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# A Natural Resource Accounting Analysis of the Contribution of Mineral Resources to Sustainable Development in South Africa

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## 1 MOTIVATION AND OBJECTIVES OF THE STUDY

South Africa depended heavily on its rich mineral resources during its early stages of economic development. Mining provided the major source of primary capital accumulation during the early decades of the 19<sup>th</sup> century, out of which the country was able to support diversification into a strong manufacturing sector. The main question this study is concerned with is whether mineral resources have been developed and managed sustainably in South Africa, given their historical economic importance. Although the contribution of mining to national income is recorded in the current system of national accounts (SNA), the cost of depletion of these natural assets as a result of its commercial exploitation is not captured in the balance sheet of the assets. This is a very serious omission and of crucial importance to macroeconomic management and sustainable development planning, since minerals are non-renewable natural assets that can be completely exhausted.

By not accounting for the depletion of the country's natural capital (or accumulation through discoveries) the current SNA conveys an incorrect picture of the state of national wealth and social welfare. As natural wealth is depleted and converted into income through extraction and commercial exploitation, it is important to understand how much of that value (resource rent) is being captured and reinvested in other forms of capital wealth. If all revenue from the liquidation of natural assets is spent on current consumption, the opportunity cost to future generations of wasting such resources that are in limited supply is very high. It is crucial for intergeneration equity and sustainable economic development to reinvest at least a portion of the value of such scarce natural wealth in other forms of capital. This will partially compensate future generations for the income and employment opportunities foregone as a result of the depletion of natural wealth.

Natural resource accounting provides a framework for the construction of various physical and monetary indicators to evaluate the state of the resource and its exploitation and management for the larger benefit of the society. Among the key instruments employed for the sustainable management of natural resources and environmental assets are the capturing and rational investment of economic rents from their exploitation and liquidation. The present study intends to derive such resource accounting indicators and measures of sustainable management of the mineral resources sector in South Africa. The mineral accounts will then be used to analyse broader aspects of economic performance and sustainable development of mining in the country.

Moreover, mining causes environmental damage as a result of pollution externalities and emissions, the social costs of which are typically omitted from

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the current SNA. Although this study attempts to analyse the change in the state and value of the mineral resources of South Africa and how they have been managed to support sustainable development, the social costs of environmental damage caused by mining activities will be assessed in the second phase of the project. Phase two of this research project will be completed during the year 2001.

Section 2 briefly introduces the natural resource accounting framework and its state in South Africa. An overview of the role and contribution of mining to economic performance in South Africa is provided in section 3. Section 4 presents and discusses the results of the analysis on mineral accounts. Implications for policy and resource management are addressed in section 5 and conclusions are drawn in section 6.

## **2 THE NATURAL RESOURCE AND ENVIRONMENTAL ACCOUNTING: PRINCIPLES AND STATE IN SOUTH AFRICA**

### **2.1 The concept of sustainable income and resource rents**

NRA methods are mainly based on Hicks's (1946) definition of *sustainable income* and the concept of *wasting assets*. Sustainable income is understood as the "the level of consumption that can be sustained indefinitely without diminishing the asset stock". This, however, does not necessarily mean that stocks of natural assets be maintained constantly, but rather their capacity to generate the same stream of income in the future remains intact. This definition requires a non-declining asset base for sustainability of income and well-being. With substitution allowed between the various forms of capital, sustainable income can be understood to require that the total stock of assets, not that of its individual components, remain intact (e.g. growth in one component can compensate for a decline in others). The role of technological progress and the degree of substitution between natural and other assets (manufactured and human capital) are critical assumptions in support of this paradigm of sustainable income.

Unlike the case of renewable resources where optimal resource use programs can be designed for sustainable rates of harvesting (e.g. steady states), stocks of exhaustible resources, such as minerals, decline with extraction (in absence of new discoveries). Consequently, their capacity to generate the same stream of income and employment for future generations is reduced with depletion due to commercial exploitation. It is therefore crucial to compensate future generations for the consumption of natural assets with fixed stocks by reinvesting at least part of their value (resource rent) in other forms of capital assets (manufactured,

human or technological/scientific) that are capable of providing the same stream of economic benefits in future.

In NRA terms, this means that net receipts from the sale of exhaustible assets contain an element of capital consumption that needs to be set aside (or reinvested) to compensate for depleting the stock of the asset. The said consumption allowance (user cost), which represents depreciation in the stock of an exhaustible natural resource, must then be deducted from the SNA measure of NNP to derive the true indicator of sustainable income and consumption (El Serafy, 1989, Hartwick, 1990). Hartwick and Hageman (1993) trace El Serafy's user cost to Keynes's (1936) treatment of depreciation of equipment and to Hotelling's (1925) royalty on the extraction of finite resource stock. User costs (royalties) on depletable natural assets are also recognised in the mining economic literature long before Hicks's definition of sustainable income, as a charge for reducing the value of a mine through extraction (Marshall 1936)<sup>2</sup>.

El Serafy (1989) derives the following formula to decompose total resource rent ( $R_t$ ) into its *capital component* ( $R_t - X_t$ ) as the proportion that needs to be reinvested and its *income component* ( $X_t$ ) as the portion that can be consumed:

$$X_t = R_t * \left[ 1 - \frac{1}{(1+r)^{N+1}} \right]$$

Where  $r$  is the rate of return and  $N$  is the number of years extraction can take place at the current rate.

## 2.2 Development of the resource accounts for minerals

In general, the compilation of all natural resource accounts follows two basic steps. First, physical accounts are compiled and then the monetary accounts are developed after resource values are established.

**The physical accounts:** To construct physical accounts for mineral resources, this study follows the international standard format as described in the Norwegian case study (Sorensen & Hass, 1998). The said format starts with opening stocks at the beginning of the period of analysis to which additions are added and from which extractions are subtracted to arrive at the closing stock. In the case of South Africa, the following three additional entries were derived and included in the physical accounts:

- volume sold,
- change in inventories (calculated as the difference between the production volume and the volume sold), and

- closing stock including inventory changes.

There are three alternative definitions and measures of the reserves of minerals. The first measure considers the total stock of the mineral that is available to be the reserve. The second measure only considers economically proven reserves defined as that proportion of the mineral resource that is economically feasible to extract. Under this definition, price, resource quality, technology and exchange rate variations will therefore determine the reserve base at each time period and hence the reserve base will consequently fluctuate over time. The third definition subtracts from the second (economically proven reserves) any possible wastes that may occur during the extraction process. According to the third definition proven reserves should only include the volume of the resource that has the potential to be formally marketed. Reserve figures for all minerals in South Africa are generally not of a high quality, or not published. Nevertheless, this study has made the best possible efforts to estimate economically proven reserves using data from the Minerals Bureau of South Africa.

**The monetary accounts:** Construction of the monetary accounts for minerals resources in South Africa also follows the Norwegian practice (see Sorensen & Hass, 1998), which is described below:

- the value of the opening stock (equal to the value of the closing stock of the previous year),
- less the value of the depleted stock (valued at the unit rent multiplied by the volume of depletion),
- plus the value of new discoveries, additions and other volume changes (valued at the changes in the present value due to the increase in the number of years over which production can go on at current extraction rates given these new volumes),
- plus any revaluation due to time passing (valued by discounting for one year less),
- plus the nominal holding gain (calculated as a residual), must
- equal the closing stock or the value of the resource asset at the end of the period.

The following formula was used to calculate the value of the stock of the resource at period  $t$  as equivalent to the present value of the discounted expected future stream of net economic benefits from the resource over its remaining production cycle (e.g. until depletion at terminal time  $N$ ):

$$V_t = R_t * q_t * \frac{(1+r)^N - 1}{r * (1+r)^N}$$

$$N_t = Q_t / q_t$$

Where

- $V_t$  is the value of the stock at the close of period  $t$   
 $R_t$  is the unit rent at  $t$   
 $q_t$  is the volume of extraction at  $t$  (from the physical accounts)  
 $Q_t$  is the volume of the stock at the close of  $t$  (from the physical accounts)  
 $r$  is the social discount rate  
 $N$  is the remaining number of years during which extraction can take place at the current rate (calculated as the volume of the closing stock divided by the current extraction volume).

The compilation of the monetary accounts therefore presupposes the calculation of the resource rent and the unit rent as well as the number of years to closure at current extraction rates. In general, rates of extraction are usually assumed to remain constant over the production cycle. Similarly, discount rates are typically kept constant as well - see the discussion below. This study followed this same international practice.

### 2.3 Measurement of resource rents for mineral resources

Resource rent is considered a measure of the scarcity value of extractive resources such as minerals as their finite stocks are reduced with extraction. Calculation of resource rents is therefore the first step in developing the monetary accounts. The present study adopts the method of resource rent calculation as defined in the 1993 SNA (United Nations, 1993). Accordingly, resource rents for each mineral are calculated as the value of output (at producer prices) less production costs. Production costs are defined to include the cost of intermediate inputs in mining, plus compensation of employees and consumption of fixed capital plus a normal rate of return on invested capital. The normal rate of return on fixed capital investments is considered to represent the opportunity cost or economic value of financial capital that may be invested in alternative profit-making economic activities. This study uses the average long-term nominal interest rate (or bond rate) less the prevailing inflation rate (in other words real interest rate) as the rate of return to capital, which is multiplied by the fixed capital stock in mining to derive estimates of normal profits. For the period 1966 to 1972, the average real rate of interest was 3 per cent, for the period 1973 to 1982, the average was -2 (minus two) per cent and for the years 1983-1998 the average was 3,3 per cent. A social discount rate of 3 per cent was used in this study<sup>3</sup>. Furthermore, average rather than marginal



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costs were used in calculating resource rents. This is expected to introduce an upward bias in rent estimates, as average costs are generally lower than marginal costs. The unit rent was calculated as total rent divided by the volume of depletion for a specific year.

#### **2.4 The state of natural resource accounting in South Africa**

Natural resource accounting is an important tool for integrated macroeconomic and environmental management and policy analyses that is rapidly gaining ground world-wide. Omissions in the current SNA related to the cost of depletion of natural capital, environmental externalities and non-market values of environmental goods and services are dealt with and accounted for under natural resource accounting. In recognition of such deficiencies in the SNA, the United Nations has proposed the construction of satellite natural resource accounts (NRA) to go with the SNA (United Nations, 1993). The effort to augment and restructure current national economic accounting systems to provide for environmental values and natural capital has also been supported by many international agencies. While still a newly emerging tool, NRA is currently being constructed for key resource sectors in a number of countries<sup>4</sup>. Few African countries have started the development and use of NRA under regional initiatives in eastern and southern Africa. The Natural Resource Accounting in Southern Africa (NRASA) project and the Resource Accounting Network for Eastern and Southern Africa (RANESA) are two major examples of such efforts<sup>5</sup>.

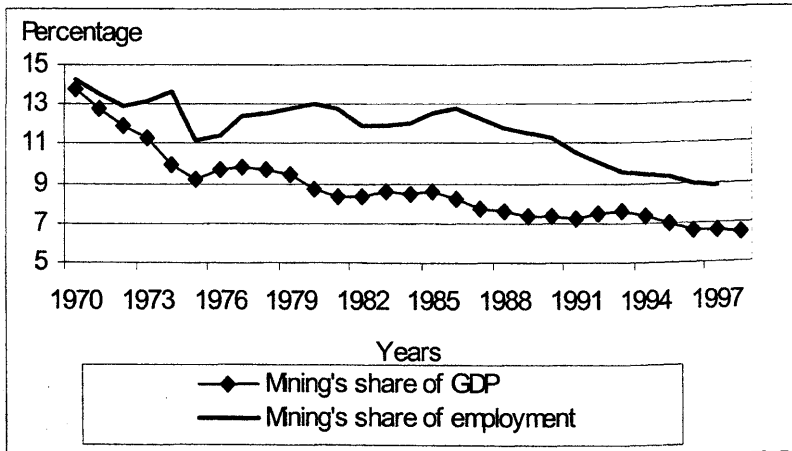
In South Africa, a number of studies attempting to construct NRA and use them for policy analysis have been completed over the past three years or are currently in progress. Examples of pilot efforts in this area include the South Africa National Economic and Environmental Policy (SANEEP) model (DBSA, 1997) and the forest sector studies of the CSIR (Hassan *et al.*, 1998 and 1999). In 1998, the Department of Environmental Affairs and Tourism (DEA&T) in collaboration with a number of national institutions and partial financial assistance from the World Bank (WB) produced a framework document for the implementation of NRA in the country (DEA&T, 1998). Other NRA studies on selected resource sectors have been completed on cultivated forests (Hassan, 1999), natural forests and woodlands (Shackleton *et al.*, 1999) and fynbos resources (Turpie *et al.*, 1999). The present study on minerals' accounts represents the second set of more complete sectoral NRA following the woody resources sector studies. NRA work on two other important resource sectors: water and fisheries, is currently underway. The water and fisheries studies form part of the above-mentioned regional initiatives to enhance capacity in integrated economic and environmental management and planning in sub-

Saharan Africa. The water study is funded under the NRASA project while the fishery study is funded by RANESA.

### 3 MINING AND THE SOUTH AFRICAN ECONOMY

Mining has always been a very important economic activity in South Africa, especially during its early stages of economic growth. However, the contribution of mining to national income and employment followed the general trend of decline of primary sector activities observed world-wide. These trends are illustrated in Figure 1 below. The contribution of mining to GDP fell from 13,2 per cent in 1970 to only 6,5 per cent by 1998. Similarly the contribution of mining to employment declined from 14,2 per cent of employment in the formal non-agriculture sector in 1970 to 8,8 per cent in 1998.

**Figure 1 Contribution of mining to GDP and employment in South Africa: 1970-1998**

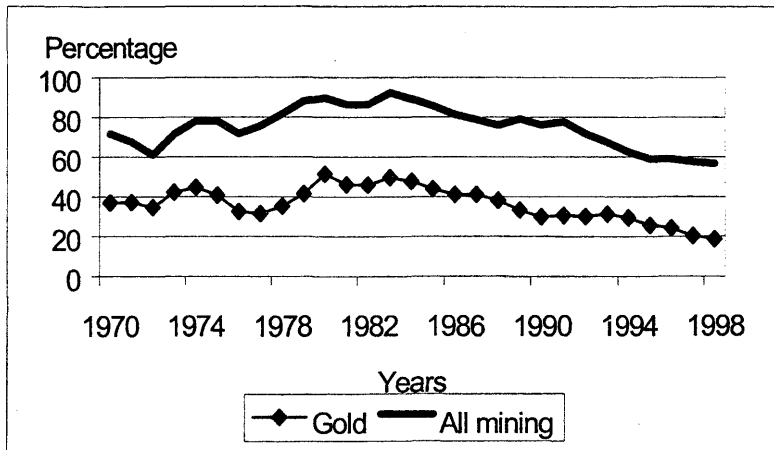


Source: South African Reserve Bank, *Quarterly Bulletin*, various issues.

On the other hand, the share of mining in the country's total exports revenue remains very high in spite of the steady decline in its share since the early 1980s (Figure 2). Gold contributed 37 per cent of total exports in 1970, which peaked in 1980 at 51,4 per cent and then declined to a low of 18,5 per cent in 1998. Total mining contributed 71,6 per cent of total exports in 1970. This figure rose to as high as 92,4 per cent in 1983 and then started declining, but still contributes 56,6 per cent of South Africa's exports. Concerning mining's contribution to government revenue, only information on the share of gold

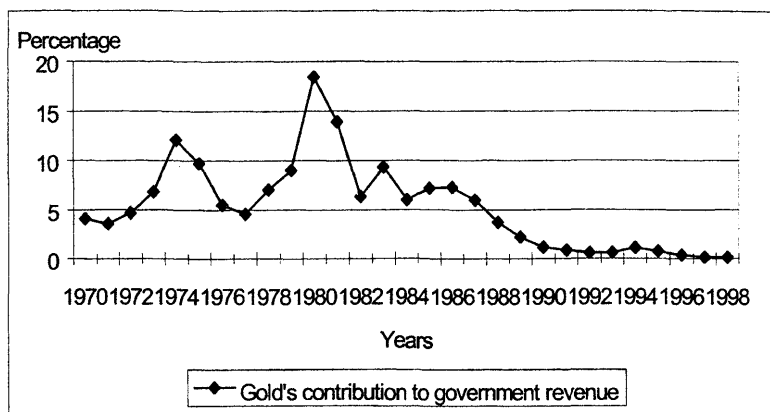
mines' is readily available. Neither Statistics South Africa (SSA), the South African Reserve Bank (SARB), the South African Revenue Service nor the Department of Finance could provide time series data for the tax revenue from all mines. Figure 3 therefore depicts the contribution of gold mines to total government revenue. During the period of high gold prices in the early 1980s, gold mining contributed as high as 18,4 per cent of total government revenue. However, this figure dropped substantially to only 0,2 per cent in 1998.

**Figure 2 Contribution of gold and total mining to exports in South Africa: 1970-1998**



Sources: South African Reserve Bank, *Quarterly Bulletin*, various issues  
South African Reserve Bank, unpublished data.

**Figure 3 Contribution of gold mining to government revenue in South Africa: 1970-1998**



Source: South African Reserve Bank, unpublished figures.

It is clear from the above that since the mid-1980s, except for its contribution to the current account of the balance of payments (exports), the mining industry has lost its position of dominance in the South African economy. Within the sector itself, gold and coal contributed about 70 per cent of total income from all mining activities in 1993. The dominance of gold and coal together with major problems of data availability encountered in the case of other mineral resources, have led to the decision to focus the present resource accounting analysis exclusively on gold and coal mining activities.

#### 4 THE NATURAL RESOURCE ACCOUNTS FOR MINERALS IN SOUTH AFRICA

As mentioned earlier, gold and coal dominate mining activities in South Africa, contributing 70 per cent of income from mining. Because of this and due to difficulties encountered in obtaining the necessary data on other minerals, this study focused the analysis mainly on gold and coal. South Africa has 35 per cent of the world's gold resources and the fifth largest coal producer. The rest of the minerals are grouped together in the *other minerals* category for the purposes of this analysis. Those minerals include precious metals and minerals such as Diamonds, Platinum, Silver and semi-precious minerals such as Tiger's-eye. Additionally there are non-ferrous metals and minerals such as Cobalt, Copper, Lead and Titanium and ferrous minerals, which include Chromium,

Iron ore, Manganese, Silicon and Vanadium. The other minerals category also included is industrial minerals such as Asbestos, Dolomite, Fluorspar, Phosphate rock, Limestone and Vermiculite. In virtually all of these minerals, South Africa is ranked among the ten top producing countries in the world. For example, South Africa is ranked first in both Platinum and Titanium production, third in world Phosphate rock and Fluorspar production, seventh in Asbestos, eighth in Aluminium, Lead and Cobalt and twelfth in Copper production. With a few exceptions where major beneficiation takes place in the country, the majority of the raw materials are exported, for example, 97 per cent of the Platinum production in 1998 was exported.

#### **4.1 Gold resource accounts**

The detailed physical accounts derived for gold for the 1966-1998 period is presented in appendix A. The year 1966 is chosen as the base year since it was the year in which SSA conducted its first ever census of mining. Although the period under consideration extends until 1998, the most recently available census is for 1993. Accordingly, some calculations, notably resource rent, were only done until 1993. These censuses are conducted, on average, every three years. Financial information pertaining to gold is provided in appendix B.

Proven reserve figures for gold are extremely unsatisfactory. The South African Mining Industry handbook kept the reserve level fixed from 1983 until early 1990 at 20 000 ton. In later editions of the handbook, the Minerals Bureau published figures of 39 933 ton, 37 885 ton and 40 154 ton for 1994, 1995 and 1996, respectively. The latest available figure is 35 877 ton for 1998 (Department of Minerals and Energy, 2000:35). Our independent enquiry indicates that this figure is a reasonable estimate. Both Handley, a mining sector expert and a Chamber of Mines representative, (Personal communications) independently estimated the reserve base to be 35 000 ton. However, neither the Chamber of Mines, nor Handley, the Minerals Bureau or the Institute for Geo Sciences was able to provide acceptable time series of the proven reserves for gold. Also, no information could be found on new additions or other volume changes either.

For the period 1966 to 1975 the figures for volumes sold and not production figures were published. Therefore, the figures for volumes sold were set equal to production for that period. Since 1976 only production figures have been published and volumes sold have been calculated by dividing the value of total sales by the average gold price.

Since the reserve figure for 1998 has been established and production figures have been available, the opening stock for 1998 was calculated and set equal to

the closing stock of 1997. This procedure was repeated recursively for all the other years to regenerate the reserves series back to the base year, 1966.

According to the derived physical accounts presented in appendix A, it is clear that gold reserves have continued to decline since 1966 from the level of approximately 59 000 ton to 35 877 ton in 1998. This constitutes a reduction of economically proven gold reserves by about 40 per cent over the period of 33 years. This gives an average rate of extraction of about 701 tons/year. As no information has been available for new discoveries, the only difference between closing and opening stocks in the calculations pertains to extraction and net changes in inventory. Accordingly, the proven reserves' estimates may be biased downwards as new discoveries may have occurred over the period. Nevertheless, extraction/production data, which represents published (actual) information, shows a steady but relatively small decline as well, especially after 1973. Gold extraction in 1966 was 960 ton, 855 ton in 1973, 619 ton in 1993 and 464 ton in 1998. At current extraction rates gold reserves in South Africa can last for another 76 years.

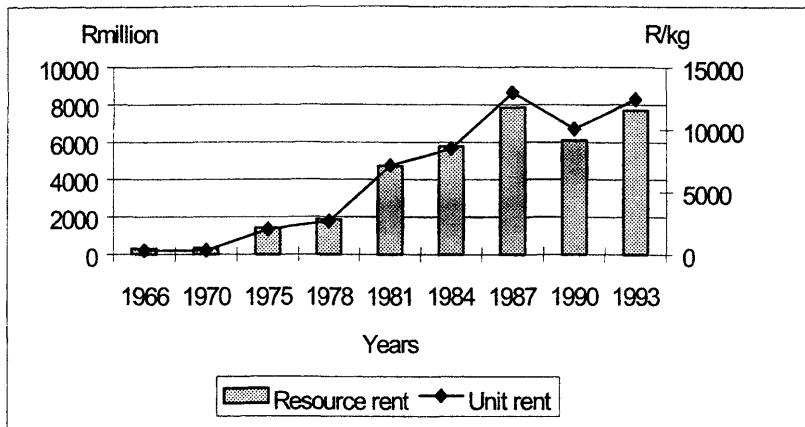
Given the physical account information displayed in appendix A, the resource rent as described above could be calculated for those years for which detailed financial data for gold are available. Resource rent calculations are shown below in Table 1 and Figure 4. As can be seen the unit rent increased substantially in 1981 due to the high price of gold that year (see appendix B) and continued to increase during the 1980s and early 1990s.

**Table 1 Resource rent and other calculations for gold in South Africa in Rmillion at current prices: 1966–1993**

	1966	1970	1975	1978	1981	1984	1987	1990	1993
Output	776,20	830,34	2560,40	3900,03	8554,30	11573,50	17561,14	19062,52	23239,32
Intermediate consumption	217,11	208,05	456,32	943,04	1860,62	2602,22	4345,91	5758,65	6845,99
Compensation of employees	212,07	250,89	604,15	973,89	1791,81	2851,19	4802,33	6591,29	7705,54
Consumption of capital	0,03	0,04	0,06	0,17	0,13	4,83	7,80	22,90	39,44
Opportunity cost of capital	47,90	57,16	77,60	125,55	197,22	347,31	564,38	591,97	935,80
Resource rent	299,08	314,20	1422,27	1857,38	4704,53	5767,95	7840,71	6097,71	7712,56
Unit rent (R/kg)	311,39	314,06	1993,52	2636,65	7104,47	8458,28	12973,88	10077,31	12453,17
Royalties	9,72	2,41	9,95	32,34	211,20	236,07	492,16	301,77	326,51
Taxes & royalties	104,74	90,40	9,95	32,34	2453,15	2329,17	3280,32	1446,04	977,11

Sources: Own calculations

Statistics South Africa, *Census of Mining*, various issues.

**Figure 4 Resource and unit rent from gold in South Africa: 1966-1993**

Source: Own calculations.

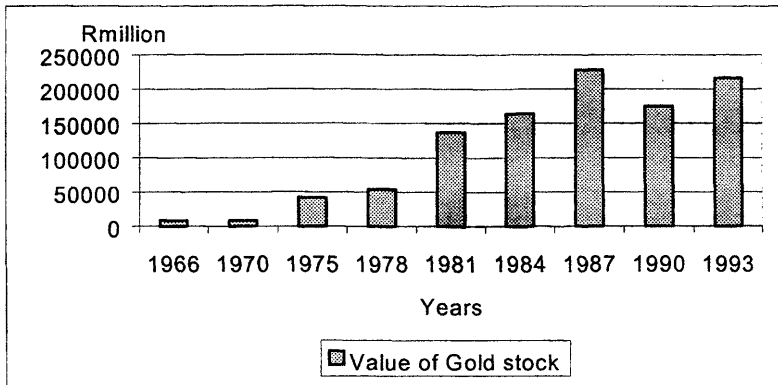
With unit rents established, the monetary accounts for gold have been compiled as displayed in Table 2 and Figure 5a. Of course, the value of gold reserves follows the same pattern as rents and mineral prices, showing a sharp jump during the late seventies to early eighties due to the high commodity prices then. This rise is illustrated by the fact that the average gold price in 1978 was \$6 370/kg and \$14 874/kg in 1981 with an all time high of \$19 811/kg in 1980. When the value of the gold stocks is expressed in US Dollar terms a dramatic decline is observed after 1981 (see Figure 5b).

**Table 2 Monetary accounts for gold in South Africa in Rmillion at current prices: 1966-1993**

	1966	1970	1975	1978	1981	1984	1987	1990	1993
Opening stock	8611	8689	42907	55536	141437	169504	235857	180925	223736
Depletion	299	314	1422	1857	4704	5767	7840	6097	7712
Revaluation	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Discoveries	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Other volume changes	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Nominal holding gains	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Closing stock	8312	8375	41485	53679	136732	163736	228016	174827	216024

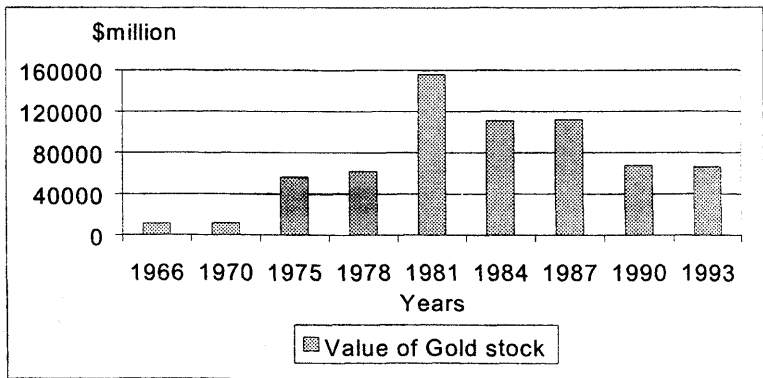
Source: Own calculations.

**Figure 5a** The value of the gold stock in South Africa in Rmillion at current prices: 1966-1993



Source: Own calculations.

**Table 5b** The value of the gold stock in South Africa in US\$million at current prices: 1966-1993



Source: Own calculations.

Due to the exchange rate depreciation ( $1\$ = R0,717$  in 1966 and  $1\$ = R3,266$  in 1993), the value of gold in Rand terms increased (Figure 5a), but declined considerably in Dollar terms (Figure 5b). The exchange rate therefore has a significant impact upon the value of the resource.



## 4.2 Coal Resource Accounts

The period under consideration regarding the coal accounts is, as in the case for gold, 1966 to 1998 with the exception that for the period 1994 - 1998 some financial data are not available. The Minerals Bureau has no records of any new discoveries or other volume changes, but publishes extensive information regarding production, volume sold and proven reserve figures. The different tables for coal for the entire period are consistent and it was possible to compile the physical accounts, as displayed in appendix C.

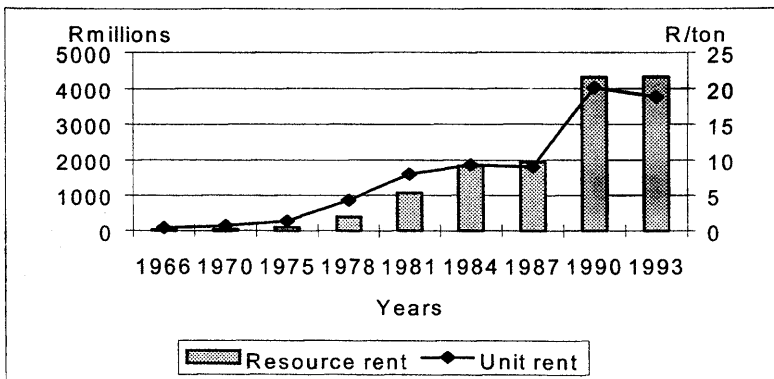
Coal reserves decreased from over 40 billion ton to about 36 billion ton over the 33 years between 1966 to 1998, showing an average annual rate of extraction of about 150 million ton. However, the extraction of coal grew steadily over the period from about only 53 million tons in 1966 to close to 300 million tons in 1998 at an average rate of growth of 7 million tons/year (appendix C). This increase in coal production is due to an increase in both local and foreign consumption. The domestic use of coal locally produced remained more or less constant between 1989 and 1998 at approximately 75 per cent. The largest single domestic consumer is ESKOM consuming 60 per cent of all local sales (buying coal at an average price of R41,31/ton in 1998), but the fastest growing consumer of coal is SASOL, currently consuming 29 per cent of all local sales and buying the coal at an average price of R54,55/ton. Metallurgic industries comprise 3,7 per cent of the local market, but pay R156,36/ton compared to other industries which consume 4 per cent of the local market at an average price of R80,98/ton. All prices are for 1998 and the differences can be attributed to different contract arrangements and the quality of coal. At current extraction rates South Africa's coal resources can last for more than 122 years after 1998.

The Bureau publishes two prices for coal, a domestic and an export price as well as the volume sold for each on a monthly basis since 1980. A weighted average price for January and December is used as opening and closing prices, respectively. The mean price has been calculated as the total value of sales divided by the volume sold. These financial data are captured in appendix D.

**Table 3 Resource rent and other calculations for coal in South Africa in Rmillion at current prices: 1966-1993**

	1966	1970	1975	1978	1981	1984	1987	1990	1993
Output	81,46	109,91	316,14	874,45	2146,50	3473,90	4825,30	8164,90	9713,96
Intermediate consumption	27,91	33,06	79,42	237,28	609,86	883,98	1634,17	1990,40	2839,78
Compensation of employees	25,62	32,71	131,33	213,88	393,17	592,93	972,15	1494,10	1925,01
Consumption of capital	0,61	1,03	1,35	10,02	26,11	63,34	126,88	186,87	364,96
Opportunity cost of capital	4,08	4,77	8,89	20,71	52,20	98,94	152,42	183,52	264,79
Resource rent	23,23	38,34	95,15	392,56	1065,17	1834,72	1939,67	4310,02	4319,43
Unit rent (R/ton)	0,44	0,70	1,37	4,34	8,01	9,31	9,05	20,15	18,83
Royalties	0,71	1,89	3,50	8,85	16,43	7,81	24,45	24,90	32,44
Taxes & royalties	4,51	7,31	3,50	8,85	89,15	63,35	117,65	144,64	75,37

Sources: Own calculations

Statistics South Africa, *Census of Mining*, various issues.**Figure 6 Resource and unit rent from coal in South Africa: 1966-1993**

Source: Own calculations.

Once the resource and unit rents have been established, the monetary accounts have been compiled and the value of coal reserves calculated (Table 4 and Figures 7a and 7b). It is clear from Figure 7a that the value of the country's coal resources in Rand terms is steadily appreciating over time indicating net positive change (gains) in national wealth and welfare compared to the sideways

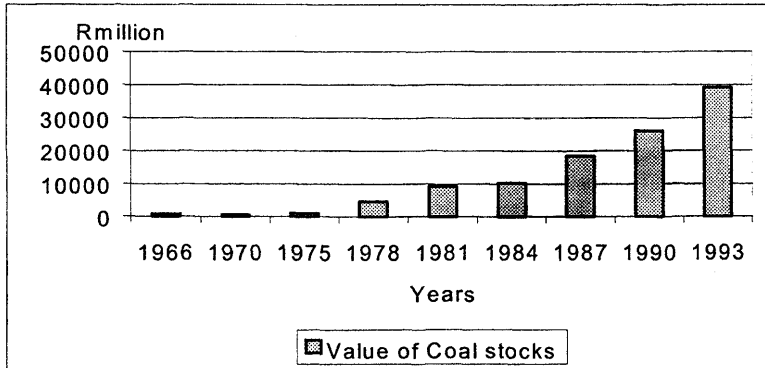
movement of the value of gold resources since the mid-1980s (see Figure 5a). In Dollar terms, the resource value, with the exception of 1981, is steadily increasing as well, but, in contrast to gold, only 25 per cent of coal earnings are generated abroad. The value of coal in 1981 in Dollar terms is exceptionally high due to a strong domestic currency and good commodity prices (Figure 5b). The value of the coal resources in 1993 is also significantly lower (US\$12 023 million) than the value of gold (US\$66 143million).

**Table 4 Monetary accounts for coal in South Africa in Rmillion at current prices: 1966-1993**

	1966	1970	1975	1978	1981	1984	1987	1990	1993
Opening stock	798	550	1097	5011	10327	12028	20413	30431	43587
Depletion	23	38	95	393	1065	1835	1940	4310	4319
Revaluation	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Discoveries	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Other volume changes	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Nominal holding gains	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Closing stock	774	511	1002	4618	9262	10193	18473	26121	39268

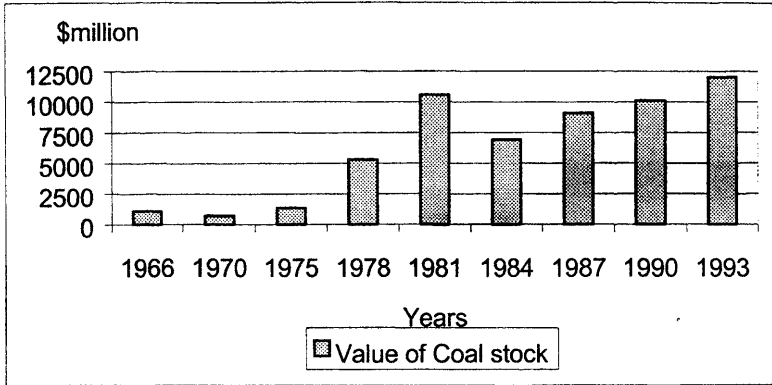
Source: Own calculations.

**Figure 7a The value of coal stocks in South Africa in Rmillion at current prices: 1966-1993**



Source: Own calculations.

**Figure 7b The value of coal stocks in South Africa in US\$million at current prices: 1966-1993**



Source: Own calculations.

### 4.3 Other minerals and total mining

As stated earlier, coal and gold mining contributed approximately 70 per cent of total output in 1993. The remaining 30 per cent therefore constituted all other mineral resources. Physical and monetary accounts for the other mining activities could not be compiled due to the unavailability of physical data on reserves and production/extraction of these minerals. However, the financial data necessary to calculate the resource rent, in other words output, intermediate consumption, compensation of employees, consumption of capital and fixed capital stock have been obtained from Statistics South Africa for selected years. Accordingly, only resource rents for all the other minerals and for total mining are derived. The results are displayed in Tables 5 and 6 and Figure 8. Due to definition changes in the mineral categories reported between 1966 and 1993, the data for other minerals are calculated as a residual item by subtracting the values of gold and coal from total mining figures.

Table 5 suggests that production values of minerals other than gold and coal have increased over time from R391 million in 1966 to reach R9 billion in 1993, showing an average annual growth of over R3 million/year. The main activities contributing to this increase in the other mining are Platinum and Diamonds – both of which are produced especially for the export market. Figure 8 shows a steady growth trend in mining rents except for the sharp dip in 1984 due to the sharp decline in total output from R2,7 billion to R1,7 billion mainly due to the weak performance of Diamonds. Since values for

other minerals are calculated as 30 per cent of total mining values, the two curves follow the same shape and trend.

**Table 5 Resource rent and other calculations for other mining in South Africa in Rmillion at current price: 1966-1993**

	1966	1970	1975	1978	1981	1984	1987	1990	1993
Output	391,09	607,32	1149,07	1750,76	2756,07	1730,78	5883,72	9757,06	9171,33
Intermediate consumption	86,82	124,38	289,02	547,83	909,88	871,00	1469,56	2725,01	3458,95
Compensation of employees	59,14	93,87	175,42	296,01	471,62	685,26	437,11	1224,77	3458,13
Consumption of capital	13,08	19,94	33,82	60,29	99,84	113,28	173,64	294,29	448,43
Opportunity cost of capital	7,20	12,58	30,48	45,69	57,10	90,04	91,87	154,46	298,45
Resource rent	224,85	356,55	620,33	800,95	1217,63	-28,80	3711,53	533,54	1507,36
Royalties	3,70	4,99	11,00	13,22	21,97	18,99	34,55	66,79	285,10
Taxes & royalties	28,84	60,10	11,00	13,22	88,93	181,99	474,75	1532,63	647,47

Sources: Own calculations

Statistics South Africa, *Census of Mining*, various issues.

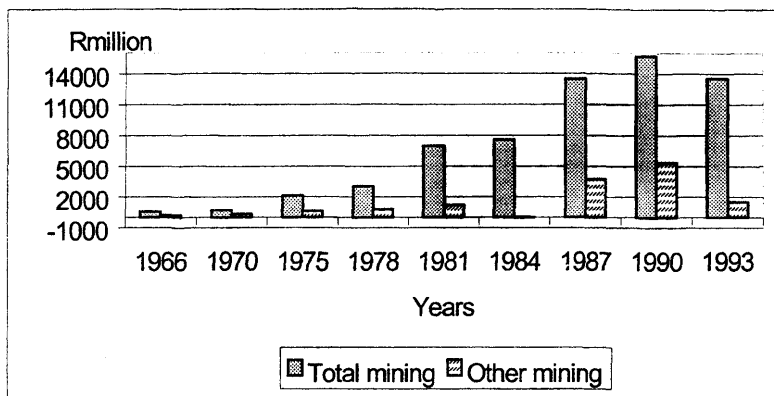
**Table 6 Resource rent and other calculations for total mining in South Africa in Rmillion at current prices: 1966-1993**

	1966	1970	1975	1978	1981	1984	1987	1990	1993
Output	1248,75	1547,57	4025,60	6525,25	13456,8	16778,18	28270,15	36984,49	42124,61
Intermediate consumption	331,85	365,49	824,76	1728,14	3380,36	4357,20	7449,65	10474,06	13144,71
Compensation of employees	296,82	377,47	910,89	1483,79	2656,59	4129,38	6211,59	9310,16	13088,68
Consumption of capital	13,72	21,01	35,23	70,48	126,08	181,44	308,33	504,05	852,83
Opportunity cost of capital	59,19	74,51	116,97	191,95	306,52	536,29	808,67	929,94	1499,04
Resource rent	547,17	709,08	2137,74	3050,89	6987,33	7573,87	13491,92	15766,27	13539,34
Royalties	14,13	9,28	24,44	54,41	249,60	262,87	551,16	393,47	644,05
Taxes & royalties	138,09	157,81	24,44	54,41	2631,23	2574,50	3872,72	3123,31	1699,95

Sources: Own calculations

Statistics South Africa, *Census of Mining*, various issues.

**Figure 8 Resource rent for other and total mining in South Africa: 1966-1993**



Source: Own calculations.

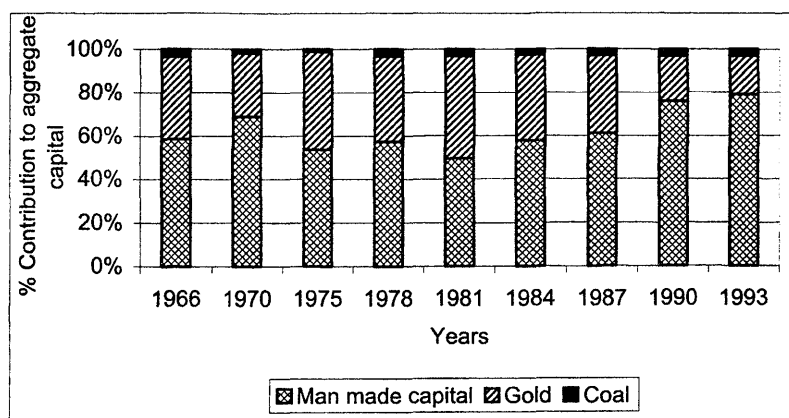
#### 4.4 The share of mineral assets in national wealth

The 1993 version of the SNA (United Nations, 1993) expanded the definition of capital to include natural assets together with manufactured (produced) assets. To date however, there has been very limited implementation of the United Nations recommendations world-wide<sup>6</sup>. This study corrects the conventional measure of national wealth to add the value of mineral assets to manufactured capital (e.g. construction works, buildings, machinery and equipment). The results are presented in Table 7. Since the value of only gold and coal stocks is calculated, the value of the stocks of other minerals could not be included. The aggregate capital indicated in Table 7 is therefore incomplete as far as minerals are concerned. The comparative shares of manufacturing capital and the value of gold and coal stocks are displayed in Figure 9, showing a steady decline in gold and coal shares. This is an indication that South Africa is substituting mineral for manufactured assets in its wealth portfolio.

**Table 7 The value and share of manufactured capital, gold and coal stocks in total assets in South Africa in current prices: 1966-1993**

	Manufactured capital (Rmillions)	Gold stocks (Rmillions)	Coal stocks (Rmillions)	Aggregate capital (Rmillions)	Manufactured capital (% share)	Gold stocks (% share)	Coal stocks (% share)
1966	12923,47	8312,00	774,00	22009,47	58,72	37,77	3,52
1970	19757,48	8375,00	511,00	28643,48	68,98	29,24	1,78
1975	49421,79	41485,00	1002,00	91908,79	53,77	45,14	1,09
1978	78543,35	53679,00	4618,00	136840,35	57,40	39,23	3,37
1981	143217,23	136732,00	9262,00	289211,23	49,52	47,28	3,20
1984	237892,65	163736,00	10193,00	411821,65	57,77	39,76	2,48
1987	388563,71	228016,00	18473,00	635052,71	61,19	35,91	2,91
1990	632090,93	174827,00	26121,00	833038,93	75,88	20,99	3,14
1993	966310,98	216024,00	39268,00	1221603,0	79,10	17,68	3,21

Sources: Own calculations.

**Figure 9 Shares of manufactured capital, gold and coal stocks in total assets in South Africa: 1970-1993**

Sources: Own calculations.

#### 4.5 Calculation of the user cost of capital for gold and coal

Given the discussion in 4.1, it is now possible to calculate the component of the resource rent that needs to be reinvested and the true income using the formula provided by El Serafy. The results of the calculations, using two different social discount rates namely 3 and 5 per cent respectively, are presented in Table 8 below. X gives the income component that can be consumed whereas the capital component (or user cost) that needs to be reinvested is the remainder of

the resource rent (R-X). It should be clear that the capital depreciation factor  $((R-X)/R)$  is relatively small, namely 15,5 per cent for gold and 1 per cent for coal in 1993. It would have been interesting to compare the capital component of the resource rent (R-X) with actual investments in sustainable industries by the gold and coal industries. Unfortunately, this could not be done for lack of data on investment expenditure for the period studied. Nevertheless, the following section attempts to evaluate aspects related to sustainable management of mineral assets using international resource management concepts and measures.

**Table 8 Resource rent for gold and coal divided into their income and capital components in Rmillion at current prices: 1966-1993**

	Resource rent		Income (X (3%))		Capital (R-X)		Income (X (5%))		Capital (R-X)	
	Gold	Coal	Gold	Coal	Gold	Coal	Gold	Coal	Gold	Coal
1966	299	23	251	23	48	0	284	23	15	0
1970	314	38	253	38	61	0	293	38	21	0
1975	1422	95	1250	95	173	0	1379	95	44	0
1978	1857	393	1618	393	240	0	1794	393	63	0
1981	4705	1065	4120	1065	585	0	4554	1065	151	0
1984	5768	1835	4937	1829	831	5	5532	1835	236	0
1987	7841	1940	6870	1930	971	10	7591	1939	250	0
1990	6098	4310	5270	4286	828	24	5872	4309	226	1
1993	7713	4319	6517	4282	1196	37	7357	4318	356	2

Source: Own calculations.

## 5 IMPLICATIONS FOR SUSTAINABLE RESOURCE MANAGEMENT AND MACROECONOMIC DEVELOPMENT AND POLICY

As discussed earlier, given the importance of mineral resources for economic development in South Africa, it is important to understand how receipts from the commercial exploitation of such fixed asset stocks have been allocated between society and private owners, as well as between current consumption spending and capital formation. Sustainable exploitation and development of such exhaustible natural assets requires that at least part, if not all, of their scarcity value (resource rent) must be reinvested to maintain, if not increase, the current stream of economic benefits (income and employment) from the total asset stocks in the future. This is commonly referred to as Hartwicks's rule in the relevant literature (creation of a permanent stream of income as a perpetual social pension fund).



Various NRA-based indicators and measures of economic sustainability are used to evaluate the said sustainability concept. Measures deriving the share of resource rent (user cost) reinvested in other forms of economic assets (manufactured, technological or human) are most commonly used for evaluating the economic sustainability of resource management policies. In addition to the user cost criteria, other fiscal and financial sustainability measures have been developed to assess the manner in which revenues from the liquidation of extractive natural resources like minerals, have been used to support sustainable development (Lange *et al.*, 1999).

*Resource rent and sustainable management of the mineral wealth in South Africa*

The answer to the question of how the economic rent of mineral resources has been used depends on the nature of property rights to the resource, and the system of royalties and levies in place for its exploitation. While owners of private capital also invest their profits from productive activities (and usually do so more efficiently), the nature of public and private investments is different. Public investments usually target social development projects, which mainly include investment in public works, infrastructure and basic services such as health and education. On the other hand, private investments are typically made in assets that support private economic activities like mining, manufacturing, agriculture and services, and are mainly in the form of equipment and construction.

Like all other governments, the South African government collects some revenue from mining activities. Prior to 1992 a profit-sharing system prevailed in which mining companies were required to pay a part of their profits to the government. This share was calculated according to a particular formula that varied between companies, depending on many factors. The rule applied to both private and government land leased to mining companies. After 1992 ownership right to mining was revised, leading to a new dual system of royalties. In the new system, profit sharing applies only to public (government) land leased to companies, and the government collects no royalties from companies on privately owned land. However, a system of royalties prevails on private land leased to companies, based on free agreement between the private land owners and the companies. Most recent policy (RSA 1998) proposes a change in rights to minerals to be vested in the state, with a system of royalties similar to the current one to continue. Royalties on private (collected by private owners) and public land (paid to government) are to be calculated as a percentage of gross revenue rather than profit (as under the profit sharing system). Due to lack of published information, opinions of experts were surveyed to estimate the distribution of ownership in the minerals sector. The investigation indicates that

about 70 per cent of the land on which gold mines are operating, concentrated in Gauteng and the Free State, is privately held. More than 80 per cent of the land used for coal mining, (concentrated in Mpumalanga and Kwazulu/Natal) is in private hands.

As discussed above, while the government collected royalties from mineral activity from both private and publicly owned land prior to 1992, no royalties have been collected from privately owned land after 1992. Royalties collected by government have now become part of total fiscal revenue and are no longer earmarked as a mineral resource management tool. In fact, there is no monetary instrument currently in place to serve as a mineral resource management tool in South Africa.

In some countries, royalties and special taxes are targeted and used to manage the extraction of natural resources, through appropriate environmental policies and fiscal arrangements for the development and conservation of the sector. Similarly, it can also be argued that profit taxes, being a fiscal instrument used to collect tax from all kinds of economic activity, should not be considered as a royalty directed at managing the resource in question. This is so mainly because profit tax revenues typically go into the general government treasury (as do royalties in South Africa) and are not usually spent on the management of a specific natural asset which is the source of the revenue. It is rather spent in pursuance of broader national economic policy objectives and priorities.

To appreciate the magnitude of the resource rent in relation to the royalties and taxes collected, figures 10, 11, 12 and 13 and Table 9 show these variables for gold, coal, other and total mining. Figure 10 shows that total tax collections (royalties and profit taxes) yielded only about 13 per cent of the resource rent of gold. On the other hand, in the case of royalties alone almost all the gold resource rent (96 per cent) went into private hands. It is also clear that virtually all rent from gold accrued as a windfall profit to private companies before 1981 and that the government share of the resource rent, even for total taxes, began to decline after 1987. The decline in revenue from taxes and royalties is mainly due to the decline in the profitability of mining companies and the changed profit-sharing dispensation after 1992, as discussed above.

The picture is different in the case of coal, where almost all the rent (98 per cent) accrued as a windfall profit to private owners (Figure 11), which suggests that coal resources may not have been sustainably managed and are probably over-extracted (i.e., above socially optimal production levels). It also indicates that coal is generally more privately owned than gold. This is of special importance to environmental management in South Africa, given the fact that coal is a major source of negative environmental externalities in the country. It

seems to follow that South Africa has overproduced electric power and over-polluted the environment (again, above socially optimal production and pollution levels), as more than 90 per cent of power generation is based on coal-fired generators.

As can be seen from Table 9, total rent captured by the government from all mining was 12,6 per cent in 1993. Due to the dominance of gold, the total rent captured follows the same pattern as the rent accrued from gold mining (Table 8 and Figure 13). On the other hand, a considerable percentage of the resource rent from other minerals has been captured (43 per cent) (Figure 12).

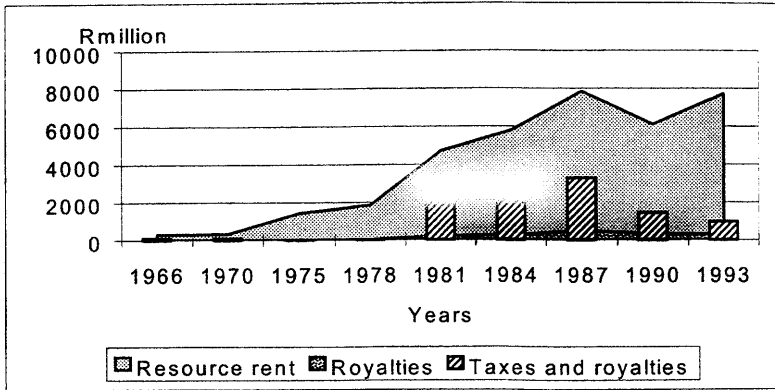
**Table 9 Taxes and royalties as a percentage of resource rent for both gold and coal: 1966-1993\***

	Gold		Coal		Total mining	
	Royalties	Taxes and Royalties	Royalties	Taxes & Royalties	Royalties	Taxes & Royalties
1966	3,3	35,0	3,0	19,4	2,6	25,2
1970	0,8	28,8	4,9	19,1	1,3	22,3
1975	0,7	0,7	3,7	3,7	1,1	1,1
1978	1,7	1,7	2,3	2,3	1,8	1,8
1981	4,5	52,1	1,5	8,4	3,6	37,7
1984	4,1	40,4	0,4	3,5	3,5	34,0
1987	6,3	41,8	1,3	6,1	4,1	28,7
1990	4,9	23,7	0,6	3,4	2,5	19,8
1993	4,2	12,7	0,8	1,7	4,8	12,6

Source: Own calculations.

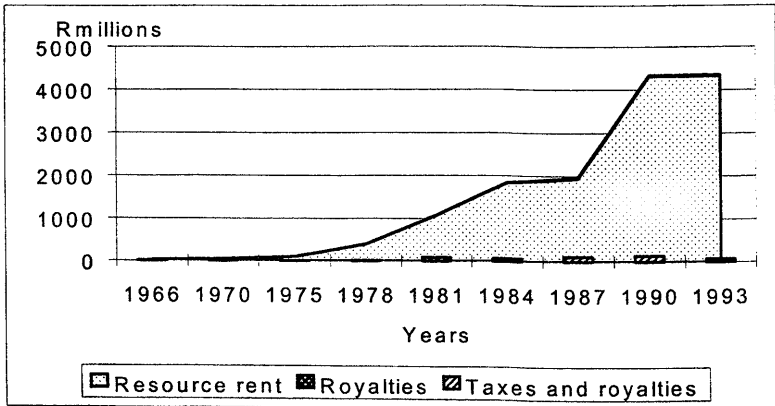
\*Note: The data for 1975 and 1978 concerning taxes are extremely unreliable due to a different method of disclosure during those two census years.

**Figure 10 Resource rent, royalties and taxes and royalties from gold in South Africa: 1966-1993**



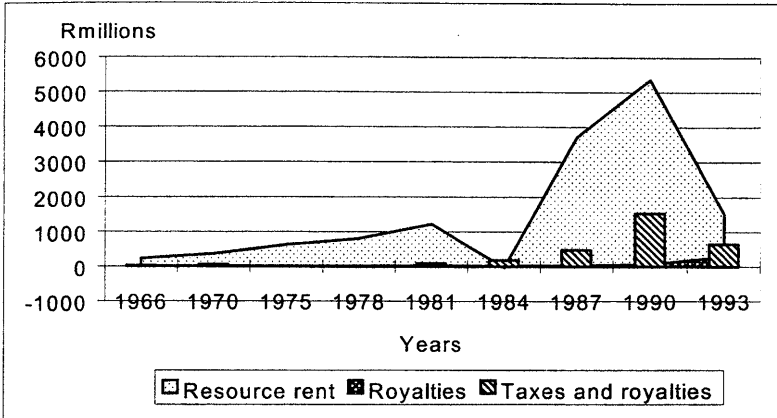
Source: Table 1.

**Figure 11 Resource rent, royalties and taxes and royalties from coal in South Africa: 1966-1993**



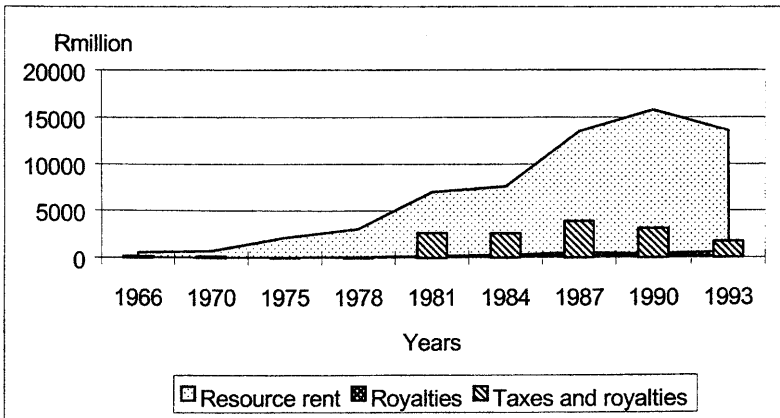
Source: Table 3.

**Figure 12 Resource rent, royalties and taxes and royalties from other mining activities in South Africa: 1966-1993**



Source: Table 5.

**Figure 13 Resource rent, royalties and taxes and royalties from all mining in South Africa: 1966-1993**



Source: Table 6.

The low level of rent capture from minerals observed in Table 9, can be attributed to a number of factors. Prior to 1992, the profit-sharing system had severely underestimated the capital consumption component of the rent. After

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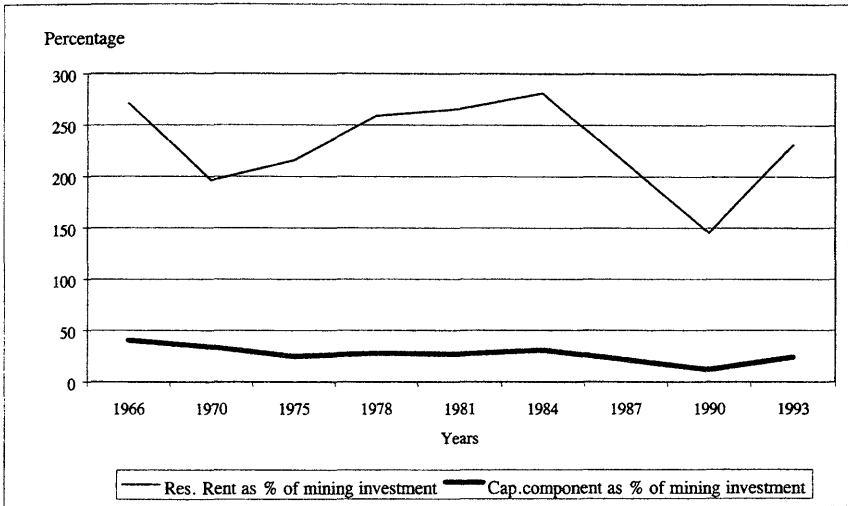
1992, the fact that royalties have been collected only from minerals on government-owned land, estimated to be less than 30 per cent, partly explains the decline in rent collection during recent years.

The 12,7 per cent total royalties share of the resource rent from gold (Table 9) compares well with the 15,5 per cent user cost (capital component) calculated in Table 8 for 1993. On the other hand, the government collected twice the user cost on coal (0,8 per cent according to Table 8) in total royalties and taxes (1,7 per cent according to Table 9) from coal mining in 1993. If one considers that after 1992 royalties were collected only from public land (representing 30 per cent of total gold and 25 per cent of coal), then this means that the 1993 figures for royalties in Table 9 may underestimate total rent income. This is so because royalties and taxes collected by the government do not include royalties collected by private owners from mining companies. If one assumes that private owners of mining lands collect royalties from mining companies, then the total rent captured from minerals in South Africa will be higher than El Serafy's user cost in Table 8. On the other hand if one assumes that only royalties (excluding other taxes) represent the true share of the rent, then the rent capture would be comparable to the user cost estimates of Table 8.

According to the user cost (capital component) calculations, gold mines should have reinvested 15,5 per cent and coal mines 0,8 per cent of the resource rent in other forms of capital assets. To address the question of how resource rents have been used, it is essential to compare the capital component of the resource rent (R-X) with actual investments made by the gold and coal mining industries, especially private sector investment spending where the lion's share of the rent (more than 70%) accrues.

The ratios of the total resource rent of minerals and its capital component to capital formation in the mining industry are depicted in Figure 14. Although total mineral rent is more than double the rate of capital formation in mining, the reverse is true for the capital component of the rent (user cost). According to Figure 14, the mining sector in South Africa had invested in alternative forms of capital more than twice the user cost. The user cost contributed 40 per cent of total mining investment in 1966 and its contribution then declined to fluctuate around an average of 25 per cent for the rest of the period under review. This indicates that the capital component of the mineral rent is fully reinvested, which suggests that mineral resources have not been wasted (e.g. liquidated in current consumption) in South Africa.

**Figure 14 Resource rent and the capital component of the rent as percentage of gross capital formation in the mining sector at current prices: 1966-1993**



Sources: South African Reserve Bank, *Quarterly Bulletin*, various issues.

## 6 CONCLUSION

Although South Africa is richly endowed with mineral resources and was heavily dependent on them for economic welfare in the past, it is not so any more. The contribution of minerals to GDP is at present approximately 6 per cent only. This does not imply that the resource should not be managed efficiently. On the contrary, like all other exhaustible resources, as mineral assets become increasingly scarce and depleted, the more important it becomes to substitute income from alternative productive assets for income generated by the liquidation of the resource. This requires adequate rent capture and reinvestment of its capital consumption allowance component in other forms of capital assets to compensate for depletion.

Prior to 1981, almost all the mineral rent accrued to mining companies in South Africa. Rent capture through royalties and taxes began to increase during the 1980s to reach about 30 per cent of total rent by the late 1980s, when it started to decline again with the change in mining policy. The most recent mining policy, however, proposes changes in defining rights to minerals that are expected to

improve rent capture by the public authority. Nevertheless, the share of total taxes and royalties in total rent compares well with El Serafy's capital component (user cost) that is to be recovered and reinvested. Moreover, the mining industry in South Africa seem to have not only adequately captured user costs, but also succeeded in fully reinvesting the capital component of the resource in alternative forms of capital to compensate for the depletion of mineral assets.



**APPENDIX A Physical accounts for gold in kilogram for South Africa:  
1966-1998**

	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979
Opening stock	59261680	58301213	57351534	56384387	55411430	54411013	53434716	52525085	51669906	50911347	50197900	49484510	48784623	48080174
Production (Extraction)	960467	949679	967147	972957	1000417	976297	909631	855179	758559	713447	713390	699887	704449	703473
Discoveries	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other vol. changes	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Closing stock	58301213	57351534	56384387	55411430	54411013	53434716	52525085	51669906	50911347	50197900	49484510	48784623	48080174	47376701
Volume sold	960467	949679	967147	972957	1000417	976297	909631	855179	758559	713447	711500,1	699000	704448,9	705400,2
Net change in inventory	0	0	0	0	0	0	0	0	0	0	1890	887	0	-1927
Closing stock (incl. Invent.)	58301213	57351534	56384387	55411430	54411013	53434716	52525085	51669906	50911347	50197900	49486400	48785510	48080174	47374774

	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
Opening stock	47376701	46701619	46039426	45376748	44698872	44016942	43343998	42703970	42099624	41479715	40872050	40266957	39665944	39052908
Production (Extraction)	675082	662193	662678	677876	681930	672944	640028	604346	619909	607665	605093	601013	613036	619325
Discoveries	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other volume changes	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Closing stock	46701619	46039426	45376748	44698872	44016942	43343998	42703970	42099624	41479715	40872050	40266957	39665944	39052908	38433583
Volume sold	674839,3	661080,1	661,931,10	669223,8	685100,5	677494,3	642071,3	602099	617776,5	605872,4	595751,3	601380,4	612995,1	618965,1
Net change in inventory	243	1113	747	8652	-3171	-4550	-2043	2247	2133	1793	9342	-367	41	360
Closing stock (incl. Invent.)	46701862	46040539	45377495	44707524	44013772	43339448	42701927	42101871	41481848	40873843	40276299	39665577	39052949	38433943

	1994	1995	1996	1997	1998
Opening stock	38433583	37853382	37329567	36831317	36341216
Production (Extraction)	580201	523815	498250	490101	464216
Discoveries	0	0	0	0	0
Other volume changes	0	0	0	0	0
Closing stock	37853382	37329567	36831317	36341216	35877000
Volume sold	580239,7	541383,476	494997,233	508467,476	465567,018
Net change in inventory	-39	-17568	3253	-18366	-1351
Closing stock (incl. Invent.)	37853343	37311999	36834570	36322850	35875649

Source: Own analysis based upon data from the Minerals Bureau of South Africa.

## APPENDIX B Auxiliary financial information pertaining to gold: 1966-1998

	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
Average Market Price (R/kg)	807,5	808,1	888,5	852,0	830,0	915,0	1215,0	2019,0	3449,0	3589,0	3345,0	4027,0	5536,0	8305,0	15413,0	13045,0	13246,0
Average Market Price (\$/kg)	1126,2	1127,0	1239,2	1186,6	1159,2	1283,3	1573,8	2909,2	5079,5	4856,6	3849,3	4634,1	6370,5	9863,4	19811,1	14874,6	12208,3
Opening price (Jan) (R/kg)	807,3	807,9	808,3	943,9	807,9	859,7	1048,1	1606,9	2297,5	4065,1	3894,1	3739,8	4486,3	5811,2	12227,9	14477,1	12786,7
Closing price (Dec) (R/kg)	807,9	808,3	943,9	807,9	859,7	1048,1	1606,9	2297,5	4065,1	3894,1	3739,8	4486,3	5811,2	12227,9	14477,1	12786,7	15540,4
ST-Interest rate (%)	6,5	7,0	6,5	7,0	7,5	7,5	7,0	7,0	9,5	9,5	9,5	9,5	8,5	7,0	8,0	11,5	15,0
LT-Interest rate (%)	6,5	6,5	6,5	6,5	7,8	8,5	8,1	8,0	9,5	10,0	11,0	10,7	9,7	9,3	11,8	13,3	11,3
Inflation rate (%)	3,8	3,0	1,8	2,9	5,1	6,4	6,1	9,4	11,6	13,5	11,2	11,2	11,0	13,2	13,8	15,2	14,7
Exchange rate (R/\$)	0,717	0,717	0,717	0,718	0,716	0,713	0,772	0,694	0,679	0,739	0,869	0,869	0,869	0,842	0,778	0,877	1,085

	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
Average Market Price (R/kg)	14973,0	16938,0	22765,0	27005,0	28821,0	31702,0	31998,0	31503,0	32210,0	31851,0	36601,0	42408,0	43343,0	53500,0	48980,0	52180,0
Average Market Price (\$/kg)	13440,8	11483,4	10222,3	11828,7	14162,7	13953,3	12203,7	12177,4	11670,3	11171,9	11206,7	11799,7	11950,1	12453,4	10631,6	9434,1
Opening price (Jan) (R/kg)	15540,4	15175,0	19396,4	27766,6	27938,2	30537,5	31597,4	33894,9	30725,5	32165,3	32401,2	41599,8	43434,8	45633,7	55591,7	45275,3
Closing price (Dec) (R/kg)	15175,0	19396,4	27766,6	27938,2	30537,5	31597,4	33894,9	30725,5	32165,3	32401,2	41599,8	43434,8	45633,7	55591,7	45275,3	55030,3
ST-Interest rate (%)	16,0	18,0	14,5	9,5	10,5	14,5	17,0	16,5	15,5	12,0	11,0	12,5	14,0	14,5	13,5	15,5
LT-Interest rate (%)	13,6	16,3	18,1	15,3	15,5	16,7	15,9	16,0	16,7	14,9	12,3	16,8	14,6	16,2	14,1	16,4
Inflation (%)	12,4	11,5	16,3	18,6	16,1	12,9	14,7	14,4	15,3	13,9	9,7	9,0	8,7	7,4	8,6	6,9
Exchange rate (R/\$)	1,114	1,475	2,227	2,283	2,035	2,272	2,622	2,587	2,760	2,851	3,266	3,594	3,627	4,296	4,607	5,531

Sources: South African Reserve Bank. *Quarterly Bulletin*. Various Issues.  
South African Reserve Bank. Unpublished data.

## APPENDIX C Physical accounts for coal in tons for South Africa: 1966-1998

	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
Opening stock	40269598829	40216752134	40209407706	40152467358	40094516307	40039904575	39981238556	39922798139	39860446197	39794390587	39724950989
Production (Extraction)	52846695	7344428	56940348	57951050,68	54611732	58666019	58440417	62351942	66055610	69439598	76453002
Discoveries	0	0	0	0	0	0	0	0	0	0	0
Other vol. changes	0	0	0	0	0	0	0	0	0	0	0
Closing stock	40216752134	40209407706	40152467358	40094516307	40039904575	39981238556	39922798139	39860446197	39794390587	39724950989	39648497987
Volume sold	46922274	48327311	50562352	51196749	53124790	56981846	57187846	61548554	64631333	69120924	75721232
Net change in inventory	5924421	-40982883	6377996	6754301,677	1486942	1684173	1252571	803388	1424277	318674	731770
Closing stock (incl. Invent.)	40222676555	40168424823	40158845354	40101270609	40041391517	39982922729	39924050710	39861249585	39795814864	39725269663	39649229757

	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
Opening stock	39648497987	39563087444	39472729616	39368961750	39253923504	39120880000	38948000539	387727250184	38580090906	38366431809	38146853447
Production (Extraction)	85410543	90357828	103767866	115038246	133043504	172879461	170750355	197159278	213659097	219578362	214403067
Discoveries	0	0	0	0	0	0	0	0	0	0	0
Other vol. changes	0	0	0	0	0	0	0	0	0	0	0
Closing stock	39563087444	39472729616	39368961750	39253923504	39120880000	38948000539	387727250184	38580090906	38366431809	38146853447	37932450380
Volume sold	85004282	85686907	98220051	113083437	129905377	140333887	144610277	161315800	17200537	176208529	172570739
Net change in inventory	406261	4670921	5547815	1954809	3138127	32545574	26140078	35843478	41658560	43369833	41832328
Closing stock (incl. Invent.)	39563493705	39477400537	39374509565	39255878313	39124018127	40222676555	38803390262	38615934384	38408090369	38190223280	37974282708

	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
Opening stock	37932450380	37707005051	37483761189	37269836704	37047699793	36835384436	36606021545	36363086705	36104428680	35838422908	3556977438
Production (Extraction)	225445329	223243862	213924485	222136911	212315357	229362891	242934840	258658025	266005772	281445470	289478558,9
Discoveries	0	0	0	0	0	0	0	0	0	0	0
Other vol. changes	0	0	0	0	0	0	0	0	0	0	0
Closing stock	37707005051	37483761189	37269836704	37047699793	36835384436	36606021545	36363086705	36104428680	35838422908	3556977438	35267498879
Volume sold	183607676	179922793	184448080	181869225	179217628	184001530	193662615	205710319	206579409	219868938	222327000
Net change in inventory	41837653	43321069	29476405	40267686	33097729	45361361	49272225	52947706	59426363	61576532	67151558,87
Closing stock (incl. Invent.)	37748842704	37527082258	37299313109	37087967479	36864842165	36651382906	36412358930	36157376386	35897849271	35618553970	35334650438

Sources: Own analysis based upon data from the Minerals Bureau of South Africa (Mining Statistics, Mineral Industry Handbook and unpublished data).

## APPENDIX D Auxiliary financial information pertaining to coal: 1966-1998

	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
Average Market Price (R/ton)	1,736	1,798	1,917	2,072	2,069	2,095	2,217	2,471	3,094	4,574	6,350	8,887	10,205	11,641	13,239	16,524	18,904
Opening price (Jan) (R/ton)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	12,182	13,460	19,029
Closing price (Dec) (R/ton)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	12,182	13,460	19,029
ST-Interest rate (%)	6,500	7,000	6,500	7,000	7,500	7,500	7,000	7,000	9,500	9,500	9,500	9,500	8,500	7,000	8,000	11,500	15,000
LT-Interest rate (%)	6,5	6,5	6,5	6,5	7,8	8,5	8,1	8,0	9,5	10,0	11,0	10,7	9,7	9,3	11,8	13,3	11,3
Inflation rate (%)	3,8	3,0	1,8	2,9	5,1	6,4	6,1	9,4	11,6	13,5	11,2	11,2	11,0	13,2	13,8	15,2	14,7
Exchange rate (R/\$)	0,717	0,717	0,717	0,718	0,716	0,713	0,772	0,694	0,679	0,739	0,869	0,869	0,869	0,842	0,778	0,877	1,085

	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
Average Market Price (R/ton)	18,335	21,535	29,635	30,760	27,961	32,202	41,745	44,267	48,304	52,583	52,793	53,457	62,310	72,141	74,036	80,756
Opening price (Jan) (R/ton)	19,537	19,451	25,178	33,939	28,827	27,452	35,547	42,878	47,020	51,547	56,440	53,939	53,000	66,445	70,918	75,526
Closing price (Dec) (R/ton)	19,451	25,178	33,939	28,827	27,452	35,547	42,878	47,020	51,547	56,440	53,939	53,000	66,445	70,918	75,526	78,448
ST-Interest rate (%)	16,000	18,000	14,500	9,500	10,500	14,500	17,000	16,500	15,500	12,000	11,000	12,500	14,000	14,500	13,500	15,500
LT-Interest rate (%)	13,6	16,3	18,1	15,3	15,5	16,7	15,9	16,0	16,7	14,9	12,3	16,8	14,6	16,2	14,1	16,4
Inflation (%)	12,4	11,5	16,3	18,6	16,1	12,9	14,7	14,4	15,3	13,9	9,7	9,0	8,7	7,4	8,6	6,9
Exchange rate (R/\$)	1,114	1,475	2,227	2,283	2,035	2,272	2,622	2,587	2,760	2,851	3,266	3,594	3,627	4,296	4,607	5,531

Sources: South African Reserve Bank. *Quarterly Bulletin*. Various Issues

South African Reserve Bank. Unpublished data

Minerals Bureau of South Africa.

N/A: Not available.

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**ENDNOTES**

- 1 The authors acknowledge the funding of JN Blignaut's work on this project through the Research Development Programme of the University of Pretoria. Errors remain the sole responsibility of the authors.
- 2 The same rule was shown to also apply to the depreciation of stocks of renewable resources (Hartwick 1994, Vincent and Hartwick 1997, Vincent 1997). Similar arguments and results were derived for the case of depletion of environmental quality stocks through pollution, and for adding direct and indirect non-market benefits of natural assets and environmental services to income and GDP (Vincent and Hartwick 1997).
- 3 This rate is slightly lower than the rates in other studies world-wide, see also Lange and Gaobotse (1999:9), but can be attributed to the peculiar political dispensation and application of monetary policy in South Africa, leading to low (and even negative) real interest rates during the period under consideration.
- 4 For more information on NRA concepts and applications see Ahmed *et al.* (1989) and Lutz (1993).
- 5 The NRASA project is funded by the USAID Regional Center for Southern Africa (RCSA), which includes Namibia, Botswana and SA. RANESA is a newly established regional network funded by the Swedish International Development Agency (SIDA). Under these two projects similar efforts to construct and use NRA for a number of key resource sectors have been completed or are in progress in many countries in the eastern and southern Africa region (see Lange and Hassan 1999; and Hassan *et al.* 1998 for reviews of examples of such work) (for more information on these activities visit the RANESA website at: <http://www.ranesa.co.za>).
- 6 Few countries such as Australia (ABS 1998), Canada (Statistics Canada 1997) and some European countries (Norway and Sweden) began to include some of their tangible assets such as minerals in the national capital stocks. However, none has yet accounted for major intangible natural and environmental assets such as biological and ecosystems resources. In the case of SA, the value of cultivated forests have been recently included in the asset portfolio with the implementation of the new SNA, but the value of the mineral resources are still excluded (Stats SA 1999).

## REFERENCES

- 1 AHMAD, Y.; EL SERAFY, S. & LUTZ, E. (1989) *Environmental Accounting for Sustainable Development*, Washington, D.C.: The World Bank.
- 2 AUSTRALIAN BUREAU OF STATISTICS (ABS) (1998) *Australian National Accounts: National Balance Sheet*, ABS: Canberra.
- 3 DBSA (1997) *South African National Economic and Environmental Policy (SANEEP) Model*, DBSA Discussion Paper, Half Way House.
- 4 DEA&T (1998) *Natural Resource Accounting Framework for South Africa*, Department of Environmental Affairs and Tourism (DEA&T).
- 5 DEPARTMENT OF MINERALS AND ENERGY *Mineral Statistics*, Various issues. Pretoria: Department of Minerals and Energy.
- 6 DEPARTMENT OF MINERALS AND ENERGY, *South Africa's Mineral Industry*, Various issues, Pretoria: Department of Minerals and Energy.
- 7 EL SERAFY, S. (1989) "The Proper Calculation of Income from Deplorable Natural Resources", In Ahmad, Y., El Serafy, S. and Lutz, E. (eds.) *Environmental Accounting for Sustainable Development*. Washington, D.C.: World Bank.
- 8 HARTWICK, J. (1977) "Intergenerational Equity and the Investing of Rents from Exhaustible Resources", *American Economic Review* 67(5): 972-74.
- 9 HARTWICK, J. (1990) Natural Resources, National Accounting, and Economic Depreciation. *Journal of Public Economics*, 43: 291-304.
- 10 HARTWICK, J. (1994) "National Wealth and Net National Product", *Scandinavian Journal of Economics*, 96(2): 253-56.
- 11 HARTWICK, J. & HAGEMAN, A. (1993) "Depreciation of Mineral Stocks and the Contribution of El Serafy", In E. Lutz (ed.), *Environmental Accounting for Sustainable Development*. A UNSTAT-World Bank Symposium, Washington D. C.: The World Bank.
- 12 HASSAN, R.M. (1999) *Values of Cultivated Forests Missing from National Income and Wealth Measures*, Environmental Economics Network for Eastern and Southern Africa Working Paper (forthcoming).
- 13 HASSAN, R.; HAMILTON, K. & LANGE, G. (1998) "The Natural Resource Accounting Approach to Integrate Environmental and Economic Management and Planning: Experiences from Africa", *Agrekon* 38: 78-108.
- 14 HICKS, J. R. (1946) *Value and Capital*, Oxford: Oxford University Press.
- 15 HOTELLING, H. (1925) "A General Mathematical Theory of Depreciation", *Journal of the American Statistical Association*, 20: 149-52, 340-53.
- 16 KEYNES, J.M. (1936) *The General Theory of Employment, Interest, and Money*, London: Macmillan.

- 
- 17 LANGE, G. and GAOBOTSE, D. (1999) *The Contribution of Minerals to Sustainable Economic Development in Botswana*, Unpublished research paper.
  - 18 LANGE, G. and HASSAN, R. (1999) *Natural Resource Accounting: A Tool for Sustainable Macroeconomic Policy and Planning in Southern Africa*, IUCN-regional Centre for Southern Africa (ROSA), Policy brief 4, Harare, Zimbabwe.
  - 19 LUTZ, E. (ed.) (1993) *Toward Improved Accounting for the Environment*. An UNSTAT-World Bank Symposium, Washington, D. C.: The World Bank.
  - 20 MARSHALL, A. (1936) *Principles of Economics*, London: Macmillan.
  - 21 RSA (1998) *A Minerals and Mining Policy for South Africa*, Pretoria: Department of Minerals and Energy.
  - 22 SHACKLETON, C.; HASSAN, R.; DE WIT, M., SHACKLETON, S. & BEUKMAN, R. (1999) *The Contribution of Natural Woodlands and Forests to National Income and Economic Welfare*, Environmental Economics Network for Eastern and Southern Africa Working Paper (forthcoming).
  - 23 SORENSEN, K.O. and HASS, J.L. (1998) *Norwegian Economic and Environmental Accounts Project*, Final report to Eurostat, Project no. 72950002.
  - 24 SOUTH AFRICAN RESERVE BANK *Quarterly Bulletin*, Various issues.
  - 25 STATISTICS CANADA (1997) *Eco-connections: Linking the Environment and the Economy*, Ministry of Industry: Ottawa.
  - 26 STATISTICS SOUTH AFRICA. (1999) *Gross Domestic Product: Revised Estimates: 1993-1998*. Statistical release P0441, Pretoria: Statistics South Africa.
  - 27 STATISTICS SOUTH AFRICA. *Census of Mining*, Various issues. Pretoria: Statistics South Africa.
  - 28 TURPIE, J.; HEYDENRYCH, B. & HASSAN, R. (1999) *Accounting for Fynbos: A Preliminary Assessment of the Status and Economic Value of Fynbos Vegetation in the Western Cape*. Environmental Economics Network for Eastern and Southern Africa Working Paper (forthcoming).
  - 29 UNITED NATIONS (UN) (1993) *Integrated Environmental and Economic Accounting: Interim Version*, Studies in Methods, Handbook of National Accounting, Series F, No. 61. New York: United Nations.
  - 30 VINCENT, J. & HARTWICK, J. (1997) *Accounting for the Benefits of Forest Resources: Concepts and Experience*, Draft. Rome: FAO Forestry Department.
  - 31 VINCENT, J.R. (1997) "Resource Depletion and Economic Sustainability in Malaysia", *Environment and Development Economics*, 2(1): 19-37.
-