MERIT RESEARCH JOURNALS
www.meritresearchjournals.org

Merit Research Journal of Accounting, Auditing, Economics and Finance Vol. 1(5) pp. 081-105, October, 2013
Available online http://www.meritresearchjournals.org/aaef/index.htm

Full Length Research Paper

Environmental effects associated with the depletion of timber stocks in Ghana

William Angko

Department of Banking and Finance, School of Business and Law, University for Development Studies, Wa Campus, Box UPW 36, Wa.

Email: angwillie@gmail.com or wangko@uds.edu.gh

Abstract

Economic activity in Ghana is largely dependent on the natural resource base. The wrongful perception that natural resources are unlimited in supply has encouraged a massive exploitation and uncontrolled use of these resources. As a result, forests are being depleted at rates that raise concern, water bodies have become polluted and the stock of aquatic life is deteriorating amongst others. Despite the fact that natural resources are used in the generation of output, the current system of accounting for the level of output in Ghana and other developing countries fails to incorporate an element that will capture the depletion of these resources and the associated environmental degradation cost. A failure to capture fully environmental effects into the broader macroeconomic framework will make it difficult for Ghana to ascertain the extent to which her natural resource base is being used in the generation of output. Bearing in mind that disinvestment in natural capital cannot be sustained indefinitely, it is, imperative that the conventional account of Ghana is adjusted for environmental effects, (that is, an environmentally adjusted GDP). The study sort to account for some environmental effects associated with the depletion of timber stocks. This adjustment will generate a measure of GDP that is sustainable and would go a long way to help achieve the objectives of the Ghana Vision 2020 programme as well as the Millennium Development Goals (MDG). An economic and environmental accounting framework will help formulate an effective planning mechanism and appropriate policies to facilitate the sustainable use of our resources.

Keywords: Natural Resource accounting, Environmental Effects, Forest resource base, depletion

INTRODUCTION

The environment refers to the natural physical surroundings on which man depends for his activity. In times past, natural resources were considered as free gifts of nature which were in unlimited supply. Consequently, there was no need to account for their depletion as they were regarded as resources that would always be available for man's use. The environment provides a number of services to man which are used in the production of economic goods and services. These are inputs or raw materials for production, life support services, sinks for the assimilation of wastes generated in production and consumption as well as amenity services. According to the World Bank, over half of a billion people who are extremely poor depend on forests for a living.

Forests provide a dwelling place to a minimum of 80% of the remaining terrestrial biodiversity worldwide, they are also a major sink for carbon, assist in maintaining soil fertility, protect watersheds and minimize the risk of natural disasters such as landslides and floods.

Many countries in the world including Ghana do not have comprehensive balance sheets or accounts for their environmental assets or natural resource base. The few countries that have developed these accounts have generally limited this to selected resources. This exclusion of natural resources from the conventional accounts makes it difficult for countries to accurately access changes in these assets as they are used up in production. Increased awareness on the impacts of issues such as scarcity of resources, environmental degradation, resource depletion and global warming on economic activity, however, has intensified efforts by countries to incorporate environmental effects into their conventional accounts. These factors have supported the call to include environmental effects into the broader macroeconomic model. The System of National Accounts has received some criticism based on certain factors. These include the fact that it only considers economic activities that occur in organized markets, since they have a market price and can be easily measured. By so doing, the SNA fails to account for economic activities that occur outside the market as they do not have an economic price. The un-priced or inappropriately priced nature of most environmental goods and services arises from the absence of exclusive property rights. In cases where property rights exist, they may not be well enforced and so the resources have subjected to open access exploitation, resulting in high rates of exploitation. Forest resources provide a wide range of both timber products and non timber products. The forest accounts of the SNA currently computes values for commercially traded timber species and overlooks the values of standing timber which provides ecological and amenity values and by so doing contribute to social welfare. The amenity value of forests for example, is also ignored as it fails to meet the definition of 'production' in the SNA (The SNA defines a produced asset as one that comes into existence due to a production process). The consumption of fuel wood and other non timber forest products (NTFPs) by households are omitted as these transactions occur outside the market. Other services provided by forests such as the protection of watershed and the processing of timber into finished products (such as veneer, furniture) are recorded in the accounts of the beneficiary industry, such as manufacturing, rather than in the forestry sector.

A second criticism is the fact that the conventional account fails to make amendment or an adjustment for the depletion of natural resources used in production. Man made (reproducible) and natural capital are both used in the production of economic goods and services. Notwithstanding this, the SNA treats the depreciation associated with these forms of capital differently. GDP is adjusted for the depreciation of manmade capital used in production to obtain NDP but overlooks the depreciation associated with the use of environmental resources. Thus NDP estimates of Ghana do not provide a true indication of welfare because it omits the disinvestments associated with the depletion of natural resources. A third area in which the SNA has been criticized is its failure to account for economic costs imposed by degradation of environmental capital such as soils, fisheries and forests. Furthermore, defensive expenditures (Defensive expenditures are expenditures undertaken to mitigate environmental degradation. Examples include increased medical expenditure due to the use of polluted water bodies or poor air quality, and government expenditure to clean up pollution) which offset environmental damage are regarded by the SNA as an addition in income instead of as a reduction in wealth. With the emergence of sustainable development, the contributions made by the environment and natural capital in the generation of income have received major attention and a number of countries have attempted to develop national accounts for their natural resources (capital). It is therefore, imperative, that nations all over the world maintain an account for the use of natural resources in their economic activities. This will enable countries to determine whether or not they are using their resources sustainably.

Ghana's national income account as it now does not give the true contribution made by the environmental resources to economic activity. It fails to account for the depreciation of timber stocks and the economic costs of environmental degradation resulting from forestry. Using the GDP and the NDP as a welfare measure is, therefore, misleading. This, therefore, calls for the need to capture the depletion and degradation of natural resources in our national accounts to enable policy makers draw up appropriate policies to ensure the sustainable use of resources.

Objectives of the study

The main objective of this study, therefore, is to account for the net accumulation (depreciation or the loss in asset value) of timber stocks for the period 2000 – 2007. Specifically, the study seeks to;

- Account for the contribution made by the forestry sector to Ghana's GDP.
- Adopt an environmental accounting framework to account for the loss in asset value of timber stocks.
- Amending the current values of GDP for net accumulation of timber.
- Adjust estimates of GDP for the cost of environmental degradation resulting from forestry and wildlife to arrive at an Environmentally Adjusted GDP (eGDP).

- Determine whether Ghana is using her natural resources on a sustainable basis as measured by a weak sustainability index.
- Determine the level of genuine savings rates in Ghana.

METHODOLOGY

This study draws upon the methodologies proposed by the System of Integrated Economic and Environmental Accounts (SEEA). In accounting for the contribution of forest resources to GDP, this study will consider commercial logging activities, plantation development, selected non timber forest products- such as fuel wood, a major plants and forest amenity values. In the estimation of the asset value of timber, this study will draw upon the methodology prescribed by Hartwick and Vincent (1998). Thus the net price, net depletion and net price variation methods will be used to estimate asset values. Whilst the net price and net depletion methods will be applied to all species of timber, the net price variation method will only be applied to particular specie - teak. With the net price method, the asset value of a hectare of forest is calculated as follows:

$$D(t) = [P - C(Q(t))]Q(t) \quad \text{..........} \quad (1)$$

Using the net depletion method, asset value would be calculated by deducting the removal of timber stocks from additions or growth to of timber stocks to obtain net growth in timber. We then multiply the ensuing value by the resource net price.

$$D(t) = [P - C][Q(t) - G(S(t))] \quad \text{..........} \quad (2)$$

In estimating the asset value for one hectare of mature timber using the Net Price Variation method, we make use of the following expression;

$$D(T) = [P - C(Q(T))]\, Q(T)[1 - (1+r)^{1-T}]/r$$

And for immature timber, this is given as

$$D(t) = [P - C(Q(T))]Q(T)\,(1+r)^{t-T} \text{for } t = 1, ..., T-1, \quad \text{......} \quad (4)$$

Here, $D(t)$ represents the asset value, P the price of timber, $C(Q(t))$the cost of extracting a unit of timber and $Q(t)$ represents the volume extracted. T represents the time to maturity of timber stock, t is the time at which the growing timber is felled and r represents the discount rate. Thereafter, net accumulation will be obtained by deducting the asset value in the current period from the asset value in the next value. This is expressed as follows: $D(t) = V(t+1) - V(t)$ .... (5)

Consequently, available estimates of Gross Domestic Product (NDP) will be adjusted for net accumulation. GDP will be adjusted for the cost of environmental degradation from forest and wildlife to obtain an environmentally adjusted GDP.

In determining whether Ghana is using her natural resources on a sustainable basis, a weak sustainability basis will be measured using the expression as

$$Z = S/Y - (\partial_M/Y + \partial_N/Y) \quad \text{...............} \quad (6)$$

The Sustainability Index (Z) requires that the level of savings (S), in an economy should exceed the depreciation on both manmade capital (∂_M) and natural capital (δ_N). In the expression above Y represents the Gross Domestic Product. Generally, the index should be greater than or equal to one. If the value of Z is less than zero, it means the economy is not sustainable. Where the value of Z is greater than one, it implies that the economy is sustainable. This is due to the fact that less capital has been consumed and consumption can, therefore, be sustained. The larger the positive value of Z is, the more sustainable the economy is. The larger the negative value of Z is, the larger the level of effort needed to move the economy back to a sustainable path. A sustainability index will, therefore, be estimated to ascertain whether Ghana's economy is on a sustainable path. The level of genuine savings would be obtained by deducting the value of depreciation of manmade capital and depreciation of timber stocks from the level of gross savings.

Data sources

Secondary data would be used mainly in this research. Specifically data would be sourced from the Forestry Commission (FC), Bank of Ghana (BOG) and Ghana Statistical Service (GSS). Other sources are the World Bank (WB), Food and Agriculture Organization (FAO), the United States Statistical Division (USND) as well as other relevant materials and publications.

.... (3)

Values of environmental resources

Generally, environmental resources provide some values, which can be broadly classified into two groups; use values and non use values. The use value of an environmental resource refers to the benefit derived from the direct or indirect use of the resource. Use values can further be broken down into direct and indirect use values. Direct use values of forests include harvested timber, non timber forest products gathered and consumed by households, for example, fuel wood, medicinal plants and electricity poles. Other direct but non-consumptive uses of forests are recreation, tourism, water for domestic usage and irrigation. Indirect use values include the life support and other ecological services provided by forests such as watershed protection, carbon sequestration which helps reduce the effect of global warming, forests acting as a protective cover to minimize the effects of soil erosion. Option value, another use value refers to the willingness to pay

(WTP) to guarantee the availability of the forest resource for future use by an individual for recreation, educational or scientific research.

The non use value of an environmental resource on the other hand, is the value a consumer attaches to the resource independently of his or her use of it. Some examples of non use values are bequest and existence values. The bequest value of a resource is the value people place on the conservation of a particular resource for use by future generations. An existence value arises from the knowledge that the resource continues to exist, independently of any actual or prospective use by the individual. Examples are attaching value to certain species of timber or pleasure from picturesque views of forests. In the case of forest resources, computing monetary values for the direct use values of consumptive products such as timber can be easily done with simple methods. However, computing monetary values for non use values is relatively difficult as it would require the use of indirect valuation methods, such as the contingent valuation method.

Functions of forests

Forest resources are multi-functional, providing a wide range of services to the owner and the society at large. The FAO (2007) classifies the functions provided by forests into three groups. These are productive, protective and socio-economic functions. Productive functions of forests include the production of timber and non timber forest products. An important issue of this function is in determining whether the volumes of timber extracted exceed the Annual Allowable Cut (AAC). Protective functions of forests include the ecological and life support services provided by forests. It also considers efforts that are aimed at protecting the environment such as the afforestation of degraded areas and the establishments of wind breaks. The socio-economic functions of forests consider the change in the value of timber stocks in each year, the overall contribution of the forest sector to employment, trade and GDP.

Forest resource accounts

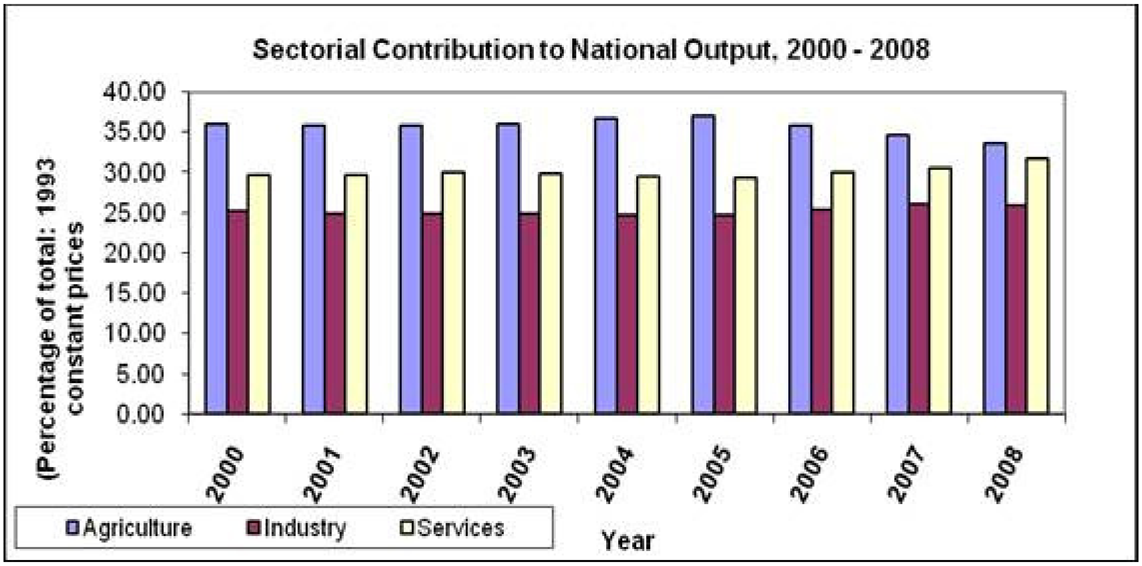
A forest resource account is made up of a physical account and a monetary account. The physical account is an outline of the total stock of timber. Monetary accounts assign economic values for entries made into the physical account. Physical accounts are measured in cubic metres (volume) or in hectares (area) while monetary accounts are measured in currency values. A physical account for timber consists of an asset account and a flow account. Generally an asset account compiles data on opening stock levels as well as all changes that occur during the period to obtain the quantity of the stock that remains at the end of the accounting period (closing stocks). This serves as a measure of depletion. The flow account on the other hand shows the flow of goods and services provided by forest to related sectors (such as wood producing firms). This account usually employs an input-output framework to show how forest resources are used in an economy.

Physical accounts verses monetary accounts

A physical account for a resource provides information that allows policymakers to determine the rate at which the resource is being depleted. This will enable policy makers design appropriate strategies for the use of the resource. Nonetheless, the use of physical accounts is limited because these accounts are expressed in different units of measurement. For example, a physical account for timber stocks, stocks of oil reserves, gold and fisheries will be expressed in hectares, barrels, ounce and tones respectively. This practice makes it difficult to incorporate physical accounts for different assets into a broader set of accounts. A monetary account on the other hand facilitates the aggregation of assets of different classes as well as the integration of environmental and economic variables since it is expressed in monetary values. Converting an asset account into a monetary account, demands the adoption of certain techniques or methods to determine the value of the asset in question. In cases where market prices exist, these have been used in the construction of monetary accounts. In the absence of market prices, other valuation methods which are non market based, such as the contingent valuation and the hedonic pricing methods can be employed.

Overview of Ghana’s economy

The total land area of Ghana is about 23.85 million hectares, with agricultural land accounting for 64.8% and forest area 24.2% of the total land area. Population of the country as at 2007 stood at about 23.46 million people, GDP (at current prices) was 15.25 billion US dollars and Gross National Income (GNI) per capita is $590 over the same period (WDID, September 2008). The major vegetation belts are the high forest, northern savannah (Guinea and Sudan savannah), coastal savannah and coastal strand and mangrove. The wildlife estate in Ghana consists of fifteen permanently protected areas which occupy approximately 13,000km^2 of the land area in Ghana (World Bank 1998). This includes six national parks, six reserves, two wildlife sanctuaries and one natural reserve. Ghana’s economy has witnessed appreciable growth, from 4.2% in 2003 to 6.2% in 2007 and 7.3% in 2008. Policies that have been tailored to foster growth of the economy include the Vision 2020 Plan and the Growth and Poverty



Source: WDID, 2008

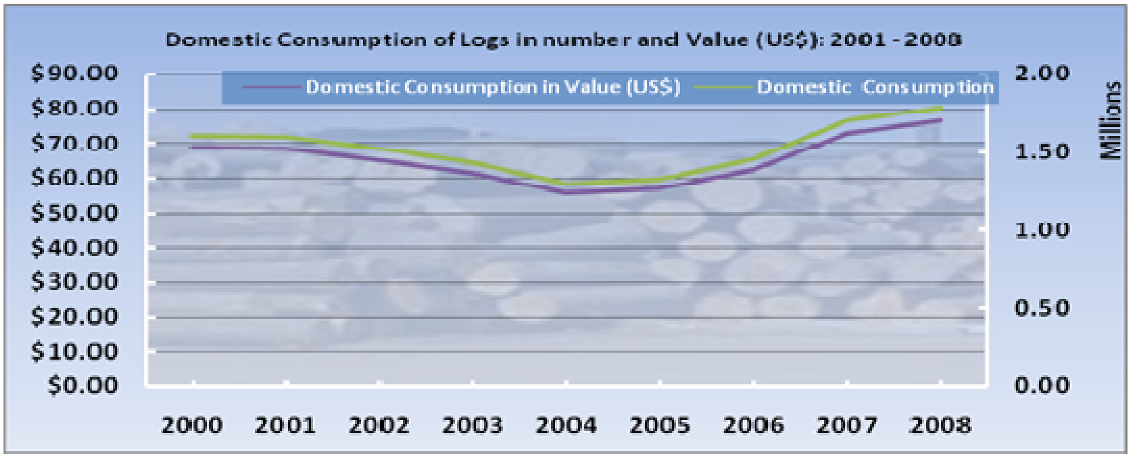
Figure 1. Sectorial Contribution to National Output (2000 – 2008)

Reduction Strategies (GPRS II). About 50% of Ghana's GDP is derived from sectors that are closely related to the natural resource base (Our major natural resource base consists of large deposits of minerals, notably gold and bauxite, forests and in recent times, oil): crops and livestock (29%), forestry and wood processing (7%), fisheries (4%), electricity and water (3%) and tourism which accounts for about 5% of GDP (CEA, 2006 pp 16). In Ghana, GDP is measured through the output approach. This approach measures the sum of value added which is created through the production of goods and services within the economy. The output approach shows the contributions made by the various economic sectors to the level of GDP. (Figure 1)

The economy which is largely agrarian has four major sub sectors; crops and livestock; cocoa; forestry and logging; and fishing. Other major economic sectors are manufacturing and services. Close to 50% of Ghana's GDP is obtained from the exploitation of renewable natural resources. The crops and livestock sub-sector is the largest contributor to GDP in the agricultural sector, contributing 25.0% to GDP in 1997, 24.7% and 23.8% in 2002 and 2005 respectively. The forestry sub-sector contributed 3.1%, 3.6% and 4.1% to GDP respectively over the same period but remained fairly stable at 3.6% from 2001 to 2004 (GSS reports). Ghana has depended largely on revenues from exports of primary products, notably, cocoa and gold for the financing of its budget. Apart from revenue obtained from the sale of cocoa and gold, timber also provides substantial revenue to the country. Ghana was rated among the top five exporting countries of tropical veneer to European Union (EU) destinations (Malaysia was the leading exporter, followed by Brazil, Gabon and La Cote d'Ivoire in that order. For further details, refer to the Annual Review and Assessment of the World Timber Situation (2007) by the International Tropical and Timber Organization) between 2005 and 2007. The enormous contribution made by natural resources to economic activity in Ghana, therefore, cannot be overlooked.

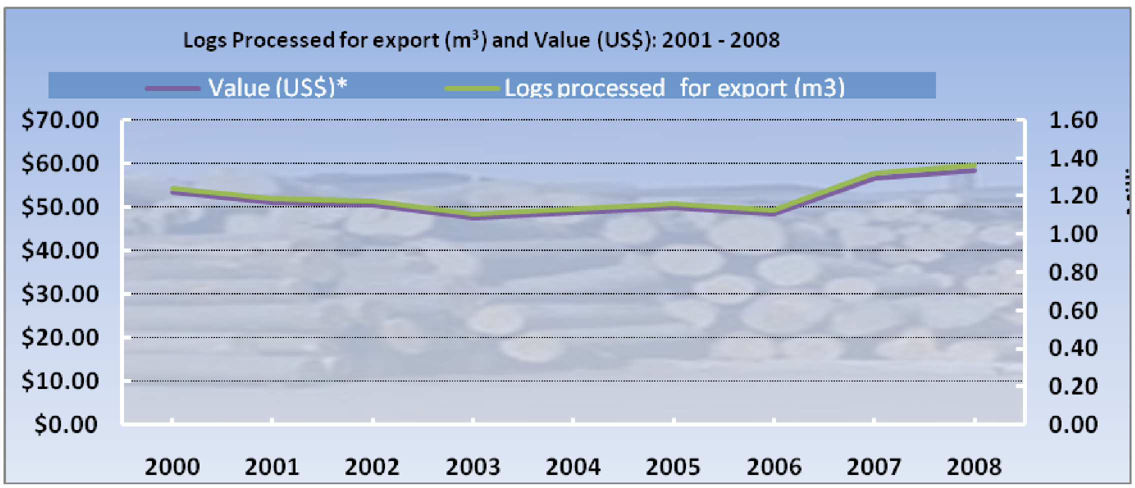
In spite of the huge benefit provided by forests resources to our economy, timber stocks are being over exploited whilst forest land is being converted into agricultural land and for settlement purposes at an alarming rate. Other resources such as soils are deteriorating in quality whilst air and water pollution has become evident in almost all sectors of the economy. The extraction of natural resources when done in an unsustainable manner has the potential of impacting negatively on economic activities through reduced output (both current and future). It also poses a threat to reducing the level of Ghana's GDP and hence economic growth. For Ghana's economy to be sustainable it requires that rents obtained from exhaustible resources are invested in other asset, that is, reproducible assets; whist renewable resources are extracted at sustainable rates. (Figure 2, 3)

Following the downturn in our economy in the period prior to 1983, the Economic Recovery Programme (ERP) was introduced in 1983 with the major objective of improving upon the performance of the economy. The ERP encouraged the massive exploitation of forest resources, particularly for timber. Even though this led to an increase in export earnings from timber from $44.1 million in 1986 to $118.0 in 1990, it has been estimated that an environmental cost of US$33.4 billion was imposed on our economy due to the exploitation of forest (GSS, 2002).



Source: (GSS, 2002)

Figure 2. Domestic Consumption of Logs in US$ value (2001 -2008)



Source: (GSS, 2002)

Figure 3. Value of logs processed for export in US$ value (2001 – 2008)

Overview of the forest sector

Ghana currently has 266 established forest reserves classified into natural (uncultivated) forests and plantations (cultivated) forests. Natural forests can be further grouped into two; on reserves which accounts for 216 of forests and cover an area of 1,634,100 hectares in the High Forest Zone (HFZ) and off reserves which account for 50 forests estimated at 400,000 hectares. (Hawthorne and Abu-Juam 1995). Controlled harvesting of timber is usually done in the on-reserves. Thus the bulk of timber which is felled is largely from off reserves. Natural forests account for the bulk of timber species whilst plantation development account for a limited number of species such as teak, cedrela and emire. The optimal rotation period or felling cycle is 25 years for plantations and 40 years for natural forests.

There are about 82 species of timber exploited for commercial usage in Ghana. Tree species have been classified based on their scarcity or rate of exploitation with the different groups represented by different colour codes. Black species are species which rare internationally, uncommon in Ghana and thus highly protected. Whereas gold species are rare both in Ghana and internationally, blue species are widespread internationally or rare in Ghana or vice versa. Scarlets consist of traditional timber currently under threat of extinction. Consequently, greater restrictions apply to their cutting as they are cut in excess of 200% of levels deemed to be sustainable. The red specie on the other hand is common but tend to be over-exploited. It refers to other traditional timber for which current exploitation rates poses a threat of extinction and are presently cut at rates exceeding 50% but below 200% of the AAC. Pinks are lesser known species exploited at rates which cause no concern for their economic future as they are cut at rates less than 50% of the Annual Allowable Cut (AAC). Finally green species are tree species that are of no particular concern for conservation as the rate of exploitation is very low. Commercial species of timber in Ghana are the pink, red and scarlet. This classification is based on the depletion rate for 64 economic timber comprising 32 pink species, 17 red specie and 15 scarlet species. Each group has a different minimum diameter for felling (that is, breast height) ranging from 50 metres to 190 metres.

Forest degradation and depletion in Ghana

According to a report by the FAO, about 13 million hectares of the world's forest is lost annually through deforestation. Between 1990 and 2000, the net forest loss was estimated at 8.9 million hectares per year and 7.3 hectares per year between 2000 and 2005. It has been estimated that during the 1970s, the annual deforestation rate of forests in Africa was 0.5%, increasing to 0.8% and 0.9% in the 1980s and 1990s respectively (FAO 2004). Deforestation rates are very high in West Africa where about 1.2 million hectares of forest was felled on an annual basis during the 1980s (This citation is taken from an exposition on the Poverty-Environment Nexus in Africa by Charles Lufumpa and published in the African Development Review. Volume 17 No. 3, December 2005). Available estimates of the extent of forest land in Ghana shows a decline in forest area from 7.45 million hectares in 1990 to 6.09 million hectares in 2000 and 5.52 million hectares in 2005 (FAO, 1995).

Deforestation in Ghana is largely caused by the extraction of timber, wood harvest for fuel wood, the practices of shifting cultivation, mining activities and bush fires. These practices tend to result in a loss of biodiversity, encourage soil erosion as well as the drying up of water bodies. The demand for logs in Ghana has been found to be in excess of supply. A study by Birikorang et al (2001) established that Ghana's forest industry is built on unsustainable logging. It revealed that of the total log harvest of about 3.72 million cubic meters (m^3) in 1999, illegal log harvest accounted for 0.925 million m^3, legal log harvest was estimated at 1.01million m^3 and round wood equivalent of chain saw harvest (The legal harvest was estimated from the Forest Commission, illegal harvest was estimated from survey data and round wood harvest was estimated from output of the tertiary sector) was 1.696 million m^3. This upward trend in the industry's milling capacity has continued and is now estimated at an annual rate of 5.1 million m^3, due mainly to the capital deepening among existing firms as well as the inability of the Forestry Commission to control the production of log and lumber.

To control the massive rate of forest depletion, the AAC has been set at 1 million m^3 for on reserves and off reserves; that is 0.5 million m^3 on reserves and 0.5 million m^3 off reserves. Even though this new limit is expected to help control the exploitation of timber, the forestry sector continues to be threatened by the impact of excess milling capacity in the domestic timber industry and the activities of illegal timber loggers and chainsaw operators. Depreciation simply refers to a decline in the value (quality) of an asset. It measures the reduction in the income generating abilities of an asset or capital overtime. Forest degradation involves changes in the forest that affect negatively the structure or function of the stand or site, thereby lowering its capacity to supply products and or services (FAO, 2001).

Depletion of timber is defined as the part of logging that exceeds sustainable wealth accumulation. (FAO 1998) and this accounts for a major loss of forest land in Ghana. It includes the transformation of forest into other land uses such as agricultural land, urban areas. Deforestation leads to a reduction in the stream of future benefits provided by forests. Depletion of natural resources in Ghana is occurring at an alarming rate (See report prepared by Aryeetey et al (2005) report for the World Bank for further discussion). Over 50% of original forest area in Ghana has been converted into land use for agriculture since the 1950s. A comparison of 1989 and 2001 forest reserve inventory reveals that the gross national standing in productive forest reserve land has fallen from 191 to 102 million cubic metres over the last three decades. Over the last decade, land use for the production of cocoa has also increased due to migration towards unoccupied virgin forests in the Western and Brong Ahafo regions (World Bank, 2005). The Forestry Commission estimates a deforestation rate of 22,000 hectares in the Forest Zone per annum, with 65,000 hectares of forest land being lost annually over the country. The high rate of deforestation raises concerns over the sustainable use of forest resources as forests provide a source of livelihood and other benefits for the society. This has serious implications for our economy as it has the tendency of resulting in increased floods, increased rate of soil erosion and emissions of green house gases (GHG) which contribute to global warming.

The degradation and depletion of natural resources in Ghana can be attributed to a number of socio-economic and political factors. High population growth is a major contributing factor to deforestation as it results in a clearing of forest land for settlement, agricultural activity and other infrastructural purposes. In addition, the inability of the market to accurately price natural resources has often led to a misallocation of resources that will be used in production. Furthermore, the relatively low market price for timber on the local market as compared to higher prices on the international market has resulted in the exploitation and near extinction of certain species such as mahogany, sapele and odum. According to estimates, over 60% of Ghana's forests have been destroyed in the search for agricultural land, firewood, minerals and logging for timber. Logging and cocoa production were the major cause of the loss of closed forests until the mid 1960s. The principal sources of deforestation in recent times, however, have been shifting cultivation and fuel wood harvest, both of which are poverty driven (Baytas and Rezvani, 2000). Mining in forest reserves, inadequate control and management of exploitations in forest concessions, poor farming practices such as slash and burn and shifting cultivation (Agyemang and Brookman-Amissah (1987) ascribed 70% of the depletion of forests to the practice of shifting cultivation (bush fallow). It should also be noted that shifting cultivation has minimal impact on the environment when population is low and fallow periods long. On the contrary, rapid population growth has resulted in increased pressure on agricultural land, leading to shorter fallow periods, degradation of forest land and sometimes permanent conversion of forest land to agricultural land), legal and illegal activities of timber companies has also reduced the stock of forest resources and has impact on sustaining long term economic activities.

Available estimates indicate that the total cost of environmental degradation in Ghana was US$128.3 million in 1988. This amounted to about 4% of GDP. The agricultural sector was identified as the leading cause of degradation, accounting for about 69% of the total cost of degradation or US$88.5 million. Environmental degradation cost resulting from the production of crops was estimated at US$80 million whilst the cost from grazing was put at US$8.5 million. The forestry sector on the other hand accounted for US$33.4 million of the total environmental cost, which was as a result of the exploitation of forest resources. (GSS, State of the Economy Report, 1992). In estimating the environmental cost imposed on the economy by environmental degradation in agriculture, mining and manufacturing, the Willingness To Pay (WTP) to avoid the impact of degradation was estimated using market prices where available or approximate estimates of market prices where market information was not available. Concerns about the impact of resource depletion and environmental degradation on economic activity and development led to the Government of Ghana (GoG) instituting some policy measures to address the rate of resource depletion and environmental effects in Ghana. These include the National Environmental Policy (NEP) which provided a broader framework for the implementation of Ghana's Environmental Action Plan (EAP). Other polices are the National Environmental Action Plan (NEAP) which reviews the key sectors of the economy along the lines of environmental sustainability. The NEAP serves as a basic policy framework for land and environmental management. The Forest and Wildlife Policy of 1994 also identifies strategies for the conservation and sustainable development of the country's forest and wildlife resources.

Other measures which are being undertaken to control the depletion and degradation of forest resources include felling controls for harvesting in off-reserves, regulations to control the activities of chain-saw operators and strengthening the capacities of regulatory and institutional agencies to enforce environmental laws and policies. To control the rate of felling of timber, the Timber Utilization Contract (TUC) has been introduced to allow for allocation of timber through a competitive bidding process. With this process, the stumpage fee that is charged is based on the star rating of the various timber species. Thus, the scarlet specie which is in high demand and so becoming relatively scarce attracts 20% of the free on board price of air dried lumber prices; whilst the red specie which is normally used attract 10% with the lesser used pink specie attracting 5% of the free on board price as stumpage fees. This move is expected to realize higher efficiency in the utilization of timber, encourage more utilization of the lesser use species whilst discouraging excessive use of species in high demand.

The National Forest Plantation Development Programme (NFPDP) was also launched in 2001 with the objective of restoring the nations' degraded forest area through the development of forest plantations, provide employment for rural communities to alleviate poverty in forest fringe communities, increase the production of food in the country and also address the wood deficit situation in the country. Under the PDP, 36,000 hectares of forests would be planted each year and over 81,000 hectares have been planted to date throughout the country. The Modified Taungya System (MTS), a mechanism under the PDP involves the establishment of plantations by the Forestry Services Department of the Forestry Commission. This is done in joint partnerships with peasant farmers in the communities. The Forestry Commission provides the technical support whilst farmers provide labour inputs. The farmers are allowed to cultivate their food crops which are interspersed with tree crops on the same piece of land. Aside the produce from their food crops, the farmers are also obtain a 40% share in returns made from the investment. The second strategy which is funded under the Heavily Indebted Poor Countries (HIPC) benefits involves the establishment of industrial plantations. Activities are monitored to ensure adherence with quality standards for the establishment of plantations. With the third strategy, the Forestry Commission gives out degraded forest lands to private bodies to revamp. These strategies aim at the conservation of forests as well as the recovery of degraded forest into better forests through the cultivation of exotic and endogenous species of timber.

The Forestry Commission, 2007 estimates that about 123,193 hectares of forest plantation has been established under the Plantation Development Project. In 2007, about 16,754 hectares of degraded forest lands had been planted. Some agencies which have been formed to help address the issue include the present Forestry Commission, formed from a merger of five organizations- the Forestry Department of the Ministry of Lands and Forestry, the former Forestry Commission, the Department of Game and Wildlife, the Timber Export Development Board and the Forest Products Inspection Bureau- in 1999. The Forestry Commission is the principal regulator and implementation agency in the forest and wildlife sectors. The failure to account for the depletion of natural resources and the associated costs of degradation means that Ghana's estimates of GDP and GNP are over-valued. Using the current estimates of GDP as a welfare measure is, therefore, misleading. This is because it fails to account for disinvestments of the natural resources which cannot be sustained forever. This strongly supports the need to adjust current estimated of GDP for the depletion of natural resources as well as the cost of environmental degradation.

Literature

The System of National Accounts

The System of National Accounts (SNA) is the internationally accepted standard for measuring economic activity in a country. The SNA consists of two accounts, the assets (stock) accounts and current (flow) accounts. The asset account is a balance sheet of national assets and liabilities and shows changes in the value of economic assets that result from depreciation, accumulation or revaluation during an accounting period. The current account on the other hand measures economic transactions which occurred in the economy during the accounting period and have often been used to measure a nation's output. Introduced by the United Nations Statistics Department (UNSD) in 1953 and subsequently revised in 1968 and 1993 (The revised SNA gives a better presentation of assets since it defines what constitute an economic asset (that is an asset that contributes to production) and also revises the classification of assets), the principal objective of the SNA is to provide a detailed theoretical and accounting framework which can be used to evaluate and analyze the performance of an economy.

The System of Economic and Environmental Accounts (SEEA)

The System of Environmental and Economic Accounts (SEEA) developed by the United Nation Statistical Division (UNSTAT) has a major objective of expanding the SNA to integrate environment and social dimensions in the accounting framework. The SEEA has four principal groups of accounts. The first account usually referred to as physical accounts deals with physical data on the flow of materials and energy and includes data on green house gas emissions. It is measured in physical and monetary units. The second account considers aspects of the SNA pertinent to the management of the environment. Often referred to as pollution expenditure accounts, it shows economic accounts and environmental transactions such as expenditures incurred by households, businesses and governments to preserve the environment. The third account consists of environmental asset accounts measured in physical and monetary terms with the fourth being an extension of the SNA to account for economic impact on the environment. With the fourth account, adjustments are made to the SNA for defensive expenditures as well as depletion and degradation of natural resources.

Distinction between the SNA and SEEA

The SEEA is based on satellite accounts which are supplementary accounts developed for environmental and natural resources and would be used alongside or linked to the conventional accounts. A major difference between the SNA and the SEEA is that the latter has a more detailed asset classification with estimates and imputations made in near-market or non-market areas (for depletion and degradation), whereas the former continues to concentrate on income and assets that can be valued based on market price information (Hamilton et al 1996). In other words, the SEEA makes a distinction between economic assets (these include produced assets such as timber plantations and non-produced assets such as natural forests (A produced asset is a product that comes into being through an economic activity whereas a non-produced asset is one that arises from natural processes.)) which form the core of the SNA and environmental assets (Economic assets are used as inputs in production and provide a return to its owners. Environmental assets on the other hand provide environmental services such as flood control and are also classified into produced asset *(*for example plantations) and non-produced assets (such as recreational land and land underlying buildings)) as well as changes in these assets.

In the asset classification of the SEEA and the 1993 SNA, forest land and standing timber are classified as two separate assets. Land is a non-produced asset, while standing timber is a produced asset if the forest is cultivated and a non-produced asset if it is non-cultivated (SEEA 2003). Theoretically, forest land and standing timber should be separated and each valued accordingly though this is practically difficult to achieve. The SEEA also integrates issues of environmental concerns into the SNA by isolating and explaining all environmentally related flows and stocks (as this allows for a better assessment of environmental impacts) and also estimates all expenditures made to protect or restore the environment. Thus for an asset account, the SEEA makes use of information on depletion, degradation, other accumulation (additions to the quantity of an asset arising from economic decisions) and other changes in volume (qualitative or quantitative changes in assets not caused by economic decisions). Another feature that distinguishes the SEEA from the SNA is that the former includes the degradation of natural resources as well as depletion through measuring the change in value of the asset in the asset account whereas the latter currently records environmental degradation and depletion as 'other changes in volume' in the asset account. Thus within the SEEA, there is a reclassification of information on "other changes in volume' for non- produced economic assets into four categories; these are depletion which refers to reductions in the quantity of assets due to economic use such as the harvesting of timber; degradation refers to a change in the quality of assets due to economic use or discharge of residuals (an example is damage caused by acid rain to commercial timber stands). The third group is other accumulation resulting from additions to the quantity of assets due to economic decisions such as the transfer of virgin forests to the commercial timberland base. The fourth category considers other volume changes -quantitative or qualitative- in assets not caused by economic decisions with an example being the destruction of forests by natural fires (Bartelmus and van Tongeren 1994, p). Bartelmus and van Tongeren (1994) in an operational guide to the SEEA review the net price (NP), the Net Present Value (NPV) and the El Serafy methods (ESM) for the valuation of timber stocks. Theoretically the Net Price and El Serafy methods should yield equivalent results for net accumulation. Bartelmus and van Tongeren following Repetto et al recommend the valuation of opening stocks by multiplying them by the net price of the resource at the beginning of the accounting period. In addition, depletion should be valued by multiplying the quantity of timber harvested by the average net price during the period whereas closing stocks should be valued by multiplying stocks by net price at the end of the period. This study adopts these recommendations in the construction of monetary accounts. Man made assets - buildings and equipment, for example – are valued as productive capital and are written off against the value of production as they depreciate. This practice recognizes that a consumption level maintained by drawing down the stock of capital exceeds the sustainable level of income. Natural resource assets are not so valued, and their loss entails no debit charge against current income that would account for the decrease in potential future production. A country could exhaust its mineral resources, cut down its forests, erode its soils, pollute its aquifers, and hunt its wildlife and fisheries to extinction, but measured income would not be affected as these assets disappeared (Repetto et al 1989).

Measuring Sustainable National Income

A true measure of living standards should be one that incorporates sustainability. The Brundtland Commission Report (World Commission on Environment and Development 1987) defines sustainable development as 'development that meets the needs of the present without compromising the ability of future generations to meet their own needs'. A true measure of sustainability is one that accounts for all forms of capital; namely, natural capital, manmade capital and human capital. Sustainability requires that an economy deducts the consumption of environmental resources from Net Domestic Product to obtain a measure which reflects truly social welfare and wealth creation (Asheim, 1994). Human capital is often not included in the definition of capital as no agreement has been arrived at in terms of how it would be measured (Lange, 2003). Three generally accepted but divergent views of sustainability identified in the literature are the three pillar approach, ecological and the capital theoretic approaches. The three pillar approach embraces three major systems; economic, social and environment. These systems which are interconnected should simultaneously be sustainable in and of themselves. In addition, all the three pillars should be satisfied. The SEEA offers comprehensive information on the economic and environmental systems as well as interactions between them. However, little information is provided on the social system. The ecological approach on the other hand shares the view of an environment with the social and economic systems being sub-systems of this environment. From the ecological viewpoint, development means the ability of the ecosystem to act positively in response to change and opportunities. The SEEA which offers information on the environment and its sub-systems is yet to be fully developed on an approach based solely on ecosystems.

From the viewpoint of capital theory, sustainable development is one in which the per capita wealth (Wealth from the capital theoretic view refers to the stocks of produced (manufactured or manmade, natural, social and human capital. The SEEA dwells extensively on natural capital as social and human capital *(though vital)* do not fall in the scope of integrated environmental and economic accounting) of a nation is non-declining and this can be achieved through the conservation or replacement of the wealth used in the generation of income. The SEEA provides a framework for measuring sustainable development based on capital theory. Researchers generally agree that in measuring sustainable development, all forms of capital should be considered. Nonetheless, there are opposing views as to whether or not the different forms of capital are substitutes for natural capital (with some researchers arguing that human capital can be used as a substitute for natural capital) or complements to natural capital. The extent to which natural capital can be substituted for other forms of capital has resulted in different capital theory based approaches to sustainable development. Two concepts of sustainability identified in the literature which are based on capital theory are weak sustainability and strong sustainability. Weak sustainability requires that the total stock of capital, that is natural capital and manufactured capital be non declining overtime, and allows for the substitution of one form of capital with another. Proponents of weak sustainability argue that natural resources can be depleted and environmental systems degraded provided that the depletion or degradation is accompanied by compensating investments or increases in other forms of capital. Weak sustainability is usually measured in monetary terms. Strong sustainability on the other hand requires that the stock of natural capital be non-declining, that is, it should be maintained constant independently of the other forms of capital. The strong sustainability concept is based on complementarily between natural and manmade capital rather than substitutability as advocated by the weak sustainability theory. To this school of thoughts, the different forms of capital are complementary and for any form of capital to be of value, the other forms must be essential. In the absence of timber stocks (natural capital) for example, the machinery (produced capital) used in the harvesting and processing of timber has no value. Advocates of strong sustainability express the view that renewable resources can be exploited so long as the rate of exploitation equals new growth. This approach measures the stock of natural capital in both physical and monetary units.

Weak sustainability clearly allows for the depletion or degradation of natural resources, so long as such depletion is compensated by increases in the stocks of other forms of capital (for example, by investing royalties from depleting mineral reserves in factories). Only by maintaining both natural and produced capital stocks intact, the proponents of strong sustainability argue, can non-declining income be assured (SEEA, 2003, pp. 6). Capital theoretic models are based on a weak sustainability indicator. The capital-theoretic approach to sustainability requires the assumption of complete substitutability between the relevant forms of capital, and the presumption that the ‘prices are right’ in the sense that all forms of capital are correctly valued in terms of their sustainability (Harris and Fraser, 2002). Following from Pearce and Atkinson (1993), an economy is sustainable if and only if the level of its savings exceeds total depreciation on the stock of natural and manmade capital. That is;

$$Z > 0 \text{ if and only if } S > (\delta_M + \delta_N) \quad \ldots\ldots (7)$$

Where Z represents the sustainability index, δ_M and δ_N the values of depreciation of manmade and natural capital respectively, and S signifies the level of savings. They measured natural using market based estimates of environmental damage. For example, soil erosion can be measured in terms of the loss of crop output. Dividing through the equation above by income (Y) gives

$$Z > 0 \text{ if and only if } S/Y > (\delta_M/Y + \delta_N/Y) \ldots \ldots (8)$$

The term δ_M/Y allows for unlimited substitution possibilities between natural and manmade capital and is referred to as the weak sustainability rule. The above inequality is used to derive a weak sustainability index of the form

$$Z = S/Y - (\partial_M/Y + \partial_N/Y) \quad \ldots\ldots\ldots (9)$$

The Sustainability Index Z requires that the level of savings in an economy should exceed the depreciation on both manmade and natural capital. Pearce and Atkinson (1993) indicated that the index should be equal to or greater than one. If the index is less than zero, it means the economy is not sustainable. A sustainability index of less than one means that the economy has consumed too much capital and the level of consumption cannot be sustained indefinitely. Where the index is greater than one, it means the economy is sustainable because less capital has been consumed and consumption can, therefore, be sustained. The larger the positive number, the more sustainable the economy is. The larger the negative value of Z is, the larger the level of effort needed to move an economy back to a sustainable path. Pearce and Atkinson used this formula to assess the sustainability of growth in eighteen countries. Results of their study indicated that many countries are not likely to achieve a pass on a sustainability test, even when based on a weak sustainability indicator. Developing countries such as Burkina Faso, Mali and Ethiopia were found to be unsustainable. Marginally sustainable economies included the Philippines and Mexico with Japan, Costa Rica and the Netherlands identified as sustainable economies. The weak sustainability concept on which capital theory is based has, however, been criticized on its assumption of complete substitutability between the two forms of capital (In some cases natural capital is virtually not substitutable. A classic example is the absorption of ultra violet radiation by the atmosphere. Ultra violet radiation cannot be substituted by manufactured capital, at least for now). The uncertainty associated with the long run impacts of economic activities on the environment and damage caused to the environment from economic activity raises concern on the weak sustainability concept.

Measures of income

Income is defined as that part of value added that remains after due allowance has been made for maintaining the total stock of capital intact (Harrison 1993). Two generally accepted definitions or measures of income provided in economic literature are Hicksian and Schanz-Haig-Simons (SHS) income. Hicksian income (Y_{HICKS}) is defined as the maximum amount an individual can consume during a period and remain as well off at the end of the period as at the beginning. It is the amount that can presently be consumed without exhausting the wealth used in generating this income. Hicksian income, therefore, considers the effect of present consumption on future consumption possibilities. Hicksian income from the stance of an individual can be likened to the income of an economy. In this case, it can be interpreted as the maximum amount of income an economy can consume to achieve future levels of consumption as its present consumption levels. Computing income in the Hicksian sense, therefore, requires a deduction of the depreciation of both manmade and natural capital since both forms of capital are used in the generation of income. Hicksian income which considers only consumption is represented by

$$Y_{HICKS}(t) = \max C(t),\ subject\ to\ \dot{C}(t) \geq 0, for\ all\ t \quad \text{……… (10)}$$

Where $C(t)$ represents consumption at a given time period and $\dot{C}(t)$ *is* the change in consumption at time t.

Schanz-Haig-Simons (SHS) definition of income, based on accounting principles is the aggregate of current consumption and the change in the market value of capital. The conventional account is based on the Schanz-Haig-Simons definition of income represented by (Y_{SHS}). This is so because GDP, which is the gross version of national income, allows for the additions of new capital to consumption and production whilst the net version, that is, NDP enables us deducts the depreciation associated with the capital stock. SHS income which measures consumption and accumulation of capital is represented by

$$Y_{SHS}(t) = C(t) + \dot{k}(t) \quad \text{……. (11)}$$

Where $\dot{k}(t)$ denotes the change in the capital stock at time t. Following from equation 4, if the accumulation of net wealth is positive, then it augments future consumption possibilities. On the other hand if the accumulation of net wealth is negative, then consumption possibilities in the future are bleak.

If we assume that the change in net wealth is zero, then the two views of income can be said to be equivalent and thus used interchangeably. Even though the conventional accounts is based on SHS measure of income, researchers are more interested in Hicksian income since it serves as a standard of what measured income is. In making a distinction between (Y_{HICKS}) and (Y_{SHS}), Bradford (1990) expresses the view that the former is a forward looking measure, in that, it takes into account how much can be consumed whereas the latter is a backward looking measure as it considers how much value has been added. Economic theory puts forward two distinct views on the amount of the natural resource productive base which can be utilized. The two views, each in its own way seeks to measure the impact caused by resource depletion on welfare in the long term. The first view based on Net Domestic Product (NDP) is attributed to Weitzman (1976). His analysis assumed an optimal growth path for a country and social welfare equaled consumption. He represented the NDP for a country with balanced trade as $NDP_t = C_t + NI_t$. Where C_t denotes consumption and NI_t represents net investments. If NDP_t is thought of as income along Hicksian lines, then the wealth of a nation could be represented by the present value of the optimal consumption path that society could afford well into the future. Weitzman showed that $NNP_t = \rho W_t$, meaning that the Net National Product is given by the product of ρ, the social discount rate and wealth W_t.

Following from this, Weitzman maintained that a true measure of NDP is one that considers the value associated with changes in the stock of resources. Thus, an economy's measure of net investment should be one that incorporates the depreciation associated with all forms of capital. The second view which is credited to Hartwick (1977) is based on the assumptions that natural capital (K_N) and manmade capital (K_M) are close substitutes for each other. The principle also assumed that an individual derives satisfaction only from the consumption of goods and not directly from the environment. Using a simple model of an economy which uses only these two forms of capital in its production process, Hartwick showed that non declining consumption was feasible provided that the capital stock did not decline over time.

Through the expression for net investment $NI_t = [(\delta K_M/\delta t)] + [(\delta K_N)/\delta t]$, Hartwick explained that the consumption level of an economy can be sustained if the level of net investment (Hartwick defined net investment as gross investment less the depreciation in natural and manmade capital) is greater than or equal to zero. On the other hand, consumption is unsustainable if net investment is less than zero. He further explained that where a non renewable or exhaustible resource is used in production, then non declining consumption is feasible if the Hotelling rents generated from an efficient extraction process of the exhaustible resource are saved and reinvested in manmade capital. This is the Hartwick rule which when employed ensures that as the stock of natural capital is depleted the stock of manmade capital increases to guarantee non-declining consumption over time. This will allow for the sustainable use of resources because exploitation will occur only to the extent to which new substitutes are available.

The Hartwick rule has, however, been criticized because it is viewed as an ex-post description of a sustainable path. For this reason, if an economy is already on a sustainable path, adopting the rule is not sufficient for sustainability from that point onwards. This factor tends to reduce the practical usefulness of the rule. The rule also requires that the Hotelling rents should be generated from an efficient extraction programme in a competitive economy. In most economies, particularly, developing ones, the exploitation of many most natural resources is characterized by a monopolistic environment rather than a competitive environment. Furthermore, adherence to the savings rule itself does not guarantee sustainability as technological conditions may rule out the existence of a feasible path. Weitzman and Hartwick's views are based on the weak sustainability rule which assumes substitution possibilities between natural and manmade capital. It is worth noting, however, that some forms of natural capital have thresholds or limits and, therefore, cannot be easily substituted with manmade capital.

Theory of environmental accounting

According to Solow (1992, 1993) an appropriate means of measuring national income should be one that promotes sustainability. His theory involves two prepositions; first of all, properly defined Net National Product (NNP) measures the maximum current level of consumer satisfaction that can be sustained forever and is, therefore, a measure of sustainable income given the state of an economy. Solow's second preposition is as follows; properly defined and calculated, this year's NNP can always be regarded as this year's interest on society's total stock of capital (that is natural and manmade capital). He argued that for an economy to be on a sustainable path, its total stock of capital should be kept intact. This could be achieved by consuming only the interest income on the capital stock or by adding to the stock of manmade capital, an amount equal to the depreciation of the resource stock.

Solow's prepositions are based on the assumption that the 'right prices' are used in the valuation of the capital and resource stock. The right prices are the prices associated with a constant consumption path. For the prices to be right, they must be such that they 'make full allowance even for the distant future, and will even take account of how each future generation will take account of its future.' Using a simple optimal growth model with a single produced good that can either be consumed or invested, Solow showed that an individual will choose a consumption path that would maintain a constant level of wealth over time. This result can then be generalized to an economy. The similarity between an individual and the economy is that, whereas an individual will maximize utility subject to a given constraint, an economy on the other hand would choose a consumption plan that maintains a constant level of wealth over time.

Solow's theory has, however, been critiqued on the fact that a wealth maximizing individual will not necessarily choose a constant consumption path unless he is constrained to do so. Yet Solow's approach is almost practical because it makes use of the right prices and not observable market prices prevailing at a point in time. In line with this, if an economy knows its level of sustainable income, it would be able to determine whether or not it is sustainable. This is because an economy that consumes over and above its level of sustainable income is deemed to be unsustainable whereas an economy that consumes less than or equal to its level of sustainable income is considered sustainable. Aronson and Lofgren (1996) in an analysis of welfare in an economy where the accumulation of human capital is a key factor in the economic system aimed at determining the contribution of the educational sector to economic growth and made adjustments to the conventional accounts for the contribution of human capital. Their study was based on the assumption that the accumulation of human capital depended on the number of years spent in education. The amount of leisure was also included in the utility function of the consumer. Results of their study indicated that in a command economy, the correct measure of welfare is NNP adjusted for the values of investment in human capital and leisure. For an decentralized economy, however, an adjusted NNP will under estimate the level of welfare.

Work by Hartwick (1990), Mäler (1991) also established that the maintenance of the total stock of a country's capital is vital to ensure that the future population of the country is as well off as the present generation. The total stock of capital includes manmade capital such as equipment and infrastructure; natural capital such as forests, water and air quality; and human capital, examples of which include human skills and creativity. Increasing welfare, therefore, demands that the total capital stock does not only remain constant but increases over time.

Accounting for forest resources in the national accounts

In an attempt to establish a relationship between the conventional account and an environmental account that adjusts for the current and future economic contributions of forestry, Vincent and Hartwick (1998) recommend that two adjustments should be made to GDP. These adjustments are related to household consumption of nonmarket values. They argue for the addition of the value of household consumption of tangible nonmarket forest products (such as fuel wood, game and fruits) as well as the less tangible forest amenities (such as existence values associated with biodiversity). To this end, adjusted GDP will be equal to the sum of conventional GDP, final consumption of nonmarket forest products and final consumption of forest amenities. Vincent et al further advocated for the reallocation of value added within GDP. Thus, value added from other industries will be reallocated to the forestry sector as in the case of environmental and pollution disposal services provided by forests. They assumed a four-industry economy with balanced trade, where conventional GDP is given by the sum of value added in manufacturing, value added in agriculture, value added in logging and value added in forestry. Consequently, the adjusted value added in forestry is given by the sum of conventional value added in forestry, value of pollution damage to forests and value of environmental services provided by forests. The authors were of the view that no adjustment is needed for the logging industry. This reallocation of value added leaves the level of GDP unchanged. Vincent et al further advocated for the adjustment of conventional NDP (Vincent et al defined Conventional NDP as the sum of conventional GDP and net investment in human-made capital) to include net accumulation of timber, net accumulation of carbon, net accumulation of forestland and net accumulation of converted land.

Adjusted NDP is, therefore, given by the sum of conventional GDP plus the change in the value of the total capital stock. This change in value is referred to as net accumulation. In the case of forest resources, they further net accumulation into four facets; net accumulation of timber, net accumulation of carbon, net accumulation of forestland and net accumulation of converted land.

Estimating the Asset Value of a Natural Resource

The asset value of a renewable or non renewable natural resource is equal to the discounted sum of total resource rents that is generated by the resource over time. In the case of a nonrenewable resource, the asset value at a given time t is given by the expression

$$V(t) = \sum\{(1+r)^{t-s}[PQ(S) - C(Q(S))]\} \quad \ldots\ldots\ldots \quad (12)$$

Where P represents the unit price of the extracted resource in question and is assumed to be constant over time. $Q(S)$ is the quantity of the resource that is extracted in period S and $C(Q(S))$ represents the total cost of extracting the resource in a given period. r represents the discount rate which is assumed to be constant over time. The sum is estimated over the interval $S = t, \ldots, T$, where T represents the terminal period in which the resource is exhausted respectively. The expression $[PQ(S) - C(Q(S))]$ represents the resource rent in the current period. If we separate the undiscounted resource rent in the current period from the discounted sum, we obtain an equivalent expression for the asset value of the form

$$V(t) = PQ(t) - C(Q(t)) + V(t+1)/(1+r) \quad (13)$$

Where $V(t+1)$ denotes the asset value in the next period, that is, (t+1). Thus net accumulation is given by the difference between the asset value at the beginning of the next period and the asset value at the beginning of the period. Net accumulation is expressed as follows:

$$D(t) = V(t+1) - V(t) \quad (14)$$

If we substitute the second expression for $V(t)$ into this equation above, we obtain an expression of the form

$$D(t) = rV(t+1)/(1+r) - [PQ(t) - C(Q(t))] \quad (15)$$

Hartwick and Hageman (1993) refer this equation as the fundamental equation of asset equilibrium. This equation above indicates that net accumulation is given by the difference between two opposing forces; the shifting of the discounted stream of future rents towards the present, which turns to increase the asset value of the resource (net accumulation approaches a positive value) and the realization of current resource rent which decreases asset value (net accumulation approaches a negative value). Following this, they argue that net accumulation is not equal to the negative of the current resource rent.

Valuation methods for standing timber

Theoretically, the value of standing timber is equal to the discounted future stumpage values (Stumpage value refers to the willingness to pay for timber and is equivalent to the market price of timber) for mature timber after deducting the costs of bringing the timber to maturity (SEEA 2003 p292). Where market prices are known, these can be used in the valuation of the resource. In the absence of market prices, however, the Net Present Value (NPV) of future benefits accruing to the resource owner from holding or using the resource is estimated. In the event that there are no market prices and calculation of NPV is impossible, then the cost of producing the asset (sunk cost) may be used and this will serve as a lower boundary on the value of the asset. The net present value method, used in estimating asset value is quiet complicated. This method requires information on the growth rate of the forest, the age structure of the forest and the volume of standing timber per hectare at the harvesting age. This method requires that we multiply the volumes extracted by the stumpage price to obtain future receipts, which would then have to be discounted. Due to differences in the yields, pricing and harvesting ages of the different species of timber, this method will have to be applied separately to the major species of timber.

Vincent and Hartwick (1998) in their study made use of some simplified methods in estimating the asset value of timber. Under the assumptions that an optimal extraction process is adopted in the exploitation of the resource, the cost of extraction, prices and the discount rate are constant over time, they argued that net accumulation could be estimated directly without estimating the present value of future flow of resource rents. They identified the net price (NP) and the El Serafy variation methods as two basic methods which theoretically would yield equivalent results for net accumulation. With the net price method, the asset value of the timber stock is obtained by multiplying the resource net price by the negative of the volumes extracted. This is expressed as:

$$D(t) = -[P(t) - C'(Q(t))]Q(t) \text{........ (16)}$$

The net price method requires data on the marginal cost schedule which is often not available. We can, however, make use of average net price, in which case we end up calculating the negative of total resource rent, which is an over statement of net accumulation. Vincent et al argued that where data exists on the average cost schedule and the elasticity (The elasticity of the marginal cost curve is given by the percentage change in the marginal cost per unit percentage change in the quantity extracted) of the marginal cost curve is known, then we can make use of the Net Price method by the following expression;

$$D(t) = -[P - (1+\beta)C(Q(t)/Q(t))]\ Q(t) \text{....... (17)}$$

The term $C(Q(t)/Q(t))$ represents the average costs of extraction and β represents the elasticity of the marginal cost curve with respect to the extracted resource.

Young and da Mota (in Harris and Fraser 2002), however, criticize this method on the fact that in estimating net accumulation using the net price method, average cost rather than marginal cost is employed due to the lack of information on marginal costs and this tends to overestimate net accumulation. Vincent et al (1998) also note that by using average net prices, one ends up estimating the negative of total resource rent which overstates net accumulation. On the other hand, other authors have expressed the view that the use of average cost may be useful for valuing a heterogeneous resource such as timber. With the use of the El Serafy method, the second direct method for estimating net accumulation, Vincent et al argues for the multiplication of the negative of the total resource rent by a conversion factor which involves the discount rate, the number of years to which the resource is exhausted, given by $(T-t)$ and the elasticity of the marginal cost curve. The El Serafy method is expressed as;

$$D(t) = -[PQ(t) - C(Q(t))]\ (1+\beta)/\ [1+\beta(1+r)^{T-t}] \text{........(18)}$$

This expression above is the generalized version of the original El Serafy method, which implicitly assumes that $\beta = \infty$, thereby reducing to

$$D(t) = -[PQ(t) - C(Q(t))]/\ (1+r)^{T-t} \text{....... (19)}$$

r represents the discount rate. It reveals the risk tolerance level as well as time preference of the resource owner for receiving income today rather than in the future. The choice of an appropriate discount rate has been found to be problematic as economic agents have different time preferences. Generally households and firms require demand higher returns from owning a resource than do governments. Higher (lower) rates of return usually result in higher (lower) discount rates. Similarly, higher levels of risk tolerance result in higher discount rates. The El Serafy method is deficient in the fact that it yields correct estimates of net accumulation only when the elasticity of the marginal cost curve is equal to infinity which is very unlikely in practice. The net depletion method, calculates the asset value by finding the difference between growth and other additions from the level of harvest and other deductions. The resulting figure will then be multiplied by the ensuing value of the net price of the resource. Net accumulation is estimated as expressed below

$$D(t) = -[P - C'(Q(t))]\ [Q(t) - G(S(t))] \text{...(20)}$$

If we assume a linear cost curve, then we can substitute the term for marginal cost expressed as $C'(Q(t))$ with average costs given by $C(Q(t))$, which reduces the equation above to

$$D(t) = [P - C(Q(t))]\ [Q(t) - G(S(t))] \text{........ (21)}$$

Where $G(S(t))$ denotes growth of the timber stock in a given time period,

$[Q(t) - G(S(t))]$ represents the net change in timber stock expressed in terms of hectares.

Vincent et al. next identified the Net Present Variation method (NPVa) as a more appropriate version of the net price method. This is because the NPVa considers variations in the stock of standing timber. Where a linear cost function is assumed, the NPVa is expressed as:

$$D_H(T) = [P - C(Q(T))]Q'^{(T)}[1 - (1+r)^{1-T}]/r \text{...... (22)}$$

$$D_H(t) = [P - C(Q(T))]Q'^{(T)}[1 - (1+r)^{t-T}], for\ t = 1, \dots, T-1 \text{... (23)}$$

T and t represent the time for harvesting matured and immature timber respectively, and r represents the discount rate.

In the case of mature forests, equation (15) makes provision for growth at the optimal rotation age. Equation 16 makes provision is made for growth of immature forests at the optimal rotation age. Using the net price variation method, therefore, requires information on the discount rate, the average net price of harvested timber, the growth rate per hectare at the optimal rotation age

(This refers to the current annual increment to the timber stock), the optimal rotation age as well as the age of the forest. The authors argued that the net price variation derived for even-aged forests can also be applied to uneven-aged forests, so long as the level of harvests are approximately the same whenever the forest is harvested. In using the net price variation method, additions to the timber stock resulting from future harvests in immature forests where a linear cost function is assumed, is expressed as $\sum A_t[P-C]Q'(T)\ (1+r)^{t-T}$ and future harvests in mature forests is given by the expression $A_T[P-C]Q'(T)\ (1+r)^{1-T}/r$.

Deduction to timber stock resulting from harvesting activities is given by $-[A_T(P-C)]\ Q'^{(T)}/r$ whilst removal resulting from catastrophic losses is expressed by the equation below:

$$\sum A_{t^*}[V_H(0)-\ V_H\ (t)]+\ A_{T^*}[V_H(0)-V_H(T)\ ]$$

Following this, they expressed the asset value per hectare of mature timber by the expression

$V_H(T)\ =\ [P-C]Q(T)\ /\ [1-\ (1+r)^{-T}]$; and the asset value for a hectare of immature timber as

$$V_H(T)=(1+r)^{t-T}(P-C)\,Q(T)/\,[1-(1+r)^{-T}], for\ t=1,\ldots,T-1 \quad \text{........ (24)}$$

Valuation of non timber forest products

Non timber forest products (NTFPs), notably fuel wood, medicinal plants and amenity values are used for domestic and commercial purposes in most developing countries. Despite this, the values of most NTFPs are not captured formally in the conventional accounts. This can be attributed to the "timberisation" of forest products for policy formulation and regulation and the un-priced nature of most non timber forests products. In the event that a portion of NTFP is sold in the market, then valuation can be done by multiplying the quantity of the resource collected by the market price. This is possible as long as the product consumed and the products sold do not differ appreciably. Collection can also be valued by using the price of a substitute product when the degree of substitution is high.

Empirical review

In spite of the numerous efforts that have been made to develop an Environmental and Natural Resource Accounts (ENRA), a generally accepted ENRA has not materialized due to the lack of a standardized approach in the estimation of depreciation of natural resources and in the valuation of environmental services. Whilst some studies on environmental and natural resource have been comprehensive, others have been conducted on a pilot basis, usually for selected natural resources or are purely academic work. Often, results have not been translated into policies and in cases where they have been, there is minimal or no institutional follow up. In spite of these setbacks, a number of countries have taken the necessary steps to develop and modify the conventional accounts to reflect the contribution of natural resources to economic activity so that what gets measured is sustainable national income.

The Environmental and Natural Resources Accounting Project (ENRAP) is an accounting framework that has been adopted by the Philippines since the 1990s to account for its stock of environmental resources. The ENRAP gives equal treatment to the services of manmade assets and economically valuable environmental assets. However, physical degradation of environmental and natural assets is of no importance in this system unless the physical decline implies economic losses in the value of these assets (DENR 1994). ENRAP also accounts for environmental services such as recreation and aesthetic services which are consumed directly by the society and the non marketed production of food and fuel wood by rural households, considered to be very important due to their possible links with deforestation.

Natural resources accounting exercises undertaken by some countries

Brazil

da Motta and do Amaral (1997) adopted Vincent and Hartwick's approach in the estimation of timber depreciation in the Brazilian Amazon, an area that accounts for over 70% of total round wood produced in Brazil. Their study focused on the depletion of all timber as well as a particular specie-mahogany-which account for about 50% of timber export value. Agriculture and logging activities were identified as the major causes of deforestation in the Amazon as it was subjected to semi open access exploitation. Thus timber extraction occurs at a quicker pace compared to a situation where an optimal extraction path is pursued. Physical accounts for all timber species were identified and represented by stock estimates for 1990 and 1995. In the case of mahogany, however, a stock estimate was done for only 1990. A sensitivity analysis was also carried out due to the lack of estimates on the elasticity of the marginal cost curve. For the sensitivity analysis, two extremes, zero and infinity as well as rates of one and three percent were used. Another sensitivity analysis was carried out with the discount rate assuming values of 2%, 4% and 10% aimed at analyzing the differences in the scarcity rents due to the different time preferences. Results of depreciation estimates showed that the time to exhaustion was longer for the entire timber stock which had an exhaustion period of 258.6 years and 242 years respectively for 1990 and 1995 compared to the mahogany specie with an exhaustion period of 42 years in 1990. The proportions of depreciation of value added for timber were found to be 39.72% and 41.7% for 1990 and 1995 respectively with the Net Price approach. Changes in timber and more generally forest wealth were not considered, making it difficult to conceive the broader picture of sustainable development. Nonetheless, da Motta and do Amaral concluded that the depreciation values obtained were insignificant due to the existing large stock of timber in the country.

Papua New Guinea

Bartelmus, Lutz and Schweinfest in 1992 undertook a pilot study of the SEEA on Papua, New Guinea, a country that was at the initial stage of industrial development thus had minimal environmental problems. They adopted the user-cost method for the valuation of depletion of minerals, a non renewable resource over a five year period that is from 1985 to 1990. With this method, the stream of net revenue from the sale of non renewable resources is split into two parts. One part of this income, usually referred to as permanent income (user cost allowance) is saved and invested in other resources. The other part which remains is then considered as true income from the extraction of the resource. A 10% discount rate was employed in the valuation of user cost. Owing to the difficulty in assessing the financial statements of most companies, the 1986 and 1987 Annual Reports of the Bougainville mine was used as it contained useful information such as the cost structure of the mine and profits before tax. The cost structure information on other mines obtained from the national statistics service was used in the estimation of total profits. Results from the user cost method showed that mine owners had to make a depletion allowance of 8.8 mio Kina in the year 1985 and this reduced value added in the mining sector by 3.7% and GDP by 0.4%. The depletion allowance was 39.8 mio Kina in 1987, 9.2 in 1989 and 35.8 mio Kina in 1990. Fluctuations in the depletion allowance were attributed to new discoveries (New discoveries tend to lengthen the lifespan of a natural resource, thereby reducing the amount available for investment in physical capital), relative importance of the mines among other factors.

A second method, the Net Price method was also used to estimate an environmental depletion cost of minerals. The annual rate of depletion of mineral resources was found to be significant compared to the depreciation cost of produced capital. For instance in 1986, the depletion cost of minerals was 126.8 mio Kina compared to 241.5 mio Kina for the depreciation of produced capital and in 1990, the former was 180.7 mio Kina whereas the latter was 342.8 mio Kina. Results from the user cost method were relatively smaller (ranged between 12% and 46% of the depletion allowance) compared to those from the Net Price method where the depreciation allowance ranged from 50% to 90%. Forests cover about 75% of the total area of Papua New Guinea and this sector contributed about 4.1% of value added total GDP in 1988. Owing to the lack of reliable data on forest, a depletion allowance was not calculated for the forestry sector. However, Bartelmus et al (1992) proposed the computation of a net price (rent) for timber as and when reliable data became available as this would serve as a basis for the government of Papua New Guinea to establish the appropriate level of taxes and royalties as this provided government with the much needed revenue and will also help prevent over exploitation of the resource. The loss of ecological values of forests through conversion to shifting cultivation was valued at 7 mio Kina per cubic metre and this served as a compensation rate paid to land owners.

Following the compensation approach, Bartelmus et al also estimated the degradation of environmental quality. Their approach though different from that recommended by the SEEA (which uses either WTP or WTA compensation for the decline in environmental quality) was preferred due to the nature of compensation negotiations (There exists a compensation scheme for the impact of environmental effects in local areas. The amount of compensation is also determined through negotiations with land owners and logging companies) in that country. Sectorial impacts of economic sectors such as agriculture, forestry, mining and energy on the degradation of environmental quality were also evaluated. Annual costs of degradation in environmental quality were calculated in a lower to upper bound range for these sectors. For the agricultural sector the decline in environmental quality through the clearing of forest for cultivation ranged from - 0.3% to 4.4% of NDP. Decline due to logging activities and water pollution from mining were - 1.2% to 1.8% and - 1.3% to 3.8% respectively. For the energy sector, however, the associated cost was 0.1%. Results for the country study showed that whereas EDP1 reduced the values of NDP within a range of 1% to 8% EDP2 reduced NDP by a range of 3% to 8% (EDP1 is obtained by subtracting the cost of depreciation and depletion of natural capital from NDP. EDP2 on the other hand is the additional accounting done for the degradation of environmental quality (cost of environmental degradation) deducted from EDP1). A shift from EDP1 to EDP2 led to a further decline in NDP by an average of 2.1%.

Mexico

The objective of the Mexican study undertaken by van Togeren, Schweinfest and Lutz in 1990 and 1991 was to integrate and link environmental and economic information and also examine whether or not environmental adjusted aggregates of national product could be derived for Mexico. Using Mexico's SNA that is Sistema de Cuentas Nacionales de Mexico (SCNM) as a starting point, environmental concerns such as oil depletion, deforestation and land use, and degradation of environmental assets associated with air, soil and water pollution, ground water use and solid waste deposits were incorporated to arrive at an economic and environmental accounts known as Sistema de Cuentas Economicas y Ecologicas de Mexico (SCEEM). Oil depletion centered on the quantitative decline in stocks which was not considered in the SNA. Deforestation and land use considered the loss of timber from commercial and non-commercial activities and the transfer of forest land to agricultural land use or for urbanization with degradation focusing mainly on the qualitative degradation of eco-systems. Depletion costs for oil, timber and ground water reserves were also estimated and deducted whereas net accumulation were added to GDP values. The Net Price and User Cost (UC) methods were employed to obtain environmental accounts in physical units. The avoidance cost method was used to estimate quality changes (degradation) in the assets. Using the NP, the stock of produced assets was computed as closing stock plus gross capital formation (investment) less depreciation plus an allowance for revaluation of produced economic assets. Monetary values were also estimated for the depletion of oil, deforestation and land use. On the basis of macro analysis, two values of EDP; that is EDP1 and EDP2 were obtained. Results showed that Mexico with an NDP of 42,060 million Pesos in 1985 had an EDP1 of 39,662 million pesos representing about 94.3% of NDP. EDP2 on the other hand amounted to 36,448 million peso representing about 87% of NDP. Using an input-output analysis, a comparative analysis of expenditure distribution of NDP, EDP1 and EDP2 also showed that with a final consumption of 83.09% of and a net capital accumulation of 11.18% of NDP, adjusting for depletion, deforestation and land use (EDP1) resulted in an increase in final consumption to 88.12% but net investment declined to 5.81%. A move from EDP1 to EDP2 showed a further increase in final consumption to 95.73% and a decline in net investment to -2.33%. Van Tongeren et al were of the view that macro analyses though useful did not provide the needed information for operational government policies. Due to this, they also undertook a sectoral analysis on value added, balances of economic assets (produced and non produced) as well as expenses borne by different economic sectors on environmental protection. NDP, EDP1 and EDP2 were then calculated for each of the sectors. Results from the value added analysis (Value added considered production data by economic activities as well as the values of depletion, degradation and effects of land use. Expenditures on environmental protection by each industry were also considered. For the oil industry, only extraction was considered. Deforestation considered logging and transfer losses due to the transfer of environmental land to economic uses. Environmental impacts of solid waste were attributed to consumption activities of households) revealed that the incorporation of environmental effects resulted in considerable changes in the distribution of value added. Contributions of the forestry, oil and animal farming sectors were negatively affected. Forestry's contribution for example declined from 0.54% for NDP to 0.15% for EDP1 and -0.08% for EDP2. Contribution of agriculture remained at 5.61% for NDP and EDP1, declining to 5.57% for EDP2. With the balances of economic assets analysis, changes in the distribution of capital between sectors for produced assets (CAP) (In this study, CAP is synonymous to NDP. The addition of produced and non produced economic assets to CAP gives CAP1 and this is identical to EDP1. Because there were no changes in the stock of economic assets between EDP1 and EDP2, only a CAP1 view is considered) were obtained. The change in the distribution of capital for oil was from a CAP of 4.83% to a CAP1 of 23.89%. For the entire economy, the average value of expenditure on environmental protection as a percentage of the total value of the effects of degradation was estimated at 23.26%.

The Republic of Korea

In a pilot study van Tongeren et al compiled environmental and economic accounts from 1985 to 1992 for Korea, a country though poorly endowed with natural resources has over the past thirty years seen impressive economic transformations due to export led industrial development. Associated with the industrialization process was rapid urbanization with its attendant problems of environmental pollution, land degradation and the conversion of agricultural land to other uses. The Korean System of Environmental and Economic Accounts (KORSEEA) framework is obtained by appending environmental accounting entries to the supply and use table and produced asset accounts of the SNA. KORSSEA aims at segregating and elaborating environmentally related flows and stocks of the SNA, linking physical resource accounts with monetary asset accounts, accounting for natural capital and the assessment of environmental costs. In the Republic of Korea, about 29% of forest is considered as national forest with the remaining 71% owned by individuals. Unlike some countries were forest depletion is occurring at rate that raises issues of concern, forests in Korea have been increasing over the past decades which are a result of extensive reforestation programmes and protective policies which have been vigorously pursued by the government. Forests were classified into coniferous, deciduous and mixed and physical and monetary asset accounts constructed for each group.

The study revealed that was there no net depletion of forests since the additions to the timber stock exceeded rates of exploitation.

Asset accounts were compiled for non economic and produced assets. Emission of pollutants into the air was valued based on the unit cost of the best technology used in the prevention or treatment of emissions. These were calculated in physical and monetary terms to facilitate adjustment of the NDP to an EDP. The lack of data on fish stock made it impossible to calculate a depletion allowance for marine resources. Nonetheless, a physical account was constructed for fish in adjacent water using available data on species of fish catch. Physical accounts were also constructed on land use foe agricultural land, built up land, forest land and other land. Monetary accounts on land use were obtained by multiplying physical units by the market price of land. For minerals, asset accounts were compiled for coal, limestone, iron, copper and tungsten. The net price and user cost methods were used in valuing timber. The user cost method revealed negligible costs irrespective of the discount rate used and this was attributed to the long life span of the resource based on the rates of current extraction. Emissions of wastes were valued using maintenance costs. For stationary sources such as power generating plant, data on fuel consumption was considered whereas or mobile sources such as the transport industry, pollution was estimated by multiplying the emission factor of the vehicle by the daily distance traveled in kilometers. The unit cost of abating pollution of sulphur dioxide and nitrogen oxide was also calculated. Deterioration of water quality due to the discharge of pollutants by economic agents was also considered.

A comparison of NDP and EDP revealed that between 1985 and 1992, the share of EDP over NDP increased from 96.57% to 97.36%. The share of net capital accumulation compared to net capital formation fell from 20.92% to 18.12% in 1986 and from, 29.44% in 1986 to 27.53% in 1992. Enforcement of environmental protection policies and environmental protection activities led to a decrease in emission abatement cost by industries from 2.39% of NDP in 1986 to 1.96% in 1992. Abatement costs for households, however, increased from 0.14% (1985) to 0.27% (1992). With high import figures for minerals, depletion of Korea's mineral resources fell from 0.30% in 1985 to 0.06% in 1992. A time series data of selected indicators showed that the share of EDP over NDP experienced considerable fluctuations during 1985 to 1992, indicating an upward trend. This showed that with a reduction in environmental cost, the value of EDP gets closer to the value of NDP over time. A review of literature on environmental and natural resource accounting exercises undertaken by a number of countries highlights the need for countries to account for the use of natural resources. Accounting for the depletion and degradation of the natural capital stock as well as environmental degradation gives a smaller figure is obtained which serves as a true measure of sustainability. This will also enable governments adopt appropriate measures to use their natural resources on a sustainable basis. For countries that have successfully undertaken natural resource accounting exercises, results should be translated into policies and follow ups made to avoid a depletion of the natural resource base, without which economic activity would not be possible.

Zimbabwe

Mabugu and Chitiga (2002) in an attempt to account for forest resources which contribute about 3% of GDP in Zimbabwe focused on timber stocks, NTFP collected and consumed by households and some ecological values (carbon sequestration and the marginal value of water). Estimates of household consumption of fuel wood were obtained from a previous study undertaken by Campbell et al (2000). This was multiplied by the market price to obtain values for fuel wood consumption. A comparison of estimated values of the consumption of fuel wood to value added in agriculture and GDP showed fluctuations throughout the study period. It was found to be 14.62% of agricultural GDP and 2.38% of overall GDP in 1994; whereas for 1999, it was estimated at 14.66% of agricultural GDP and 2.45% of overall GDP. A physical account was also constructed for commercial plantations particularly for the pine, eucalyptus, walter and poplar species over the 1999 to 2000 period. Each specie was found to have depleted over the years. In constructing a monetary account, price data and extraction costs were adopted from an industry survey. Using a discount rate of 15% per annum, results revealed that the NP method in all cases overstated the values of depreciation and appreciation in contrast to the current asset value by a factor of 1.2% on the average. In valuing carbon sequestration, Mabugu et al made use of a damage function as it contained physical information details and also related damages to monetary values. For instance, an activity that reduces the concentration of carbon dioxide in the atmosphere could be measured by multiplying the amount of carbon dioxide sequestered by the cost of damage caused by an additional tone of CO_2. Using results from a earlier study by Kunhlander et al (2000) who developed a model for carbon flow by monitoring the amount of biomass in living and dead trees, grasses and shrubs, Mabugu et al estimated the value of carbon at Z$250. The present value of carbon benefits for 50 years was then estimated at Z$3000. The marginal value of water was obtained by the introduction of minimal variations in the mean rainfall values and determining the impact of rainfall on the value of crops, wild foods, production of grass and carbon sequestration. The capitalized marginal value of water over a fifty year period was found to be Z$4,830 per hectare with the national aggregate estimated at Z$2.03 billion which amounted to about 15% and 2.5% of agricultural GDP and GDP respectively.

Tanzania

This study by Mkanta and Chitambo (2002) aimed at estimating the contribution of natural forests to Tanzania's national income for the year 1985 through to 1995 by valuing non-market forest products as well as offering a means by which the national accounts could be modified to incorporate all values of forest resources. The Urambo district was chosen for the exercise due to the extensive cultivation of flue cured tobacco in the area. This study made use of secondary data as well as data generated from household surveys. About 94% of households were identified as farmers with 63% of them being regular growers of tobacco. The study revealed that about 61% of tobacco growers cleared a new piece of land for cultivation each year and the mean value of land cleared was estimated at 3.255 hectares implying a high rate of depletion in the catchment areas. Estimated area of land cleared for cultivation decreased from 1985/86 to 1989/90 and increased thereafter. Similarly, production of tobacco was found to have declined from 1985/86 to 1989/90 after which it began to increase reaching a peak of 17.1 million kilograms in 1994/95. Estimated consumption of fuel wood also declined gradually up to 1985/86 and therefore was found to have increased. A scenario used in estimating the demand for forest products by households considered annual income, size, total time spent in the collection of forest products and total land area owned by the household. The demand for forest products was found to vary directly with household income, size and total land area owned and inversely with the time spent in collection. A second scenario considered the effect of newly cleared land on the collection of forest resources using the same variables. The variables retained the same relationship as was found with the first scenario. The total value of forest products consumed per person and household were valued at $350 and $2,098 respectively. The existence value of forests was also estimated and about 82.6% of the respondents attached value to the existence of forests.

Ghana

Baytas and Rezvani (1993) attempted to construct physical and monetary accounts for timber resources from 1970-1987. Using 1980 as a benchmark year, they established the growing stock of timber in physical units. Estimates for the other years were computed using annual additions and reductions. With an opening stock of 6,975,000 hectares, the closing stock was estimated at 8,768,000 hectares whilst total stock was estimated at 428,313,000m^3, implying an overall average stocking rate of 48.8m^3/hectare. A growth rate of 1.5m^3/ha/yr and 1.27m^3/ha/per was assumed in productive and unproductive forests respectively whilst a rate of 1m^3/ha/yr was assumed in open forests. Their choice was influenced by a 1982 FAO study that used a growth rate of 1-5m^3/ha/yr in gross volumes and a study by Repetto et al (1989) that put growth rate of common species trees in Indonesia in a range between of 1-2m^3/ha/yr. following this the annual gross increment in the volume of trees was estimated at 9,426,00m3/yr and a constant rate of reforestation was assumed for each year. Based on this, the annual increment to a plantation area in a given year was estimated at 10m^3/ha. Following the work of Page et al (Collins 1998), who estimated timber rents in Ghana at 26% of the log output value in 1970s, a rent of 26% of the free on board (fob) value was assumed for each year. Making reference to the Indonesian study which assumed an average resource rent in secondary forests to be equal to 50% of the rent obtained from the harvesting of timber, timber harvested for industrial use was assigned the full rent (primary rent) of 50% whereas a secondary rent equal to 25% of the primary rent was applied to the valuation of deforestation, degradation and growth. Baytas et al assigned a value of $7.68/m^3 to growth, deforestation and logging damage with the total harvest of timber which stood at 12,932,000m^3 in 1980 valued at $30.7/m^3. They concluded that the years considered GNP would have to be adjusted downwards. For the base year 1980, a loss of $97,386 thousand was estimated and this required that GNP be adjusted by 2.2%. The year 1987 witnessed the greatest loss of $130,088 in timber resources, requiring an adjustment of 2.64% in GNP.

Earlier estimates of the costs of degradation of natural resources have been extended by the CEA to include the costs of environmental health effects. The mean estimated annual cost of environmental degradation was put at nearly US$850 million, equivalent to 10% of GDP. The degradation of natural assets (such as agricultural soils, forests and savanna woodlands, coastal fisheries, wildlife resources and Lake Volta's environment) was estimated at an annual cost of at least US$520 (6% of Ghana's annual GDP), whilst health effects accounted for nearly US$330 million or 3.8% of GDP. Among the natural assets, 63% of the estimated costs of environmental degradation were found to be from forest reserves and off reserves while the depletion of soil nutrients accounted for 20%. About 55% of the total estimated health cost was due to inadequate supply of water and sanitation, 36% of the cost was from indoor air pollution, and 9% of the cost from urban outdoor air pollution (PM10). The cost of environmental degradation to GDP has been put at almost fifty percent of Ghana's US$1.5 billion annual Overseas Development Assistance (CEA, 2006). Other estimates by the World Bank puts the annual cost of degradation from agriculture at 1.57% of GDP, 0.56% for wildlife and 3.49% for forests. Outdoor air pollution accounted for an environmental cost of 0.35% of GDP while indoor air pollution had a cost of 1.4%. The annual cost of degradation from the supply of water, sanitation and hygiene was put at 2.1% of GDP. (World Bank 2005a and 2006).

Convery and Tutu (1992) also estimated the cost of environmental degradation resulting from agriculture (crops and livestock overgrazing), among others, on GDP in 1988. In an assessment of the cost of environmental degradation for Ghana, their estimate showed that the cost to the economy in 1988 was about 4% of GDP. Of this, agriculture (crops and overgrazing) contributed about 69% to this cost. Alfsen et al (1997) working on soil degradation and economic growth in Ghana showed that there is a 1% reduction in real growth over the years due to soil degradation alone. Environmental degradation has a significant impact on the country's capacity to sustain its growth. This is so because it reduces substantially the genuine savings rate of a country (Genuine savings is a measure of growth sustainability that takes into account environmental factors. If the genuine savings rate of a country is greater than zero, then future generations will be able to meet their needs. This implies that the economy in question is sustainable). Ghana has a genuine savings rate per capita of -US$18 after adjusting the conventional account for resource depletion and population growth (CEA, 2006). The Ghana Statistical Service (GSS) with support from UNSD undertook a pilot project of the SEEA from 1991-1993 for soils, water and forests. In the case of forests, values for forest land were calculated using the compensation paid by mining companies to the owners of forest land for their destruction. Data on the AAC was not available, thus, made it impossible to estimate depletion rates. In view of the discussions held above on the importance of environmental resource accounting, this study will seek to address some of the shortcomings in Ghana's conventional accounts.

METHODOLOGY

Accounting for the contribution of forest resources to the national accounts

The forest's sector contribution to GDP will consider timber values and non timber values. In doing this, timber values would be obtained by summing the values of logs consumed on the domestic and export markets. For non timber values, this study will consider selected non timber forest products; fuel wood, bush meat, the export of wild animals and plants and forest amenity values (wild life based tourism). This study does not consider all non timber forest product due to the difficulty in requiring reliable data on these products.

Valuation of non timber forest products

Non timber forest products such as wood fuel and charcoal provide a major source of energy for most households in Ghana, It has been estimated that 14 million m^3 of wood is consumed for energy in Ghana with an annual value of US$200 million. Valuation of the national annual trade in bush meat revealed a range between US$9 million (Hofmann et al. 1999) and US$200 – US$300 million (Ntiamoa-Baidu 1998). The Wildlife Development Plan (1998) estimates an annual quantity of 305,000 tonnes with a value of US$275 million for bush meat, consumption of medicinal plant and animal is estimated at annual value of GH¢13 million, the export of live animal at US$600,000 and export of pharmaceutical products at US$2 million. A report by the World Bank (World Bank, 2006a) estimated a value of US$18 million for exports of wild animals and wild plants in 2003. In the case of forest amenity values, revenue from wild life based tourism is put at US$2.5 million (Johnson 1999). Visits made by nationals and foreigners to national parks were estimated at an annual rate of US$160,000 and US$180,000 respectively, whilst zoo visits was estimated at an annual rate of US$240,000.

Contribution of forestry and wildlife sector to GDP

This study will add to conventional estimates of GHP, the value of fuel wood consumption, estimated at US$164.28 million, the value of bush meat value of US$275 million, US$18 million for the exports of wild animals and wild plants as well as amenity values of US$2.5 million would be added to conventional estimates of GDP to obtain an adjusted GDP.

Valuing environmental resources

Natural and manmade resources offer a number of services to the economy. Just as man made capital used up in production declines in value, so do natural capital. With natural resources, depreciation is analogous to the decline in the flow of future good and services produced by the resource as it get depleted.

Estimating the asset value of timber

A stand of timber in the forest is considered to be of no value until it is brought to the market place. Yet this timber has value since it provides ecological services such as the protection of watershed and nutrient recycling. Timber in the forest gets depleted through extractions at rates that exceed the Annual Allowable Cut. Thus it is necessary to estimate the depletion of timber as well as the decline in the future flows of goods

Table 1. Total Economic Costs of Timber (US$m^3)

Cost, Insurance and Freight Value	255.82
Plus 10% export levy	25.58
Plus 7% port/bank charges	19.70
Plus 3% TIDD Levy	9.03
Plus transport and handling	18.50
Total Economic Costs	328.63

and services (depreciation) provided by forests as it get depleted. This would enable policymakers' ascertain whether or not the resource is used on a sustainable basis and develop appropriate policies for its use. This study adopts the lines of Vincent and Hartwick and uses the net depletion method and the Net Price Variation (NPVa) method to obtain estimates of net accumulation.

Estimating net accumulation of timber

In estimating the loss in the value of timber which is no longer available for future uses due to deforestation, we need to consider the value which would have accrued to the owner of the resource if the timber had been left standing in the forest. This value (rent) is also known as stumpage value or net price of timber. We would assume a competitive market and arrive at the stumpage value by finding the difference between the market price of a unit of timber in the highest priced market and all factor costs incurred in the extraction of timber. To obtain the unit price (free on board price) of timber, we must first find the ratio of the revenue obtained from timber exports and the volume of logs exported. Data on log export volumes and values were obtained from the Forestry Commission (TIDD data tapes). In obtaining the unit cost of extraction, this study draws upon the work of Birikorang et al (2007) which identified the value of cost insurance freight (cif) as US$255.82. The cif value will then serve as the border price of timber. Subsequently, a 10% export levy, 7% port /bank charges and 3% export levy will be added to the cif value as shown in the Table below.

The stumpage value is, therefore, expressed as $SV = FOB - TCE$

Where SV represents the stumpage value, FOB represents the free on board price per unit of timber and TCE is the total economic costs of extracting a unit of timber.

Estimating net accumulation by the net price method

The Net Price method is based on the assumption that the rate of discount is equal to the natural growth rate of the forest, thus offsets the need for discounting. By this method, the reduction in asset value is given by the product of forest area deforested, which is expressed in hectares and the marginal net price of the resource. Thus, the loss in asset value is given by

$D(t) = -[P(t) - C'(Q(t))]Q(t)$ .... (26)

$P(t)$ represents the market price of timber at a given period, $C'(Q(t))$ represents the marginal cost of extraction and $Q(t)$ represents the area deforested.

Due to the fact data on the marginal cost of extraction is not available; we would assume a linear cost function throughout this study. This enables us to make use of the expression

$D(t) = [P(t) - C(Q(t))]Q(t)$

… …. (27)

In equation (6) above $C(Q(t))$ represents the average cost of extraction.

Net accumulation will then be obtained by deducting the asset value in the current period from the asset value in the nest period. In Ghana, the SNA is computed through the output approach, which has already made provision for depreciation of manmade capital. Thus GDP will be adjusted for the depreciation of timebr stocks to obtain an environmentally adjusted GDP

The economic cost will be assumed to be constant throughout the study periods considered. We then deduct the constant cost from the average fob prices for each of the years under consideration to obtain the stumpage value of timber per cubic meter, also known as net gain or loss. This will then be multiplied by the nominal exchange rate in each year to obtain the cedi equivalent of stumpage value. The total economic cost is assumed to be constant throughout the periods considered in this study. We then deduct the constant economic cost from the average free on board (The free on board price is the price of timber in the highest priced market, that is, the value of exported timber divided by volume exported) (fob) prices for each of the years under consideration to obtain the stumpage value of timber per cubic meter., also known as net gain or loss. Since the unit of measure for net accumulation in expressed in a per hectare basis, we convert stumpage value per cubic meters to stumpage value per hectare. To do this, we make reference to a study on the Implications of the Forest Protection Proposal (FIMP, 1994) in which a minimum of 22.27m^3 and a maximum of 25.6m^3 of timber was found in every hectare of forest. We then strike an average of 23.94m^3 and obtain the stumpage value in a hectare of forest (stu/ha) by the expression stu/m^3 multiplied by 23.94m^3.

We multiply estimates of stumpage value expressed in hectares by the negative of the current volumes extracted or area deforested, also expressed in hectares. The FAO estimates the annual rate of deforestation has slowed down in the 1980s to about 22,000 ha (FAO, 1988). A report by the Ghana Statistical Service (2002) also puts the annual rate of deforestation at 25,000 hectares. Even though the current rate of annual deforestation is not known, it is estimated to be lower than what is used to be in the 1980s. The lower limit of 22,000 hectares per annum will be adopted for this study and this will be assumed to be constant throughout the periods considered.

Net depletion method

In applying the net depletion method to calculate net accumulation of timber, we obtain estimates of net depletion of the timber stock by deducting growth (resulting from afforestation, reforestation and natural regeneration) from harvest and other deductions (such as fires, occurrences of diseases and pests). Thereafter, we multiply the negative of the ensuing value by the resource net price.

$D(t) = -[p - C'(q(t))]\,[q(t) - g(S(t)))]$ ……… (28)

For additions to the timber stock,

The net depletion method, which is a generalization of the net price method has also been criticized on the fact that it assigns the same value to a stand of timber which consists of mature timber ready for harvesting in the current period (A_T) and immature timber that will be harvested in the future (A_t). This can lead to biased estimates for the value of timber. By assuming that all trees in the forest are of the same age, all timber is harvested at the optimal rotation age (This implies there is no intervention production from the thinning practices) and q(T)represents the quantity of timber in a hectare of mature forests, total harvest is given by ATq(T). Net accumulation for a forest disaggregated by age class is then equal to

$A_T D_H(T) + \Sigma A_t D_H(t)$ ……… (29)

Here $D_H(T)$ and $D_H(t)$ denote net accumulation values of mature and immature forests respectively on a per hectare basis.

Thus net depletion method when applied to a hectare of mature timber is expressed as

$DH(T) = [p – C(q(T))]\, q(T)$ ………… (30)

This expression indicates that the change in the value of a hectare of mature forest is given by the product of average net price and the volume currently harvested.

In applying the net depletion method to immature timber stocks, the expression

$DH(t) = [p – C(q(T))]\, q'(t)$, for t = 1, … , T-1 is adopted. …………………….. (31)

This expression states that the change in the value of a hectare of immature timber is given by the product of average net price and the volume of current growth.

This method values both mature and immature timber by the same factor, that is, the average net price of the resource, without factoring in the number of years to which an immature stand of timber will grow to the mature stage. In deriving the correct versions of net accumulation, we assumed constant prices over time. In practice, however, prices are not constant. Thus to calculate the resource net price, the price of timber will be obtained by using the price in the highest valued market. This is the free on board price, which is obtained by dividing the total values of timber exported by the total volume exported. The choice of a method depends on the current structure of the stock and the felling and their assumed evolution in the future. The NPV method is best used when the forest is managed optimally according to the principles of forestry economics and for large-scale afforestation, where the structure of the stock and felling will change over time. The stumpage value method gives good results when the current felling structure can be assumed to continue in the future (SEEA 2003 p294). Data on additions, deductions to the timber stock, volumes and values exported would be obtained from the Forestry Commission. In using this method, the following assumptions are made. A sustainable forest management is practiced in Ghana, all tree species are harvested at the optimal rotation age, a linear cost function holds for all tree species.

Note: net accumulation of timber will be added to conventional NDP

Expected Results

The value obtained for consumption of NTFP and forest amenities will be added to GDP. This is expected to increase the value of GDP. Thus a GDP will be larger than conventional GDP. It is also expected that estimates of net accumulation using NP would be lower than similar estimates using NPVa methods. NP understates the value of depreciation because it excludes the harvesting of immature timber. The values obtained for net accumulation using NPVa will then be deducted from NDP to obtain an environmentally adjusted NDP (eaNDP).

Measuring the sustainable budget index

In Ghana, GDP is measured using the output approach. Due to the fact that this method implicitly makes provision for depreciation of manmade capital or the consumption of fixed capital, we cannot directly obtain estimates of the values of depreciation. However, based on the assumption that the three approaches to measuring GDP will theoretically yield the same results, we will make use of some estimates of fixed capital consumption provided by the Ghana Statistical Service. However, only historical data on depreciation of manmade capital is available. Thus the growth rate will be obtained from one period to another. Thereafter, an average of the growth rate will be strike and depreciation will be assumed to grow at this constant rate.

To determine whether or not natural resources are being used on a sustainable basis in Ghana, the SBI identified earlier on as Z = SBI = S/Y - (∂_M / Y + ∂_N / Y) would be estimated. In estimating this, data on the level of formalized savings (S) by households, firms and the government as well as nominal GDP (Y) would be obtained from the Bank of Ghana. Estimates of depreciation of man-made capital (∂_M) would also be obtained from the Ministry of Finance and Economic Planning. Estimates of depreciation of timber resources (Ideally the depreciation value should be for all natural resources; instead of only timber stocks as this study is doing) obtained using the NP and NPVa methods would serve as a proxy for the depreciation of natural capital.

Estimated Volume and Value of logs processed into wood products for exports (2000 – 2008)

Deforestation

In the notation of the previous section, the asset value of one hectare of forestland for timber production is VH (t) for a forest of age t. If timber is the only benefit provided by forests, then the reduction in asset value due to deforestation is given by the product of area deforested and per-hectare asset value: -Area deforested × VH (t). If all commercial timber is felled and sold before deforestation occurs, then the second term is the asset value of bare-land, VH (0). In that case, the only loss of timber production is from future rotations, not from the current standing volume. As mentioned, we recommend including deforestation-induced losses in current standing volume in the net accumulation of timber, not in the net accumulation of forestland.

More generally, of course, forests provide nontimber benefits as well as timber. The decrease in asset value due to deforestation then equals the sum of decreases related to both timber and nontimber benefits. If nontimber benefits are, like timber, provided on a harvest cycle spanning more than one year from regeneration to harvest, then the expression for VH(t) given in the previous section can be applied to calculate their contribution to the value of deforested land. If instead they are provided at a constant annual value per hectare, regardless of the forest's age, then the loss in value of nontimber benefits due to deforestation is given by the annuity value.

-Area deforested × Annual per-hectare value of nontimber benefits / i .

This expression should be calculated for the full range of nontimber benefits, even those that do not affect the overall level of GDP or NDP: nontimber forest products, forest amenities, environmental services, and carbon sequestration. 37 If the annual value is not constant—for example, if it rises with the age of the forest—then one needs to perform more complex calculations. If VNH(t) is the annual per-hectare value of nontimber benefits provided by a forest of age t, then the correct expression is:

-Area deforested × {Σ [VNH(s)/(1+i)s] + (1+i)t-T[Σ VNH(s)/(1+i)s] / [1-(1+i)-T]},

where s in the first summation (which denotes nontimber values during the remainder of the current rotation) is evaluated from t to T and in the second (which denotes nontimber values during future rotations) is evaluated from 1 to T.

Asset accounts must also include the net accumulation of converted (developed) land. Calculation of this entry depends, of course, on the nature of the use. If the land yields a constant annual per-hectare flow of rent (e.g., annual crop agriculture), then the simple annuity formula applies. This study draws conclusions from a previous study by the World Bank in 2006 which put the annual cost of environmental degradation as a percentage of GDP that accrued from the depletion of forests at 3.5% and from the depletion of wildlife at 0.56%. Thus, adjusted GDP will be amended accordingly for the cost of environmental degradation arising from the depletion of forests and wildlife. This is compounded by the fact that reliable records on non market activities do not exist in Ghana. In estimating the value of fuel wood consumption, this study draws upon an earlier by the Food and Agriculture Organization (FAO). According to *an FAO (2005)*, approximately 23 million m^3 of fuel wood is consumed in Ghana each year. The study identified the prevailing rate of collection of fuel wood for wood fuel from forest reserves at GH10/m3. Thus household consumption of wood fuel is estimated by multiplying the quantity collected by the market price. This puts the annual value of fuel wood consumed in the country at GH230 million, equivalent to US$164.28 million. The World Bank (2005) gave a rough estimate of the annual cost of depletion of non timber forest products (this excludes wildlife) at about US$30 million.

REFERENCES

Ahmad JY, S El Serafy, E Lutz, eds., (1989). Environmental Accounting for Sustainable Development. The World Bank, Washington, D.C.

Aronsson T, Lofgren KG (1996). "Social Accounting and Welfare measurement in a Growth Model with Human Capital." Scandinavian J. Econ. 98(2), 185-201.

Asheim GB (1994). "Net National Product as an Indicator of Sustainability." Scandinavian J. Econ. 96: 257–265.

Bartelmus P, C Stahmer, I van Tongeren. *"Integrated environmental and economic accounting: framework for an SNA satellite system"*, Review of Income and Wealth, ser. 37, No. 2, pp. 111-148.

Bartelmus P, E Lutz, S Schweinfest (1992). "*Integrated Environmental and Economic Accounting – A Case Study for Papua New Guinea."* The World Bank Environment Working Paper No. 54.

Birikorang G, Hansen CP, Treue T (2007). *"Review of the current taxation system relevant to the forest sector in Ghana".* VLTP Background Paper No. 1. Validation of Legal Timber Programme, Forestry Commission, Accra, Ghana.

Donkor BN, Vlosky RP (2003). A review of the Forestry Sector in Ghana, Louisiana Forest Product Development Center (Working Paper #61.

Environmental Protection Agency (2005). State of Environment Report.

Food and Agriculture Organisation (1988). *"An interim report on the state of forest resources in developing countries"*

Food and Agriculture Organisation (2000). Forestry Outlook Study for Africa (FOSA), Ghana, Ministry of Lands and Forestry (2nd Draft). forest Resources Assessment. FRA

Forestry Development Master Plan (FDMP) (1996). Master Plan for the Development of the Forest Sector. Ministry of Lands and Forestry, Accra.

Ghana Country Environmental Analysis September 6 (2006). Environmentally and Socially Sustainable Development Department. The World Bank, September. Report No: 36985-GH

Ghana Country Environmental Analysis, Report No: 36985-GH, (September 2006). The World Bank, Agence Française de Développement, Royal Netherlands Embassy.

Glenn-Marie Lange (2003). *"Policy application of environmental accounting."* Environmental Economic Series, Paper No. 88 the World Bank Development Department.

Hamilton K, Ernst L (1996). Green National Accounts: Policy Uses and Empirical Experience. Environmentally Sustainable development. The World Bank. Washington. DC. 48p

Hamiltopn K, Lutz E (1996). "Green National Accounts: Policy Uses and Empirical Experience." Environmentally Sustainable Development. The World Bank. Washington DC. Department Paper No. 039.

Handbook of Integrated Environmental and Economic Accounting (2003). The World Bank

Harris M. and Iain F., *"Natural Resource Accounting in Theory and Practice,"* The Australian J. Agric. Res. Econ. 46:2, 2002, pp. 139 - 192.

Hartwick JM (1994). *"National Wealth and Net National Product,"* Scandinavian J. Econ. Vol. 98 (3), pp. 439-443

Hassan MR (2002). *"Accounting for Stock and Flow Values of Woody Land Resources*," Methods from South Africa.

Hawthorne WD, Abu JM (1995). *"Forest protection in Ghana."* Forest Conservation Series no. 14, IUCN, Gland.

Hicks JR (1946). *Value and Capital.* 2nd Edition, Oxford University Press, Oxford.

Johnson P (1999). *"Proposed Tourism Development Framework for the Western Region of Ghana with Particular Reference to Ankasa and Bia Protected Areas."* Accra: Protected Areas Development Project (PADP), Wildlife Division

Kim SW, A Alfieri, P Bartelmus, J van Tongeren (1998). "*Pilot Compilation ofEnvironmental-Economic Accounts – Republic of Kore*a." Korea Environment Institute, Seoul.

Lange GM. *"Policy Applications of Environmental Accounting."* World Bank Environment Department. Environmental Economic Series, paper No. 88.

Lufumpa C (2005). *"Poverty –Environment Nexus in Africa."* Published in the African Development Review. Volume 17 No. 3

Mkanta WN, Chimtembo MMB (2002). *"Towards Natural Resource Accounting in Tanzania: A Study on the contribution of natural forests to National Income."* CEEPA Discussion Paper Series. Septemebr.

Monographs Series No. 17. World Bank. Washington, DC. 110p.

National Forest Plantation Development Programme – Forestry Services Division of the Forestry Commission (2007)

National Forest Plantation Development Programme, Annual Report (2007). Forestry Commission

Ntiamoa-Baidu Y (1998). *"Sustainable harvesting production and use of bush mea*t." Wildlife Development Plan. Accra, Ghana: Wildlife Department.

Pearce DW, Atkinson GD (1993). *"Capital Theory and the Measurement of Sustainable Development: An Indicator of Weak Sustainability," Ecological Economics,* vol.8, pp. 103- 108.

Pilot compilation of environmental-Economic Accounts Republic of Korea (1998). UNDP Assisted Project – ROK/93/015 March.

Powell M (1996). Ghana Statistical Service. *"Integrated Environmental and Economic Accounting for Ghana."* Proceedings of the Symposium Integrated Environmental and Economic Accounting in Theory and Practice (Tokyo, 5-8 March).

Ronaldo Seroa da Motta, Claudia A. Ferraz do Amaral (FAO 1998). *"Estimating Timber Depreciation in the Brazilian Amazon."* Policy and Planning Division.

State of the World's Forests (2001). Food and Agriculture Organization of the United Nations, Rome, 2001 FAO.

Stern D (1997). *"The Capital Theory Approach to Sustainability" Journal of Economic Issues,* vol. 31 (1), pp/ 145 -173.

Towards Improved Accounting for the Environment (1993). The World Bank, Washington DC

Updated System of National Accounts 1993 (1993 SNA): Volume 1

van Tongeren J, S Schweinfest, E Lutz (1991). *Integrated Environmental and Economic Accounting – A Case Study for Mexico.* The World Bank Environment Working Paper No.50.

Vincent J, Hartwick T (1998). *"Accounting for the benefits of forest resources: Concepts and experience."* Draft report. Food and Agricultural Organization (FAO).

Wildlife developmental Plan (1998 – 2003). Volume 1, July 1998**,** Department of the Environment and Natural Resources (DENR), United Nations Development Programme (UNDP) and National Economic Development Authority (NEDA) (1996). *"A Case Study on the Compilation of Natural Resources Accounting in the Philippines."*

World B (1997). *"Expanding the Measures of Wealth: Indicators of Environmentally Sustainable Development."* Environmentally Sustainable Development Studies and

World B (1998). Natural Resource Management Project. World Bank Project Document, Project ID No. GH-Nat.Res.Management-P000946.

World B (2005). An Independent Review of World Bank Support to Capacity Building in Africa: Case of Ghana. Washington, D.C.: World Bank, Operations Evaluation Department.

World B (2006a). Ghana: Natural Resources Management and the Sustainability of Economic Growth. Economic and Sector Work. Washington D.C.: World Bank

World B (2006a). Where is the Wealth of Nations? Measuring Capital for the 21st Century. World Bank: Washington, DC.

World B (2006b). World Development Indicators 2005, World Bank, Washington, DC.