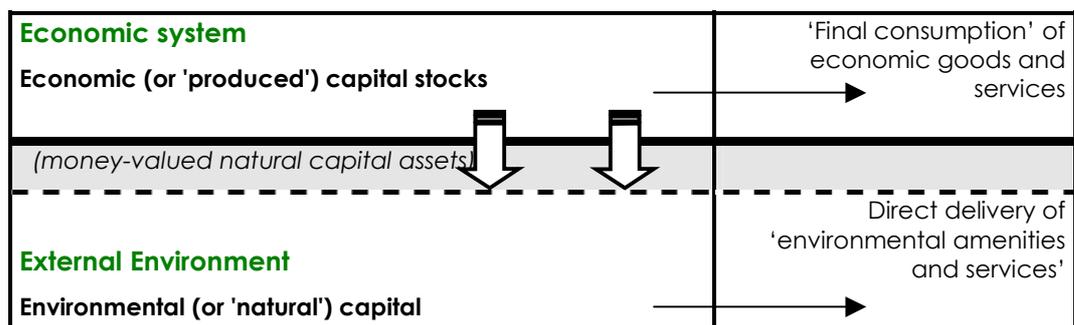
This study is concerned with procedures for defining 'environmentally adjusted' macro-economic indicators, henceforth called *adjusted aggregates* for short. The literature on this subject is quite large. Most (though not all) of the effort linked to official statistics has been focussed on the factoring into national accounts of the maintenance, or not, of key environmental functions and ecological services. This is now widely agreed as necessary for meaningful sustainability indicators. But, of

course, it is not enough. It is necessary also to resituate greened national accounting preoccupations in a full social-economic-ecological perspective. This includes, among other things, addressing international inter-dependencies as factors in national economic and environmental performance.

## I.2 Two Concepts of Adjustment

Developments at the international level in greened national accounting have focussed mainly (although not exclusively) on the national economic accounting system with its standardised basis for statistical reporting of domestic production, imports and exports, and final consumption of economic goods and services. In this context, as we will develop in detail in **Section II**, two main concepts have emerged for defining 'environmentally adjusted' macro-economic indicators for a national economy.

- The first type of adjustment, relative to standard national accounting conventions, is a change in the system boundary, an enlargement of the scope of national accounting to include specified categories of environmental assets. In the schematic diagram below, this is shown as a shifting of the frontier (the heavy horizontal line) dividing the economy from its external environment. This shift brings some environmental capital (such as minerals, oil and gas, forest or fisheries stocks — we will later expand the horizons of types of capital) into the field of economic accounting, signalled by the fat arrows pointing downwards.
- The second is adjustment of the economy itself, that is, an 'adjusted economy' with a new pattern of production processes, levels of production and consumption activity, technologies employed, etc., which respects specified environmental performance standards. In the schematic diagram below, the key focus is on the interface between the economic system and its environment, the heavy horizontal line, which is 'crossed' by environmental pressure indicators such as natural resource inputs and pollutant emissions.



The two adjustment concepts are complementary and both play major roles in structuring the work of environmental policy and supporting statistics. In effect, the 'country manager' (that is, the assortment of policy making agencies) must manage a portfolio of assets, economic and social as well as environmental. The decision to include a particular category of natural resource or environmental function within an enlarged 'asset' portfolio with monetary evaluation will reflect judgements about the country's capacity to exercise a management control over the assets and about the significance of about the asset as a source of revenue (such as resource rents and export receipts, burden on public funds for water purification investments, etc.). But, as well as managing assets in a commercial perspective, there is also the concern for wider environmental conditions. Just as a company may undertake a variety of foresight, forward studies, market research and scenario studies, so a country manager (or, more generally, the policy community) will engage in a variety of forecasting and strategic forward studies exercises. In the case of environmental and economic sustainability an example is the investigation of feasibility of meeting simultaneously specified economic and environmental performance goals. This can be done through the modelling of various 'environmentally-adjusted national economies'.

Throughout this paper we will emphasise not only the distinct adjustment concepts but also, with examples, the distinctive sorts of requirements that the different indicator concepts have for economic and environmental data.

### I.3 Costs Caused & Costs Borne: International Environmental Load Displacement

It is agreed by all involved in greening of national accounts, that a comprehensive system of national accounts must take account of external linkages between national economies, both economic and environmental. This means addressing the openness of the national economy, and of the national territory, to the rest of the world. In what sense can it be said that one country shifts an environmental burden onto other countries or, conversely, suffers a burden caused by another country?

Direct economic linkages are dealt with, more or less conventionally, via the accounting of balances for exports and imports, and capital flows. These accounting categories allow the important distinction to be made between a nation's domestic product, and its income (which, relative to the domestic product, may be augmented/diminished by inflows/outflows in such categories as repatriation of funds, international development aid, interest/debt servicing payments, direct commercial investment, and so on). Although net income flows across national boundaries can, in extreme cases, reach the same order of magnitude as the annual national product, the difference is quite often unimportant for our purposes and so we do not further discuss these financial interdependencies as such.

Of more particular interest is the accounting of inter-country environmental linkages, viz., indicators of direct and indirect ecological interdependence of a national economic activity with the Rest of the World. Despite many years of research and political interest, there is not, as yet, a systematic national accounting for the important category of *environmental services and damages provided to and received from the Rest of the Planet*. This is an admittedly complex topic with formidable data as well as conceptual challenges. It is, however, important for policy relevance to be able to situate national macro-economic indicators in their context of regional and global ecological — as well as economic — interdependencies.

Examples are the direct and indirect dependence of a national economy on the world community for primary energy, water, agricultural land and/or photosynthesis potential, fisheries harvest, stockage of toxic wastes, emissions of atmospheric pollutants, and so on. The literature is quite large, but very heterogeneous and scattered. However enough work has been done around the world, that the effects that such considerations can have on adjusted aggregate indicator concepts, quantitative results, and their interpretation, can clearly be discerned. While not aiming to be comprehensive, we lay out the general issues in **Section III** and illustrate with selected empirical examples.

### I.4 The Societal Significance of Adjusted Aggregates

After outlining the types of macroeconomic aggregates associated with each adjustment type and accounting conventions, we will discuss briefly the policy uses of each indicator type (**Section IV**). After more than 20 years of experimentation, there now exist many different variations and estimation methods, more or less inclusive, for each of these two indicator concepts. We propose that the policy uses, and likely usefulness, of the various different recipes, can be assessed with reference to:

- (1) What each specific indicator concept seeks to measure relative to national policy agendas;
- (2) the robustness of each indicator concept in the face of various economic and ecological systems uncertainties;

- (3) possibilities for implementing meaningful empirical estimation procedures for each indicator concept.

Apart from the variety of technical matters relating to estimation methods and data availability — which will be highlighted in the **Section II, III and IV** discussions — some broad societal considerations bear on indicator pertinence. The most important is to be clear about the way that indicators relate to underlying notions of (current and future) societal well-being.

To some extent, of course, this consideration is inherent already in the very notion of 'greening' the national accounts. The various adjustment concepts all seek, one way or another, to give a more adequate weight to the roles of natural resources — and environmental functions and ecological services more generally — for individual and societal well-being. However, attention must also be given to the roles in human well-being of the integrity of societal infrastructures and tissues of human relations, and this is a broader question than the natural environment alone.

If we adopt the framework common to political economy since the 19<sup>th</sup> century, we may propose three broad classes of 'funds' — that is, material structures with a capacity for self-renewal — as important to societal well-being:

- the stocks and infrastructures of produced economic capital;
- the health of the population and the wider communal infrastructures (so-called social capital);
- the systems/funds of 'natural capital', which are at the origin of direct delivery of many environmental amenities and life-support services as well as providing inputs and waste absorption services for production and consumption activities.

These three categories all have important interfaces with each other. Up until now, however, the 'green' extensions to national accounting systems have mostly focussed on the interface of economic and natural capital assets within the national territory (including, perhaps, an exclusive economic zone for some fisheries resources). This includes, notably, depletion of stock resources and damages or depreciation to the national funds of environmental capital caused by certain forms of pollution, as this paper has discussed up until now. There has been relatively less systematic attention to the interfaces between economic and environmental funds, and 'social capital'. In particular,

- The relation between the formal and the informal economy*, while the object of in-depth analysis for several decades, has been rather left to one side in the context of 'greening' the national accounts.
- The linkage between local community infrastructures, informal and unpaid labours (including community care, and subsistence production), and local ecosystem integrity*, which is a key to achieving a minimum of economic security in many societies, has been relatively neglected in green accounts practices oriented around national statistics conventions and policy priorities of the affluent industrialised countries.

This suggests that the treatment (implicit or explicit) of all of the three fund-fund interfaces, within different indicator concepts, should be closely examined. Recent work by the World Bank looking at social capital is a step in this direction, which as yet only touches the tip of the iceberg. There is, on the other hand, a very rich body of research, both academic and activist, on subsistence economies, local ecosystem degradation and maintenance, and communal infrastructures, which can usefully be exploited.\* Some of this research points to the importance of local knowledge, not codified in formal models or data sets, as a resource for sustainability.

\* For example: Ivan Illich (1973), *Shadow Work*. Serge Latouche (1998), *L'Autre Afrique: Entre don et marché*; (1991), *La Planète des Naufragés (In the Wake of the Affluent Society)*. Marcel Mauss (1923-24), *The Gift: Forms and Functions of Exchange in Archaic Societies* (Routledge 1990). Maria Mies (ed. 1988), *Women: The Last Colony*. Marc Penouil & Jean-Pierre Lachaud (eds. 1985), *Le Développement Spontané: Les activités informelles en Afrique*. Vandana Shiva (1990), *Staying Alive: Women, Ecology and Development*. J.J. Thomas (1992), *Informal Economic Activity*. Thierry Verhelst (1991), *No Life Without Roots: Culture*

It is beyond the scope of this attempt at survey and typology, to treat systematically the issues associated with informal economy and household and communal investments in production, repair and restoration (including, not least, the repair of worn out human capital that has been fatigued by its incursions into commercial activities and the formal economy). Although some provision for informal economic activity is already provided for in standard national accounting practices, the great importance of this activity in many Third World societies makes a fuller economic treatment appropriate before discussing adequacy or not of various measurement concepts and categories.

## Section II

# Two Families of Environmentally Adjusted National Aggregates

### II.1 A Little Bit of History

We will, in this Section, develop in systematic fashion the two concepts of adjustment outlined in the Introduction, which are complementary rather than exclusive, and progressively make an attempt at classifying the variety of recipes currently existing with in statistical and theoretical literature, by reference to our systematic typology. We will start by a bit of the history of green accounting, sustainable national income and adjusted aggregates, showing (in a simplified way) how the two distinct adjustment concepts have emerged in the literature.

There are several roots of the concern for monetary valuation of natural resources and of environmental benefits and damages, in an enlargement of national accounting. Many are related to the idea, present in economists' writings since the 1960s, that environmental damages and resource pollution caused by economic activity, should somehow be registered as a dis-investment or a welfare loss, and therefore set against the benefits of this economic activity as measured in the GDP. The question of precisely how to set these environmental costs in relation to economic benefits, has been a matter of debate throughout the ensuing decades. The arguments took a particular focus as the notion of 'sustainable development' took form, and the two following questions were posed.\* First (for rich countries), "*Can the current level of aggregated national consumption be sustained indefinitely?*", and, second (for poor countries), "*is there an upper limit to the future income level that, once attained, could indefinitely be maintained?*"

It should be noted immediately that each of these questions can be given a precise quantitative formulation only in the framework of a deterministic mathematical model. The role of modelling is thus to provide a framework for checking the logical consistency for important concepts, hypotheses, results and interpretations, while holding in mind that real development and environmental change processes are not so deterministic at all.

The key question posed for national accounting, and that has underlain the push for 'adjusted aggregates' since the 1980s, is:

- "*Can an estimate be obtained for a nation's sustainable national income, on the basis of appropriate adjustments to the conventional GFP figure?*"

And, if the answer is "yes",

- "*What are these adjustments and how can an estimation procedure be implemented in practice?*"

These are the questions to which the neoclassical growth theory claimed to furnish a response when Solow (1986) and others noticed, on the basis of results from Weitzman (1976), that in a model solution for an economy having constant consumption indefinitely (that is, sustaining its national income), the 'net savings' or change in the value of the capital assets in the economy, is zero. This dovetailed nicely with the Hicksian concept of income (Hicks 1946) which was: "*The maximum*

\* Formally, these two questions can be rephrased in terms of two distinct definitions that can be put forward of a sustainable national income (SNI) :

— *Immediately and thereafter perpetually obtainable income*, is the highest level of 'income' that can be attained *immediately*, from some given vector of stocks, subject to the constraint that the income level during  $t > 0$  is permanently non-decreasing. This is a maximin utility path.

— Later but thereafter perpetually obtainable income, is the highest level of 'income' that the economy can continuously attain *at and after a finite time*, starting from some given vector of stocks, subject to the constraint that the income level is permanently non-decreasing.

This distinction has been

amount which can be spent during a period if there is to be an expectation of maintaining intact the capital value of prospective returns."

Under certain assumptions, this 'income' equals consumption plus net savings. So, turning the formula around, the conclusion would be that when net savings are zero, the consumption is at the sustainable level. Translated into the language of national accounting, this gives the proposition that the sum of national net savings plus national consumption, if net savings are calculated taking natural capital into account, will be an estimate for the level of income that the economy could, in principle, maintain indefinitely — that is, the 'sustainable national income' (SNI) for the country.

On the basis of this reasoning (which, as it turned out, was incorrect on a crucial point), it would be sufficient to estimate the 'green NDP' defined as the net national product *taking into account changes in all capital assets including natural capital*, in order to have an estimate for the country's SNI. Therefore, environmental economists and statisticians should go to work to obtain information on the state of natural capital from year to year, and attribute money values to the changes, and the job is done. This was the motivation underlying, for example, the preliminary work reported by Pearce & Atkinson (1993) for a cross-section of countries (see Box).

#### A 'Weak' Indicator of Sustainability?

Pearce & Atkinson (1993) developed estimates for the 'net savings' ( $\Delta S$ ) taking into account not only economic capital savings and depreciation but also depletion of natural resources. Using  $SNI = C + \Delta S$ , their interpretation was:

- If the net savings are negative, then current consumption (C) exceeds the sustainable consumption level (SNI).
- If current consumption (C) is less than the SNI, then there is room for continued consumption growth without nuisance to future generations.

\* Some of the other key works on these points are: Norgaard (1990); Faucheux, Muir & O'Connor (1997). An underlying point is that, in neoclassical equilibrium theory, a zero price for an environmental good or service should signal non-scarcity of that good or service relative to the demands on it over the time horizon considered, for example abundant air and water as an input or as a sink for wastes. Recognising that a good is 'scarce' should then result in a positive price. But not if the "demands" of those persons — present or future — for whom scarcity means physical non-availability are not heard. A zero-price may signal not non-scarcity per se, but a relation of power in a situation of conflict. Pollutants or toxic wastes may be discharged in ways that degrade the living habitat of others who are unable to stop the event. Power is the capacity of a dominant social group to ignore or discount the "demands" of other group(s) who

The Pearce & Atkinson results were admittedly tentative, because they took into account only a very limited number of categories of natural resources such as petroleum, minerals and forest. In the ensuing debates, criticisms were made of these results and their interpretation as a sustainability indicator along three lines:

- First, that "*far more has been left out than has been included*" (see, e.g., Victor, Hanna & Kubursi, 1998);
- Second, that the existing or estimated resource prices employed for the calculations are unlikely to reflect inter-temporal opportunity costs as the underlying theory presupposes (see, e.g., Martinez-Alier & O'Connor 1996);
- Third, that, even within the confines of the relevant theory, the 'greened NDP' and the 'sustainable national income' are not necessarily the same. On the contrary, depending on the assumptions made about — inter alia — technological progress, openness or closure of the economy towards the rest of the world, relative abundance of different sorts of capital, population change, substitutability and income elasticities, efficiency or not of current prices (etc., etc.), the green NDP can be much higher, or much lower than the SNI — so much different that nothing reliable can be inferred about the SNI relative to current consumption from the sign or magnitude of the estimated net savings (see Asheim, 1994; Asheim & Buchholz, 2000, 2001; Pezzey & Withagen, 1998; Weitzman, 1997).\*

These criticisms cumulatively are compelling. Pure theory justification for using an adjusted aggregate (viz., the green NDP) as a way to estimate the sustainable national income, is very weak. This does not mean that there is no relevance in estimates for changes in various categories of natural capital. Rather, it means that

the 'silver bullet' approach to getting a 'SNI' indicator is abandoned. By comparison, there are strong reasons for treating prices and asset changes on a straightforward period-by-period accounting basis, as in business accounting (without appealing to welfare theoretic notions of efficiency and optimality) — as we outline with the AICCAN concept a bit further on.

Roefie Hueting, working since the 1970s on the same indicator problem, had followed a somewhat different line of reasoning. He started with the argument (Hueting 1980) that sustainability policies mean the maintenance through time of all key 'environmental functions' and that this should be pursued by setting restrictions on the extraction of renewable resources, the emissions of pollutants and other sources of environmental damage, in order to ensure the sustaining of environmental qualities and life support capacity. He further argued that an economy not respecting the sustainability standards, could be 'adjusted' by adopting measures such as pollution abatement, substitution away from over-used resources, etc., in order to make it meet these standards. These adjustments would cost money (more exactly, they implied the redeployment of resources within the economy), so they could be considered as imposing a reduction in the value of economic goods and services available for current consumption. This led to the simple suggestion that the 'sustainable national income', meaning the national consumption level for the economy respecting the standards, could be estimated by subtracting these costs of adjustment from the current income.

The early Hueting formula thus appears, in one respect, to be similar in character to the formula for SNI obtained on the basis of the neo-classical growth theory. Both involve the subtraction of environmental values from GDP. But whereas the Pearce & Aktinson (for example) results are based on using estimates for monetary values of natural capital in the existing economy, the Hueting approach is based on calculations associated with adjustments to the existing economy. The reference points for the two approaches are not the same.

Since the 1980s, the early Hueting approach has been refined progressively (see Section II.5 below). One of the difficulties that presented itself, is related to scales of analysis, viz., what level of sectoral aggregation and what time-frame over which costs of adjustment should be calculated? What may appear as a high cost for a firm, for a sector or for the national economy if measures for (say) water pollution reduction are implemented in the short term, could also appear as a relatively low or even 'negative' net cost if adjustment and investment opportunities are appraised over a longer time-frame. Since sustainability is the concern and adjustment processes take time, the opportunity costs for forward-looking policy should usually be estimated in an inter-temporal analysis framework.

These scale-related problems were given careful attention during the mid-1990s in a multi-country European study, The GREENSTAMP Project.\* This work suggested that it was useful to introduce directly the concept of a 'greened economy GDP' as a characterisation of an 'adjusted economy' — that is, an economy that, over time or hypothetically, is altered in structure so as to respect specified environmental performance criteria. In this approach, *the greened-economy GDP, or geGDP, refers to the feasible economic production, for the accounting period(s) in question, subject to the condition that the economy is respecting the specified set of environmental standards.*

This 'greened economy GDP' concept is thus developed directly at a whole-economy level, and would be estimated through comparative static or dynamic scenario modelling approach. Importantly, this direct recourse to modelling creates a link in between the green national accounting agenda and an independently existing body of work since the 1970s concerned with developing scenarios for 'soft energy paths' and, more generally, for 'alternative' and 'green' economies. Many examples for a 'geGDP' are therefore to be found directly in the guise of aggregate

\* The GREENSTAMP research project on *Methodological Problems In The Calculation Of Environmentally Adjusted National Income Figures*, was carried out during 1994-1996 for the European Commission DG-XII, and involved a collaboration between several statistics offices and economics and environmental research institutions. The acronym refers to the methodological perspective on GREENed National STATistical and Modelling Procedures developed in this research project and currently being implemented in several pilot applications for European nations, as discussed below. This project investigated the different theoretical options for defining an 'environmentally adjusted national income figure' — a geGDP — that could be estimated based on available statistical data and analytical tools and that would be plausible as an indicator about

output or income indicators of models developed for exploring alternative energy or environmental scenarios in sustainability studies, even if these latter were not conceived for geGDP estimations as such.

Unlike the original Hueting proposition, the geGDP indicator is not obtained as an 'adjusted aggregate' by subtracting specified quantities from the conventional GDP. Rather, it is indeed the conventional GDP being estimated for a (hypothetical) adjusted economy.

These brief paragraphs of history show clearly the coexistence of two distinct adjustment concepts: first, an adjusted aggregate for an existing economy, and second, the adjustment of the economy. These two concepts can both, we will affirm, be the basis of a useful sort of 'environmentally adjusted national income' figure. The **Table** below highlights the four combinations that are logically possible.

\* For simplicity, though at the price of some technical inconsistencies, we refer throughout this section to NDP and GDP, and do not dwell on conceptual and estimation differences of 'national' and 'domestic', and 'product' and 'income' that are, in this immediate context, secondary. (The same is not as true for the inter-country considerations to be raised in **Section III**).

Note also that, if one wanted, there could be a 'greened economy NDP', by applying conventional procedures as in the case of the 'normal' GDP and NDP. This does not materially affect the arguments and typology that we want to develop

- The **TOP LEFT** box refers to the 'traditional' macro-economic indicators based on the standard national accounting conventions for estimating GDP and NDP.
- In the **TOP RIGHT** box, there are 'environmentally adjusted' net domestic product figures (often called EDP) for an existing economy. These are based on using an enlarged asset boundary when assessing *net asset change* for the national economy during the current accounting period. We introduce the acronym **AICCAN**, meaning **Aggregate Indicator for the Change in the Current economic Assets of the Nation**. The 'environmentally adjusted national income' or 'green NDP' is then defined as this net asset change (net savings) plus national consumption. Both consumption and asset changes are valued using current prices (or, in the case of environmental assets for which real prices don't exist, using shadow prices obtained by reference to other goods or costs for the current period). This gives an '**environmentally adjusted**' or '**green**' NDP for an unadjusted economy. analyses (see **Section II.3** below).
- In the **BOTTOM LEFT** box, there are the '**unadjusted**' GDP and NDP for an '**environmentally adjusted economy**'. These are figures obtained for a hypothetical economic structure, using suitable statistical and analytical techniques, responding to the question: *What would be a feasible macro-economic performance, is the existing economy were modified so as to respect specified environmental performance standards?* These are '**greened economy GDP**' figures, henceforth as geGDP for short. Such figures may be obtained notably by comparative static and dynamic scenario modelling analyses (see **Section II.5** below).\*

	<b>System boundary (capital stocks included in the measure of asset value change)</b>	
	Usual set of produced economic assets	Enlarged to include all produced assets plus specified environmental and other assets

<b>Reference economy for</b>	Statistics for the current really existing economy	<b>[A-1]</b> The traditional or 'unadjusted' GDP and NDP (NDP = consumption + net savings)	<b>[A-2]</b> An 'environmentally adjusted' Domestic Product for an enlarged portfolio of national assets
	Shadow aggregates for a model economy respecting environmental performance standards	<b>[B-1]</b> GDP and NDP 'volume' measures for an 'environmentally adjusted economy'	<b>[B-2]</b> (...waiting to be done...)

The top right and bottom left boxes each involve only one of the two forms of 'adjustment' to estimation procedures. The bottom right box provides, logically, for indicator measures that combine both types of adjustment together. This combination; which involves hypotheses about changes to economic structure or activity patterns together with a shift of the asset boundary for accounting purposes, is of conceptual and policy interest for forward-looking analyses (Faucheux & O'Connor, 2000), but systematic estimations of this concept have not (as far as we know) yet been developed.

We next make brief expositions that situate these adjustment procedures, the statistical entities — or hypothetical macroeconomic attributes — that they measure (or try to measure), and the valuation concepts typically associated with each of them. These discussions, making up the rest of **Section II**, are the underpinnings for the synthetic remarks, in **Section IV**, on appropriate policy uses of the distinct aggregate indicators that each adjustment procedure can give rise to.

## II.2 Valuation of Natural Capital — the Frontier of Monetisation

\* The Frontier concept was elaborated, at the initiative of Martin O'Connor and Anton Steurer, during the March 1999 Workshop of the European Union funded Concerted Action 'EVE' (Environmental Valuation in Europe), held in Paris, on the theme of Natural Capital. The concept with its essential motivation was presented in O'Connor & Steurer (1999), and the published exposition is found in O'Connor (2000), **EVE Policy Brief No.3, Natural Capital**.

Much debate in the fields of greening the national accounts and in the evaluation of trade-offs between environmental and other economic, fiscal and social objectives, turns around the question of the usefulness of monetary valuations of environmental assets, goods and services, and degradation. Reflection around this question has led to the development of a simple heuristic concept, the *Frontier of Monetisation*. Valuation methodology debates hinge around differing views on the extent to which monetary valuation can be scientifically meaningful, and the policy relevance, or not, of the monetary figures.\*

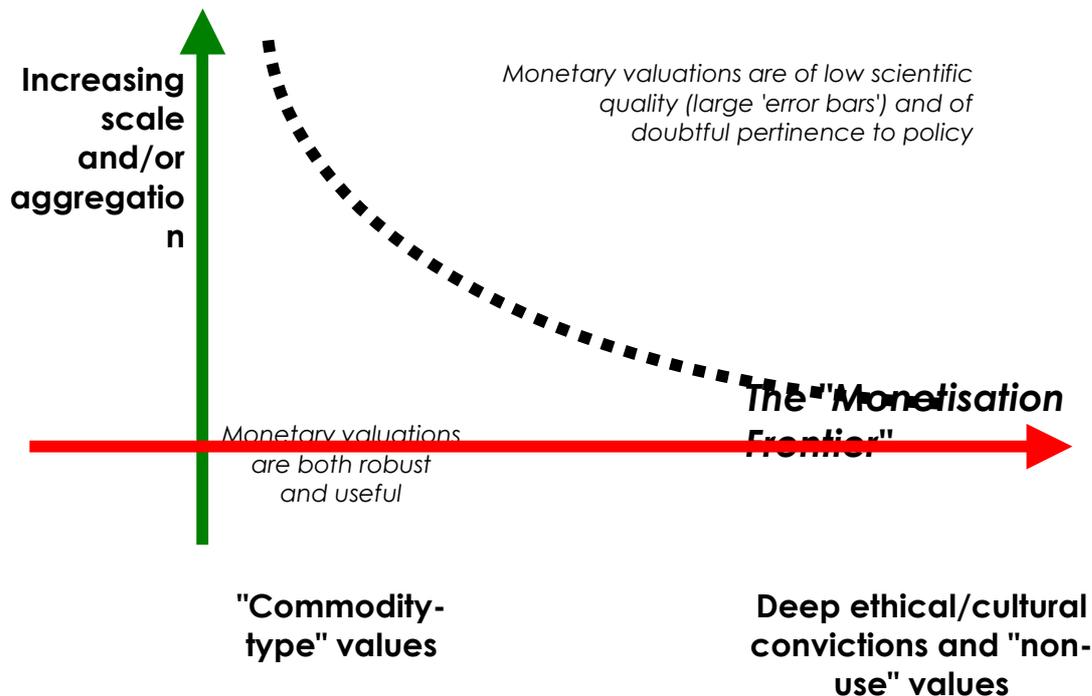
O'Connor & Steurer (1999) suggested that it is particularly useful to distinguish two main dimensions along which these debates are aligned. The first concerns matters of scale and aggregation, the second concerns the kinds of value involved.

- On the one hand, where the physical and temporal scales of the systems under scrutiny are very large (e.g., climate and marine ecosystem changes, irreversible genetic and toxic chemical transformations), the scientific uncertainties about what may come to pass are inevitably high. The definition of relative opportunity costs, as required for monetary valuation estimates, becomes difficult and sometimes arbitrary.
- On the other hand, sustainability policy choices include ethical components. In part these are seen in questions of present fairness, as in North-South redistribution, and also in the equity issues relating to future generations, to the opportunities afforded to them and to the dangers and burdens we have imposed. In part they are seen, also, in the debates about the moral acceptability or social justifications for (e.g.) intervening in the genetic integrity of organisms, destroying habitats of endangered species... This touches on

\*\* A similar structuring of problems of quantification and pertinence has emerged in the domain of risk and uncertainty in contemporary applied science. In work by Jerome Ravetz and Silvio Funtowicz, the concept of *Post-Normal Science* has been developed as an orientation in science practice for major environmental management issues. It is a perspective to be applied when, typically, facts are uncertain, values in dispute, stakes

environmental valuation dimensions such as heritage and existence values, and also so-called intrinsic value.

The considerations can be portrayed schematically, as below.\*\* The idea is to highlight zones where monetary valuation is relatively more, or less, meaningful and policy-relevant.



The scale consideration, along the vertical axis, has important consequences for aggregation, hence for all work with monetary macro-economic aggregates applying broadened monetisation boundaries. Any attempt to establish a monetary figure for changes in natural capital stocks or in the value of environmental services at a comprehensive national or global scale, will encounter systems uncertainty and time-scale related complications. Where systems complexity is high and relevant time-scales of environmental effects (or their economic feedback consequences) are long, such as with climate changes or biodiversity reduction through ecosystem modification, the resulting aggregate numbers will be of low quality from a scientific point of view. Putting low-quality numbers — which may have parametric uncertainties of one or two orders of magnitude (or more) — in quantitative relation to other statistics of more small-scale economic phenomena (such as current sectoral output measured on a firm by firm, sector by sector basis) will degrade the statistical quality of the aggregates. This loss in quality can, in turn, interfere with policy-relevance.

The value type consideration, along the horizontal axis, has important consequences for aggregation and also for measurability per se. An example would be to seek willingness-to-accept or willingness-to-pay figures, from peoples whose ecological base of subsistence such as forest or coastal waters, is menaced by a development project such as oil or mineral exploitation, or deforestation and cattle ranching. This axis also brings into sharp focus the question of the pertinence of monetary valuations. Where cultural or ethical convictions are fundamental, and where the values of nature in question are not oriented uniquely towards commodity production and consumption but involve notions of self, of justice and honour, cultural identity, cosmic harmony..., then the management conflict resolution problems do not take the form of an economic optimisation. Some quantification of the opportunity costs of respecting this or that value commitment may be pertinent,

but this is more in the context of assessing the re-distribution of economic opportunities and the sustaining, or not, of different types of human community. Aggregate monetary measures of resource value or depreciation do not address the key policy issues.

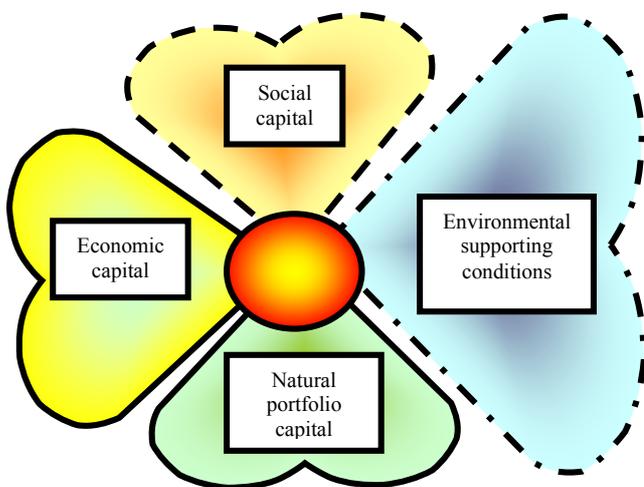
**Where Should the Monetisation Frontier be Drawn, and Why ?**

The AICCAN and geGDP measures are based on quite different conventions about where to situate the Monetisation Frontier and how to work at, and across, the boundary. This results in quite different quantitative accounting requirements as well as distinctive policy relevance. In order to appraise the usefulness of each class of adjusted aggregate, it is important to specify the sorts of economic action or policy objective that they are addressing. In this regard:

- The AICCAN-type monetary measures of net asset change involve the assessment of natural resources and assets essentially from the point of view of their contribution (actual or potential) to the production of commercially priced goods and services (trees into wood products, human health for its impact on worker effectiveness, for example).
- The greened economy GDP, or geGDP, by contrast, assesses the significance of natural capital systems in non-monetary terms and gives an indicator of prospects for maintaining economic development while ensuring the maintenance of the environmental functions of natural capital in situ — that is, as sites, scenery, scientific interest and ecological life-support in complement to human economic activity.

Let us first appraise the feasibility and pertinence of monetary valuation for different

categories of natural capital for inclusion in a AICCAN-type adjustment process. The key classification issues for valuation can be portrayed by a 'shamrock diagram' (see below), which distinguishes the main classes of a society's capital. Three inter-related questions arise.



- What is to be placed in the petal of natural portfolio capital and what is to be left over on the right hand side in the environmental supporting conditions?
- Where, more generally, will the Frontier of Monetisation be drawn, separating societal and environmental assets whose value to society is presented in monetary terms, from assets whose significance is defined through non-monetary indicators, goals and sustainability standards?
- What methods can be used, in each domain, for obtaining the needed quantifications?

A great part of produced economic capital can be inventoried, and aggregated, in monetary terms; this is the usual work of traditional national accounts. It is also widely agreed that certain elements constituting 'natural portfolio capital', such as standing forests or proven mineral resources, can be inventoried in monetary terms. The categories of social capital and the supporting physical environment, that are outside the commercial sphere, might also, in principle be inventoried with an appropriate variety of quantitative and non-quantitative monetary indicators. Where do we draw the line, and why?

The extent to which particular categories of assets, or damages to them, or other changes, can or should be evaluated in monetary terms, is a wide open question that has been energetically addressed, for more than 30 years, by a wide range of

economists, theologians, philosophers, accountants, ecologists, and persons from many other disciplines.

Answers to the question, what is to be placed in the 'leaf' of natural portfolio capital and what is to be left over?, may be partly circumstantial. But a number of broad considerations may be put forward, which we will discuss with reference to 'Weak' and 'Strong' precepts for sustainability.

\* For example, Barbier and Markandya (1990). For a review of the literature, see Faucheux & O'Connor (eds., 1998, notably chapters 2, 3 and 4).

\*\* 'Weak' sustainability is usually associated with neoclassical economics because many neoclassical theoretical results about optimal resource use make the presumption of substitutability in production and for consumer satisfaction.

\*\*\* 'Strong' sustainability is associated with various names; among its most clear cut proponents are ecological economists such as Herman Daly, Roefie Hueting, Peter Victor, Paul Ekins and Sandrine Simon.

However, it is not just a matter of ideological preference. The hypotheses are about properties of ecological and economic systems, in the context of exploration of sustainability prospects. While the 'necessary complementarity' hypothesis about the systems is difficult to test directly (unless a deliberate 'experimental' strategy is adopted of depleting important categories of natural capital to see if economic activity is

In the ecological economics literature, sustainability requirements have typically been expressed in terms of three sorts of constraints to be imposed on economic growth paths so as to respect ecological limits.\*

- that the utilisation of renewable resources should not exceed their rate of renewal;
- that waste emissions should be less than the assimilation capacity of the environment; and
- that exhaustible resources should be extracted at such a rate as permits their replacement by renewable sources.

The Weak sustainability perspective, which relies on the hypothesis of some degree of substitutability between differing types of capital for production or direct welfare purposes, would allow that each of these three constraints might be relaxed by virtue of technological progress. That is, substitution between inputs, and/or productive efficiency improvements can permit a continuous reduction in dependency on natural capital as a production input or as a sink for pollutants.\*\*

The Strong sustainability perspective, by contrast, treats major categories of natural capital as 'critical' in the sense of being strongly complementary with produced capital for the maintenance of durable economic activity. The presumption is that there are not unbounded possibilities of substitution away from environmental sources and sinks.\*\*\*

As suggested by Faucheux & Froger (1994; see also O'Connor, Faucheux & O'Connor 1994), the two perspectives can be considered complementary rather than exclusive if they are applied to complementary rather than overlapping domains. The above considerations suggest that an appropriate line of demarcation is as follows.

- The 'Weak sustainability' precepts can be regarded as applying to the exploitation of non-renewable, and also some renewable resources, to the extent that the latter are not deemed essential and permanent pre-conditions for durable economic activity.
- The 'Strong sustainability' precepts, by contrast, apply to all components of natural capital that, considered as components of functioning natural systems, are deemed necessary supports for viable economic activity. This refers, notably, to the essential roles of ecosystems in life-support services, waste assimilation, renewal of water and biological resources, and so on.

The demarcation between domains where the 'Weak' and 'Strong' sustainability precepts are respectively applied, is thus based on a fundamental difference in the role that the natural capital plays for achieving sustainability. This shows up directly in the manner in which the question of the value of natural capital is approached in each case, which means that the Frontier of Monetisation is a methodological demarcation between two zones of natural wealth:

- on the one side the resources and assets that are valued *from the point of view of their potential conversion into commercially priced goods and services* (trees into wood products, for example);

\* An analysis by Serôa da Motta (1998) on water resources for Brazil, illustrates the Weak/Strong demarcation. They describe the way they obtain monetary figures on the basis of a range of different propositions about the desirable levels of industrial and domestic effluent reduction, treatment and water purification. First, they suppose that the marginal damage to society of additional water pollution might be reflected in existing expenditures to partially clean the polluted water. They deduce a figure for the 'depreciation' of water natural capital for comparison with GNP, closely aligned to 'Weak' sustainability. Second, they estimate the economic costs associated with fully respecting norms of preserving intact the existing capital stock levels and quality. This is close to 'Strong' sustainability, and suggests an 'economic opportunity cost' for

- on the other side the assets that are valued from the point of view of their roles as *in situ* services as sites, scenery, scientific interest and ecological life-support in complement to human economic activity.

When long-run sustainability of economic activity is the policy orientation, the decision whether or not to make the valuation of an asset from the point of view of market value, may therefore be addressed on the basis of the perceived systems requirements for sustainability (depletable versus non-depletable, critical versus non-critical natural capital, etc.). The Strong perspective suggests to approach valuation from the point of view of the *economic costs of avoiding depletion or degradation*. This avoids assumptions about substitutability and about preferences on the 'demand side' of the problem, because the policy goal is maintenance of the key features of natural systems.\*

This is, in effect, the line of reasoning developed by Hueting since the 1970s. Building on Hueting's arguments and also those in ensuing years of a large number of other ecological economists, a judgement about the 'criticalness' of a category of natural capital was explicitly recognised in the **GREENSTAMP** project as a justification *prima facie* for adopting a policy norm of non-negative change to the asset in question. (We will return to this theme in Section II.4 below, where sustainability standards are also further discussed.)

Quite separately from the systems criticality considerations just outlined, there may be an institutional basis for the existence, or not, of monetary figures (prices) associated with specific categories of natural capital or services derived from them. This consists, rather prosaically, of whether or not the asset in question entails monetary or legal liabilities (e.g., emissions fees or fines, compensation for damages), or potential for commercial benefits (sale of the asset or derivatives of it). If the answer is "yes", then there will exist *de facto* some sort of prices, costs, or other fiscal elements that give some sort of indication of the direct economic significance of the asset in question. However, for various reasons already discussed (uncertainty, complexity, power relations, etc.), these money values will not necessarily signal the opportunity costs of asset use for the society as a whole.

This leads us to introduce a further consideration for affirming the pertinence, or not, of monetary valuation. The question to be posed is. Taking account of systems complexities, time-scales and uncertainties, is a meaningful and relevant monetary quantification possible for the long-term consequences of the 'asset change' in question? The answer to this question has a great impact on the policy-relevance, or not, of including monetary figures for asset change in an adjusted aggregate. The less the monetary figures are reliable as signals of long-run societal opportunity costs, the less relevance they will have as policy information at a macroeconomic level.

Having established this background on natural capital, sustainability and valuation, we now turn to the discussion of the analytical and accounting basis for constructing the different classes of adjusted aggregates. We first outline the AICCAN concept based on monetary figures for selected natural capital assets (**Section II.3**). Then we outline the basis for constructing *geGDP* measures for macro-economic performance potential subject to the constraint of respecting non-monetary sustainability standards (**Sections II.4 and II.5**).

### II.3 An Aggregate Indicator of the Change, during the Current year, in the economic Assets of the Nation (AICCAN) \*\*

The adjustment of the 'asset boundary' is a procedure that has its roots in economic capital theory where, for example, a firm estimates the value of its productive assets with reference to the capacity to sustain a revenue. At present, this approach is

\*\* The exposition in this section benefits from presentations by Kirk Hamilton of work at the World Bank, notably at the EVE Milan workshop in March 2000 and again at the ABCDE workshop in June 2000 in Paris. The theoretical underpinnings and some representative results are presented in Hamilton (2000), "Formal Models and Practical Measurement for Greening the Accounts", and extensive country results are contained in an unpublished paper, "Genuine Savings as a Sustainability Indicator" made available at the June 2000 ABCDE conference. The World Bank website gives further

strongly represented by work within the World Bank, aimed at defining and estimating indicators for changes in a country's capital stock including specified environmental resources.

\* The stock value will therefore be sensitive to the market price and, more particularly, to the time-discount rate that is employed. This can be criticised as failing to provide for sustainability. Pragmatic arguments were used by Repetto and his colleagues in *Wasting Assets* (1989) in favour of the current market interest rate, as this would yield values that were not 'distorted' relative to other market-based values. To the extent that the objective is an accounting 'adjustment' that is faithful to the existing economic situation, this rough and ready procedure can be justified, without saying more.

\*\* Empirical estimations of an adjusted aggregate taking account of a limited number of depletable resources for a cross-section of countries, were calculated and presented by Pearce & Atkinson (1993). Although making use of some country statistics, these do not constitute full 'country experiences' because the work was carried out mostly by a group of university-based researchers in a single country (the UK).

\*\*\* An example is the **GARP II** project, a recent major European study aimed at establishing monetary values for damage categories. **GARP II** applied a variety of valuation techniques as the final step in a damage quantification procedure known as *Impact Pathway Analysis*. It mainly focussed on the impacts of air pollution in terms of human health, crops and building materials. An important contribution of the project has been a

- One application of this concept, widely discussed in the late 1980s and early 1990s, is the direct estimation of the capital value of a stock of natural resources (such as standing timber of milling quality), as the imputed 'present value' of the 'annuity' — the constant perpetual income — that the stock can generate under the prevailing or anticipated market conditions.\*
- During the 1990s a variety of empirical analyses and extrapolations were carried out that addressed renewable and non-renewable resource depletion in this way\*\* and, also, sought to include estimates in monetary terms for damages incurred to natural assets (e.g., loss of productivity due to pollution).\*\*\*

Where possible, the value of environmental assets such as primary resources (minerals, oil, gas, forests) is estimated with market prices. Attempts are also made, however, to estimate losses in economic potential that are not directly reflected in market prices, such as health damage due to air pollution (morbidity and mortality) or irreversible ecosystem damages such as erosion, water and soil contamination, or productivity losses due to future climate change.

Most natural resource and environmental damage and benefit valuation work is carried out on specific topics, e.g., landscapes, ecosystems or economic project and process levels. The hope is that the individual results can be aggregated and extrapolated (by various stratagems of 'benefit transfer') up for whole sectors or national economies, thus becoming standard inputs for monetary green national accounting. However, the 'transfer' and aggregation processes often reduce statistical quality, especially where there are gaps in data or where different conventions have been applied for obtaining values that are subsequently added together. This limitation must always be kept in mind when employing this perspective on the compilation of adjusted aggregates.

We will return to valuation matters in **Section IV**. For the moment, our attention is on the character of the 'adjusted aggregate' indicator thus obtained. We take the example of the World Bank's work, which is by far the most systematically developed of its kind.

Results have by now been compiled, by the Bank, of time series for the past 30 years for selected countries. These are not quite country experiences, because they do not necessarily involve the systematic collaboration with national statistics and environmental services; rather they can be called country studies carried out by the World Bank. The figures obtained are highly dependant on the categories of environmental assets included, and this point requires further comment (see below). Yet, some rather persistent trends are clear. These include:

- very low or negative 'net savings' over many years for many South countries, for the basket of economic and environmental assets being considered;
- convincing evidence that a large range of environmental assets are being persistently depleted, in many (though not all) of the countries for which figures are produced, without much evidence of investment of the proceeds of this resource-exploitation into other productive assets.

The terminology '**genuine savings**' has been used by the World Bank analysts to refer to the net change in a country's assets. This label, although by now widely in currency, is misleading. This is for two reasons.

- First, the indicators produced inevitably take account only of a small number of 'natural assets' of a country — being limited to those for which some sort of money figure for 'change in the asset value' can reasonably easily be obtained.

It is not plausible that such monetary evaluations can meaningfully be extended to measure, as asset changes, all the changes to environmental systems and the circumstances of economic activity that are significant for the vitality and durability of a nation's economic activity.

- Second, there is not a direct link from this measure of asset change in the current period to an estimate of the country's long-run wealth-creation and income-generation capacity.

These two considerations are inter-linked. On the one hand, many environmental conditions that do not have direct commercial significance (viz., they are not 'assets' with readily quantifiable money value) are, nonetheless of great significance for long-run economic vitality and sustainability. Examples are biota, wetlands and other complex ecosystems whose environmental 'functions' may include everything from repose for sore eyes to flood moderation to climate regulation. On the other hand, even where some form of monetary evaluation is possible, the monetary valuations that can be obtained will not suffice to judge long-run 'sustainability' considerations.\*

\* The term 'genuine savings' has been popularised by the World Bank (see World Bank, 1997; Hamilton & Clemens, 2000). This is because of a presumed close linkage, in the underlying theory, to 'green net domestic product', defined as national consumption plus net savings. As already outlined at the beginning of Section II, the interest in net savings has partly grown up because of the interpretation, during the 1980s, of the green NDP (net savings plus national consumption) as an estimate for the sustainable national income for a country, which could be compared with the current consumption. (The argument was: If the net savings are negative, then current consumption exceeds the sustainable consumption level). However (as explained earlier) it is now clear that, even within the confines of the relevant theory, the green NDP and the sustainable national income are not necessarily the same. Moreover, there are impassable obstacles to meaningful calibration of relevant model parameters for a comprehensive empirical estimation procedure. In this light, interest in using green NDP as a proxy for long-run sustainable national income has greatly diminished. The term 'genuine' refers therefore to the intent to assess a 'complete' portfolio of those assets whose change can meaningfully be quantified and whose change is a policy-relevant

As we discuss below (in Sections II.4 and II.5), such a generalisation of monetary asset change measures is not actually needed for sustainability policy indicator purposes. So, for the highest usefulness of this AICCAN approach, and for possible comparisons between countries, the emphasis should be placed on a clearly specified but limited set of natural assets where monetary figures have obvious economic meaning. It is thus important also for the World Bank to put some more effort into explanation where the dividing line is being drawn between a country's money-valued assets and the (much larger) set of environmental capital not being included (see Box, below).

#### Portfolio Definition for Calculating and Interpreting an AICCAN

Suppose that a well endowed country is exploiting mineral resources, forest resources, oil and gas resources, and also engaging in intensive agriculture with heavy chemical inputs and making non-sustainable use of aquifer water resources. As accounts are developed, an estimate is made for the net asset change in each domain.

- In the cases of petroleum and minerals, unless there are new discoveries, the stocks simply diminish and, unless there are major shifts in prices that result in 'capital gains', this will immediately show up as negative contributions to net capital assets.
- In the case of forest resources, the inventory may show that current exploitation greatly exceeds the estimated forest biomass renewal rate, so this gives a further negative contribution to the change in net capital assets.
- The environmental costs of agriculture can be estimated in various ways. For example, if a result of current practices is soil erosion or salinisation, an attempt might be made to estimate the (present value of) future losses in production due to the loss of soil quality. If river or ground water contamination with nitrates and pesticides is taking place, and this water has previously been used for town supply (etc.), then an estimate may be made of the opportunity costs associated with establishing alternative clean water supply (either through water treatment plants or through exploitation of alternative sources). If the aquifer depletion would be a long-term phenomenon (e.g., recharge would require many years or decades) and/or ecological effects of lowering the water table and of possible saline infiltration etc. are significant, then estimates for these future costs, if translated into monetary figures, would also yield further negative contributions to the change in net capital assets.

The figures obtained, including the sign (positive or negative) of the net savings for a given accounting year, are thus highly dependant on the categories of environmental assets included in the calculations.

We see that, rather than having one single indicator of 'genuine savings', we have a single concept — the *AICCAN* — whose numerical estimation *depends very specifically on the portfolio of assets* that the country managers (or, in practice, their economists, environmental services and statisticians) define for their attention. This choice will, as in the analogy with a private sector firm, reflect the perceptions of a country manager about (a) his or her real capacity — or duty — to exercise a management control over the assets and (b) the real financial consequences of the management (such as resource rent revenues, export receipts, burden on the state for water purification investments, etc.).

Also to be emphasised is that the *AICCAN* is an indicator relating to a country's revenue-creation capacity under prevailing conditions (including market, political and institutional as well as environmental conditions). Examples are the depletion of oil, forest or fisheries stocks, measured using current market prices. If the direction of the net assets change, measured in this way, is persistently negative, the nation is liquidating its portfolio of assets and probably jeopardising its future economic prospects... This is, clearly, a useful and easy-to-interpret signal. In brief, an *AICCAN* helps in the *diagnosis* of an 'asset-stripping' problem — in the case that the *AICCAN* is negative or very small.

However, the diagnosis does not, in itself, tell where a *remedy* might be found. For example, in an abstract way (following arguments by Hartwick and others), it might be suggested that revenues obtained at the cost of depreciation of natural capital assets, should, for sustainable development purposes, be channelled into investments that build up other capital stocks. But, what is the appropriate balance of investment for maintenance or even restoration of natural capital, and investment in education, and investment in industry (etc.)? This cannot be answered simply by an abstract investment criterion (e.g., desirable rate of aggregate savings). The development of further concepts and of country scientific capacities for exploring prospects for 'economically and environmentally sustainable' development strategies is therefore a crucial component of national policy analyses. This opens up a distinct and complementary domain for environmental accounts and, more particularly, for adjusted aggregates, as information and tools in support of explorations of sustainable development pathways (see **Sections II.4** and **II.5** below).

The analogy can again be made between a firm and a country. A company that is momentarily making a loss may undertake a variety of foresight, forward studies, market research and scenario studies. In the same way, a country manager (or, more generally, the policy community) will engage in a variety of forecasting and strategic forward studies exercises. In the case of environmental and economic sustainability an example is the investigation of feasibility of meeting simultaneously specified economic and environmental performance goals, through the modelling of various 'environmentally-adjusted national economies', as we will discuss below.

#### Summary Recommendations for Good Practice with AICCAN

An *AICCAN* indicator, set alongside the country's GDP so that the change in capital assets, positive or negative, can be portrayed as a percentage of GDP, can be a highly useful diagnostic tool for "taking the pulse" of overall macroeconomic and environmental performance. However, in order to avoid misunderstandings:

1. It is essential to have a clear explicit presentation of what is, and is not, included in the portfolio of economic and environmental assets being considered for an *AICCAN* estimate. This portfolio can be outlined, in a presentation document, with reference to strategic development goals or management objectives of the relevant ministries, for example. It would often be appropriate to list the key

\* The same structured approach — setting monetary investment/dis-investment considerations in a complementary relationship with a portrayal of non-monetised aspects of societal health — should be taken for the complex of 'social capital' and societal infrastructures that, as outlined in the Introduction to this paper

categories of assets, showing how (positive and negative) changes in quantity and (positive and negative) changes in price contribute, in each case, to the change in the given accounting period of net asset balance. This can be repeated period by period, for producing indicator time-series.

2. It is essential that, in complement to the assessment of the basket of assets included in the AICCAN asset balance estimation, attention be drawn to key issues of environmental services and environmental change that are not treated as 'country assets' from a monetary point of view. These key issues for integrating environmental and economic dimensions of sustainability could also be outlined in a presentation document — as a complement to the exposition of the AICCAN portfolio — again with reference to strategic development goals or management objectives of the relevant ministries.\*

## II.4 Environmental Values and Sustainability Standards

The second type of adjustment procedure focuses on the prospects for really altering the economic system, in order to improve environmental performance in a cost-effective way.

The ecological dimensions of sustainability are, in this approach, specified through non-monetary targets relating to maintaining key **Environmental Functions** such as vital natural resources, environmental waste absorption and life-support capacities, biodiversity, air, soil and water quality. An example of this perspective is given below (in Box, below), outlining policy frameworks put forward by **English Nature**.

This general orientation has important consequences for the uses that will be envisaged for both economic and environmental statistics. On the one hand, there is an economic performance question being posed: what are the prospects for development of economic activity that is less 'costly' in environmental terms (that is, a 'greened economy')? On the other hand, there is the environmental performance question: what are the key criteria by which we judge whether or not an economy has been or is being 'greened'?

Satellite accounts may be used to organise information concerning the state of the environment and key economy-environmental interface measures — that is, environmental 'pressure' indicators relative to estimates of environmental carrying capacities. Then, within this framework, estimates are developed of economic performance prospects for a national economy which is respecting, or moving towards fuller respect of, these environmental pressure standards.

\* In **English Nature's** framework, for the terrestrial environment, four broad categories of CNC are identified:  
 (1) habitats supporting rare, threatened or declining species;  
 (2) ecosystems that have full expression of a characteristic biodiversity;  
 (3) environmental service provision such as stabilisation of soil, assimilation of wastes or maintenance of water table and water quality features;  
 (4) earth sciences interest, meaning formations of exceptional geological interest or unique character.

\*\* It may be noted that the combined CNC + CNA approach is very close to the rule of 'maintaining key environmental functions'

**Constant Natural Assets and Critical Natural Capital \***

Since the early 1990s, the British agency **English Nature** has developed and tested a variety of classification schemes and proposed policy rules for the maintenance of environmental functions. They argued (English Nature, 1995) as follows:

*"The UK's current stock of environmental assets represents a level from which there should be no further loss in quantity or quality if environmental sustainability is to be achieved. It is made up of Critical Natural Capital (CNC) and Constant Natural Assets (CNA). Our Critical Natural Capital comprises those assets which are irreplaceable. Our Constant Natural Assets are made up of environmental features which may be traded in issues of land use change, but the loss must be fully and directly compensated to give no overall loss."*

An aspect of the natural environment will be classed as CNC if it is, on the one hand, essential for human health and/or for the functioning of life support systems, and, on the other hand, irreplaceable or practically unsubstitutable. The envisaged policy rule is that CNC assets, which are irreplaceable, must be afforded the strictest protection.

The concept of *Constant Natural Assets (CNA)* brings together two interesting features. First, in the term 'constant', a normative rule is implied. Second, although possibilities of replacement, restoration or re-creation are admitted, a very cautious approach is taken towards aggregation and substitution. The normative policy rule follows the criterion of a 'non-negative change' to natural capital as enunciated in the academic economics literature, viz., *"The overall levels of our CNA must not decline – in some cases they must increase"*. No attempt is made to compare very disparate types of natural assets. The idea is that, for example, an area of woodland can be cut down or built upon, or a bird habitat diminished, if a compensating area of similar forest or habitat is elsewhere established. Compensation is permitted only within each class of natural asset or identified environmental function.\*\*

The basic concepts for characterising a 'greened' or 'greening' economy are closely aligned to what we have called the Strong sustainability perspective, and are as follows:

- On the basis of physical and life science analyses, norms are set which intend ensuring maintenance of key environmental functions;
- Remedial measures are identified that would be sufficient to ensure that the economy will satisfy these norms;
- Analyses are undertaken of the economic performance potential for a hypothetical or future economy that is respecting these norms;
- Analyses can be conducted to estimate the costs that the society would need to incur, in order to achieve these norms.

These considerations place the analysis in a Cost Effectiveness framework. Broadly speaking, effectiveness is measured by reaching environmental standards, and the costs are associated with obtaining the specified improvements (or, as the case may be, of avoiding further reduction in an environmental asset or service).

The costs in this sense must be assessed in a comparative way. There is a trade-off or opportunity cost to be estimated: How much loss of income or economic output, in order to get how much gain in environmental performance? Quantitative results require specifications of, among other things, the level of aggregation and the time-scale over which an analysis is to be conducted. This is particularly important for the definition and empirical estimation of adjusted aggregates in the strong sustainability perspective. Over the past 20 years, a number of responses to this question have been developed, and subjected to refinements. We will review the main steps and methodological options.

To begin, the norms-based approach leads directly to the identification of an interesting class of non-monetary measures that can be used as indicators for sustainability. These are the **Sustainability Gaps**, measured in non-monetary units.\*

A **Sustainability Gap** is the difference between the **observed state of natural capital** (in quantity and/or quality terms) or level of *environmental pressures* that may degrade the natural capital in question, and a **threshold level** that is considered compatible with a sustainable development of the economy. For 'Critical Natural Capital' categories — judged to be essential for long-run economic and environmental sustainability — the 'gap' corresponds to the distance between the current situation and a hypothetical situation where resources/ecosystems are being managed sustainably.

On the basis of identified Sustainability Gaps, it is possible to develop estimates of costs associated with adjustments of economic activity to respect the sustainability norms. This leads to several further classes of measures, as follows:

- Sectoral costs of 'Closing the Gaps'**. Estimates may be made, for each sector of economic activity, of economic costs associated with respecting the sustainability standards. For an individual sector, costs of meeting a sustainability standard through, e.g., technological improvements, pollution treatment, substitution of inputs of over-exploited renewable resources, can be estimated with partial equilibrium methods — such as pollutant abatement cost curves.\*\*
- A National Index of the 'Distance from Sustainability'**. The adjustment costs for each sector, say  $C_i$ , may be summed to give  $\Sigma C_i$ , which is a rough and ready aggregate monetary indicator for the *Distance from Sustainability* of the current economy. This is an estimate, in terms of current consumption (expressed in money units or as a percentage of GNP), of the extent to which current economic activity violates the specified sustainability norms. It is thus also a

\* The concept of the Sustainability Gap has been systematically developed by Ekins & Simon (1999), who build on the earlier work of Huetting (1980), de Groot (1992) and others. A recent research project funded by the European Commission, the **CRITINC** project, led by Paul Ekins at Keele University, explores through case studies ways that the identification of such 'gaps' may be made the basis for analyses of technological, land use and other response options in evaluating policies for sustainable development. For a recapitulation of the

\*\* Methodological and data issues associated with the construction of abatement cost curves are comprehensively discussed by Rademacher, Riege-Wcislo & Heinze (1999), in work carried out as part of the **GREENSTAMP** project. These analyses have highlighted how the cost estimation concepts and statistical procedures applied at micro-economic (individual firm or process) level, are quite distinct from those having application at a meso-economic (sectoral) level (such as a sectoral abatement cost curve), which are distinct again from cost effectiveness

rough indication of the magnitude of the *reorientation of economic activity* that would be required to respect the sustainability norms.

Care is required with the use and interpretation of the above indicator information. Analyses at a sectoral level of the economic costs of 'closing the gaps' are usually made on the basis of estimating costs of input substitution or pollution control with current market prices. This is a satisfactory procedure, for sectoral policy, as long as the adjustments in question are small compared with the overall volumes of economic activity. At the national aggregate level however, quite different considerations apply.

Hueting's original idea, as mentioned already in **Section II.1**, was to estimate an 'environmentally corrected' national income through subtracting the costs of 'closing the gaps' away from current GDP.\* The formula proposed was of the form:  
**ENI = GDP - ΣC<sub>i</sub>.**

However, this is not a reliable way of estimating a 'sustainable national income', for two reasons.

First, the intention of this analysis is to estimate what level of national income could have been generated, in the existing economy, if the specified sustainability standards had been respected. But, the formula as written does not take account of the whole-economy effects of re-allocations of economic resources between sectors associated with meeting the sustainability standards.\*\*

Second, the main interest for policy in estimating costs of respecting sustainability standards, is to assess what level of national product might be feasible, looking into the future, for the economy while respecting the sustainability standards. But almost certainly, the Hueting formula significantly under-estimates the *sustainable national income* potential in this forward-looking sense. In order to answer this policy question, one must model the *potential* of the (future) economy as a whole, subject to the sustainability standards as constraints.

## II.5 Estimating a 'greened economy' GDP, the 'geGDP' Concept

The basic preoccupation that lies behind the Sustainability Gap concept, is to provide the platform for assessing ways of re-orienting an economy to respect environmental sustainability standards. Re-orientations of economic activity to improve environmental performance, such as reductions in pollutant emissions, do often have significant economic costs. These costs may be set against the environmental benefits in a Cost Effectiveness appraisal. A monetary figure can be sought for the minimum cost that would have to be borne in order, through preservation, prevention, protection or restoration measures, to respect the designated sustainability norms. This would then be a quantification of the opportunity cost of achieving sustainability, expressed in money terms as an amount of consumption that would have to be forgone by the society to achieve or maintain the specified levels of environmental functions. Such analysis thus aims at quantifying the policy trade-off between: (i) depleting/degrading environmental functions (critical natural capitals) by not making the adjustments required to satisfy the norms; and (ii) forgoing consumption and/or using up economic capital if it makes the resource commitments required for achieving the norms. However:

- It must be made clear whether cost estimates are being made for an individual firm, or for a sector as a whole based on a least-cost allocation of effort, or for the whole economy. If the concern is with national aggregate indicators, then the relevant indicators must be obtained on the basis of a whole-economy analysis. This means that comparisons will be made between a non-adjusted and an environmentally adjusted economy (or, more generally, between several differently adjusted economies — viz., comparative scenario analysis).

\* In addition to the early formulation in Hueting (1980), see notably, Hueting (1991) and Hueting, Bosch & de Boer (1992).

\*\* This limitation was comprehensively assessed in the **GREENSTAMP** project (see Brouwer & O'Connor (eds., 1997a, 1997b; Brouwer, O'Connor & Radermacher, 1999). Major investments in abatement technology or in new technological options will impact on relative prices and economic resources available for other sectors. Further, if technological measures within a sector are not able to achieve the goal at reasonable cost, a policy option is to reduce the output of offending sectors, which again liberates economic resources for other sectors. These issues had been noted by Hueting himself, who suggested, as a first approximation, to reallocate the 'cost savings' from sectoral volume reductions, to non-offending sectors. Where major adjustments of economic activity are under consideration, a whole-economy analysis is nonetheless called for. Such an analysis, using a computable general equilibrium model for adjustments to economic activity according to the Hueting precepts, has recently been carried out

- The time scale of assessment needs to be specified. What may appear as a high cost for a firm, for a sector or for the national economy if measures are implemented in the short term, may be a relatively low — or even 'negative' — net cost if adjustment and investment opportunities are appraised over a longer time-frame. Since sustainability is the concern and adjustment processes take time, the opportunity costs for forward-looking policy should usually be estimated in an inter-temporal analysis framework.

The environment is 'taken into account' not by direct monetisation but through quantification of the opportunity costs for a national economy associated with the respect of specified environmental standards. This is cost-effectiveness analysis carried out at a macro-economic level. Typically it may be carried out through comparative static or dynamic scenario modelling approach which permits the definition and estimation of macro-economic indicators for an 'environmentally adjusted economy', or, in other words, a 'greened economy GDP' (and also, if one wanted, a 'greened economy NDP', etc.). Such indicators measure *the value (in money units) of the feasible economic production for the accounting period or periods in question, subject to the condition that the economy is respecting a specified set of resource stewardship goals or environmental standards.*

#### Estimating a Greened Economy GDP

The *geGDP* concept and its policy relevance has been explored in the context of the **GREENSTAMP** project (mentioned in **Section II.1**), whose aim was to develop a methodology for the actual calculation of the prospects for a national economy constrained by environmental standards. Application of the cost-effectiveness at a whole-economy level, through comparative static or dynamic scenario modelling approach, leads to a particular conception of an environmentally-adjusted national product, namely a greened-economy GDP.

*The greened-economy GDP, or geGDP, refers to the feasible economic production, for the accounting period(s) in question, subject to the condition that the economy is respecting the specified set of environmental standards.*

It is also worth noting how — again at the macro-economic level — a quantified response is given to the valuation question, "How much is a country's environmental performance level worth?" in the sense of identifying the economic consumption or investment options that a society may choose, or might have chosen, to put aside in order to pursue the environmental objective (see also **Section IV** below).

Several variants of indicators can be compiled within this category of aggregates. Their general purpose is to appraise, in an integrated way, the potential for future environmental and economic performance and, more particularly, to permit quantification of economy-environment policy trade-offs at the macro-economic level — that is, estimating output losses or economic opportunity costs associated with improving environmental performance, the latter being measured by reductions in specified environmental pressures at the aggregate national level. In this respect, the key accounting conventions are:

- The Frontier of Monetisation is set at the interface between economy and environment where the non-monetary environmental pressure criteria are specified. No attempt is made to place monetary values directly on natural assets.
- The adjustments being considered in this procedure involve the economy being modelled, not just the accounting conventions. The 'greened economy GDP' is

an indicator about possible future performance integrating economic output and environmental standards as complementary criteria of performance.

- ❑ The 'greened-economy GNP' does not set out to measure overall welfare delivery, because it quantifies only one part of welfare delivery (viz., the produced economic output that is or would be feasible subject to environmental performance constraints). It does not try to monetise the direct environmental contributions to welfare. (Many analysts would anyway argue that attempts to evaluate in a comprehensive way the welfare contributions of nature to humans individually and collectively, on a monetary scale, is misplaced.)
- ❑ The key roles for economic and environmental statistics are not directly to furnish data which is compiled into an 'adjusted aggregate', but rather to organise and compile the relevant data sets that are needed as inputs into the modelling work that will generate the indicators for the 'adjusted economies'.

Building on this basic characterisation, we now outline the main variants in the ways that a *geGDP* may be specified and estimated. Some of the diversity relates simply to the variety of models that might be employed, and to the coverage of different environmental pressures. We do not go into these, rather our interest is to define the distinct concepts that exist. There are three sets of distinctions to be made, and each *geGDP* indicator estimation procedure can be classified according to where it lies along each line of distinction.

### I. Ex post versus ex ante appraisal

The first distinction refers to the difference between:

- an estimate of what the existing economy might have been able to produce if (counter-factually) it had been required to respect tighter environmental performance standards, and
- an estimate of what the national economy might (hypothetically) in the future be able to produce while constrained to meet specified environmental pressure standards.

We say that the first approach is **ex post** or '**counter-factual**' because it responds to the question, what *would have been* the feasible output of an existing economy if sectoral activities are restricted and/or economic input resources are engaged to reduce environmental pressures to levels deemed acceptable.

We say that the second approach is **ex ante** or **hypothetical** because it seeks to explore future macro-economic performance potential subject to environmental performance requirements. It should be noted that such futures studies can use back-casting and comparative static analyses of alternative economic structures, as well as iterative dynamic simulations.\*

\* The *ex ante* scenario-based approach was recommended as having pertinence in the European Commission's GREENSTAMP project in 1994-96 (see Brouwer & O'Connor 1997a, 1997b; Brouwer, O'Connor & Radermacher 1999). However, this project did not, itself, include any new modelling. Rather it noted the pertinence of experiences around the world with 'greened economy' scenarios since the 1970s.

The *ex post* approach is most clearly associated with the work of Hueting, as represented in the recent whole economy

### II. Snapshot (comparative static) versus dynamic simulation modelling

Whether *ex post* (counter-factual) or *ex ante* (hypothetical) analyses is being conducted, a plausible and internally consistent estimation of economic opportunity costs of supplying sustainability requires use of a multi-sector economic modelling approach. Typically, this can be either (or both) of:

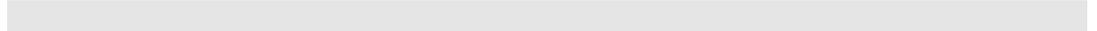
- comparative static** analyses of economic structures and related environmental performance;
- dynamic scenario** modelling.

Such modelling, while inevitably involving various simplifying assumptions and postulates about technologies (etc.), takes into account the inter-dependent adjustments between sectors. Many different types of economic change can (and must) be considered in analysis. Examples are: expenditures within production sectors to improve efficiency of resource use or to reduce polluting emissions per unit of output, through changes to technologies; shifts between different natural resources or physical locations of environmental exploitation, including exploitation of renewable resources and respect of sustainable yields or assimilation capacities; replacement of products or activities by alternatives less noxious for the environment, that is, changes to products and consumption patterns. Dynamic simulation or scenario analyses must, in addition, make explicit hypotheses about the timing of various policy and investment responses.

In a comparative analysis, one assesses the difference between the consumption opportunities associated with a transition towards sustainability, and the consumption opportunities (presumably higher in the short term) associated with a trajectory that depletes or degrades critical natural capital. In principle, more than one 'greened economy GDP' figure or time series might be calculated. In a comparative static analysis, essentially alternative feasible structures of economic activity are compared; in the simplest case, a non-greened economy GDP is compared with a geGDP. In a comparative dynamic scenario analysis, the time-

\*\* The scenarios then furnish information about opportunity costs, distributed through time, associated with meeting the specified environmental targets. A good exposition of this analytical perspective is found in the empirical modelling studies carried out at French national and regional levels, for atmospheric emissions (including greenhouse gases) and agricultural pollution respectively, by Schembri (1999a, 1999b); Schembri & Douguet

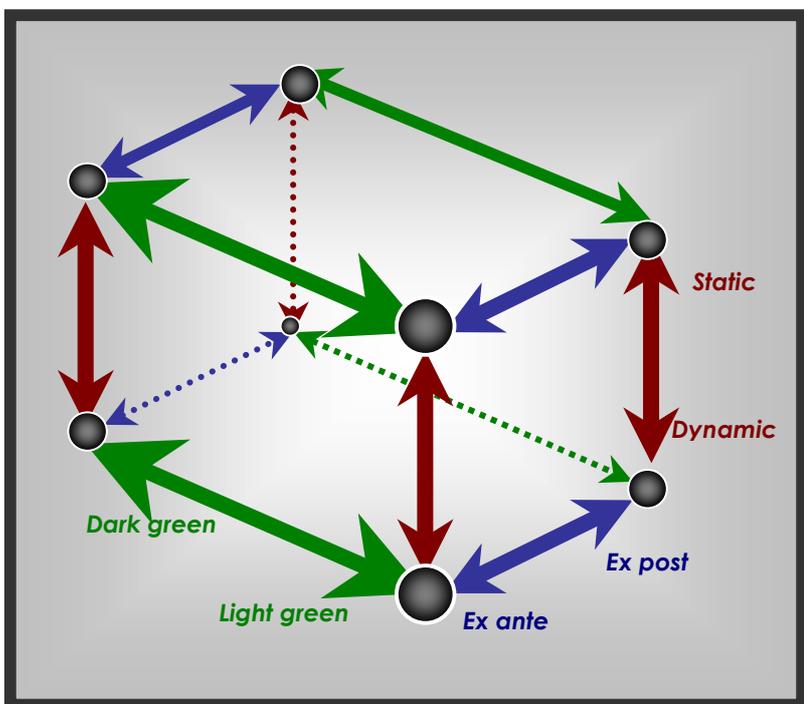
trajectory for the respective consumption aggregates can be compared in terms of relative growth/abatement rates for final consumption and environmental pressures.\*\*



**III. Complete or only partial respect of requirements for long-run sustainability**

Figures for *geGDP* will depend partly on environmental standards specified, on demographic assumptions, on hypotheses about future consumption patterns, the environmental standards imposed and the technological options explored. So the distinction should be made between:

- ❑ A model 'greened economy' or transition path that respects **all** environmental standards felt to be requisite for long-run sustainability of economic activity and the relevant critical natural capital (we will call this '**dark green**');
- ❑ Model analyses for 'environmentally-adjusted' economies that are constrained by only an **incomplete** set of standard such that, while perhaps 'greener' than a business-as-usual scenario, the future economy still does not achieve full compliance with ecological requirements needed for long-run sustainability (we will call this '**light green**')



**Examples of Modelling Exercises that do or could furnish *geGDP* Indicators**

In the paragraphs below we give some selected examples from published literature, corresponding to different combinations of the three distinctions outlined above. The classification schema establishes the existence of  $2 \times 2 \times 2 = 8$  distinct combinations, or ideal types, of *geGDP*. These are represented schematically by the corners of the cube in the diagram on the left.

In reality, modelling and statistical practices will not necessarily be found 'at the corners'. For example, scenario modelling can be partly dynamic or iterative; and there is a continuum between 'light green' and 'dark green' depending on the range of environmental performance goals that are incorporated. So this schema is intended simply as a guide to understanding and as an aid to interpret results and to choose

modelling techniques for different policy purposes.

- ❑ The *ex post* approach is exemplified, as already mentioned, in the analyses developed by Roefie Hueting and his colleagues at The Netherlands CBS over the years (Hueting & De Boer, 1999, 2000). These analysts initially presented formulae for the subtraction of abatement/restoration (etc.) costs from current national product, meaning that they were not constructing a *geGDP* in the sense outlined here. However, the rationale for the environmental performance standards is the permanent maintenance of important 'environmental functions'; the approach clearly seeks to specify a 'cost-effective' economy respecting environmental standards. The most recent work in this lineage, reported in a very rigorous documentation (Verbruggen, ed., 1999), uses a full-economy computable general equilibrium modelling approach with careful attention to specifying sustainability standards for all major sectors and a large range of environmental pressures. This set of results, which show the high sensitivity of the aggregates to the standards adopted (notably for some toxic metals emissions) is by far the clearest full empirical example of this class. We

place it in the category *ex post-static-dark green*, at the top back left of the cube.

- ❑ An example of *ex ante* comparative static modelling incorporating a wide set of environmental standards (viz., category *ex ante-static-dark green*; at the top front left corner) is the study by B. De Boer, M. de Haan and M. Voogt (1994), "What would Net Domestic Product Have Been in an Environmentally Sustainable Economy? Preliminary Views and Results", in the Papers and Proceedings of the Meeting on National Accounts and the Environment, London, 16-18 March 1994.
- ❑ *Ex ante* scenario-based analyses focussed around the 'trade-off' between macro-economic output performance and environmental pressure performance, can readily be found. Examples treating atmospheric pollution including greenhouse gas emissions, are found in work using a numerical dynamic multi-sector model with an input-output core (the model M3ED), reported by O'Connor & Ryan (1999) and Schembri (1999a, 1999b) for the French and Netherlands economies. This work illustrates the category *ex ante-dynamic-light green*, at the bottom front right corner. A similar dynamic modelling exercise evoking the question of 'balancing pollutant emissions and economic growth' is reported by Crane (1996) for the U.K. economy.\*
- ❑ Modelling work by Lange (1997), building on the general perspective of Duchin & Lange (1994), uses a multi-sector dynamic input-output framework with analytical solution techniques, to explore possible evolutions in natural resource requirements for the Indonesian economy as a function of technology choices and growth scenarios. This modelling treats a spectrum of environmental pressure categories in a relatively integrated way, although it did not specifically set out to estimate *geGDP* for a scenario respecting designated environmental performance targets. It could also be classed in the category *ex ante-dynamic-light green*.

\* There is a lot of 'grey literature' reporting scenario modelling studies. For example, unpublished work by Ryan (1996) has modelled scenarios for primary energy use, output growth and acid rain and greenhouse pollutant emissions for the New Zealand economy. A major study led by Foran (1999) in Australia has investigated land use and sectoral prospects for an

These cases illustrate diversity in the field, without trying to cover all scenario exercises that might be unearthed. It is important to note that all *geGDP* estimates, whatever the concept that they engage, are highly sensitive to model calibration, specification of environmental standards, technological change and other hypotheses.

## II.6 The Complementarity of the AICCAN and *geGDP* Indicators

The original ambition behind the definitions and estimations of environmentally adjusted aggregate indicators was to furnish guideposts to policy, helping to chart national economic development paths and to evaluate trade-offs between output growth, final consumption and environmental performance objectives. We conclude that both of the indicator concepts outlined in the pages above — the AICCAN current-period figures for money-valued net asset change, and the *geGDP* scenario analyses for long-term economic and environmental performance trade-offs — can contribute importantly to policy orientations. Each can play a role in the iterative policy process of identifying options and informing social actors about the directions of action and economic change that may promote sustainability. They address different, and to some extent complementary, sustainability issues.

- ❑ The AICCAN indicator of net change in economic assets, enlarged to include commercially valued natural stocks, is an important indicator for a country manager looking at the prospects for revenue generating activity in the short and the medium terms.
- ❑ But, as outlined in **Section II.3**, the establishment of measures of net asset change in monetary terms does not reduce the need *also* to specify targets for the

ecological aspect of sustainability, viz., the maintenance of critical environmental functions.

- Long-term sustainability prospects — to enhance economic performance while maintaining critical environmental functions — can be addressed through exploratory scenario modelling which, as outlined in **Sections II.4 and II.5**, is the basis for geGDP estimations.

The two types of indicators — AICCAN and 'greened economy GDP' — are thus useful complements. But they are not substitutes for each other. They refer to quite different economic entities; they address distinct roles of natural capital; and they treat the question of investment (or dis-investment) in natural capital from quite different points of view.

## Section III

# Adjustments for Inter-country Environmental Load Displacement

### III.1 From 'Costs Borne' to 'Costs Caused' — Introducing a Third Adjustment Concept

In the previous section of the paper we dealt with two adjustment procedures for a national economy, first the enlargement of the portfolio of assets which is the object of monetary accounting and, second, the (modelling of the) adjustment of the real economy for improved environmental performance. There is a third type of adjustment that must also be considered. This is the question of adjustment to national accounting conventions and, more especially, to indicator definitions in order to take account of *external linkages between national economies*.

Direct economic linkages between national economies are dealt with, more or less conventionally, via the accounting of balances for exports and imports, and capital flows. These accounting categories allow the important distinction to be made between a nation's domestic product, and its income (which, relative to the domestic product, may be augmented/diminished by inflows/outflows in such categories as repatriation of funds, international development aid, interest/debt servicing payments, direct commercial investment, and so on). Net income flows across national boundaries can, in some cases, reach the same order of magnitude as the annual national product and thus be a major influence on a country's economic activity. In this paper, however, we do not further discuss these financial interdependencies as such.

Of more particular interest is the accounting of inter-country environmental linkages, viz., indicators of direct and indirect ecological dependence of a national economic activity on the Rest of the World. Despite many years of research and political interest, there is not, as yet, a systematic national accounting for the important category of *environmental services and damages provided to and received from the Rest of the Planet*. This is an admittedly complex topic with formidable data as well as conceptual challenges. It is, however, important for policy relevance to be able to situate national macro-economic indicators in their context of regional and global ecological — as well as economic — interdependencies.\*

Examples are the direct and indirect dependence of a national economy on the world community for primary energy, water, agricultural land and/or photosynthesis potential, fisheries harvest, stockage of toxic wastes, emissions of atmospheric pollutants such as greenhouse gases, and so on.

These indicator concepts — variously called '**ecological footprints**', '**ecological rucksacks**', '**environmental load displacement**' indicators and other such names — address the inter-national distribution of ecological inter-dependence. Such

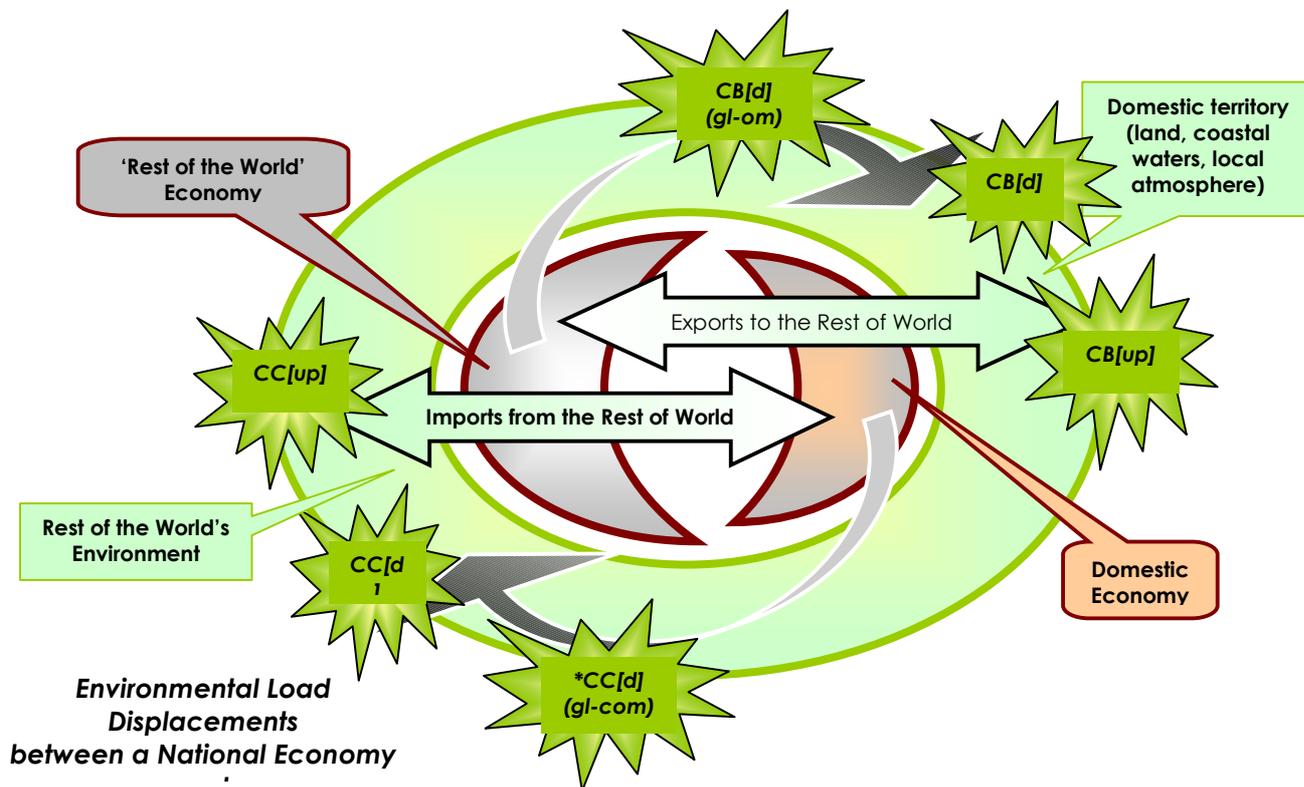
\* The recently published United Nations Operational Manual on *Integrated Environmental and Economic Accounting* (Alfieri & Bartelmus, eds., 2000, p.156) merely notes, without elaboration, that "physical and monetary information on trans-boundary pollution will be essential to developing international strategies that address this problem and assessing financial compensation of receiving countries by polluting ones."

I thank my colleague Roldan Muradian for his work collating and appraising the literature examples exploited in the

indicators have an obvious policy relevance for international relations, notably in the negotiation of notions of equitable distribution of access to the benefits of — and the costs of sustaining — the planet's fund of ecological goods and services. In particular, the integration of the inter-country dimensions of ecological goods and services requirements may significantly alter the estimation results, or the interpretations, for policy indicators such as AICCAN and geGDP based on national economic territories.

The AICCAN and geGDP approaches as outlined in Section II above, typically refer to depreciation of natural assets taking place within the country (that is, on the national territory, or in territorial waters, etc.). Yet, a significant part of these environmental changes for the national territory may nonetheless be 'caused' by foreign activities. And conversely, a nation may be the cause of natural resource depletion or environmental damage outside its own territorial borders. Thus, an extremely important distinction is to be made between depreciation or damages to natural capital 'borne by' a nation's territory and the depreciation or damages 'caused by' the nation's economic activity (see diagram below).

The chains of causality between local economic activities and foreign environmental consequences may be more or less direct. In a general way, it is useful to distinguish between 'upstream' [up] and 'downstream' [d] directions of the impact between the domestic economy and the rest of the world.



In the schema, we represent the main categories of environmental load displacement from the point of view of a national economy in relation to the rest of the world. On the one hand there are 'costs borne' (CB) by the national economy, due to economic activities taking place in the rest of the world. On the other hand there are 'costs caused' (CC) by the national economy that, rather than being felt within the national economy, are displaced onto other economies elsewhere in the world.

It may be argued that, in order to assess the national economy's responsibilities in an international context, measures of environmental pressures or of natural capital

depreciation should be 'adjusted' by, on the one hand, subtracting the 'costs borne' (- CB) that are imposed from other economies, and, on the other hand, adding the 'costs caused' (+ CC) by the national economy but displaced onto the rest of the world.

Within this overall framework for indicator adjustment, we further distinguish two fundamentally different mechanisms of load displacement, as follows:

□ **'Downstream' impacts [d]** are damages and depreciation of natural capital occurring in one country that are directly caused by another country's (or, more generally, other countries') production and consumption activities. In the schema these are shown as damages **CB<sub>[d]</sub>** imposed by the Rest of the World on the domestic environment/economy and **CC<sub>[d]</sub>** imposed by the domestic economy's activities on the Rest of the World environment/economy. This depreciation is often attributed to the 'side-effects' of economic activity — such as trans-boundary pollutant emissions, associated with the 'sink' category of environmental functions.\* However, all categories of environmental functions should be considered (site, scene, source of energy and raw materials, and life support). Economic activities can provide trans-boundary physical disturbances or ecological disruptions, for example water extraction on the national territory that alters conditions of access to water for other nations (including damming of rivers and even cloud seeding); fishing within territorial waters or activities in littoral regions that affect fish populations for other fishing nations; and forest resource exploitation within the national territory that may lead to changes in water quality, dust storms and climate at wider regional scales.

□ **'Upstream' impacts [up]** are environmental damages occurring in one country (that is, the land, coastal or territorial waters and local atmosphere) in the course of production of goods and services which are exported to another country. The importing country is thus implicated in the environmental damage associated with the goods/services it consumes. An example of 'upstream' damages 'caused by' a national economy, written as **CC<sub>[up]</sub>**, would be the importing into the national economy of food products grown in other countries where there is degradation of aquifers and soil resources. An example in the other sense, of 'upstream' damages 'borne by' the national economy, written as **CB<sub>[up]</sub>**, would be the exporting of refined ore or metal products from a country which suffers local extensive air and water pollution and ecological degradation due to the minerals extraction and energy-intensive refining activities.\*\*

The importance of the distinction between 'costs borne' and 'costs caused' for setting and achieving environmental policy targets, is immediately clear by reference to the two categories of aggregate indicators AICCAN and geGDP. On the monetary side, an AICCAN figure may change considerably if depletion or degradation of foreign natural capital caused by the local economic activity is taken into account, e.g., imports of timber and other forest resource products, imports of fossil fuels, and so on. On the non-monetary side, the feasibility and economic costs of achievement of goals for reducing environmental pressures within a national territory — as may be incorporated into modelling to estimate geGDP figures — will depend partly on whether the pressures are caused by domestic or offshore activity. The example already given of acid rain deposition in European countries, illustrates this rather well.

Are policy targets to be set in relation to damages caused or damages borne? In terms of national welfare, the **damages borne** by the nation can seem a rational reference point. However, this focus could lead to policies deliberately aiming to off-load or export environmental pressures onto other countries (e.g., relocation of 'dirty' industries, dumping of toxic wastes offshore...), which obviously would provoke objections by the victims of such practices. It follows that, in the context of

\* A good example of 'downstream' or direct environmental impact is trans-boundary acid rain deposition. Many European countries, taken individually, experience a substantial share of damages caused by sulphur and nitrogen oxide air emissions due to emissions that originate in neighbouring countries. For some countries (the net victims), much of 'national' damage is imported (viz.,  $CB_{[d]} > CC_{[d]}$ ), whereas for other countries (the net donors) much of the damaging emissions that are 'domestically produced', are then exported away from the national territory (viz.,  $CB_{[d]} < CC_{[d]}$ ).

\*\* Any given country can, in principle, both 'cause' and 'bear' environmental damages that are 'imputed' to economic goods and services

\*\*\* For example, the Dutch NAMEA approach

participation in an international community, the **damages caused** — viz., a nation's contributions to total environmental pressures — will be an unavoidable reference point. This can be seen already in such examples as negotiations over access to marine fisheries in international and coastal waters, agreements (and disagreements) over sharing of freshwater and pollution control for rivers and aquifers that cross national boundaries, and the distribution of burden for reductions in sources of long-range or global atmospheric pollution (CFCs, greenhouse gas emissions, acid rain, etc.).

Many 'downstream' impacts are relatively easy to define and monitor. A range of trans-boundary pollutants are well known and some are easily measurable. Examples of this kind of pollution are: heavy metals in the Baltic and Black Sea and in the Danube, acid rain in Western and Eastern Europe (see **Section III.2** below), international radioactivity spreading after the Chernobyl accident, ozone layer depletion and climate change at the global level, etc. The international displacement of pollution has already been taken into account in some attempts to include international environmental considerations into national accounting systems.\*\*\*

On the other hand, the assessment of 'upstream' environmental impacts poses significant challenges, both conceptually and empirically, for researchers and policy makers trying to include environmental themes into the national accounts. The quantification of the environmental impacts and, more particularly, the attribution (or 'imputation') of responsibilities depends on clear specification of the relevant systems boundaries, of conventions about how the environmental impacts are to be assessed, and of where in the production chain the environmental liability is to be assigned.

Although the typology of 'upstream' and 'downstream' impact transmission mechanisms is logically clear, in practice there are a number of complications. Some of these are essentially empirical and statistical, having to do with measurement, data availability and aggregation. Others have to do with real properties of interdependence which affect the sense in which a cost may be 'borne' and/or 'caused'. We mention two such properties:

□ First, as is inherent in the definitions, 'upstream' and 'downstream' impacts can be linked. For example, country Alpha might be importing manufactured goods whose production in country Beta involves atmospheric pollution. If the pollution is entirely borne by Beta, we class it as an 'upstream' cost caused by Alpha. If the pollution or consequent environmental damage is displaced onto Alpha, this displacement constitutes a 'downstream' cost caused directly by Beta onto Alpha, yet it is indirectly caused by Alpha itself. Analytical frameworks similar to life-cycle analysis and multi-sector input-output analyses may, in principle, be developed for estimation of these indirect environmental requirements in cases where they are thought to be significant.\*

□ Second, many categories of natural capital depreciation or environmental damage relate to 'environmental functions' that provide services jointly to many nations. This is notably the case for 'global commons' such as the atmosphere (ozone layer, climate stability, etc.), tropical forests (for their climate regulatory effects) and the oceans (complex marine habitats and migratory fish populations, etc.) and for major inland waters — these are signalled by 'gl-com' in the above diagram. In such cases, special care must be given to the estimation of (1) on the 'cause' side, the contribution of each nation to the environmental change and (2) on the 'effect' side, of the burden or damage borne by each nation. The complexity of environmental processes means, inevitably, that the attribution of shares of responsibility and the estimation of damage distribution will be speculative and based on simplifying conventions.

\* As another example, country Alpha (perhaps Madagascar) might be importing manufactured goods (e.g., pigmented plastic toys) whose production in country Beta (perhaps the USA) involves the use of intermediate goods (such as minerals or agricultural or forest products) exported from Alpha to Beta, with environmental degradation (such as erosion, water contamination, coastal ecosystem pollution) taking place in Alpha. In this case, Alpha's imports are indirectly the 'cause' of some resource depletion and/or environmental degradation in its own territory. The magnitude of such effects can be estimated with extended input-output analysis including coefficients for import-export sectors and for environmental pressures associated with sectoral production. Usually the 'indirect' impacts will be relatively small. Issues of data quality, aggregation and attribution of impacts mean that quantification can, at best, only be approximate.

\*\* This focus on

In addition, the attribution of responsibility does not involve purely scientific decisions, but partly political ones. In a general way, the inclusion of the supra-national environmental consequences of imports in national accounts is supported by particular ethical and political stances concerning, for example, responsibility towards one's neighbours. One important theme in this regard is the focus on consumption patterns as a key driving force in environmental change. The causation of costs can be located at the point of 'final consumption' of economic goods and services. The national consumption patterns — and hence the consumers themselves as members of the national community — can become a key target of policies seeking to promote more sustainable patterns of economic activity.\*\*

The scientific and political challenges for developing accounts of international environmental load displacement may seem daunting. Nonetheless, starting from the theoretical distinction that we have outlined — between environmental costs caused and costs borne by a nation — a variety of indicators of environmental load displacement through trade have been developed in the literature. Building on our **Section II** typology of sustainability indicators, measures of upstream impacts can be classified in two general categories: (1) those which are an extension of the *AICCAN* approach and (2) those which provide relevant information about environmental pressures in non-monetary units, that can be used in the estimation of various 'sustainability gaps' and, in principle, as considerations for the setting of environmental standards in the estimation of *geGDP* indicators.

The **Sections III.2** and **III.3** that follow, describe examples of some of the already developed indicators of environmental load displacement through trade, including a short definition, some relevant results, and major conceptual and methodological shortcomings in each case.

### III.2 Monetary Estimates of Damage Transfer — Contributions towards Trade-adjusted AICCAN figures

As already mentioned, an AICCAN indicator that is estimated on the basis of a national asset inventory, will refer to changes (that is, to damages/reductions or gains/benefits) in domestic natural assets, that is, changes **borne** in the country. Yet, a significant part of these environmental changes for the national territory may be '**caused**' not by domestic production and consumption but rather by foreign activities. Conversely, the nation may be the cause of environmental damage outside its own territorial borders, such as the transportation of pollutants in air or water or solid media across the national boundaries.

The differences between damage "on a nation's territory" and the damage "directly or indirectly due to the nation's economic activity (including imports and exports)" can be extremely important and, as outlined in **Section III.1**, the distinction obviously has high policy significance. On the one hand, a nation's relatively good AICCAN performance might be neglecting the ways that the national economic activity is 'exporting' environmental damage upstream and downstream. On the other hand, a nation's relatively poor AICCAN performance might be due, in part, to the degradation of natural assets being used as a primary resource or as a sink for other nation's activities (e.g., contamination of water and coastal ecosystems from export-oriented mining operations, or the arrival across national boundaries of chemicals from other countries' productive activities that cause water resources contamination within the national territory).

Although the distinction between environmental costs caused and costs borne by a nation has been made for several years in green national accounting circles, there is not yet a fully systematic treatment. Over the years, a range of partial measures of 'environmental load transfer' have been calculated, and some of these have been expressed in monetary terms. An example is the set of estimates produced by the **GARP II** project, mentioned previously, where monetary values for trans-boundary effects of air emissions were calculated for a large range of European countries (see Table below, adapted from Markandya, Hunt & Mason, 2000).

		Receptor Countries																
		AT	BE	DE	DK	ES	FI	FR	GR	IE	IT	LU	NL	PT	SE	UK	EU	No n EU
		Damage Costs caused by the Source Countries within the Receptor Countries [billion ECU/a]																
EU		2.8	4.5	40.9	2.3	8.9	0.4	21.4	2.0	0.4	15.3	0.1	7.0	1.2	2.1	19.4	128.8	34.9
		Percentage of Damage Costs Caused in the Receptor Countries [%]																[bn]
AT		12.2	0.2	0.9	0.6	0.2	0.9	0.2	0.9	0.1	2.2	0.3	0.2	0.0	0.8	0.1	1.2	1.8
BE		1.1	12.3	3.7	3.8	1.2	1.4	3.7	0.0	1.4	0.7	4.8	13.0	0.4	2.6	1.1	4.4	0.4
DE		47.0	14.2	53.8	43.7	4.8	38.7	13.4	2.0	6.9	15.6	33.3	15.6	0.9	49.6	6.7	34.4	17.0
DK		0.6	1.0	0.9	9.2	0.1	4.6	0.5	0.0	0.6	0.1	0.8	1.0	0.0	8.9	0.8	1.2	0.4
ES		1.7	8.6	3.8	1.8	51.8	0.0	16.3	0.0	16.1	5.6	8.9	6.1	50.4	1.0	7.3	13.5	0.4
FI		0.1	0.1	0.1	0.4	0.0	29.5	0.0	0.0	0.1	0.0	0.0	0.1	0.0	1.9	0.1	0.3	0.1
FR		8.7	33.5	15.3	7.2	16.8	2.1	36.2	0.1	11.2	10.3	31.9	23.8	5.9	5.4	11.4	23.2	2.0
GR		1.1	0.0	0.1	0.2	0.1	0.0	0.1	78.0	0.1	2.3	0.1	0.0	0.0	0.2	0.0	2.1	3.7
IE		0.0	0.3	0.2	0.5	0.4	0.1	0.4	0.0	18.8	0.0	0.2	0.4	0.3	0.2	2.1	0.7	0.0
IT		23.3	3.0	6.9	2.5	8.8	1.6	5.9	18.9	2.8	60.1	4.1	2.4	2.6	2.8	1.2	15.8	6.8
LU		0.2	0.3	0.4	0.2	0.1	0.1	0.2	0.0	0.1	0.1	1.6	0.4	0.0	0.1	0.0	0.3	0.0
NL		1.2	8.0	4.6	7.1	1.0	2.3	3.8	0.0	1.4	0.6	5.6	13.8	0.3	5.0	1.8	4.9	0.5
PT		0.0	0.6	0.2	0.1	6.8	0.0	1.1	0.0	2.4	0.1	0.6	0.4	36.0	0.0	0.7	1.6	0.0
SE		0.2	0.3	0.4	1.5	0.0	11.7	0.1	0.0	0.2	0.0	0.2	0.3	0.0	8.1	0.3	0.5	0.3
UK		2.6	17.5	8.6	21.2	8.0	7.0	18.1	0.0	37.8	2.0	7.7	22.4	3.3	13.4	66.5	24.7	1.2

The **Table** shows an estimated attribution of damages caused within the EU-15 states. It can be seen that most of the approximately 130 billion EURO/year of damage costs that occur within the EU are received and caused by Germany, France, UK, and Italy. 'Net imports/exports' of damages are calculated by subtracting the figure for damage costs occurring within one country (row), away from the corresponding damage costs caused by the same country within the EU (column). The results show that often less than fifty percent of the damages that are borne within a given country, are caused by that country.

A variety of country results have been reported, building on the sort of results just illustrated, that make 'adjustments' of monetary national sustainability indicators to take account of certain categories of environmental source and sink functions (viz., the 'displacement' of natural resource depletion, and the asymmetries of trans-boundary pollution).

An example is the work on "weak sustainability for an open economy" reported by Proops & Atkinson (1998) and more recently by Proops, Atkinson, Schlottheim & Simon (1999). This work adjusts the estimations for the AICCAN-type 'net savings' indicator (related to so-called "weak sustainability") for a closed economy introduced by Pearce and Atkinson (1993), to include the effects of trade on the depletion of non-renewable resources. Input-output matrices are used to explore trade relationships between countries, which allow — subject to the hazards of estimating coefficients for direct and indirect requirements of resources (etc.) — the imputation of depletion or degradation of natural capital, wherever it occurs, with national consumption of non-renewable resources.

Thus, the value of natural capital depletion occurring within a certain country, is taken into account to estimating the indicator of weak sustainability for the national territory where consumption of these resources takes place. The **Table** below gives a sample of the results.

<b>Net savings (1990) in millions of US \$</b> ( <i>approximate numbers</i> )			
<b>Most sustainable countries</b>		<b>Less sustainable countries</b>	
	<i>(among industrialised countries)</i>		
Japan	600000	Iceland	1500
Italy	190000	Norway	2500
Germany	155000	Ireland	3500
USA	150000	Greece	7000
Spain	115000		
France	100000		
<b>Most sustainable regions</b>		<b>Less sustainable regions</b>	
Western Europe	750000	Africa	-30000
South-East Asia	750000	Latin America	10000
		Oceania	25000
<b>Net importers of natural capital are</b> Western Europe, Eastern Europe, USA, Central America, South-East Asia.			

The major attractive feature of these results is that an ready interpretation in terms of 'net savings' adjusted for international responsibility, is offered for policy making. However, there are several conceptual and methodological difficulties. In the published work to date, there has been no discussion of the question whether or not the available price data can plausibly be interpreted as signalling inter-temporal resource opportunity costs in the way that the underlying theory presumes. Several questions might be raised. The assumptions about discount rates incorporated in estimates are difficult to reconcile with the long-run perspectives of sustainability policy. Uncertainty makes very difficult the estimation of future costs. All market prices depend on the distribution of income and power. One reason that natural resource prices are unlikely to reflect the long-term opportunity costs of critical natural capital depletion is the variety of structural geopolitical conditions that tend to force downward the natural resources prices.

Furthermore, the calculated indicator figures take into account only a limited range of natural resources. Not all environmental assets are measurable in monetary terms: implicitly a zero value has been adopted for a great many categories. No effort has been made, in the studies reported here, to assess the importance of these categories for sustainability prospects relative to other categories of damage or depreciation to environmental functions not included.

In short, the 'internationally adjusted' AICCAN indicators are subject to all the caveats of the non-adjusted indicators as discussed in **Section II.3**, plus in addition, the admission of various uncertainties and gaps in data for the estimation of the inter-country transfers.

### **III.3 'Load displacement' Indicators relating to Environmental Pressures measured in Non-monetary Units**

As outlined in **Section III.1**, the feasibility and economic costs of achievement of goals for reducing environmental pressures *within* a national territory depends partly on whether the pressures are caused by domestic or offshore activity. The example already given of acid rain deposition in European countries, illustrates this rather well. If a large fraction of acid depositions borne by a country (such as Sweden) have their source overseas, there is relatively little scope for using technology change or consumption change policies within the country in order to reduce the acid rain pressure. In this sort of context, countries are being asked to give attention to the

extent to which they are exporting their 'unsustainability' — that is, their utilisation and possible degradation of environmental functions beyond thresholds necessary for assuring long-run ecological-economic sustainability — onto other nations. A variety of indicators have been developed for this purpose, which are based on key environmental pressure categories such as primary energy resource use, land use or territorial photosynthesis potential, pollutant emissions or depositions, water resources use and so on.

**A. The Ecological Footprint \***

\* See in particular the overview paper by Wackernagel, et al. (1999) and also several other papers appearing in issues of the same year of the journal *Ecological*

In work now going back more than a decade, Wackernagel and his colleagues have developed analyses of the natural capital required by a national economy in order to function, by making the proposition that it can be quantified through the biologically productive and mutually exclusive areas necessary to continuously maintain current resources consumption and to absorb current waste generation levels, given prevailing technology. This hypothetical area, which is called the **Ecological Footprint**, can be compared to the biocapacity really available within a country, in order to estimate by how much national land requirements exceeds local natural capital availability. The Ecological Footprint is thus calculated using material and energy apparent consumption data (*production + imports - exports*) for a certain spatial domain.

Country	Biocapacity - EF (ha/cap)	Country	Biocapacity - EF (ha/cap)
USA	-3.6	Venezuela	-1.1
UK	-3.5	Egypt	-1.0
Japan	-3.4	India	-0.3
Germany	-3.4	Bangladesh	-0.2
Italy	-2.9	France	0.1
Greece	-2.6	Norway	0.1
South Africa	-1.9	Ethiopia	0.3
Thailand	-1.6	Malaysia	0.4
Spain	-1.6	Ireland	0.6
Mexico	-1.2	Chile	0.7

These flows are evaluated for different economic sectors, including housing, food, transportation, consumer goods and services. The land appropriated by these consumption categories is estimated for different land categories: fossil energy, built up area, arable land, pasture, forests and sea. The final output is a consumption/land requirement matrix. Summing all the area figures in this matrix gives an estimate of the ecological footprint of the region considered. Some illustrative results are shown in the **Table** above.

The major advantage of this approach is that, conceptually, it is relatively easy to understand and to implement. However, the complexity of ecological systems and requirements of aggregation and comparison across different spatial territories brings difficulties, including:

- The indicator relies on biological productivity. This means that emissions of some pollutants may actually decrease the Ecological Footprint. For instance, CO<sub>2</sub>, N, P and organic wastes may increase biological productivity. This complications interpretation of the indicator.

- The aggregation process depends on particular assumptions (not well explained in the published papers) about the rate of substitution between different environmental pressures. These assumptions are not always justifiable as 'realistic' from an ecological systems science point of view.
- In the estimations carried out to date, no distinction between different quality of land uses is made.
- The conversion scheme that establishes an equivalence between energy consumption and land use is debatable, because the suggested sustainable energy scenario may be not technically or environmentally feasible (e.g., it is based on the estimation of the forest area necessary to absorb CO<sub>2</sub> emissions).
- The national scale for this indicator has no particular pertinence from an ecological systems point of view. Therefore more work should be put into implementations at territorial scales having clear ecological significance, and also into the policy significance of a positive or negative EF result for one country/territory relative to others (e.g., its neighbours).

**B. Environmental Space / Material Flow Analysis \***

\* The exposition and illustrations developed here are adapted from Friends of Earth Europe (1995); Adriaanse et. al.

This family of indicators starts from the notion that there are limits to the amount of environmental pressure that Earth's ecological systems can handle without irreversible damage. The environmental services provided by these systems, for which there is a limited space, include both stocks (of renewable and non-renewable resources) and sinks, to absorb wastes and pollution. Examples of results are shown in the **Table** below.

Item	European consumption				Global average consumption			
	(per capita/year)							
CO <sub>2</sub> emissions	7.3 t				1.7 t			
Fossil fuels	100 GJ				25 GJ			
Wood	0.66 m <sup>3</sup>				0.56 m <sup>3</sup>			
Pig iron	273 kg				36 kg			
Aluminium	12 kg				1.2 kg			
	Total material requirement				Hidden flows associated with imports			
	Per Capita (met. Tons per capita)		Total (mill. metric tons)		Per Capita (met. tons per capita)		Total (mill. metric tons)	
Year	1975	1994	1975	1994	1975	1994	1975	1994
Germany	40	49	3147	3989	20	19	1611	1512
Japan	67	82	7475	10247	14	20	1541	2466
Netherlands	63	78	854	1199	23	35	313	540
USA	100	90	21597	23453	2	3	398	763

These types of indicators are based on the calculation of actual direct and indirect flows of materials, including inputs and emissions. The 'environmental space' approach involves comparing global mean use of a given resource, expressed in per capita units, with national per capita consumption. Once again, this is an approach whose main advantage is that the concept and implementation are relatively straightforward. However, various conceptual and estimation difficulties can be identified, which include:

- Targets for the reduction of material consumption cannot be easily justified.
- The equality principle is politically unfeasible and ecologically hard to justify.

- Links between materials flow and actual environmental change are difficult to establish.
- Changes in the 'quality' of the material throughput are not always considered (in term of environmental consequences, one Kg of sand is not equivalent to one Kg of gold or of dioxin): loss of information in the aggregation process.
- Data availability can be a problem, especially in developing countries.
- Calculation of hidden flows is subjected to heavy assumptions about technology and extraction procedures.

**C. Entailed Pollution in Imports \***

\* This exposition is based on Wyckoff & Roop (1994)

The basic idea of this approach is to estimate the "environmental memory" of the products imported by a national economy. Specifically, using input-output production matrixes and international trade data; this methodology intends to calculate the share of pollutant emissions associated to local consumption that is entailed in national imports. (This is similar to the work of Atkinson and colleagues for the adjusted AICCAN estimations mentioned in Section III.2 above, except that the imputed requirements are quantified in physical rather than monetary terms). Some selected results are shown in the **Table** below.

<b>% carbon embodied in manufactured imports (relative to total C emissions)</b>	
Canada	23 %
France	41 %
Germany	19 %
Japan	7 %
UK	26 %
USA	7 %
Average	13 %

Chemicals and ferrous and non-ferrous metals are the sectors whose imports imply the larger levels of entailed carbon emissions.

*Note: these embodied emissions in imports are normally not included in the official estimations of national CO<sub>2</sub> emissions.*

An attractive feature of this indicator concept is that it is based on the measurement of specific environmental pressures, viz., particular categories of pollutant emissions. *Difficulties with the implementation and interpretation of the concept include:*

- Boundaries of the system are hard to delimit;
- Due to price variations, it is hard to link monetary values of imports with actual emissions;
- Input-output matrixes are difficult to construct: international chains of extraction-production-consumption may be difficult to track.

**D. Embodied Effluent Trade \***

\* This exposition is based on the article by Following Lee & Holand-Host (1993).

Like the preceding indicator, this measure is based on the idea that traded commodities embody an environmental service: the amount of pollution produced

domestically when goods are produced for exports. This method generates an index of weighted aggregate effluent levels for a given composition of domestic production (in monetary terms), which is calculated using the Linear Acute Human Health and Terrestrial Ecotoxicity index (Hettige, 1995). The EET index measures the effluent potential of domestic output in units relative to the United States and it can be used to evaluate the implicit effluent content of trade. Thus, if this index exceeds unity, then the composition of the country's existing trade represents (in their production) a higher level of pollution per unit than representative output in the US. Some illustrative results are shown in the **Table** below.

**EET Index for 1990**

<b>Indonesia</b>		
<i>Imports from</i>	Japan	rest of the world
	1.72	3.34
<i>Exports to</i>	Japan	rest of the world
	10.64	7.23
<b>Japan</b>		
<i>Imports from</i>	Indonesia	rest of the world
	10.19	4.78
<i>Exports to</i>	Indonesia	rest of the world
	1.62	1.54

An attractive feature of this indicator is that it emphasises explicitly the notion of 'transfer of environmental costs' between two countries. Difficulties with implementation and interpretation include:

- Interpretation of the index is not easy because no reference to actual emissions levels is made. Moreover, the weighting procedure of the different pollutant emissions to obtain the index is complicated.
- Due to prices variation, it is hard to link monetary values with actual emissions.
- Due to technological differences, effluents by unit of production may vary importantly from one country to another. This methodology assumes that emissions by sector's output are similar in any country (equivalent to those in the USA).
- Data availability can be a problem.

### III.4 Outlook for Work on 'Environmental Load Displacement'

As the various examples in the preceding pages show, work has been undertaken on measurement of international environmental load transfer and 'ecologically unequal exchange' for many years now. Yet the field is still very much in its infancy. A systematic review of the usefulness of these different types of environmental load displacement measures has not — to our knowledge — yet been published.\*\*

It must be emphasised that, as already seen with the AICCAN (net asset change) and 'sustainability gap' concepts applied to national territories, there is no one indicator for environmental load transfer that can somehow encapsulate the full story about inter-country interdependence. As work matures in this field, the key policy questions themselves become more clearly stated. We will return in **Section IV.5** to discuss briefly some of the policy perspectives for open-economy indicators.

\*\* Quite a bit of empirical work and conceptual synthesis — as yet mostly unpublished — has been carried out by Juan Martínez-Alier and colleagues in Barcelona and Latin America which promises at least partly to

## Section IV

# The Adjustment Concepts and their Policy Applications

### IV.1 Policy Uses of the *AICCAN* and *geGDP* Indicators

Our main purpose in this paper has been to help return the technical literature on adjusted aggregate indicator estimation back towards its roots — viz., back to focussing on the real purposes of the search for macroeconomic sustainability indicators. This requires both a clarification of concepts (as we have sought to provide in **Section II** and **Section III**) and a clarification of policy applications.

The original ambition behind the definitions and estimations of environmentally adjusted GDP and NDP figures was to furnish guideposts to policy, helping to chart national economic development paths and to evaluate trade-offs between output growth, final consumption and environmental performance objectives.

The policy uses, and likely usefulness, of the various different adjusted aggregate recipes, can be assessed with reference to:

- What each specific indicator concept seeks to measure relative to national policy agendas;
- the robustness of each indicator concept in the face of various economic and ecological systems uncertainties;
- possibilities for implementing meaningful empirical estimation procedures for each indicator concept.

Referring to the first point, we have argued in **Section II** that both forms of indicator work — the *AICCAN* current-period figures for money-valued asset change, and the *geGDP* scenario analyses for long-term economic and environmental performance trade-offs — can contribute importantly to policy orientations. Each can play a role in the iterative policy process of identifying options and informing social actors about the directions of action and economic change that may promote sustainability. But they address, as we have highlighted, different and to some extent complementary sustainability issues — regarding, as it were, different sides of the 'Monetisation Frontier'.

The *AICCAN* type of current account measure of change in assets (valued at current market prices, or similar) can give a useful quick impression of the direction in which a country's asset use is headed.

However, the diagnosis of an 'asset-stripping' problem — in the case that the *AICCAN* is negative or very small — does not, in itself, tell where a remedy might be found. The establishment of such measures of net asset change in monetary terms does not reduce the need to specify targets for the ecological aspect of sustainability, viz., the maintenance of critical environmental functions.

For this reason, the development of concepts and country capacities for exploring prospects for 'economically and environmentally sustainable' development

strategies is also important, using modelling concepts *for ex ante geGDP*. The definition and estimation of *geGDP* figures is intended, precisely, to furnish guideposts in the context of explicit explorations of possible national economic development paths and trade-offs between output growth, final consumption and environmental performance objectives. Where the purpose is to investigate sustainability prospects for the medium to long term, a robust and transparent approach is to develop scenarios based on explicit propositions about consumption, technological change, and environmental performance requirements.

The two types of indicators — *AICCAN* and '*greened economy GDP*' — are thus useful complements, in that they refer to quite different economic entities and answer to quite different estimation needs. Indeed, as outlined in **Section II**, they typically address quite different roles of natural capital. Therefore, they address the question of investment (or dis-investment) in natural capital from different points of view, and they apply distinct valuation concepts for natural capital. We will now elaborate on these points, in order to bring out the role of distinct concepts, statistical procedures and modelling in response to a diversity of policy needs including (as developed in **Section III**) the requirements of policy for 'open economies'.

## IV.2 Valuation Concepts underlying the *AICCAN* and *geGDP*

We will first summarise in a synthetic way the key concepts of valuation that are embodied in the *AICCAN* and *geGDP* indicator concepts, and then discuss the role of various valuation methods in the construction or estimation of the two different types of adjusted aggregates.

- The *geGDP* approach considers *economic costs of reducing dis-investment in natural capital* — that is, costs associated with maintaining or restoring specified environmental functions. For the purposes of estimating a *geGDP*, there is no monetisation of the environmental assets themselves. Yet, there is a sense in which the cost-effectiveness approach imputes an economic value on the 'supply side' to changes in the availability of the environmental functions, because there is identified an economic opportunity cost of assuring maintenance or of augmenting these functions. An answer is being given to the question, "how much more environmental functions" is obtainable in exchange for "how much less economic output"? This macroeconomic opportunity cost is estimated for defined model assumptions, system boundaries and time horizons (etc.). We can say, therefore, that the *geGDP* estimates are based on a 'supply-side' approach at a macroeconomic scale of analysis.
- The *AICCAN* approach also seeks to assess appreciation (or depreciation) in natural capital from the point of view of the measurable economic benefits to be gained (or lost). This is not done by a comparison of alternative ecological economic situations (e.g., comparative static or comparative scenario analyses) as in the *geGDP* approach. Rather the approach is to place monetary values directly on the various categories of economic output, human health, (etc.) that are affected by the changes in natural capital. These money valuations can, in turn be obtained from disaggregated 'demand side' or 'supply side' analyses, as will be discussed below.

Not only will these two approaches to valuation often lead to divergent, indeed incommensurate results, we can also perceive the difference in terms of what specifically is being measured or estimated in the two approaches. To illustrate this, take the case of a depletable marine fish stock.

Suppose the question is to assess the value of an increment in fish,  $\Delta F$ , that is to be caught or, alternatively, left in the sea so as to assure maintenance of the capital

stock. If the fish are not caught, this represents a foregone revenue of  $\phi \Delta F$ , where  $\phi$  is the market price per unit of the fish. So  $\phi \Delta F$  is a measure of the immediate economic opportunity cost of choosing to leave the natural capital stock intact, and it is also a measure, in current prices, of the reduction to the natural capital stock if the fish are caught.

The AICCAN current period accounting approach makes use of market prices under prevailing exploitation conditions. It may thus be considered appropriate to use the price  $\phi$ , applied to the estimated change in fish stocks, in an annual accounting procedure for natural capital. The geGDP approach, by comparison, which aims to estimate the economic costs associated with reducing fishing effort — that is, the cost of supplying fisheries sustainability — cannot simply adopt the figure  $\phi \Delta F$  (the loss of fishing revenue if the fish are not caught) as the economic cost of maintaining fish stocks. On the one hand, if fishing effort is reduced there can — over time — be reallocation of economic resources to other sectors. On the other hand, policies such as tradable fishing permits alter the value of economic assets (in this case, the permits constitute a capital asset which generate a revenue that flows into the economy). Where fishing is a major sector of activity, and where longer-term sustainable development is the policy concern, regional or national economy analysis with an inter-temporal focus may be called for.\*

It can be seen from these remarks and examples that the valuation concepts associated with the two indicator classes are quite distinct. Whereas geGDP estimation depends fundamentally on a whole economy comparative modelling process, leading to an 'opportunity cost' estimation at the macro-economic level, an AICCAN estimation relies much more directly on monetary valuation procedures to assess the appreciation (or depreciation) of various components of natural capital. This means that, although specific environmental valuation concepts are clearly put to work in the case of geGDP estimation, the main methodological issues relate to modelling procedures, scenario assumptions and data requirements. By contrast, AICCAN estimation depends on bringing together a variety of monetary figures for different components of natural capital change, which brings the requirement to address the various issues of market versus shadow prices, aggregation, discounting and benefit transfer (etc.) associated with the use of a range of monetary valuation methods. In this context, two points should be emphasised.

First, it is important to make clearly the distinction between natural capital 'stocks' and the 'flows' of benefits or services that are provided by the natural capital — and that may be lost through depletion or degradation or pollution (etc.). The AICCAN indicator refers to changes in a nation's assets. Often, however, the monetary values that can be obtained from market data or via valuation studies, refer in the first instance to 'flows' (or loss of flows) of materials and services. For example, commercial logging of a forest may reduce — perhaps irreversibly — future availability of timber; it may also destroy a subsistence food source or a recreational resource. Acid rain may degrade forest, lake and agricultural ecosystem quality, as measured by reductions in production potential for timber products, fish and crops. Or, local urban air pollution may damage human health (e.g., respiratory problems) and this damage may be given a monetary value by reference to medical care costs, reductions in working capacity, and individuals' willingness-to-pay for avoiding health damage.

Second, much emphasis has been placed, in valuation literature, on 'demand-side' money figures for the 'damages' to the environment's capacity for delivery of human welfare. The idea is to estimate the (money) value attached to the benefit or service (or the loss/damage to service) by the persons concerned. However, monetary valuation objectives for can be pursued, in principle, from either the 'demand side' or the 'supply side' (see Box, below).

\* In particular, the link between current prices and future economic opportunities must be scrutinised. Only if there is a well enforced access control system and a stable political environment, is it plausible that the market price of the fish will, at least to some extent, reflect the 'user cost' viz., the loss of the nation's future earnings potential due to depletion of the fish stock. The market fish price can indeed be very different depending on whether there is 'open access' (as with some deep sea species) or a regime of strict access controls (including, for example, a closely policed regime of fishing permits whose commercial value can be capitalised on the stock exchange). Fish population dynamics are also critical. Some species replenish within 1–5 years, others (notably deep ocean species) may require decades for population recovery after stock depletion. These

**Environmental Valuation on the Supply and Demand Sides**

An underlying principle for *monetary environmental valuation* is that although we cannot introduce all ecological goods and services into actual markets, it is nevertheless possible to extrapolate in various ways from actual market transactions so as to get an estimate in money terms of the value of some environmental good, or the cost of some environmental harm. The pricing of environmental goods and services, or of environmental damage in money terms can be approached in two distinct ways:

- On the *supply side*: by estimates of economic costs — that is, the reduction in other opportunities for assuring goods and services provision — that is required in order to obtain an extra environmental benefit, or to repair damage, or to avoid further deterioration;
- On the *demand side*: by estimates of the monetary value of the benefits that are lost or at risk — that is, the value of the lost or potentially damaged environmental asset, amenity or service in the eyes of producers and consumers.

\* Examples of approaches to environmental valuation from the *supply side* are: — Restoration costs paid (or potentially to be paid) by individuals, firms and state institutions in response to environmental pollution, to maintain or restore buildings, rivers and lakes to certain levels of water quality, fishery stock, etc., or to remedy human health problems due to pollutants. — Avoidance costs incurred (or potentially incurred) by individuals, firms and state authorities to avoid environmental damage: e.g. the costs incurred in introducing traffic calming and noise buffer measures in town; of reducing atmospheric greenhouse gas emissions; of installing catalytic converters; of improving safety measures against toxic chemical spills in storage, factory use, and transportation; of diverting a road out of a site of special environmental value.

Monetary figures obtained with *supply-side approaches* relate to expenditures to achieve improvements in environmental quality or to avoid degradations in quality. Such figures do not necessarily provide an estimate of the monetary value to society of the benefits gained. For example, the restoration benefits of forest replanting might be much greater than the costs to a landowner, but these benefits may partly accrue to other persons over a long period of time (e.g., future wood harvest, soil stabilisation, groundwater quality).\*

The *demand* for environmental benefits refers to how much people are, or would be, *willing to pay* (usually but not necessarily measured in money units) for specified environmental benefits or to avoid environmental damage. For natural capital used as productive inputs, it is possible to specify a 'derived demand', that is, amount that a user would be willing to pay as reflected by the revenue stream that is obtainable, e.g., timber products from a forest. For non-commodified environmental services, no such commercial reference point exists and various artifices must be employed.\*\*

In some circumstances, supply-side and demand-side valuation approaches can lead to directly comparable figures. But this will not generally be so. Indeed, supply and demand side approaches to valuation can often lead to divergent results even for the same resource. There is nothing surprising in this. The measurement concepts are not equivalent even in theory, except under very special conditions of an economic equilibrium and good information (which are rarely satisfied for environmental assets and changes!). The two angles of attack engage quite different analytical frameworks for estimation, and also there may be very different underlying policy orientations which bear on the way that the valuation problem is set up (e.g., which benefits and costs are taken into account, over what time frames, for what classes of persons, at what scales, etc.).

We can now bring together these various points about 'demand' and 'supply' side valuation concepts, in order to summarise schematically the respective roles of the different valuation concepts and scales of analysis for AICCAN and geGDP estimations. The diagram below (over the page) portrays the respective 'pathways' through different data sets and value estimation procedures, for arriving at an 'environmentally adjusted aggregate' that may be compared with the conventional macroeconomic indicators of GDP and national net savings.

- The geGDP concept uses non-monetary information on environmental functions and pressures threatening their maintenance, and proceeds to estimation of the macroeconomic cost of 'closing the gap' between a baseline situation and a 'sustainability' scenario.

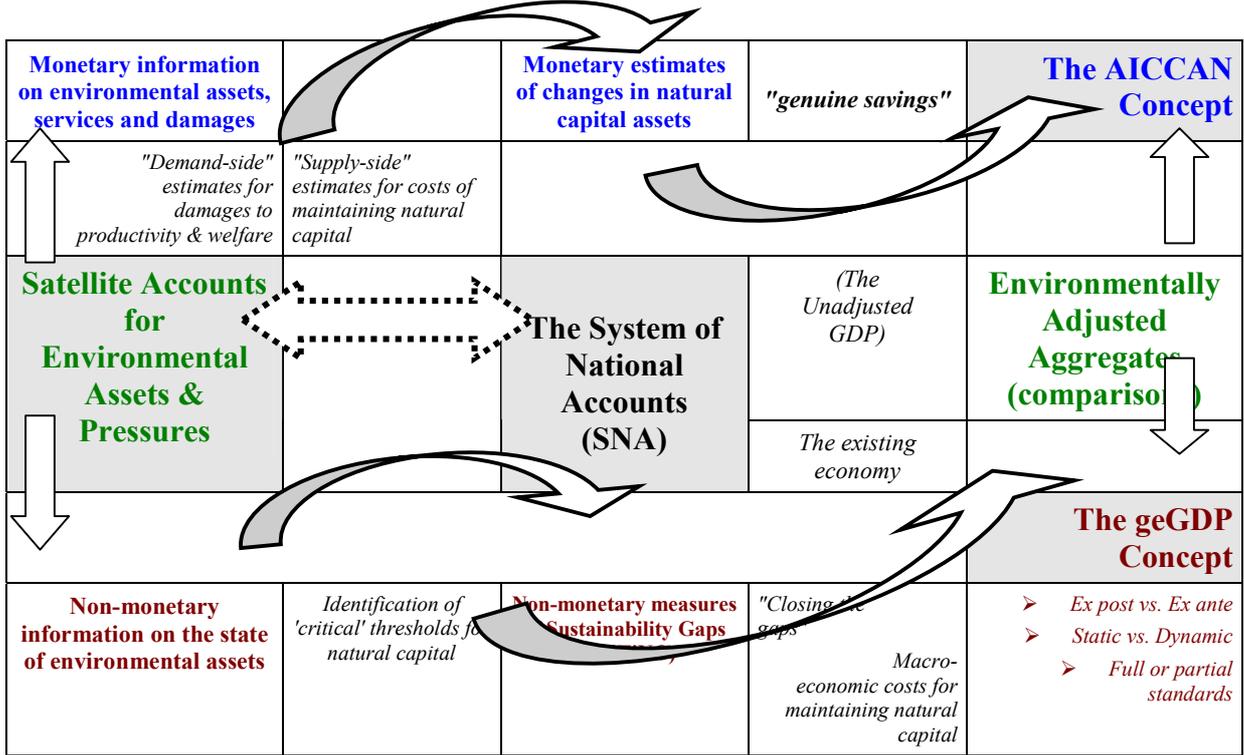
\*\* Commonly used

- The AICCAN concept requires estimates of the monetary value of changes in natural capital assets on a period-by-period basis. These asset values can be calculated, on the demand side, as the 'present value' of the changes in flows of benefits. Or, they can be valued on the supply side, as economic costs of maintaining the asset at its existing level.

\*\*\* Quite apart from empirical and institutional factors, there are clear theoretical reasons for this possible divergence. The monetary demand-side valuations presume (in the theoretical underpinnings) the optimising decisions of producers and consumers confronted by current prices and resource availability conditions, which might be far away from the conditions for long-run economic sustainability. The supply-side maintenance cost figures, by contrast, are based on a presumed 'social demand' for

For the AICCAN procedures, supply side and demand side valuation procedures are two different angles of attack for assessing the opportunity costs associated with maintenance or exploitation (including degradation) of natural capital assets. But, as several times emphasised, different valuation procedures will not necessarily yield equivalent results.

Take, for example, the sectoral estimates of the costs of 'closing the sustainability gaps' mentioned in **Section II.4** above. Such data, based on analyses at firm and sectoral levels, provide information on economic opportunity costs of restoring, maintaining or not degrading (etc.) the specified natural capital quality and quantity. So, these data can be interpreted as *supply cost* information for the various categories of natural capital, e.g., the cost of supplying unpolluted water through abatement of chemical fertiliser and pesticide use in agriculture, or the cost of reducing greenhouse gas emissions and thus stabilising greenhouse gas concentrations in the atmosphere. In principle, such figures (when available) might be used as a basis for *pricing* natural capital depreciation, as an input in AICCAN calculations. However, as illustrated by the example from Serõa da Motta (1998) cited in **Section II.2**, it is quite possible that these maintenance cost figures will differ significantly from 'demand side' figures obtained on the basis of the value of clean water as revealed 'in the market' for current economic activities.\*\*\*



**Green National Accounts and the Pathways for Adjusted Aggregate Construction**

\* In some situations, the current level or quality of natural capital may be lower than what is thought to be needed for long-run sustainability. In this case, one could also estimate costs of restoration, and apportion these on a year-by-year basis. But these (hypothetical) restoration costs should not be included in the AICCAN of the current year.

\*\* Costanza et alia (1997) attempted to make a monetary estimation of the total value of nature's services for a year. They obtain a figure, subject to very large uncertainty range due to mixed valuation methods and extrapolations, that is maybe 5 times higher than the world's annual GDP. If (for the sake of the argument) it were supposed that nature's services are being degraded at 5% per year (which is plausible for some water degradation, tropical forest and fisheries harvesting, etc.), and that the monetary value of nature's current

A final point concerns the relation between maintenance costs assessed at firm or sectoral scale, and macroeconomic cost-effectiveness calculations. If environmental standards (for pressures, for example), are specified to prevent further degradation of the natural capital, then the individual costs, written  $C_j$  that would be entailed by the  $j^{th}$  sector in the current year, can be interpreted as the (hypothetical) investment costs for maintaining the natural capital intact.\* The sum  $\sum C_j$  would appear, in this regard, to be an estimate for the aggregate investment costs that would be required in the current year — but that have not been really undertaken — for maintaining the stocks of natural capital at the existing levels. The non-invested amount  $\sum C_j$  might therefore be taken as a monetary estimate for natural capital depreciation, to be incorporated into the net asset change for the national economy.\*\*

Yet, for all the reasons already discussed, this procedure can produce misleading results. It is conceivable that the  $\sum C_j$  is very large compared with GDP (or even exceeds it!). If the sum of costs,  $\sum C_i$ , exceeds the GDP, then the estimated net national product (NDP) would be not only less than the current period's national consumption, but actually negative! This would suggest that the cheapest way to avoid environmental degradation is to close down the economy. Some commentators may pessimistically fear that this could be the case for certain highly polluting economies. However, the  $\sum C_j$  estimated in this way, involves aggregation of separately estimated sectoral adjustment and abatement costs. As explained in the **GREENSTAMP** project and in early commentaries on Hueting's work (Faucheux & Froger, 1994; Faucheux, Froger & O'Connor, 1994; see **Section II.4** above), such an aggregation procedure is not equivalent to an estimation of net costs for the economy as a whole. Rather,

- the  $\sum C_j$  relative to the GDP is really an indicator, with current cost and price structure, of the extent to which current economic activity is incompatible with sustainability standards;

- it is likely that  $\Sigma C_j$  is significantly larger than the reduction in final consumption, compared to the present level, that would be imposed for a transition path to a future 'greened' economy that seeks to optimise output while satisfying the sustainability standards.

This reiterates the argument that assessment of prospects for an economy that respects environmental conditions for long-run sustainability, requires forward-looking scenario studies.

### IV.3 The Monetisation Frontier Revisited

Having highlighted the distinction in conceptual and methodological terms of the AICCAN and geGDP indicator types, it is now also useful to reiterate their respective roles in the face of different dimensions of environmental complexity and uncertainty. The key issue here is to assure that the concepts are applied for domains of natural assets and environmental change where indicator estimates can be robust and pertinent for policy.

**Section II.2** introduced the 'Monetisation Frontier' as a demarcation between domains where the 'Weak' and 'Strong' sustainability precepts are respectively applied, based on different roles that natural capital can play for achieving sustainability. The Frontier of Monetisation is thus a methodological demarcation between two zones of natural wealth:

- on the one side of the Frontier, the 'Weak' sustainability precepts are applied to those resources and assets whose permanent maintenance is not deemed essential for durable economic activity; such resources are valued *from the point of view of their potential conversion into commercially priced goods and services*.
- on the other side of the Frontier, the 'Strong sustainability' precepts are applied to elements of natural capital that, considered as components of functioning natural systems, are necessary supports for viable economic activity. These assets are valued in terms of economic costs of maintenance, that is, from the point of view of their roles as *in situ* services as sites, scenery, scientific interest and ecological life-support in complement to human economic activity.

The AICCAN type monetary measures of net asset change involve the assessment of natural resources and assets essentially from the point of view of their contribution (actual or potential) to the production of commercially priced goods and services (trees into wood products, human health for its impact on worker effectiveness, for example).

The greened economy GDP, or geGDP, by contrast, assesses the significance of natural capital systems in non-monetary terms and gives an indicator of prospects for maintaining economic development while ensuring the maintenance of the environmental functions of natural capital *in situ* — that is, as sites, scenery, scientific interest and ecological life-support in complement to human economic activity.

Scientific knowledge combined with practical valuation experience to date, allows identification of a number of clusters of environmental assets and their functions which, for the purposes of adjusted aggregate estimation, will be placed typically on one side or the other of the Monetisation Frontier. For example:

- The AICCAN approach can be particularly useful for issues of quantified natural resource depletion such as forests, minerals and petroleum. It can also be of great help for scorekeeping, e.g., aiding the monitoring of resource rents captured (or not captured) from period to period.
- On the other hand, fisheries, climate change, health impacts of pollution, and biodiversity/land cover change are examples where, for reasons of systems complexity and measurement difficulties, the discussion remains open about the usefulness of placement in or out of the monetised asset basket — hence, inclusion or not of money estimates of asset value changes in the current account asset balance indicator.
- Some resource depletion and ecosystem protection issues which are associated with high uncertainties, and hence difficulties in quantifying long run environmental and economic consequences, can nonetheless be treated meaningfully with the geGDP cost-effectiveness approach. Examples are

fisheries (where catch limits can be proposed), freshwater pollution (where concentrations of contaminants can be measured and various emissions thresholds can be applied) and atmospheric pollution (including greenhouse gas emissions and CFCs implicated in ozone-layer destruction), for which emissions and concentration targets can be made the primary policy reference points.

- Some environmental issues (biodiversity protection, for example) may pose difficulties for both approaches to indicator specification. Measures for protection of individual ecosystems or population levels of target species can sometimes be put into cost-effectiveness analyses, and thus incorporated within *geGDP* estimates for specific country purposes. But there is little consensus about meaningful indicators of biodiversity change and biodiversity value on a global scale or across a wide diversity of ecosystems. This limits the applicability not only of monetary valuation concepts, but also standards-based analyses.

In the above points, we have given a full spectrum of cases. Many categories of air, water and soil pollution furnish examples of 'dis-investments' in natural capital that could be the object of valuation approaches on *both* sides of the Monetisation Frontier. This can be conceived of as a sort of *tâtonnement* process, not in the sense of finding a 'market equilibrium' between supply and demand, but rather in the sense of the integration of scientific, economic and social dimensions of information in political processes that resolve the 'social demand' for maintenance (or not) of environmental functions. For example,

- On the one side of the Frontier, economic analyses may seek to estimate monetary value of losses to economic production due to health and ecosystem damages from, for example, air pollutants such as acid rain, urban smog, particulates (etc....).
- On the other side of the Frontier, economic costs of meeting atmospheric emissions targets can be estimated, based on various scales of firm, sectoral and national economy analyses. The less tangible benefits of lower pollution are layered in as qualitative considerations.

Costs of meeting targets, estimated through model analyses of the economy, can then be presented and considered, in a policy process, in relation to the identified economic production and human welfare benefits of less pollution. In this way an understanding is built up of justifications for lower pollution and of the implications for the economy and for society of achieving lower pollution. The procedure can be repeated for each major category of environmental risk or damage, thus establishing an information base for negotiation of environmental and economic policy targets and priorities.

It can also be emphasised that the information of most value is not found in the aggregate figures and time series themselves — which are always open to alteration through changing assumptions and data sets. What matters most is the learning about natural systems, technological potential, economic systems, and policy processes that can take place through construction and comparison of the different aggregates, model outputs and scenarios.

#### IV.4 A Note on the 'Hicksian' Income

We may highlight this emphasis on indicator estimation as a permanent social learning process rather than a search for purely scientific accuracy, with reference to the question posed at the outset of **Section II**, viz., "*Is the current national consumption level sustainable?*". One of the highest profile interests of green national accounting has been the prospect of estimating a 'sustainable national income' (SNI). This has usually been based on the 'Hicksian income' concept,

\* A series of papers by Geir Asheim and others (Withagen & Asheim, 1998; Asheim & Buchholz, 2000, 2001) discuss meticulously the different possible formulations of a Hicksian income for a national economy, in relation to the measurement of capital stock quantity and value change, net national product, and indicators

which, by analogy with the arguments of Hicks (1946) means the revenue that a firm (or country) may take for use without impairing the capacity to continue to generate at least the same revenue level indefinitely into the future.

In some formulations, the Hicksian income is specified as the revenue stream obtainable while maintaining the total capital stock intact. The premise here is that a non-decreasing capital stock can assure, iteratively, a non-decreasing revenue. This formulation is not always exactly valid, but it can be used as a simple guide for thinking about the meaning of different adjusted aggregates.\*

In this perspective, the AICCAN type measure of a net change in country asset value can provide a starting point for thinking about defining a 'Hicksian income' figure. Following the neoclassical growth theory results (**Section II.3** above), the net national income is defined as *the sum of national consumption plus net asset change*, which is an estimate for the revenue stream that would be obtainable while maintaining net assets intact.

The figure obtained in this way for a 'Hicksian' country income — as the sum of national consumption plus net asset change — is (just like any firm's income) basically an accounting result. It gives an evaluation of the performance of the firm (or country) *during the current year, calculated with present year prices*. But, for all the reasons outlined in **Section II.3** and **Section III.1**, analysts should resist the temptation to use this current-account based Hicksian income as a hasty estimate for the 'sustainable national income' (SNI). If we continue with the analogy of a firm, the Hicksian income for a firm is 'sustainable' only if the prevailing prices and external conditions for the firm do not change for the time horizon of interest. But, if the conditions will change in any ways that are not already 'internalised' into these prices and asset valuations then the Hicksian income as defined using the AICCAN for the current period, does not, in itself, provide a reliable guide as to future viability (for better or worse) of the nation's enterprise.

This is the context in which the term 'genuine savings' has been popularised by the World Bank. The term 'genuine' refers to the intent to assess a 'complete' portfolio of those assets whose change can meaningfully be quantified in monetary values and whose change is a policy-relevant consideration for the country manager. The numerical figure obtained for the AICCAN *depends very specifically on the portfolio of assets that the 'country manager' (or, in practice, policy and statistical services) defines for his or her attention*. This choice will, as in the analogy with a private sector firm, reflect the perceptions of the country manager about (a) his or her real capacity — or duty — to exercise a management control over the assets and (b) the real financial consequences of the management (such as resource rent revenues, export receipts, burden on the state for water purification investments, etc.).

The monitoring of net asset change in monetary terms does not reduce the need to specify targets for the ecological aspects of sustainability, viz., the maintenance of critical environmental functions. For sustainability policy purposes, the monetary 'genuine savings' indicator must be set in the context of (1) policy targets for the maintenance of critical environmental functions, and (2) the possible significance for national sustainability prospects of environmental load displacement to or away from the country.

In this respect, the Hicksian analogy between a firm and a country may be carried further. Just as a company may undertake a variety of foresight, forward studies, market research and scenario studies, so a country manager (or, more generally, the policy community) will engage in a variety of forecasting and strategic forward studies exercises. In the case of environmental and economic sustainability an example is the investigation of feasibility of meeting simultaneously specified economic and environmental performance goals, precisely through the modelling of various 'environmentally-adjusted national economies' as with the geGDP

concepts. As has been noted in **Section III.1** (and see **Section IV.5** below), any empirical scenario modelling for exploration of national sustainability prospects will need to take account of resource depletion and other degradation of environmental functions due to the economic activities of other countries.

These considerations do not really take us away from the 'Hicksian income' concept. Rather, they push us to give a more complete and empirically more satisfying specification of the ecological as well as economic dimensions of capital stock maintenance. One intuitive way of formulating 'Hicksian income' is explicitly to estimate the income that can be consumed while maintaining the firm's (or country's) capital stock intact. In the *geGDP* cost-effectiveness approach (**Section II.5**), environmental stock maintenance is indicated by respect of appropriate pressure and state standards for 'critical' environmental functions.

If, in the context of *ex ante* modelling, a set of environmental standards is specified that is felt to assure the ecological basis for long-run sustainability (*viz.*, the 'dark green' category of the **Section II.5** classification), a basis is established for estimation or forecasting of the 'Hicksian income' in an enlarged ecological-economic framework. Explorations may be made of a hypothetical structure of economic activity that respects these standards (*viz.*, *comparative static* modelling) or of possible transition paths towards full respect of these standards (*dynamic scenario* modelling).

The high sensitivity of *geGDP* results to modelling assumptions has already been emphasised. So once again, care with interpretation is required. In policy practice, model calculations are more often made for performance prospects subject to only an incomplete (*viz.*, 'light green') set of standards or only partial compliance with ecological requirements for long-run sustainability. In such circumstances it is more exact simply to speak of scenario estimates being made for the national income of an 'environmentally adjusted economy'. The important feature of all such analyses is the explicit linkage established between economic and environmental performance objectives, in a forward-looking framework of analysis.

#### IV.5 Costs Caused/Costs Borne: Policy Questions for Open Economies

**Section III** of the paper has been oriented around the idea of the 'adjustment' of national asset change or environmental pressure indicators to reflect the difference between depreciation or damages to natural capital '**borne by**' a nation's territory and the depreciation or damages '**caused by**' the nation's economic activity. In order to assess a nation's responsibilities in an international context, measures of environmental pressures or of natural capital depreciation, two complementary adjustments can be proposed:

- On the one hand, subtracting those 'costs borne' (– CB) within the national territory that are imposed from other economies;
- On the other hand, adding those 'costs caused' (+ CC) by the national economy that are displaced onto the rest of the world.

Within this overall framework for indicator adjustment, we further distinguished two mechanisms of load displacement:

- '**Downstream**' impacts [*d*], which are damages and depreciation of natural capital directly caused in one country by another country's (or, more generally, other countries') production and consumption activities. We thus refer to costs borne  $CB_{[d]}$  for damages imposed by the Rest of the World on the domestic environment/economy, and to costs caused  $CC_{[d]}$  for damages imposed by the domestic economy's activities on the Rest of the World environment/economy.

- **'Upstream' impacts [up]**, which are environmental damages occurring in one country (that is, the land, coastal or territorial waters and local atmosphere) in the course of production of goods and services which are exported to another country. Environmental costs borne  $CB_{[up]}$  refer to environmental damage or resource depletion taking place in a country for the production or supply of goods and services that are exported for other countries' use. Environmental costs caused  $CC_{[up]}$  are imputed to an importing country for the environmental damage or resource depletion taking place in other countries associated with the goods/services that are imported.

For each of the four categories thus defined, it is necessary to define conventions for measurement and attribution of the costs. In principle, either monetary or non-monetary units of quantification can be used; this returns us to the Monetisation Frontier considerations already developed.

At the conceptual level, the distinction between AICCAN and geGDP is retained for open-economy indicators. Therefore, the general issues of scientific quality and policy pertinence are posed. However, the quality and pertinence challenges are deepened once inter-country load displacement is addressed. At a statistical level, the challenges of reliable measures of the environmental pressures 'caused by' other countries (directly and indirectly) are quite large. At the policy level, international relations come to the fore. Attention to inter-country environmental load displacement brings us to emphasise again that many environmental functions are not 'allocated' through markets or other institutional mechanisms at all. Even where markets exist, a low or zero-price may not signal non-scarcity, but rather a relation of power in a situation of conflict. There are many ecological distributional conflicts that involve struggles between commercially oriented interests and territorially defined social groups resisting (as they see it) the dispossession of their lands, water and forests (etc.). Also, pollutants or toxic wastes may often be discharged in ways that degrade the living habitat of others who are unable to stop the event. Attention should be given to these asymmetries or market and non-market power when resource price information is used for indicator construction.

One of the starting points of the environmental load displacement literature has been the desire to assess the extent to which one nation's apparent sustainability potential — as measured by, say, a positive AICCAN for net asset change or by a modelled potential for geGDP growth while respecting strong environmental pressure standards — actually depends (for better or for worse) on its linkages with the rest of the world. As work matures in this field, the key policy questions themselves become more clearly stated. For example, once the costs borne/costs caused distinction is made, this leads naturally on to the question, are there systematic inequalities in the ways that natural asset depreciation or loss of environmental functions is distributed across countries? And, if so, to what extent can this be attributed to systematic 'cost shifting' from some countries onto others? \*

This is a question which is currently the topic of research in many parts of the world. Formally, one seeks to assess whether some countries are systematically subject to net  $CB_{[up]}$  and/or  $CB_{[d]}$  for a wide range of sectors, while others may be responsible for positive  $CC_{[up]}$  and/or  $CB_{[d]}$  for a wide range of sectors. If such asymmetries in country relations are observed, they would constitute indicators of patterns of ecologically unequal exchange.

## IV.6 Concluding Remarks and Recommendations

In the course of this paper we have worked with three distinct adjustment concepts. Each type of adjustment relates to distinct environmental accounting considerations for sustainability, and *all three* adjustment concepts are important for integrated environmental and economic policy purposes.

\* World systems analysis in development economics has sought to explain some features of persistent 'under-development' in terms of systematic asymmetries in the terms of trade between Centre and Periphery (or, 'North' and 'South') countries, e.g. for primary commodity prices. As work matures on indicators of environmental 'costs caused' compared with 'costs borne', it should become possible to assess whether asymmetries of environmental load

This also means that integrated environmental and economic accounting should not aim at the production of one single adjusted aggregate indicator. Rather, the emphasis should be placed on the development of information systems and analysis concepts and tools, that permit calculations to be made for each of the three adjustment types, based on explicit decisions about the key sustainability issues being addressed.

- ❑ In the case of the AICCAN indicator — that is, the figure for change in the monetary value of the defined portfolio of assets — we have a single concept whose numerical estimation *depends very specifically on the portfolio of assets* that the 'country manager' (or, in practice, policy and statistical services) defines for his or her attention. It is essential to have a clear explicit presentation of what is, and is not, included in the portfolio of economic and environmental assets being considered for an AICCAN estimate.
- ❑ The chosen portfolio of AICCAN assets to be subject to monetary accounting should be outlined, in a presentation document, with reference to strategic development goals or management objectives of the relevant ministries, for example. It would often be appropriate to list the key categories of assets, showing how (positive and negative) changes in quantity and (positive and negative) changes in price contribute, in each case, to the change in the given accounting period of net asset balance. This can be repeated period by period, for producing indicator time-series.
- ❑ In complement to the assessment of the basket of assets included in the AICCAN asset balance estimation, attention must be drawn to key issues of environmental services and environmental change that are not treated as 'country assets' from a monetary point of view. These key issues for integrating environmental and economic dimensions of sustainability could also be outlined in a presentation document — as a complement to the exposition of the AICCAN portfolio — again with reference to strategic development goals or management objectives of the relevant ministries.
- ❑ Forward-looking work needs to be conducted in a macro-economic cost-effectiveness framework, based on specification of the key Sustainability Gaps to be closed and time-scales over which progress is to be achieved (e.g., greenhouse gas emissions, water resources pollution).
- ❑ Priorities will differ from country to country, so emphasis should be on clear concepts that are adapted to different country circumstances. All geGDP estimates, whatever the concept that they engage, are highly sensitive to model calibration, specification of environmental standards, technological change and other hypotheses. For some purposes, a model 'greened economy' or transition path can be explored that respects **all** environmental standards felt to be requisite for long-run sustainability of economic activity and the relevant critical natural capital (we will call this '**dark green**'). However, for many policy purposes it is pertinent to conduct model analyses for 'environmentally-adjusted' economies that are constrained by only an **incomplete** set of standards such that, while perhaps 'greener' than a business-as-usual scenario, the future economy still does not achieve full compliance with ecological requirements needed for long-run sustainability.
- ❑ Concerning the third category of adjustment, estimating differences between costs caused and costs borne by a country, again there is no one calculation that will encapsulate all relevant concerns. In parallel with the AICCAN/geGDP distinction, both monetary and non-monetary indicators for this difference should be developed.
- ❑ Although empirical experiences are fragmented to date, the field is now sufficiently developed that some broad guidelines should now be formulated for

\* The international policy and statistical community could consider developing a few pilot country studies. Two contrasting examples of 'small open economies' would be Madagascar and New Zealand. The former has a significant mineral wealth, the latter has a highly productive and diversified export-oriented agriculture activity. Both countries have large EEZ (exclusive marine economic zones) and both have terrestrial (and marine) biodiversity that is of international significance and highly vulnerable to degradation through various forms of pollution.

'standard' practices for estimating environmental load displacement indicators at country level. We suggest, as a starting point, that concerted efforts be made to collate and analyse data for inter-country costs caused/costs borne for the same categories as are prioritised in the national AICCAN and geGDP analyses. This can potentially allow rapid progress and exchange of experience between countries and will, within a few years, establish a good information base that can clarify the terms in which North-South and other international environmental policy issues may be discussed and resolved.\*

To conclude, it is once again emphasised that all approaches to construction of environmentally adjusted national aggregates have to rely on multi-layered sets of assumptions and have to cope with practical valuation and quantification problems of various kinds. There is not one AICCAN figure but many (depending on the portfolio of assets included and the conventions for estimating asset value). There is not one geGDP figure but many (depending on the modelling specifications and the character of the economy adjustments taken into the calculations). Hence, results will often not conform to usual statistical quality standards. Forward-looking analyses are explorations of the domains of possibility, not deterministic forecasts. There is not one single indicator to be sought for inter-country environmental load displacements, but many (depending on the categories of environmental pressures and the mechanisms of displacement that are considered), each of which will highlight different aspects of 'ecologically unequal exchange'.

For all three 'adjusted aggregate' procedures, data deficiencies and systems complexities will mean that results will often not fully satisfy statistical quality standards sought for national accounts traditionally. In practice, all empirical implementations will face limits in their coverage of environmental phenomena (viz., the range of impacts or pressures considered). Not all categories of impacts and pressures can be included, and meaningful estimations for long-term outcomes are not always possible. Modesty and tact is appropriate in the communication of all indicator information.

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