SOUTH AFRICA

Initial National Communication under the United Nations Framework

Convention on Climate Change

October 2000

EXECUTIVE SUMMARY

In August 1997 the Government of the Republic of South Africa ratified the United Nations Framework Convention on Climate Change (UNFCCC). The fundamental objective of the UNFCCC is to achieve stabilisation of the concentrations of the greenhouse gases in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system.

The national government must ensure that effect is given to the provisions of the UNFCCC. Activities relevant to the Convention fall within the responsibility of many different government departments and at all levels of government. To avoid fragmented administration of the Convention, the government has designated the Department of Environmental Affairs and Tourism to be the lead department responsible for co-ordination and the implementation of South Africa's commitments and related matters in terms of the Convention.

The National Committee on Climate Change (NCCC) was established to act as an advisory body to the Minister of Environmental Affairs and Tourism. Representatives from relevant government departments, as well as representatives from business and industry, mining, labour, community based organisations and non-governmental organisations constitute the NCCC.

This Initial National Communication on Climate Change has been prepared in accordance with Article 12 of the Convention. As required, the Communication reports on: the national circumstances; the national inventories of greenhouse gases for 1990 and 1994; South Africa's vulnerability to climate change and its potential to adapt; the systematic observation and research undertaken in this field; education, training and public awareness programmes required; projections and policies made and measures taken; mitigation options and possibilities for adaptation; and a preliminary needs assessment.

National Circumstances

The Republic of South Africa occupies the southernmost part of the African continent with a surface area of 1 219 090 km^2. South Africa lies within a drought belt with an average rainfall of only 464 mm, with fluctuating rainfall patterns. The population was estimated at 43.1 million in 1999 with a 2.1% annual growth rate. It is Government's aim to stabilise the population at approximately 80 million by the year 2100 with a 1.9% growth rate.

Unemployment is estimated to be 30.5% of the population, which is currently growing at 2.2% per annum. This is balanced by an expansion of the informal sector, which is estimated to provide approximately 12% of the labour force and 7% to Gross Domestic Product (GDP).

South Africa has a stable and growing economy with a GDP of 888 billion Rand in 2000. The economy was originally built on natural resources, with mining and agriculture being the main contributors. The financial sector is the largest industry in the country followed by manufacturing. Tourism and related industries follow and this, together with agriculture, has been recognised as one of the key drivers for job opportunities and economic empowerment.

The pre-1994 apartheid economy was characterised by a deepening recession and a shrinking economy, with a budget deficit of 6.8% of GDP. As a result of sound economic policy currently being implemented the budget deficit has been reduced to 2 to 2.5% of GDP. South Africa remains at the forefront of multilateral initiatives aimed at promoting a more equitable international order and ensuring a better future for Africa's people.

South Africa has played a critical part in the African Union and the New Partnership for Africa's Development (NEPAD), as well as in regional conflict resolution. This is opening up a new era of growth and investment in sub-Saharan Africa.

The National Inventory of Greenhouse Gases

The greenhouse gases addressed in the inventory are carbon dioxide, methane and nitrous oxide for the years 1990 and 1994. The inventories were prepared in accordance with to the 1996 Intergovernmental Panel on Climate Change (IPCC) Guidelines.

The total greenhouse gas emissions for 1990 were 347 346 Gg CO_2 equivalents and 379 842 Gg CO_2 equivalents for 1994. The total emissions for each sector, calculated as carbon dioxide equivalents show that the energy sector contributed 75% of the total emissions in 1990, and 78% in 1994; agriculture contributed 11.6% of the total emissions in 1990, and 9.3% in 1994; industrial processes contributed 8.9% in 1990, and 8.0% in 1994; and, waste contributed 4.4% in 1990, and 4.3% to the total emissions in 1994.

Carbon dioxide is the most significant greenhouse gas for South Africa. It contributed more than 80% of the total of the three greenhouse gas emissions for both 1990 and 1994. The main source of carbon dioxide emissions was from the energy sector, which generated 89.7% of the total carbon dioxide emissions in 1990 and 91.1% of the total carbon dioxide emissions in 1994. The high level of emissions from the energy sector relates to the high-energy intensity of the South African economy, which is dependent on large scale primary extraction and processing, particularly in the mining and minerals beneficiation industries. The only significant sink for carbon dioxide in South Africa is through afforestation, and at present South Africa is undergoing net afforestation. The net uptake of carbon dioxide through afforestation activities has increased from 16 983 Gg in 1990 to 18 616 Gg in 1994.

Methane emissions from agriculture, energy fugitive emissions and waste amounted to 2 053 Gg in 1990 and 2 057 Gg in 1994. Enteric fermentation emissions from livestock were the largest contributor to methane emissions, contributing 40% of the total methane emissions. The waste sector contribution increased from 33.5% in 1990 to 36% in 1994 due to the extension of waste services to sectors of the population previously that were not serviced.

The total nitrous oxide emissions were 75 Gg and 67 Gg for the years 1990 and 1994, respectively. The main contributor was the agricultural sector, which generated 77% in 1990, and 80% in 1994 of the total nitrous oxide emissions. Road transportation contributed to more than half of the transport sector emissions, which increased by about 36% between 1990 and 1994.

Vulnerability and Adaptation to Climate Change

Potential changes in climate may have significant effects on various sectors of South African society and the economy. The South African Country Studies Programme identified the health sector, maize production, plant and animal biodiversity, water resources, and rangelands as areas of highest vulnerability to climate change, and proposed suitable adaptation measures to offset adverse consequences. Two key cross-sectoral adaptation options that link the various sectors are the establishment of improved national disaster co-ordination and management and the raising of awareness on the potential effects of climate change.

The South African economy is vulnerable to the possible response measure implemented by Annex 1 countries, since the economy is highly dependent on income generated from the production, processing, export and consumption of coal. Conversely, export could increase to non-Annex 1 countries. Investigations have been recently initiated to evaluate the potential impact of response measures on the South African economy.

Global Climate Model (GCM) computer simulations were used to develop regional climate change scenarios and to assess the potential effects of a changed climate. The potential changes to the South African climate over the next 50 years included: a warming of between 1°C and 3°C; a potential reduction of approximately 5 to 10% of current rainfall**;** increased daily maximum temperatures in summer and autumn in the western half of the country; increased incidents of flood and drought; and, enhanced temperature inversions exacerbating air pollution problems.

Malaria

In the absence of corrective health measures, the projected climate change scenarios for South Africa may result in an extension of the malaria prone areas, and due to the increasing length of summer, a greater number of people could be exposed to the risk of malaria for longer periods of time. The modelling predicted that the area of the country potentially prone to malaria will more than double in 50 years, and that 7.8 million people will be at risk, with 5.2 million of these people not previously resident in malaria risk areas. Significant resources are currently being applied to implement control measures to limit the rates of infection, but should the affected areas increase as predicted by the studies, the disease would become more difficult to manage. The increased resistance to pesticides has recently necessitated the re-introduction of DDT for malaria vector control.

Schistosomiasis (Bilharzia)

It has been estimated that in 1996, between 3 and 4 million people were infected with one or more species of schistosome in South Africa. Theoretical modelling suggests that as temperature increases occur, a larger area of South Africa could be conducive to the survival of schistosomoa, and consequently a greater portion of the population will be at risk of infection. With the increases in unexpected weather phenomenon, for example flooding, the distribution of the snail host may increase, and the potential for urinary schistosomiasis could exist in areas that are currently free of the disease. Community Water Supply and Sanitation projects currently being undertaken by the Department of Water Affairs and Forestry will contribute to the prevention of infection by schistosomiasis.

Water Resources

Even without climate change it is predicted that South Africa will utilise most of its surface water resources within a few decades. The most significant impacts of climate change on water resources are the potential changes in the intensity and seasonality of rainfall. While some regions may receive more surface water flow, water scarcity, increased demand for water and water quality deterioration are very likely to be problems in the future. Climate change may also alter the magnitude, timing and distribution of storms that produce flood events. The arid and semi-arid regions, which cover nearly half of South Africa, are particularly sensitive to changes in precipitation. Desertification, which is already a problem in South Africa, could be exacerbated as the climate changes. Adaptation options identified to limit the effect that climate change may have on water resources include strategic resource management issues, drought relief measures, design of infrastructure and communication.

Rangelands

Climate change scenarios predict a general aridification of rangelands. The predicted lower rainfall and higher air temperatures will affect fodder production and impact on the marginal costs of ranching. Over the savanna regions in the northeast of the country, forage production may decrease by about one fifth, which would impact on the cattle ranching industry by reducing the national cattle herd by about 10%. Beef production would, however, not be affected to the same degree, as greater numbers of the beef herd are fattened in feedlots before being slaughtered. Fire intensities are predicted to increase by about 20% due to the increase in grass fuel load. Climate change may also affect the frequency and spatial extent of livestock disease outbreaks, such as foot and mouth disease. An improved monitoring and forecasting system for fire hazards and droughts will assist and will be beneficial even without climate change occurring.

Maize

Maize production contributed to 71% of grain production during 1996. To meet the increasing food demand, agriculture has to expand by approximately 3% annually. Under the climate scenario that predicts a hotter drier climate, maize production will decrease by approximately 10 to 20% over the next 50 years, and speciality crops grown in specific environmentally favourable areas may also be at risk. An increase in pests and diseases would also have a detrimental effect on the agricultural sector, and invasive plants could possibly become a greater problem. Adaptation measures should mainly focus on changing agricultural management practices, such as more effective use of water resources, planting drought resistant crops, or changing the land use to grazing. To reduce the risk of famine, marginal production areas could be kept economically viable by planting drought resistant crops or changing land use to grazing.

Forestry

The South African forestry industry is highly sensitive to climate change. Currently, only 1.5% of the country is suitable for tree crops and the forestry sector is affected by factors such as land availability, water demand and socio-economic conditions. General aridification, due to lower rainfall and higher air temperatures, will affect the optimal areas for the country's major tree crop species, and impact on the marginal costs associated with planting in sub-optimal areas. Shifts in the optimum tree growing areas could impact on the profitability of fixed capital investments such as saw mills and pulp mills. The decrease in production would also be detrimental to the planting of trees to serve as carbon sinks. More temperature tolerant cultivars within the current tree species could be selected, but it is more probable that more lucrative uses for the land, such as sub-tropical fruits, may compete for the land currently under tree plantations.

Biodiversity

Biodiversity is important for South Africa because of its importance in maintaining ecosystem functioning, its proven economic value for tourism and its role in supporting subsistence lifestyles. The combined effect of climate change, increasing human population and increasing per capita consumption will result in major changes to biodiversity. Climate change scenario modelling indicates a reduction of the area covered by the current biomes by between 38 and 55% by the year 2050. Of the 179 species of animals examined, 143 indicated range contractions and four are predicted to become extinct. Of concern is the predicted expansion of insect pests, such as the brown locust, to areas that were previously cooler.

The predicted rise in temperature would have an effect on the sea surface temperature and this would result in the migration of species residing along the coast. Studies have also indicated that there will be an increase in the occurrences of 'red tide' on the west coast. Other results of climate change are predicted changes in sand inundation on the eastern coast and a predicted increase in storms.

The establishment of a biodiversity monitoring network would identify those species that will be impacted on by climate change, and may assist in the identification of species that could serve as indicator species. Conservation planning is required to ensure that the effects of climate change are buffered.

Systematic Observation and Research

A number of monitoring programmes and research projects closely related to the issues of climate change are currently underway or under development. Various government departments, private sector companies and research institutions are also actively involved in projects to minimise the vulnerability of South Africa to climate change.

Monitoring and research of the ozone layer, solar radiation, as well as measuring atmosphere trace gases and ozone-depleting gases are undertaken by the South African Weather Services (SAWS). The Weather Forecasting Research programme focuses on the consolidation of methods to evaluate and improve weather forecast accuracy. Ongoing research on cloud seeding is being conducted to enhance rainfall.

The Agricultural Research Council, with funding from the National Department of Agriculture is maintaining a number of databases that store and process climatic data and other environmental parameters. The National Department of Agriculture has also launched a number of research projects whose results will assist the agricultural sector in minimising the effects of climate change. Projects include: an investigation into more effective water use in irrigation systems and evaluation of a number of irrigation models; the development of a national standard for potential evaporation; generation of water saturation index values that can be combined with a vegetation index to indicate the status and severity of a drought; investigating water harvesting techniques to conserve rainfall; determining appropriate tillage practices; and compiling a provisional carbon map for South Africa that illustrates the organic carbon value of the soil.

The Department of Health is planning to implement an effective response mechanism for the identification and control of epidemics at the national, provincial and local government level. The Medical Research Council has established an atlas of the spatial epidemiology of malaria in Africa for strategic planning for malaria control.

A number of projects are being conducted to investigate the potential for renewable sources of energy and the use of energy efficiency mechanisms. These include projects that have been initiated by the Department of Minerals and Energy, for example guidelines for energy efficient buildings and effective energy use. Eskom is undertaking various feasibility studies on the potential use of wind and solar energy, as well as the promotion of efficient lighting technologies.

The Cleaner Production Scheme has been introduced by the Department of Trade and Industry (DTI) to promote the development and implementation by industry of environmentally friendly technologies. Organisations, which represent industry, have developed standards to improve environmental performance and raise awareness of environmental management.

The Southern African Regional Science Initiative (SAFARI 2000) was initiated in July 1999 to acquire a better understanding of the links between emissions from both natural and anthropogenic sources, as well as of the mechanisms responsible for transporting the emissions over the subcontinent and the impact of emissions on the environment.

Education, Training and Public Awareness

The United Nations Framework Convention on Climate Change emphasises the principle of stakeholder participation in all activities and processes related to climate change. This principle is endorsed by and is currently being implemented in South African environmental policies.

Education, training and raising public awareness of issues related to climate change will aim at increasing awareness to deal with the negative impacts of climate change, such as floods, droughts and the spread of diseases, both locally and regionally. The public will also be empowered to participate effectively in climate change processes. Social co-operation and partnerships will be encouraged to reduce the negative economic impacts that may occur.

The Department of Environmental Affairs and Tourism (DEAT) has been tasked with the responsibility to build environmental capacity in all spheres of government, as well as civil society. An Environmental Capacity Building Unit has been established to assist DEAT in fulfilling this obligation. A long-term strategy for capacity building in climate change issues needs to be developed. Business and industry have developed some capacity on climate change to meet the challenges this poses but the need to build further capacity, particularly in the small and medium sized businesses, has been recognised. Current capacity on climate change and related issues within the labour movement is limited and needs to be improved. Capacity needs identified for the NGO sector include the availability of funding that will enable capacity building of permanent staff members and ensure the integration of climate change issues into other relevant programmes.

A number of initiatives are currently being undertaken to raise public awareness on a range of environmental issues. Many of these initiatives have direct relevance to climate change, and could be expanded to accommodate the specific requirements of the climate change awareness programmes.

The formal educational system could be utilised to raise public awareness and also to educate learners about issues related to climate change through general education, and primary, secondary and tertiary education and educational curricula. Education is a long-term mechanism for raising awareness, but ultimately it can create a paradigm shift in attitude towards the environment that will facilitate future implementation of climate change adaptation and mitigation measures.

Projections, Policies and Measures

A climate change response strategy is being finalised to address the climate change issues in the country. Policies and measures to combat the effects of climate change are being developed within the context of the national priorities, which are: the alleviation of poverty; the provision of basic services for all South Africans; equity; employment creation; and economic growth. Policies have also been initiated to meet the environmental rights enshrined in the Constitution of the Republic of South Africa, which states that all South Africans have the right to a healthy environment and the right to protect their environment.

The population of South Africa is expected to increase by 2025 to a total of 62 million. A steady growth in the Gross Domestic Product (GDP) is projected due to the benefits of globalisation and the resultant creation of employment, higher fixed investment, and lower interest rates. The Department of Environmental Affairs and Tourism has developed a number of policies and strategies and formulated environmental legislation with the objective of facilitating sustainable that will ensure that significant impacts on the environment are avoided, minimised or mitigated.

Energy

By the year 2025, the total energy demand is projected to be 5 727 Peta Joules. The number of households electrified by the year 2030 is expected to increase to 84%, which is equivalent to 12.2 million households. Since 51.5% of rural households currently do not have access to electricity, photovoltaic-based solar home systems have been integrated into the National Electrification Programme to provide a basic energy source for those households that cannot be grid-connected within acceptable cost parameters. The average potential growth rate in the industrial sector is estimated to be 5%. Eskom, the national power utility, has developed awareness raising programmes to promote energy efficiency in industry, as well as in the domestic sector, and demand side management is being promoted to meet peaks in energy demand.

The White Paper on Energy Policy aims to increase access to affordable energy services; improve energy governance; stimulate economic development; manage energy-related environmental and health impacts; and secure supply through diversity of energy sources. A draft White Paper on Renewable Energy and Clean Energy Development is also being formulated, which sets a target of 10 000 Giga Watt hours for renewable energy contribution to final energy consumption by 2012. This is in addition to the existing renewable energy contribution of 67 829 GWh/annum.

Several initiatives are ongoing to introduce natural gas into South Africa. Agreements have been signed between the Mozambican government and the chemicals group, Sasol, to pipe gas from the Pande and Temane gas fields to the Sasol Secunda plant by the year 2004.

Transport

Long-term energy forecasting and trend modelling has estimated that the average annual growth rate of fuel consumption will be 2.1% for petrol and 2.4% for diesel; the estimated car fleet will grow by 64% between 2000 and 2020; rail growth rate is estimated to be 2.4% per annum; domestic aviation will grow by 1.9% and international aviation by 2.8%. Despite improved fuel efficiency and technological advances in the manufacture of motor vehicles, carbon dioxide emissions from motor vehicles are currently increasing at approximately 2.4% per annum.

The White Paper on National Transport Policy aims to achieve sustainable development in the transport sector by minimising the energy usage and environmental impact of the transport sector. The Moving South Africa project that was implemented in 1998 sets out the strategy for the transport sector in South Africa until 2020. Specific proposals made in this project include the implementation of integrated development planning and promoting the use of public transport.

Mining

Coal currently provides over 90% of the energy for electricity generation and is expected to dominate power generation until the year 2040. South Africa has about 60 billion tonnes of coal reserves, which is sufficient to meet this demand. The tonnages of coal mined are expected to increase to 281 million of tonnes per annum by 2004 up to the year 2030. Approximately 50% of the production is expected to be acquired from surface operations. The mining industry is currently participating in an international project called the Global Mining Initiative, which is aimed at ensuring that future mining developments are environmentally sustainable and socially acceptable.

Waste

It is estimated that about 50 % of the South African population do not have access to adequate solid waste management services. This situation has been identified as a short-term priority that needs to be addressed. The greatest percentage increase in the per capita waste generation rate is anticipated in the residential areas, particularly in informal settlements

(40%) and middle-income areas (35%). The extension of waste collection services, as well as an increasing population will result in a declining capacity for solid waste disposal at existing landfill sites. The White Paper on Integrated Pollution and Waste Management represents a paradigm shift in the approach to pollution and waste management with the focus on pollution prevention rather than impact management. The waste management hierarchical approach of pollution prevention, minimisation and recycling before resorting to treatment and disposal is promoted.

Agricultural

The national Department of Agriculture places an emphasis on prevention and mitigation strategies such as supporting risk management initiatives; research of large-scale epidemics and hazards; providing information to farmers on markets, climate, and taxation and insurance measures. As a mechanism to support these initiatives, the interim National Disaster Management Centre was established by an inter-ministerial Committee. The NDMC resides under the control of the Department of Provincial and Local Government and has strong links to the agricultural sector. LandCare is an initiative undertaken by the government to promote sustainable land management by supporting activities, which encourage individuals and communities to adopt sustainable agricultural practices.

Forestry

The National Forests Act acknowledges that natural forests and woodlands need to be conserved and developed according to the principles of sustainable management. Community forestry is promoted, as is the greater participation of previously disadvantaged persons in all aspects of forestry and the forest products industry. The National Veld and Forest Fire Act provides for a range of institutions, methods and practises to prevent and combat veld, forest and mountain fires in South Africa.

Health

Data has been collected since 1981 in the three provinces where malaria occurs, and this information will be used to predict future outbreaks of the disease. The maps generated by the climate change models have been integrated with other data sets, such as administrative and population boundaries, and will provide national governments, donors, researchers and international agencies with a more empirical basis for strategic evidence-based planning for malaria control. Resistant patterns of malaria are being monitored and future policy and strategy will be adapted accordingly. Since South Africa borders countries that have high infection rates of malaria, a memorandum of understanding on malaria control was signed between Mozambique, Swaziland and South Africa. A programme has been implemented in the province of KwaZulu-Natal, which targets the elimination of schistomiasis through chemotherapy, snail control, health education and sanitation. The national Department of Health participates in provincial disaster management committees in South Africa, as well as in the disaster management committees of the Southern African Development Community (SADC) region.

Water Resources

The growth in water requirements will be mainly in the domestic and industrial sectors. The National Water Act (1998), which gives effect to the National Water Policy (1997), introduced into legislation the principles of equity and sustainable use of freshwater resources. In order to ensure equity of access to water, a Water Pricing Policy has been developed to reflect the true cost of water to users and makes provision for a minimum allowance (lifeline) for human consumption. A Water Conservation and Demand Management Policy has been adopted, and voluntary as well as mandatory measures for water conservation will ensure that water is used efficiently. In order to manage water-related disasters effectively, the Department of Water Affairs and Forestry was one of a number of departments that contributed to the National Disaster Management Policy (1999), which outlines strategies to deal with such disasters and risks. A Water Balance Model (WBM) has been developed by DWAF to assist managers at the national, provincial and regional level with the long-term planning of water resources.

Biodiversity

South Africa is a signatory to the international Convention on Biological Diversity, which aims to promote sustainable use of natural resources through regional co-operation. The White Paper on the Conservation and Sustainable Use of South Africa's Biological Diversity aims to promote sustainable use of natural resources and the sharing of benefits of these resources with local communities. The draft National Environmental Management: Protected Areas Bill and the draft Biodiversity Bill provide some of the tools for the implementation of this policy by consolidating and rationalising existing legislation dealing with protected area.

South Africa ratified the United Nations convention to Combat Desertification (UNCCD) in 1998 and a national action plan to implement the requirements of the convention will be developed.

Recent government policies developed to protect the coastal environment include the White Paper for Sustainable Coastal Development and the Marine Living Resources Act.

Mitigation and Adaptation Strategies

As a developing country, South Africa is not obliged to reduce the emissions of greenhouse gases. Due to national priorities, such as poverty alleviation, providing basic facilities and health issues, as well as financial and technological limitations, the approach to specific greenhouse gas mitigation measures is currently (2000) only at an exploratory phase.

The South African Country Studies Programme Mitigating Options project investigated possible mitigating options that could be implemented and the impact of various greenhouse gas mitigating options and scenarios on the macro-economic situation in South Africa. The outcome of the project is intended to assist policy-makers in developing future strategies, and to highlight opportunities for the development and improvement of efficiency and skills, especially in the sphere of technology transfer. The future approach to be taken to reduce emissions will be based on a holistic evaluation of the options, taking into account life cycle assessments, the impact of implementing the options on the macro-economy, as well as the national priorities.

Electricity

The energy sector is the largest single source of greenhouse gases in South Africa. Integrated energy planning at the national level should ensure the optimum overall mix of energy sources, with clean coal technologies expected to be part of such a mix for the medium-term future. Technologies currently being investigated include renewable energy sources such as hydroelectric power, wind power, solar power and biomass, and non-greenhouse gas emitting energy sources, such as nuclear power. Furthermore, technologies are currently being investigated and developed to make coal power stations less polluting and more efficient. Peaks in electricity demand can also be reduced by management of the demand for energy and providing energy more efficiently by introducing new supply technologies and adjusting pricing policies. In addition, there is a potential for importing energy, such as gas and hydroelectricity, from other countries in the region. To explore this further, The White Paper on the Promotion of Renewable Energy and Clean Energy Development, which aims to inform the public and the international community of the Government's goals and objectives for renewable energy is being formulated. This policy commits the Government to a number of enabling actions to ensure that renewable energy becomes a significant part of its energy portfolio over the next ten years.

Two possible scenarios to mitigate greenhouse gas emissions from electricity generation were evaluated, namely demand side management and a second scenario that uses a mix of more efficient supply technologies. It is estimated that demand side management could reduce greenhouse gas emissions by a total of 265 000 Gg of carbon dioxide during the period 2001 to 2025. The second mitigation scenario considered the use of a cost-effective mix of options of electricity generating processes, in order to reduce carbon dioxide emissions effectively. By the year 2025, the energy-generating plant mix was assumed to be 10% nuclear, 9% combined cycle gas turbine, 12% imported hydropower, 1% generated by renewable sources and the balance by coal-fired power stations. It was estimated that during the period 2001 to 2025, a total reduction of 1 055 000 Gg of carbon dioxide could be achieved with this mitigating option.

Liquid Fuels, Natural Gas and Synthetic Gas

Mitigating options were considered for both the refining of crude oil and the production of synthetic fuel. One mitigating option would be to import refined petroleum products and not to build additional refinery capacity. It is estimated that during the period 2000 to 2030, a total reduction of 103 331 Gg of carbon dioxide equivalent could be achieved with this mitigating option. In the synthetic fuel production industry, the substitution of 10% coal consumption with natural gas would result in a total reduction of 168 331 Gg of carbon dioxide equivalent.

Commercial and Residential

Mitigation in the commercial and residential sectors mainly involves using energy more efficiently or fuel switching. The most effective option to reduce emissions in the residential sector is to convert to solar heating which would achieve a total reduction of 88 000 Gg of carbon dioxide during the period 2000 to 2030. In the commercial sector the greatest reduction of emissions could be achieved by the implementation of energy efficient buildings, achieving a total reduction of 88 000 Gg over a thirty year period.

Transport

At present the transport sector accounts for about one tenth of South Africa's greenhouse gas emissions. It is expected that a greater impact in reducing greenhouse gas emissions will be achieved by implementing a range of mitigating options rather than introducing only one of the options. A range of possible mitigating options for the transport sector were evaluated and their associated carbon dioxide equivalent reductions over a period of 30 years: Imposition of a fuel tax would achieve a total reduction of 45 498 Gg; improved fuel efficiencies are estimated to reduce emissions by 143 426 Gg; fuel switching could reduce emissions by 148 225 Gg; travel demand management could reduce emissions by 33 854 Gg and mode switching could reduce emissions by 42 856 Gg.

Mining

In the coal mining industry, methane emissions are directly linked to the volume of coal mined and the methods used in the mining. Mitigation can be achieved either by reducing the emissions at source or removing the emitted material before it escapes into the environment. Possible options for reducing these emissions include: adopting higher extraction ratios underground and ash filling; extraction of remnant pillars; improved coal washing; improved combustion technology to burn discards; removal of emitted methane prior to mining; and the catalytic combustion of methane.

Industrial

Potential mitigating options considered feasible for implementation during the period up to 2030 in the industrial sector included the following initiatives:

Cement Industry: The cement industry has already started to reduce emissions by implementing a strategy of using industrial waste products in combination with cement and reducing energy consumption. Energy savings can also be achieved with the addition of a high efficiency classifier that separates out the fine products and thus prevents over grinding. The cement industry expects to see the clinker content of all cementitious binders used in 2030 to be about 60%.

Ferroalloys Industries: Optimisation of the process conditions could result in a maximum reduction of emissions of 3.5% by the year 2015. A long-term option is to recover the carbon monoxide off-gas from the furnace to pre-heat the raw materials or to generate electricity. The maximum reduction efficiency with this option would be 7%.

Chemical Industry: It is expected that new production technology will include cleaner technology, which will minimise greenhouse gases. Energy consumption in this sector is receiving attention and improvements in energy efficiency may be possible, particularly at the level of steam production.

Pulp and Paper Industry: Upgrading or replacing recovery boilers, increases the boiler capacity and the energy values of higher black-liquor solids. More feasible options include efficiency improvements (e.g. long-nip press), and recycling of paper.

Aluminium Industry: Substituting raw materials with secondary materials (recycled material) can reduce energy consumption during the production of aluminium by up to 95 percent.

Agricultural

The mitigating options and their potential total reductions of greenhouse gases measured as carbon dioxide equivalents during the period up to 2030 include: optimisation of herd composition and feed intake could achieve a reduction of 207 756 Gg; manure management could reduce emissions by 49 817 Gg; reduced burning of agricultural residues could reduce emissions by 9 120 Gg; reduced frequency of fires could reduce emissions by 22 200 Gg, promoting savanna thickening could reduce emissions by 237 000 Gg; and increasing afforestation could reduce emissions by 116 100 Gg.

Preliminary Needs Assessment

In order to facilitate the preparation of future communications, more permanent institutional arrangements need to be established. An urgent need exists for the establishment and maintenance of a greenhouse gas emissions inventory database. An independent verification system to ensure that only verified data is included in a national emissions database needs to be developed and maintained.

Based on the results of the vulnerability and adaptation assessment undertaken as part of the South African Country Studies Programme, relevant government departments will be evaluating the financial and technical assistance that is required to undertake planning for adaptation. An integrated National Climate Change Response Strategy incorporating each vulnerable sector is being finalised. A national research policy is being developed to guide and consolidate research into climate change. Dissemination of the results of research to a wider audience needs to be undertaken. Significant work needs to be undertaken to ensure that capacity is built in all sector of the society to deal with issues relating to climate change and to utilise the opportunities presented by the Convention in respect of adaptation and in particular the potential investment offered through the Clean Development Mechanism.

The preliminary investigation into potential mitigation options needs to be extended to include more specific macro-economic modelling to evaluate the impact of different measures on the economy. Approaches to the evaluation of the measures need to be developed and implemented. Climate friendly technologies need to be incorporated into government’s cleaner technology initiatives. Appropriate tools to model impacts and consequences of climate change need to be developed.

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ABBREVIATIONS

ABET	Adult Basic Education and Training
AGIS	Agricultural Geographic Information System
ANC	African National Congress
ARC-ISCW	Agricultural Research Council, Institute for Soil, Climate and Water
C	Carbon
CAIA	Chemical and Allied Industries' Association
CBO	Community-based Organisation
CCGT	Combined Cycle Gas Turbine
CDI	Capacity Development Initiative
CH_4	Methane
CO_2	Carbon Dioxide
CONNEPP	Consultative National Environmental Policy Process
COP	Conference of Parties
CSIR	Council for Scientific and Industrial Research
CSM	Climate System Model
CWSS	Community Water Supply and Sanitation
DANCED	Danish Cooperation for Environment and Development
DEAT	Department of Environmental Affairs and Tourism
DME	Department of Minerals and Energy
DoH	Department of Health
DSM	Demand Side Management
DTI	Department of Trade and Industry
DWAF	Department of Water Affairs and Forestry
ECBU	Environmental Capacity Building Unit
EIA	Environmental Impact Assessment
ELI-RSA	South African Efficient Lighting Initiative
EMP	Environmental Management Programme
ESGI	Environmental Standards Generating Initiative
GCM	Global Climate Model
GDP	Gross Domestic Product
GEAR	Growth, Employment and Redistribution
GEF	Global Environment Facility

Gg	Gigagram (1 Gg = 10^9 grams)
GHG	Greenhouse Gas(es)
GIS	Geographic Information System
GTZ	Deutsche Gesellschaft für Technische Zusammenarbeit
GWP	Global Warming Potential
HEAT	Household Energy Action Training
ICAO	International Civil Aviation Organisation
IPCC	Intergovernmental Panel on Climate Change
IEF	Industrial Environmental Forum
IIEC – Africa	International Institute for Energy Conservation-Africa
IEM	Integrated Environmental Management
LPG	Liquid Petroleum Gas
Mha	Mega hectare (10^6 hectares)
MEETI	Mineral and Energy Education and Training Institute
MRC	Medical Research Council
MSA	Moving South Africa
Mt	Megatonnes (1 Mt = 10^{12} grams)
MW	Megawatt
N	Nitrogen
NA	Not Available
NASA	National Aeronautical and Space Agency
NBI	National Botanical Institute
NCCC	National Committee on Climate Change
NDA	National Department of Agriculture
NEEP	National Environmental Education Programme
NER	National Electricity Regulator
NGO	Non-governmental Organisation
N_2O	Nitrous Oxide
NQF	National Qualification Framework
NRA	National Roads Agency
PJ	Petajoule (10^{15} joules)
SAA	South African Airways
SABRE-Gen	South African Bulk Renewable Energy Generation
SACAN	South African Climate Action Network
SACS	South African Country Studies
SADC	Southern African Development Community

SAEDES	Energy and Demand Efficiency Standard
SAFARI	Southern African Regional Science Initiative
SANAP	South African National Antarctic Programme
SAWS	South African Weather Services
SDI	Spatial Development Initiative
SEED	Sustainable Energy, Environment and Development Programme
SSN	South-south-north
STE	Solar Thermal Electric
THRIP	Tertiary Higher Educational Research Industrial Programme
UNDP	United Nations Development Programme
UNFCCC:	United Nations Framework Convention on Climate Change
WBM	Water Balance Model

1. INTRODUCTION

In August 1997 the Government of the Republic of South Africa ratified the United Nations Framework Convention on Climate Change (UNFCCC). The fundamental objective of the UNFCCC is to achieve stabilisation of the concentrations of greenhouse gases in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system. All parties to the Convention committed themselves, through common but differentiated responsibilities, to undertake measures to address their emissions of greenhouse gases and to prepare for the predicted impacts of climate change.

This document has been prepared in accordance with Article 12 of the Convention and serves as South Africa's Initial National Communication to the UNFCCC. It reports on: the national circumstances; the national inventories (1990 and 1994) of greenhouse gases; South Africa's vulnerability and potential to adapt; the systematic observation and research undertaken; education, training and public awareness; projections and policies made and measures taken; mitigation options and adaptation; and a preliminary needs assistance.

1.1 Geographic Profile

The Republic of South Africa occupies the southernmost part of the African continent, stretching latitudinally from 22°S to 35°S and longitudinally from 17°E to 33°E, with a surface area of 1 219 090 km². It has common boundaries with the Republics of Namibia, Botswana, Zimbabwe and Mozambique and the Kingdom of Swaziland. Completely enclosed by South African territory, is the Kingdom of Lesotho. To the west, south and east, South Africa borders on the Atlantic Ocean and southern Indian Ocean respectively. Prince Edward, Marion and Gough Islands that are situated southeast of Cape Town in the Atlantic Ocean, also form part of the South African Republic.

Figure 1.1: The Republic of South Africa, indicating the provinces (Statistics SA 2000)

The surface area of South Africa has two distinct features, namely: an interior plateau, and the land between the plateau and the coast. Forming the boundary between these two areas is the great escarpment, the most prominent and continuous relief feature in the country. Its height above sea level varies from approximately 1 500 to 3 482 m. Inland from the escarpment lies the interior plateau, which is the southern continuation of the great African plateau stretching north to the Sahara. The plateau itself is characterised by wide plains with an average height of 1 200 m above sea level. Between the Great Escarpment and the coast lies an area which varies in width from 80 to 240 km in the east and south to a mere 60 to 80 km in the west.

The South African coastline stretches for about 3 000 km from Namibia in the west to Mozambique in the east. The coastline is rugged and its rocky shores are exposed to high wave energy with few sheltered coastal inlets. Two major ocean currents, the Mozambique Agulhas and the Benguela systems, sweep the South African coastline. The former is a warm, south-flowing current skirting the east and south coasts as far as Cape Agulhas. The Agulhas current is relatively warm (20 to 25°C) and the plant and animal diversity is high. The Benguela Current on the other hand, is cold (16 to 21°C) and flows northwards as far as southern Angola along the west coast.

1.2 History

Humankind had its earliest origins in Africa (Clarke, 1998). Rich deposits of humanoid fossils dating as far back as 100 000 years have been found in southern Africa. The Khoi and San people were the first inhabitants of South Africa followed by the Bantu speaking people who migrated southwards 2 000 years ago. European colonisation began in 1652 when the Dutch East India Company established a supply station in Cape Town to provide ships on their way East with supplies. The colonists gradually moved into the interior as farmers. By this time they were speaking their own vernacular, Afrikaans. In the Eastern Cape an aggressive colonial policy and competition for grazing land with the Xhosa resulted in nine frontier wars, which started in 1779. The white population grew substantially in the 1800s with the arrival of British settlers. In 1854, representative government on a non-racial franchise was established in the Cape Colony, followed by Natal in 1856. Disenchanted with British rule, the Afrikaner people began to migrate into the northern interior from 1835, establishing two independent republics in the Orange Free State and the Transvaal.

Mineral discoveries during the last half of the 19th century had a radical effect on the sub-continent as a whole. Diamonds were discovered in the Northern Cape in 1867 and gold in the Witwatersrand in the Transvaal in 1886. In order to secure a steady supply of largely black labour for the mines, colonial policy actively under-developed black communities and reserves. New immigrants flocked into the country transforming these areas into a thriving industrial economy. Rising tensions between the British settlers and the Transvaal authorities led to the outbreak of the Anglo-Boer war in 1880. The conflict ended in 1902 in a victory for the British.

In 1910, the Union of South Africa, a self-governing dominion of the British Empire, was formed. However, the majority black population was virtually excluded from the negotiations that led to the formation of the Union. During the years between 1910 and 1948, South Africa transformed itself into a modern, industrial nation but also began to give legal effect to the segregation of black and white races. Following the victory of the National Party in a white only election in 1948, a more rigid system of segregation, known as apartheid, was established. Black dissatisfaction resulted in the formation of the South Africa National

Native Congress (to become the African National Congress, ANC) during 1912. After 69 people were killed in a demonstration against "pass laws" at Sharpeville in 1960, political pressures forced South Africa out of the Commonwealth and into a Republic in 1961.

Continued resistance by the ANC resulted in the arrest of Nelson Mandela and other leaders, and their eventual conviction and imprisonment in 1964. Worker opposition, international sanctions and the growing economic interdependence of black and white combined to make the apartheid system increasingly untenable. In 1976 schoolchildren in Soweto revolted against the imposition of Afrikaans in black schools, which initiated a campaign of resistance, designed to make the black townships and eventually the entire country ungovernable. Successive states of emergency failed to restore law and order. By the 1980's the independence of Africa had reached South Africa's borders with the collapse of colonial rule in Angola, Mozambique and Zimbabwe. At the beginning of the 1990's, the ANC and SA Communist Party were unbanned and Nelson Mandela was released from prison.

South Africa held its first democratic election in 1994, which was won by the ANC by a wide margin. Nelson Mandela became the country's first black president in 1994. After the first non-racial election in 1994, South Africa rejoined the Commonwealth and was re-admitted to the United Nations. The country also joined the Organisation of African Unity.

1.3 Climatic Profile

The climate in South Africa is typically warm and dry, with daytime winter temperatures rarely falling below 0°C, and summer maxima often above 35°C. The subtropical location, on either side of latitude 30°S, accounts for the warm temperate conditions. The country also falls within the subtropical belts of high pressure, making it dry, with an abundance of sunshine. The wide expanses of ocean on three borders have a moderating influence on its climate, although gale force winds frequently occur along the coastlines.

South Africa lies within a drought belt with an average annual rainfall of only 464 mm, compared to a world average of 857 mm. 21% of the country has an annual rainfall of less than 200 mm, 48% has between 200 and 600 mm, while only 30% records more than 600 mm. In total, 65% of the country has an annual rainfall of less than 500 mm. Furthermore, the rainfall is typically unreliable and unpredictable with a low rainfall to of run off ratio. The central and eastern parts of the country receive summer rainfall, whilst the south-western part of the country is a winter rainfall region.

Frost often occurs on the interior plateau during cold, clear winter nights. The frost season is longest (from April to October) in the eastern and southern plateau areas, which border on the escarpment. Frost decreases to the north, while the coast is virtually frost-free. Average annual relative humidity readings show that the air is driest over the western interior and over the plateau. Along the coast, the humidity is much higher and at times may rise to 85%.

1.4 Population Profile

South Africa's population comprises a diverse range of cultures and eleven official languages are spoken. The population was estimated to be 40.6 million in the 1996 census. In 1999 the estimated growth rate was 2.2% and the total population was estimated at 43.1 million. It is expected that the population will stabilize at 80 million by the year 2100 with a 2.1% fertility rate and 1.9% growth rate.

In 2000, approximately 50% of the population resided in urban areas, with an expected increase to almost 60% percent by the year 2010.

Unemployment is high and increasing. It has been estimated that approximately 30% of the population was unemployed in 2000 and that unemployment is growing at 2.2% per annum (Statistics SA, 2000). The majority of the unemployed are black men and women under the age of 35 years. Approximately 26% of South African households have an income of less than R500 per month (Statistics SA, 2000). This situation contributes to malnutrition that is estimated to affect 2.5 million children. Poverty also exacerbates the major health risks, such as malaria, tuberculosis and AIDS. It is estimated that there are 1 500 new infections each day and that 12.9% of the population are infected with HIV (United Nations, 1998). It is predicted that by the year 2010, 21.7% of the adult population will be infected with HIV (Whiteside, 1998). Life expectancy in South Africa has reduced from 61.5 years in 1994 to 55 years in 1999, which can probably be mainly attributed to the incidence of AIDS. Malaria is currently endemic in the low-altitude areas of the Northern Province with 23 282 cases reported in 1998 and 158 deaths in this province.

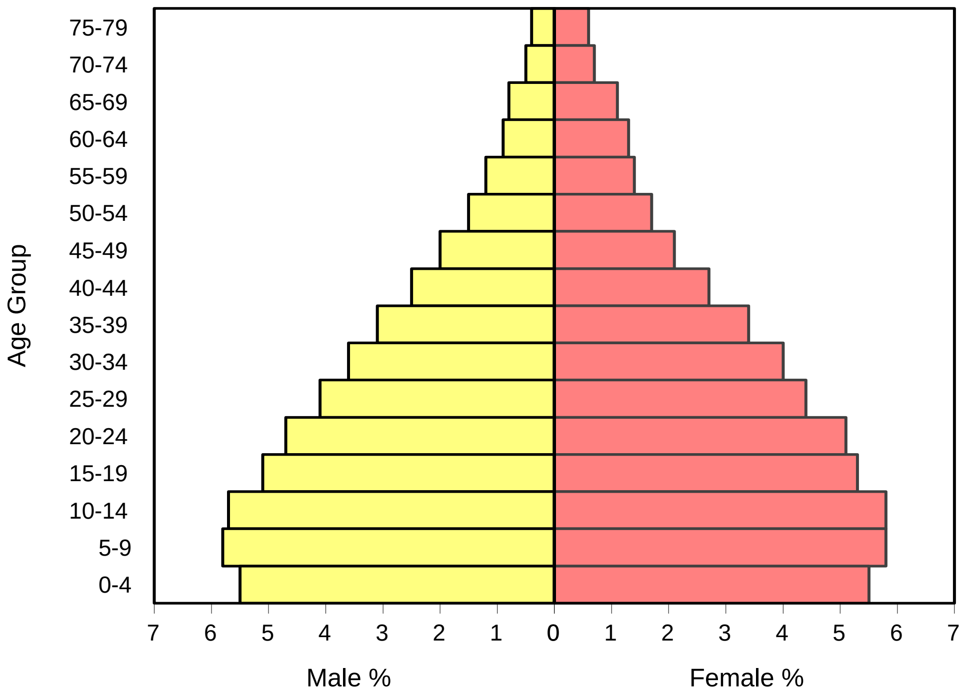


Figure 1.2: Age Distribution in SA (Statistics SA, 2000)

South Africa has an age distribution pyramid, which is typical of developing countries (Figure 1.2). The pyramid has a wide base, indicating a high number of young people. The median age of the South African population is 22.6 years and an age dependency ratio of 64.4. The age dependency ratio is an indicator of the economic burden the economically active portion of the population must carry. South Africa's national age dependency ratio suggests that there are approximately 64 persons in the dependent ages for every 100 persons in the working ages.

The percentage of the population aged 20 years or more and their highest level of education completed are represented in Figure 1.3. 21% of South Africans have received no education, while only 3% have matric or post matric qualifications. The low level off education is being addressed through the implementation of a new school curriculum; the establishment of the National Qualification Framework (NQF); Adult Basic Education and Training (ABET), as well as skills development programmes, community education, early childhood development projects, technical college education and distance education.

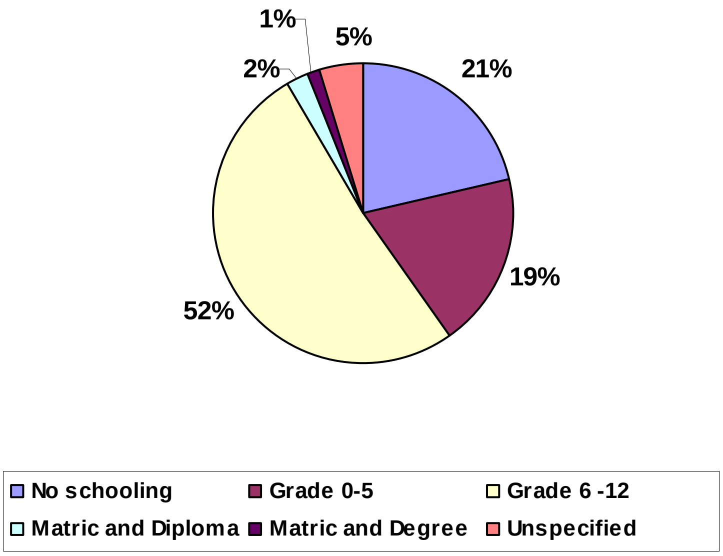


Figure 1.3: Level of education completed by the adult sector of the population based on the 1996 census (Statistics SA, 2000)

1.5 Economic Profile

South Africa is a middle-income developing country with an abundant supply of mineral resources. The urban areas of the country have well developed financial, legal, communications, energy and transport sectors; a modern infrastructure; and a stock exchange, which ranks among the ten largest in the world. The rural areas however, have limited infrastructure and development. The challenges facing the country are to create a strong and balanced economy which will eliminate poverty, develop a dynamic, skilled human resource capacity, facilitate the creation of a prosperous southern African region and compete in world markets in a sustainable manner. South Africa has a stable and growing economy with an inflation rate of approximately 6% annum. In Rand terms, the economy grew from 482 billion in 1994 to 888 billion in 2000, with an equivalent rise in GDP/capita from R12 500 to R18 600 in the same period. South Africa's real GDP slowed to a 0.8% in 1998, however, this was followed by a marked increase of 2.0% and 3.5% for 1999 and 2000 respectively.

The economy was originally built on natural resources, with mining and agriculture the main component of the GDP. South Africa holds the world's largest percentage of reserves of ores of manganese (80%), chromium (68%), platinum group metals (56%), vanadium (45%), gold (39%) and alumino-silicates (37%). It is also the leading holder of reserves of ores of vermiculite, andalusite, zirconium, titanium, antimony, fluorospar and phosphate rock. Mining is the single most important earner of foreign exchange in the economy. During the 1990's, mining generated 41% of total exports. During 1997, the mining industry contributed 8.9% to gross domestic fixed investment while sales of primary mineral products accounted for 37.3% of total export revenue. Coal provides the third largest minerals export earner at 9.8 billion Rand during 1999, after gold and platinum group metals. The mining industry also employs many people, with at least one in seven South African men being employed in the mining industry (1996-population census). In 1997, 552 000 persons were employed by mines or quarries.

There has been a shift from production towards manufacturing, with the secondary sector currently contributing approximately 24.5% to GDP compared to approximately 10.6% from the primary sector, and 64.9% from the tertiary sector (Table 1.1). The highest GDP is generated by the financial, real estate and business services sector. Coal, after gold and the platinum group metals, is the third largest minerals export earner at 9.8 billion Rand in 1999. As a result of the diminishing activity in the primary sectors in the economy, the ratio of industrial and commercial inventories to GDP in the non-agricultural sectors of the economy declined from an average of 17% in 1997 to 14.5% in 1998.

The tourism industry contributes 10% of the GDP in 1999. Tourism has been accepted by the government, business and labour as one of the key drivers for job growth, wealth creation and economic empowerment. A number of initiatives have been implemented by government to build on and increase the economic benefits derived from domestic, regional and international tourism.

Table 1.1: Primary, secondary and tertiary contribution to GDP in 1999 (SA 2000-01, 2000)

Sector	Activities	Percentage Contribution
Primary	Agriculture, forestry and fisheries	4.1
	Mining	6.5
Secondary	Manufacturing, electricity, gas, water and construction	24.5
Tertiary	Trade, commerce, transportation and communications, finance services	64.9

Average per capita disposable income decreased from R4 637 in 1984 to R4 208 in 1997, a decrease of 9% but it is now in stable upward trend. Decreasing employment opportunities in the formal sector is matched by the expansion of the informal sector, which is estimated to provide employment to approximately 1.8 million people, or 12% of the labour force, contributing 32 billion Rand annually, or 7% to GDP.

1.6 Energy Profile

South Africa has abundant fossil fuel (coal) and uranium energy resources, and limited quantities of natural gas. Approximately 3% of the country's crude oil requirements are sourced locally and the remainder is imported. Much of the primary energy is converted to other energy forms, for example: coal is converted to electricity in power stations and liquid fuels by the synthetic fuel process, and crude oil is converted to petrol and diesel in oil refineries. South Africa's estimated recoverable energy reserves are presented in Table 1.2

Table 1.2: Energy resources of South Africa (de Villiers *et al.*, 2000a)

Resource	Reserves
Coal	1 298 000 PJ
Crude oil	1 920 PJ
Natural gas in the Bredasdorp basin	1 418 PJ
Coal bed methane	3 500 PJ
Uranium	157 853 PJ
Hydro	20 PJ/year
Wind	50 PJ/year
Solar	8 500 000 PJ/year
Wood	220 PJ/year
Agricultural waste	20 PJ/year
Municipal solid waste	34 PJ/year
Bagasse	49 PJ/year

South Africa's reliance on fossil fuels as a primary energy source is approximately 90%, with coal providing 75% of the energy supply (Figure 1.4). The total primary energy demand is expected to grow on average by 3% per annum between 1993 and 2010.

The total net energy use in South Africa in 1997 amounted to 2.5 million TJ, with industry and commerce accounting for 45.1% of the consumption, followed by the residential sector (16.4%), transport (27.5%), mining (6.0%) and agriculture (2.9%) (DME, 2000b). Approximately 15% of GDP is spent on energy.

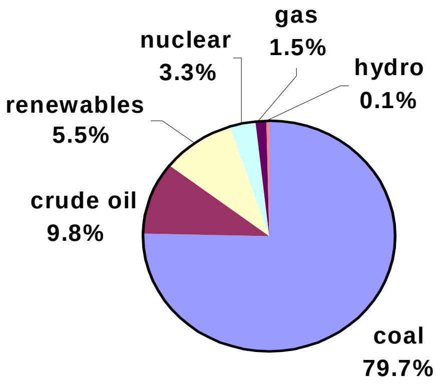


Figure 1.4: Total Primary Energy Supply for 1992 (DME, 2000b)

Eskom, a 100 % state-owned company, is the national electricity utility that generates 96% of the total electricity generated, which meets 25% of the energy market (Figure 1.5).

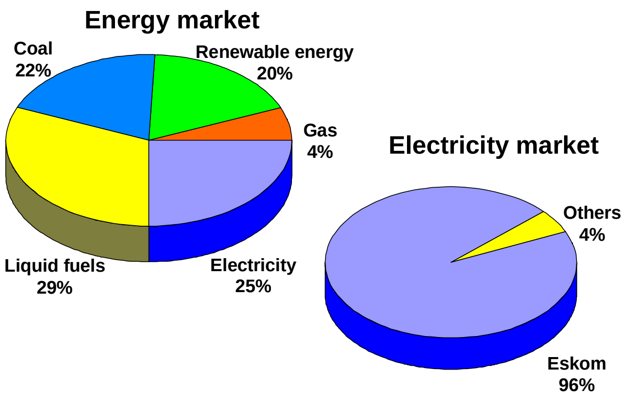


Figure 1.5: Energy market and electricity market (Eskom, 2000)

Of the total electricity generated, 91% (1999) is derived from coal (National Electricity Regulator, 2000a). Eskom consumed 88.5 million tonnes of coal in 1999, generating 181 818 GWh of electricity (Eskom, 1999). It owns and operates ten coal-fired power stations, situated near the coal fields; one nuclear power station in Koeberg, situated some 50 km north of Cape Town; two pumped-storage stations, one in the Drakensberg and one in the Western Cape; two hydro-electric stations on the Orange River, at the Gariep and Van der Kloof dams, and a number of small hydro-electric power stations in the Eastern Cape, wind farm in the Western Cape.

Eskom is, at present, the world's fourth largest producer of electricity, with a total nominal generating capacity of 40 584 MW. The peak demand in 1999 was 27 813 MW. With the demand forecasted to grow at 4.2% per year, this capacity will be fully utilised by the year 2007.

Nuclear energy is the second largest source of electric energy contributing 6.8% of the country's electricity generation capacity and 3% of the primary energy supply.

Gas provides approximately 1.6% of South Africa's primary energy. South Africa's known natural gas reserves are 33 billion cubic metres, most of which are found in the off-shore gas fields, south of Mossel Bay. A portion of the synthetic gas produced from coal through the synthetic fuel process is extracted and sold as pipeline gas. More significant gas fields have been discovered in countries neighbouring South Africa. The Kudu gas field, off the Namibian coast, is estimated to contain a potential of 7 700 PJ, and the reserves of the Pande gas field, off Mozambique, 2 500 PJ (Southern African Development Community, 1995).

Renewable energy accounts for approximately 5.5% of South Africa's primary energy resources (Figure 1.4). The rural population has limited access to electricity and utilise biomass, particularly wood and coal as their primary energy source. Although waste biomass is burnt to generate electrical energy in some agro-processing industries, this constitutes less than 1% of the total electrical energy used.

1.7 Industry Profile

South Africa's trade and industrial policy is in a process of fundamental change, moving away from a highly protected, inward-looking economy towards an internationally competitive economy that capitalises on the country's competitive advantages. The government's Growth, Employment and Redistribution (GEAR) macro economic strategy aims to achieve a balance between greater openness and improvement in local competitiveness, whilst engaging in a process of industrial restructuring to expand employment opportunities and improve productive capacity.

Despite the move towards increased beneficiation of mineral resources, mining is still the single most important earner of foreign exchange in the economy. For example, the outlook for the platinum group metals market is very positive. South Africa is the world's largest producer of platinum, having accounted for 75% of platinum and 25% of palladium supply in 1997. Demand for platinum rose to 162 tonnes during that year and growth of about 2% per annum is forecast (DME, 2000a).

One of South Africa's key industrial policies is its commitment to fostering sustainable industrial development in areas where poverty and unemployment are at their highest. This objective is operationalised through Spatial Development Initiatives (SDI), which focus high-level support on areas where socio-economic conditions require government assistance and where inherent economic potential exists. The SDI programmes focus government attention across the various national, provincial and local government spheres to ensure that investments are fast-tracked and that synergies between various types of investments are maximised.

The contribution of the different manufacturing sub-sectors to the total manufacturing production is shown in table 1.3.

Table 1.3: Percentage contribution of the different manufacturing sub-sectors to the total manufacturing production (1995 base year)

Manufacturing Divisions	Percentage
Food, food products, beverages	15.3
Basic chemicals and other chemical products	10.7
Motor vehicles; trailers; parts and accessories	8.0
Basic iron and steel products	7.6
Fabricated metal products	7.0
Textiles & clothing	6.5
Total machinery and equipment	5.8
Paper and paper products	5.3
Rubber and plastic products	4.5
Coke and refined petroleum products	4.2
Total publishing and printing	4.1
Other non-metallic minerals products	3.5
Electrical machinery, apparatus	3.4
Basic precious and non-ferrous metal products	3.2
Other manufacturing industries	2.6
Wood and products of wood	1.9
Furniture	1.6
Leather footwear	1.3
Glass and glass products	1.0
Radio, television and communication apparatus	1.0
Other transport equipment	1.0
Professional equipment	0.5

Although relatively small by international standards, the chemical industry is a significant contributor to the South African economy. At present the industry is undergoing considerable change, and is moving away from its traditional base of supplying the local market with commodity chemicals to looking for export opportunities in value-added speciality chemicals. Annual production of primary and secondary process chemicals is of the order of 13 million tonnes with a value of around 18 billion Rand. Both imports and exports are between 3 million and 4 million tonnes per annum, but the value of imports at about 9 billion Rand is nearly twice that of exports.

Significant expansions have taken place in the steel, aluminium and ferrochrome sectors during the period 1994 to 1998. Ferrochrome production more than doubled to approximately 2 million tonnes per annum; aluminium production increased from 166 thousand tonnes per annum to 675 thousand tonnes with the expansion of the plants at Bayside and Hillside. Steel production has significantly increases at Iscor (a 40% increase in 1999 to approximately 7 494 thousand tonnes), Columbus Stainless Steel (a 15% increase over the year 1999 to approximately 422 thousand tonnes), and Saldanha, which is currently at 75% production of 691 thousand tonnes per annum.

South Africa has a wealth and diversity of tourism products, especially eco-tourism and cultural attractions. Tourism is the fourth largest industry in South Africa, which resulted in more than 737 600 job opportunities in 1998. The fastest growing segment of the tourism industry is eco-tourism, which involves ecological experiences such as bird watching and botanical tours.

1.8 Transport Profile

South Africa’s transport system plays a key role in the national economy, as well as in the economy of neighbouring African states.

Over the past 20 years there has been a long-term decline in the investment in roads. A backlog in the provision of infrastructure has therefore arisen, particularly in rural areas, and to a lesser extent in urban areas. Toll financing was introduced in 1980 to supplement the financing of selected inter-city roads.

In South Africa there is both a public and a private transport system. The public transport system is largely a commuter system with traditionally low levels of service. This system uses minibus taxis, buses and trains, whereas the private transport is usually by motor vehicle.

Airline transport is also well developed in South Africa. An increase in international traffic occurred following South Africa’s democratic elections in 1994. At present there are over 30 national airports and three international airports operating in South Africa. Major upgrades at the Johannesburg, Cape Town and Durban International Airports are currently underway.

1.8.1 Road transport

The rate of growth of the number of motor vehicles has exceeded the rate of human population growth since 1970. The motor vehicle numbers have increased on average by 4.1% per annum over the period 1970 to 1980, during which time the population grew at an average of 2.8% per annum. The total estimated number of vehicles registered in South Africa since 1990 is shown in Table 1.4.

Table 1.4: The estimated total number of motor vehicles in South Africa (Department of Transport, 1998; International Road Federation, 1999)

Year	Cars	Minibuses	Commercial Vehicles	Buses	Motorcycles	Total
1990	3 403 605	196 243	1 273 257	28 107	298 941	5 200 153
1991	3 489 947	208 256	1 303 995	28 545	294 006	5 324 749
1992	3 522 129	217 037	1 338 737	28 354	285 034	5 391 291
1996	3 838 000	230 300	1 222 000	29 900	262 000	5 582 200
1998	3 784 289	248 698	1 129 471	25 133	158 895	5 850 565

In 1998, of the 5.8 million vehicles on the road, 3.8 million were private cars. Minibus taxis have shown the greatest increase following the deregulation of the industry in 1989. Over the past two decades minibus taxis have captured more that 60 % of the commuter market. Due to the increase in the number of minibus taxis, the demand for buses has not increased. The government has developed initiatives to formalise the industry, which include the replacement of the ageing 16-seater minibus fleet by more suitable 18- and 35-seater vehicles.

The deregulation of freight transport has led to an increase in the number of freight vehicles, particularly in the long-haul sector in which much traffic has switched from rail to road. On the other hand, due to high import duties, the use of motorcycles has declined.

An analysis of vehicles on the road indicated that the average age of cars has increased from 7.4 years in 1982 to 9.6 years in 1992. It has been estimated that the average age of cars on South African roads will be around 12.5 years old in the year 2000 (Van Zyl, 1989). The average age of minibus taxis is estimated to be approximately 9 years, while that of buses is estimated at more than 11 years. The increasing numbers of older vehicles on the road will have a significant impact on long-term fuel use and fuel emissions.

1.8.2 Rail Transport

In South Africa bulk rail freight operations are profitable, but general freight and main line passenger operations are not. Spoornet, the South Africa Railways Company, is currently restructuring, and is considering the commercialisation of some of its operations.

A separate business unit, Metrorail, was established in 1997 to operate suburban commuter trains in certain metropolitan centres.

1.8.3 Ports

South Africa has the largest and most efficient network of ports on the African continent. Portnet, a division of Transnet Limited, is the largest port authority in South Africa, controlling seven of the sixteen biggest ports. The ports of Richards Bay, Durban, East London, Port Elizabeth, Mossel Bay, Cape Town and Saldanha are the main commercial ports for South Africa’s imports and exports. Over 139 262 tonnes of cargo is handled by these ports every year (South African Handbook, 1999). Richards Bay port was developed primarily to handle cargoes such as bitumous coal and anthracite. The busiest port is Durban, which handles more than 70% of South Africa's containerised traffic.

1.8.4 Aviation

Domestic air transport was deregulated in terms of the Air Services Licensing Act of 1990 and the Aviation Amendment Act of 1992. Other airlines started to compete with the national carrier, South African Airways (SAA), which is the largest airline in Africa, primarily for domestic air travel. International air traffic is also increasing with the concomitant increased consumption of aviation fuel. The deregulation of long distance road coach services resulted in increased competition between air and road transport.

1.9 Profile of Agriculture and Forestry

1.9.1 Agriculture

The recently completed South African National Land Cover Data Set estimates the largest land use to be agriculture. Agriculture uses 86% of the land (mostly natural veld) of which 13% is used for cultivation of crops and 2.5 % for settlements. However, due to the increasing population and other land uses, the agricultural land available per capita of the population is significantly decreasing. In 1970 there was 0.86 hectares of agricultural land available per person in South Africa, 0.5 hectares per capita in 1980, and it is estimated that it will further decrease to 0.2 hectares per capita by the year 2020.

Approximately 8% of South Africa has been invaded by alien vegetation, and millions of hectares are affected by bush encroachment. The introduction of alien plant species has serious implications for water availability. South Africa's forestry plantations use about 3% per annum of the available surface water, while alien plants consume 7% of the available surface water per annum. Production pressures on agricultural land have resulted in the degradation of the vegetation and soil, and have rendered the land less fertile. 5% of the land has been affected by water erosion, and the average soil loss is 2.5 tonnes per hectare per year, with a maximum of 60 tonnes per hectare per year.

Agriculture contributes about 4.1% to the GDP and employs over 13% of the population. The agricultural industry in South Africa is divided into two sectors, namely the commercial sector and the predominately subsistence-oriented sector in the traditionally rural areas. Livestock is the most important contributor to the agricultural sector, generating 19.3 billion Rand per annum. Horticultural products generate 10 billion Rand per annum, with deciduous fruit and vegetables being the major contributor. Field crops, mainly maize, sugar cane and wheat, generate over 12 billion Rand per annum.

1.9.2 Forestry

South Africa has one of the largest man-made forestry resources in the world, utilising 1.5% of the cultivated land. In 1996/7 the total turnover for forestry was around 13.1 billion Rand and the industry employs more than 150 000 people. The exports are mainly converted, value-added products, with raw material exports only making up 1.8% of the total. The main products that are exported are pulp and paper (73% of the paper export), sawn lumber, wood chips and wattle extract. Some of the dominant trees used in the forestry industry include *Pinus patula, Pinus elliottii, Pinus taeda, Pinus radiata, Eucalyptus grandis, Eucalyptus saligna,* *Eucalyptus nitens and Acacia mearnsii*. The private sector currently owns 70% of the total plantation area, as well as virtually all the processing plants. The Department of Water Affairs and Forestry is currently involved in a process of restructuring the State's commercial forests and of transferring ownership of these forests to the private sector.

1.10 Water Resources

Due to the topography of the land, the natural availability of water is unevenly distributed across the country, with more than 60% of the river flow arising from only 20% of the land area. South Africa has very little groundwater as it is mainly underlain by hard rock formations. No major groundwater aquifers have been found that can be utilised on a national scale. The groundwater that is available is mostly used for agricultural purposes and rural water supply. Most metropolitan and industrial growth centres have developed around mineral deposits and harbour sites, which are remote from major river courses. This has resulted in water requirements exceeding the natural availability of water in several river catchments. Supply and needs therefore have to be balanced by large water resource development projects and the inter-basin transfer of water. Surface water resources are impounded and diverted not only within the country, but also through co-operation from adjacent countries.

A review of water availability in 1996 estimated that the total average annual surface runoff was 50 150 million cubic metres, the maximum potential annual system yield was 33 290 million cubic metres, and total water annual requirements were 20 045 million cubic metres. Water requirements could increase by about 50% by 2030 (DWAF, 2000a).

Water resources in South Africa are dependent on climate, demographics and the state of the economy. Careful planning of water resources is essential to mitigate low annual rates of rainfall, highly variable patterns of rainfall from one year to the next and low levels of water runoff. Contamination of water resources through industrialisation, urbanisation and a rapid population growth also has an adverse effect on water resources.

Management of South Africa's water resources has been achieved through the introduction and implementation of legislation, particularly during the second half of the 20th century. The National Water Act (Act 36 of 1998) provides the principles and legal framework for water resources management, within a framework of equitable access, beneficial utilisation and environmentally sustainable practices.

1.12 Air Quality Management

Air pollution is a problem in South Africa's urban areas due to the use of low-grade fuels for domestic needs. The problem is particularly severe in the Highveld region where this coal is used extensively. Due to severe nocturnal temperature inversions, the smoke does not disperse. This results in high ambient air pollution concentrations, which can endanger health. It has been found that exposure to particulate matter exceeds the World Health Organisation (WHO) standards of 180 $mg.m^{-3}$ by 6 to 7 times during winter months (Annegarn *et al*. 1996 a,b).

During the 1960's, the Government set up a network of routine air quality monitoring sites using simple methods to measure sulphur dioxide and particulate matter concentrations. These were mainly sited in urban areas, but not in the low income, high density, residential informal settlement areas that were not subject to the emission control measures introduced with the Clean Air Legislation in 1965 (Boegman *et al*., 1996). As a result, air pollution was shown to improve in those areas subjected to 'smokeless zone' regulations, but not in the unregulated areas. Most of the air quality monitors have now been decommissioned, as the methods are now considered ineffective.

Emissions from industry are subject to legislation and, in many cases, have been steadily improving over the years. Industry and local government have been initiating the use of modern continuously monitoring ambient air quality instrumentation. Plans are in place to improve the air quality monitoring network in order to obtain better air pollution and GHG gas emissions data.

At present there are 9 air pollution monitoring stations in South Africa managed by Eskom, which are strategically located in central Mpumalanga and the Vaal triangle to assess the long-term impacts from power stations and other sources, such as industrial, domestic, mining and agriculture, located in these regions.

The draft National Air Quality Management Bill is being developed. This Bill will replace the Atmospheric Pollution Prevention Act (APPA); Act No 45 of 1965. The bill seeks to enable authorities to control high levels of air pollution in the country more effectively.

1.13 Marine Resources

The South African coast has a high biodiversity, particularly along the eastern coastline. There are over 10 000 species of marine plants and animals in South African waters, which is almost 15% of global species, with 12% of the marine species being endemic to South Africa. The entire fishing industry, incorporating commercial, recreational and subsistence fishers is valued at 4.5 billion Rand. There is an increasing pressure placed on South Africa's marine resources, which causes problems such as over-fishing, pollution and poaching.

The draft Coastal Management Bill provides for important interventions to regulate, enhance, preserve and rehabilitate sensitive or overexploited coastal areas. It also ensures equitable access to South Africa's coastline and aligns South African legislation with international laws and conventions.

1.14 Biodiversity

South Africa is ranked third in the world in terms of biological diversity (DEAT, 1999a). It has a range of vegetation types, from arid shrubland and semi desert, through savanna and woodland to coastal forest and alpine forest. The Cape Floral Kingdom and the Succulent Karoo are internationally recognised biodiversity areas. The Cape Floral Kingdom covers only 4% of southern Africa, but is home to 45% or 9000 of the sub-continent's plant species (Goldblatt and Manning, 2000).

South Africa is home to an estimated 5.8% of the global total of mammal species, 8% of bird species, 4.6% of reptile species, 16% of marine fish species and 5.5% of the world's known insect species. In terms of the number of endemic species of mammals, birds, reptiles and amphibians, South Africa ranks as the fifth richest country in Africa and the twenty fourth richest in the world (DEAT, 1999a).

Conservation areas occupy only 6% of the available land area, with biodiversity being threatened due to increased demand for resources and ecosystem services. Virtually all ecosystems in South Africa have been modified or transformed by human activities. Some of the main challenges facing environmental conservation in South Africa are desertification, exploitation of natural resources, alien plant invasions, loss of biodiversity, and pollution. Some 3 435 (15%) South African plant species, 102 (14%) bird species, 72 (24%) reptiles, 17 (18%) amphibians, 90 (37%) mammals and 142 (22%) of butterfly species are at present under threat.

The current legislation governing the management of national protected areas, the National Parks Act (1976), is in many respects outdated. This is being replaced by the draft National Environmental Management: Protected Areas Bill. This bill aims to bring the system of protected area in line with the current constitutional and legal order, and with the policies and programmes of government. The bill provides for the protection and conservation of the ecologically viable area representative of South Africa's biological diversity and its natural landscapes and seascapes

The Biodiversity Bill, which is being prepared, aims to provide for the regulatory framework to ensure the implementation of the White Paper provides on the Conservation and Sustainable Use of South Africa's Biological Diversity, within the framework of the National Environmental Management Act. It covers the norms and standards for the conservation, sustainable use and equitable benefit sharing of South Africa's biological resources. It will also enable South Africa to honour its obligations under the relevant multilateral environmental agreements.

South Africa ratified the United Nations convention to Combat Desertification (UNCCD) in 1998 and will be developing a national action plan to implement the convention.

1.15 Antarctica

South Africa is one of the 26 countries with a presence on Antarctica. The Department of Environmental Affairs and Tourism has three research stations, which conduct weather research and study the impact of long-line fishing on seabird populations, krill distribution, and the impact of cosmic rays. The South African National Antarctic Programme (SANAP) funds these studies.

1.16 National Policy-making and Legislative Processes

Parliament is the national legislature whose main function is to promulgate legislation that pertains to national issues. Draft legislation is compiled by the relevant government departments in consultation with stakeholders. Involvement of stakeholders in policy making and the legislative process has significantly increased since 1994, after the first democratic elections in South Africa. A wide range of stakeholders comprising government departments at all levels, community based organisations, business and industry, mining, labour and non-governmental organisations, are extensively consulted and involved in environmental policy and legislation development.

The Constitution of the Republic of South Africa (Act 108 of 1996) states that the people of South Africa have the right to an environment that is not detrimental to human health, and imposes a duty on the state to promulgate legislation and to implement policies to ensure that this right is upheld. Steps taken to date to ensure the environmental right include; the publication of the Environmental Management Policy of South Africa (Department of Environmental Affairs and Tourism, 1998a); the White Paper on Integrated Pollution and Waste Management for South Africa (Department of Environmental Affairs and Tourism, 2000); the National Water Act (Act 36 of 1998); the National Waste Management Strategy for South Africa (Department of Environmental Affairs and Tourism, 1999b) and the National Environmental Management Act (Act 107 of 1998). The text of the Convention was published in the Government Gazette as part of South African law (Government Gazette, 1997).

The National Environmental Management Act (Act 107 of 1998) is an enabling act for government to meet its environmental responsibilities. The Act aims to improve environmental management while facilitating sustainable development and improving co-ordination and governance of environmental issues. More specifically this Act:

- Provides a framework for integrating environmental management into all developing activities.
- Establishes principles guiding the exercise of functions affecting the environment.
- Establishes procedures and institutions to facilitate and promote co-operative governance and inter-governmental relations.
- Establishes procedures and institutions to facilitate and promote public participation in environmental governance.
- Facilitates the enforcement of environmental laws by civil society.

National government is responsible for ensuring that effect is given to the provisions of the United Nations Frameworks Convention on Climate Change (UNFCCC). Many different government departments at all levels of government are be responsible for activities relevant to the Convention, and play a role in implementing climate change policy and providing information regarding the impact climate change on the sector or area for which they are responsible. To avoid fragmented administration of the Convention, the government has designated the Department of Environmental Affairs and Tourism to be the lead department responsible for co-ordination and the implementation of South Africa’s commitments in terms of the Convention. .

The National Committee on Climate Change (NCCC) was established to act as an advisory body to the Minister of Environmental Affairs and Tourism. Representatives from relevant government departments, as well as members representing business and industry, mining, labour, community based organisations and environmental non-governmental organisations constitute the NCCC. The functions of the NCCC include advising the Minister through the Director General of the Department of Environmental Affairs and Tourism on:

- Positions to be taken in international meetings, and preparation of the briefing papers.
- Legislation that may be required to give effect to the Convention.
- The allocation of international donor funding designated for climate change mitigation.
- The implementation of the Convention.
- The ratification and subsequent implementation of the Protocols.
- The impact of climate change considerations on sustainable development.
- The incorporation of climate change issues into government legislation and policies.
- Participation of South Africa on bilateral or multi-lateral UNFCCC initiatives or mechanisms.

1.17 Summarised Statistics

Table 1.5 below summarises the main statistics related to South Africa's national circumstances for the years 1994 and 1999 (Statistics SA, 2000).

Table 1.5 National Circumstances in 1994 and 1999

Criteria	1994	1999
Population (million)	38.6	43.1
Area	1 219 090 km^2	1 219 090 km^2
GDP	R482 119 million (equivalent to $135 819 million in 1994 dollar terms)	R801 114 million (equivalent to $131 330 million in 1999 dollar terms)
GDP per capita (nominal value)	R12 480 (equivalent to $3 516 in 1994 dollar terms)	R18 607 (equivalent to $ 3 045 in 1999 dollar terms)
Estimated share of the informal sector in the economy in GDP	7%	12%
Share of industry in GDP	34.6%	24.5%
Share of mining in GDP	n.a.	6.5%
Share of services in GDP	60.5%	64.9%
Share of agriculture in GDP	4.4 %	4.1 %
Land area used for agricultural purposes	81 862 km^2	82 210 km^2
Urban population	48.6%	53.7%
Livestock population	12 500 000 cattle 29 134 000 sheep	13 700 000 cattle 29 345 000 sheep
Forest area (Total)	1 365 939 km^2	1 509 610 km^2
Population in absolute poverty	n.a	50 %
Life expectancy at birth	61.5	55 years
Literacy rate (in mother-tongue)	62%	82%

2. NATIONAL INVENTORY OF GREENHOUSE GASES

2.1 Introduction

This chapter gives an overview of the inventory of greenhouse gas emissions in South Africa. The greenhouse gases addressed are carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O). The emission figures for the years 1990 and 1994 are presented according to the Intergovernmental Panel on Climate Change (IPCC) Guidelines (IPCC, 1996) for reporting the national greenhouse gas (GHG) emissions to ensure that the emission inventory is consistent and comparable across the sectors and Parties.

2.2 Inventory Methodology

In conformance with the IPCC Guidelines, the GHG emissions have been classified into the following categories:

- *Energy*: Total emission of all greenhouse gases from stationary and mobile energy activities (fuel combustion, as well as fugitive fuel emissions); Includes public electricity and heat production, petroleum refining, manufacture of solid fuels, other energy industries, manufacturing industries and construction, transport, commercial, residential, agricultural/forestry/fishing, as well as fugitive emissions from coal mining and oil and natural gas activities.
- *Industrial processes:* Emissions within this sector comprise by-product or fugitive emissions of greenhouse gases from industrial processes. Emissions from fuel combustion in industry are reported under *Energy*; Includes mineral products, chemical industry and metal production.
- *Agriculture:* All anthropogenic emissions from this sector except for fuel combustion emissions and sewage emissions, which are covered in *Energy* and *Waste*; Includes enteric fermentation, manure management, agricultural soils, prescribed burning of savannas and field burning of agricultural residues.
- *Land use change and forestry*: Total emissions from and removals by forest and land use change activities; Includes changes in forest and other woody biomass stocks, forest and grassland conversion, and emissions from and removals by soil.
- *Waste*: Total emissions from waste management; Includes solid waste disposal on land and wastewater treatment.

Emissions were calculated according to the activity data for each sector multiplied by emission factors. Where possible, emission factors appropriate to South African conditions have been used rather than the Intergovernmental Panel on Climate Change (IPCC) default factors. The IPCC reference approach (top down) and source consumption approach (bottom up) have been adopted in the compilation of the inventories. Bulk energy data has been sourced from the National Energy Balance database compiled by the Department of Minerals and Energy. Specific activity data was sourced from the relevant government departments, industries and industrial organisations, Eskom, and the Council for Scientific and Industrial Research.

Methane and nitrous oxide emissions were converted to carbon dioxide equivalents using global warming potentials (GWP). GWPs are conversion factors that are used to express the relative warming effects of the various greenhouse gases in terms of their carbon dioxide equivalents. The values for a 100 year timeframe have been used, which are equivalent to 21 for methane and 310 for nitrous oxide (IPCC, 1995).

For the purposes of this Initial National Communication, gases required in terms of the UNFCCC guidelines, namely CO_2, CH_4 and N_2O have been reported. The importance of also reporting hydrofluorocarbons, perfluorocarbons and sulphur hexafluoride, which are generated in the aluminium, minerals beneficiation and petrochemical industries in South Africa, is recognised and will be addressed in the future. It is also intended to collect and report data on carbon monoxide, nitrogen dioxide and non-methane volatile hydrocarbons in the future.

2.3 Total Emissions

This section presents an overview of the total emissions of the three greenhouse gases for the years 1990 and 1994. Table 2.1 provides an overview of the contributions of greenhouse gas emissions from each of the five IPCC categories (IPCC summary tables are presented in Appendix 1 and 2). The total emissions for 1990 were 347 346 Gg CO_2 equivalents and 379 842 Gg CO_2 equivalents for 1994.

Carbon dioxide emissions calculated according to the IPCC reference approach for the energy sector indicated a total of 325 301 Gg was emitted in 1990 and 324 920 Gg during 1994, compared to the sectoral calculations of 252 019 Gg for 1990 and 287 851 Gg for 1994. The improvement in the quality of the sectoral data collected for the 1994 inventory can be attributed to the establishment of an energy sector database by the DME in 1992, which presents data on the national energy consumption based on a sectoral breakdown.

The total emissions for each sector, calculated as carbon dioxide equivalents, are presented in Table 2.2. This shows that the energy sector contributes 260 886 Gg of GHG emissions, which represents 75% of the total emissions in 1990 and 297 564 Gg in 1994, representing 78%. Agriculture contributed 11.6% and 9.3%, industrial processes 8.9% and 8.0%, and waste 4.4% and 4.3% to the total emissions during 1990 and 1994 respectively.

Table 2.1: Greenhouse gas emissions of CO_2, CH_4 and N_2O in South Africa in 1990 and 1994

Greenhouse Gas Source	Greenhouse Gas Emissions (Gg)					
	CO_2		CH_4		N_2O	
	1990	1994	1990	1994	1990	1994
Energy	**252 019.05**	**287 850.96**	**346.96**	**375.70**	**5.10**	**5.88**
Energy Industries	159 114.62	167 816.64	0.52	0.47	2.76	2.61
Industry	47 026.25	53 186.34	5.64	6.15	0.74	0.78
Transport	30 941.18	42 716.69	8.63	10.58	1.36	1.88
Commercial	5 043.78	780.26	0.54	0.07	0.08	0.01
Residential	6 683.79	7 397.49	7.35	0.60	0.08	0.08
Agricultural/Forestry/Fishing	3 209.42	15 953.54	0.48	30.70	0.09	0.53
Fugitive Emissions			323.81	327.12		
Industrial Processes	**28 912.74**	**28 106.26**	**3.27**	**1.25**	**5.84**	**7.27**
Mineral Products	5 478.19	5 330.91				
Chemical Industry	1 658.81	1 952.10	3.27	1.25	5.84	7.27
Metal Production	21 775.73	20 823.26				
Agriculture			**1 014.45**	**937.41**	**61.84**	**50.89**
Enteric Fermentation			916.55	844.01		
Manure Management			83.42	78.47	1.40	0.07
Agricultural Soils					59.71	50.05
Savanna Burning			12.63	12.63	0.61	0.61
Agricultural Residues Burning			1.85	2.31	0.12	0.14
Land Use Change And Forestry	**-16 982.37**	**-18 615.97**				
Changes In Biomass Stocks	-13 640.99	-10 885.81				
Soil Removals	-3 341.38	-7 730.15				
Waste			**688.40**	**743.07**	**2.38**	**2.66**
Solid Waste On Land			669.27	721.74		
Wastewater Handling			19.13	21.33	2.38	2.66
International Bunkers	**7 195.41**	**10 219.71**				

Table 2.2: Aggregated emissions of CO_2, CH_4 and N_2O in South Africa in 1990 and 1994

Greenhouse Gas Source	Gg CO_2 Equivalent							
	CO_2		CH_4		N_2O		Aggregated	
	1990	1994	1990	1994	1990	1994	1990	1994
Energy	252 019	287 851	7 286	7 890	1 581	1 823	260 886	297 564
Industrial Processes	28 913	28 106	69	26	1 810	2 254	30 792	30 386
Agriculture			21 304	19 686	19 170	15 776	40 474	35 462
Waste			14 456	15 605	738	825	15 194	16 430
						Total	**347 346**	**379 842**

Table 2.3 and Figure 2.1 illustrate the relative contributions of the three greenhouse gases to the total during 1990 and 1994.

Table 2.3: Percentage contribution of CO_2, CH_4 and N_2O to the total GHG emissions in 1990 and 1994

Gas	Emissions (Gg)		CO_2 Equivalent (Gg)		Percentage of Total Emissions	
	1990	1994	1990	1994	1990	1994
CO_2	280 932	315 957	280 932	315 957	80.9	83.2
CH_4	2 053	2 057	43 113	43 207	12.4	11.4
N_2O	75	67	23 250	20 678	6.7	5.4
		Total	**347 295**	**379 842**	100	100

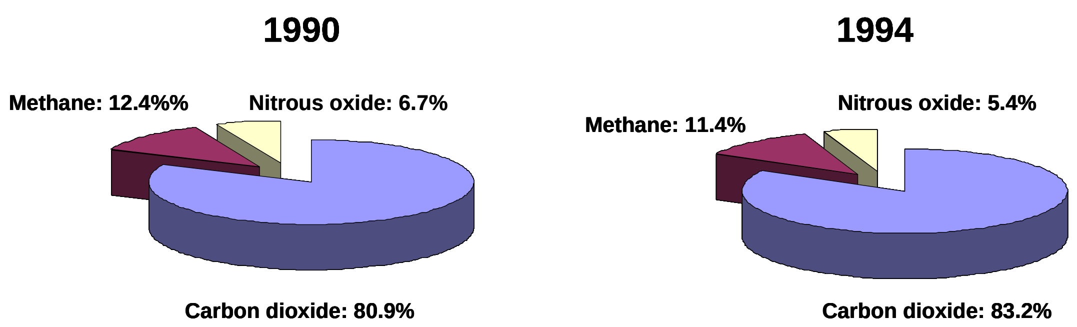


Figure 2.1: Percentage share in 1990 and 1994 of the three greenhouse gas emissions as CO_2 equivalents

2.4 Carbon Dioxide Emissions

Carbon dioxide is the most significant greenhouse gas for South Africa. It contributed more than 80% of the total of the three greenhouse gas emissions for both 1990 and 1994 (Table 2.3).

Primarily two sectors contribute to carbon dioxide emissions, namely the energy sector (electricity, other energy industries, industry, transport, commercial, residential and agriculture) and industrial processes sector (emissions from this sector are those generated in industrial processes but excluding emissions related to energy use). The main source of carbon dioxide emissions was from the energy sector, which generated 252 019 Gg of carbon dioxide or 89.7% of the total carbon dioxide emissions in 1990 and 287 851 Gg or 91.1% of the total carbon dioxide emissions in 1994. The high level of emissions from the energy sector relates to the high energy intensity of the South African economy, which is dependent on large scale primary extraction and processing, particularly in the mining and minerals beneficiation industries.

Emissions of carbon dioxide from the various activities are shown in Figure 2.2. The significant differences observed for the commercial and the agricultural sectors are due to the different energy consumption categories used during 1990, as compared to 1994. The reduction in emissions from other energy industries is ascribed to the reduction in liquid fuel production and autogeneration of electricity in the synthetic fuel industry. The small reduction in the emissions generated from industrial processes is mainly due to the reduced production of quicklime, steel and ferrochrome in 1994.

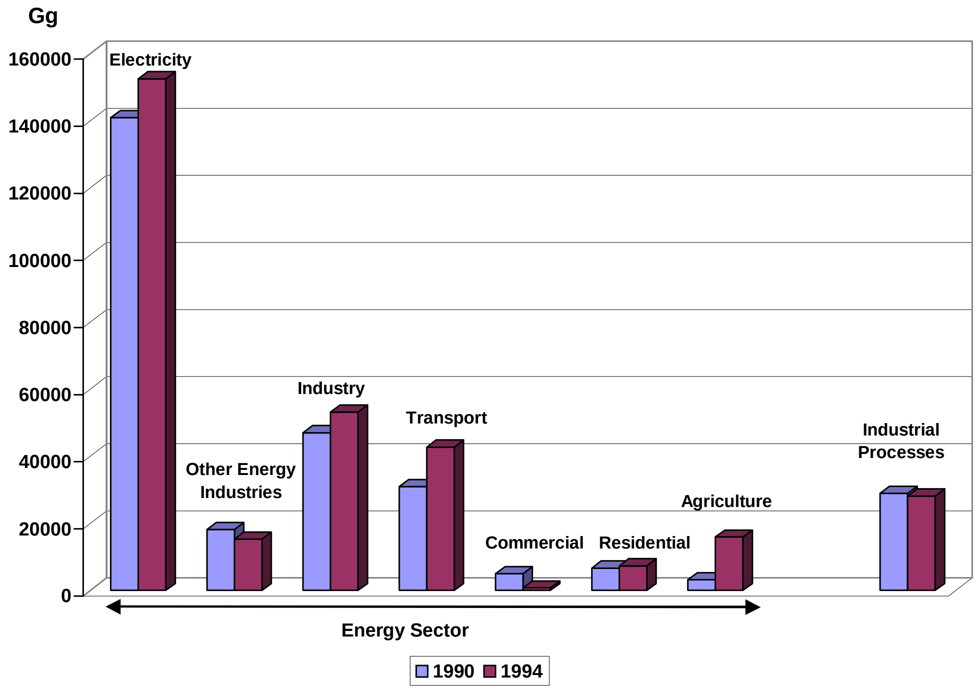


Figure 2.2: Sectoral CO_2 emissions in 1990 and 1994

2.4.1 Energy Sector

Table 2.4 indicates the carbon dioxide emissions from the different activities in the energy sector. The generation of electricity resulted in 140 952 Gg (1990) and 152 505 Gg (1994) of CO_2 being emitted, which represents 55.9% and 53.0% respectively of the total emissions from this sector. The energy consumed by the industrial sector accounts for about 18% of emissions.

Table 2.4: Carbon dioxide emissions from the energy sector in 1990 and 1994

Activity	CO_2 Emissions (Gg)		Percent of Total Emissions from the Energy Sector	
	1990	1994	1990	1994
Electricity	140 952	152 505	55.9	53.0
Other Energy Industries	18 163	15 312	7.2	5.3
Industries	47 026	53 186	18.7	18.5
Transport	30 941	42 717	12.3	14.8
Commercial	5 044	780	2.0	0.3
Residential	6 684	7 398	2.7	2.6
Agriculture	3 209	15 954	1.2	5.5
Total	**252 019**	**287 851**	100	100

The contribution made by the transport sector has increased from 30 941 Gg or 12 % in 1990 to 42 717 Gg tonnes or 14.8 % in 1994. This is attributed mainly to the increase in the number of minibus taxis since the deregulation of the industry in 1989 and the increase in the total number of vehicles on the road (Naude *et al.*, 2000). The deregulation of freight transport has also resulted in an increase in the number of freight vehicles, particularly for the long haul transport as traffic has switched from rail to road.

With the exception of the emissions factor for electricity generation, which was supplied by Eskom, IPCC default values have been used for these calculations. Eskom has conducted tests on approximately 80% of the boilers at its power station to calculate the quantity of carbon dioxide generated per tonne of coal that is burnt. An average value of 1.9 tonnes of carbon dioxide for each tonne of coal was measured for the year 1990 and 1.86 for 1994.

2.4.2 Industrial Processes

Carbon dioxide emissions from this sector have reduced slightly from 28 913 Gg in 1990 to 28 106 Gg in 1994. These represent 10.3% and 8.9% of the total carbon dioxide emissions, respectively. The contributions made to the total industrial processes emissions by the different industries are shown in Table 2.5. The most significant industrial contribution is from the production of iron and steel, which represents approximately 60% of the total industrial processes emissions. The other industrial processes that contribute significantly to carbon dioxide emissions include cement production, lime production, ammonia production and ferroalloys production.

Table 2.5: Contributions to carbon dioxide emissions from industrial processes in 1990 and 1994

Industry	Emissions			
	CO_2 Emissions (Gg)		Percent of Total Emissions from the Industrial Sector	
	1990	1994	1990	1994
Cement Production	3 931	3 952	13.6	14.1
Lime Production	1 489	1 306	5.2	4.7
Soda Ash Use	58	73	0.2	0.2
Ammonia Production	1 366	1 867	4.7	6.6
Calcium Carbide Production	293	85	1.0	0.3
Iron and Steel Production	18 489	18 035	63.9	64.2
Ferroalloys Production	3 038	2 540	10.5	9.0
Aluminium Production	249	249	0.9	0.9
Total	**28 913**	**28 106**	100	100

Emission factors determined by the industry for the South African situation were used for calculating the emissions from the production of aluminium and ammonia. For all other process emissions, IPCC default values were used. For aluminium and ammonia, on-site measurements have been made and mass balance calculations made across the process. Information from the aluminium industry indicates that the process emission factor of 1.5 tCO_2/t of aluminium produced should be used. Where ammonia is produced in the chemical processing plant in the synthetic fuel industry, emission values have been calculated to be 2.64 tCO_2/t ammonia produced in 1990 and 2.45 tCO_2/t in 1994.

2.4.3 Carbon Dioxide Sinks

The only significant sink for carbon dioxide in South Africa is through afforestation, and at present South Africa is undergoing net afforestation. The forestry industry has grown over the past two decades largely through expanded exports of woodchips, pulp and paper. At the same time domestic consumption of these products has grown very little. The expansion of plantations will be constrained by the competition for natural resources, as well as environmental and social constraints.

New afforestation has increased the total area of plantations by an average of 33 275 ha per year between 1990 and 1994. Although the trees are periodically felled, they are replaced by new forest stands that are efficient carbon sinks. In addition, harvested timber becomes incorporated into long-lived products such as construction timber. Natural woodlands cover about 7 000 Mha which is strictly conserved. The net uptake of carbon dioxide through afforestation activities has increased from 16 983 Gg in 1990 to 18 616 Gg in 1994.

2.5 Methane Emissions

The total methane emissions amounted to 2 053 Gg in 1990 and 2 057 Gg in 1994. In terms of carbon dioxide equivalents, methane emissions contributed 12.4% in 1990 and 11.4% in 1994 of the total greenhouse gas emissions. The main sources of methane were agriculture, energy (fugitive emissions) and waste. Information for a period of three years has been used for calculating emissions from the agricultural sector, as advised in the IPCC Guidelines to minimise the effect of climatic changes.

No methane emissions are ascribed to electricity generation. Measurements made at Eskom power stations have shown that methane gas is detected in the flue gas only on starting up or shutting down the boilers, and this could be attributed to the fuel oil used in the boilers.

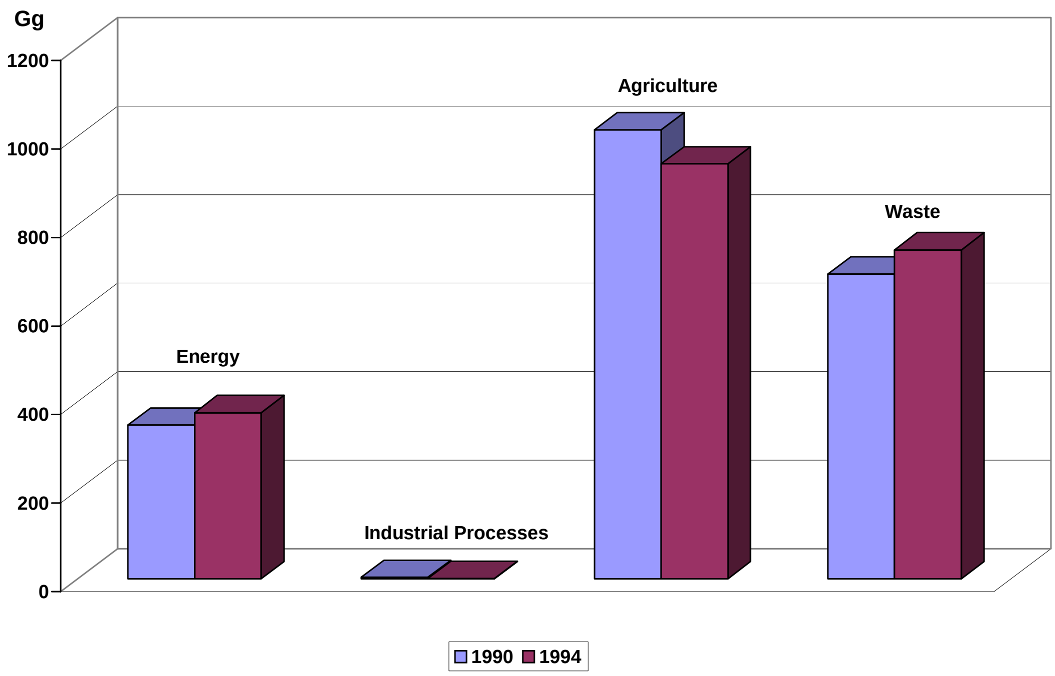


Figure 2.3: Sectoral methane emissions in 1990 and 1994

2.5.1 Agriculture

Enteric fermentation emissions from livestock were the largest contributor to methane emissions contributing 90% of the agricultural sector methane emissions and approximately 40% of the total methane emissions in South Africa. The most important and most numerous livestock types in South Africa are cattle and sheep. The cattle are kept in open range conditions where the quality of the diet is low, which results in higher methane emissions. South African methane emission values for cattle have been determined by the Agricultural Research Council. Values of 70 kgCH_4/head/year for dairy cattle and feedlot beef cattle and 50 kgCH_4/head/year for ranched beef cattle have been used for both the 1990 and 1994 inventories.

Emissions from the handling of manure are relatively low (approximately 8% of the agricultural sector emissions) since most of the animal waste is generated on semi-arid open ranges where it is exposed to the atmosphere and becomes desiccated.

The emissions generated from the burning of agricultural residues have been determined using field measurements. Methane emissions have been calculated to be 2.4 g CH_4/kg dry matter and nitrous oxide 0.15 g N_2O/kg dry matter.

2.5.2 Waste

Methane emissions from landfill sites and wastewater treatment facilities contributed 688 Gg of methane in 1990 and 743 Gg in 1994, which was approximately 33% of the total methane emissions.

Landfill site emissions were responsible for the majority of the waste sector's emissions, contributing about 97% of the total emissions from the waste sector. A waste disposal rate of 0.7 kg/capita/day has been assumed for both 1990 and 1994. The increase between the year 1990 and 1994 can be attributed to the extension of waste collection services to sectors of the population that previously did not receive adequate waste management services. The population receiving waste collection services has increased from 34 million in 1990 to 38 million in 1994. The proportion of waste disposed in managed landfill sites is estimated to be 0.57, 0.38 in unmanaged deep landfill sites and the remaining 0.05 in unmanaged shallow sites. The fraction of degradable organic carbon in the waste is estimated to be 0.167 for South African conditions. The methane that is recovered has increased from 4 Gg in 1990 to 29 Gg in 1994.

The population that is served by formal wastewater treatment facilities is estimated to be 18.3 million in 1990 and 20.4 million in 1994. The degradable organic component (BOD) of the wastewater is estimated to be 19.8 kg/capita/year and the fraction removed as sludge is 0.6. 82% of the wastewater is treated by the activated sludge process, 10% with biofilters, 1% in ponds and the remaining fraction is disposed of through sea outfalls. 80% of the sludge generated is treated by anaerobic digestion. Methane emission factors have been calculated to be 0.012 kg CH_4/kg BOD for the wastewater and 0.2 kg CH_4/kg BOD for the sludge. 26 Gg and 29 Gg of methane was recovered or flared for 1990 and 1994, respectively.

2.5.3 Energy Fugitive Emissions

Fugitive fuel emissions are those not related to combustion for energy, but fuel emissions that arise from emissions associated with production, transmission, storage and distribution of fuel, as well as from coal mining. In the energy sector, fugitive emissions contributed 323 Gg of methane in 1990 and 327 Gg in 1994, which represents about 16% of the total methane emissions. In 1990 methane emissions from coal mining contributed almost 100% of the fugitive emissions and 97% in 1994 when emissions from natural gas natural gas processing were included. Of the coal mining fugitive emissions, 88% were from underground mines.

Emission factors from coal mining activities have been developed for South African conditions. The tonnage of coal mined is multiplied by 1.00 in the case of open cast mines, 1.23 for longwall and stoping operations and 1.98 for bord and pillar operations.

2.6 Nitrous Oxide

The total nitrous oxide emissions were 75 Gg in 1990 and 67 Gg in 1994, which contributed to 6.7% and 5.5% of the total greenhouse gas emissions expressed in carbon dioxide equivalents for the years 1990 and 1994, respectively. The main contributor was the agricultural sector, which generated 82% of the total nitrous oxide emissions in 1990 and 76% in 1994.

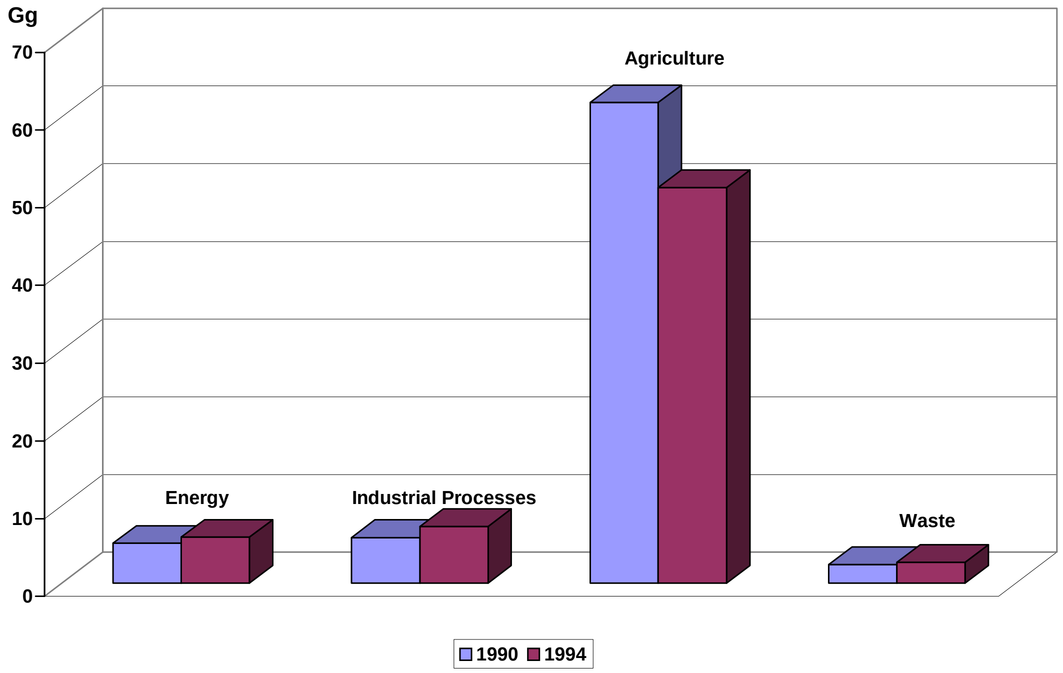


Figure 2.4: Sectoral nitrous oxide emissions in 1990 and 1994

2.6.1 Agriculture

Agricultural emissions accounted for 61.84 Gg of nitrous oxide in 1990 and 50.89 Gg in 1994. Emissions from agricultural soils due to the use of manure and synthetic fertiliser, as well as crop residues, accounted for about 96% of the agricultural emissions. Animal waste (manure) contributed half of the sector's emissions.

2.6.2 Industrial Processes

Nitrous oxide emissions are generated in the chemical industry during the production of nitric acid. During 1990, 5.84 Gg of nitrous oxide was generated and 7.27 Gg was generated in 1994, which contributed 7.8% and 10.9% respectively to the total nitrous oxide emissions.

2.6.3 Energy

Nitrous oxide emissions from the energy sector amounted to 5.10 Gg of nitrous oxide in 1990 and 5.88 Gg in 1994, which comprised 6.8% and 8.8% respectively of the total nitrous oxide emissions. The transport sector and electricity generation contributed about 75% of the energy sector emissions. In 1990, electricity production contributed 1.93 Gg of nitrous oxide and transport contributed 1.36 Gg. The emissions in 1994 increased to 1.95 Gg from electricity production and 1.88 Gg from the transport sector. Road transportation contributed to more than half of the transport sector emissions.

The emissions of nitrous oxide from electricity generation have not been accurately quantified and work is being conducted to establish appropriate emissions factors for South Africa.

2.6.4 Waste

Emissions are generated during the biological treatment of domestic sewage. The contribution from the waste sector to the total nitrous oxide emissions amounted to 3.2% in 1990 and 4% in 1994. Protein consumption is estimated to be 26 kg/capita/year.

3. VULNERABILITY AND ADAPTATION

Potential changes in climate may have significant effects on various sectors of South African society and the economy. In order to assess the possible effects of the changing climate, a study was undertaken through the South African Country Studies Programme. This study had the following objectives:

- to identify sectors and areas of highest vulnerability to climate change;
- to propose suitable adaptation measures to offset adverse consequences; and
- to synthesise the results of the vulnerability and adaptation studies across sectors for analysis by policy or mitigation initiatives.

Regional climate change scenarios were used in these investigations, which were developed using the Global Climate Model (GCM) simulation. The potential effects of a changed climate within 50 years and possible adaptation strategies were identified for the following sectors: human health; maize production; plant biodiversity; water resources; rangelands; and animal taxa.

3.1 Climate Scenarios

Global Climate Models (GCMs) are computer simulations of the global climate, atmospheric chemistry and oceanic circulation that are used to explore possible future climate scenarios of greenhouse gas emissions. At a local scale the predictions are still limited, but at a regional to global scale they predict the main features of the global climate with a reasonable degree of accuracy.

The three GCMs that were used in the climate scenario study were Genesis, an older model with simplified oceans; HadCM2, a coupled ocean-atmosphere model; and CSM, a recent generation fully coupled ocean-atmosphere model. The HadCM2 model has two options: firstly, the Hadley-no-sulphates option, which is considered to present the most pessimistic of outputs; and secondly, the Hadley-with-sulphates option, which assumes a reduction in sulphate emissions during the 21st century. For the most part, the HadCM2-no-sulphates was used in this study as it represents a worst case scenario for South Africa (Hewitson, 1999).

A set of high-resolution scenarios was created through the process of downscaling, which derived local climate response to the larger scale atmospheric dynamics. The methodology used regional and large-scale atmospheric dynamics with scale transfer functions derived from observational data, so that local scale climate data could be generated. Using the HadCM2-no-sulphates and the CSM models, the following changes to the South African climate within the next 50 years were predicted:

- A continental warming of between 1°C and 3°C, with the maximum focused on regions of aridity, and the minimum along the coastal regions.
- Broad reductions of approximately 5% to 10% of current rainfall.

- Increased summer rainfall in the northeast and the southwest, but a reduction of the duration of the summer rains in the northeast.
- Nominal increases in rainfall in the northeast during the winter season.
- Increased daily maximum temperatures in summer and autumn in the western half of the country.
- An extension of the summer season characteristics.

Some areas of the country may experience higher levels of change seasonally than others, with increased incidents of flood and drought. Air pollution will become a greater problem due to enhanced temperature inversions (Hewitson, 1999).

3.2 Health Sector

3.2.1 Vulnerability

General effects on human health of increased temperatures and changes in rainfall patterns include: an increase in the occurrence of strokes, skin rashes and dehydration, and an increase in the incidence of non-melanoma skin cancers. Indirectly, climate change affects also ecological systems: for example, incidents of diseases transmitted by water such as cholera may increase. Vector borne diseases may also be affected by changes in climatic conditions. The potential increased infection rates of malaria and shistosomiasis in South Africa were investigated in greater detail due to the potential significant impact of these diseases on public health.

3.2.1.1 Malaria

Malaria is the eleventh most frequent cause of death globally, claiming an estimated 856 000 lives each year (Murray and Lopez, 1997 and Craig and Sharp, 1999). It is believed that 90% of these deaths occur in sub-Saharan Africa, the greatest toll being on children below the age of five. Malaria is strongly affected by environmental factors, which influence the distribution, transmission intensity, outcome, small-scale variation and seasonality of the disease. Climate change in particular will affect malaria distribution. Drug resistance, which is becoming increasingly common, will exacerbate the problem (Craig and Sharp, 1999).

Climate is considered the most important factor in limiting malaria distribution on a global scale. The lower temperature limit for transmission is 18^{o}C and thermal death of mosquitoes occurs around 40 to 42 °C. In addition, 80 mm of rain is required for at least five months a year for stable transmission of the disease.

The projected climate change scenarios for South Africa will result in an extension of the malaria prone areas. There will be a greater number of people exposed to the risk of malaria for longer periods of time due to the increasing length of summer. Figure 3.1 illustrates the malaria risk areas, at present and in the future using the HadCM2 (no-sulphates and with-sulphates) models. According to the results of the modelling, the area of the country potentially prone to malaria will more than double in the future. It is predicted that 7.8 million people will be at risk, with 5.2 million of these people not previously resident in malaria risk areas.

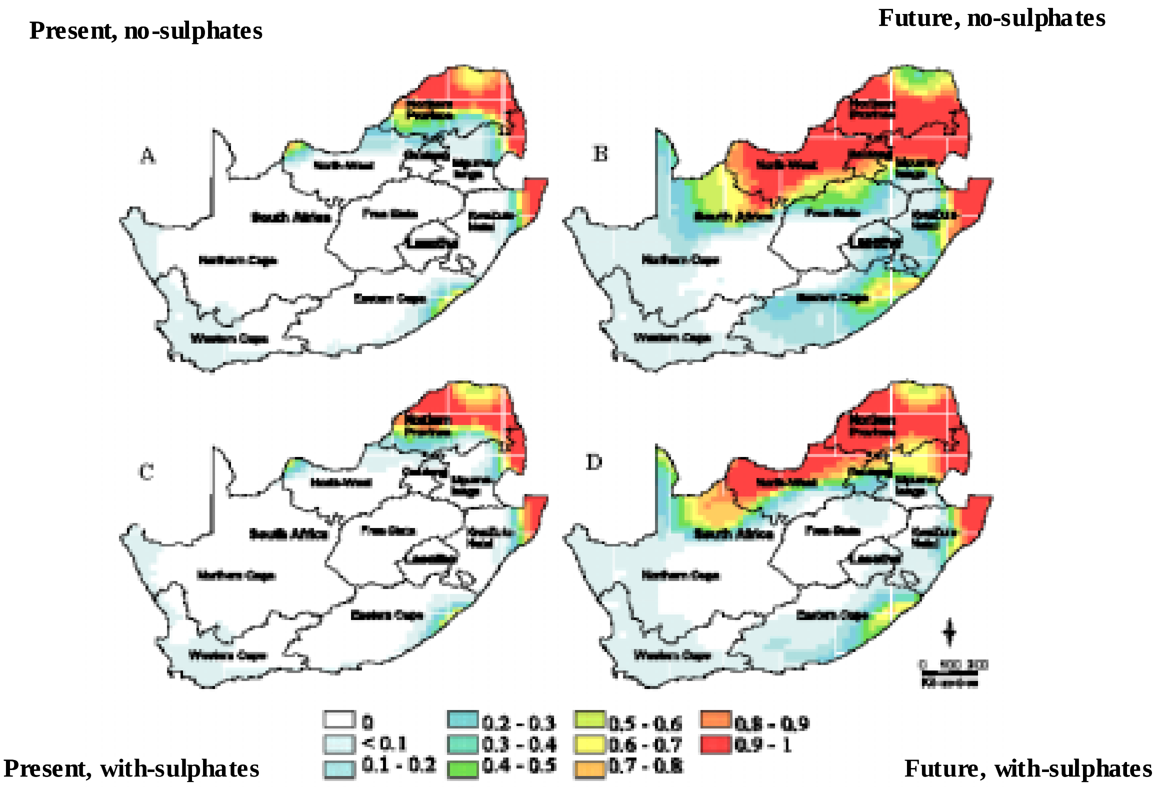


Figure 3.1: Malaria distribution models based on climate data from Hadley Centre climate models (Craig and Sharp, 1999)

The Malaria Information Systems Programme (Medical Research Council, 2000) currently monitors the spread of malaria in South Africa. To date malaria control in South Africa has been very successful, partly because the affected area is small in relation to the rest of the country and also because South Africa lies at the very edge of the malaria distribution area in Africa. Significant resources are currently being applied to implement control measures to limit the rates of infection. However, should the affected areas increase as predicted by the studies, the disease would become more difficult to manage, more people would be at risk and more resources would have to be used to address the problem. This is a particularly important consideration in view of the fact that due to increased resistance to alternative pesticides, South Africa has recently been forced to re-introduce the use of DDT for malaria vector control (Craig and Sharp, 1999).

3.2.1.2 Schistosomiasis

The parasitic disease, schistosomiasis or as it is more commonly known, bilharzia, is the second most prevalent disease in the developing world. It has been reported that 120 million people are symptomatic and 20 million people harbour severe infections (World Health

Organisation, 1998). Approximately 80% of the infected people in the world are from sub-Saharan Africa. The incidence of schistosomiasis in South Africa is difficult to quantify, as it is not a notifiable disease. Pitchford (1996a,b) reported that there were between 3 and 4 million people infected with one or more species of schistosome in South Africa in 1996. As with malaria, children are most at risk. Climatic factors affecting transmissions include temperature and to a lesser extent rainfall. The most optimal temperature for the survival of the schistosomoa parasite is 15°C and between 22°C and 27°C for the snail host.

The future climate change scenarios were obtained from the Genesis (GEN) and Climate System models (CSM). The data used for the models that were developed in this study, was sourced from the datasets of the present and future HadCM2 (no-sulphates and with-sulphates) models, as well as from the University of Natal (Schulze, 1997a), as these contained minimum and maximum temperatures, and monthly rainfall. Lesotho and Swaziland were included in the formulation of the models because of their impact upon the epidemiology of the disease in South Africa. Theoretical modelling using climate scenarios, suggests that as temperature increases occur a larger area of South Africa will be conducive to the transmission of schistosomoa and consequently a greater portion of the population will be at risk of infection. With the increases in unexpected weather phenomenon, for example flooding, the distribution of the snail host may increase, thus exacerbating the spread of the disease further. It has also been predicted that the potential for urinary schistosomiasis will exist in areas that are currently free of the disease, for example in the western region of the country.

3.2.2 Adaptation

Some measures are already in place to reduce the incidence of both malaria and schistosomiasis in South Africa. However an increased incidence as a result of high temperature and rainfall, would offset the success of these measures.

Although some monitoring and forecasting for disease warning systems are in place already, climate change needs to be considered in future prevention programmes and monitoring programmes. The use of bed nets and personal protection, which have proved successful in preventing mosquito bites, will have to be increased. Treatment facilities and prevention measures will need to be extended. Increased control of the areas affected by these diseases by the use of spraying programmes and other conventional control measures will also be required to combat the spread of the diseases.

The Community Water Supply and Sanitation (CWSS) projects currently being undertaken by the Department of Water Affairs and Forestry contribute to prevention of infection by schistosomiasis. However the goal of providing everyone with at least adequate basic water and sanitation will take many years to achieve (Moodley *et al.*, 1999).

3.3 Water Resources

3.3.1 Vulnerability

South Africa's rainfall is erratic in distribution and variable between years. Most of the country is arid and subject to droughts and floods. South Africa's industrial, domestic and agricultural users are highly dependent on reliable water supplies. Since water-supply infrastructure takes years to develop and is designed to last for decades, water resource planners need to consider the possibility of future climate change. Even without climate change, it is predicted that South Africa will have fully utilised its surface water resources by about 2030. A reduction in the amount or reliability of rainfall, or an increase in evaporation (due to higher temperatures) would exacerbate the lack of surface water resources. In order to determine the effect of climate change on South Africa's water resources the following predictive models were used CSM, Hadley (no-sulphates and with-sulphates) and Genesis (Schulze and Perks, 1999).

Results of the modelling studies indicate that climate change could have a significant effect on water resources. Changes in seasonal distribution and intensity of precipitation impact on storage of water in the soil, runoff processes and groundwater recharge, whilst temperature changes impact on evaporation rates. Increased temperatures will increase the atmospheric demand for water, and increase evaporation from soils and open water, and also result in higher transpiration rates from plants. The extent to which precipitation change will offset the increased evapo-transpiration rate is uncertain.

The arid and semi-arid regions, which cover nearly half of South Africa, are particularly sensitive to changes in precipitation because only a small fraction of rainfall is converted to runoff and the percolation to groundwater is small (Schulze, 1997b). Desertification, which is already a problem in South Africa, could be exacerbated as the climate changes. The seriousness of this problem is indicated by the fact that South Africa has ratified the Convention on Desertification. Equally important consequences of global warming are the potential changes in the intensity and seasonality of rainfall. Increased convective activity could increase the frequency and intensity of rainfall events, augmenting runoff volumes and potentially causing higher soil losses (Schulze, 1997b).

While some regions may receive more surface water flow, water scarcity, increased demand and water quality deterioration are very likely to be problems in the future both with or without climate change (Ringius *et al.*, 1996). Furthermore, climate change may alter the magnitude, timing and distribution of storms that produce flood events. The areas most sensitive to a change in precipitation are in the winter rainfall region. From the threshold study of runoff it may be concluded that a 10% decrease in runoff water could be experienced in the western areas of the country by the year 2015.

3.3.2 Adaptation

A number of adaptation options have been identified to limit the effect that climate change may have on water resources. These can be divided into strategic resource management issues, drought relief measures, design of water infrastructure and communication.

The comprehensive planning across river basins would allow for co-ordinated solutions to the problems of water quantity, water quality and water supply. Integrated planning would also seek to address the effects of population growth, economic growth, and the consequent changes in the supply of and demand for water. By marginally increasing the size of dams or changing the construction of canals, pipelines, pumping stations and storm-water drains better provision would be made for droughts and floods.

Water conservation measures would create a greater margin of safety against future predicted droughts. The demand for water may be reduced through a range of measures that encourage efficient water use, including: education in water conservation; voluntary compliance with water restrictions; amending pricing policies and strategies, such as the National Water Pricing Strategy (Section 56(1) of the National Water Act, Act 36 of 1998); legal restrictions on water–use; rationing of water; and the imposition of water conservation standards on specific technologies. By reducing water pollution, the water supply could be effectively increased, as would the safety margin for maintaining water supplies during droughts. By using market-based systems to allocate water supplies, water can be conserved since these systems can respond more rapidly to changing conditions of supply and favour lower demand.

Strategies such as short-term contingency planning to adapt to water shortages may be useful in mitigating the predicted effects of droughts. Schemes such as the inter-basin transfer of water would result in more efficient water-use under current, as well as changed climatic conditions. It would be beneficial in the long term to maintain options to develop new dams and to investigate new options. In order to have improved prediction mechanisms, the current monitoring and forecasting systems for droughts and floods would need to be improved. The public also needs to be made aware of water resource management issues and their importance. Programmes such as the Disaster Mitigation for Sustainable Livelihoods Programme, which educates communities on drought mitigation, would need to be promoted and encouraged in communities (Schulze and Perks, 1999).

3.4 Rangelands

Rangelands are defined as those natural and semi-natural ecosystems in which the husbandry of large herbivores is the principal economic activity. Rangelands occupy over 70% of the land surface in South Africa, making them the largest single land use.

3.4.1 Vulnerability

The climate change scenarios yielded by the Genesis, CSM and HadCM2 suggest a general aridification of rangelands over southern Africa. This is especially true of marginal rangelands. Predicted scenarios give increased annual mean temperatures of 2.5 - 3.5 °C by mid century, reduced rainfall, and somewhat altered rainfall seasonality in the arid Karoo fringe. Temperature, atmospheric CO_2 and rainfall are critical in forecasting the changes in vegetation structure and thus determining how the rangelands can be used. The predicted lower rainfall and higher air temperatures will affect fodder production and impact on the marginal costs of ranching. Ameliorating influences include the effect of an increased minimum temperature and the fertilising effect of higher atmospheric CO_2. Simulation studies have shown that no change would occur in the forage production potential over most of the grassland, since the drying effect of higher temperatures and lower rainfall would be compensated by the increase in the efficiency of water use due to elevated atmospheric CO_2 concentrations. Over the savanna regions in the northeast of the country, forage production may decrease by about one fifth, which would impact on the cattle ranching industry by reducing the national cattle herd by about 10%. Beef production would, however, not be affected to the same degree, as greater numbers of the beef herd are fattened in feedlots before being slaughtered.

Tree encroachment into the grassland areas is likely to increase due to the elevated global CO_2 concentrations and the increase in temperature. High intensity fires currently maintain the status quo, but increasing pressure to prevent fires is expected in terms of the Kyoto Protocol and the Convention on Persistent Organic Pollutants. A 2°C increase in temperature would increase average savanna fire intensities by 7%. With the predicted increase of grass fuel load of 15%, fire intensities are predicted to increase by about 20%. An increase or decrease in grass fuel load would have an essentially proportional effect on fire intensities; production increases of the order of 15%, as predicted, would raise fire intensities by a similar amount if the extra fuel were not grazed. A cumulative increase of around 20% will increase the fraction of tree biomass killed aboveground by fires by a similar proportion, but is unlikely to substantially affect woody plant demography.

3.4.2 Adaptation

Adaptation responses to climate change for the rangelands of South Africa are limited to a few options. An improved monitoring and forecasting system for fire hazard and droughts will assist and may be beneficial, even without climate change occurring. Specific intervention to adjust stocking rates are unlikely, since farmers already adjust their stocking rates in response to climatic and market conditions. Due to the declining C:N ratio in forage, as a result of the elevated CO_2 concentrations, it is possible that a wider use of nitrogen containing forage supplements may be needed. Although the use of feed supplements may increase livestock production and decrease methane emissions, there may be an increase in the net cost of animal production. Higher temperatures may favour those breeds that have a higher heat tolerance, for example *Bos indicus.* Climate change may also affect the frequency and spatial extent of livestock disease outbreaks, such as foot and mouth disease. Additional preventative measures, which would support existing restrictions, would be useful in controlling such diseases.

Alternative land use and a decreased dependency on ranching may be necessary to combat the effects of climate change on organised agriculture. Agricultural management practices that recognise drought as part of a highly variable climate, rather than a natural disaster, should be encouraged. Farmers should be provided with information on climatic conditions, and incentives should be given to those farmers who adopt sound practices of drought management, and therefore do not rely on drought relief funds. Planning programmes on land use planning can distinguish trends in land use that would be advantageous in the event of climate change (Scholes *et al.*, 1999).

Since natural disasters, such as fires, droughts and floods are predicted to occur more frequently under changed climatic conditions, the strengthening of the interim Disaster Management Centre, as highlighted in the National Disaster Management White Paper (1998), is recognised as essential.

3.5 Agriculture

3.5.1 Vulnerability

Of the many crops grown in South Africa, maize production contributed 71% to the grain production during the 1996 season and covers 58% of the cropping area. As the most significant crop in South Africa, maize was the only crop considered as part of this study.

Maize production in South Africa can be divided into two broad regions. The dry western areas contribute about 60% of the maize produced, and the wet eastern areas contribute the remaining 40%.

South African maize production is characterised by high variations in yield due mainly to fluctuations in seasonal precipitation. In order to determine the effect of climate change on South Africa's agricultural sector the following models were used: CSM, Hadley (no-sulphates and with-sulphates) and Genesis. To meet the increasing food demand, agriculture has to expand by approximately 3% annually. Under the climate scenario that predicts a hotter drier climate, maize production will decrease by approximately 10 to 20% (du Toit *et al.*,). Crop decreases will be most serious in the more marginal areas, although the higher production levels predicted in the east would possibly offset yield decreases in the marginal western regions.

Speciality crops grown in specific environmentally favourable areas may also be at risk, since both rainfall and temperature effects may cause changes in areas suitable for specialised production. Some of the negative crop growth effects may be mitigated by the "fertilisation effect" of CO_2 gas on plant physiology, although scientists are currently divided on the scale and sustainability of these benefits (Kiker, 1999). An increase in pests and diseases would also have a detrimental effect on the agricultural sector. In addition, invasive plants could possibly become a greater problem.

3.5.2 Adaptation

Adaptation measures will mainly focus on a change in agricultural management practices, such as a change in planting date, row spacing, planting density and cultivar choice, and other measures, which would counteract the effects of, limited moisture. Traditionally, irrigation is used to supplement low levels of precipitation; however, an irrigation demand of between 400 to 600 mm of water would be required in the western regions for optimum growth, with at least 60 mm thereof strategically applied to retain current dryland production outputs. Furthermore, the increasing scarcity of water resources might render irrigation an expensive and less effective use of water. Moving the production area eastwards may not be feasible, since the land in the higher moisture regions is usually more expensive and reserved for higher value crops. To reduce the risk of famine, marginal production areas could be kept economically viable by for example: decreasing input costs, planting drought resistant crops, such as sorghum or millet, or changing the land use to grazing.

Seed banks that maintain a variety of seed types that preserve biological diversity and provide farmers with an opportunity to diversify would counteract the effects of climate change, as well as establish possibilities for profitable specialisation. Development of more and better heat- and drought-resistant crops would help fulfil current and future national food demand by improving production efficiencies in marginal areas.

Many current agricultural practices, such as conservation tilling, furrow dyking, terracing, contouring, and planting vegetation as windbreaks, protect fields from water and wind erosion and assist in retaining moisture by reducing evaporation and increasing water infiltration. Management practices that reduce dependence on irrigation would reduce water consumption without reducing crop yields, and would allow for greater resiliency in adapting to future climate changes (du Toit *et al.,* 1999).

3.6 Forestry

3.6.1 Vulnerability

The South African forestry industry is highly sensitive to climate change. Currently, only 1.5% of the country is suitable for tree crops, and much of this area is relatively marginal. In addition to the effects of climate change, factors such as land availability, water demand, as well as environmental and socio-economic conditions will also affect the forestry sector (DWAF, 1997a). Shifts in the optimum tree growing areas could impact on the profitability of fixed capital investments, such as saw mills and pulp mills.

General aridification, due to lower rainfall and higher air temperatures, will affect the optimal areas for the country's major tree crop species, and impact on the marginal costs associated with planting in sub-optimal areas. The HadCM2-no-sulphates model was used in this study. Forest growth models suggest that there may be a substantial loss of production in the core area of current forestry, particularly in *Pinus patula* (Figure 3.2) and *Pinus radiata* plantations (Fairbanks and Scholes, 1999). This decrease in production would be detrimental to the planting of trees to serve as carbon sinks. Positive effects that would counteract the decrease in production would include the increased minimum temperatures and the fertilising effect of the higher atmospheric CO_2.

3.6.2 Adaptation

More temperature tolerant cultivars within the current tree species could be selected, but it is more probable that more lucrative uses for the land, such as sub-tropical fruits, may compete for the land currently under tree plantations. Genetic engineering could be used to develop more heat- and drought-resistant hybrids, which would allow the forestry industry to counter the threat of climate change and also to maintain current production areas.

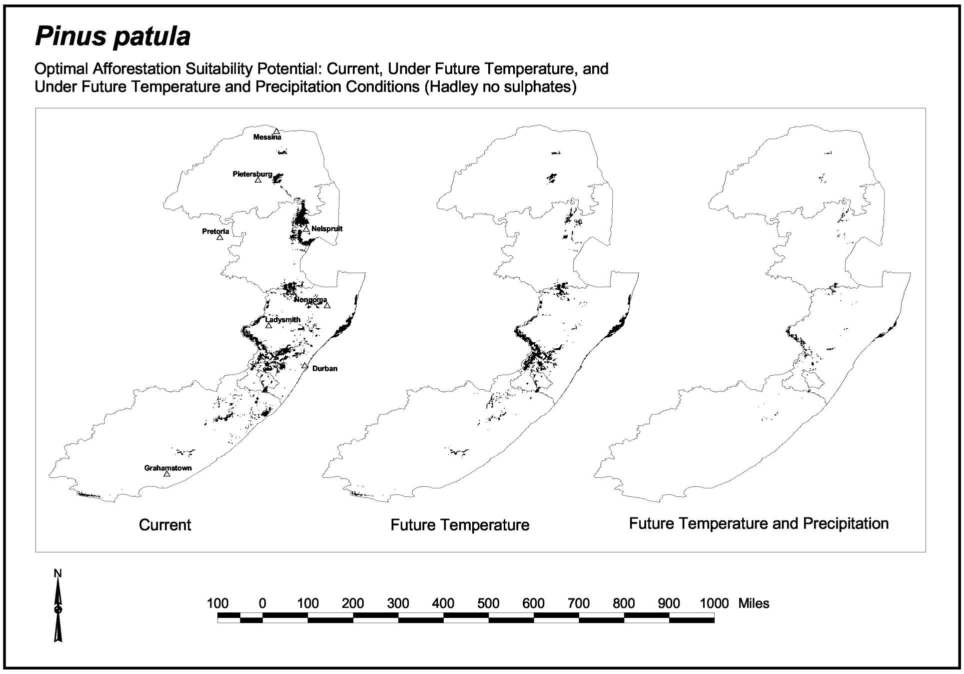


Figure 3.2: Current and future optimal areas for *Pinus patula* (Fairbanks and Scholes, 1999)

3.7 Biodiversity

Biodiversity is important for South Africa because of its importance in maintaining ecosystem functioning, its proven economic value for tourism and its role in supporting subsistence lifestyles. The global pharmaceutical industry has estimated that it could be losing a potential income of up to 1 200 million Rand per year with the extinction of each plant that has medicinal uses. It is expected that the combined effect of climate change, increasing human population and increasing per capita consumption, will result in major changes to biodiversity (Fairbanks and Scholes, 1999).

3.7.1 Plants

3.7.1.1 Vulnerability

In order to model future plant biodiversity changes under changed climatic conditions, the CSM and HadCM2 with-sulphates and no-sulphates models were used. The climate change scenario modelling indicates a reduction of the area covered by the current biomes by between 38 and 55% by the year 2050 (Figure 3.3).

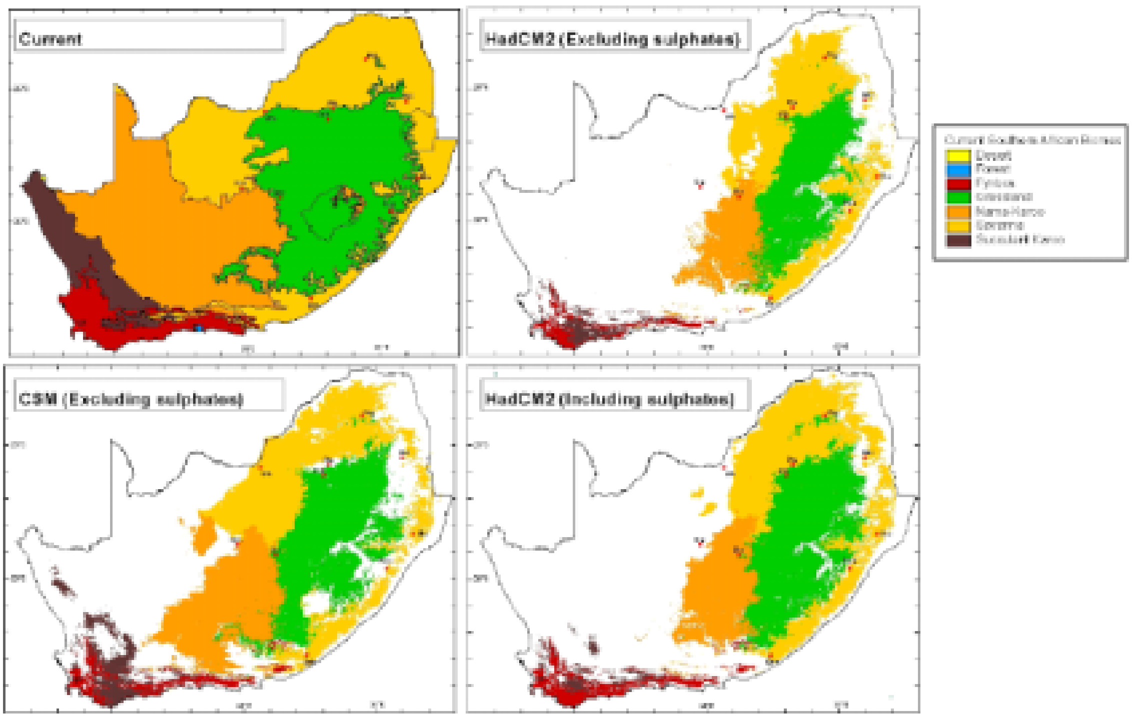


Figure 3.3: Current and potential distribution of South African biomes (Rutherford et al, 1999)

The largest losses are predicted to occur in the western, central and northern parts of the country. The southwestern area of the country is home to the Cape Floristic Kingdom – the smallest floral kingdom in the world. Species composition is expected to change, which may also lead to significant changes in the vegetation structure in some biomes. Of the 16 centres of endemism in South Africa, more than half are predicted to experience bioclimatic changes that will result in loss of species.

3.7.1.2 Adaptation

To maintain the current vegetation, the existing plant cover will have to be managed, since successful regeneration will become more difficult in some areas. Species that do not adapt to altered climatic conditions will become extinct. A biodiversity monitoring network of areas that combines areas at risk to future climate change with current high biodiversity and security of land tenure could be established in order to implement changes in the identified areas. A further recommendation to ameliorate the situation would be to identify and monitor a range of sensitive indicator species that would serve as flagship warning entities.

There is a strong motivation to extend the protected areas that are predicted to experience limited impact or to extend protected areas to adjacent land with high topographical relief, and thus to incorporate a range of micro-habitats. Climate change scenarios were a strong motivation for adopting the plan to extend the Greater Addo Park in the Eastern Cape. *Ex-situ* conservation and seedbanks are already important in South Africa and may become more important in the future as a means of propagating species. However, it will probably be impossible to conserve all species, necessitating the implementation of mechanisms to prioritise intervention. These mechanisms may include the development of a cost benefit-analysis based on considerations such as potential importance, genetic variation and uniqueness. For particular species, intensive rescue efforts might be warranted to the point where wild species are effectively "gardened". Conservation planning is required to ensure that a 10 percent conservation requirement is implemented for each vegetation type (Rutherford *et al.*, 1999).

3.7.2 Animal Taxa

3.7.2.1 Vulnerability

Species distribution changes were analysed for birds, mammals, reptiles, butterflies, and other invertebrates in South Africa. Climate modelling using the HadCM2 model with no sulphates predicted that most animal species would become increasingly concentrated in the proximity of the higher altitude eastern escarpment regions with significant losses in the arid regions of the country (Van Jaarsveld et al, 1999). Four species of the sample are predicted to become extinct. Of the 179 species examined, 30 species would expand their range, while 143 species showed range contractions (Figure 3.4). Of concern is the predicted expansion of insect pest species to areas that were previously cooler. Migrant insect pest species, such as the brown locust, may respond rapidly to climate change, and impact on agricultural activities. The efficacy of biological control agents for agricultural pests may increase or decrease, depending on the population dynamics of the control agents and range alterations.

3.7.2.2 Adaptation

As with future plant biodiversity, possible adaptation options for maintaining animal diversity could include the implementation of a conservation area network that would buffer the effects of climate change. The establishment of a species inventory and a distribution monitoring network would focus attention on potential detector species as a point of departure and highlight areas most likely to be susceptible to climate change (namely, the western arid zone and the escarpment areas). Land use practices and land use patterns outside conservation areas should be adapted to minimise the negative impacts of climate change on biodiversity conservation and/or future dispersal probabilities (Van Jaarsveld et al, 1999).

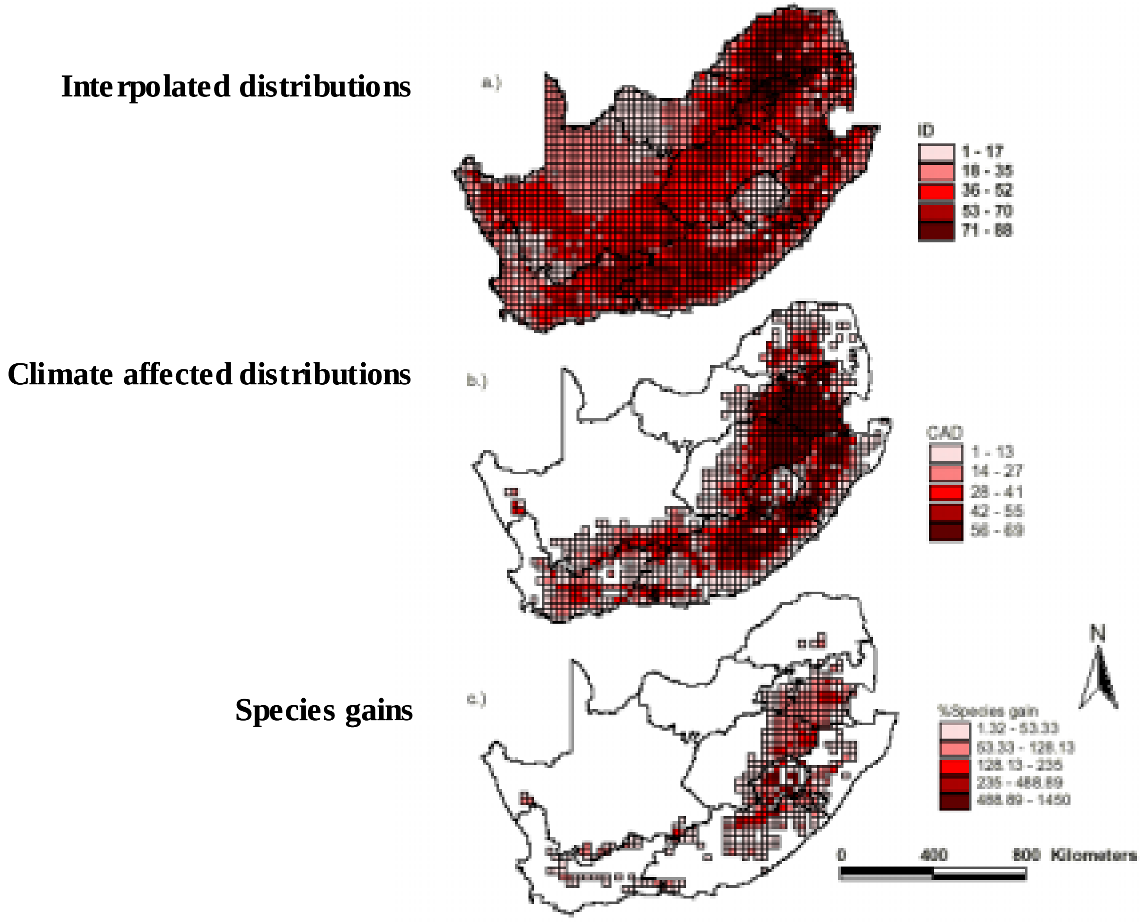


Figure 3.4: Species richness patterns (Van Jaarsveld *et al*., 1999)

3.7.3 Marine

3.7.3.1 Vulnerability

South African rocky shores are an ecologically and economically important coastal ecosystem. They support a wide range of marine organisms and are used for a broad range of activities including, recreational usage as well as subsistence and commercial exploitation (Branch *et al.*, 1981). The marine ecosystem is subject to pollution, over-exploitation and many other anthropogenic factors. The climatic model used in the study reported here was the fully coupled ocean atmospheric Climate System Model (CSM). Climate change studies have indicated that the predicted rise in sea level will not have a substantial effect on the marine biodiversity, although in extreme cases the zones of the rocky shores may be displaced and estuaries may be affected. However, the predicted rise in temperature would have an effect on the sea surface temperature and this would result in the migration of species residing along the coast. In addition, the changes in sea temperature may increase the intensity and frequency of upwelling events and cause alterations of nearshore currents, which are expected to have the most significant impact on South African rocky shores. The nutrient and larval supply to the coast would be effected and thus effect the community structures. Studies have indicated that there would be an increase in the occurrences of ‘red tide’ on the west coast (Clark *et al*., 1999). ‘Red tides’ are harmful blooms of algae which can cause mass mortalities of fish, shellfish, marine mammals, seabirds and other animals, and can result in illness and death in persons who eat contaminated seafood. In many cases the proliferation of the alga causes the water to be red in colour. Other predicted effects of climate change on marine ecosystems are changes in sand inundation on the eastern coast and an increase in storms which would accelerate the rate of disturbance events and favour short-living rather than long-living marine species.

3.7.3.2 Adaptation

The establishment of a biodiversity monitoring network would identify those species that will be impacted on by the climate change and may assist in the identification of species that could be used as indicator species (Clark *et al*., 1999).

3.8 Evaluation of Adaptation Measures

The first stage of this vulnerability and adaptation study comprised sectoral investigations to identify the potential effect of climate change and to formulate adaptation options. However, it is essential that these options are critically evaluated and integrated to ensure a co-ordinated response to climate change. Lack of adequate co-ordination and communication between sectors may result in groups/organisations taking action without consideration of other actions being implemented. For example: the forestry sector might require new higher altitude and cooler temperature sites for tree production, but expansion into these areas might conflict with the plans of water resources and biodiversity requirements, since stream flows might be reduced and areas of natural forest might be cleared.

The potentially most holistically effective adaptation measures need to be identified and studied for cost effectiveness, effectiveness in fulfilling policy goals and relative ease of implementation. A number of different approaches can be used to assess the effectiveness of the policy measures, including analyses of cost-benefit and cost-effectiveness. Any potential hindrances to successfully implementing the measures must also be identified, and an evaluation must be made of how to overcome these impediments. This activity has not yet been undertaken.

Two key cross-sectional adaptation options that link the various sectors have been identified, and proposed for consideration by government, namely:

- Improved National Disaster Co-ordination and Management
- Education and Raising Awareness on potential effects of climate change.

It is also important that potential climate change adaptation measures be integrated into existing strategies and legislative provisions already developed and implemented to address current environmental and socio-economic issues. Recently promulgated legislation, such as the National Water Act (Act 36 of 1998) and the National Environmental Management Act

(Act No. 107 of 1998) have provided the foundation to address potential climate change issues. Nonetheless, considerable further work needs to be conducted to ensure climate change issues are integrated into the planning activities of all relevant sectors.

3.9 Potential Impact of the Implementation of Response Measures

The impacts of the implementation of response measures by Annex 1 countries may have a significant impact on South Africa, particularly since South Africa's economy is highly dependent on income generated from the production, processing, export and consumption of coal.

In 1997 South Africa produced 243 million tonnes of coal, 70% of which was routed to domestic markets, while the remainder was exported. Ranked third in the world in coal exports since the mid 1980s, South Africa became the number two coal-exporting position in 1999. South Africa is also the world's largest producer of coal-based synthetic liquid fuels. In 1997, almost 20% of the coal consumed in South Africa was used to produce coal-based synthetic oil, which in turn accounted for approximately 30% of all liquid fuel consumed in South Africa during that year (DME, 2000b).

Since South Africa exports more than 80% of its exported coal to Annex 1 countries, it is clear that a reduction in the importation of coal by Annex 1 countries would lead to a profoundly negative impact on the South African economy. In addition, since 92% of South Africa's electricity is generated from coal-fired power stations this results in a high carbon intensity for energy intensive industries, such as mineral beneficiation, basic chemical manufacture and deep-shaft mining operations.

Conversely, South African exports of energy intensive products could actually increase, as production moves from the emissions-constrained Annex I countries to non-Annex I countries or as exports to other non-Annex I countries increase.

Investigations have recently been initiated to evaluate the potential impact of response measures in the South African economy.

4. SYSTEMATIC OBSERVATION AND RESEARCH

A number of monitoring programmes and research projects, which are closely related to the issues of climate change, are currently ongoing or under development. Furthermore, various government departments, private sector companies and research institutions are actively involved in projects to minimise the vulnerability of South Africa to climate change.

The programmes and projects presented in this chapter are being conducted in the fields of meteorology, agriculture, biodiversity, and energy and form part of the regional scientific initiative.

4.1 Meteorology

4.1.1 Monitoring

Currently, the South African Weather Services (SAWS) comprises 20 fully equipped weather offices, including stations on the Gough and Marion islands, as well as at the Antarctic Base, Sanae. A number of "drifting buoy" weather stations are also deployed by the SAWS every year in the Southern Atlantic Ocean. The station at Cape Point is the focal point for Global Atmosphere Watch activities in southern Africa, which include the monitoring and research of the ozone layer, solar radiation, as well as measurements of atmosphere trace gases. Since 1995, routine measurements have been made of ozone depleting gases, as well as UV-A and UV-B radiation.

A number of numerical weather prediction models are used to produce forecasts. The Weather Forecasting Research programme focuses on the consolidation of methods to evaluate weather forecast accuracy, including temperatures, rainfall and forecasts of severe weather.

4.1.2 Research Projects

A number of projects are currently being undertaken by the SAWS (in collaboration with the University of Pretoria) to improve the techniques of short-term weather forecasting. Forecasting methods are being consolidated to improve the accuracy of forecasts for flood management and severe weather occurrences. The Research Group for Seasonal Climate Studies is responsible for the development of techniques for the monthly and seasonal prediction of rainfall and temperature in the southern African region. This research will enhance the operation of dynamically based monthly and seasonal prediction models and further understanding of the underlying processes responsible for seasonal climate variability in the region. Another major aim is to promote closer interaction with the end-user in order to determine the usefulness of monthly and seasonal forecasts. Ongoing collaborative research on cloud seeding is being conducted to enhance rainfall from convective clouds, as well as to take airborne measurements of atmospheric particles that influence the climate of southern Africa.

4.2 Agriculture

4.2.1 Monitoring

The Agricultural Research Council's Institute for Soil, Climate and Water (ARC-ISCW), with funding from the National Department of Agriculture (NDA), is maintaining a number of databases that store and process climatic data and other related environmental parameters. These databases have generated information on the *status quo* of the natural resources of South Africa and provide a means for assessing the impact of climate change.

The *AgroMet database* stores climatic data collected at a number of monitoring stations located primarily in the agriculturally active areas of the country. Projects are currently being undertaken to generate spatial climate information for Geographic Information System (GIS) applications.

Since 1984, the *NOAA-AVHRR database* has monitored environmental parameters, such as: vegetation health, efficient use of rainfall, active bush fires and net primary production, both between and within seasons.

The *South African Land Cover database* has recently been completed and has used thematic mapping satellite imagery to develop a baseline inventory of land use for the years 1994 and 1995.

The *Soil and Terrain Inventory database* has documented the type of terrain of more than 95% of the country, with the remaining 5% to be documented by 2001.

4.2.2 Research

The NDA contracted the ISCW to undertake various climate related research projects that will assist the agricultural sector to minimise the effects of climate change.

A baseline database of land capability has been developed using information from the different databases. Current research on the suitability of land and potential crop production makes use of Automated Land Evaluation System software, and models the effect of a change in temperature and rainfall quantity and distribution. Specific models are being developed to investigate the effect of drought, veld degradation, and desertification in the Karoo and adjacent areas.

More effective water use in irrigation systems is being investigated and a number of irrigation models are being evaluated. A national standard for potential evaporation is also being developed as part of a project to promote good irrigation scheduling practices. A system is being developed to generate water saturation index values that can be combined with a vegetation index to indicate the status and severity of a drought. An ongoing project is investigating water harvesting techniques that would promote the conservation of rainfall. Projects are also underway to determine the most appropriate tillage practices for improving soil water storage, optimising water use and ultimately increasing crop yields.

A provisional carbon map has been compiled for South Africa that illustrates the organic carbon value of the soil. In Mpumalanga Province, this data has been grouped according to the current land use, in order to estimate possible carbon sequestration and accumulation under different cultivation practices and different ground cover.

Since the distribution and migration routes of the brown locust are influenced by climate conditions, an early warning system for brown locust outbreaks is currently under development.

4.3 Biodiversity

4.3.1 Research

The National Botanical Institute (NBI) is investigating the effects of elevated carbon dioxide levels, enhanced UV-B radiation, changes in water availability and altered incidence of frost on indigenous vegetation of southern Africa. These studies have concentrated on indigenous plants in the arid regions of South Africa, where the largest increases in UV-B radiation are expected to occur. Recently the study was extended to include agriculturally important seed legumes. A desertification programme is being conducted that involves a national assessment of the status of land degradation in South Africa, as well as a project on natural resource management in rural areas. Vegetation management research is ongoing in the Kruger National Park.

The South African Red Data Project, the SARSRES database and the Protea Atlas are also researching rare plants in South Africa.

Research on the effects of future climate change on animal diversity in South Africa is currently being undertaken by the University of Pretoria in collaboration with other organisations, such as the Avian Demography Unit, the Agricultural Research Council and various museums and universities.

4.4 Health

4.4.1 Monitoring

The Vector Borne Disease Unit, within the Department of Health develops policy and guidelines for the prevention and control of malaria. The unit oversees the monitoring, evaluation and surveillance of infectious diseases and co-operates with a number of national and international bodies e.g. World Health Organisation, universities, insecticide companies, pharmaceutical companies, as well as with neighbouring countries. Public awareness of such diseases is raised through an advisory service and the distribution of educational material.

The Department of Health is planning to implement an effective response mechanism for the identification and control of health epidemics at national, provincial and local government level. The effectiveness of the outbreak-response teams is to be facilitated through relevant training and international collaboration.

4.4.2 Research

The status of health research is updated regularly on a central database through ongoing monitoring and evaluation of health research. This database provides the government with information on which to base and determine research requirements.

The Medical Research Council (MRC) is currently undertaking research on the distribution of malaria. Malaria information is recorded and monitored and then put onto a GIS. The MRC is also compiling an atlas of the spatial epidemiology of malaria in Africa. Since the distribution and transmission intensity of malaria in Africa is not homogenous, this atlas will support the planning and implementation of research into, and control of, malaria in any given region. In order to monitor the spread of malaria, a malaria information system has been established to capture the required data and convert it into a workable format. Maps developed from the malaria models have been integrated with other data sets, such as administrative structures and population boundaries that can be used by government, donors, researchers and international agencies as a basis for strategic planning for malaria control. Research on insects and insect repellents is also being undertaken.

As a mechanism to combat the potential for increased infection rates of schistosomiasis, research is currently ongoing on the biological control of snails by replacement with competitor snail species and the use of molluscicidal plant species.

4.5 Energy projects

A number of projects are being conducted to investigate the potential for renewable sources of energy and the use of energy efficiency mechanisms. These projects include:

The South African Efficient Lighting Initiative (ELI-RSA) undertaken by Eskom is ongoing and promotes the use of efficient lighting systems to reduce the greenhouse gas emissions.

Eskom, in conjunction with DANCED, is undertaking a *wind energy resource assessment* to pilot a 10 MW test site and to evaluate the associated potential reductions in emissions.

Eskom has undertaken various feasibility studies, including a resource assessment, to construct a *100 MW Solar Thermal pilot plant*.

The South African Bulk Renewable Energy Generation (SABRE-Gen) programme was initiated in 1998 by Eskom. The ultimate objective of the programme is to evaluate the viability of renewable electricity generation as a source of electricity at a utility scale. The programme has four components, namely: bio-energy, solar thermal energy, wave energy and wind energy.

The SABRE Gen Solar Thermal Electric (STE) project at Eskom is aimed at the evaluation and assessment of STE technologies for possible implementation in South and southern Africa. The main component of the STE programme is the Concentrated Solar Power Africa study which is evaluating the possible introduction of STE technologies in southern Africa.

The Department of Minerals and Energy (DME), in collaboration with stakeholders, has completed an investigation into the energy efficiency potential of and guidelines for effective energy use in office buildings. This investigation resulted in the development of an *Energy and Demand Efficiency Standard/Guideline (SAEDES)* for new as well as existing non-residential buildings. An energy efficiency database has been developed, which will be used to evaluate and measure the success of energy efficiency programmes.

The Sustainable Energy, Environment and Development (SEED) Programme is developing low-cost housing that is designed to optimise energy efficiency; and the installation of solar panels in the homes of previously disadvantaged communities in the rural areas, where the cost of extending the national electricity grid is prohibitive.

A Biomass Initiative project has been undertaken to address the problem of supplying energy to rural areas where fuelwood, which is an unsustainable source of energy, is the main source of energy. A study was conducted in collaboration with the Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ) on the use of solar cookers. The pilot studies were successful and the project has moved into the next phase involving raising community awareness of the solar cooker and the commercial pilot dissemination of the cooker. The utilisation of the woodstove, already piloted in Kenya, is being investigated.

The Department of Minerals and Energy has initiated *a project to look at the threats and opportunities of the implementation of the UNFCCC and Kyoto Protocol*. This project will include an investigation of the impacts of response measures on the South African energy economy, as well as energy sector opportunities for Clean Development Mechanism projects.

The SABRE Gen Wind project investigates the potential of using wind energy for bulk electricity generation in South Africa. This project focuses on understanding the implications of using wind energy on a large scale in an African environment, determining the most suitable applications for wind energy and investigating the sustainability of wind energy in an African environment.

The South-south-north (SSN) project is an experimental collaboration between four southern countries (Brazil, South Africa, Bangladesh and Indonesia) and the Netherlands to identify, design and transact a number of pilot CDM projects that can be implemented quickly.

The University of the Witwatersrand and the University of Pretoria, together with consultants have undertaken *an assessment of the economics of energy efficient housing technologies for low-income housing*, including their impacts on GHG emissions.

4.6 Industry

Industry is currently facing the challenge of limiting environmental impacts while ensuring the environmental and economic sustainability of their ventures. A number of government incentives and support schemes, such as the Cleaner Production Scheme, have been established by the Department of Trade and Industry (DTI) to promote the development and implementation of environmentally friendly technologies.

Organisations that represent industry, such as the Chemical and Allied Industries' Association (CAIA) and the Industrial Environmental Forum (IEF), have developed management practices standards for their members that aim to improve environmental performance and raise awareness of the need for effective environmental management. The CAIA is currently engaged in facilitating the conclusion of an Environmental Management Co-operation Agreement between the chemical industry and the government that will address air quality management, water conservation and waste management. It is intended to extend this Agreement to include energy efficiency at a later stage.

The Fund for Research into Development, Growth and Equity has initiated a project to evaluate the potential economic impact on the South African economy of emission reduction policies in Annex 1 countries.

Eskom currently has a global and regional climate research portfolio that looks specifically at local and regional climate issues, such as trajectory transboundary analysis, rainfall forecasting and climate modelling.

4.7 Other Research Projects

4.7.1 SAFARI Project

The Southern African Regional Science Initiative (SAFARI) was initiated in July 1999 with the aim of understanding the linkages between emissions from both natural and anthropogenic sources, as well as the emissions transport mechanisms for the sub-continent, and the impact of emissions on the environment (SAFARI, 2000). Measurements taken by remote-sensing aircraft will be complemented by ground-based measurements of land surface characteristics and atmospheric constituents. The outputs from the project will include: a database of all known emissions in the region of several key pollutants; models that will predict the movement of the pollutants and how these pollutants are chemically altered in the atmosphere; and a fundamental understanding of land-atmosphere processes.

This project will assist local researchers' understanding of the effect of global climate change on the region, as well as delineating the potential impacts of multilateral environmental treaties on the region. Regional scientists will also acquire enhanced capacity and experience and benefit from the transfer of technology.

The major funding agencies of the project include, the National Aeronautical and Space Agency (NASA), the Department of Arts, Culture, Science and Technology, the Department of Trade and Industry, the National Science Foundation, the National Research Foundation, the South African Weather Services and Eskom.

4.7.2 Capacity Building

The Global Environmental Forum (GEF) Council approved the Capacity Development Initiative (CDI) in order to better understand the needs of developing countries and countries with economies in transition. The initiative is an 18-month consultative planning process, which will result in a comprehensive strategy and multi-year operations-oriented action plans to assist these countries to strengthen their capacity to address global environmental concerns so as to act both strategically and in terms of implementation of capacity building programmes comprehensively. The CDI is being developed through a strategic partnership between the United Nations Development Programme (UNDP) and GEF Secretariat.

As part of this initiative, a report has been compiled of the current status of capacity development in South Africa and the needs of the various stakeholders to undertake activities in response to the global problem of Climate Change.

5. EDUCATION, TRAINING AND PUBLIC AWARENESS

The United Nations Framework Convention on Climate Change emphasises the principle of participation by stakeholders in activities and processes related to climate change. As a Party to the Convention, South Africa is committed to building local capacity on climate change. This principle of participation is endorsed by, as well as being currently implemented in South African environmental policies, for example, the National Environmental Management Act and the National Water Act. As a result, in some instances the processes and structures required for public participation may already exist.

Education, training and raising public awareness of issues related to climate change will:

- Increase awareness of the need to develop and implement strategies to alleviate the potentially adverse impacts of climate change, such as the risk of floods, droughts and the spread of diseases, both locally and regionally.
- Enable the public to participate effectively in climate change processes.
- Contribute to the ability of civil society to exercise choices over matters that affect climate change.
- Ultimately assist the government in meeting its commitments through social co-operation and partnerships.
- Reduce negative economic impacts that may occur as a result of meeting commitments, such as reducing the need to re-train persons when employment changes are required.

5.1 Current Capacity

Although the Department of Environmental Affairs and Tourism (DEAT) is the national focal point for climate change, government as a whole is responsible for fulfilment of obligations under the Convention. The obligations and capacity requirements of the government in this regard for dealing with issues relating to climate change are summarised in Table 5.1.

DEAT's Directorate of Global Climate Change and Ozone Layer Protection is tasked with the responsibilities associated with the climate change focal point. A number of Directorates with associated responsibilities, for example air quality management, as well as the Environmental Capacity Building Unit, provide support functions to assist DEAT in fulfilling its obligations and also contribute to addressing environmental climate change issues.

Table 5.1: Government obligations and capacity requirements with regard to climate change

Obligation	Capacity Requirements
1. Representation of national positions and interest in international negotiations	Policy synthesis capacity Stakeholder management and consensus-building capacity Inter-departmental engagement, negotiations and dialogue capacity Negotiations skills Understanding of and expertise in climate change issues
2. National GHG emissions and sinks inventory	National air pollution monitoring and analysis capacity Project management capacity Coordination capacity for sectoral data collection and submission Database design, management and maintenance capacity Data analysis capacity Technical report writing capacity
3. Identification of mitigation options	Leadership and strategic management capacity Project management capacity Policy analysis capacity Regulatory systems design and management capacity Policy research capacity Regulatory capacity for monitoring and enforcement of emissions standards Understanding emitting sectors
4. National vulnerability assessment and adaptation strategies	Project management capacity Climate science capacity Report-writing capacity Understanding vulnerable sectors
5. Identification of appropriate technology	Needs assessment capacity Technological capacity Project management capacity Understanding technology and intellectual property issues
6. Education, training and public awareness regarding climate change	Research and project management capacity Public- and sectoral-awareness campaign management capacity Training capacity Programme monitoring and evaluation capacity
7. Capacity for climate-related research and systematic observation	Research capacity Synthesis and report writing capacity Expertise in systematic climate observation
8. Access international support for costs of undertakings in terms of climate change	Project design capacity Proposal formulation capacity Knowledge of international (especially GEF), multi-lateral and bi-lateral funding mechanisms Coordination capacity Donor liaison capacity Project management capacity

In fulfilling the obligations of the focal point, DEAT is supported by other government departments, as well as the private sector, NGOs and CBOs through the National Committee on Climate Change (NCCC). Nominated personnel or focal points tasked with the responsibility of co-ordinating with DEAT on climate change issues have been identified in other government departments. The departments in addition to DEAT which are significantly involved in climate change issues include: Department of Minerals and Energy, Department of Trade and Industry, Department of Water Affairs and Forestry, Department of Transport, Department of Health, Department of Agriculture, Department of Foreign Affairs, Department of Land Affairs; and Department of Science and Technology.

5.2 Capacity Building

Existing national governmental legislation, policy and strategy have tasked DEAT with the responsibility to build environmental capacity in all spheres of government, as well as in civil society. To meet this responsibility, an Environmental Capacity Building Unit (ECBU) was established at DEAT, first to build capacity within government, and then progressively to extend this activity to include the development of education, training, public awareness and capacity building programmes for civil society. The ECBU will *inter alia* assist DEAT in fulfilling its obligations to build capacity under the UNFCCC.

5.3 Capacity Building Needs Assessment

A Capacity Building Needs Assessment was undertaken as part of the GEF Enabling Activities on Climate Change Programme in order to assess the capacity building requirements for South Africa to meet its obligations as a Party to the UNFCCC (Butler, 2000). The study used information from a broad spectrum of government departments and civil society organisations and highlighted the areas in which capacity building is required. The main finding of the study was that a long-term strategy for capacity building in climate change needs to be developed with an emphasis on:

- Development and implementation of a range of capacity building programmes.
- Implementation of measures to address South Africa's vulnerability, resulting from the adverse effects of climate change.
- Development of national adaptation strategies that detail practical responses to the effects of climate change.
- Implementation of initiatives under the Clean Development Mechanism.

South Africa is well resourced in respect of scientific research and academic institutions, which have the expertise to undertake research into climate change issues. The National Research Foundation considers climate change a priority research and development area. Business and industry have developed some capacity on climate change in order to meet the challenges which climate change poses although the need to build further capacity, particularly in the small and medium-sized businesses, is recognised.

Within South African civil society, organisations with an interest in climate change are grouped under the umbrella of the South African Climate Action Network (SACAN). The overall goals of SACAN are to facilitate the participation of civil society organisations in climate change issues at national, regional and international levels, and to prompt government, industry and individual action to reduce human-induced climate change to ecologically sustainable levels. Capacity needs identified by SACAN for the NGO sector include the availability of funding, that will enable capacity building of a well-trained permanent staff members within the sector and ensure the integration of climate change issues into other relevant programmes.

Current capacity on climate change and related issues within the labour movement is limited and needs to be improved. Labour will become more directly involved when climate change measures either threaten jobs in industrial sectors identified as vulnerable, or lead to the adoption of new technologies that require additional skills training.

5.4 Public Awareness

A number of initiatives are currently being undertaken to raise public awareness on a range of environmental issues. Many of these initiatives have direct relevance to climate change, and could be expanded to accommodate the specific requirements of the climate change awareness programmes.

Raising of public awareness of climate-related issues is promoted by the government through the DEAT and the South African Weather Services. Presentations and exhibitions are used as a mechanism to promote awareness of climate change, for example through the National Atmospheric Week, World Environment Day and World Meteorological Day promotions. Publications, such as the Environmental Education fact sheets, are produced by DEAT, and highlight important environmental issues.

DEAT, together with USAID, funded a project that developed a climate change resource material to assist teachers in incorporating climate change issues into the curriculum. Teachers were also trained in using this resource material. An ongoing climate change schools competition for Grade 5-6 learners will be initiated by DEAT.

A joint venture has been implemented between the National Department of Agriculture, the Provincial Departments of Agriculture and the Agricultural Research Council for an Agricultural Geographic Information System (AGIS) to disseminate information and facilitate informed decision-making in the agricultural sector. Awareness courses are presented in communities where weather stations have been established, and farmer days are held where information about technology is transferred to communities.

The National Water Conservation Campaign publicises the concept of water conservation by means of school water audits, Water Wise gardening programmes, informative billing systems, and an annual National Water Week. This Campaign could be augmented to include climate change.

An energy-efficiency awareness campaign was initiated by the DME in 1996 to raise public awareness of the need to implement energy efficient measures in the home. This campaign was in response to a survey, conducted at the time that found that 60 percent of consumers were not aware of the need and reasons for conserving energy. Training and capacity building on energy efficiency is also being conducted by the Household Energy Action Training (HEAT) programme. The aim of the programme is to develop a household-energy capacity building and communication strategy. A joint project with International Institute for Energy Conservation-Africa (IIEC-Africa), the Minerals and Energy Education and Training Institute (MEETI) and PEER-Africa, an environmental and engineering firm, will address delivery organisations on energy and environmental issues in the housing sector. PEER-Africa is presently involved in appropriate technology transfer and capacity building in low-income communities.

The organisation, Trees for Africa, has been involved in the implementation of Urban Greening in South African cities and has also started a new programme called "Trees for Homes" which encourages and facilitates the planting of trees in government subsidised housing developments. Awareness is raised about environmental issues through workshops and nurseries that have been opened in townships. Environmental issues are taught to children through programmes such as EduPlant, which focuses on greening and permaculture. Trees for Africa also runs a national community-based tree planting programme, which provides trees to disadvantaged communities. This programme develops environmental awareness, promotes environmental education and popularises environmentally sustainable concepts.

The Forum for Economics and the Environment has recently been formed. This Forum consists of a group of non-aligned persons who have backgrounds in economics and environmental issues. They are initiating awareness and conducting training symposiums, specifically on climate change. A total of six workshops are to be held - three for training government and industry staff, and three for information and discussion sessions with interested parties. The objectives of these workshops are to raise public awareness on climate change issues, to capacitate government and industry, and debate the issues surrounding climate change. The Forum receives financial support from USAID.

The Department of Transport is promoting an awareness of fuel efficiency among the South African motoring public *inter alia* a booklet entitled Fuel Consumption of Passenger Vehicles (Department of Transport, 1998)

5.5 Education

South Africa has a well-developed formal educational system that could be utilised to raise public awareness and also to educate learners about issues related to climate change through the general, primary and higher education curricula. Education is a long-term mechanism for raising awareness and ultimately creating a paradigm shift in attitude towards the environment that will facilitate future implementation of climate change adaptation and mitigation measures.

Environmental programmes that have already been implemented within the education system are:

- Current environmental policies in South Africa emphasise the need for environmental education and capacity building for all stakeholders. In March 1999, a workshop was held at which the Environmental Standards Generating Initiative (ESGI) was established by DEAT. The aim of the ESGI is to promote environmental education and to include relevant stakeholders in the setting of standards for environmental education and training.
- In June 2000, the National Environmental Education Programme (NEEP) was launched to introduce environmental initiatives into education programmes, including:

General Education and Training; Adult Basic Education and Training; Further Education and Training; and Higher Education and Training.

- The South African Weather Services has initiated a number of school programmes that are aimed at educating pupils about climate issues. Activity booklets have been developed for schools about weather-related topics, such as rain, temperatures and seasons, as well as climate change. In addition, a number of weather workshops have been held throughout South Africa to train educators from schools. In order to reach a wider audience and a greater number of schools, additional workshop presenters have been trained by the Weather Services. Posters are also distributed to schools on World Meteorological Day, together with an activity booklet with specific activities to be incorporated into lessons.
- The Botanical Society of South Africa promotes environmental education and public awareness of the flora of South Africa. The Society is involved with conservation programmes, educational programmes and outreach programmes. The Protea Atlas project run by the National Botanical Institute is also involved with environmental education and raising public awareness.

5.6 Training

A number of universities in South Africa, e.g. Cape Town, Natal, Potchefstroom, Zululand and Witwatersrand, already undertake climate change research and related training. The main areas of research currently being undertaken include vulnerability and adaptation issues. The National Botanical Institute is also undertaking climate change research and offers a training component specifically on climate change. The Energy and Development Research Centre at the University of Cape Town has a postgraduate teaching and research programme on climate change policy and energy sector mitigation analysis. Training courses have been established by the Energy Research Institute at the University of Cape Town, as well as the Minerals and Energy Training Institute in Johannesburg who offer courses specifically in CDM implementation.

Specific weather-related training courses at tertiary education institutions are supported and sponsored by the Weather Services as a mechanism to overcome the shortage of appropriately skilled personnel. This training includes a graduate course in Atmospheric Science and Meteorological Electronic Technology. In-house training courses are offered for weather observation.

A number of industries, including Eskom, are contributing significantly to tertiary level training by funding the establishment of centres of excellence at local Universities. This also ensures access to the Tertiary Higher education Research Industrial Programme (THRIP) funding from the Department of Trade and Industry.

6. PROJECTIONS, POLICIES AND MEASURES

This chapter presents projections, policies and measures for limiting the impact of climate change. The information is presented for sectors that may be significantly impacted. Where available, projections are presented. A climate change response strategy is being finalised to address climate change issues in the country. The following national priorities were considered in the development of policies and measures for environmental management, *inter alia* to combat the effects of climate change:

- Alleviation of poverty
- Provision of basic services for all South Africans
- Equity
- Employment creation
- Economic growth.

In addition, the Constitution of the Republic of South Africa (Act 108 of 1996), states that all South Africans have the right to a healthy environment and the right to protect the environment, and policies have been developed and measures implemented to meet these environmental rights.

Policies relating to the fulfilment of obligations in terms of the UNFCCC are also being developed within the context of national priorities. Policies relating to climate change are considered as an integral part of the National Sustainable Development Strategy, which is currently (2000) being prepared.

6.1 Socio-economic Issues

The annual growth rate of the population of South Africa is expected to decrease from 2.2% in 1999 to 1.0% by the year 2025, when South Africa's population is expected to total 62 million (Holdenwag *et al.*, 1996). The White Paper on Population Policy (Department of Welfare, 1998) recognises the need for socio-economic development to meet the basic needs of the present population, but aims to improve their quality of life without depleting non-renewable natural resources or damaging the environment. This Population Policy also addresses issues of mortality, fertility and migration.

A steady growth in the Gross Domestic Product (GDP) until the year 2015 is projected (Figure 6.1) and is attributed to the benefits of globalisation and the resultant creation of employment, higher fixed investment, and lower interest rates (IDC, 1999).

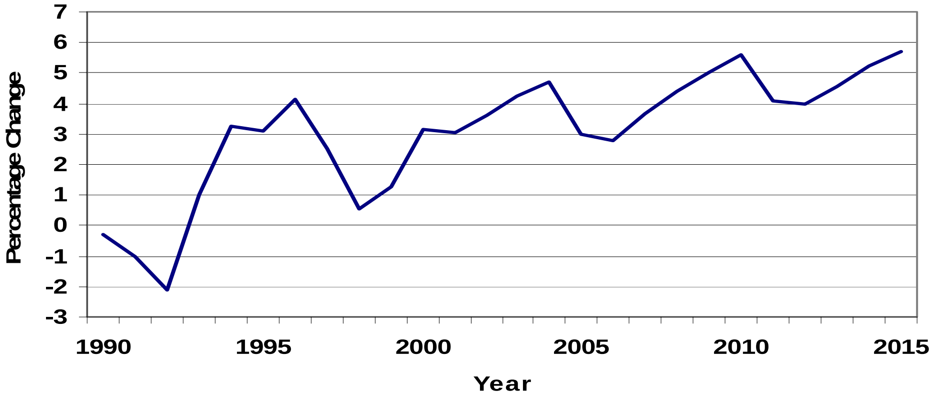


Figure 6.1: Projected growth in GDP from 1990 to 2015 (IDC, 1999)

DEAT has developed a number of policies and strategies, as well as formulating environmental legislation with the objective of achieving sustainable development. The White Paper on Environmental Policy for South Africa (DEAT, 1998) is an overarching policy framework that sets out government's objectives in relation to environmental management. It outlines how government intends to achieve these objectives and how it will assist governmental agencies and state institutions to develop strategies to meet these objectives. The National Environmental Management Act (Act 107 of 1998) and its amendments aims to improve environmental management and to facilitate sustainable development, which could ensure that significant impacts on the environment are avoided, minimised or mitigated. The then Department of Arts, Culture, Science and Technology funded a project called the SA-ISIS 2000, which aims to create a platform for informing all interested and affected parties on sustainable development and for promoting integrated land transformation.

6.2 Energy Sector

6.2.1 Projections

By the year 2025, the total energy demand is projected to be 5 727PJ (de Villiers *et al.*, 2000) (Figure 6.2).

In the early 1990s South Africa embarked on an accelerated electrification programme. In the period 1994 to 1999 about 2.8 million households were connected to the national electricity grid, increasing the electrification level from about 36% in 1994 to about 75% at the end of 1998. The number of households electrified by the year 2030 is expected to increase to 84%, which is equivalent to 12.2 million households (de Villiers and Matibe, 2000) (Figure 6.3).

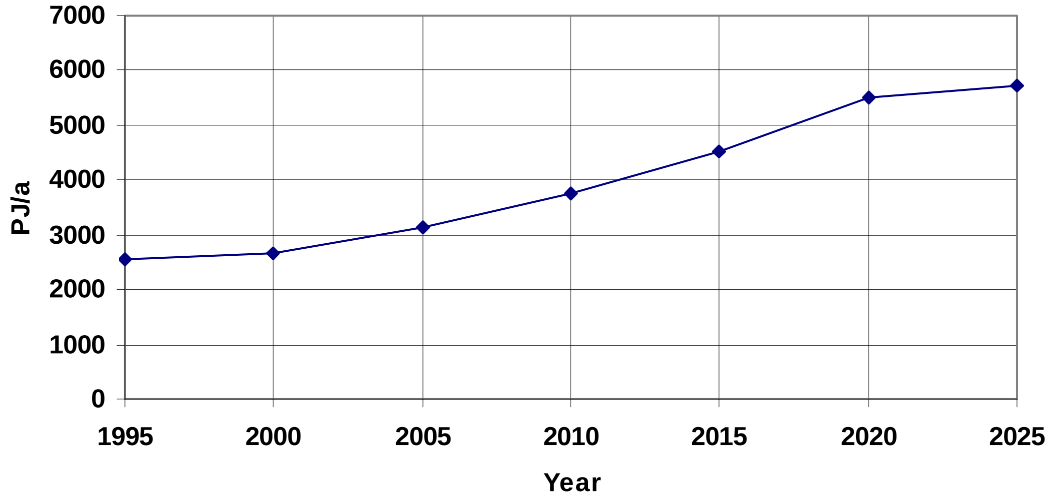


Figure 6.2: Projected Energy Demands from 1995 to 2025 (de Villiers *et al.*, 2000)

With the increased electrification of households, peaks in electrical demand are expected to result in a generation load factor of 0.7 by the year 2030. Urbanisation, improved housing, poverty alleviation and a continuation of the electrification programme will, however, result in reduced domestic coal burning and biomass use in the residential sector. Since 51.5% of rural households currently do not have access to electricity, photovoltaic-based solar home systems have been integrated into the National Electrification Programme to provide a basic energy source to those households that cannot be grid-connected within acceptable cost parameters.

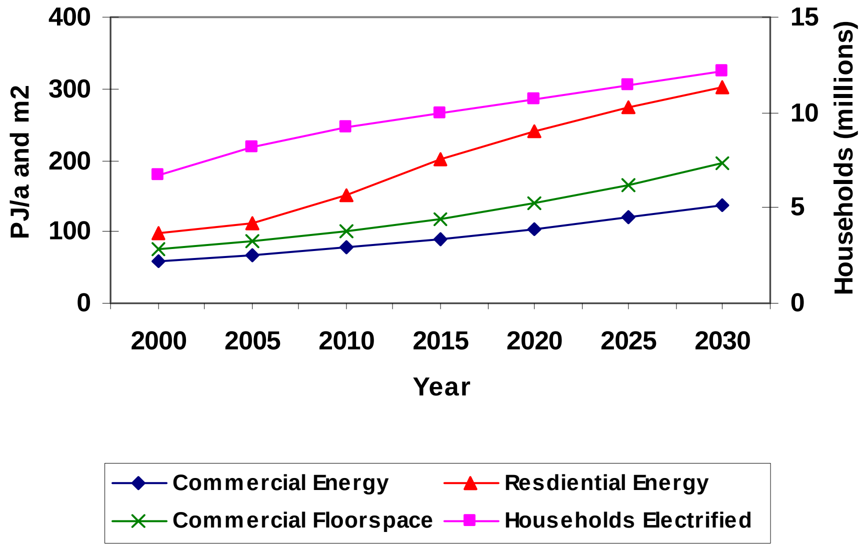


Figure 6.3: Projected energy consumption by the residential and commercial sector and the growth in these sectors from 2000 to 2030

6.2.2 Policies and Measures

The importance of promoting energy efficient and water-use efficient housing has been recognised by the Department of Housing, who have issued guidelines on developing environmentally sound housing initiatives. An Environmentally Sound Low Cost Housing Task Team was established in 1998, and charged with the responsibility of promoting environmentally sound housing initiatives, developing a national policy on environmentally efficient low cost housing, and encouraging environmentally sound practices in the housing construction sector.

In 1995, the industrial sector consumed 889 PJ, which was 35% of the total South African energy demand and 56% of the electricity supplied. It is estimated that an average potential growth rate of 5% will be achieved over the next 25 years, taking into account the government's policies of promoting the creation of employment. Eskom, the national power utility, has developed awareness raising programmes to promote energy efficiency in industry, as well as in the domestic sector. Efficient lighting, better insulation, more efficient motors and machines, and better management and control of an energy consuming plant are part of this awareness campaign. Eskom's Efficient Lighting Initiative, with assistance from the Global Environment Facility (GEF), aims to supply the South African market with 18 million Compact Fluorescent Lamps.

Demand side management is being promoted primarily to meet peaks in energy demand. Eskom's programme includes tariffs that vary according to the time of day or night and encourages energy storage during off-peak periods. Two pilot initiatives are currently underway to study municipal ripple control systems and domestic time of use systems.

The Department of Minerals and Energy regulates bulk energy supply. The White Paper on Energy Policy (DME, 1998) sets out five policy objectives:

- Increasing access to affordable energy services
- Improving energy governance
- Stimulating economic development
- Managing energy-related environmental and health impacts
- Securing supply through diversity.

A "no regrets" energy policy is promoted, which is defined as a policy that decreases and minimises environmental impact cost-effectively. It also commits the government to working towards the establishment and acceptance of broad national targets for the reduction of energy-related emissions that are harmful to the environment.

The National Electricity Regulator has initiated a process to develop an appropriate regulatory framework for non-grid electrification when the restructuring of the electrical distribution industry has been completed and independent power producers have been established (National Electricity Regulator, 2000b). Reference is made in the White Paper on Energy Policy to supporting renewable energy technologies according to researched priorities.

Several initiatives are ongoing to introduce natural gas into South Africa. Pre-feasibility studies are in progress to research the possibility of using gas from the Kudu gas field off the coast of Namibia to power a combined cycle gas turbine power station which would be located in the Western Cape, as well as to investigate the possibility of establishing industries along the pipeline. Furthermore, agreements have been signed between the Mozambican government and the chemicals group, Sasol, to pipe gas from the Pande and Temane gasfields to the Sasol Secunda plant by the year 2004. Sasol is likely to use the gas in three ways: as a supplementary feedstock to coal at an expanded Sasol Synthetic Fuels plant in Secunda; to replace coal as a feedstock at the Sasol Chemical Industries plant in Sasolburg, if a feasibility study proves positive; and to expand its existing pipeline gas market (Sasol, 2000). A draft Gas Bill (DME, 2000c) has been developed, which outlines the conditions for awarding licences for construction, operation and trading with regard to the transmission, distribution and storage of piped gas.

The White Paper on Energy supports renewable energy initiatives, and states that:

- Government will encourage competition within energy markets.
- Government will provide focused support for the development, demonstration and implementation of renewable energy sources for both small and large-scale applications.
- Government will support renewable energy technologies for application in specific markets according to researched priorities.

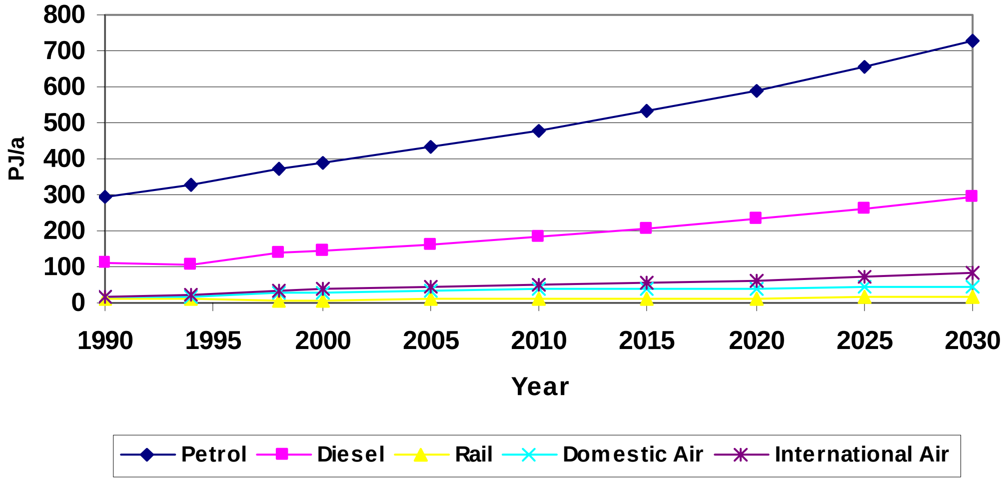
The draft White Paper on the Promotion of Renewable Energy and Clean Energy Development, aims at informing the public and the international community of the Government's goals and objectives for renewable energy. It furthermore commits the Government to a number of enabling actions to ensure that renewable energy becomes a significant part of its energy portfolio over the next ten years. This draft White Paper sets a target of 10 000 GWh renewable energy contribution to final energy consumption by 2012. This is in addition to the existing renewable energy contribution of 67 829 GWh/annum.

6.3 Transport Sector

6.3.1 Projections

Surveys undertaken for the Moving South Africa project have indicated that car-use is the dominant form of transport at earnings above R30 000 per annum, and that the percentage of the population who are willing to travel by car only is expected to increase from 19% of the population in 1996 to 88% of the population by the year 2020 (Department of Transport, 1999).

Long-term energy forecasting and trend modelling undertaken by Essman (1992) for the DME, has estimated that the average annual growth rate of fuel consumption will be 2.1 % for petrol and 2.4% for diesel, and that the estimated national car fleet will grow by 64 % between 1996 and 2020. The rail growth rate is estimated to be 2.4% per annum. Domestic aviation will grow by 1.9% and international aviation by 2.8% (Figure 6.4).



Despite improved fuel efficiency and technological advances in the manufacture of motor vehicles, CO_2 emissions from motor vehicles are increasing at approximately 2.4 % per annum due to a number of factors, including (Doppegieter *et al*., 1998):

- Increasing power and size of vehicles
- Increasing fleet size
- Increasing mileage per capita
- Decreasing car occupancy
- Poor enforcement of speed limits
- Increasing traffic congestion.

6.3.2 Policies and Measures

The DME and DEAT are studying the fitting of catalytic converters to motor vehicles in conjunction with the Motor Vehicle Emissions Investigation Programme, and their conclusions will be used to formulate policy, and if necessary, legislation to control motor vehicle emissions (Parliamentary Question, June 1998).

The White Paper on National Transport Policy (Department of Transport, 1996) aims to achieve sustainable development in the transport sector by minimising the energy usage and environmental impact of the transport sector. The White Paper promotes the use of more energy efficient and less polluting modes of transport. The Moving South Africa project (Department of Transport, 1999) was subsequently implemented which outlines the strategy for the transport sector in South Africa until 2020. It addresses urban, rural, freight and special transport needs, analyses the sustainability of the present transport system and presents possible solutions to the problems facing the industry. Specific proposals made in this project include the implementation of integrated development planning and promotion of the use of public transport.

In August 2000, the National Land Transport Transition Act was promulgated (Act 22 of 2000). This Act describes the measures required to transform and restructure the land transport system. It also advocates conducting public awareness programmes to foster energy awareness in the users of land transport systems.

The Department of Minerals and Energy and the International Institute for Energy Conservation-Africa (IIEC-Africa) launched a Clean Commute project which promotes energy conservation options such as pooling schemes for cars and vans, flexible work hours and telecommuting to reduce the numbers of single occupancy vehicles on the roads. A business plan is also being developed for the establishment of a Commuter Information Centre.

The National Roads Agency (NRA) also promotes environmental awareness through policy, which incorporates environmental education, pollution control, and promotion of sustainable development in the transport sector through integrated environmental management practices.

6.4 Mining Sector

6.4.1 Projections

Coal currently provides over 90% of the energy for electricity generation and is expected to dominate power generation until the year 2040. South Africa has about 60 billion tonnes of coal reserves, which is sufficient to meet this demand.

The tonnages of coal mined are expected to increase to 281 Mt by the year 2003 where it will remain unchanged up to the year 2030. Approximately 50% of the production is expected to be acquired from surface operations, 35% from underground at depths less than 100 m and the remaining 15% from depths greater than 100 m. The dominant mining method underground is expected to remain room and pillar mining. The Mining Industry is currently investigating and quantifying the available reserves as part of programme called CoalTech 2020.

6.4.2 Policies and Measures

In terms of the Minerals Act, (Act 50 of 1991) all mining operations are required to compile an Environmental Impact Assessment (EIA), whose content is guided by the *Aide Mémoire* and which should form part of an Environmental Management Programme (EMP). The *Aide Mémoire* is currently being revised to include, *inter alia*, the requirements of Integrated Environmental Management (IEM) and the provisions of Government's White Paper on Environmental Management Policy.

The Mining Industry is currently participating in an international project called the Global Mining Initiative, which is aimed at ensuring that future mining developments are environmentally sustainable and socially acceptable.

6.5 Waste Sector

6.5.1 Projections

The National Waste Management Strategy (DEAT, 1999b) identified as a national short-term priority the provision of basic waste management services for those who do not have access to waste collection services or who do not receive adequate services. It was estimated that about

50% of the South African population do not have access to adequate solid waste management services (DEAT, 1999c).

Figure 6.5 represents the projected future waste generation rates in the Cape Metropolitan Area of South Africa (Wright-Pearce *et al.*, 1999). The greatest percentage increase in the per capita waste generation rate is anticipated in the residential areas, particularly in informal settlements (40%) and middle-income areas (35%). In South Africa, most waste is disposed of by landfilling. The extension of waste collection services, as well as an increasing population will result in a declining capacity for solid waste disposal at existing landfill sites and will ultimately require the establishment of new landfill sites, which must be designed, constructed and operated according to the Department of Water Affairs and Forestry's Minimum Requirements (DWAF, 1998 a,b,c).

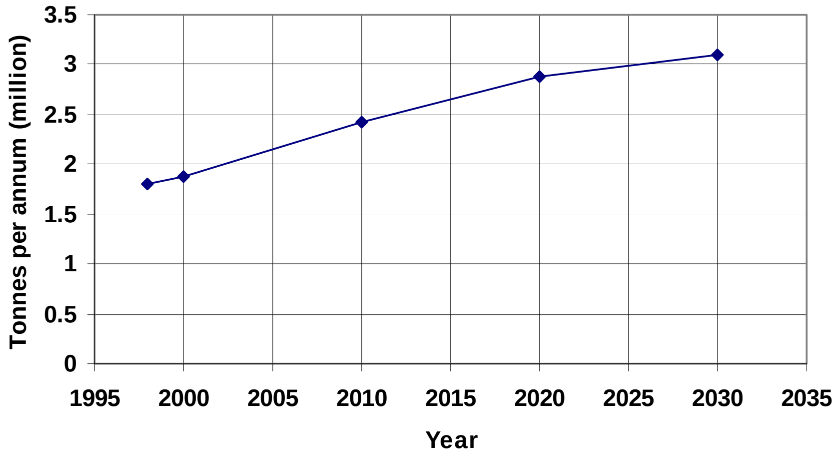


Figure 6.5: Projected Waste Generation from 1998 to 2030

6.5.2 Policies and Measures

The White Paper on Integrated Pollution and Waste Management (DEAT, 2000) represents a paradigm shift in South Africa's approach to pollution and waste management. The focus is on pollution prevention rather than impact management and remediation of pollution. The National Waste Management Strategy (DEAT, 1999b) was developed to translate the principles of integrated pollution and waste management into a strategy for practical implementation of the policy. The strategy follows the waste hierarchy approach and gives priority to pollution prevention, waste minimisation and recycling before resorting to treatment and disposal of waste.

DEAT is currently undertaking a Law Reform Programme to review all environmental legislation. The outcome of this programme will be the integration into the National Environmental Management Act (Act 107 of 1999) of existing environmental laws, *inter alia* the laws and regulations on pollution and waste management.

6.6 Agricultural Sector

The national Department of Agriculture places an emphasis on prevention and mitigation strategies such as: supporting risk management initiatives; research of large-scale epidemics and hazards; providing information to farmers on markets, climate and taxation and insurance measures. As a mechanism to support these initiatives, the interim National Disaster Management Centre was established by an inter-ministerial Committee. The National Disaster Management Centre resides under the control of the Department of Provincial and Local Government and has strong links to the Department of Agriculture.

The Conservation of the Agricultural Resources Act (Act 43 of 1983) was promulgated to provide for control over the utilisation of the natural agricultural resources of South Africa, in order to promote the conservation of the soil, water sources and vegetation and the combating of weeds and other invader plants, and for matters thereof.

LandCare is an initiative undertaken by the government to promote sustainable land management by supporting activities which encourage individuals and communities to adopt ethical agricultural practices There are five major elements to LandCare: a major works programmes for resource conservation; capacity building; awareness programmes; policy and legislation; research and evaluation.

The Valley Trust is implementing a programme on indigenous seed banks and developing drought and low nitrogen resistant species. .

6.7 Forestry Sector

The White Paper on Sustainable Forest Development in South Africa (DWAF, 1996), and the Policy of the Government of National Unity, is being applied and monitored by the Department of Water Affairs and Forestry. These policies deal with all the components of the forestry sector, including indigenous forests, woodlands, industrial forestry, community forestry, and the relationship between people and the resources provided by forests.

The National Forests Act (Act 84 of 1998) recognises that everyone in South Africa has a constitutional right to have the environment protected for the benefit of present and future generations and acknowledges that natural forests and woodlands need to be conserved and developed according to the principles of sustainable management. Plantation forests play an important role in the economy, but they impact on the environment and need to be managed appropriately. The Act legislates the sustainable use of forests for environmental, economic, educational, health, recreational, cultural and spiritual purposes, and includes special measures for the protection of certain forests and trees. Community forestry is promoted, as is the greater participation of previously disadvantaged persons in all aspects of forestry and the forest products industry.

The National Veld and Forest Fire Act (Act 101 of 1998) provides for a range of institutions, methods and practises to prevent and combat veld, forest and mountain fires in South Africa.

6.8 Health Sector

Computer models are being used to predict malaria epidemics. Data has been collected since 1981 in the three provinces where malaria occurs, and this information will be used to predict future outbreaks of the disease. The maps generated by the models have been integrated with other data sets, such as administrative and population boundaries, and will provide national governments, donors, researchers and international agencies with a more empirical basis for strategic evidence-based planning for malaria control. Resistant patterns of malaria are being monitored and future policy and strategy will be adapted accordingly (DoH, 2000).

Since South Africa borders countries that have high rates of malaria, a memorandum of understanding on malaria control was signed during October 1999 between Mozambique, Swaziland and South Africa, as part of the Lubombo Spatial Development Initiative. In terms of the agreement, the two countries are co-operating in combating the spread of malaria.

A programme has been implemented in the province of KwaZulu Natal, which targets the elimination of schistosomiasis through chemotherapy, snail control, health education and sanitation.

Sixty-four water and sanitation projects were implemented in 1999 by the DWAF to provide these services to the previously disadvantaged communities in South Africa. These projects have provided water and sanitation systems to communities in an attempt to prevent the spread of water-borne diseases. With the reductions in rainfall predicted in parts of South Africa and the increase in droughts and floods, it remains essential to provide adequate water and sanitation in all communities (DoH, 2000).

The National Department of Health participates in all the provincial disaster management committees in South Africa as well as in the disaster management committees of the SADC region, and was therefore able to give assistance during floods in Mozambique in 2000. In line with government's priorities, a White Paper on Disaster Management (South African Government, 2000) has been drafted, which gives specific attention to assisting poor communities in dealing with the effects of natural and man-made disasters. The ratification of the Montreal Protocol in 1990 committed South Africa to phasing out the production of ozone depleting substances by 2030. Currently, methyl bromide and hydrochlorofluorocarbons are still in use, but these will be phased out by 2010 and 2030, respectively.

A government policy is currently being developed with regard to aircraft engine emissions in line with the resolutions of the International Civil Aviation Organisations' (ICAO's) resolutions that member countries have a policy framework in place for environmental issues.

6.9 Water Resources

In 1996 it was estimated that the maximum potential yield of South Africa's water resources was 33 290 million cubic metres per annum, and that about 60% of this was already utilised. However, assuming that current development trends and usage patterns prevail, it is estimated that the projected growth in water requirements will utilise most of the country's water resources within about 30 years. The growth in water requirements will essentially be in the domestic and industrial sectors. Due to the predicted shortage of water, development of irrigation and afforestation schemes would have to be limited (Table 6.1).

Table 6.1: Historical consumption (1996) and projected water requirements (2030) (DWAF, 1997a)

Sector	m^3/Annum	
	1996	2030
Urban and domestic	2 171	6 936
Mining and Industrial	1 598	3380
Irrigation and Afforestation	12 344	15 874
Environmental	3 932	4 225
Total	20 045	30 415

In 1998 the Department of Water Affairs and Forestry promulgated the National Water Act (Act 36 of 1998). The National Water Act seeks to balance the ecological reserve, which will entail finding a balance between the minimum amount of water that must remain in a river or water body for it to function normally and the amount of water required for basic human needs and national production. This Act, which gives legal effect to the National Water Policy (DWAF, 1997a), introduced into legislation the principles of equity and sustainable use of freshwater resources, which are key elements of Agenda 21.

In order to ensure equity of access to water, rather than vesting riparian ownership to the state, national government is the custodian of all water resources. The key to balancing equity with sustainability lies in the legal provision termed the Reserve, which is the amount of water needed to supply for basic human requirements, to protect ecosystems and to ensure ecologically sustainable development. Only the Reserve has a legal right to water; all other users require authorisation, based on the criteria of public interest, equity, and optimal utilisation.

The Water Act makes provision for a classification system to set appropriate resource quality objectives and source controls. Resource-directed measures focus on the water resource as an ecosystem, and sets objectives for and define the level of protection for the resource. Source-directed controls include a wide range of regulatory measures focused on the sources of impacts on the ecosystem. The levels of protection required as well as the controls and management practises necessary to balance the protection and the use of the water resources are therefore both specified.

A Water Pricing Policy (DWAF, 1998d) has been developed to reflect the true cost of water to users and makes provision for a minimum allowance for human consumption. In order to promote sustainability and ensure that all water users appreciate the scarcity of this resource, all significant water users will be charged for water consumed. Eleven categories of water users are recognised in the policy. Provisions are made for re-use and recycling of water on a mutually agreed basis between users within a catchment area, as well as for market-based trading in water. A system of economic incentives will be implemented to foster the development of low-waste and non-waste technologies, and to reduce pollution and other negative environmental impacts on water resources.

Integrated water resource management at a catchment and local level has been legislated and will be implemented through the establishment of Catchment Management Agencies. These agencies will provide an institutional structure in which all appropriate government agencies and stakeholders can participate and jointly develop and manage the land and water management objectives and strategies and the for a catchment area.

A Water Conservation and Demand Management Policy (DWAF, 1999) has been adopted. Voluntary, as well as mandatory measures for water conservation will ensure that water is used efficiently. Effective management of water demand is an essential criterion in all decisions regarding water supply, water management and water development projects.

In order to manage water-related disasters effectively, the Department of Water Affairs and Forestry was one of a number of departments that contributed to the National Disaster Management Policy (1999), which outlines strategies to deal with such disasters and risks. Effective disaster management is especially pertinent due to the increased incidence of drought and floods predicted for South Africa.

A Water Balance Model (WBM) has been developed by DWAF to assist managers at the national, provincial and regional level with the long-term planning of water resources. A national database, which has captured the data presenting the base situation of water resources and water demands as at 1995, has been developed to support the WBM and forms part of a Water Resources Situation Assessment study. With this database, strategies for managing water supply and demand can be tested in the light of different land use scenarios, as well as demographic and economic changes.

6.10 Biodiversity

The White Paper on the Conservation and Sustainable Use of South Africa's Biological Diversity (DEAT, 1998b) aims to promote sustainable use, rather than exploitation, of natural resources and the sharing of benefits of these resources with local communities. A draft National Environmental Management: Protected areas bill will provide one of the tools for the implementation of this policy by consolidating and rationalising existing legislation dealing with protected area. It aims to deal with the system of protected area more broadly than the National Parks Act (1976) and the Environmental conservation Act (1989), and ensure that the system of conservation and protected areas management is linked with the current policies and programmes of government, and brings tangible benefits to all South Africans.

South Africa is a signatory to the international Convention on Biological Diversity, which aims to promote sustainable use of natural resources through regional co-operation. South Africa is also a signatory of the United Nations Convention to Combat Desertification in countries experiencing drought and/or desertification.

The draft biodiversity bill has the following objectives:

(a) to provide, within the framework of the National Environmental Management Act, for

(i) the management and conservation of biological diversity within the Republic;

(ii) the use of indigenous biological resources in a sustainable manner; and

(iii) the fair and equitable sharing of benefits arising from the commercialisation through bio-prospecting of traditional uses and knowledge of genetic resources;

(b) to give effect to international agreements relating to biodiversity which are binding on the Republic;

(c) to provide for co-operative governance in biodiversity management and conservation; and

(d) to provide for a National Biodiversity Institute to assist in achieving the above objectives.

Recent government policies developed to protect the coastal environment include the White Paper for Sustainable Coastal Development (DEAT, 1999d) and the Marine Living Resources Act (Act 18 of 1998). This Act imposes large fines for people who illegally exploit the marine environment. One of the fundamental objectives of the White Paper for Sustainable Coastal Development is equitable access to coastal resources, and particular attention is given to the needs of disadvantaged communities in this regard.

7. MITIGATION AND ADAPTATION STRATEGIES

As a developing country, South Africa is not obliged to reduce the emissions of greenhouse gases. Nonetheless, this chapter examines possible mitigating options for GHG emissions and how South Africa could develop cost-effective GHG mitigation strategies in terms of Article 12 (4) of the UNFCCC. Various mitigation options are possible. The principles of sustainable development were used to guide the assessment of mitigating options and to provide a framework for developing evaluation criteria. These criteria have been based on potential social, financial, environmental and economic impacts and are both qualitative and quantitative. A number of these options have already been fully or partially implemented, primarily for their inherent socio-economic benefits. Due to national priorities such as poverty alleviation, providing access to basic facilities and health issue such as AIDS, as well as financial and technological limitations, South Africa's current approach to specific GHG mitigation measures is only at an exploratory phase.

The current and projected GHG emissions up to the year 2030 and the possible mitigating options that could be implemented were investigated as part of a South African Country Studies (SACS) Programme. The scope of the study included an emissions estimate for a Baseline or Business as Usual scenario, and mitigation option scenarios for the period 1990 to 2030. The mitigation options were compared to a baseline scenario and evaluated according to specific criteria. These criteria are in line with the country's national priorities (James and Spalding-Fecher, 1999). The principles of sustainable development were used to guide the assessment of mitigating options and to provide a framework for developing evaluation criteria. The criteria have been based on potential social, financial, environmental and economic impacts and are both qualitative and quantitative.

The mitigating options project was intended to improve the accuracy of predictions of greenhouse gas emissions, to assist policy-makers in developing future strategies, and to highlight opportunities for the development and improvement of efficiency and skills, especially in the sphere of technology transfer which can be used in local programmes to promote sustainable development The future approach to be taken to reduce emissions will be based on a holistic evaluation of the options, taking into account life cycle assessments, the impact of implementing the options on the macro-economic situation of the country, as well as the national priority of poverty alleviation. In this regard a reduction in the rate of increase of emissions is considered the most appropriate approach for South Africa.

The sectors that were investigated in the South Africa's country study process were bulk energy, transport, residential, commercial, coal mining, industry, and agriculture. Baseline information as well as mitigation options for the individual sectors are presented in this chapter. The level of detail of the information presented varies for the different sectors depending on the availability of information. The ultimate objective of the study is to model the impact of various GHG mitigating options and scenarios on the macro economic situation in South Africa.

7.1 Energy Sector

The energy sector is the largest single source of greenhouse gases in South Africa, accounting for about half of the total emissions in 1990 and 1994. Electricity supplies 25% of the total amount of energy consumed, liquid fuel products 29%, coal 22%, renewable energy 20% and gas 4%. Conventional coal power stations generate 95.7% (1999) of the electricity produced (National Electricity Regulator, 2000a). Of the total liquid fuel generated, 72% is derived from crude oil, 23% from coal and 5% from natural gas (Howells, 2000).

Integrated energy planning at the national level, as well as within specific industrial sectors, should ensure the optimum overall mix of energy sources. In view of the abundant coal reserves in South Africa clean coal technologies can be expected to be part of that mix for the medium-term future. Technologies currently being investigated include renewable energy sources such as hydroelectric power, wind power, solar power and biomass, and non-greenhouse gas emitting energy sources, such as nuclear power. Furthermore, technologies are currently being investigated and developed to make coal power stations more efficient, and include: supercritical steam technology, integrated gasification combined cycle, and fluidised bed technology using discard coal. These technologies however can only be effectively implemented should they be economically and technically viable.

Peaks in electricity demand can also be reduced by management of the demand for energy, (demand side management), and providing energy more efficiently by introducing new supply technologies and adjusting pricing policies. In addition, there is a potential for importing energy, such as gas and hydroelectricity, from countries in the region. Estimated resources of these energy reserves as in 1995 are listed in Table 7.1.

Table 7.1: Potential sources for imported energy
(Southern African Development Community (1995); Earthscan (1998)

Resource	Reserves
***Gas*(1)**	
Pande, Mozambique	2 500 PJ
Temane, Mozambique	2 500 PJ
Kudu, Namibia	7 700 PJ
Cabinda, Angola	20 000 PJ
***Hydro* (2)**	
Zambezi Basin	190 PJ/a
Inga, Congo	1 140 – 3 150 PJ/a
Other	900 PJ/a

A baseline scenario was developed for gas distribution, grid electricity supply and petroleum supply for the period 1990 to 2030 as part of the SACS Mitigating Options study, which is described in the following sections (Howells, 2000).

7.1.1 Electricity

The business-as-usual (no-measures) scenario assumed a moderate growth of 2.8% per annum electricity demand and predicted new generation capacity to follow the established patterns, with the most economic electricity supply options being taken-up for grid supply. Two possible scenarios to mitigate greenhouse gas emissions were evaluated, namely increased demand side management (DSM) and a second scenario that uses a mix of more efficient supply technologies. This is intended to give a range for the options and possible carbon dioxide equivalent emissions reduction potential but further evaluation of the mix of options will be necessary. In each of the mitigation scenarios, the annual increase in electricity demand is 2.8%. Table 7.2 summarises the business-as-usual scenario and the two mitigation scenarios for South African power stations for the period 2001 to 2025.

Table 7.2: Operating plant configurations for the baseline and mitigating option scenarios for the years 2001 to 2025

Year	2001	2005	2010	2015	2020	2025
Energy to be supplied (GWh)	196 379	223 927	254 749	285 874	319 780	354 147
System Load Factor (%)	73.3%	71.9%	70.6%	71.1%	69.9%	70.1%
Coal fired (%)						
Baseline	82.35	79.33	78.91	76.50	77.56	78.40
Increased DSM	82.35	77.64	75.94	74.32	72.67	73.13
Efficient mix	82.35	79.33	61.90	54.43	55.23	53.98
Pump storage (%)						
Baseline	3.63	3.50	3.94	6.87	6.20	5.65
Increased DSM	3.63	3.47	3.96	4.98	6.39	5.81
Efficient mix	3.63	3.50	3.91	6.81	6.15	5.60
Nuclear (%)						
Baseline	4.77	4.60	4.18	3.72	3.36	3.06
Increased DSM	4.77	4.56	4.20	3.82	3.46	3.15
Efficient mix	4.77	4.60	7.09	9.10	9.12	9.63
Hydro (%)						
Baseline	4.34	5.10	4.63	4.12	3.72	3.39
Increased DSM	4.34	5.05	4.66	4.23	3.83	3.48
Efficient mix	4.34	5.10	11.37	12.11	11.65	11.94
Gas (%)						
Baseline	0.89	0.86	0.78	0.69	0.62	0.57
Increased DSM	0.89	0.85	0.78	0.71	0.64	0.58
Efficient mix	0.89	0.86	7.54	8.71	8.58	9.14
Demand Side Management (%)						
Increased DSM	4.02	8.44	10.46	11.94	13.02	13.85
Efficient mix	4.02	6.62	7.51	8.03	8.48	8.85

The first mitigation scenario considers the implementation of a comprehensive DSM and electrical energy efficiency drive. It is estimated that during the period 2001 to 2025, a total reduction of 265 000 Gg of carbon dioxide could be achieved with this mitigating option (Figure 7.1).

The second mitigation scenario considers the use of a cost-effective mix of options of electricity generating processes, in order to reduce carbon dioxide emissions effectively. By the year 2025, the energy-generating plant mix is assumed to be 10% nuclear, 9% combined cycle gas turbine (CCGT), 12% imported hydropower, 1% generated by renewable sources and the balance from coal fired power stations. It is estimated that during the period 2001 to 2030, a total reduction of 1 055 000 Gg of carbon dioxide could be achieved with this mitigating option (Figure 7.1).

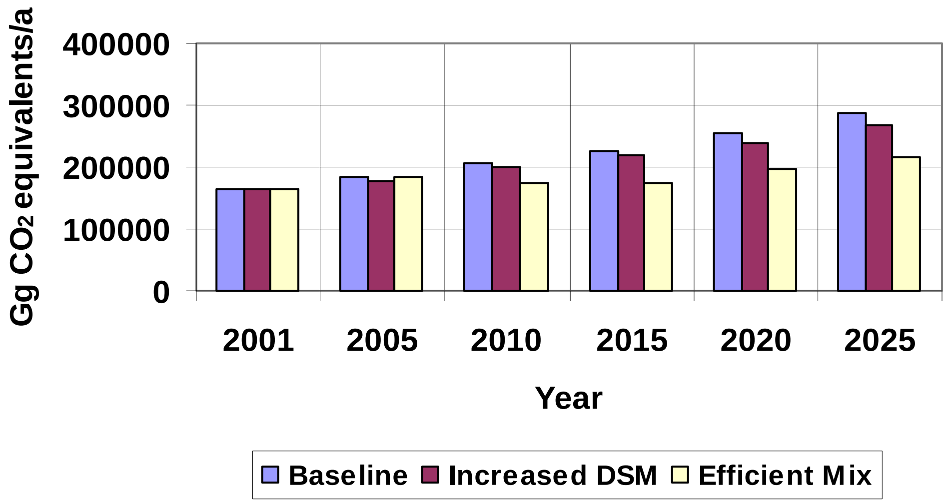


Figure 7.1: GHG emissions from electricity generation according to the different scenarios

7.1.2 Liquid Fuels, Natural Gas and Synthetic Gas Emissions

The business-as-usual scenario assumes that all refineries expand to their maximum capacity with an annual expansion of 2 %. It is assumed that a new refinery will be built to meet the increasing demand for oil and that exports will decrease. It is estimated that synthetic fuel production from coal will increase over the period of this scenario with an annual capacity increase of 2% and that Mossgas will continue producing at its current capacity until 2010, from which time it will be phased out by 2015. The business-as-usual GHG emissions are illustrated in Figure 7.2.

Mitigating options were considered for both the refining of crude oil and the production of synthetic fuel. One mitigating option would be to import refined petroleum products and not build additional refinery capacity. It is estimated that during the period 2000 to 2030, a total reduction of 103 331 Gg of carbon dioxide equivalent could be achieved with this mitigating option. In the synthetic fuel production industry, the substitution of 10% coal consumption with natural gas will result in a total reduction of 168 331 Gg of carbon dioxide equivalent (See Figure 7.2).

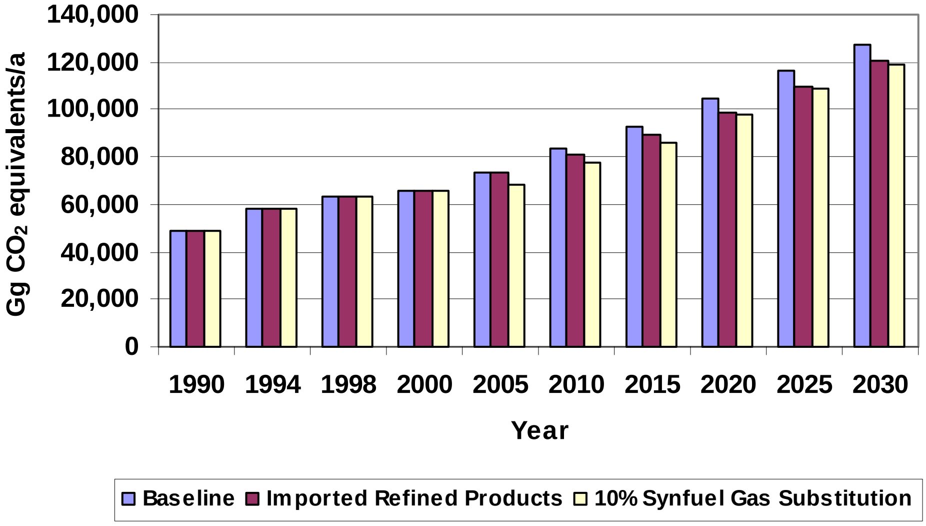


Figure 7.2: GHG emissions in liquid fuels according to different scenarios from 1990 to 2030

7.1.3 Residential and Commercial Sector Energy Consumption

Mitigation in the commercial and residential sectors mainly involves using energy more efficiently or fuel switching (de Villiers, 2000 and de Villiers and Matibe, 2000). The design of housing and buildings is the most important factor determining energy consumption. Fuel switching options include the use of solar water heating, switching from coal to natural gas for boilers and from coal to natural gas for heating. Energy efficiency programmes could include the retrofitting of heating, ventilation and cooling systems, retrofitting of lighting systems, as well as the efficient use of lighting and hot water in the home.

In the residential sector the most effective option to reduce GHG emissions would be to convert to solar water heater, which would achieve a total reduction of 88 000 Gg CO_2. Other options and their associated total reductions of GHG emissions over the full mitigation period include: efficient lighting practices - 18 000 Gg; insulation of geysers - 25 000 Gg; efficient use of hot water - 22 000 Gg; and heat pumps for hot water - 19 000 Gg.

In the commercial sector the greatest reduction of GHG emissions could be achieved by the implementation of energy efficient buildings. A total reduction of 88 000 Gg is estimated. Other options and their associated total GHG reductions include: efficient heating, ventilation and cooling systems - 50 000 Gg; retrofit of heating, ventilation and cooling systems - 41 000 Gg; and solar water heating - 22 000 Gg.

7.2 Transport Sector

The projected increase in the transportation sector will be influenced by changes in economic growth and the growth of the population (Naude *et al.*, 2000). At present the transport sector accounts for about one tenth of South Africa's greenhouse gas emissions. The projected increase in car usage over the next 20 years is partly due to the lack of an efficient and safe public transport system, and partly due to financial incentives such as company cars and car allowances that make the use of cars relatively cheap. The current land planning practices locate cheaper housing developments on the periphery of the urban centres and commercial development in the suburbs creating urban sprawl. This urban development has resulted in average commuter distances of 17 km for private cars and 20 km for public transport, compared to 10 km in European and Latin American cities. Business-as-usual emissions are presented in Figure 7.3.

The Moving South Africa Action Agenda has proposed a number of actions to reduce the greenhouse gas emissions from the transport sector. Implementation of government planning policy and legislation to improve spatial development and road planning would reduce commuter distances and traffic jams. The construction of additional roads to ease traffic congestion is not considered to be the solution to the problem since this would encourage further growth in car usage. The preferred approach is the implementation of some form of travel-demand management, such as parking and access control or incentives, in conjunction with developing an improved public transport system.

As a first step in evaluating potential mitigating options for the transport sector, the study focused primarily on the impact of urban transport. It is anticipated that the options of improving transportation in the rural areas, for example by upgrading roads, will be investigated in further studies.

The Mitigating Options study assumed an average GDP growth rate of 2.4% per annum in estimating GHG emissions to the year 2030. Rate of growth of passenger vehicles was taken to be 2.1%; growth of public transport vehicles 1.92% until 2015 and 1.06 thereafter; growth of road freight 2.4 %; growth of rail freight 2.4%; growth of passenger rail 1.92% and tourist rail 2.4%; growth of domestic air travel 1.92% and 2.8% for international air transport.

Mitigating options considered for the transport sector included:

Fuel Tax: A tax could be included in the fuel price that could be used to address the effects of climate change. For example, the tax collected could be used to finance an improved public transport system. It was assumed that this option would reduce the emissions from passenger vehicles by 20%. This option would achieve a total reduction of 45 498 Gg carbon dioxide equivalents between 2000 and 2030.

Energy efficiency improvements: Between 1970 and 1990, fuel efficiency improved from 20*l*/100km to 10*l*/100km (Doppegieter *et al.*, 1998). Further developments in the use of hybrid technology could dramatically reduce fuel combustion to 3*l*/km (IEA, 1997). It was assumed that emissions from passenger vehicles would be reduced by 30%, emissions from heavy vehicles by 20 %, and emissions from air transport by15 %. This option would achieve a total reduction of 143 426 Gg carbon dioxide equivalents between 2000 and 2030.

Fuel switching: Options that are under investigation include liquefied petroleum gas, compressed natural gas, the electric car and biological fuels. It was assumed that emissions from passenger vehicles would be reduced by 35%, emissions from heavy vehicles by 25%, and emissions from air transport by 15%. This option would achieve a total reduction of 148 225 Gg carbon dioxide equivalents between 2000 and 2030.

Travel demand management: This option is primarily aimed at traffic management, with the ultimate objective of restricting passenger car usage and promoting the use of public transport. It was assumed that emissions from passenger vehicles would be reduced by 15%. This option would achieve a total reduction of 33 854 Gg carbon dioxide equivalents between 2000 and 2030.

Mode Switching: This option promotes the use of public transport and aims at reducing the use of private transport. It was assumed that emissions from passenger vehicles would be reduced by 10 % by the year 2020. This option would achieve a total reduction of 42 856 Gg carbon dioxide equivalents between 2000 and 2030.

Emissions for the business-as-usual scenario and the potential mitigating options are presented graphically in Figure 7.3.

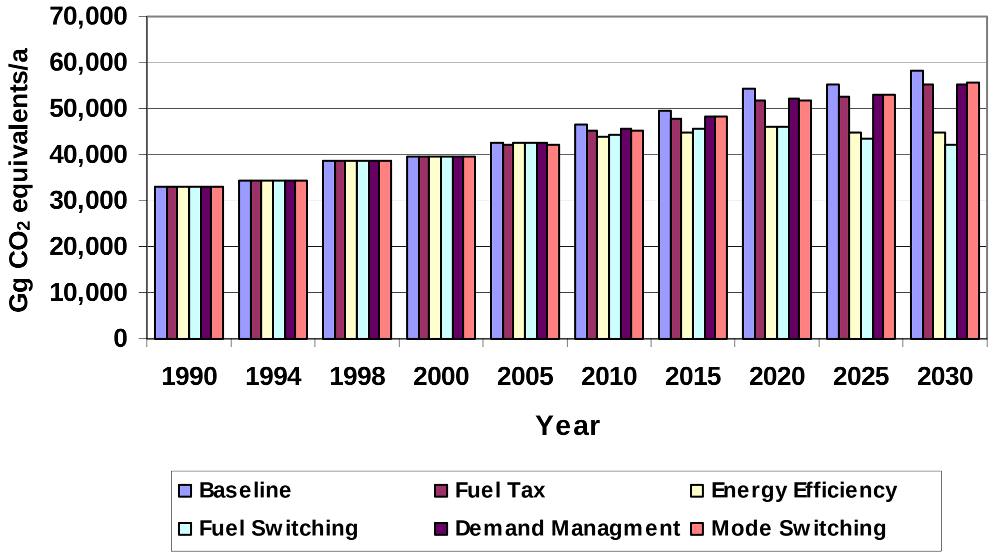


Figure 7.3: GHG Emissions from the transport sector according to different scenarios for the period 1990-2030

It is expected that a greater impact in reducing greenhouse gas emissions will be achieved by implementing a combination of mitigating options rather than introducing only one of the options.

7.3 Mining Sector

The SACS Mitigating Options project only allowed for the investigation of the coal mining industry. Other mining sector activities, such as gold and platinum mining, were not included and will be investigated at a later stage.

In the coal mining industry, methane emissions are directly linked to the volume of coal mined and the methods used in the mining. For the Mitigating Options study, methane emissions were calculated by estimating the potential methane content of the coal from its fixed carbon content and based on the depth at which the coal is mined, and the degree of saturation of the coal with methane (Lloyd *et al.*, 2000). The methane emissions were estimated from the rate and method of mining, using correction factors employed internationally to allow for methane released from coal exposed, but not extracted, by mining. Coal bed methane in South Africa has been strongly mobilised during the coalification process and much methane has already been lost. As a result, the methane content of the coal is about one fifth of what it would be if losses had not taken place. Business-as-usual emissions from coal mining activities are given in Figure 7.4

Mitigation can be achieved either by reducing the emissions at source or removing the emitted material before it escapes into the environment. Possible options for reducing these emissions include:

Adopting higher extraction ratios underground: Pillar methods of mining leave considerable quantities of coal not mined in the form of support pillars from which methane diffuses into the atmosphere. However, there are significant limitations on the widespread use of total extraction underground. The disadvantages of total extraction would be reduced if other means of roof support, such as ash filling, could be employed. It has been assumed that the emission factor for total extraction followed by ash filling is 1.23, in comparison to the factor of 1.93 for pillar support measures. Where some pillar support is still required a factor of 1.6 is assumed.

Extraction of remnant pillars: The extraction of remnant pillars that are readily accessible by open-casting would stabilise the under-mined ground permanently and would prevent spontaneous combustion. It is assumed that there are 15 billion tonnes of coal immobilised in pillars, of which one third is close enough to the surface to be mined by opencast methods. It is therefore assumed that 5 million tonnes of the coal immobilised in pillars will recovered, which will replace coal currently produced from deeper and more methane-rich areas.

Improved coal utilisation resulting from improved coal washing: Improving the efficiency of the washing plants will result in a reduced discard coal fraction. Efficiencies of 0.15% per annum have been achieved and are assumed for the mitigating options study.

Improved combustion technology to burn discards: At present there are difficulties in burning discard coal because of the high ash content that leads to excessive erosion of boiler internals. Eskom is undertaking a pilot study of fluidised bed combustion that would allow coal discards to be used, and thus reduce the amount of coal that would need to be mined.

Removal of emitted methane prior to mining: Methane drainage prior to mining through holes drilled from the surface has been widely practised. Widespread investigations into the possibility of establishing an industry to recover the methane for local heating duties have been undertaken.

Catalytic combustion of methane: An investigation being undertaken in Canada to evaluate the catalytic flow reversal process, which catalyses the exothermic conversion of methane to carbon dioxide and water. The heat generated by the combustion can also be recovered.

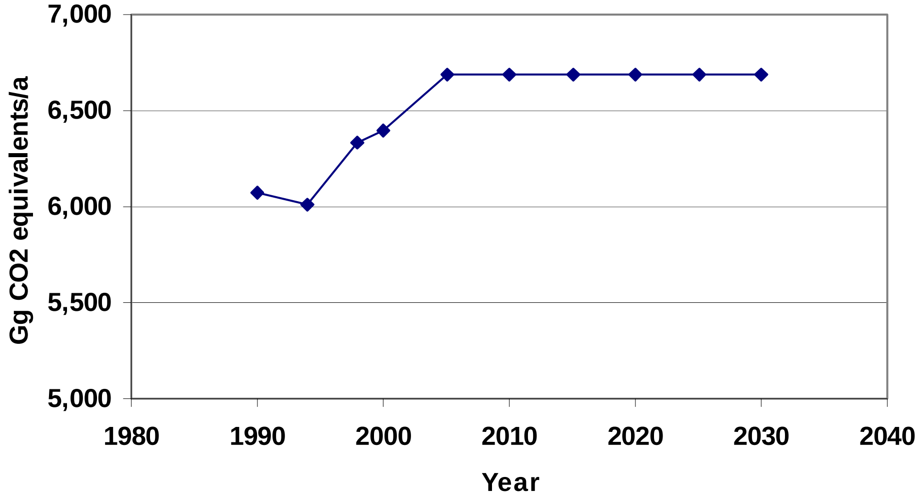


Figure 7.4: Business-as-usual emissions from the coal mining sector for the period 1990 to 2030

In addition to methane emissions associated with coal mining, spontaneous combustion of coal occurs in abandoned mines and discard dumps. This combustion has not been quantified and requires further research to evaluate the potential emissions.

The quantity of methane in South African coals is generally low compared to coals of an equivalent composition elsewhere in the world (Lloyd *et al.*, 2000). This is due to the relative shallowness of the coal reserve and the relative under-saturation of coals caused by past losses of methane. From a global climate change perspective it is considerably more beneficial to mine South African coal, intensively, rather than mine coals in other countries that are at far greater depths and are close to methane saturation.

Despite the relatively low cost of energy in South Africa, the large amount of energy needed for deep mining and mineral beneficiation, coupled with the currently relatively low mineral prices, have given the mining industry incentives to improve energy use efficiency, independently of any climate change considerations.

7.4 Industrial Sector

Mitigation options were investigated for the following industrial process categories (Borland *et al.*, 2000):

- Industrial Chemicals
- Basic Iron and Steel Products (e.g. iron and steel and ferroalloys)
- Other Non-Metallic Minerals
- Pulp and Paper Products
- Non-Ferrous Metallic Products
- Other Industrial Processes.

The industrial processes that were specifically *excluded* from the brief of this study included oil refineries, which were included in the bulk energy sector, and mining and minerals refining.

Industrial processes for which information was readily available included: cement, limestone, pulp and paper, iron and steel, ferroalloys, calcium carbide, nitric acid, propylene, ethylene, ammonia, formaldehyde, phthalic anhydride, aluminium, and sugar refineries. Emissions generated from the industrial process and energy consumed for the processes were reported separately.

Although economic growth in the last few years has remained well below 5%, the restructuring of the economy, which has been initiated, has provided a much sounder base for future economic growth. It is therefore anticipated that higher growth rates can be expected. A growth rate of 5% was used to predict emission growth up to 2030. The growth in emissions generated from the industrial processes sector is shown in Figure 7.5

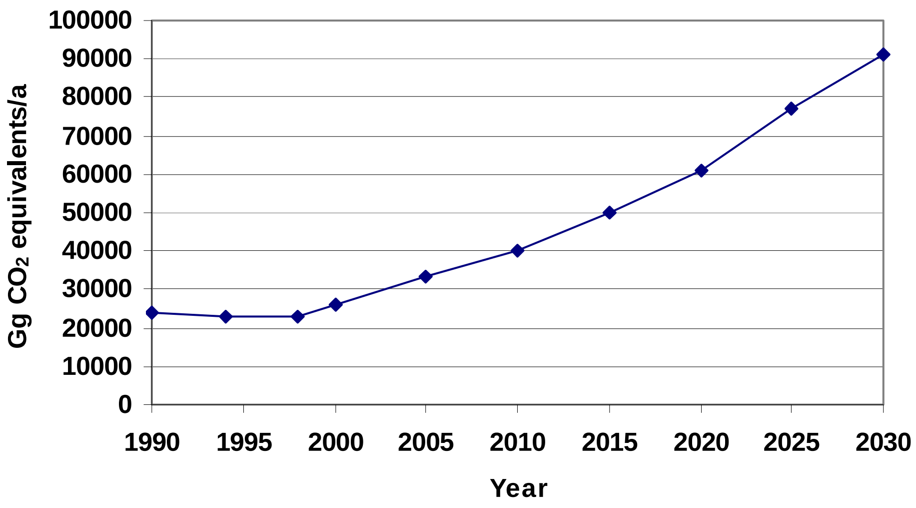


Figure 7.5: Total industrial sector business-as-usual process emissions (1990 to 2030)

Potential mitigation options can be divided into three categories:

Policy/regulatory options: Government intervention in this option is aimed at encouraging industry to introduce measures to reduce the rate of increase in greenhouse gas emissions proportional to the growth in the sectors. These measures would include: promotion of environmental management co-operation agreements between government and industry both in respect of energy efficiency and process emissions; promotion of recycling and re-use of waste; standards for industrial sector equipment, (e.g. motors, pumps and lighting), and a more stringent approach to emission standards for greenfields investment.

Energy related options: The current level of energy use implies that potential exists for greater energy efficiency. However, many industrial processes are a function of the chemical stoichiometry and the thermodynamics of the process reaction, which are fixed variables. It is estimated that approximately 80% of the energy utilised in the key manufacturing industries is prescribed for the specific processes and thus cannot be significantly reduced. An increasing commitment to sustainable development by industry will go some way towards ensuring that new investment decisions exploit opportunities provided for energy efficiency and emissions reduction offered by cutting-edge technologies. In addition, the long economic life of major industrial installations requires investment decisions to be made as if constraints had been placed on GHG emissions.

Technologies: Existing and new, processes, and new product design concepts that could reduce energy-related greenhouse gas emissions from the industrial sector include such measures as:

- Improving efficiency (e.g., energy and materials savings, co-generation, energy cascading and steam recovery, and use of more-efficient motors and other electrical devices);
- Recycling materials (e.g., aluminium, steel, and paper) which will reduce production volumes and associated greenhouse gas emissions;
- Using fuels with a lower carbon content, e.g. gas rather than coal;
- Implementing more advanced technologies with lower greenhouse gas emissions; and
- Process related options.

Potential mitigating options considered feasible for the period 2000 to 2030 included the following initiatives:

Cement Industry: The cement industry has already started to reduce emissions by implementing a strategy of using industrial waste products in combination with cement. Other measures being considered to reduce energy consumption include additional pre-heating stages where the raw material allows this, which is in cases in which the moisture content is low enough or pre-calcining of the feed. These measures could reduce energy consumption by 4.5% per tonne of product. Energy savings can also be achieved with the addition of a high efficiency classifier that separates out the fine products and thus prevents over grinding. Energy savings could be in the region of 5 to 10%. The dilution of cement clinker with selected industrial waste materials such as granulated slag, fly ash, silica fume or milled limestone also has the effect of reducing the net emissions per tonne of cementitious material used. The cement industry expects to see the clinker content of all cementitious binders used in 2030 to be about 60%. A further mitigating option is to phase out existing wet process clinker kilns.

Ferroalloys Industries: Two mitigating options have been considered in the ferroalloys industry. A potential reduction of emissions could be achieved by optimisation of the process conditions. A maximum reduction of 3.5% may be possible by the year 2015. A long-term option is to recover the carbon dioxide off gas from the furnace to pre-heat the raw materials or to generate electricity. The maximum reduction efficiency with this option would be 7%.

Chemical Industry: Current technology in use in the chemical industry is operated at the highest level of efficiency practically attainable and negligible improvement in direct emissions can be effected without major investment in new technology. The industry is currently undergoing major consolidation and restructuring worldwide. As a result companies are likely to focus on a more limited range of products and to promote research into new technologies. It is expected that new production technology developed for these processes will include cleaner technology, which will minimise greenhouse gases. Energy consumption in this sector is receiving attention and improvements in energy efficiency may be possible, particularly for steam production.

Pulp and Paper Industry: Upgrading or replacing recovery boilers increases the boiler capacity and the energy values of higher black-liquor solids. The realisation of energy, through the incineration of organic residuals reclaimed from spent cooking liquor, has significant potential in terms of increased energy efficiency levels. The technology used in the recovery process is expensive and introducing any improvement in the efficiency of existing technology would involve significant capital expenditure. More feasible options include efficiency improvements (e.g. long-nip press), and recycling of paper.

Aluminium Industry: Substituting raw materials with secondary materials (recycled material) can reduce energy consumption during the production of aluminium by up to 95%. However, only 4% of the total local production is used in South Africa, and the balance is exported. Of the 4% used in South Africa, approximately 10% is at present being returned for recycling.

Industrial activity cannot be seen in isolation and the impact of implementing alternative processes will have a crosscutting effect in other sectors. Hence it has been recommended that a life-cycle approach should be adopted as a more appropriate method to investigate the real effect of mitigation on the South African macro-economy. An example of such a cross-cutting effect is the increased production of aluminium for use in vehicle manufacture, which will increase carbon dioxide emissions for aluminium production, but will result in reduced carbon dioxide emissions due to the lighter aluminium vehicles on the roads, which would have lower fuel consumption.

7.5 Agricultural Sector

The activities in the agricultural sector that contribute to GHG emissions include: enteric fermentation; manure management; burning of agricultural residues; fire frequency; reduction and thickening of savanna; and afforestation (*Scholes et al*., 2000).

The business-as-usual scenario assumed that: livestock numbers would remain constant until the year 2030; the feedlot industry would grow at 4%; half of the manure would be treated in lagoons; tillage practises would be reduced by 5%; cane burning would remain at 80 % of planted area; the frequency of veld fires remains constant; bush encroachment occurs at the same rate and afforestation occurs at the maximum rate permissible within government policy. The business-as-usual emissions are illustrated in Figure 7.6.

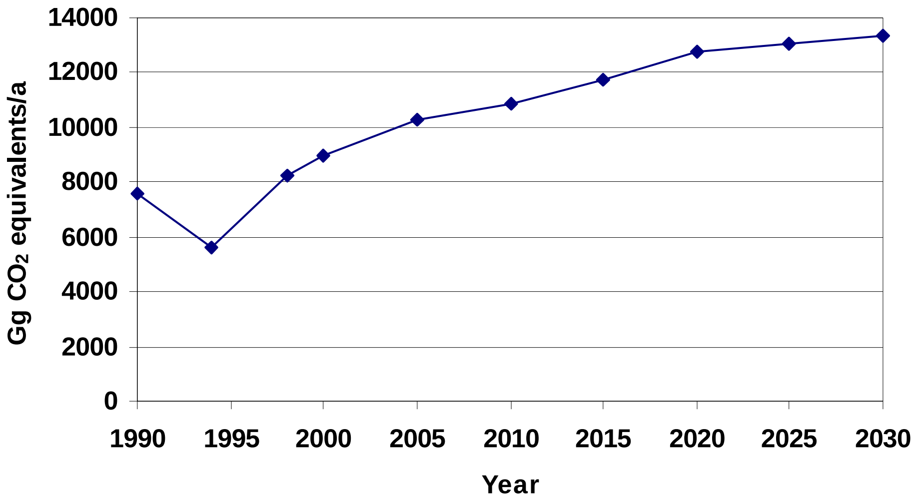


Figure 7.6: Total agricultural sector business-as-usual emissions between 1990 and 2030

The mitigating options that were considered for the agricultural sector included the following:

Optimising herd composition and feed intake: Optimisation of the herd sex, age and breed would allow the national herd to be reduced while maintaining the same level of production. Supplementing the feed with high protein forage would reduce the methane production and increase productivity. A 30% reduction in the free-range herd and a 15% increase in feedlot were assumed. It is estimated that total emissions can be reduced by 207 756 Gg carbon dioxide equivalents with these initiatives over the period 2000 to 2030.

Manure management: It was assumed that 40% of the manure from feedlots is digested anaerobically and that the methane gas is collected for re-use, 10% in lagoons and the remaining 50% by dry spreading. It is estimated that total emissions can be reduced by 49 817 Gg carbon dioxide equivalents with these initiatives.

Burning of agricultural residues: It was assumed that the fraction of area planted with sugar cane that is burned prior to harvest declines to 60% by the year 2005 and remains at that level until 2030. It is estimated that total emissions can be reduced by 9 120 Gg carbon dioxide equivalents with these initiatives.

Fire frequency reduction: The frequency of fires is assumed to be halved over the period 1990 to 2030. It is estimated that total emissions can be reduced by 22 200 Gg carbon dioxide equivalents with these initiatives.

Savanna thickening: It is assumed that savanna thickening is promoted over 40% of the total savanna area. It is estimated that total emissions can be reduced by 237 000 Gg carbon dioxide equivalents with these initiatives.

Afforestation: An additional 330 000 ha planted as a mitigation option would reduce the total emissions by 116 100 Gg carbon dioxide equivalents.

7.6 Waste

The waste sector was not included in the SACS Mitigating Options project. However, a paradigm shift in the approach to waste management is currently underway with an emphasis on implementing the waste management hierarchy rather than applying end-of-pipe treatment.

With the extension of waste management services to an increasingly urbanised population that are currently either poorly serviced or unserviced, the quantities of waste requiring disposal at the landfill sites will increase, as will the methane gas generated. Mechanisms are currently under investigation to promote sustainable recycling of post-consumer waste in order to minimise the amount of recyclable material that is currently landfilled. Currently, collection of the methane gas generated at the landfill sites is limited. Pilot studies are being conducted to collect the biogas, which contains on average 50 to 60% methane, and to purify it to a methane concentration of 90 to 95%, using a membrane separation process developed by the Atomic Energy Corporation in South Africa. The purified methane is to be compressed and stored in cylinders to be used as a fuel source for waste collection trucks.

A number of government initiatives and support schemes, such as the Cleaner Production Scheme, have been developed by the Department of Trade and Industry to promote the implementation of environmentally friendly technologies, which include initiatives to prevent and minimise industrial waste production.

7.7 Evaluation of Mitigating Options

The various mitigating options identified in sections 7.1 to 7.5, have been evaluated utilising the criteria developed for the SA Country Studies Programme (James and Spalding-Fecher, 1999). Table 7.3, lists the benefits and constraints of their implementation. Table 7.4 evaluates the benefits and constraints of the adaptation measures to limit the vulnerability issues that were identified in Chapter 3.

The evaluation of these options is preliminary, based on initial work undertaken in the SA Country Studies programme. This evaluation is reported for information purposes only. It illustrates that climate change mitigation measures have significant sustainable development benefits. More detailed and quantitative analysis of mitigation options is ongoing. A consultative process will be implemented to determine which mitigating options should be pursued.

Table 7.3: Evaluation of mitigating options

Sector	Benefits	Constraints
Bulk Energy		
Demand side management	Lower energy costs due to promotion of off-peak electricity consumption Increased productivity in industrial sector Increased employment in the medium-term	Lower demand for coal in the short-term may slow the rate of increase of job opportunities The need for the development of appropriate tools required, for example: legislation, awareness raising
Cleaner generation mix	Extend natural resources Provide demand for new construction Less environmental impact Lower consumption of water	Expensive new plant required More expensive electricity, which may hamper economic growth Concerns about disposal of spent nuclear fuel should nuclear power be included Visual and noise pollution associated with wind generation
Import of refined products	Construction of new plant not required	Loss of foreign exchange Decrease in job opportunities Lower skills growth
Synthetic fuel production feed stock change from coal to gas	Reduction of electricity demand Reduced need for ash dumps Reduced local air pollution	Loss of foreign exchange Decrease in job opportunities
Residential and Commercial		
Replace incandescent lights	Local manufacturing facilities will create job opportunities Lower life cycle cost Reduce electricity costs	Large promotional campaign necessary Lack of awareness of benefits High initial cost of compact fluorescent lights

Sector	Benefits	Constraints
Efficient wood/coal stove	Reduce depletion of vegetation Local air pollution, including particulates reduced Reduction of expenditure on energy, particularly for the poor	High initial cost Lack of awareness
Solar water heaters	Local manufacturing facilities and installation will create job opportunities Local air pollution, including particulates reduced Household savings on fuel expenditure	High initial cost of conversion
Thermal Efficient Buildings	Reduce requirement for energy and energy expenditure by the poor Local air pollution, particularly indoor air pollution and the associated health risks, reduced	Marginally higher initial cost Lack of building codes Pressure to build houses as quickly and cheaply as possible
Conversion to gas as an energy source	Reduce the incidence of paraffin poisoning and paraffin related fires and burns Reduced air pollution from coal and wood smoke	High initial cost of conversion Inconvenience of obtaining LPG Limited availability of natural gas
Transport Sector		
Fuel tax	Equitable allocation of costs Low administration costs Additional revenue could be used to finance an improved public transport service Reduced local air pollution	Additional revenue collected may be retained as a general tax Rate of taxation considered to be high by stakeholders
Energy efficiency improvements	South Africa is a technology receiver so limited intervention necessary Reduced local air pollution Reduced consumer expenditure on transportation	High cost to the consumer

Sector	Benefits	Constraints
Coal Mining		
Higher extraction ratios underground and ash filling	Underground disposal of a waste Increased extraction of coal Increased productivity Prevention of fires and spontaneous combustion	Possibility of fractures propagating through to the surface Ingress of waste leading to pollution Damage to roof structure Ash filling imposes additional cost, which is unlikely to be economically viable
Extraction of remnant pillars	Permanent stabilisation of undermined ground Prevention of spontaneous combustion	Higher extraction cost
Removal of emitted methane	Minimises the risk of methane gas explosion Local utilisation of methane as a fuel source	Quantity recovered is too low to justify commercial exploitation No system available for distributing methane gas
Agriculture and Land Use		
Enhanced livestock productivity through herd optimisation and improved feed	Small increase in carbon sequestration in the soil Decrease in soil erosion and veld degradation Increased job opportunities in the feedlot industry Properly treated manure can be used as a fertiliser Methane generated from anaerobic digestion of the manure could be used as a fuel source	Higher cost of meat production Manure must be properly managed to minimise pollution potential Smaller herd owners may be forced to reduce their stocks with the possibility of job losses
Reduced burning of agricultural residues	Improvement of air quality Reduced impact on electricity transmission lines Mechanised harvesting lowers labour costs Burnt residue can be incorporated into the soil to generate energy	Sugar cane grown on steep slopes cannot be harvested mechanically High capital cost of equipment Reduced job opportunities for farm labour Small farmers may have to form co-operatives

Sector	Benefits	Constraints
Reduced fire frequency	Job creation opportunities in fire fighting teams Reduction in loss of life and property Reduced impact on electricity transmission lines Improved air quality during winter Thickening of savanna More carbon stored in woody savanna	Policy intervention necessary Investment in fire detection and response infrastructure Loss of free range for livestock
Afforestation	Forest by-products can be used for bio-energy generation Job creation opportunities in the forestry sector	Increased water consumption Loss of biodiversity

Table 7.4: Evaluation of adaptation measures

Sector	Benefits	Constraints
Biodiversity		
Improvement in quality of information on plant and animal diversity	Better monitoring and prediction information Allows for better conservation methods	The information would need to be updated regularly It would need to be integrated into land-use planning
Causal links between climate change and plant and animal distribution	Better future prediction models Future research can be better directed and more specific	Not much local knowledge is available Cost constraints
National conservation strategy	Ecological benefits Species conservation Awareness and education Improved control over development	Much co-operation and co-operation required between sectors Costly
Bio-monitoring network in areas of high biodiversity and high predicted climate change.	More species would be conserved The identification of a suite of sensitive indicator species to serve as flagship warning entities	Costly to implement and manage
Vegetation and animal management policies: Future management will need to be more opportunistic, taking advantage of rare good rainy seasons and managing droughts with extreme caution.	Better conservation of biodiversity Promotes adaptation to changing weather conditions Encourages land use practices which promote biodiversity	The government would have to be proactive Requires research into vegetation management
Focused ex-situ conservation: e.g. seedbanks and botanical gardens, especially for agricultural, horticultural and domestic species.	Saves species bound for extinction	Requires extensive funding

Sector	Benefits	Constraints
Plant translocation action and direct intervention: the rescuing and planting or breeding of certain species from the wild	Saves species bound for extinction	Costly May not necessarily work due to different environmental conditions in various parts of the country. It is not only climate which restricts particular species to particular areas Natural gene pools become disrupted
Tolerating loss: It will be impossible to conserve all species in the face of climate change, a mechanism for prioritising intervention decisions will be crucial. Cost-benefit analysis development taking into account species ecological redundancy/equivalency, potential importance and genetic variation and uniqueness.	Prioritises species for protection Does not attempt to conserve everything, and is thus more cost effective Not costly	Requires much planning and research The planning and research can be costly
Screening species for potential invasiveness.	Lessens the chance of species becoming invasive under changed climatic conditions	Costly, because there are many potentially invasive species in South Africa.
Health		
Improved personal protection devices and strategies such as bed nets and house spraying	Cost effective Creates jobs	Requires awareness and education of users
Monitoring system – environmental parameters	Assists in coping with challenges presented by increased prevalence Would keep track of environmental conditions which impact on spread of diseases Useful in the prediction of disease outbreaks / epidemics	Costly Requires capacity and long-term commitment institutions and government.
Environmental control of snail hosts of schistosomiasis	Would reduce prevalence of disease	Costly
Climate based spatial disease models	Useful in prediction models	Requires effective monitoring system

Sector	Benefits	Constraints
Forestry		
Genetic engineering to produce new tree hybrids which are drought and heat resistant	Maintains production areas Counters the effect of climate change	Requires extensive research Costly
Shifting the geographical location of the tree planting areas	This would counter the effect of climate changes in certain areas Promotes the planting of new trees that are a potential carbon sink.	Reduces biodiversity by allowing more land to be used for forestry Afforestation permits may be difficult to obtain. Industrial capacity will need to be moved, thus costly.
Carbon sequestration marketing	Potential Clean Development Mechanism project	Not viable at present
Tailor land use planning i.e. better planning and monitoring of land use patterns	Helps distinguish trends in land use Promotes land use trends that are advantageous in the light of future climate change scenarios Climate change can be factored into future predictions	Requires land use monitoring network Costly
Rangeland		
Monitoring and forecasting of fire hazards and droughts	Promotes better long-term planning Beneficial even without climate change	Costly
Promotion of nitrogen containing supplements due to declining levels of nitrogen in forage	Increased livestock production Decreased methane emissions	Costly
Disease outbreaks may increase: Veterinary Health Services would need to be aware of the diseases which may become a problem	Improved detection of diseases Improved monitoring of diseases	Requires awareness raising and capacity building Costly

Sector	Benefits	Constraints
Drought management to recognise droughts as part of a highly variable climatic system	Promotion of more resistant crops Farmers need information on drought resistant crops Farmers need to be discouraged from relying on drought relief	Requires flexibility and adequate research Requires planning
Water Resources		
Plan and co-ordinate use of river basin	Improvement of water quality and supply Ecological needs will be incorporated into planning Proper planning allows for changes in human factors e.g. population growth	Requires co-ordinated future planning
Infrastructure changes to allow for increased capacity	Improves long-term viability of the infrastructure Cost effective	Costly
Conserve water (many methods can be used to conserve water, some of which are in place already e.g. Water pricing policy)	Improves environmental awareness Reduces pressure on ecosystem as the climate changes	Involves public awareness campaigns and education Requires strict policy on and monitoring of water use
Use interbasin transfers	Relatively easy to implement Effective short-term measure to provide water during variable climatic conditions	Requires extensive and co-operative planning and foresight
Maintain options to develop new dam sites, which are currently very limited in S.A	Is not costly to maintain sites Is a good long term investment	Requires planning and possibly the purchasing of land where dams can be built Some sites may be costly to purchase
Improve quantity and quality of drinking water by reducing water pollution	Increases amount of clean water available Promotes environmental awareness and ecosystem conservation	Requires monitoring network and efficient policing Costly

Sector	Benefits	Constraints
Agriculture		
Changed planting dates	Not costly Relatively easy to implement Reduces chances of crop failures	Requires education and awareness of farmers
Healthy and drought resistant crops need to be promoted as well as the growing of a variety of crops	Reduces vulnerability to crop failure Monocultures will need to be discouraged in the future These methods allow for climatic variability	Requires education and public awareness programmes Requires research Costly for farmers to change the crops which are planted and to plant many different crops
Government aid for subsistence / marginal farmers	Reduces the impact that climate change has on farmers who are already struggling	Government may not have funds available
Altered irrigation methods by improving flexibility in water-use in order to allow for decreases in available water and changed precipitation patterns	Irrigation systems will have to be changed to allow for variable climatic conditions Improved systems would potentially conserve water and buffer the effect of climate change	Costly for farmers to change irrigation patterns and systems
Improved information network regarding farming practices e.g. conservation tilling, furrow dyking, terracing, contouring, and planting vegetation to act as windbreaks	Reduction in wind erosion. Improved water use efficiency Reduce the impact of agriculture on biodiversity Improved resiliency to climate change impacts	Requires capacity building and awareness programmes to operate effectively Costly to implement many of the mentioned farming practices

8. PRELIMINARY NEEDS ASSESSMENT

8.1 Greenhouse Gas Inventories

An urgent need exists for the establishment and maintenance of a greenhouse gas emission inventory database. All the emission data collected for this communication was provided voluntarily by emitting sectors or calculated from a variety of data sources.

Data needs to be collected for all emissions not included in this communication for at least 1994 in order to have a full inventory for that year. Collection of this data should be integrated with the establishment of an emission inventory data management system. The determination of appropriate emission factors for local conditions and recognition of these in future IPCC guidelines is an issue requiring attention. This is particularly important in respect of the need to establish baselines for potential CDM projects under the Kyoto Protocol.

An independent verification system to ensure that only verified data is included in a national emissions database needs to be developed and maintained. It is believed that independent verification of the emission data will contribute to an improvement in the level of certainty of the data.

The low level of certainty attributed to emission data from some sectors needs to be addressed. It is believed that sound institutional arrangements will facilitate improvements in the levels of certainty, as these arrangements will ensure continuity thus building on a institutional knowledge base rather than establishing a new one for each inventory.

8.2 Vulnerability and Adaptation

While expertise in the various areas covered by the vulnerability and adaptation studies exists in South Africa, a permanent co-ordinating mechanism to facilitate the preparation of future national communications does not exist. Although the integration of climate change into planning and policy formulation in the vulnerable sectors should go some way to overcoming this problem. Guidance on international best practice in this area would be useful.

The vulnerability and adaptation assessment undertaken as part of the South Africa Country Studies programme has provided the foundation for progressing to Stage 2 Adaptation studies. All relevant government departments will now be considering what financial and technical assistance will be required to undertake planning for adaptation. It is intended to formulate a National Climate Change Response Strategy, which will include adaptation strategies for each of the vulnerable sectors. This approach will facilitate the preparation of an integrated response strategy.

8.3 Systematic Observation and Research

Although some steps have been taken towards a holistic national approach to climate change research, this needs to be consolidated in national research policy. Dissemination of the results of research projects to a wider audience needs to be undertaken and at the same time research institutions encouraged to make use of international funding available for this purpose.

8.4 Education, Training and Public Awareness

One of the key elements of increasing capacity to deal with climate change issues is the need to promote integration of relevant aspects into the work of all government departments on the one hand and to encourage incorporation into business strategies on the other. Although a number of international programmes have been initiated to assist developing countries with capacity building, significant work is needed to ensure that capacity is built in all sectors of society.

Sector and topic specific programmes need to be developed to cover not only the specific issues relating to climate change but also to disseminate best practices in incorporating climate change into relevant planning activities.

Climate change activities should be incorporated into educational curricula at primary, secondary and tertiary levels in order to broaden public awareness of the issue. In this regard climate change needs to be seen as an integral part of modules on sustainable development.

8.5 Mitigation options

The preliminary investigation into potential mitigation options needs to be extended to include more specific macro-economic modelling to evaluate the impact of different measures on the economy. In this regard, approaches to the evaluation of measures need to be developed and implemented. The promotion of climate friendly and energy efficient technologies needs to be further incorporated into government's cleaner technology initiatives. In addition appropriate tools to model impacts and consequences of climate change need to be developed.

8.6 Institutional Arrangements

No institutional arrangements exist in South Africa to ensure continuity in the preparation of future national communications. The data that has been collated for this communication exists in a number of different data management systems, both in the public and private sector. The team that prepared the communication was comprised almost entirely of experts external to government. In order to facilitate the preparation of future communications, more permanent institutional arrangements need to be established. Incorporation of climate change into a consolidated approach to sustainable development may improve the situation for future communications. The dissemination of information on international best practices in this area would be useful in considering the establishment of suitable institutional arrangements

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Appendix 1

1990 GHG Inventory Summary Tables

TABLE 7A SUMMARY REPORT FOR NATIONAL GREENHOUSE GAS INVENTORIES

(Sheet 1 of 3)

SUMMARY REPORT FOR NATIONAL GREENHOUSE GAS INVENTORIES (Gg)

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 Emissions	CO_2 Removals	CH_4	N_2O
Total National Emissions and Removals	**280,931.79**	**-16,982.37**	**2,053.09**	**75.15**
1 Energy	**252,019.05**	**0.00**	**346.96**	**5.10**
A Fuel Combustion (Sectoral Approach)	252,019.05		23.15	5.10
1 Energy Industries	159,114.62		0.52	2.76
2 Manufacturing Industries and Construction	47,026.25		5.64	0.74
3 Transport	30,941.18		8.63	1.36
4 Other Sectors	14,936.99		8.36	0.24
5 Other (please specify)	0.00		0.00	0.00
B Fugitive Emissions from Fuels			323.81	
1 Solid Fuels			323.20	
2 Oil and Natural Gas			0.61	
2 Industrial Processes	**28,912.74**	**0.00**	**3.27**	**5.84**
A Mineral Products	5,478.19			
B Chemical Industry	1,658.81		3.27	5.84
C Metal Production	21,775.73		0.00	0.00
D Other Production	0.00			
E Production of Halocarbons and Sulphur Hexafluoride				
F Consumption of Halocarbons and Sulphur Hexafluoride				
G Other (please specify)	0.00		0.00	0.00

TABLE 7A SUMMARY REPORT FOR NATIONAL GREENHOUSE GAS INVENTORIES

(Sheet 2 of 3)

SUMMARY REPORT FOR NATIONAL GREENHOUSE GAS INVENTORIES (Gg)				
GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 Emissions	CO_2 Removals	CH_4	N_2O
3 Solvent and Other Product Use	**0.00**			**0.00**
4 Agriculture			**1,014.45**	**61.84**
A Enteric Fermentation			916.55	
B Manure Management			83.42	1.40
C Rice Cultivation			0.00	
D Agricultural Soils				59.71
E Prescribed Burning of Savannas			12.63	0.61
F Field Burning of Agricultural Residues			1.85	0.12
G Other (please specify)			0.00	0.00
5 Land-Use Change & Forestry	**(1) 0.00**	**(1) -16,982.37**	**0.00**	**0.00**
A Changes in Forest and Other Woody Biomass Stocks	(1) 0.00	(1) -13,640.99		
B Forest and Grassland Conversion	0.00		0.00	0.00
C Abandonment of Managed Lands		0.00		
D CO_2 Emissions and Removals from Soil	(1) 0.00	(1) -3,341.38		
E Other (please specify)	0.00	0.00	0.00	0.00
6 Waste			**688.40**	**2.38**
A Solid Waste Disposal on Land			669.27	
B Wastewater Handling			19.13	2.38
C Waste Incineration				
D Other (please specify)			0.00	0.00
7 Other (please specify)				

TABLE 7A SUMMARY REPORT FOR NATIONAL GREENHOUSE GAS INVENTORIES

(Sheet 3 of 3)

SUMMARY REPORT FOR NATIONAL GREENHOUSE GAS INVENTORIES (Gg)				
GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 Emissions	CO_2 Removals	CH_4	N_2O
Memo Items				
International Bunkers	**7,195.41**		**0.00**	**0.00**
Aviation	1,404.50		0.00	0.00
Marine	5,790.91		0.00	0.00
CO_2 Emissions from Biomass	**0.00**			

TABLE 8A OVERVIEW TABLE FOR NATIONAL GREENHOUSE GAS INVENTORIES

(Sheet 1 of 3)

OVERVIEW TABLE									
GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2		CH_4		N_2O		Documentation	Disaggregation	Footnotes
	Estimate	Quality	Estimate	Quality	Estimate	Quality			
Total National Emissions and Removals									
1 Energy									
A Fuel Combustion Activities									
Reference Approach	ALL	M					H	1	
Sectoral Approach	ALL	M	ALL	M	ALL	M	H	3	
1 Energy Industries	ALL	M	ALL	M	ALL	M	H	3	
2 Manufacturing Industries and Construction	ALL	M	ALL	M	ALL	M	H	3	
3 Transport	ALL	M	ALL	M	ALL	M	H	3	
4 Other Sectors	ALL	M	ALL	M	ALL	M	M	3	
5 Other (please specify)									
B Fugitive Emissions from Fuels							M	3	
1 Solid Fuels			ALL	M			H	3	
2 Oil and Natural Gas			PART	L			M	3	
2 Industrial Processes									
A Mineral Products	ALL	M					H	3	
B Chemical Industry	PART	L	PART	L	PART	L	M	3	
C Metal Production	ALL	M					H	3	
D Other Production									
E Production of Halocarbons and Sulphur Hexafluoride	NE		NE		NE				

TABLE 8A OVERVIEW TABLE FOR NATIONAL GREENHOUSE GAS INVENTORIES (Sheet 2 of 3)

OVERVIEW TABLE									
GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2		CH_4		N_2O		Documen-tation	Disaggre-gation	Footnotes
	Estimate	Quality	Estimate	Quality	Estimate	Quality			
Industrial Processes (cont...)									
F Consumption of Halocarbons and Sulphur Hexafluoride	NE		NE		NE				
Potential (1)									
Actual (2)									
G Other (please specify)									
3 Solvent and Other Product Use	NE		NE		NE				
4 Agriculture									
A Enteric Fermentation			ALL	M	ALL	L	H	3	
B Manure Management			ALL	M	ALL	L	H	3	
C Rice Cultivation	NA		NA		NA				
D Agricultural Soils					ALL	L	H	3	
E Prescribed Burning of Savannas			ALL	L	ALL	L	H	3	
F Field Burning of Agricultural Residues			ALL	L	ALL	L	H	3	
G Other (please specify)									
5 Land-Use Change & Forestry									
A Changes in Forest and Other Woody Biomass Stocks	PART	M					M	1	
B Forest and Grassland Conversion	NE		NE		NE				

TABLE 8A OVERVIEW TABLE FOR NATIONAL GREENHOUSE GAS INVENTORIES (Sheet 3 of 3)

OVERVIEW TABLE									
GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2		CH_4		N_2O		Documen-tation	Disaggre-gation	Footnotes
	Estimate	Quality	Estimate	Quality	Estimate	Quality			
5 Land-Use Change & Forestry (cont....)									
C Abandonment of Managed Lands	NE		NE		NE				
D CO_2 Emissions and Removals from Soil	ALL	M					H	2	
Other (please specify)									
6 Waste									
A Solid Waste Disposal on Land			PART	L			M	2	
B Wastewater Handling			PART	L	PART	M	M	2	
C Waste Incineration	NE		NE		NE				
D Other (please specify)									
7 Other (please specify)									
Memo Items:									
International Bunkers									
Aviation	ALL	M					H	2	
Marine	ALL	M					H	2	
CO_2 Emissions from Biomass	IE	L					L	2	

NOTATION FOR OVERVIEW TABLE

Estimates		**Quality**		**Documentation**		**Disaggregation**	
Code	***Meaning***	***Code***	***Meaning***	***Code***	***Meaning***	***Code***	***Meaning***
PART	Partly estimated	**H**	High confidence in estimation	**H**	High (all background information included)	**1**	Total emissions estimated
ALL	Full estimate of all possible sources	**M**	Medium confidence in estimation	**M**	Medium (some background information included)	**2**	Sectoral split
NE	Not estimated	**L**	Low confidence in estimation	**L**	Low (only emissions estimates included)	**3**	Sub-sectoral split
IE	Estimated but included elsewhere						
NO	Not occurring						
NA	Not applicable						

Appendix 2

1994 GHG Inventory Summary Tables

TABLE 7A SUMMARY REPORT FOR NATIONAL GREENHOUSE GAS INVENTORIES

(Sheet 1 of 3)

SUMMARY REPORT FOR NATIONAL GREENHOUSE GAS INVENTORIES (Gg)				
GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 Emissions	CO_2 Removals	CH_4	N_2O
Total National Emissions and Removals	**315,957.22**	**-18,615.97**	**2,057.43**	**66.70**
1 Energy	**287,850.96**	**0.00**	**375.70**	**5.88**
A Fuel Combustion (Sectoral Approach)	287,850.96		48.57	5.88
1 Energy Industries	167,816.64		0.47	2.61
2 Manufacturing Industries and Construction	53,186.34		6.15	0.78
3 Transport	42,716.69		10.58	1.88
4 Other Sectors	24,131.30		31.38	0.62
5 Other (please specify)	0.00		0.00	0.00
B Fugitive Emissions from Fuels			327.12	
1 Solid Fuels			316.90	
2 Oil and Natural Gas			10.22	
2 Industrial Processes	**28,106.26**	**0.00**	**1.25**	**7.27**
A Mineral Products	5,330.91			
B Chemical Industry	1,952.10		1.25	7.27
C Metal Production	20,823.26		0.00	0.00
D Other Production	0.00			
E Production of Halocarbons and Sulphur Hexafluoride				
F Consumption of Halocarbons and Sulphur Hexafluoride				
G Other (please specify)	0.00		0.00	0.00

TABLE 7A SUMMARY REPORT FOR NATIONAL GREENHOUSE GAS INVENTORIES

(Sheet 3 of 3)

SUMMARY REPORT FOR NATIONAL GREENHOUSE GAS INVENTORIES (Gg)				
GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 Emissions	CO_2 Removals	CH_4	N_2O
Memo Items				
International Bunkers	**10,219.71**		**0.00**	**0.00**
Aviation	1,592.43		0.00	0.00
Marine	8,627.28		0.00	0.00
CO_2 Emissions from Biomass	**0.00**			

TABLE 8A OVERVIEW TABLE FOR NATIONAL GREENHOUSE GAS INVENTORIES

(Sheet 1 of 3)

OVERVIEW TABLE									
GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2		CH_4		N_2O		Documentation	Disaggregation	Footnotes
	Estimate	Quality	Estimate	Quality	Estimate	Quality			
Total National Emissions and Removals									
1 Energy									
A Fuel Combustion Activities									
Reference Approach	ALL	M					H	1	
Sectoral Approach	ALL	M	ALL	M	ALL	M	H	3	
1 Energy Industries	ALL	M	ALL	M	ALL	M	H	3	
2 Manufacturing Industries and Construction	ALL	M	ALL	M	ALL	M	H	3	
3 Transport	ALL	M	ALL	M	ALL	M	H	3	
4 Other Sectors	ALL	M	ALL	M	ALL	M	M	3	
5 Other (please specify)									
B Fugitive Emissions from Fuels									
1 Solid Fuels			ALL	M			H	3	
2 Oil and Natural Gas									
2 Industrial Processes									
A Mineral Products	ALL	M					H	3	
B Chemical Industry	PART	L	PART	L	PART	L	M	3	
C Metal Production	ALL	M					H	3	
D Other Production									
E Production of Halocarbons and Sulphur Hexafluoride	NE		NE		NE				

TABLE 8A OVERVIEW TABLE FOR NATIONAL GREENHOUSE GAS INVENTORIES

(Sheet 2 of 3)

OVERVIEW TABLE									
GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2		CH_4		N_2O		Documentation	Disaggregation	Footnotes
	Estimate	Quality	Estimate	Quality	Estimate	Quality			
Industrial Processes (cont...)									
F Consumption of Halocarbons and Sulphur Hexafluoride	NE		NE		NE				
Potential (1)									
Actual (2)									
G Other (please specify)									
3 Solvent and Other Product Use	NE		NE		NE				
4 Agriculture									
A Enteric Fermentation			ALL	M	ALL	L	H	3	
B Manure Management			ALL	M	ALL	L	H	3	
C Rice Cultivation	NA		NA		NA				
D Agricultural Soils					ALL	L	H	3	
E Prescribed Burning of Savannas			ALL	L	ALL	L	H	3	
F Field Burning of Agricultural Residues			ALL	L	ALL	L	H	3	
G Other (please specify)									
5 Land-Use Change & Forestry									
A Changes in Forest and Other Woody Biomass Stocks	PART	M					M	1	
B Forest and Grassland Conversion	NE		NE		NE				

TABLE 8A OVERVIEW TABLE FOR NATIONAL GREENHOUSE GAS INVENTORIES

(Sheet 3 of 3)

OVERVIEW TABLE									
GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2		CH_4		N_2O		Documen-tation	Disaggre-gation	Footnotes
	Estimate	Quality	Estimate	Quality	Estimate	Quality			
5 Land-Use Change & Forestry (cont....)									
C Abandonment of Managed Lands	NE		NE		NE				
D CO_2 Emissions and Removals from Soil	ALL	M					H	2	
Other (please specify)									
6 Waste									
A Solid Waste Disposal on Land		PART	L				M	2	
B Wastewater Handling			PART	L	PART	M	M	2	
C Waste Incineration	NE		NE		NE				
D Other (please specify)									
7 Other (please specify)									
Memo Items:									
International Bunkers									
Aviation	ALL	M					H	2	
Marine	ALL	M					H	2	
CO_2 Emissions from Biomass	IE	L					L	2	

Refer to Appendix 1 for Notation Key for Overview Table