# INCORPORATING FUELWOOD PRODUCTION
# AND
# CONSUMPTION INTO THE NATIONAL ACCOUNTS

A CASE STUDY FOR ZIMBABWE

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# EXECUTIVE SUMMARY

Natural resource accounting methods are applied in a case study of fuelwood consumption in Zimbabwe. The study estimates values of economic depreciation of timber stocks from fuelwood consumption from 1990 to 1996. Fuelwood is an appropriate variable to study because of the country's high dependency on wood for energy, particularly in rural areas where most of the population lives.

There is substantial criticism of the linkage between the environment and national accounts in most countries including Zimbabwe. Traditional national income data such as Gross Domestic Product (GDP) do not fully capture the total economic value of natural resource stocks such as forests. First, the depreciation of natural capital upon which subsequent commercial uses are based is not measured. Second, only market-based uses such as logging, lumber and pulp production are included in GDP. Non-market consumptive uses such as domestic fuelwood cut by villagers, fruits and building materials are excluded.

Distinct natural resource accounting methodologies for valuing fuelwood depletion are reviewed and applied to commercial/domestic consumption. The main difference in the various approaches commonly used is in the valuation of physical stocks. Most studies use average net price as a measure of economic rent while a more refined approach suggested by Vincent and Hartwick (1997) uses marginal net price. Using average net price can increase bias in calculating net depreciation values of timber stocks. Using either method, the resulting depreciating values are then used to adjust the national accounts.

The results for Zimbabwe, based on specific methods, data and assumptions, imply no significant difference between normal GDP and an adjusted Net Domestic Product (NDP). A general conclusion based only on these data is that the economy could have actually consumed more per capita and still not jeopardised sustainable development. However, the results are aggregated at the national level and mask local sustainability issues with forest stocks. Many regions of Zimbabwe suffer from severe and unsustainable deforestation. The results also show that economic depreciation of timber stocks from fuelwood consumption alone represents about 0.16 percent of annual GDP. This figure is quite substantial and suggests that estimating other non-market forest values might be worth undertaking as part of a broader forest policy review. Finally, the study demonstrates some of the advantages, disadvantages and practical data limitations inherent in trying to adjust national accounts for resource depletion in a developing country context. Data limitations are especially problematic, even in Zimbabwe, which has a fairly well-developed system of national accounts and natural resource statistics. This case study demonstrates that natural resource accounting can be used even where data constraints exist. However, to fully capture the benefits of more refined methods such as using marginal net price for resource consumption, better quality data are required.

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# 1 INTRODUCTION

## 1.1 Background

Like many other countries in Sub-Saharan Africa, Zimbabwe's indigenous forest stocks supply fuelwood for commercial sale and domestic consumption. The primary purpose of fuelwood collection is for cooking, in all rural areas and in many high-density suburbs in urban centres (Campbell and Mangono, 1995). Fuelwood harvesting is a contributing factor to deforestation, rated as the most serious environmental issue in the country during a 1992 national survey by the Ministry of Environment and Tourism (Marongwe and Milne, 1993). Policy makers, particularly those in central planning and finance agencies, are not fully aware of the monetary value of forest stocks in the country. This information gap pertains to both direct-use values from products such as fuelwood, fruits, fodder and building materials, and indirect values from ecological functions including reducing soil erosion and maintaining water quality. Without good information on the value of forests, policy makers are in a weak position to establish guidelines and institutions for addressing forestry management issues. With deforestation, policy formulation should be based on the total economic value of forest stocks, the costs of forest loss and the contribution made by fuelwood to these benefits and costs.

Measures such as gross domestic product (GDP) from the system of national accounts (SNA) are frequently used to value the contribution of various economic sectors (agriculture, forestry, etc.) to total national income. For man-made capital such as buildings and lorries, the SNA captures the normal depreciation of capital stocks to derive a net product. In forestry for example, the annual depreciation of harvesting and processing equipment used to manufacture commercial wood products is deducted when deriving value added. The same would hold for commercial logging of fuelwood. However, the SNA does not capture the depreciation of the natural capital (the forest stocks) upon which subsequent commercial uses are based. As well and of direct concern to this study, national accounts only measure market-based transactions and exclude consumptive uses such as domestic fuelwood cut by villagers, which occurs outside the market place. As a result of these conceptual problems, incorrect policy decisions may be made regarding forestry development, resource management and land use. A better approach for valuing natural resources such as forests is to try and measure the net product by accounting for the depreciation of the natural capital stock and include non-market costs and benefits. Then, the national accounts can be adjusted to show the macro-economic values of forest stocks and the costs of deforestation from fuelwood consumption.

Fuelwood is an appropriate variable to study in Zimbabwe because of the country's high dependency on wood for energy, particularly in rural areas. About 70 percent of Zimbabwe's energy consumption is derived from wood energy. This high figure is related to the fact that approximately 70 percent of the country's population is rural based, often with poor access to electrical supply. Even where rural electrification has occurred, income constraints prevent many households (as opposed to businesses) from connecting to the grid and purchasing electrical appliances. These households continue to consume fuelwood for energy because of its perceived status as a free good. Since the early 1990's, a steady decline in real per capita income has occurred as a consequence of macro-economic structural adjustment reforms in Zimbabwe and periodic droughts. A reasonable hypothesis is that fuelwood will continue to provide a significant energy source for Zimbabwe into the next century. Therefore, this case study is important by identifying analytical methods and data requirements to improve the quality of economic information for policy makers tasked with addressing forest management issues. The methods tested in this case study will be useful to researchers and policy-makers in other developing countries who share similar forestry issues.

## 1.2 General Analytical Framework and Study Objectives

The study will build on previous work, especially Crowards (1994), by trying to estimate values of economic depreciation of timber stocks using the more refined approach of Vincent and Hartwick (1997). The main difference in approach is in the valuation of physical stocks by multiplying the net depletion of the resource by an estimate of rent. Most studies use average net price as the measure of rent while Vincent and Hartwick use marginal net price. As the authors show, using average net prices can exacerbate bias in calculating net deprecation values of stocks.

The objectives of this case study are to:

- identify data needs and gaps to implement improved methods of estimating the economic depreciation of timber stocks for fuelwood in Zimbabwe
- test methodologies for valuing fuelwood depletion for commercial/domestic consumption and subsequent economic depreciation following methods proposed in Vincent and Hartwick (1997)
- adjust national income accounts
- make recommendations regarding incorporating environmental components into national accounting systems

# 2 ZIMBABWE OVERVIEW[1]

## 2.1 Geography, Climate and Social Development

Zimbabwe is a land-locked country of 39 million hectares. Zimbabwe's natural vegetation cover is characterised by savannah woodlands interspersed with open grassed drainage lines or dambos. Impeded drainage gives rise to limited areas of open grassland. A few patches of sub-tropical forests occur in the eastern districts.

Zimbabwe has few perennial rivers and no natural lakes. Storage development is therefore dependent on run-off water accumulated during the rainy season. There are over 8,000 dams in the country with a storage capacity of about 4,900 million cubic metres. Rainfall is the major climatic factor influencing the performance of renewable natural resource sectors such as agriculture, forestry and wildlife in Zimbabwe.

Zimbabwe's population from the 1992 Census was 10.4 million and is now estimated at almost 12 million. A declining infant mortality rate has been largely credited for the rapid increase in the country's population over the years although the effect of the AIDS pandemic on population growth still remains to be seen. Almost 50 percent of the total population are under 15 years of age, which poses long-term challenges to biodiversity conservation. In rural areas, characterised by low investment, poverty and lack of economic alternatives, people tend to rely on natural resources for subsistence and income generation.

## 2.2 Land Tenure, Property Rights and Land Use Systems

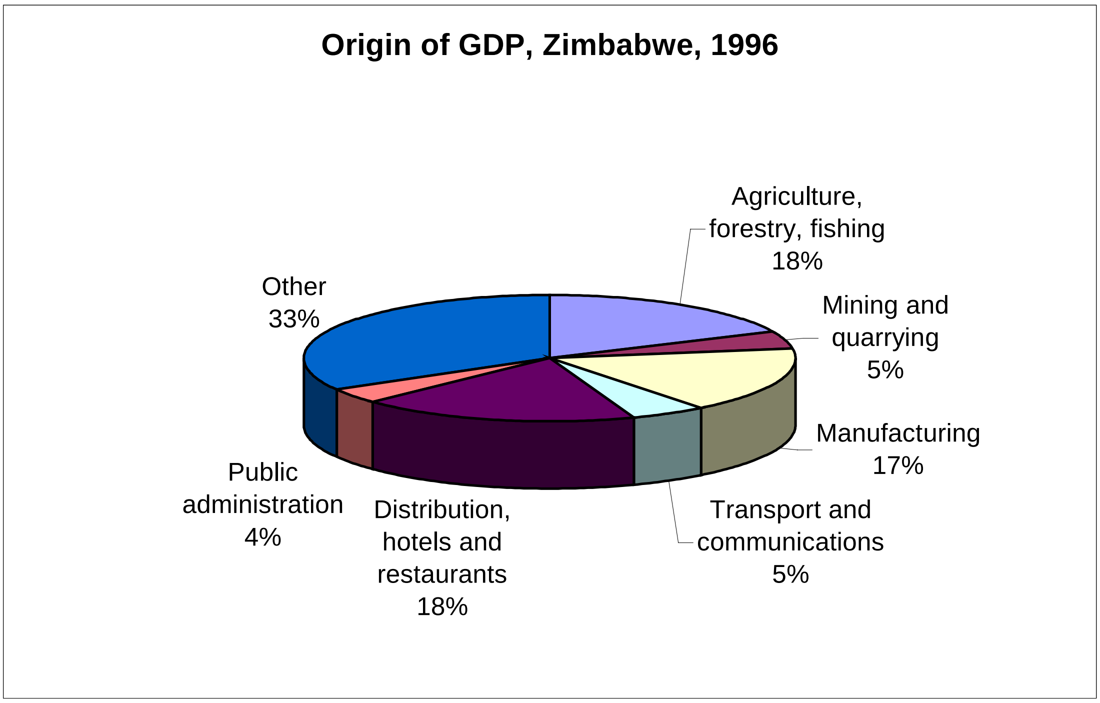
Four land tenure systems are generally recognised in Zimbabwe. These are the freehold (private), state land, communal and leasehold (resettlement) tenure systems. The land tenure system in the country is extremely complex, however in a strict legal sense, there are only two tenure categories; freehold and state land. Communal and resettlement tenure systems are a subset of the state land category. The freehold tenure system is prevalent in the commercial farming sector which, consists of large scale and small-scale commercial farmers, and covers about 32 percent of the country. The communal land tenure system is applicable to 42 percent of Zimbabwe's land area where the majority of the country's population resides. Factors such as high population growth, a limited land base of low productivity, and a shift from subsistence to an income-based economy have contributed to a general failure of communal tenure and subsequent environmental degradation.

## 2.3 Macroeconomic Structure And Policies

Zimbabwe is a developing country with a per capita income of $718 USD[2], based on total GDP (in nominal terms) of $85.5 billion ZD[3], total population of approximately 11.9 million, and an average exchange rate of $10.00 ZD per USD in 1996 (CSO 1997). However, in real terms, the GDP per capita has declined from $271 USD in 1980 to $201 USD in 1996 largely due to high inflation and the depreciation of the Zimbabwe dollar. In local currency, real GDP per capita is largely unchanged from 1985.

The Zimbabwe economy is heavily dependent upon the natural resource base for generating employment, income and foreign exchange. In particular, the economy is dominated by manufacturing, agriculture/forestry/fishing, tourism and mining (Figure 1). Forestry GDP mainly reflects logging of commercial pine plantations in the eastern part of the country. The consensus is that primary commercial forest production might contribute at most 2 to 3 percent of total GDP with primary agriculture accounting for 11 to 12 percent. Fishing accounts for the remainder. Tourism is captured by the GDP category of Distribution, hotels and restaurants. The category "other" includes finance and insurance, electricity and water, construction, real estate, education and health, and domestic services.

**Figure 1 Share of GDP by sector, Zimbabwe, 1996**




Zimbabwe's economy has undergone dramatic changes during the last six years due to the implementation of two successive economic reform programmes. The major policy objectives of these economic reform programmes are:

- trade and investment liberalisation
- removal of trade restrictions
- deregulation of financial and labour markets
- removal of price controls
- the attainment of a 5 percent annual growth in GDP
- reduction in the budget deficit
- reforming public enterprises and rationalisation of the civil service

While the first four objectives have been largely met, the last three have been more problematic due to several constraints. These include severe droughts earlier this decade, government assumption of large parastatal debts, and increased social expenditures on issues such as the AIDS pandemic and war veterans. Declining economic situations for many rural and urban poor will only serve to increase the demands on the natural resource base.

## 2.4 Forest Resources and Forestry in Zimbabwe

### a) Land Use and Forest Cover Types

Sixty six percent of the country's land area is under various woodland types compared to 27 percent under cultivation (Table 1). The heaviest concentrations of indigenous woodlands occur in the gazetted state forests, national parks, the Eastern Highlands and large-scale commercial farms. Forest and woodlands are classified into five cover types according to the Forestry Commission (Table 2). The total area of forest types in Table 2 does not exactly correspond to the total of natural forests, plantations and indigenous woodlands in Table 1 due to differences in terminology and measurement. Table 2 represents more recent information.

**Table 1 Land classification in Zimbabwe.**

| Land Use | Area (000ha) | % of total |
|---|---:|---:|
| Natural forests[a] | 11.60 | 0.03 |
| Plantations | 155.60 | 0.40 |
| Indigenous woodlands | 25,771.40 | 65.92 |
| Grasslands | 1,893.90 | 4.85 |
| Cultivated land | 10,738.10 | 24.47 |
| Settlements[b] | 139.10 | 0.36 |
| Other[c] | 379.40 | 0.97 |
| Total | 39,089.40 | 100.00 |

*a Tropical rain forest*
*b Cities and towns*
*c Rock outcrops and water bodies*

**Table 2 Forest resource classification by crown closure and height**

| Cover class | Canopy closure (%) | Height (metres) | Area (000ha.) | % of forest area |
|---|---:|---:|---:|---:|
| Natural forests | 80-100 | 15+ | 11.60 | 0.03 |
| Exotic plantations | 80-100 | <1-15+ | 155.90 | 0.40 |
| Woodlands | 20-80 | 5-15 | 20,797.40 | 53.20 |
| Bushlands | 20-80 | 1-5 | 974.10 | 12.72 |
| Wooded grassland | <20 | 1-15+ | 1,204.80 | 3.08 |
| Total | | | 27,143.80 | 69.43 |

*Source: Forestry Commission, 1997*

### b) Exotic plantations

Zimbabwe has a well-established plantation forest resource base covering some 155,853 ha. About 90 percent of the plantations are located in the eastern districts. This area is characterised by high altitudes (700 to 2,200 metres above sea level) and high rainfall (average of 1,000 mm/annum). About 71 percent of the planted area is under softwoods (pines), 13 percent under hardwoods (eucalyptus) and 16 percent under wattle. With respect to the plantation ownership pattern, about 42 percent belong to the State, 54 percent to private companies and the remainder to small private growers who include co-operatives.

**c) Indigenous forests**

The area of indigenous forest is comprised of natural forests, woodlands, bushlands and wooded grasslands cover types from Table 2. Unfortunately, the Forestry Commission's inventory work has not progressed to the stage where the areas of these forests can be matched to the cover types in Table 2.

**d) Causes of forest decline**

About 70 percent of the country's total population live in communal areas and depend directly on forests for firewood, construction timber, food and fodder. The open access, common property situation in these forests lends itself to over-exploitation. The gradual erosion of cultural and ethical values tied to forests has also contributed to woodland degradation. Fires, insects, disease and browsing by wildlife are also significant factors. By far however, the opening up of forestland for agricultural expansion tied to resettlement, is the major reason for the loss of forest biodiversity. Although no accurate figures on deforestation exist due to inadequate forestry change data, it is estimated that about 70,000 ha. of Zimbabwe's natural forests are lost each year (FAO, 1997) due mainly to agricultural expansion.

**e) Economic values and wood supply in non-commercial forestry**

Although a significant proportion of the country (69 percent) contains indigenous forests in the various cover type categories (Table 2), there is still no corresponding information on timber volumes by species and age class. Furthermore, the available inventory data do not classify these forests by dominant species which could help identify the various timber and non-timber products and services flowing from them.

Zimbabwe's natural forests generate a wide range of timber and non-timber products and services. The products include fuelwood for charcoal making, sawn timber and pulpwood, building materials, wood for small artisanal crafts, fodder, fruits, honey, mushroom, insects, bark for rope, medicine, leaf litter and gum. The services include watershed conservation carbon fixation; and the provision of windbreaks, shade, soil stability and wildlife habitat. No accurate economic value has been established for these goods and services but specific studies can provide some point estimates. For example, a modified contingent valuation study (CVM) estimated the mean direct and indirect values of a range of timber and non-timber products in miombo woodlands. An average value was ZD $200/ha per year (Campbell, et al. 1991). Based on this figure (and mindful of many caveats about extrapolating the very specific Campbell et al. results), the total stock value of indigenous woodlands (21 million ha from Table 2) can be crudely estimated at ZD $4.2 billion. This figure is an order of magnitude estimate only, based on a specific study in one small area of the country. More accurate estimates of woodland values require extensive CVM research across a wider range of geographic areas and forest types.

**f) Forest stocking densities**

Millington and Townsend (1989) suggest the following stocking densities for the three woody biomass classes that compare well with the Forestry Commission (1997) woody cover classes:

- Wooded grassland 11.42t/ha
- Bushland 23.36t/ha
- Woodland 49.89t/ha

These stocking levels are conservative when compared to Chidumayo (1995)'s levels of 53t/ha in western dry miombo and 72t/ha in eastern dry miombo of Zambia. However, the figures are within the general ranges of 21.16 tonnes of wood biomass per ha to 39.73 tonnes per ha for the miombo plots in Sengwa and Marondera respectively (Frost 1996). The average growing stock across all provinces was 30.2 t/ha-1 (ranging from 6.129 in Bulawayo to 37.3 in Matabeleland North).

# 3 METHODS AND THEORETICAL CONCEPTS

The economic literature suggests two main conceptual approaches to deal with the depletion of natural resources. Both aim at measuring the impacts of resource depletion on long run human welfare. The two approaches are conditions, which must be met if a country's population is to be as economically well off in the future as in the current period.

The first approach, often referred to as the depreciation approach, is to treat natural capital in the same way as human-made capital is treated in conventional accounting and estimate the value of the net change in the total capital stock (broadly defined). The value of the net change in total capital stock is given by equation 1:

$$INt = dKt/dt + dHt/dt + dRt/dt \quad (1)$$

Where: I = value of net change in total capital stock
Kt = value of physical capital in period t
Ht = value of human capital in period t
Rt = value of natural capital in period t

The condition is then that net investment must be greater than or equal to zero. If investment equals zero, then a country just maintains its total capital and can sustain its current consumption levels. This result is referred to as "Hartwick's Rule", after Hartwick (1977, 1990). If INt >0, then an increase in consumption is possible. Therefore, in this approach depreciation associated with all forms of capital is netted out. Investments in human-made capital to match the drawing down of natural capital fits the criterion for weak sustainability described by Pearce et. al. (1989).

The second approach uses the Net National Product (NNP) alternatively called net domestic product (NDP) or domestic product. It can be shown that NNP is equal to a constant level of product whose present value equals the present value of consumption along an efficient path for a competitive economy (Maler, 1991; Hamilton et. al. 1994). To sustain economic welfare, net domestic product (NDP) should remain constant or increase from one period to the next (Dasgupta et al 1996). NDP differs from GDP in that it represents net investment after deducting depreciation. Unlike conventional NDP in national income accounts however, with natural resource accounting, NNP adjusts all forms of capital, not just physical capital (equations 2 & 3).

$$NDPt = Ct + INt \quad (2)$$

Where: NDP = net domestic product
Ct = consumption
INt = net change in capital

$$GDPt = Ct + IGt \quad (3)$$

Where: GDP = gross domestic product
Ct = consumption
IGt = gross change in capital

A country can evaluate whether its long-term welfare is rising, falling or remaining constant by examining the change in NDP. An increase in long-run welfare is only possible if dNDPt/dt>0.

There are two direct methods to estimate economic depreciation in natural resource accounting. The first method is commonly referred to as the net price method. This approach multiplies the net price of the resource (gross price (p) less the marginal cost of extraction (c')), by the physical quantity extracted (q(t)) to get depreciation (equation 4).

$$D(t) = [(p-c' (q(t))] \, q(t) \quad (4)$$

Where: D = depreciation
p = gross price
c` = marginal cost of extraction
q(t) = physical quantity extracted

As discussed by Vincent and Hartwick (1997), it is important to use marginal net price whenever the cost function is non-linear. The reason is that use of average cost computes total resource rent, which often exceeds economic depreciation. A major obstacle in applied analysis however, is the fact that data on marginal costs are typically not available. Average costs are fairly simple to derive while marginal costs could require extensive and expensive data collection.

To circumvent this problem, the approach suggested in Vincent and Hartwick (1997) is followed to utilise average cost figures and the elasticity of the marginal cost curve (percent change in marginal cost per one percent change in quantity extracted). The following expression then yields the net price method (equation 5).

$$D(t) = [p - (1+b) \, c \, (q(t))/q(t)] \, q(t) \quad (5)$$

Where: D = depreciation
p = price
c(q(t))/q(t) = the average extraction cost
b = the elasticity of the marginal cost curve

The second direct estimation approach, often referred to as the El Serafy method (El Serafy 1989), multiplies total resource rent by a conversion factor involving the discount rate, the number of years until the resource is exhausted (T-t) and the marginal cost elasticity[4] (equation 6).

$$D(t) = [pq(t) - C(q(t))] \, (1+b)/(1+b)(1+i)T-t \quad (6)$$

Where: D = depreciation
pq = price x quantity extracted
i = the discount rate
T = years till resource exhaustion
b = the elasticity of the marginal cost curve

Vincent and Hartwick (1997) argue that this expression is reliable only when b equals infinity. To convert total rent (TR) to Hotelling Rent (HR), Vincent (1996) assumes that the real price of a tonne of an extracted resource is constant over time and the discount rate is given by i. If the remaining stock at the beginning of the period is denoted by St, then one can approximate the number of years until terminal time by St/qt-1. The ratio of Hotelling rent to total resource rent (HR/TR) becomes[5] (equation 7):

$$HR_t/TR_t = (1+b)/(1+b)(1+i)S_t/q_{t-1} \quad (7)$$

Where: HR = hotelling resource rent
TR = total resource rent
b = the elasticity of the marginal cost curve

# 4 NATURAL RESOURCE ACCOUNTING FOR FUELWOOD IN ZIMBABWE

## 4.1 Population and Annual Forest Depletion for Fuelwood

Population estimates, numbers of households using fuelwood and fuelwood consumption rates can be used to estimate the quantity of fuelwood used in Zimbabwe. Frost (1997), for work on greenhouse gas emissions, used research by Campbell and Mangono, (1995) and Marufu et al. (1997), to estimate domestic fuelwood consumption for 1994 (Table 3). Extrapolating this data for the period 1990-1996, estimates of fuelwood consumption are shown in Table 4.

**Table 3 Estimated fuelwood consumption in Zimbabwe, 1994.**

| Sector | Est. 1994 population (individuals) | No. of Households | Number of households using wood | Fuelwood Consumption (t $hh^{-1}$ $yr^{-1}$) | Total domestic fuelwood consumption (tonnes) |
|---|---|---|---|---|---|
| Communal | 5,623,263 | 1,120,172 | 1,120,172 | 6.25 | 7,001,075 |
| LSCF [a] | 1,236,151 | 246,245 | 202,660 | 5.71 | 1,157,189 |
| SSCF [b] | 178,782 | 35,614 | 29,310 | 6.77 | 198,429 |
| RA[c] | 448,288 | 89,300 | 73,494 | 7.77 | 571,048 |
| Other rural | 107,029 | 25,915 | 21,328 | 6.63 | 141,405 |
| Urban | 3,346,169 | 810,210 | 99,089 | 2.18 | 216,014 |
| Total | 10,939,682 | 2,327,456 | 1,546,053 | 6.01 | 9,285,160 |

*Source: Frost, 1997*
*a Large scale commercial farms*
*b Small scale commercial farms*
*c Resettlement areas*

**Table 4 Population, distribution and fuelwood demand estimates, 1990 - 1996.**

| YEAR | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 |
|---|---|---|---|---|---|---|---|
| **Population (million)** | | | | | | | |
| Communal | 5.031 | 5.189 | 5.352 | 5.541 | 5.623 | 5.924 | 6.121 |
| Large Scale Comm. Farms | 1.106 | 1.141 | 1.176 | 1.217 | 1.236 | 1.302 | 1.345 |
| Small Scale Comm. Farms | 0.159 | 0.164 | 0.171 | 0.176 | 0.178 | 0.188 | 0.194 |
| Resettlement | 0.401 | 0.413 | 0.426 | 0.441 | 0.448 | 0.472 | 0.487 |
| Other Rural | 0.095 | 0.098 | 0.101 | 0.105 | 0.107 | 0.112 | 0.116 |
| Urban | 2.994 | 3.088 | 3.185 | 3.297 | 3.346 | 3.573 | 3.691 |
| Total Population | 9.786 | 10.093 | 10.411 | 10.777 | 10.938 | 11.571 | 11.954 |
| **Fuelwood Demand (mill.t)** | | | | | | | |
| Communal | 6.211 | 6.405 | 6.606 | 6.838 | 7.001 | 7.312 | 7.554 |
| Large Scale Comm. Farms | 1.026 | 1.058 | 1.091 | 1.131 | 1.157 | 1.208 | 1.248 |
| Small Scale Comm. Farms | 0.176 | 0.181 | 0.187 | 0.193 | 0.198 | 0.207 | 0.214 |
| Resettlement | 0.506 | 0.522 | 0.538 | 0.557 | 0.571 | 0.596 | 0.616 |
| Other Rural | 0.125 | 0.129 | 0.133 | 0.138 | 0.141 | 0.147 | 0.153 |
| Urban | 0.191 | 0.197 | 0.203 | 0.211 | 0.216 | 0.225 | 0.233 |
| Total Demand | 8.235 | 8.492 | 8.758 | 9.068 | 9.284 | 9.695 | 10.018 |

The average annual consumption of fuelwood in non-urban areas ranges from 8.24 million tonnes in 1990 to just over 10 million tons in 1996. By far, the largest component of demand is within the communal areas, which contain approximately 70 percent of the country's total population. Given the estimating methods used, fuelwood consumption mirrors population growth.

The amount of fuelwood derived from agricultural field clearance must be subtracted from the gross depletion figures since the timber felling arises from shifting land-use rather than simply harvesting trees for energy. The fuelwood is a by-product. Based on Atwell et al 1989, and discussions with Forestry Commission staff, we assume that for fuelwood from both urban and rural areas, 50 percent is derived from field clearance.

The amount of fuelwood collected as dry wood must also be subtracted since it does not represent a reduction in standing timber stocks. For urban areas this will be presumed to be zero, based on Campbell and Mangono (1995) which states that most urban fuelwood is cut from indigenous trees. In rural areas, the percentage of households using deadwood for household cooking ranges from 91 percent in resettlement areas (where there is a lot of wood) to 73 percent in communal areas (baseline survey quoted in Campbell and Mangono 1995). This case study uses a figure of 75 percent to carry out the adjustments (Table 5).

The residual is fuelwood cut directly from the standing woodlands and thus contributing to deforestation. From the calculations, this volume amounts to 1.395 million tonnes in 1996.

**Table 5 Total woodland loss after adjusting for dry wood and land clearance, 1990 – 1996.**

| YEAR | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 |
|---|---|---|---|---|---|---|---|
| **Total Gross Fuelwood Demand (million tonnes)** | 8.235 | 8.492 | 8.758 | 9.068 | 9.284 | 9.695 | 10.018 |
| **Net of Field Clearance** | | | | | | | |
| Communal | 3.105 | 3.202 | 3.303 | 3.419 | 3.501 | 3.656 | 3.777 |
| Large Scale Comm. Farms | 0.513 | 0.529 | 0.545 | 0.565 | 0.578 | 0.604 | 0.624 |
| Small Scale Comm. Farms | 0.088 | 0.091 | 0.093 | 0.096 | 0.099 | 0.103 | 0.107 |
| Resettlement | 0.253 | 0.261 | 0.269 | 0.278 | 0.285 | 0.298 | 0.308 |
| Other Rural | 0.062 | 0.064 | 0.066 | 0.069 | 0.071 | 0.073 | 0.076 |
| Urban | 0.095 | 0.098 | 0.101 | 0.105 | 0.108 | 0.112 | 0.116 |
| **Net of Dry Wood** | | | | | | | |
| Communal | 0.776 | 0.801 | 0.825 | 0.854 | 0.875 | 0.914 | 0.944 |
| Large Scale Comm. Farms | 0.128 | 0.132 | 0.136 | 0.141 | 0.144 | 0.151 | 0.156 |
| Small Scale Comm. Farms | 0.022 | 0.023 | 0.023 | 0.024 | 0.025 | 0.026 | 0.027 |
| Resettlement | 0.063 | 0.065 | 0.067 | 0.069 | 0.071 | 0.073 | 0.076 |
| Other Rural | 0.062 | 0.064 | 0.066 | 0.069 | 0.071 | 0.073 | 0.076 |
| Urban | 0.095 | 0.098 | 0.101 | 0.105 | 0.108 | 0.112 | 0.116 |
| **Total Net Demand Fuelwood From Standing Stocks** | 1.146 | 1.183 | 1.218 | 1.262 | 1.294 | 1.349 | 1.395 |

## 4.2 Forest Growth and Yield

The area of indigenous woodland in Zimbabwe has shown a continuous decline in the past decade (Table 6). Between 1985 and 1996 the woodlands of Zimbabwe were depleted at an average rate of 2.01 percent per annum. Overall, biomass depletion has been taking place at a uniform rate of 30.1 million tonnes per annum between 1985 and 1996. The depletion rate was greatest in the bushland category (4.14 percent per year). The expansion in the wooded grassland (7.23 percent per year) appears rather high and cannot be easily explained. These figures must be tempered by the knowledge that Forestry Commission's inventory, growth and yield data for indigenous forests are not well developed. Until recently, the emphasis on forest mensuration has been on managed commercial plantations of exotic pines, which underpin a growing forest industry. It is hoped that in time, more comprehensive and accurate growth and yield data, based on permanent sample plots and remote sensing will emerge from an expanded inventory programme presently being implemented.

The next step is to estimate the net annual increment of the forest after allowing for losses from harvesting for fuelwood (Table 7). The mean annual increment (mai) is the average annual increase in forest stock volume comprising many individual stands and is measured by dividing the cumulative stand volume by the age of the stand (Husch, Miller and Beers, 1972). The mai basically represents forest growth. Mean annual increments were derived from discussions with the Forestry Commission where mai was estimated as 2.23 percent of the total accessible growing stock volume. This approach leaves much to be desired from a mensuration point of view, but it is the best that the Forestry Commission could offer at this time.

**Table 6 Forest cover type changes between 1985 and 1996.**

| Biomass Type | Growing Stock (million of tonnes) | | | | |
|---|---|---|---|---|---|
| | 1985 | 1996 | Gross Change | Annual Change | % Change per Year |
| Woodlands | 1278.00 | 1038.10 | -239.90 | -21.80 | -1.71 |
| Bushland | 214.10 | 116.20 | -97.90 | -8.90 | -4.14 |
| Wooded Grassland | 7.60 | 13.70 | 6.10 | 0.55 | 7.23 |
| Total | 1499.70 | 1168.00 | -331.70 | -30.10 | -2.01 |

Not all of the forest increment is directly available for fuelwood harvesting as some is in protected forest areas and national parks. In the absence of more recent data, we use the estimates from a study by Touche Ross (1992) which, found that only 30 percent of the mean annual increment is available. Total growing stock from 1990-1996 is derived by beginning with the 1985 growing stock figure from Table 6 (1499.7 million tonnes) and deducting five years of average losses (30.1 million tonnes x 5). The resulting figure (1349.2 million tonnes) is shown for 1990 in Table 7. Thereafter, total growing stocks are reduced by 30.l million tonnes per annum. The accessible growing stock is then calculated by multiplying the total growing stock figures by 30 percent. The net annual increment is calculated as accessible mai less annual depletions.

**Table 7 Net annual increment estimates (million tonnes), 1990 - 1996**

| YEAR | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 |
|---|---|---|---|---|---|---|---|
| Total Growing Stock | 1349.20 | 1319.10 | 1289.00 | 1258.90 | 1228.80 | 1198.70 | 1168.60 |
| Accessible Stock | 404.80 | 395.70 | 386.70 | 377.70 | 368.60 | 359.60 | 350.60 |
| Accessible MAI | 9.03 | 8.83 | 8.63 | 8.43 | 8.22 | 8.02 | 7.82 |
| Total Depletions | 1.15 | 1.18 | 1.22 | 1.26 | 1.29 | 1.35 | 1.40 |
| Net Annual Increment | 7.88 | 7.65 | 7.41 | 7.17 | 6.93 | 6.67 | 6.42 |

## 4.3 Prices

Campbell and Mangono (1995) derived estimates of fuelwood prices for each sector from a survey of fuel prices. The average price of rural fuelwood is estimated to be Z$120 per tonne in 1994 while urban fuelwood is Z$230 per tonne. These are then extended to other years based on changes in the consumer price index published by the Central Statistics Organisation (Table 8). A weighted price, based on volumes used (from Campbell and Mangono, 1995) is presented for all years.

**Table 8 Fuelwood prices (Z$/tonne), 1990 – 1996**

| YEAR | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 |
|---|---|---|---|---|---|---|---|
| Rural Price/tonne | 43.90 | 54.10 | 76.90 | 98.10 | 120.00 | 147.10 | 178.60 |
| Urban Price/tonne | 84.10 | 103.70 | 147.40 | 188.10 | 230.00 | 281.90 | 342.40 |
| Weighted Price/tonne | 44.79 | 55.20 | 78.47 | 100.10 | 122.50 | 150.10 | 182.20 |

## 4.4 Costs of Extraction

For household collection costs of fuelwood, an indirect valuation approach is required since most fuelwood is collected in the forest by the consumer rather than purchased through markets. The following opportunity cost method is used:

Collection cost = amount of time spent collecting x opportunity cost of time

The amount of time spent collecting firewood is a function of several variables including population in a given area relative to existing forest stocks, rate of deforestation, existence of eucalyptus plantations and their age structures. In the absence of community woodlots, the time required to collect indigenous fuelwood is likely to increase with rising deforestation. Indeed, discussions with the Forestry Commission suggests that in resettlement and well-wooded communal areas, collection trips for wood are largely within one kilometre (km) of the homestead and less than one hour in duration. Collection in deforested areas on the other hand, may be 200 percent longer in duration for firewood and 50 percent longer for construction wood than in well-wooded areas. The general tendency is to do most firewood collection in the dry season compared to the wet season. A comprehensive survey to derive average collection times for fuelwood throughout the country was beyond the scope of this study. Using previous surveys from Campbell and Mangono (1995), rural households spend an average of 10 hours per week collecting firewood in the dry season and four hours per week in the wet season, presumably because agricultural activities are more time consuming in the latter period. The average time per week thus works out to be seven hours per week, slightly higher than the six hours per week for the 1980's period implied by estimates in Du Toit et al (1984). This is a crude symptom of increasing scarcity of easily accessible forests for domestic fuelwood. Using an average of seven hours per week collecting time, the total time per year is 364 hours. This rate is assumed to remain constant for the period 1990-1996.

The opportunity cost of labour used in the collection of firewood is the cash income the person (usually women) might otherwise have earned by working as unskilled agricultural labour on a commercial farm or horticultural operation. The minimum wage for casual agricultural labour has risen in nominal terms from $100 per month in 1990 to $503 in 1998. It is perhaps unrealistic to suppose that this minimum wage is the true potential earnings (Crowards 1994). In a study of female wage labour in Zimbabwe, Adams (1991) found a value of Z$52 per month for the 1986/87 period, or 61 percent of the minimum wage. We extend this ratio to the period 1990-1996 under the assumption that casual labour wages remain a constant fraction of the minimum agricultural wage, an assumption also used by Crowards (1994). Another approach is to estimate the value of extra food or cash crops that could have been grown in village gardens with the time required instead to collect fuelwood. This approach has merit but no recent studies were available to review.

To calculate the average time spent collecting fuelwood, the average collection time per year (364 hours per household) is divided by the average consumption of fuelwood per household of 6.01 tonnes (from Frost, 1997). The resulting figure of 60.56 hours is assumed to remain constant throughout the study period. Better estimates, perhaps reflecting increased scarcity of fuelwood could only have been derived if time series data were available from surveys. The hourly casual wage is calculated by dividing the casual monthly wage by 242 hours per month, which reflects on average, a 10-hour working day, six days per week. The cost weighting is the same as used by Crowards (1994) and is similar to that derived in Campbell and Mangono (1995) to reflect the higher cost of urban fuelwood to rural fuelwood. The weighted opportunity costs are found by multiplying the collection costs/tonne by the collection cost figures (Table 9).

**Table 9 Opportunity costs of fuelwood extraction (Z$/tonne), 1990 - 1996**

| YEAR | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 |
|---|---|---|---|---|---|---|---|
| Collection Time/year | 364.00 | 364.00 | 364.00 | 364.00 | 364.00 | 364.00 | 364.00 |
| CollectionTime/tonne (hrs/hshold) | 60.56 | 60.56 | 60.56 | 60.56 | 60.56 | 60.56 | 60.56 |
| Min. Agriculture Wage/month | 100.00 | 150.00 | 250.00 | 250.00 | 350.00 | 350.00 | 350.00 |
| Casual Agriculture Wage/month | 61.00 | 92.00 | 153.00 | 153.00 | 214.00 | 214.00 | 214.00 |
| Hourly Casual Agriculture Wage | 0.25 | 0.38 | 0.63 | 0.63 | 0.89 | 0.89 | 0.89 |
| Fuelwood Collection Cost/tonne | 15.14 | 23.01 | 38.15 | 38.15 | 53.89 | 53.89 | 53.89 |
| Cost Weighting | 1.05 | 1.05 | 1.05 | 1.05 | 1.05 | 1.05 | 1.05 |
| Weighted Costs/tonne | 15.90 | 24.16 | 40.06 | 40.06 | 56.60 | 56.60 | 56.60 |

## 4.5 Rent Estimates

Total resource rents for fuelwood are calculated by multiplying average residual or stumpage values (the difference between weighted fuelwood price and weighted cost) by the total annual depletions (Table 10). Estimated rents have been rising rapidly over the period. The average annual increase in rent values over the six-year period is around 72 percent.

**Table 10 Resource rents for fuelwood depletions (million Z$), 1990 - 1996**

| YEAR | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 |
|---|---|---|---|---|---|---|---|
| Weighted Costs ($/t) | 15.90 | 24.16 | 40.06 | 40.06 | 56.60 | 56.60 | 56.60 |
| Weighted Price ($/t) | 44.79 | 55.20 | 78.47 | 100.10 | 122.50 | 150.10 | 182.20 |
| Rent/unit Extracted | 28.89 | 31.04 | 38.41 | 60.04 | 65.90 | 93.50 | 125.60 |
| Total Depletion | 1.15 | 1.18 | 1.22 | 1.26 | 1.29 | 1.35 | 1.40 |
| Total Rent Value | 33.22 | 36.63 | 46.86 | 75.65 | 85.01 | 126.23 | 175.84 |

To estimate Hotelling Rents, the total rent for depletions in Table 10 must be multiplied by the right-hand side of equation 7. In applying equation 7 to the data, a discount rate of 18 percent is used, which represents an average discount rate during the 1980's and 1990's. In addition, some estimate of marginal cost elasticity must be used. No published figures are available which lend themselves directly to this case study, however for the purpose of illustrating the method, a marginal cost elasticity of 0.6 is assumed[6]. This figure is equivalent to the FAO estimate of deforestation in Zimbabwe and is comparable to that used by Vincent (1996) for Malaysia. A plausible hypothesis is that average collection distances and hence opportunity costs have increased by this amount during the study period. Clearly, to apply accurate estimates of marginal cost elasticity would require much richer time series data on opportunity costs of fuelwood collection throughout the country. The Hotelling Rent increases significantly over the study period (Table 11).

**Table 11 Total rent and hotelling rent, 1990 – 1996.**

| YEAR | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 |
|---|---|---|---|---|---|---|---|
| Total Rent | 33.22 | 36.63 | 46.86 | 75.65 | 85.01 | 126.23 | 175.84 |
| Hotelling Rent | 31.89 | 35.16 | 44.99 | 72.62 | 81.61 | 121.18 | 168.81 |

## 4.6 Estimates of Net Domestic Product

Net investment is calculated as gross fixed capital formation minus depreciation of physical capital and Hotelling Rents. Ideally, figures of physical capital depreciation should be obtained from the system of national accounts. Unfortunately, the Central Statistics Office does not collect such figures and could not provide any data. Thus, indirect estimates are required.

A theoretically elegant method for estimating depreciation in view of data gaps is the Perpetual Inventory Method. The last value for the capital stock was contained in the Industrial Census of Production of 1967/68. Extrapolating from this period to the present is fraught with danger. While results are plausible for the early half of the 1970's, from the 1980's, the estimation procedure completely breaks down and yields highly implausible results.

An alternate approach to estimate depreciation is to use a version of the Harrod-Domar equation (equation 8).

$$K = aKX\ X \quad (8)$$

Where: K = capital stock
X = output (GDP)
a = amount of capital required per unit of output

A routinely used assumption in macroeconomic analysis is that investment cumulates nicely to generate capital growth. Using this assumption, we can compute due allowance for physical depreciation of the existing capital stock at a (constant) rate d[7] (equation 9):

$$D = dK \quad (9)$$

Where: D = depreciation
d = rate of depreciation
K = capital stock

The national accounts are still the most convenient source of data to estimate the parameters in equations 8 and 9. However, in the absence of capital stock data, professional intuition and the literature must be drawn upon. The stylised fact from the development economics literature is that (aKX) ought to take a value between 2.5 and 6, with 2.5 being considered too low and 6 being on the high side (Taylor 1990). A figure of 4.0 for Zimbabwe is used based on our understanding of the economy and the literature elsewhere. The value of capital implied by a capital-output ration of 4.0 and resulting depreciation for the 1990-1996 period are estimated in Table 12. The rate of depreciation of physical capital for equation 9 is 0.04, a figure which compares well with a figure of 0.043 often used by the National Economic Planning Commission in Zimbabwe.

**Table 12 Estimates of capital and depreciation for Zimbabwe (million Z$), 1990 – 1996.**

| YEAR | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 |
|---|---|---|---|---|---|---|---|
| GDP | 21494 | 29623 | 34392 | 42481 | 56441 | 66551 | 85585 |
| Capital | 85976 | 118492 | 137568 | 169924 | 225764 | 266204 | 342340 |
| Depreciation | 3439 | 4740 | 5503 | 6797 | 9031 | 10648 | 13694 |

Equipped with the previous depreciation estimates, CSO data on gross fixed capital formation (GFCF) and Hotelling Rents, the national accounts of Zimbabwe can then be adjusted (Table 13). Net investment[8] is calculated as GFCF less depreciation and Hotelling Rents. Net domestic product is calculated as GDP less depreciation and Hotelling Rents for fuelwood depletions.

**Table 13 Net investment and net domestic product for Zimbabwe (million Z$), 1990-1996.**

| YEAR | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 |
|---|---|---|---|---|---|---|---|
| GDP | 21494 | 29623 | 34392 | 42481 | 56411 | 66551 | 85585 |
| GFCF | 3913 | 6097 | 7690 | 10021 | 12265 | 15940 | 18804 |
| Capital (K) | 85976 | 118492 | 137568 | 169924 | 225764 | 266204 | 342340 |
| Depreciation | 3439 | 4740 | 5503 | 6797 | 9031 | 10648 | 13694 |
| Hotelling Rents | 31.89 | 35.16 | 44.99 | 72.62 | 81.61 | 121.18 | 168.81 |
| Net Investment | 442 | 1322 | 2142 | 3151 | 3152 | 5171 | 4941 |
| NDP | 18023 | 24848 | 28844 | 35611 | 47298 | 55782 | 71722 |

At the macro level, net investment was positive throughout the period, suggesting that the economy did better than Hartwick's Rule. A general conclusion, based only on these data, is that the economy could actually have consumed more per capita and still not jeopardised future growth. This result is very robust for a wide range of capital output and depreciation ratios. However, this finding should be qualified by pointing out that we did not adjust for changes in human capital. Also, looking at this from a macro framework may be misleading. From a disaggregated local perspective with a high rate of depletion, the result may be negative. Other studies, such as Vincent (1996) for Malaysia, also found a positive net investment. In Vincent's study, net investment was negative in only one year out of the 20 evaluated. More discussion about the quality of the results is in section 5.0.

Another way to interpret the data is to consider the annual average percentage changes in both GDP and NDP. If the percentage change in NDP is less than for GDP, there could be concerns raised about the sustainability of fuelwood harvesting at the macro-level. Estimates of average annual percentage changes in GDP and NDP, and the difference between the two percentage changes are shown in Table 14.

**Table 14 Average annual GDP and NDP growth, 1990 - 1996.**

| YEAR | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 |
|---|---|---|---|---|---|---|---|
| GDP Growth (%) | - | 37.82 | 16.10 | 23.24 | 32.86 | 17.91 | 28.60 |
| NDP Growth (%) | - | 37.87 | 16.08 | 23.46 | 32.82 | 17.94 | 28.58 |
| GDP-NDP (%) | - | -0.05 | 0.02 | -0.22 | 0.04 | -0.03 | 0.02 |

Looking at individual years, there is a mix of results and no consistent trend between the rates of average growth as evidenced by the difference between the two values. In three years, GDP growth is slightly less than for NDP; the situation is reversed for the other three years.

These percentage values can also be averaged over the time period. For GDP growth, the average percentage change is 26.09 percent while for NDP the figure is 26.13 percent. In other words, there is virtually no difference between the two estimates. For all intents and purposes and accounting only for fuelwood depletion out of the forest stock, adjusting the system of national accounts results in a very insignificant transformation to NDP. This result implies that in the narrow context of fuelwood harvesting, the economy did indeed grow in a sustainable manner.

# 5 DISCUSSION AND CONCLUSIONS

This case study represents a considerable effort to adjust the system of national accounts in Zimbabwe to include the consumption of domestic fuelwood. The results suggest that using the specific methods, data and assumptions in this study, there is no significant difference between GDP and an adjusted NDP. This case study attempted to apply the Vincent-Hartwick approach of using marginal rather than average costs.

This case study illustrates the difficulties and limitations of estimating net investment and net domestic product in developing countries. First, there were serious data gaps. Improvements in data availability over previous natural resource accounting studies in Zimbabwe for forestry (for example Crowards, 1994) were not as great as initially hoped. Serious constraints were imposed by gaps in growth and yield data on indigenous forests despite major progress by the Forestry Commission in its mensuration programme. While better data are now available on forests cover types, the corresponding data on age class structures, growth and yield still need further developed. The computation of marginal cost, central to Vincent and Hartwick's approach, was hampered by inadequate data. Better data are required which relate the opportunity cost of collecting domestic fuelwood to distance travelled. Logically, one would expect collection times to rise as deforestation increases. Adger (1993) in a preliminary study of natural resource accounting for Zimbabwe, suggested that average extraction costs for fuelwood were rising. He was unable to derive estimates of marginal extraction costs. These data could be gathered over time through ongoing national surveys under the auspices of the Forestry Commission's District Offices if funds were made available either to the Commission or the CSO. In this study, the estimated elasticity of marginal cost was quite low. Better measures of value (especially if higher) would change the results dramatically.

The Forestry Commission appears to have many unpublished studies and several were useful in this current research. This raises the question of research in different agencies in Zimbabwe being easily accessible and how institutions can be strengthened to improve sharing of research results. Considerable time was spent in this study soliciting information from various agencies.

The Central Statistical Office does maintain a comprehensive set of national accounts. Experience by the authors suggests that Zimbabwe's national statistics situation is better than many other countries in the region. However, the fact that current data on depreciation were not available forced the study team to make indirect estimates. While these estimates are felt to be reasonable, there is no way to test if they actually mirror capital depreciation. The CSO suffers the problem shared by many statistics agencies of a time lag between data collection and publication. Largely in response to criticism of long time lags in national statistics by local businesses, the CSO recently published national income data up to 1996. One anomaly however is the inclusion for the first time of estimated national income from the informal sector. This has caused some concern in business circles as to the accuracy of earlier data sets and the issue of comparability. A further problem, again not unique to Zimbabwe, is the level of aggregation of national income statistics. One of the original objectives of the study was to try and adjust in turn, the energy and forestry sector national income accounts. Unfortunately, the energy sector in the national accounts combines water and electricity sectors. This situation provided an insurmountable challenge when trying to isolate wood energy and estimate depreciation. Similarly, forestry had until 1996 been part of agriculture and fishing. Now, this sector is reconfigured as agriculture, fishing and hunting. Forestry is considered by the CSO to be part of agriculture and disaggregating it out proved difficult within the time frame of the study. Therefore, a broader macro-economic adjustment of national income was done.

This study illustrates methods of using a patchy database to estimate net investment and net domestic product. Further refinements could be made in the future. For example, the focus of this study was only on fuelwood. A wider array of forestry related costs and benefits could be evaluated in future studies. As an example, the benefits of forests for carbon sequestration and prevention of soil erosion and river siltation could be assessed in terms of net domestic product. On the cost side, the impact of cutting trees for other products not usually captured in GDP such as domestic building materials, woodcrafts, etc. could be added. Restricting the case study to fuelwood may limit the utility of the research. Although data on these other forest benefits and costs would be lacking in some areas, a long-term research programme could generate some useful information for policy makers.

Given the problems of data and the subsequent need to make a range of assumptions and estimates, why bother estimating NDP within a natural resource accounting programme? Using NDP instead of GDP in an economy highly dependent on natural resources such as Zimbabwe is vital. As shown by the results, the likely adjustments for fuelwood depletions average only around 0.16 percent of GDP (calculated as Hotelling Rent / GDP as a percent)[9]. This figure would however, appear to be a substantial underestimate given other uses of indigenous forests and issues not dealt with in this study. Still, this percentage adjustment to GDP is quite substantial and indicates some need for a forest policy review in Zimbabwe. The results do emphasise that using GDP as a measure of welfare can be misleading. The consequences could be severe by sending the wrong signals to policy makers. Development might be biased towards short-term goals, which could lead the country down an unsustainable path. For planning purposes, especially in central government agencies such as Planning Commissions and Ministries of Finance, using NDP rather than GDP provides a better measure of natural resource capital and the impact of drawing down this stock on the national economy.

In a perfect world, Zimbabwe would either have adjusted national accounts or a system of satellite accounts for planning and policy purposes. However, as this study has amply demonstrated, the world is not perfect. Questions must be asked about priorities for operational programmes either funded internally by the government, or subsidised by donors. Rather than agonising over whether to use marginal or average costs in calculating net domestic product, perhaps a point of departure in some developing countries is to focus scarce financial and technically-trained human resources on developing better data-bases.

A first stage would be to establish an inventory of change data on natural resources, initially in biophysical terms, and then gradually adding measures of value to the resources and changes over time. The data base programme could be supported by a slightly expanded data collection effort in the CSO as well as existing geographical information systems (GIS) and low-cost remote sensing. With a better database, adjustments to the system of national accounts for many natural resources would be much easier.

One objective of this study has been to identify data gaps in. These gaps could be turned around into targets for new programmes to strengthen database development and management in Zimbabwe and elsewhere. Data must have a purpose, otherwise there is no point is expending resources to collect it. In any data base programme, goals and objectives for identifying data sets, collecting, and using data must be clearly formulated at the outset. Data base development programmes could identify establishing data sets for national income account adjustments as one objective.

This study has demonstrated some of the advantages, disadvantages, and data limitations of trying to adjust GNP for natural resource utilisation. The methods of Vincent and Hartwick can be used, even where data gaps exist. However, to fully capture the benefits of this policy tool, better data are required. This must be a priority in future donor-funded development programmes. Further case studies should be carried out for other natural resource sectors as part of a broader programme of identifying data gaps and refining methodologies.

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# ENDNOTES

1 Much of the information in this section was derived from unpublished research papers compiled for Zimbabwe's national biodiversity strategy and action plan.
2. This figure is significantly higher than previous estimates published by the World Bank, World Resources Institute and FAO. The reason is that in recently released national statistics by the Central Statistical Office, estimates of GDP from the informal sector were included. This has increased official GDP per capital figures by almost 60 percent over values in older publications.
3. ZD = Zimbabwe Dollars
4. This is in fact a generalisation of the original El Serafy method (El Serafy (1989))
5. For derivations see Vincent (1996)
6. i.e. from this, Hotelling Rent = Total Rent x 0.96
7. Here and elsewhere, the physical depreciation rate d is assumed to be the same as the financial rate business owner's use in calculating depreciation reserves. This identity of two conceptually distinct rates is not always observed, especially under inflation.
8. Note that we do not adjust for changes in human capital, so that the estimates of net investment are only partial ones.
9. If we also take physical capital depreciation into account, the adjustments are about 17 percent, or roughly equivalent to the entire share of agriculture in GDP.