3

An Introduction to Environmental and Natural Resource Accounting

3.1 Notions of Sustainability

In this Chapter, the literature on two characterisations of sustainability and their measurement is reviewed. The first, strong sustainability, derives more of its foundations from ecological science than does the second, weak sustainability. In each case, the basic idea, as developed in Chapter 1, is that continued well-being depends on the assets available to each generation for generating that well-being. These assets are 'capital' in all its forms. Hence, this total stock of capital must not decline through time unless technological progress is such that it offsets the declining quantities of capital. The fundamental distinctions between the two concepts of sustainability are (Pearce *et al*, 1996):

- that strong sustainability denies to a greater or lesser extent that there is substitutability between natural assets and other assets – human and manufactured assets; and
- that strong sustainability tends to stress 'discontinuity' and 'non-smoothness' in ecological systems and, hence, in the economic damages to which ecological impairment gives rise.

No business is sustainable if it fails to put savings to one side at least equal to the depreciation of its capital assets. It is the same for nations. In fact, this is the weak sustainability principle. Savings can be measured from the national income accounts as well as depreciation on human-made capital equipment, although the data are not very good. If we can value environmental depreciation in money terms, the 'savings rule' for sustainable development becomes:

$$\mathbf{S > [D_{Km} + D_{Kn}]}$$

and the magnitude:

$$\mathbf{S - [D_{Km} + D_{Kn}]}$$

is 'genuine savings'

where

$\mathbf{S}$	=	savings rate
$\mathbf{D_{Km}}$	=	depreciation on human-made capital
$\mathbf{D_{Kn}}$	=	depreciation on natural capital

In other words, the weak sustainability principle allows for a substitution between natural and human-made capital, as long as the total capital stock is non-declining over time.

With strong sustainability there is 'something special' about natural assets. The argument would be, for example, that we cannot substitute for the life-support functions of many natural assets such as the stratospheric ozone layer, or nutrient cycling in an ecosystem. If this is true then there must be certain 'critical' natural assets which can either be conserved at all times in the name of sustainability, or which can be damaged or reduced only after the most careful and cautious consideration. Deciding what is critical is hotly debated: all environmental assets, or just some? If some, which ones? Ecologists sometimes suggest that 'keystone species', species on which the functioning of an ecosystem depends, constitute critical natural capital, but it is not always clear what these species are, nor is it clear that their removal results in non-substitution by some other species. Other approaches suggest that sustainability is best thought of as 'resilience', the capacity of a system to respond to shocks and stresses and to return to some equilibrium path of change. In turn, some ecologists argue that resilience depends on the diversity of species and processes within an ecosystem. Hence one indicator of sustainability, i.e. resilience, would be the diversity of species.

3.2 Measuring Weak Sustainability: Green Net National Product (gNNP)

Gross Domestic Product (GDP) is the value of all goods and services in the economy in a given period such as a year. Gross National Product (GNP) measures the same thing but includes net income from abroad. In the national accounts, Gross National Product (GNP) differs from Net National Product (NNP) by the amount of depreciation on capital equipment. Although GNP is invariably used as a measure of economic well-being, the net concept is more relevant because it allows for the fact that we have to replace worn-out equipment, and only after doing that do we have output that contributes to current well-being:

GNP = NNP + depreciation on capital

Since environmental assets are also capital, we can extend the definition of GNP to become GNP =NNP+ depreciation on human-made capital + depreciation on natural capital

Writing KM for human-made capital and KN for natural capital,(respectively, and rearranging the equation to express NNP), we have:

$$gNNP = GNP - \text{depreciation } K_M - \text{depreciation } K_N$$

Where the 'g' reminds us it is 'green' NNP. The depreciation on KN is measured by its 'rental', defined as the difference between the price obtained for the extracted or harvested resource and its marginal cost of extraction or harvesting. R is written for rental. For non-renewable resources we need to calculate R on the extracted resources (Q) but include in the rental, any newly discovered resources (N). So, depreciation KN for non-renewables is R(Q- N). Much the same goes for renewable resources but this time we have to allow for the fact that instead of discoveries adding to the resource base we have the natural biological growth rate of the resource (G). For renewable resources, then, we get R(Q-G) as the adjustment. The final formula for 'green' NNP is then

$$gNNP = GNP - d(K_M) - R(Q\text{-}N)_{NON\text{-}RENEW} - R(Q\text{-}G)_{RENEW}$$

What is the link between gNNP and sustainability ? Unfortunately, it is rather complex and we cannot assume that if gNNP is positive and rising, the economy is sustainable. This is why other approaches, still based on gNNP, have been developed.

Case Study:
Applying Green Accounting in Papua New Guinea

Conventional indicators of national income such as gross domestic product (GDP) are typically used to measure economic growth. As discussed earlier, Green Net National Product (gNNP) accounts for the costs and benefits of natural resource depletion and environmental degradation, and can be used to measure sustainable development. This method estimates gNNP and does not estimate the genuine savings rate (discussed later), which may provide a better indicator of sustainability.

Green accounting has been applied in Papua New Guinea. The study estimated Net National Product (NNP), and Green Net National Product (gNNP), which was estimated in two stages. gNNP 1 deducted the costs of using scarce natural resources (gold, copper, silver) from NNP. Costs were calculated as market price minus marginal extraction costs. gNNP 2 deducted the costs of environmental quality loss from gNNP 1. These included losses from land cleared for agriculture, river damming for hydroelectric power stations, and pollution from mining activities. It was more difficult to value than gNNP 1.

The Net National Product(NNP) of Papua New Guinea grew from 1986 to 1988 by some 20 per cent, only to fall by 6 per cent in 1989. It rose again in 1990 by 2 per cent.

gNNP 1 reduced NNP by 1-8% over 1986-1990. gNNP 2 reduced gNNP 1 on average by 2% over the same period.

Green accounts therefore show that Papua New Guinea's income was 3-10% lower than that estimated through conventional measures.

The study concludes that Papua New Guinea grew sustainably from 1986 to 1988 but then may have failed to do so thereafter. However, estimating the genuine savings rate may be a more robust technique by which to judge sustainability.

Source: Bartelmus, 1994

3.3 The 'Genuine Savings' Approach

The genuine savings approach is different from the green NNP approach in that the adjustment for depletion of natural capital and pollution is made to national savings, not to national income. Nonetheless, the genuine savings approach is derived from the gNNP approach. Hamilton (1994) argues that green NNP *per se* is not particularly useful for policy applications, even though it is important to know the true level of income in an economy. The rate of 'genuine savings', i.e. net savings adjusted for environmental degradation has much greater importance. This is based on the principle that the total capital stock should at least remain constant over time. According to this rule, the returns from depreciating natural capital should be turned into savings and hence investments in creating either human-made (weak sustainability) or natural capital (strong sustainability).

Genuine savings can be estimated as:

$$\mathbf{SG = S - dK_M - dK_N - (MCP.E)}$$

where SG is the genuine savings and S is the savings as measured in the conventional way; dKM and dKN are depreciation of human-made and natural capital, respectively; MCP is the marginal unit cost of pollution; and E represents total emissions of pollutants. MCP.E is therefore the total cost of pollution.

The provisional wealth measures used at the World Bank show an important conclusion: human capital tends to dominate modern wealth. This is entirely consistent with modern economic growth theory which does indeed suggest that the factors 'causing' economic growth are human and social capital. Therefore, the genuine saving concept can be defined more extensively to include at least human capital. Hence:

$$\mathbf{SG = S - dK_M - dK_N - (MCP.E) + Ed - dKh - NFB}$$

where the new elements are Ed: education expenditures, a surrogate for the **increase** in human capital; dKh: depreciation of human capital, usually taken to be zero; and NFB: net foreign borrowing.

Although a positive genuine savings ratio is not evidence by itself of sustainable growth, persistent negative savings rates imply that countries deplete their capital more than they save. This is not sustainable. Hamilton (1994) shows that Britain appears to have persistently under-saved during much of the 1980s. Between 1980 and 1986, genuine savings rates were between –1.6% and –3.1% of GDP. Britain stopped dissaving towards the end of the 1980s. Some of the increase in genuine savings is attributable to a reduction in the value of resource depletion as a result of decreased oil prices.

When a country destroys natural capital in order to export goods and services to another, a question can be raised as to whose national accounts should be adjusted – the exporter or the importer? Hamilton argues that only the country initiating the damage – i.e. the exporter – should adjust accounts, otherwise the resource depletion would be counted twice. The accounts of the importing country can, however, show the extent to which its own sustainability has been secured at the expense of resource depletion in the exporting country.

Preliminary estimates have been made of genuine savings rates in different regions of the world during the period 1980-1990 (Hamilton 1995). These suggest that East Asian, South Asian and OECD countries consistently had positive genuine savings rates, while the Middle

East/North Africa and the Sub-Saharan African regions experienced negative genuine savings rates (in the case of the latter, the rate of dissavings increased substantially during the period). In the Latin American/Caribbean region, the genuine savings rate was positive in 1980-1981, negative in 1982-86, and then positive again from 1987 onwards.

3.4 Potential Uses of gNNP and Genuine Savings

The purpose of estimating **gNNP** and genuine savings is largely to make the point that incorporating environmental costs significantly changes the picture of progress painted by conventional **GNP**. Estimates may well be successful in this purpose even if they fail to incorporate all costs and in spite of a high degree of inaccuracy and arbitrariness. The same does not apply where estimates are intended as a tool for policy-making (Lintott, 1996). However, both **gNNP** and genuine savings adjustments show that policies in many countries have not encouraged even weak sustainability. What sort of policies would help achieve sustainable development? For natural resource management, government rent (royalty) regimes should be designed to capture higher resource rents without unduly penalising extractors and harvesters. Tenurial arrangements or property rights for resource exploiters should encourage efficient production over time. Resource rents should be re-invested in produced assets, human resources or natural capital to ensure that wealth is maintained. For maintaining/improving environmental quality, optimal policies should be implemented at national, regional and global levels. Creating incentives for higher genuine savings also includes micro and macroeconomic policies such as government current expenditure, relative taxation of savings and consumption, positive real interest rates and viability of the financial sector. These and other incentive creating instruments are the subject of Chapter 4.

3.5 A More Technical Note [This note can be ignored without loss of continuity]

Conventional GNP is defined as:

$$\mathbf{GNP} = \text{NNP} + \boldsymbol{\delta}\mathbf{Km} \qquad \mathbf{...[1]}$$

where Km is depreciation on human-made capital. We need to extend this to allow for natural capital, Kn, and for pollution damage. Take natural capital first. [1] is extended to

$$\mathbf{GNP} = \text{NNP} + \boldsymbol{\delta}\mathbf{Km} + \boldsymbol{\delta}\mathbf{Kn} \qquad \mathbf{...[2]}$$

Hence,

$$\mathbf{NNP} = \text{GNP} - \boldsymbol{\delta}\mathbf{Km} - \boldsymbol{\delta}\mathbf{Kn} \qquad \mathbf{...[3]}$$

How is δKn measured?

For **non-renewable resources** for each kind of natural capital (Kn_i) it is given by:

$$\boldsymbol{\delta}\mathbf{Kn_i} = [\mathbf{P_i} - \mathbf{MC_i}][\mathbf{Q_i} - \mathbf{N_i}] \qquad \mathbf{...[4]}$$

where

$\mathbf{P_i}$	is the shadow price of the resource (= market price in a competitive economy),
$\mathbf{MC_i}$	is the marginal cost of extraction,
$\mathbf{P_i\text{-}MC_i}$	is then the user cost or royalty on the resource,
$\mathbf{Q_i}$	is output of the resource (its 'draw down'),
$\mathbf{N_i}$	is new discoveries.

So, the first extension gives:

$$\mathbf{NNP} = \text{GNP} - \boldsymbol{\delta}\mathbf{Km} - \boldsymbol{\Sigma}_i[\mathbf{P_i} - \mathbf{MC_i}][\mathbf{Q_i} - \mathbf{N_i}] \qquad \mathbf{...[5]}$$

where subscript i refers to non-renewable resources.

If $N_i > Q_i$, NNP grows relative to the conventional definition. Otherwise it is less. (Note: the way in which new discoveries are treated here is open to dispute).

For **renewable resources** (subscript j) the principle is the same but we now have to allow for the natural growth rate of the resource $\mathbf{g(X_j)}$ and its harvest rate $\mathbf{H_j}$. The net growth $\mathbf{[g(X_j) - H_j]}$ is then valued at the royalty $\mathbf{P_j - MC_j}$.

This second extension now produces:

$$\mathbf{NNP} = \text{GNP} - \boldsymbol{\delta}\mathbf{Km} - \{\boldsymbol{\Sigma}_i[\mathbf{P_i} - \mathbf{MC_i}][\mathbf{Q_i} -$$

$N_i] + \Sigma_j[P_j - MC_j][g(X_j) - H_j]\}$ ...[6]

Note that if the harvest rate exceeds the growth rate, the last bracketed expression is negative and, depending on non-renewable resources, NNP could fall.

For **pollution damage** we proceed as follows. Let D_k be the **flow** of pollution of type k in physical units; Pk is the shadow price of pollution damage (estimated, e.g. by contingent valuation etc.), and MC_k is the marginal cost of pollution abatement. There are **two** effects of pollution: one on households – the disutility of pollution – and this will equal the flow of pollution multiplied by the shadow price of pollution, i.e. $P_k.D_k$; and the other on production and this will equal $MC_k.D_k$. The **sum** of these two impacts is then:

$$(P_k + MC_k).D_k$$

and this needs to be **deducted** from GNP to get to NNP. Thus, if $D_k > 0$ there is more pollution and a positive value of damage $P_k.D_k$ to householders and this should be deducted from GNP. Hence NNP < GNP. If pollution damage **falls**, i.e. $D_k < 0$, and with both P and MC positive, the expression $(P_k + MC_k).D_k$ is *negative* and since it is being deducted from GNP the effect is to *add* to NNP. NNP > GNP.

So the final expression for NNP is:

$$NNP = GNP - \delta Km - \{\Sigma_i[P_i - MC_i][Q_i - N_i] + \Sigma_j[P_j - MC_j][g(X_j) - H_j] + \Sigma_k[P_k + MC_k]D_k\} \quad ...[7]$$