The Potential Contributions of Natural Resource Accounting to the Sustainable Development Debate

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1. The Purpose of Natural Resource Accounting

A country's economic performance is conventionally measured by its Gross Domestic Product (GDP). Growth in GDP is a major objective in national policy. However, a major question raised by critics of economic growth is whether we have been growing at all in a meaningful sense. GDP statistics cannot give the answers, for GDP is not a measure of economic welfare. Erlich is right in claiming that the maximization of GDP is not a proper objective of policy (Nordhaus and Tobin 1972).

Since it has often been noted that GDP can not be regarded as an index of welfare, it is suggested that GDP measure should be revised or extended such that it will measure welfare. This view has gained prominence recently because of the mounting concern with changes in the quality of the environment. An increasing awareness of resource and environmental quality problems, and their effect on the health, nutrition and daily lives of millions of people have led to considerable interest in making the GDP accounts reflect more fully the costs of economic activities that are not reflected in market transactions but are felt through diminished availability of environmental amenities and resources.

Thus, dissatisfaction of GNP as an overall measure of economic performance give rise to the need for Natural Resource Accounting.

1.1 What is Natural Resource Accounting?

Natural Resource Accounting (NRA) describes a variety of methodologies which use accounting frameworks to present information on natural resources, the environment, and their use (Gilbert and James 1990). The concept of NRA is a wide and varied one. Like sustainable development, natural resource accounting means different things to different people. The different interpretations can be broadly grouped as follows (Young 1990):

- modifications to the national accounts so that they include environmental considerations;

  a variety of satellite accounting systems that account for changes in the value of natural resources and the environment and can be tacked onto natural accounting systems;

  physical accounting systems that bring together large amounts of environmental data into a coherent framework; and

- GIS based accounting systems, that have both a spatial and temporal dimension, and organise physical data into an economic framework that is relevant in decision making.

The different systems identified have much in common and there are many differences between them. Full examples of Natural Resource Accounting are rare and most of the work done so far is of theoretical in nature. The concept of Natural Resources Accounting was developed initially in response to the various criticisms associated with the System of Natural Accounts (SNA) of the United Nations or the GDP computations. The different methods show that much of the NRA activity has focused on correcting the GDP deficiencies or on establishing complementary accounting framework with the aim of guiding economic planning towards a broader perspective. It is also important to note that at present, none of the systems that have been developed have had much influence on natural resource management (Gilbert and James 1985). This however does not mean that Natural Resource Accounting will not have a major impact in the future. It does emphasise that Natural Resource Accounting is still on its infancy.

1.2 What kinds of policy choices are helped by NRA?

Households make many decisions including the obviously economic ones such as which commodities to consume, how to earn an income to pay

for them, how much to save, and what assets to hold, etc. Natural Resource Accounting is aimed to help policy makers identify available bundles of goods and services that better reflect the household choice on the basis of its preference.

Although the major stated rationale for Natural Resource Accounting adjustments seem to be macroeconomic, it seems plausible that the procedures will be a useful regional planning aid. Public decision- making occurs at the regional level, primarily in response to regional issues, which comprise economic, social, environmental and other aspects. Oftentimes, however, national interests which involve natural resources or the environment, are poorly represented in regional decision making. This might be due to regional planners' failure to recognise or identify national interests in regional level. The current NRA measures if implemented would not effectively reflect national objectives in regional decisions.

The national or multi-regional perspective in resource and environmental planning involves the following issues (Gilbert and James 1990):

(a) multiple or shared use of a common resource by a number of regions - the "shared resource issue";

(b) export of a region's products to a market also used by other regions - "the shared market issue";

(c) problems common to a number of regions - "the shared problem issue", and

(d) long-term viability of economic, resource and environmental systems - "the sustainability issue".

Natural Resource Accounting methods are seen as a tool for developing a national perspective to tackle the issues identified and so guiding integrated economic, resource and environmental planning. However, for maximum usefulness, NRA should also serve the decision-

maker as well as facilitating dialogue between the diversity of decision-makers and national planners.

Thus, the ultimate goal of NRA must be to improve economic management, either directly through influence on economic planners; or more indirectly through influence on resource and environmental managers.

1.3 Is there a positive correlation between GNP and social welfare?

To distinguish between `economic welfare' and `social welfare', we can illustrate the situation as follows:

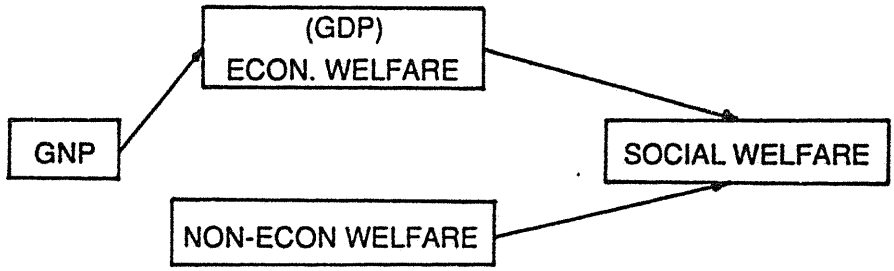


Diagram 1

Following Pigou's (1924) view, economic welfare may be defined as all those items covered by GDP, while non-economic welfare refer to all other considerations such as climate, natural beauty and quality of human relationships. If the Pigou diagram above is true, one could expect to find a positive correlation between Gross National Product (GNP) and social welfare. Furthermore, the diagram implies that increases in GDP would lead to increases in total welfare. Such conclusions depend, however, on the absence of any systematic link between GNP and non-economic welfare (Pearce 1983). If, for instance, there are increases in pollution or land degradation, then it cannot be concluded that social welfare in increased.

2. Consumption: the Welfare of the Representative Consumer

One obvious shortcoming of the GDP measure is that it is an index of production, not consumption (Nordhaus and Tobin 1972). In contrast, the goal of economic activity, after all, is consumption. Although this goal is the central premise of economics, the profession has been slow to develop, either conceptually or statistically, a measure of economic performance oriented to consumption, broadly defined and carefully calculated (Nordhaus and Tobin 1972).

This paper take the view that society's welfare ultimately depends upon the welfare of its constituent households. Following Usher (1980), it is assumed in succeeding discussions that the economy consists of only one person, called the representative consumer, whose well being may be described by an ordinary utility function entirely dependent on the quantities consumed of a finite set of consumption goods, and who obtains different amounts of consumption goods each year. Consumption goods is used in this paper to mean both goods and services.

2.1 Household choice in a static certain environment

The simplest economic model of household decision-making concerns a household that must choose how to spend an exogenous income on different goods. The framework is static, in order to abstract from intertemporal choice considerations such as saving for future consumption. The framework is also certain, in order to abstract from issues relating to differences between the actions of the household and the uncertain utility consequences of these actions.

According to the basic theory of household choice, the household has a preference ordering over all alternative bundle of commodities which satisfies certain assumed properties. In Figure 1, the farther the utility function (U) from the origin, the greater is the utility associated with it. Also, from the above figure, it can be seen that the consumer is confronted with a social state which is represented by a budget set (D) from which a consumer

can choose a bundle of commodities. The budget set is determined by the set of prices and income facing the household.

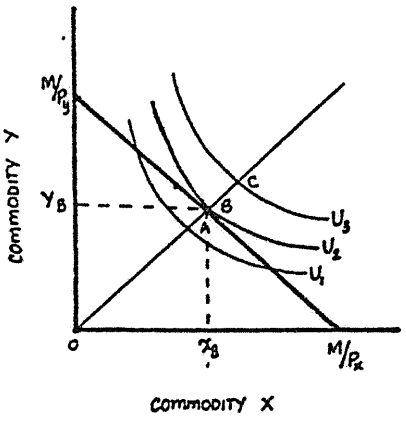


Figure 1

Given a certain income and certain set of prices for X and Y, the household make a choice, shown as point B in Figure 1, where it achieves its highest utility subject to the constraints of its budget. Thus, the measure of welfare is given by U_2, for which (X_2, Y_2) are proxies.

2.2 Household welfare in static certain environment

When some event (such as when the economy experiences economic growth) alters the households' (maximum) utility level, it is useful to express such an effect in the same units in which income and expenditures are measured. There are two ways to measure the changes in welfare.

(a) method 1

The first way is via Figure 2. The expenditure function e(P, U) gives the minimum expenditure required by the household to achieve utility level (U) when facing prices (P). The superscript 0 in Figure 2 denotes the initial situation and the superscript 1 denotes the terminal situation. Assume that

economic growth affects the household by changing the prices it faces and the income it has from [P^0 M^0] to [P^1 M^1], which alters the consumption

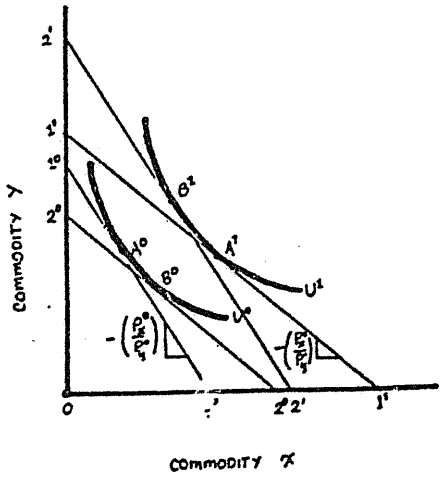


Figure 2

bundle chosen from A^0 to A^1 and the utility level from U^0 to U^1 in Figure 2. There are two methods identified by Hicks (1939) that are valuable in measuring the change in welfare in this case. The first is to find the change in expenditures that would just compensate the household for the change if the household were to face a new set of prices. The second is to find the change in expenditures that would have an effect on household utility equivalent to that of policy change itself if the consumer were to face the original set of prices.

For concreteness, it is assumed that economic growth increase the utility of the household ($U^1 > U^0$) and the Hicksian measures are as follows:

(a) Hicksian compensating variation

$$CV = M^1 - e(P^1, U^0)$$

where

CV = compensating variation
M = money income
P = prices
U = utility

After the economic growth has been experienced, the household has a money income M^1 and faces prices P^1. If it had a money income $e(P^1, U^0)$ and faces prices P^1 it could just achieve the utility level U^0. Thus CV is the change in household income that would restore to the household its initial utility level. In Figure 2, the compensating variation is shown for the case where the money price of good X falls, shifting the households' budget line from I^0 to I^1 and changing the households' chosen consumption bundle from A^0 to A^1 and its maximum utility from U^0 to U^1. The compensating variation is equal to I'2 units of the numeraire good y.

(b) Hicksian equivalent variation

$$EV = e(P^0, U^1) - M^0$$

By definition of the expenditure function, adding EV to the households' initial income will result in the same change in utility as the change in economic growth. In Figure 2, EV is shown as 2'1 units of the numeraire good Y.

(b) method 2

The second way to illustrate the concept is via Figure 3. Here we are looking at changes in real income to be equal to changes in welfare when there are changes in prices.

Using the example of Usher (1980), Figure 3 depicts a representative consumer whose tastes are invariant over time in the sense that he evaluates bundles of goods consumed in different years with respect to a single, unchanging set of indifference curves. For an increase in the economy's output to have taken place, the production possibility curve of the economy must have shifted outward overtime because, otherwise, the quantities consumed would have remained the same, year after year. The production possibility curves for years 1, 2, and 3 are indicated by P_1, P_2 and P_3. The

budget lines are represented by D_1, D_2, and D_3. Each year the representative consumer chooses the point on that year's production possibility curve yielding the greatest possible utility. These points are given by A, B and C for years 1, 2 and 3. Points A, B and C are the points at which the production possibility curve is tangent to an indifference curve. In this economy without any distortions in the price mechanism, the relative price of X each year is the common rate of substitution in production and in use between X and Y as indicated by the slopes of the common tangents of the utility curves and the production possibility curves at the points A, B and C.

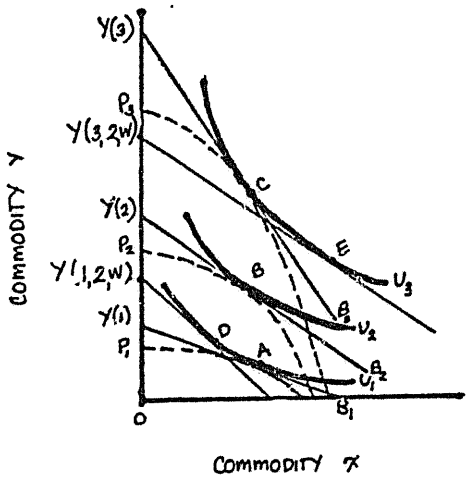


Figure 3

To depict money income in the diagram, it is assumed that the price of Y is constant at $1.00 at all times and it is only the price of X which is variable. Consider any point (Q_x, Q_y) where Q_x is the quantity of commodity X and Q_y is the quantity of commodity Y, and suppose that the prices of X and Y are Px and Py at that point. Money income, M, as normally defined is $P_xQ_x + P_yQ_y$, and income in units of y is Px/Py which is equal to Qy + Qx(Px/Py) and which may be represented on the diagram as the projection of (Qy, Qx) and which may be represented on the diagram as the projection of (Qy, Qx) onto the vertical axis by a line of the slope Px/Py. Following this rule, the incomes for the years 1, 2 and 3 can be represented by units of Y

given by the heights of the points Y(1), Y(2) and Y(3) above the horizontal axis.

But it is the change in real income or welfare that is important. For instance, with the average bundle of goods consumed in year 2, it is important to know how much money the representative consumer at prices of X and Y in year 2 would need to get onto the indifference curve U_1. To determine the real income in year 1 with respect to year 2 as the base year, shift B(2) downwards such that it is just tangent to the indifference curve U_1 at a point labelled E. The intersection of this line with the vertical axis is labelled [Y(1, 2, D)]. The measure of real income in year 1 when year 2 is the base year is the height of Y(1, 2, D) above the horizontal axis. Y(1, 2, D) signifies the amount of money one would require to be as well off as an average person in year 1 if the price of Y are $1.00 and the relative price of Y signifies a welfare measure of income.

2.3 Household welfare in an intertemporal setting

In the previous sections, household welfare was identified with its utility in a given period which, in turn, was constrained by its fixed level of expenditure in that period. In practice, the household is not constrained by a fixed level of expenditure in any given period because it can reallocate its expenditure among periods by saving and dissaving. In a framework which includes such intertemporal substitution in consumption, the analysis of the household choice can be extended to include intertemporal issues. Figure 4 represents such a situation.

The consumption of a commodity is distinguished not only by the type but by date at which it is consumed. For example X_i, t is the consumption of commodity type at date t and is different from X_i, t+1, although they might be very close substitutes.

In the case of Figure 4 where T=2, N=1, the vertical and horizontal axes are measured period two and period one consumption of the single good, respectively. The strict quasi-concavity of the utility function implies

whether the inequality $P_n(t)Q_i(t) > P_n(t)Q_i(0)$ holds true for each household, consider Figure 5.

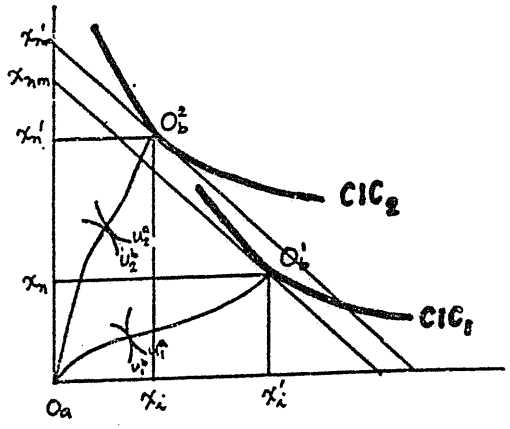


Figure 5

The Community Indifference Curve (CIC) is the locus of all combinations of X_1 and X_n which will leave the individuals on indifference curves $U_1{}^a$ and $U_1{}^b$. The income level M is the aggregate amount of income required at the relative price given by the slope O_b inorder to allow the two individuals to reach utility levels $U_1{}^a$ and $U_1{}^b$.

Figure 5 shows that at year 0, the community reaches competitive general equilibrium at point 1, and that the resulting allocation of goods is pareto optimal. An increase in the level of the community's income or a decrease in prices of commodities in year t causes the M (aggregate income) to shift to the right. The new M will now be tangent to a higher CIC level represented by CIC_2. The new equilibrium level will now exist given by point 2.

Samuelson (1956) showed that one can not infer from the inequality that the everyone is better off in year t than in year 0. As shown by Figure 5, everyone could be made better off by redistribution of goods and services. The inequality will hold true if the utility functions for all households are identical and homothetic.

that the household will not want to concentrate its consumption in one period but spread consumption over its lifetime.

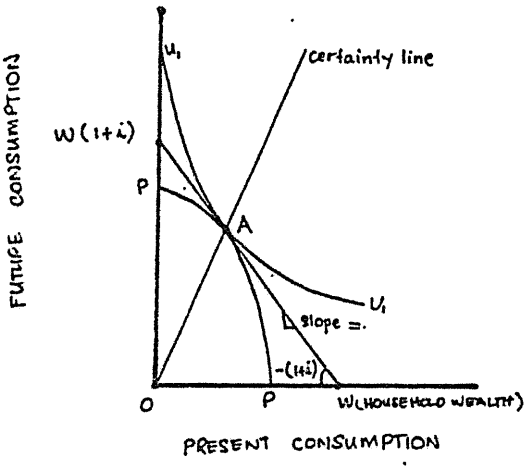


Figure 4

The analogue to the one period budget constraint is the households' lifetime wealth constraint. The households' lifetime budget set is given by the set OAB. it is assumed that the money price of the commodity is constant, the budget line AB has a slope of -(1 + i) and intersects the household wealth (W). The household is assumed to maximize its lifetime utility. Thus, it equates marginal rate of substitution (MRS) between any two commodities (distinguished by type and/or date) to their relative price. In Figure 4, the maximum lifetime utility point occurs at C, where the MRS between present and future consumption is equal to (1 + i).

3. Consumption: The Welfare of the Community

Much of the literature on the theory of welfare economics and real income are on the welfare of the representative consumer. It is a known fact,

for instance, that an individual j is better off in year t than he was in year 0 if

$$\sum_{i=1}^{n} P_n(t)Q_i^j(t) > \sum_{i=1}^{n} P_i(t)Q_i^j(0)$$

where P_n = prices of the commodities
Q_i = quantities of commodities

The points at issue in most debates on welfare aggregation are whether and in what sense the same can be said for the economy as a whole, i.e., will the equation hold true if all $Q^j_i(t)$ and $Q^j_i(0)$ are replaced by total quantities consumed.

3.1 Welfare in many household economy

Natural Resource Accounting methods like the GDP measure, are aimed at knowing and evaluating the circumstances of the many households for a given period of time. Unlike GDP However, NRA must take account of changes in the environment. The average household in time t is better off if the air is cleaner, the water purer, the hours of work shorter, the length of life longer, and if there is greater access to nature than in time 0, and vice versa, if the balance of advantage goes the other way. Given X_1 and X_2 where X_1 refers to environmental goods and X_2 to market goods, the utility function of the households is represented by Figure 5.

Before proceeding, it is worth being very clear about what assumptions are involved in analysing a single-person economy, i.e., discuss the circumstances under which a single-person economy is a sensible surrogate for a multi-person economy. This was addressed by Usher (1980).

Treating a many-person economy as if it were a single-person economy implies that just as individual demand functions reflect the preference orderings of an individual, the aggregate demand function represents an aggregate preference ordering, or set of social indifference curve. Also, the aggregate welfare change measures must have normative significance in the sense that if, say, aggregate compensating variation (CV's) rises, society must be better off or vice versa. To answer the question of

3.2 Economic efficiency in an exchange economy

There are several issues associated with real income measurement in a many household economies. These issues are as follows:

(a) aggregation problem

Basically, it is necessary that the marginal social utility of income be identical for all persons, whether that be due to a clever government that continually redistributes income so as to maintain the equality of marginal social utilities or whether it be because one is prepared simply to assume that the marginal utility of income is the same for all households. If unless both of the assumptions are met, aggregation of single individual to the economy is erroneous.

However, most practitioners of applied welfare economics proceed to measure welfare by aggregating CV's. The usual rationale is that the use of aggregated CV's to measure welfare change should not be interpreted as measuring social welfare in any direct sense but, rather, it should be interpreted as indicating whether or not there has been a potential Pareto improvement in social welfare. A potential pareto improvement means that gainers from the change could hypothetically compensate the losers from the change.

(b) separability

The problem of separability arises when the two goods in question are closely related. Given vacation as X_1 and forest trees as X_2, one would have difficulty separating the utility derived from vacation and the forest trees especially when the choice for vacation was greatly influenced by its location such

as the adjacent forest trees. The same problem also hold true for complementary goods

3.3 Interrelationships between production possibility and utility functions

The production possibility frontier represents the productive capacity of the economy while the utility function represents the welfare of the households of the economy. So, there could actually be two parallel sets of measurements of real income. One as a welfare measure and the other as productive capacity.

The concept of productive capacity avoids interpersonal comparisons and all of the difficulties associated with the identity of the representative consumer if real income can be defined as a property of the technology of the economy. However, studies show that the size of the real income of the economy is not a property of its technology alone, but is taste-dependent even if real income is defined as an indicator of productive capacity.

Also, the utility function is more amenable to measurement than the sequence of production possibility curves because utility function remains invariant over time, while the production possibility curve can change its slope substantially every year. Usher (1980) suggested that to correctly measure real income, the utility function must be fixed.

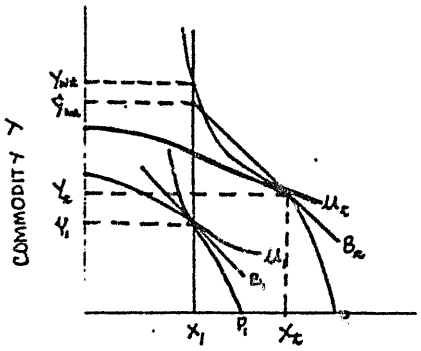
Whatever the differences between the two measures, what is important to note is that both sets of functions is needed to evaluate whether the representative consumer has increased his/her level of welfare. NRA might measure the change in welfare via the indifference curve.

4. The Relevance of the Utility Function and the Production Possibility Function in NRA.

Utility depends on amounts consumed of a finite set of commodities with considerations to the conditions of sanitation, the environment in which

an individual lives, working conditions, air pollution, crime rates and ownership of consumer durables. While money income is (a) the value of all goods and services purchased during the year; (b) the above, plus the value of goods and services acquired outside the market but which might have been purchased with money under a different but plausible form of economic organization; (c) the above, plus the value of change in the environment.

Natural Resource Accounting describes a variety of methodologies which use accounting frameworks to represent information on natural resources, the environment and their use. The utility function and the definition of money income from above help to provide a good theoretical representation of the objective of NRA. Take for example a change in the environment:



SOURCE: USHER (1980)

Figure 6

Figure 6 shows the utility function of a representative consumer for two arguments, commodity Y and sunshine. Two indifference curves are shown, one containing commodity Y and sunshine in year 1 and the other containing the same commodities in year t. If it is assumed that commodity Y is part of money expenditure but sunshine is not, commodity Y can be the numeraire, and income can be measured in units of Y. The real income in year t is the quantity consumed of commodity Y in year t plus the extra quantity of commodity Y required in year 1 to compensate for the change in sunshine index from year 1 to year t. The true measure of real income is the height of the intersection of the indifference curve attained in year t with a vertical line

at the value of the sunshine index in year 1. The production possibility curve in Figure 6 shows the productive capacity of the economy. Since NRA is aimed at measuring the true change in welfare, production possibility and utility functions are necessary components of NRA analysis.

5. Review of NRA

There are basically three approaches to Natural Resource Accounting. These approaches are as follows:

(a) Purely Economic Approach

Economic approaches have concentrated on direct modification or expansion of the traditional GDP measure. The objectives behind these activities have been twofold: firstly, to make the use of natural resources and environmental services more explicit within traditional accounting frameworks and to adjust certain aggregate indicators so that they reflect social welfare more accurately. In short, NRA will serve as an index of total consumption not of total production.

Much work which fall into this category of NRA involves adjustment of various indicators. The work of Olson (1977) and Herfindahl and Kneese (1973) have suggested a negative adjustment of GNP reflecting the social damage caused by pollution. Hueting (1980) has suggested a national prosperity indicator, derived from the inclusion of environmental decline as a negative item in the calculation of National Income. Peskin (1981) extends such arguments to suggest adjustment of GDP by an amount reflecting deterioration in the stock of environmental capital.

The earlier works of Nordhaus and Tobin (1972) was directed at the generation of alternative measures of social well-being, at least partially derived from the national accounts and attempted to include the disamenities of urbanization.

(b) Purely Physical Approach

The physical approach attempts to document stocks and flows in physical units. These approaches argue against the use of monetary units for a number of reasons. These are:

(i) the use of monetary units in accounting systems implies a very limited view of welfare;

(ii) monetary units are subject to the vagaries of inflation, and

(iii) physical units are more consistent overtime, less subjective and of application to a variety of discipline.

Its rationale is based more on the problem of dealing with externalities within economics, and inconsistencies between economic theory and fundamental physical laws (Gilbert and James 1990).

Few physical approaches to NRA have been developed beyond the conceptual design. The purely physical approach was attempted by Kneese et al (1970) and the Norwegian government (1970's). Odom et al 1983 present an "energy system procedure", i.e., stocks and flows are compared on the basis of an ability-to-do-work for the combined system of humanity and nature.

The purely physical approach have two drawbacks. The first is associated with data collection and the tracing of all stocks and flows in physical units. The second is on its limited relevance on economic planners.

(c) Mixture of Economic and Physical Approaches

This approach is characterised by some combination of the following (Gilbert and James):

(i) modification of the GDP so that monetary flows associated with the maintenance of resource stocks and environmental quality are explicit;

(ii) construction of accounts describing environmental processes and interactions in physical units; and

(iii) linkage of these via quantification in both economic and physical units of flows in the economic-environment interface.

France and Norway have devised and are constructing such accounting frameworks. Canada has undertaken work preparatory to the construction of NRA, and other individuals and research groups in the USA and the Netherlands have developed methodologies for mixed accounting systems. In most cases researches have concentrated on developing large, expanded accounting framework. Repetto (1985) on the other hand developed an NRA for a resource based economy. Repetto's accounts emphasise depletion of stocks.

The general shortcoming of this approach is that the policy makers would have difficulty choosing which of the physical or monetary items to consider in their analysis.

6. Do Conventional NRA Adjustments Meet Welfare Model?

The implications of natural resource scarcity for welfare have always been considered an economic problem. As at different times, economists have seen scarcity in different functions of the environment, economic perspectives or views of it necessarily change.

These changing economic perspectives have been due to the emergence of a new class of scarcity problems - outcomes are cumulative and often irreversible, and many kinds of environmental degradation are perceived as important. All this demands an alternative view of resource scarcity.

6.1 Does NRA give better information on sustainability itself?

The wider, highly normative view of sustainable development defines the concept as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs (World Commission on Environment and Development 1987). More specifically, a sustainable development approach - particularly as applied to the Third World - requires that:

> 'the strategies which are being formulated and implemented are environmentally sustainable over the long-term, are consistent with social values and institutions, and encourage "grassroots" participation in the development process ... In general terms, the primary objective is reducing the absolute poverty of the world's poor through providing lasting and secure livelihoods that minimize resource depletion, environmental degradation, cultural disruption and social instability' (Barbier 1987).

An objective of Natural Resources Accounting is to measure sustainable income not productive income. True income may be thought of as the maximum amount which a recipient can consume in a given period without reducing possible consumption in a future period. Prudent economic management requires that governments know the maximum amount that can be consumed by a nation without eventual impoverishment. It is important, therefore, that national income be measured correctly to indicate sustainable income.

Consider Figure 7

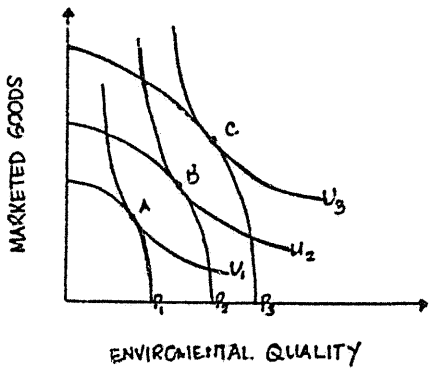


Figure 7

Think of a representative consumer whose tastes are invarriant over time. Each year, this consumer chooses the point on the year's production possibility curve yielding the highest utility. This is the point at which the production possibility is tangent to an indifference curve. This is represented by points A, B and C in the above diagram.

Natural Resources Accounting should measure the representative consumer's welfare via the utility curves and not the production possibility curves. Thus, NRA would be a measure of consumption not production. Figure 6.1 can be used to represent the three approaches to Natural Resources Accounting. From the diagram, the quantities of the environmental goods and market goods can be determined. These quantities could then be used to compute the physical flow of resources for the purely physical approach or as a measure of outputs for the purely economic and mixed approaches.

Nordhaus and Tobin's (1973) purely economic approach towards NRA effort attempted to construct an experimental measure of economic welfare (MEW) by allowing for the more obvious discrepancies between GNP

and economic welfare. Both authors did not deny the importance of the conventional SNA or of the output measures based upon them. They stressed that their MEW is largely a re-arrangement of the items in the national accounts.

The study involves the calculation of GNP and MEW for the USA between 1929-1965. The adjustments were as follows:

(a) Reclassification of GNP final expenditures as consumption, investment and intermediate;

(b) Imputations for capital services; leisure, and non-market work; and

(c) Subtraction of disamenities associated with urbanization since many of the negative externalities of economic growth are connected with urbanization and congestion.

The GNP measure were 203.6 billion (B) for 1929 and 617.8 B for 1965. The sustainable MEW were computed to be 543.6 B in 1929, and 1,241.1 B in 1959 (Nordhaus and Tobin 1973). Hence, with the adjustment made on GNP, a different set of numbers were arrived at reflecting MEW's for the years covered by the study. However, it should also be noted that just as GNP is growing, so is MEW.

In terms of its theoretical basis, it can be said that the Nordhaus and Tobin approach uniformly follows known economic theory (e.g the acknowledgement that increases in welfare can occur even if net national product decreases as leisure is increased). In as much as Nordhaus and Tobin's approach is a simple and logical method, inherent weaknesses in a purely economic approach such as theirs are inevitable. Primary among these limitations are the valuation and determination of shadow prices. In addition, there is also the problem of non-linearity associated with the economic production function. Thus, the MEW is a measure of production not consumption. Lastly, expenditures compensating for or ameliorating environmental deterioration may contribute a variable or undefinable amount by the system (Gilbert and James, undated perhaps 1985).

Gillen's (1974) calculations for MEW (termed as adjusted domestic product or NDP) follow the method employed by Nordhaus and Tobin, but this time, applying it to Australia from 1948 to 1973. The conclusion from Nordhaus and Tobin attempt also to apply to Gillen. However, the following are some further observations on Gillen's NRA attempt for Australia.

In the computation for disamenities to urbanization, Gillen examined the marginal or last migrant's wage. He argued that this particular wage will just be balanced by the marginal cost involved in moving from the rural to the urban centre. The figure he arrived at (A$-0.6 billion and A$-1.7 billion for the two periods) involves these disamenities. It is however doubtful, whether these values are anywhere near the true value. More importantly, aside from the disamenities involved in urban living, it can not be denied that benefits can also be derived if one lives in the urban centre (e.g. better health services, existence of socio-cultural amenities, etc.). Therefore, it can also be argued that such disamenities may also be effectively balanced out by the amenities involved in urban living.

Hultkrantz (1991) on the other hand, extended the national accounting measure to account for sustainability. He expanded the national account of forest resources in Sweden, 1987 by incorporating changes in timber inventories, production of non-marketed timber and non-timber goods, and depletion or improvement in vital environmental stocks (e.g. soil nutrients, biodiversity and carbon sinks). However, instead of computing the value of the changes in outputs, Hultkrantz included the cost of inputs to do his assessment. Based on welfare procedures, it should be the outputs that should be included and not the inputs to determine the welfare level of the representative consumer.

6.2 Depletion of resources

Classical and early neo-classical economists recognized long-ago that the relative scarcity of these natural resources, appropriated as productive inputs, is linked to their rate use or depletion. The earth can only supply a finite amount of available energy or raw material to the economic

process. Traditionally, a distinction is made between non-renewable resources and renewable resource stocks. The general convention is to call "extractive resources" renewable or non-renewable depending on whether they exhibit economically significant rates of regeneration.

Renewable resources are those which are capable of being replaced by natural ecological cycles or sound management policies (e.g. fisheries, forestry etc.). Non-renewable resources are those which can be exhausted (e.g. fossil fuel, mineral deposits).

Consider Figure 8. Further assume that society's output can be classified into two types only, namely the environmental or land output and the market goods.

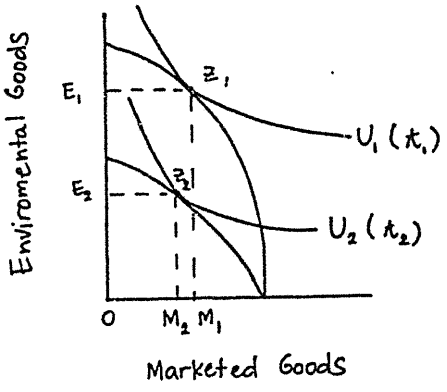


Figure 8

At period 1, the economy is at equilibrium. at point Z_1. If environmental depletion took place in period 2, this will cause the production possibility frontier to shift to the left. Society now reaches equilibrium at point Z_2. The optimal welfare adjustment is the measure of the welfare loss from Z_1 to Z_2.

current Standard Accounting Systems nor the proposed NRA methods (Clarke and Dragun 1989).

Resource depletion was measured by Young (1991) for Australia by using on-site and off farm land degradation calculations. Young's approach to soil degradation does not involve going through a physical accounting stage, but is based on productivity loss estimates. On site productivity losses are estimated to average $5,000 per farm across Australia's 126,500 farms that produce more than $20,000 per annum. Off-farm costs are assumed to be 50 per cent of productivity losses costs. Productivity and of-farm costs are then weighted by the inverse of Australia's annual wheat yield (tonnes per hectare) on the assumption that damage is highest in years of low rainfall. Like Repetto et al, Young ignores other renewable resources. Unlike Repetto et al, Young does include some accounting for environmental pollution effects, by means of subtracting an estimate of expenditures by households and government to offset the adverse effects of waste accumulation (Common 1990).

Hulkratz (1991) determine the annual depletion of exchangeable cations in forest soils in Sweden to correspond to a compensating supply of one million metric tonnes of limestone ($CaCO_3$). Hulkrantz estimated the cost of liming one hectare of forest land from air with 3 tonnes of limestone and magnesium to be 1,800 SEK. Thus, in rough estimates, the replacement cost of the annually depleted exchangeable base cations in forest soils totals 600 mill. SEK.

Young (1991) computed the value of depletion in terms of the value of the output lost while Hulkrants (1991) related it in terms of the amount of inputs used to correct the depletion.

But neither the change in input nor the change in production is an appropriate measure of changes in consumption.

Common (1990) concluded that the Extended Market Valuation approach to Natural Resource/environmental Accounting has little to offer in

Many of the arguments against the use of NRA proposals stem from the fact that there seems to be no published theoretical rationale for what is being proposed. According to Repetto (1986 and 1988), all we need to do for non-renewable resources like oil or gas, was to account for change in the economy's stock of reserves as discoveries less depletion. While it must be acknowledged that Repetto's work was a pioneer in this field, it is also essential to understand that his work only holds true for non-renewable resources. It is incorrect if renewable stock changes are computed as additions (e.g. regrowth, reforestation, etc.) less losses (e.g. harvests, firedamage stocks, etc.) because (a) it fails to account for the fact that current harvest decisions influence future growth possibilities and (b) that there are possibilities of both sustainable exploitation and depletion of the resource. Point (c) will now be illustrated.

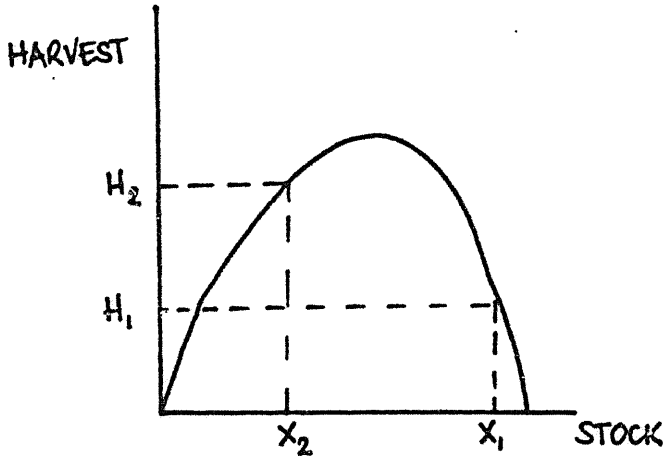


Figure 9 Sigmoid Diagram for Renewable Resources

Figure 9 shows that a reduction in stock from X_0 to X_1, due to say an increase in the level of effort, will increase cost and thus reduce the level of NNP, ceteris paribus. The diagram, however, also shows that such a reduction in stock may lead to an increase in the level of harvest and thus an increase in welfare. This analysis has not been presented in any of the

terms of promoting sustainable development. The conclusion was derived based on the following arguments:

(a) The reliability of the Extended Market Valuation methods for surrogate market valuation of goods which do not pass through markets remain in doubt.

(b) It is not clear that any single number export performance indicator would of itself usefully inform progress toward sustainable development.

(c) The Extended Market Valuation approach failed to offer the prospect of bringing together the economic and the ecological approaches to the question of sustainable development.

6.3 Growth or discovery

Growth of renewable or discovery of non-renewable resources is shown in the diagram as a rotation of the PP curve to the right. Before the discovery of additional non-renewable resources, the economy is at equilibrium at point W_1. When the discovery took place, the economy reaches a higher equilibrium point given by W_2. The change in welfare is the difference between W_2 and W_1.

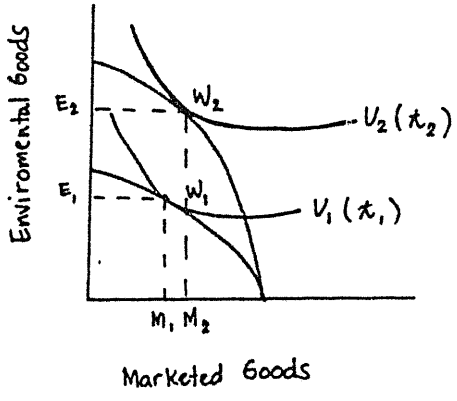


Figure 10

7. Conclusions

The different methods show that much of the NRA activity has focused on correcting the GDP deficiencies. The main thrust of NRA, it seems, is the search for a single indicator, adjusted net national income or comprehensive wealth, which would necessarily be expressed in value terms. The NRA methods known do not take into consideration the question of sustainability. NRA have to be restructured in such a way that the sustainability issue is addressed. What is proposed in this paper is for NRA to take the consumption approach rather than the production approach.

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ASSESSING THE IMPACTS OF PRODUCTION TECHNOLOGY ADOPTION IN THE AUSTRALIAN PRIME LAMB INDUSTRY

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Abstract

Technology adoption is a major source of sustainable productivity gains in agricultural production. These gains either take the form of increased outputs or reduced inputs. New production technology may also have market effects where its widespread adoption results in increased output. The nature of most agricultural markets suggests that both producers' and consumers' prices are likely to fall from production increases.

Examination of the impacts of new production technology comprises four main considerations; (i) comparison of the direct costs and returns of alternate production practices, (ii) the costs of adjustment from one production system to another, (iii) the output responses of producers, and (iv), the overall benefits and costs from an industry–wide level of technology adoption. This economic framework implies that the adoption of new production technology has implications for both producers and consumers.

This paper is concerned with the assessment of the farm and market impacts of technology adoption in livestock production, and considers the production of prime lamb as an example. Some preliminary results are presented.