Ecosystem Services in Southern Africa: A Regional Assessment

Edited by R.J. Scholes and R. Biggs

The Regional-Scale Component of the

Southern African Millennium Ecosystem Assessment

Millennium Ecosystem Assessment

STRENGTHENING CAPACITY TO MANAGE ECOSYSTEMS SUSTAINABLY FOR HUMAN WELL-BEING

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ECOSYSTEM SERVICES IN SOUTHERN AFRICA: A REGIONAL ASSESSMENT

Editors

R.J. Scholes and R. Biggs

Contributors

J.J. Cooper

G.J. Fleming

T.P. Malungani

A. A. Misselhorn

2004

Council for Scientific and Industrial Research, Pretoria, South Africa

A contribution to the Millennium Ecosystem Assessment, prepared by the regional-scale team of the Southern African Millennium Ecosystem Assessment

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Guidance: SAfMA Advisory Committee, SAfMA Technical Group

Technical input: Blondie Rapholo, Marius Claassen, Akhona Damane

Data: Charles Vorosmarty, Pamela Green, Greg Hughes, Russ Kruska, RETOSA, Michael O'Donnell, Scott Drimie, Steve Hine

Reviewers: Pete Ashton, James Blignaut, Richard Cowling, Rod de Vletter, Sheila Heileman, Brian Huntley, Fredrick Owino, Hillary Masundire, Tom Roach, Mary Scholes, Charlie Shackleton, Sheona Shackleton, Anthony Turton, Mieke van Tienhoven, Gert Venter, Coleen Vogel

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Executive Summary

'Ecosystem services' are the benefits that people derive from nature. This document reports on selected ecosystem services in Africa south of the equator, an area of 10.7 million km^2, around the year 2000, explores two scenarios extending to 2030, and discusses response options for the different services. The study forms part of the Southern African Millennium Assessment (SAfMA) and is coordinated with studies in the Zambezi and Gariep river basins, local-scale assessments within these basins, as well as being linked to the global Millennium Ecosystem Assessment (MA). This report is aimed at decision-makers in national governments and non-governmental organisations in the region, as well as the public.

Human well-being

The MA approach links human well-being to the state of ecosystem services. By standard measures of well-being, the countries of the southern African region are on average in the bottom quarter of the world ranking, and even the best-off countries rank in the bottom half. The total population in 2001 was 275 million, increasing at 2.2% per annum. One third of the population lives in urban areas, and this fraction is rising rapidly.

Freshwater

Southern Africa, broadly speaking, has a water-scarce south and a water-rich north. Virtually all the water basins are shared between countries, creating high potential for conflict both between countries and between water-use sectors. International treaties and institutions are partly in place to manage this issue. Water policy in the region is globally innovative. A key policy response in the critically-dry countries has been to make water allocation more market-related, after first protecting the minimum needs of people and riparian ecosystems. In the dry areas people are dependent on groundwater, which in most places is being used at a rate that exceeds its recharge.

Food and nutrition

The study analyses the multiple, interacting causes of food insecurity in the region. Most do not relate directly to food production, but to food access. The region as a whole produces enough carbohydrate crops to in principle meet the aggregated minimum needs of its population. In practice, because of distribution inequities, up to 25% of the population are undernourished. The agro-ecological potential exists in the region to meet the food needs both now and in the future, if the known technological, economic and political constraints can be overcome. Meeting the Millennium Development Goal on hunger reduction will not occur without decisive intervention.

The situation regarding protein nutrition is particularly serious. The average protein supply for people living north of the Zambezi River is below the minimum daily requirement, and declining. The root cause is the low natural nitrogen-supplying capacity of ecosystems in this area, coupled with a levelling-off of fertiliser inputs over the past two decades. Three-quarters of protein requirements are supplied from plants sources. There is little scope for increased off-take from natural fisheries, half of which are already overfished. There is technical opportunity for greater protein off-take from livestock. Currently, a significant but poorly documented part of the nutritional needs in the region are probably derived from natural (non-agricultural) ecosystems.

Energy from natural sources

Three quarters of energy for household cooking and heating in the region is supplied by wood and charcoal. There are woodfuel supply shortages in a number of clearly identified areas, but overall wood growth is adequate for a sustainable harvest. Use of biomass fuels has climate change mitigation advantages, but if burned improperly, is the major cause of poor indoor air quality, leading to severe health problems.

Air quality

Domestic wood burning, wild fires and industrial emissions currently contribute almost equal amounts to regional air pollution, which due to the unique semi-closed circulation pattern over southern Africa, often reaches alarming levels during the winter months. Unless a collective, multi-national approach to managing regional air quality is put in place, significant human and ecosystem health problems will result.

Biodiversity

Africa south of the Equator has a disproportionately high fraction of global biodiversity. Overall, this biodiversity is remarkably well preserved, both inside and outside protected areas. Using a new index developed for the study, it is calculated that 84% of the pre-colonial biodiversity is intact in the region. Certain well-defined groups of species are endangered: Those that are economically valuable, a threat to humans, or are restricted to small habitats highly suitable for human use. The most highly transformed ecosystem type is grassland, which makes up only 4% of the area, and has been one-third converted to croplands and human settlements. The forests and woodlands cover about 40% of the region (4 to 5 million km^2, depending on the forest definition adopted), and are being cleared at a rate of 25 to 50 thousand km^2 per year.

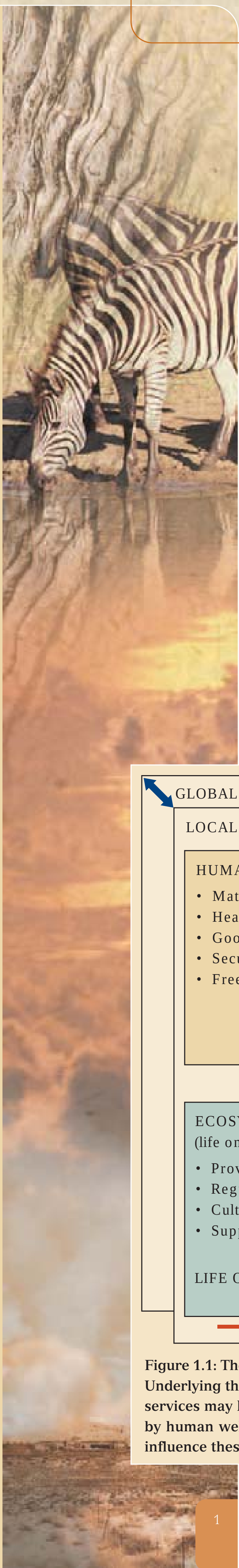
The greatest potential for limiting biodiversity loss in the region is through preventing the degradation of currently sustainably used semi-natural ecosystems outside of formal protected areas. The major causes of degradation are forest and woodland clearing at a rate exceeding regrowth; overstocking of savannas, shrublands and grasslands with domestic livestock, relative to the number of wild grazers that would have been supported by the ecosystems in the past; and overfishing, particularly of the freshwater and East Coast resources.

The natural features of the region form the basis of a major nature-based tourism sector that provides a significant part of the regional economy, and is growing three times faster than agriculture or forestry. Biodiversity also has a large direct economic and human well-being value through the provision of medicines, as well as significant but poorly quantified indirect value through many other services that ultimately depend on biological variety.

Looking to the future

The study explored the consequences to ecosystem services under two political and economic scenarios. One projects forward the current trends of slow economic growth, marginalisation from the global economy, and weak governance. The other assumes that efforts to put the region onto a different development pathway through stronger governance are successful, leading to higher economic growth rates, greater industrial and infrastructural development and closer integration into the global economy. In the first scenario, demands on ecosystem services, especially in rural areas, overwhelms local supply in many places, leading to accelerated degradation and transformation. In the second, the limited water supply and deteriorating air and water quality constrain the improvements in quality of life that can be achieved unless specific mitigation actions are taken. Under both scenarios, agricultural expansion leads to significant biodiversity loss. The land area converted to agriculture is less in the second scenario, but the more intensive nature of the agriculture practiced increases the on-site and off-site impacts, particularly on freshwater biodiversity. Various response options for mitigating the negative effects under both scenarios are explored.

Overall, there is a remarkable spatial congruence between areas where ecosystem services are under pressure, and locations of recent conflict. This interaction probably goes both ways: in some cases, the conflict may be a result of the shortage of resources; in others, the resultant breakdown of authority may be the cause of the resource exploitation. At least four of the eight Millennium Development Goals (reducing hunger and child mortality, combating diseases, and ensuring environmental sustainability) will not be met in the region unless attention is given to stabilising ecosystem services.



1. Introduction

1.1 THE MILLENNIUM ECOSYSTEM ASSESSMENT

The Millennium Ecosystem Assessment[1] (MA) is a four-year international effort to assess the capacity of ecosystems to provide the services needed to support human well-being and life on earth. Ecosystem services include i) provisioning services such as food and water; ii) regulating services such as flood and disease control; iii) cultural services such as spiritual, recreational and cultural benefits; and iv) supporting services such as nutrient cycling, that maintain the conditions for life on Earth.

Several hundred social and natural scientists from all over the world are conducting the MA. In addition to evaluating the current condition and recent trend of ecosystem services, the assessment explores future scenarios and response options with respect to the provision and management of ecosystem services. The MA is funded by the World Bank, donor countries and private foundations, which are represented on the MA Board together with representatives of various user groups and United Nations organisations.

At the global scale, the MA primarily serves multilateral environmental agreements such as the Convention on Biodiversity (CBD), the Convention to Combat Desertification (CCD) and the Ramsar Convention on Wetlands. A novel feature of the MA is that the assessment is also being conducted at regional and local scales in several parts of the world, serving users at those scales. The "Southern African Millennium Assessment" (SAfMA) is one of the sub-global assessments contributing to the global MA. This document reports on the regional-scale aspect of SAfMA and is aimed at improving decision-making in southern Africa at national to regional scales.

Human well-being depends on ecosystem services

Humans are directly dependent on ecosystems for air, water, food and other basic needs. Ecosystems also provide recreational opportunities and aesthetic, cultural and spiritual values. The dependence of people on ecosystems is often more apparent in rural communities whose lives are directly affected by the availability of resources such as food, medicinal plants and firewood. Urban communities and wealthier groups in society may be partly buffered from changes in ecosystem services, for example by water treatment plants performing the water cleaning services that healthy rivers provide. The links between human well-being,ecosystems services, and the factors which affect these are represented in Figure 1.1.

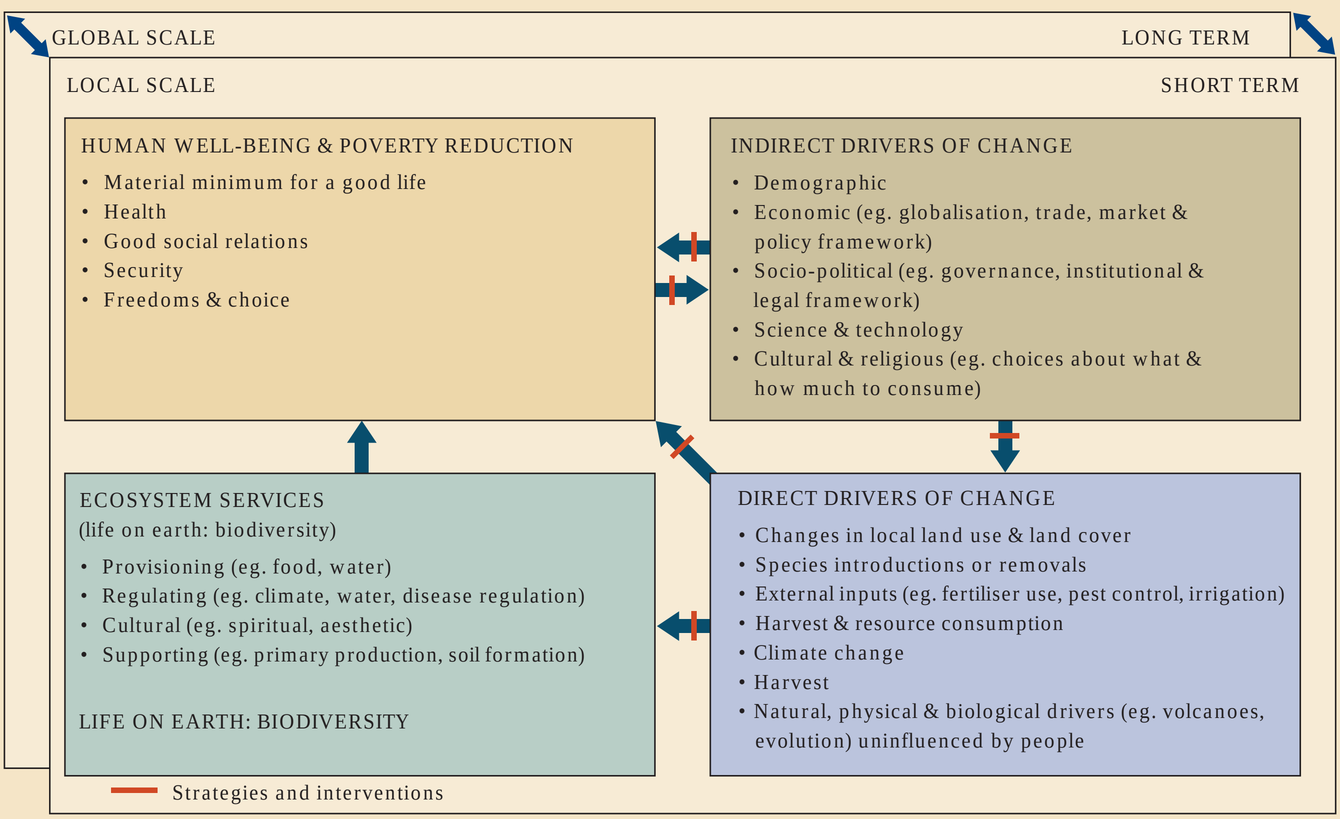


Figure 1.1: The conceptual framework of the MA (MA 2003). Human well-being is partly dependent on the availability of ecosystem services. Underlying the provision of these services are supporting ecosystem processes such as nutrient cycling, hydrology and climate. Ecosystem services may be affected by factors such as pollution and land cover change. Ultimately, the drivers of change are themselves influenced by human well-being. Feedbacks occur at all scales, from an individual household to the entire globe. Interventions at key points can influence these feedbacks in beneficial ways.

[1] www.milleniumassessment.org

1.2 THE SOUTHERN AFRICAN MILLENNIUM ASSESSMENT

The Southern African Millennium Assessment (SAfMA) aims to assess several key services provided by ecosystems in southern Africa, and their impacts on the lives of the region's people. For the purposes of this study, the southern Africa region consists of the nineteen countries on mainland Africa that lie entirely or partially south of the equator. The region lies between approximately 5°N and 35°S and 10°E and 40°E, and includes about 40% of the land area of Africa. It was delineated as a useful basis for analysis because it exhibits a rough convergence of biological, climatic, social and economic factors. Regional stakeholders were represented on the SAfMA Advisory Committee, which directed the work of the SAfMA team.

Multi-scale approach

An important objective of SAfMA was to test ways of integrating results obtained at different scales of assessment. SAfMA was therefore designed and carried out at three 'nested' scales: the region; two major drainage basins within the region; and five local-government areas within the basins (Figure 1.2). Since a multi-scale assessment had never been conducted in the region, SAfMA adopted an experimental approach. Each contributing study was encouraged to test the assessment method that they deemed most appropriate. Much of the local level data was collected using participatory research approaches, while the basin and regional scale studies made use of quantitative modelling approaches. All SAfMA studies assessed three core services (food, water, and the cluster of services associated with biodiversity), as well any additional services of interest to stakeholders at that scale.

The assessment reports

This report covers only the assessment at the regional scale. Following this introduction, chapter 2 paints a background of ecosystems and human well-being in the region, and chapter 3 presents scenarios of social and economic development over the next three decades. Six chapters dealing with key ecosystem services follow: Biodiversity and Land Cover, Food and Nutrition, Freshwater, Biomass Fuel, Air and Nature-based Tourism. A synthesis chapter concludes the report.

Independent reports are available for the studies at basin and local scales, and an integrated SAfMA synthesis report extracts important themes across the full set of studies. In addition, there are five volumes associated with the MA overall, including the Conceptual Framework (MA 2003), the three 'Global MA' reports on Condition and Trends, Scenarios, and Responses, and a fourth report synthesising all the sub-global assessments linked to the MA. The latter four documents are to be published by Island Press in 2005.

Figure 1.2: The SAfMA study area and its nested, multi-scale design. Five local-scale assessments, each covering the area of a community or local authority, were nested within two basin-scale assessments (the Gariep and Zambezi), which in turn lie within an assessment of the entire southern African region south of the equator. All contribute to the global-scale MA. Note that the actual Gariep Basin (indicated by a dashed line) extends beyond the area assessed

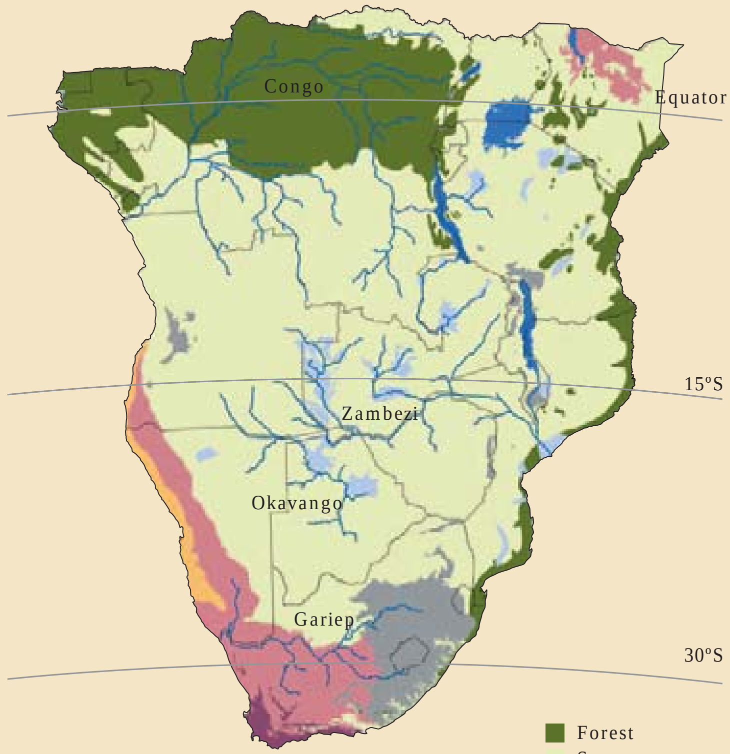


Figure 2.1: The biomes of southern Africa. Savannas cover more than half the region. The central plateau is drained by four major river systems, while the coastal regions are drained by numerous smaller rivers.

2.1 SOUTHERN AFRICAN ECOSYSTEMS

The services that a particular ecosystem provides are determined by the characteristics of that ecosystem, most fundamentally by the geology and climate. The soil, together with the rainfall and temperature, largely determine which plants (or crops), and in turn, which animals (including pests and diseases) survive in a particular area. At the highest level of ecosystem classification, the resulting groups of ecological communities in southern Africa can be classified into eight 'biomes': Forest, savanna, grassland, arid shrublands, desert, Fynbos, wetlands and lakes (Figure 2.1).

Most of southern hemisphere Africa consists of a plateau above 1000 m in altitude, largely underlain by granite-like rocks. Because of their antiquity and original acidic nature, they provide relatively infertile soils. Around the edges of the plateau, and associated with the volcanic Rift Valley in the northeast, are younger landscapes that provide more fertile soils. The centre of the plateau is slightly hollow and covered by a wind-blown sand sheet, forming the Kalahari. This hollow has captured a major drainage system, the Okavango, which dissipates in the inland Okavango 'delta'. The other major river basins in the region are the Congo, draining the high rainfall area in the north of the region, the Zambezi, draining

Table 2.1: The main ecosystems of southern Africa, based on a reclassification of the WWF Terrestrial Ecoregions (Olson *et al.* 2001). Africa has been shaped by humans for hundreds of thousands of years, but the area transformed for settlements and crop agriculture is believed to have been small before the colonial period starting in 1600. The final column refers to the percentage of the pre-colonial area that remains untransformed.

			Climate[1]			Area (1000 km^2)		
Biome and sub-biome		Soil/geology	MAT	P:E	Other	PreCol.	2000[3]	%
Forest	Lowland (Rain) forest	Generally infertile	23-25	0.6-1.6		1815	1693	93
	Montane forest	Fertile but steep	14-22	0.5-1.3		190	149	78
Savanna	Broadleaf (Miombo)	Infertile, sandy	19-24	0.4-1.2		3558	3217	90
	Mopane		20-25	0.2-0.6		605	469	77
	Fineleaf (Acacia)	Fertile, loamy & clayey	18-27	0.1-0.6		1785	1504	84
Grassland	Montane grassland	Fertile ('sweet') or infertile ('sour')	12-20	0.3-1.0	Winter frost	434	298	69
Arid Shrubland	Non-succulent	Fertile, often calcareous	15-27	0.1-0.3	Summer rain	671	663	99
	Succulent	Often very stony	14-18	0-0.2	Winter rain	103	102	100
Desert	Namib	Sandy or gravelly	15-20	0-0.3		126	126	100
Fynbos	Fynbos	Generally infertile	13-17	0.1-0.3	Winter rain	78	68	87
Wetland	Permanent wetland	Organic (peaty)		always	Any climate if	172	153	89
	Seasonal (dambo, vlei)[2]	Often cracking clays (turf)		wet	water supply	990	885	89
	Estuaries & mangroves	Saline, organic			> evaporation	23	22	95
	Salt pans					40	38	95
	Inland water & coastal waterways					197	197	100
REGION						**10788**	**9584**	**89**

[1]MAT = Mean annual temperature; P:E = Ratio of mean annual precipitation to mean annual potential evaporation, and is an indicator of the water available to plants. Figures represent the 5th and 95th percentile ranges for each ecosystem. [2] Includes an estimated 20% of Broadleaf Savanna and 10% of Grassland. [3] The area remaining in 2000 that is untransformed by cultivation or urbanisation, as estimated from GLC 2000.

eastward across central plateau, and the Gariep (also known as the Orange), draining the southern plateau westward.

In the northern part of the region, the climate is dominated by a tropical low-pressure convergence zone, resulting in high rainfall. In the south, a high-pressure divergence zone (Hadley cell) is anchored over the subcontinent, especially during winter, resulting in drier conditions. The cold, north-flowing, nutrient-rich Benguela current on the west coast and the warm, south-flowing, nutrient-poor Mozambique current on the east coast set up an east-west gradient of increasing aridity in the southern part of the continent. The extreme southwest experiences winter rainfall; the rest of the region has summer rainfall, generally in one peak between October and April, but with two peaks in East Africa.

Savannas cover more than half the region (Table 2.1). Almost 90% of the area is still covered by natural vegetation, although only 15% of the region is formally protected (Table 4.7, page 25). The areas of natural vegetation outside protected areas are used mainly for livestock grazing, and also play an important role as a source of fuelwood and fibre, as well as of fruits, vegetables and bushmeat to supplement people's diets. Climate change (Box 2.1) is projected to have important impacts both on the natural vegetation and on agricultural cropping patterns.

Box 2.1: Projected climate change in southern Africa

There is now little doubt that the climate of the world is changing as a consequence of human actions (IPCC 2001). The world is on average about 0.6 °C warmer now than when climate records began, 150 years ago. This trend is confirmed in many places in southern Africa. Further climate change is inevitable due to the inertia in both the climate system, and the human system that is perturbing it. All global climate models agree that under all scenarios, by 2050 the mean annual temperature in southern Africa will be 2 to 5°C warmer than it was in 1990 (IPCC 2001). The warming is likely to be with greater in the interior, and less near the oceans (Figure 2.2a).

The key uncertainty is where, and by how much, the warming will be accompanied by net drying of the soil. While at a global scale, a warmer climate will lead to more rain this is not necessarily true within certain regions, notably the subtropics. The majority of models indicate a net drying on the western two-thirds of the subcontinent, south of about 10° S, and net wetting on the eastern and northern edges of the domain. The magnitude of the drying and wetting are both less than about 15% of the current mean (Figure 2.3b).

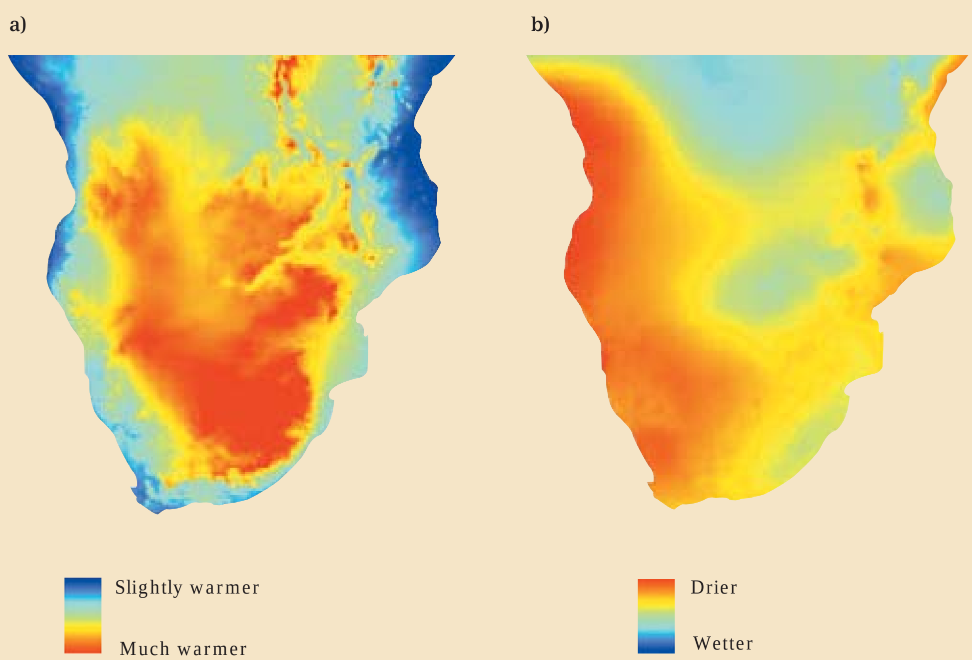
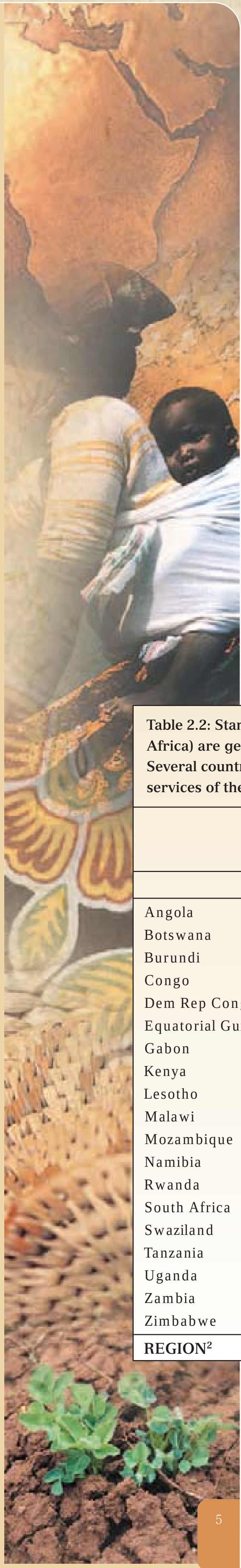


Figure 2.2: HADCM3 climate model projections of changes in a) temperature and b) precipitation for 2050 relative to mean conditions over the 1961 to 1990 period, under the IPCC SRES A2 (high emissions) scenario. Source: Interpolated by G. Hughes, National Botanical Institute, South Africa.



2.2 HUMAN WELL-BEING IN SOUTHERN AFRICA

In terms of standard indicators of human well-being, Sub-Saharan Africa has some of the poorest conditions to be found on the globe: the largest proportion of people living below US$1 a day, the greatest percentage of malnourished people, the highest under-five mortality rate, the lowest primary school enrolment ratio, and the lowest proportion of people with access to safe drinking water or adequate sanitation (UNDP 2003). Nevertheless, there are large within-country disparities: The wealthiest 20% of the population typically possess well over half the income (UNDP 2003). Conditions are relatively better in the southern parts of the region (Table 2.2): South Africa, Namibia, Botswana, Swaziland and Lesotho, as well as Equatorial Guinea, Gabon and Congo are classified as medium human development countries. All other countries in southern Africa fall in the UNDPís low human development category. The Democratic Republic of Congo, Mozambique and Burundi rate in the lowest 5% of all countries.

Many of the poor, and in some cases, worsening conditions are related to the services provided by ecosystems. Life expectancy in Sub-Saharan Africa has declined from 50 to 47 since 1990 (World Bank 2003), mainly due to the high infant mortality rate. HIV/AIDS is the leading cause of deaths, exacerbated by increased susceptibility to diseases carried in, for example, unpurified water. Malaria and tuberculosis also present serious health problems. Lack of clean, affordable energy sources increases susceptibility to illness and malnutrition and also contributes to the poor domestic air quality experienced in many African cities. Cyclical droughts, political instability and ongoing conflict in parts of the region disrupt food production systems and have displaced large numbers of people, increasing pressure on resources in asylum areas. Meeting the Millennium Development Goals, adopted by the nations of the world and strongly reiterated at the Johannesburg World Summit on Sustainable Development in 2002, requires that substantial attention be paid to several issues directly related to ecosystem services (Box 2.2).

The freedom and choice of individuals, and their ability to proactively improve their living conditions, is tightly coupled to literacy, financial viability and social stability and freedom. Gaining substantial, widespread improvements in human well-being is therefore largely dependent on the establishment of enabling conditions by institutions and systems that operate at national, regional and even global levels.

Table 2.2: Standard indicators of human well-being. Conditions in the southern parts of the region (Botswana, Namibia, Lesotho and South Africa) are generally better than in the northern parts, but may decline as the effect of the high HIV prevalence in these countries is felt. Several countries in the north-eastern parts of the region house large numbers of refugees, which places extra pressure on the ecosystem services of these countries. Source: UNDP (2003).

	Human Development Index[1] 2001		Under-five mortality rate 2001	Adult HIV prevalence 2001	Adult literacy rate 2001	Population living below $1 a day 1990-2001	Refugees in country of asylum 2001
	value	*rank*	*per 1000 live births*	*% age 15-49*	*% age 15 & above*	*%*	*thousands*
Angola	0.38	164	260	6	42	-	12
Botswana	0.61	125	110	39	78	24	4
Burundi	0.34	171	190	8	49	58	28
Congo	0.50	140	108	7	82	-	119
Dem Rep Congo	0.36	167	205	5	63	-	362
Equatorial Guinea	0.66	116	153	3	84	-	-
Gabon	0.65	118	90	-	71	-	16
Kenya	0.49	146	122	15	83	23	239
Lesotho	0.51	137	132	31	84	43	0
Malawi	0.39	162	183	15	61	42	6
Mozambique	0.36	170	197	13	45	38	0
Namibia	0.63	124	67	23	83	35	31
Rwanda	0.42	158	183	9	68	36	35
South Africa	0.68	111	71	20	86	<2	19
Swaziland	0.55	133	149	33	80	-	1
Tanzania	0.40	160	165	8	76	20	647
Uganda	0.49	147	124	5	68	82	200
Zambia	0.39	163	202	22	79	64	284
Zimbabwe	0.50	145	123	34	89	36	9
REGION[2]	**0.46**	**150**	**155**	**13**	**71**	**24**	**212**

- No data

[1] HDI is a composite index based on health, education and income. Values are ranked from high to low for 175 countries across the globe.

[2] Population-weighted averages

Box 2.2: The Millennium Development Goals and ecosystem services

The *Millennium Development Goals*[1] are an ambitious global agenda, agreed on at the Millennium Summit in September 2000, for reducing poverty and improving human well-being. For each goal, one or more measurable targets have been set. The targets highlighted below are directly related to the services provided by ecosystems.

Goal 1 - Eradicate extreme poverty and hunger

Target 2: Halve, between 1990 and 2015, the proportion of people who suffer from hunger.
All food is ultimately provided by ecosystems, as a direct service, or through the use of other services such as water or nutrient cycling. In southern Africa, a significant fraction of nutrition, particularly of the poor, is provided by semi-natural ecosystems, and is not accounted for in formal agricultural statistics.

Goal 2 - Achieve universal primary education

Goal 3 - Promote gender equality and empower women

Goal 4 - Reduce child mortality

Target 5: Reduce by two-thirds, between 1990 and 2015, the under-five mortality rate.
One of the main causes of child mortality in southern Africa, often working in tandem with HIV/AIDS, is disease associated with unclean water and inadequate sanitation. The supply and purification of water is an ecosystem service that is expensive or impossible to substitute using engineering solutions.

Goal 5- Improve maternal health

Goal 6- Combat HIV/AIDS, malaria and other diseases

Target 8: Have halted by 2015 and begun to reverse the incidence of malaria and other major diseases.
There are strong and undisputed links between the progress of diseases such as HIV/AIDS and malaria, and the state of human nutrition and degree of exposure to secondary infections and stresses.

Goal 7- Ensure environmental sustainability

Target 9: Integrate the principles of sustainable development into country policies and programs and reverse the loss of environmental resources.
Biodiversity conservation is an important aspect here, although not explicitly mentioned in the MDGs. A target of reducing the rate of loss of biodiversity by the year 2010 was adopted by the Convention on Biological Diversity, and endorsed as part of the World Summit on Sustainable Development Jonannesburg Declaration.

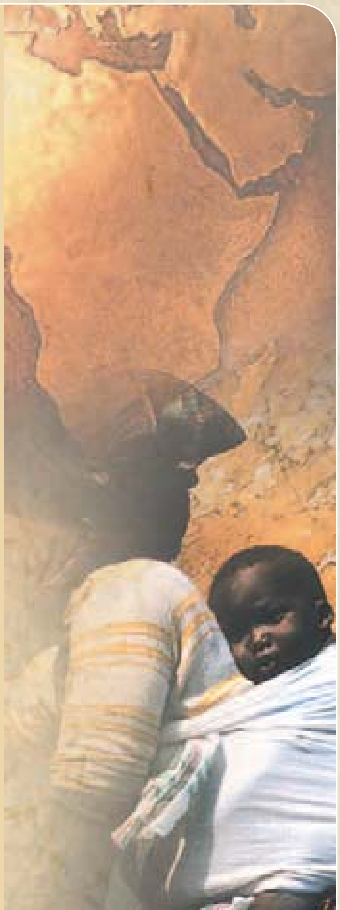
Target 10: Halve by 2015 the proportion of people without sustainable access to safe drinking water.
Freshwater originates almost entirely from ecosystems. The constancy of its supply, and its safety for drinking, are strongly related to land management and ecosystem conditions in the catchment areas.

Target 11: By 2020 to have achieved a significant improvement in the lives of at least 100 million slum dwellers.
Urban communities also depend on ecosystem services, both in their immediate environment, and within the areas from which they draw their resources.

Goal 8 - Develop a global partnership for development

The *Millennium Project*[2] has been launched to recommend the best strategies for achieving the MDGs, by identifying operational priorities, organizational means of implementation, and the necessary financing structures. Current progress towards the goals is mixed. In Sub-Saharan Africa, the rate of progress towards most targets is lagging behind that needed to meet the target, and in some cases conditions are worsening rather than improving (UNDP 2003). The reasons are many, but often include insufficient and inefficient public spending, crippling debt burdens, inadequate market access in developed countries, and declining official development assistance.

[1] www.developmentgoals.org; [2] www.unmillenniumproject.org



2.3 SOCIO-ECONOMIC CONDITIONS UNDERLYING ECOSYSTEM CHANGE

Over the past decades, southern Africa has been transforming from a predominantly rural population engaged directly in natural resource extraction and agrarian activities, and governed by traditional rules and customs, to an increasingly urbanised, literate population (Table 2.3). This transition has been accompanied by changing values and expectations, as well as political and economic changes that have had a marked influence on the natural environment and the services it provides. The most important factors underlying changes in ecosystems services in the region include population growth, the economy and infrastructure of the region, and political governance. These factors are strongly interrelated with one another.

Sub-Saharan Africa has the fastest growing population in the world (World Bank 2003) but growth rates are declining steadily due to a combination of HIV/AIDS (Box 2.3) and the growing use of contraception. Rapid urbanisation is occurring in many regions, resulting in the growth of urban agglomerations. Past and projected population growth and urbanisation are presented in Figure 2.3. Migration of both skilled and unskilled workers from poorer countries to especially South Africa is an important regional factor.

While the economic growth rate of the region is marginally higher than the population growth rate, it remains far below that needed to substantially reduce poverty. The economy of southern Africa is dominated by South Africa, which accounts for almost 60% of total GDP (Table 2.3). Most countries have dualistic economies, dominated by a large informal subsistence sector. The commercial sector is typically small and highly dependent on commodity exports, which are vulnerable to global economic fluctuations. Intra-regional trade is limited. Many countries have heavy debt burdens and are highly dependent on foreign aid. For this reason, a number of countries have adopted economic reform programmes prescribed by the World Bank and International Monetary Fund (IMF). This is leading to increasingly market-orientated macro-economic policies and privatisation, often through public-private partnerships. Poverty Reduction Strategies Papers (PRSPs) adopted in several southern African countries promote pro-poor economic reform programmes

Table 2.3: Demographic and economic characteristics of the region. By far the highest population densities occur in Burundi and Rwanda, with over 250 people per km^2. By 2030, Malawi and Uganda will also have crossed the 100 people per km^2 threshold.

	SURFACE AREA[1]	POPULATION					ECONOMY		
		Estimated total 2001		Average growth[2] 1997-2001	Projected total[4] 2030 (medium-variant)		GDP[2] 2001	Average growth[2] 1997-2001	Economic Community[7]
	1000 km^2	*million[2]*	*%urban[3]*	*annual %*	*million*	*%urban*	*mil US$*	*annual %*	
Angola	1247	13.5	35	2.9	28.6	54	9471	4.9	SA,EC,CO
Botswana	582	1.7	49	1.6	1.6	64	5196	6.8	SA
Burundi	28	6.9	9	1.9	13.7	22	689	1.3	EC,CO
Congo	342	3.1	66	2.8	7.6	78	2751	2.2	EC
Dem Rep Congo	2345	52.4	31	2.8	107.0	49	5187	4.4	SA,EC,CO
Equatorial Guinea	28	0.5	49	2.7	0.9	69	1846	30.6	EC
Gabon	268	1.3	82	2.5	2.0	91	4334	1.2	EC
Kenya	580	30.7	34	2.2	41.1	57	11396	1.2	IG,CO
Lesotho	30	2.1	29	1.4	1.6	49	797	2.6	SA
Malawi	118	10.5	15	2.1	19.8	30	1749	2.3	SA,CO
Mozambique	802	18.1	33	2.1	26.6	58	3607	9.3	SA
Namibia	824	1.8	31	2.0	2.4	49	3100	3.4	SA,CO
Rwanda	26	7.9	6	2.3	13.5	14	1703	8.6	EC,CO
South Africa	1221	43.2	58	1.4	42.2	74	113274	2.2	SA
Swaziland	17	1.1	27	2.5	1.0	42	1255	2.9	SA,CO
Tanzania	945	34.5	33	2.3	56.9	55	9341	4.3	SA
Uganda	241	22.8	15	2.7	64.0	30	5675	5.2	IG,CO
Zambia	753	10.3	40	2.1	15.2	55	3639	2.4	SA,CO
Zimbabwe	391	12.8	36	1.7	12.8	55	9057	-1.7	SA,CO
REGION	**10788**	**275.1**	**34**	**2.2[5]**	**458.3**	**49**	**194065**	**2.7[6]**	

[1] FAOSTAT. The total area of a country, including areas under inland bodies of water and some coastal waterways. http://apps.fao.org. [2] The World Bank Group. World Development Indicators Online database. http://devdata.worldbank.org/data-query. [3] UNDP (2003). Data refer to medium-variant projections. [4] UN (2002). [5] Population-weighted annual average. [6] GDP-weighted annual average. [7] SA = SADC (Southern African Development Community), EC = ECCAS (Economic Community of Central African States), IG= IGAD (Intergovernmental Authority for Development), CO = COMESA (Common Market for Eastern and Southern Africa)

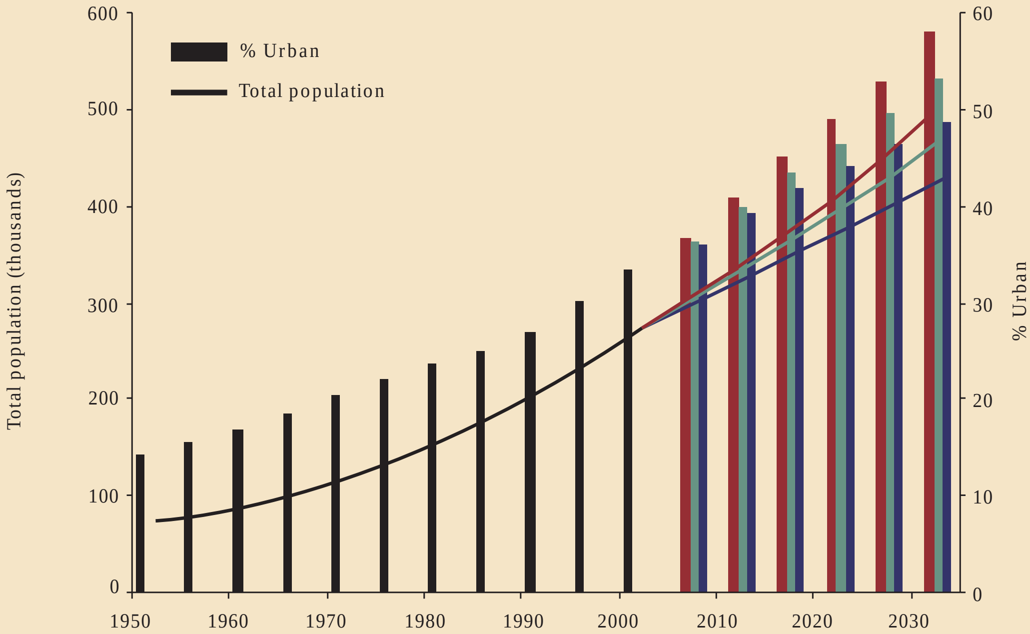


Figure 2.3: Past and projected population growth and urbanisation for the region covered in this study. The high variant (red) gives a total population 8% larger than the medium variant projection (green) and 18% larger than the low variant projection (blue) by 2030. Similarly, projected urbanisation levels differ by 5% and 9% respectively. Source: UN (2002).

Infrastructure in Sub-Saharan Africa is not well developed: only 12 percent of the roads are paved, and three percent of the population has access to a telephone line or mobile phone (World Bank 2003). Investment in research and development is very low, resulting in a chronic shortage of skilled workers, which in turn hampers effective governance and economic growth. Due to weak regulation and implementation, parts of the region are internationally targeted for 'dirty' industries and waste dumping, resulting in air, water, marine and soil pollution. Parts of the region are also used as a testing ground for biotechnology and genetically modified products.

Politically, the emphasis in the 1990's has been on promoting good governance, giving rise to initiatives such as the New Partnership for Africa's Development[1] (NEPAD). There is an increasing demand on national governments to be accountable, transparent and to respect human rights, both from the international community and from the citizenry. Nevertheless, democracies in many countries remain weak, characterised by ineffective and corrupt government institutions. The provision of social services, such as health, education, transport, water and sanitation, is generally weak and unreliable, particularly in rural areas. Poor enforcement of law and order and localised military conflict compromise social security in the region. In certain countries, multinational and transnational companies, non-governmental organisations, or terrorist guerrilla organisations dominate the political and economic arena. Throughout the region, tension exists between traditional leadership and government authority, and traditional resource management and social support systems are weakening

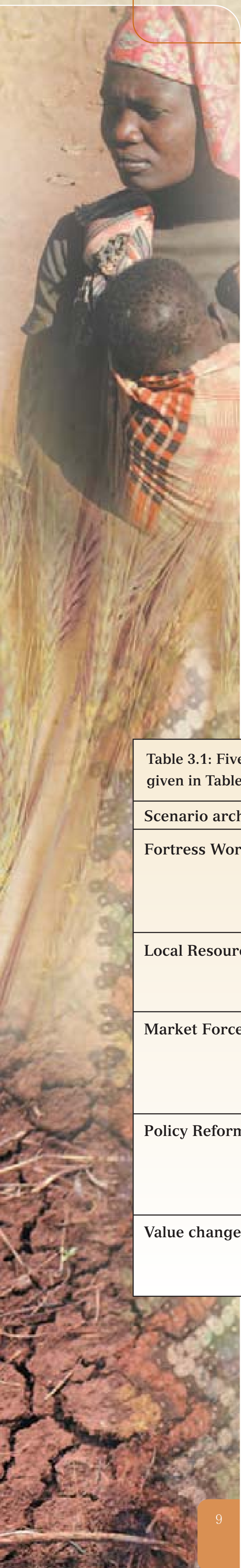
Box 2.3: HIV/AIDS and ecosystem services

No study of human well-being in sub-saharan Africa in the year 2000 can ignore the pervasive impact of the AIDS pandemic. The demographic effects – for example, the plummeting life expectancy at birth throughout the region – will have a noticeable but probably transient impact on the human population growth rate over the next quarter century. Perversely, the impact of humans on ecosystems may well increase as a result of the economic stresses caused by the disease. Families without other resources, and burdened with the care of the formerly economically active and labour-providing members, fall back on the use (and sometimes over-use) of natural resources to survive. At the same time, the knowledge and skills needed to manage natural resources, from the local to the regional scale, are being lost through premature death.

The existence of important interactions between ecosystem service based issues (such as poor nutrition, unsafe water and diseases such as malaria), poverty and the impact and spread of AIDS is one of the reasons that the disease has had such a high impact in the region. For instance, inadequate protein and micronutrient supply results in a more rapid progression from infection to a debilitated state and death; in consequence there is no money or labour to grow better crops, leading to further under-nourishment. Similar exacerbating feedback loops exist for water and sanitation and for control of vector-borne diseases.

[1] www.nepad.org

3. Southern African Scenarios



Ecosystems and the services they provide are constantly changing, often in ways that we cannot anticipate. These changes may result from intentional policy or technological interventions, unintentional impacts of human actions, or from natural ecological processes. Scenarios provide a way of exploring plausible alternative futures and their implications for ecosystem services. Scenarios are not predictions; they are a tool for imagining alternative worlds that could result given differences in a few key factors e.g. the integration and stability of the global economy. Scenarios are designed to challenge our assumptions, focus on key uncertainties, understand cause-and-effect linkages, and test our strategies and plans.

The MA specifically aims to link changes in ecosystems to the futures of ecosystem services and the aspects of human welfare that depend on these services. Within the MA, scenarios have been developed at global, regional and local scales. The global-scale scenarios exercise focuses on cross-scale ecological feedbacks, trade-offs among ecosystem services, and the effectiveness of different policies in making ecosystem services available at various scales. These larger-scale scenarios can provide the context and constraints for smaller-scale scenarios constructed at sub-global scales and which fill out region-specific details. Larger-scale scenarios typically relate to longer time periods than smaller-scale scenarios, as changes that influence large areas generally occur more slowly than those that have only local influence. Integrated models, which link socio-economic and biophysical systems, are used by the MA to translate qualitative scenario storylines into quantitative illustrations of changes in ecosystem services.

3.1 PERSPECTIVES ON THE FUTURE OF SOUTHERN AFRICA

Scenario development has a rich history in southern Africa, but with few exceptions (e.g. Huntley *et al.* 1989) has been applied solely to political, demographic and economic futures. While considerable diversity exists in the details of scenarios developed by different groups, they generally correspond to a handful of archetypal visions of the future. We have interpreted five archetypes for the southern African situation (Table 3.1), and classified four recently developed regional scenarios (IGD & FESSA 2002; SAIIA 2003; Shell 2002; UNEP 2002a), the MA global scenarios (MA in prep.) and the two scenarios developed in this study accordingly (Table 3.2).

Table 3.1: Five scenario archetypes interpreted for the southern African context. Descriptions are based on a synthesis of the scenarios given in Table 3.2.

Scenario archetype	Main elements
Fortress World	Region torn apart by violent conflict. Elite minorities live in enclaves of wealth and security, mostly in the southern parts of the region. The poor majority are deprived of basic services and rights, and rely on the informal economy for survival. Wealth and power are in the hands of the elite; relations are unequal and exploitative. Little to no regional cooperation exists. General environmental degradation, except in isolated enclaves.
Local Resources	Weak states with little economic growth are ineffective at delivering services. Community organisations and traditional authorities hold power. Absence of state services and formal employment force communities to rely on their own resources, managed communally. Relative stability in the region, although localised conflicts are endemic.
Market Forces	Unbridled private sector economic activity linked to globalized markets for products and labour. Privatisation of many state functions. Countries and economies largely controlled by big business. The majority of people remain poor and survive in the informal economy. Economic growth benefits mainly the elite, and occurs at the cost of the environment. Regional cooperation centred on corporate interests.
Policy Reform	Visionary leadership and strong national governments. Most countries are multi-party democracies. Region still poor and unequal but characterised by political stability, and social and economic progress. Economies diversified to create a competitive industrial base. Market-driven growth constrained by environmental and social sustainability policies. Significant regional cooperation and integration.
Value change	Notions of sustainability fundamentally change the values and lifestyles of society. Markets are the main economic mechanism, but are constrained by social, cultural and environmental goals. Values of simplicity, tranquillity and community displace values of consumerism, competition and individualism.

Table 3.2: Classification of the global MA scenarios and four recently developed regional scenarios into the five archetypes described in Table 3.1, showing their relation to the two scenarios developed in this study. Scenarios were classified according to their dominant elements within the southern African context.

Scenario archetype Scenarios	MA Global	Africa Environmental Outlook (2002)	Institute for Global Dialogue & Friedrich Ebert Stiftung (2002)	Shell Africa (2002)	SAIIA (2003)	SAfMA Regional
Fortress World	Order from Strength	Fortress World	Danger! Ingozi! Kotsi!		Decline & Decay	
Local Resources	Adapting Mosaic		Poor but Proud, The Slow Slide	Business Class		African Patchwork
Market Forces		Market Forces	Market Madness		Asymmetrical	
Policy Reform	Global Orchestration, Technogarden	Policy Reform	Regional Renaissance	Prism	Renaissance	African Partnership
Value Change		Great Transitions				

The SAfMA regional-scale scenarios

SAfMA identified the effectiveness of national and regional governance as the key uncertainty facing the development of southern Africa over the next three decades. Two scenarios, corresponding to the "Local Resources" and "Policy Reform" archetypes, were developed for the period up to 2030 by synthesising information from existing regional scenarios (Table 3.2) and interpreting the consequences for ecosystems, ecosystem services and human well-being given current understanding of ecosystem functioning (Box 3.1). This was done using the MA Conceptual Framework (Figure 1.1, page 1). Some elements, such as climate change and population trends, are common to both scenarios in the timeframe considered (Chapter 2). Where human well-being is compromised by the degradation of ecosystem services, possible interventions that could improve conditions within the context of each scenario were explored.

The **African Patchwork** scenario (Section 3.2) is based on an extrapolation of current trends. While democracy and good governance take hold in some countries in southern Africa, severely limited state effectiveness, economic mismanagement and conflict in most countries prevent the region from improving the well-being of its citizens. Regional food security does not improve, and expansion of agricultural land together with a lack of environmental regulation and enforcement holds negatives for biodiversity, biomass fuel, freshwater and air quality. Nature-based tourism survives under protected, high cost conditions.

The **African Partnership** scenario (Section 3.3) is based on the successful adoption and implementation of current political initiatives, such as NEPAD[1], that aim to significantly improve governance and security, and consequently economic growth, development and human well-being in the region. Regional food security improves, and nature-based tourism greatly expands. Increased populations and industrial and agricultural development initially impact negatively on biodiversity, freshwater, biomass fuel and air quality, but then stabilise as effective institutions develop to regulate resource use.

Box 3.1: Uncertainties about how ecosystems function

Some of our uncertainty about the future is because we are still learning about how ecosystems function and respond to the impacts of human activity. The MA global scenarios group specifically explores some of these uncertainties, for example:

- How resilient are ecosystems? If ecosystems are resilient they are able to absorb human impacts, and we have room for experimenting and learning. If, on the other hand, they are brittle and can collapse unexpectedly, a conservative approach to ecosystem management is needed. Market Forces and Policy Reform type scenarios typically assume that nature is resilient, whereas Fortress World, Local Resources and Value Change type scenarios are often based on the assumption that nature is brittle.
- To what degree can ecosystem services be substituted? The MA Technogarden scenario imagines a world of highly engineered ecosystems. Is this possible, and what unknown side effects could it have?
- Do policies that focus on long-term economic and social sustainability automatically ensure ecological sustainability? If specific environmental policies are needed, at what scales do they need to be implemented?

[1] New Partnership for Africa's Development (www.nepad.org)

3.2 THE AFRICAN PATCHWORK SCENARIO: 2030

Storyline

Development trends apparent in the SADC region over the past few decades generally persist until 2030. While democracy and good governance take hold in some countries, ineffective governance, corruption and economic mismanagement in most of the region keep it impoverished. Low economic growth rates and declining foreign investment lead to the increased economic marginalisation of Africa. Localised military conflicts continue to drain resources, damage infrastructure and impede the provision of services.

Box 3.2: Key drivers: Patchwork scenario

- Ineffective governance in most countries
- Regional fragmentation
- Informal sector dominates
- Little investment in health & education
- Ongoing localised military conflicts

Improvements in agricultural productivity per hectare are not sufficient to meet the needs of the growing population, resulting in large-scale conversion of woodlands to crops, and the expansion of agriculture into marginal lands. While the maintenance of agricultural diversity affords some protection against pest outbreaks, climate change brings more frequent droughts and consequently crop failures, especially in marginal areas. The rural population relies heavily on a declining natural resource base for their subsistence, and many people migrate to cities, where they remain impoverished. In much of the region, wealthier middle-class citizens support their lifestyles through private boreholes, electricity generators and in some cases, kitchen gardens, and directly import a range of basic goods. Large quantities of food aid are needed to support the urban poor in particular; delivery of food aid in rural areas is impeded by poor infrastructure and conflict. Those rural people with access to land and resources are highly self-reliant, and locally organised. Protected areas are encroached, and wildlife and high-value plants virtually disappear from many areas.

Most governments are unable to ensure the provision of reliable, safe water or modern energy sources, resulting in high mortality from waterborne diseases and indoor air pollution aggravated by the high incidence of HIV/AIDS, and large-scale deforestation for charcoal production. Poor enforcement of environmental standards, where they exist, result in deteriorating water and air quality. Water quality is further degraded by increased soil erosion and untreated sewage. A water supply crisis in the shared river basins in the southern part of the region is a major source of regional tension. Box 3.2 and Figures 3.1 and 3.2 summarise the drivers, dynamics and impacts on ecosystem services under this scenario.

Biodiversity	Food security	Freshwater	Biomass fuel	Air Quality	Nature tourism
↘	↘	↘	↘	↘	↗

Figure 3.1: Summary of trends in the ecosystem services covered in this study under the Patchwork scenario between 2000 and 2030. All services except nature-based tourism show significant declines under this scenario

Possible Interventions

Spurred on by emerging environmental problems, coalitions of development aid agencies, NGOs and local communities devise inexpensive and innovative ways to ensure the continued supply of key ecosystem services at the local level, including land reform and community-based management. These, although unevenly adopted, provide a degree of protection from the vagaries of climate and the global economic system. In the cities, higher efficiency stoves and lights and small-scale water purification schemes help to reduce the health impacts of air and water pollution.

With time, however, the lack of functional governance structures at higher levels result in increasing problems in the management of regional and global resources. While countries in the southern parts of the region are able to enforce environmental regulations with some success, their efforts are hindered by the lack of enforcement in other countries. There is growing recognition that the management of services such air quality, water resources, marine fisheries and the regulation of diseases such as malaria can only be effective if there is regional and, in some cases, global coordination. More powerful countries start investing increasing resources in the development of effective governance structures in poorer regions, realising that in many respects their own well-being is connected to the well-being of other regions.

- Minor improvement in nutrition, food security, water supply and safety & infant survival.
- Minor improvement in access to energy.

HUMAN WELL-BEING & POVERTY REDUCTION

Health: Weak or non-existent public service provision for majority, some quality private services for elite. Malnutrition & HIV/AIDS result in high mortality rates, respiratory & bacterial diseases especially in urban areas, malnutrition especially in drought years.

Economic security: Very low formal employment levels, most people forced to survive in informal economic sector, elites employed by big business. Increase in the number of poor people, communities in deep rural areas remain extremely poor.

Environmental security: Subsistence agriculture prominent in food security, food aid reaches only small fraction of needy communities. No planning or service provision in informal settlements in urban areas, inadequate clean domestic energy & water, middle-class communities rely partly on own service provision.

Social security: Communities largely police themselves, high crime levels in urban areas, poor social security.

Education: Low quality facilities & education, poor access to secondary & tertiary education.

Equity: Huge wealth gap between elites & poor, media suppression.

ECOSYSTEM SERVICES

Provisioning: Reduction of streamflow & groundwater south of the Zambezi, localised depletion further north, erratic supply in urban areas, slowly declining ground water availability. Low & variable cereal production, collapse of many inland & coastal fisheries, fluctuating but non-increasing total livestock herd size with low productivity. Woodfuel becomes increasingly scarce & expensive. Genetic resources generally exploited without benefit to local communities.

Regulating: Decreased availability of good quality water in rural areas, erratic quality in urban areas, increased risk of flooding due to reduction in vegetation. Poor air quality in urban & industrial areas, trend to charcoal leads to greater greenhouse gas emissions. Agricultural diversity reduces vulnerability to pest outbreaks. Tropical diseases spread due to climate change.

Cultural: Niche market for ecotourist 'adventurers' & high-paying elites. Spiritual & religious sites are protected by local communities.

Supporting: Declining soil fertility; high soil loss. Primary production reduced due to climate change.

- Limited improvement in water availability & quality in rural & urban areas through local projects
- Limited improvement in food production potential through low-input technologies
- Limited improvement in energy utilization & conservation.
- Establishment & sustainable management of woodlots by some communities

CONSEQUENCES OF INTERVENTIONS

INDIRECT DRIVERS OF CHANGE

Demographic: Total population continues to increase, fertility & mortality rates remain high, mortality largely due to AIDS. Steady urbanisation, large & relatively stable communities in rural areas.

Political: Most states nominally multiparty democracies, but weak, corrupt & with little legitimacy and capacity to enforce law & order. Ongoing localised military conflict. Weak regional institutions & cooperation, poor enforcement of regulations & environmental standards. Remaining influence over formal government is wielded by small numbers of urban elite. Most people live in parallel society beyond government reach, community leaders & organisations more important than formally elected representatives & political parties, traditional leadership plays significant role. No effective institutions to mediate conflict between traditional & non-traditional leadership.

Economic: Most countries have deteriorated formal economies, low or negative economic growth, restricted industrial activity, inadequate state financial resources. Agricultural & manufacturing sectors undermined by abolition of tariff barriers & preferential market access. Extractive industries dominated by large corporations, programmes to support small to medium enterprises have collapsed, weak public-private partnerships. Indigenous handicraft markets generate locally significant income where tourism survives. Development assistance goes straight to communities.

Science and Technology: Very low formal skills base & high brain drain. Little new infrastructure development, core services are maintained only in commercial & middle-class residential areas. Community-level water supply schemes in some areas, poor development of communication technologies, weak research capacity.

Values: Self-help and self-reliance, strong family & community ethic, corruption among governing elites, culture of non-payment for services, dependence on foreign aid, traditional values important.

POSSIBLE INTERVENTIONS

Enabling civil society: Community based natural resource management, investment in education and training, largely initiated by development agencies & NGO's.

Governance: Improved national governance to encourage development support, land & resource tenure reform toenable local responses, community responses & adaptations.

Technology: Enhanced low-input technology infusion, largely through aid organizations & NGO's.

DIRECT DRIVERS OF ECOSYSTEM CHANGE

Land transformation: Extensive land clearing for low-input agriculture extensive in northern parts of region. Widespread overgrazing and erosion. Extensive deforestation for fuelwood & charcoal for ~200km around cities.

Biodiversity loss: Agricultural crop diversity maintained, over-harvesting of 'bush meat', fisheries, medicinal plants, timber and fruit leads to severe reduction in populations of many species. Encroachment of protected areas.

Nutrient loading: High sediment load resulting from erosion, localised faecal contamination.

Atmospheric emissions: Most industrial & urban areas heavily polluted.

Climate Change: Slightly warmer & drier, higher rainfall variability.

CONSEQUENCES OF INTERVENTIONS

Figure 3.2: The African Patchwork scenario, developed by collating projections of economic and demographic growth, technology adoption and value systems from corresponding scenario studies listed in Table 3.2. These projections formed the basis for populating the indirect drivers box of the MA conceptual framework diagram (Figure 1.1, page 1). Changes in direct drivers were inferred by expert opinion within the SAfMA group, based on causal links between indirect and direct drivers and predictions of factors such as climate change. The effect of on ecosystem services and consequently human well-being is based on the work reported in this study. As a final step, the types of ecosystem-related interventions possible given the governance and economic constraints of the Patchwork scenario, and the expected consequences of such interventions, were explored.

3.3 THE AFRICAN PARTNERSHIP SCENARIO: 2030

Storyline

African leaders commit themselves to improving human well-being in the region by boosting economic growth. By promoting good governance and regional peace and security, the region is able to attract increased foreign investment and obtain debt relief. Improvements in infrastructure, health (especially HIV/AIDS programmes) and education are accompanied by the modernisation of information and communication technologies.

Box 3.3: Key drivers: Partnership scenario

- Strong, effective central governance
- Regional cooperation and integration
- Political stability and security
- Strong formal economic sector
- Technological development and modernisation
- Significant reduction in poverty
- Significant investment in health an education

High economic growth is underpinned by the intensification of agriculture, using highly selected seeds (including genetically modified organisms), irrigation, pesticides and fertilisers. This boosts productivity, relieving pressure to cultivate new lands. Regional-scale food security is greatly improved, but water pollution and pressure on water supplies increases. A dominant focus on cash crops, grown commercially, and a strong linkage to the global economy marginalizes small growers and impoverishes agricultural diversity. Consequently, vulnerability to pest outbreaks increases, and together with an increased frequency of droughts and floods resulting from climate change, leads to large swings in cereal production and intermittent food shortages. Rising wealth accelerates a change in diet towards meat products, largely satisfied by expanded cattle ranching north of the Zambezi. Reduced pressure for land facilitates the development of an extensive system of state, private and community protected areas, which over time forms the cornerstone of a growing tourism sector, serving both foreign visitors and a growing urban middle class. Good land management practices outside of protected areas contribute to the maintenance of biodiversity in the region.

A growing proportion of the energy needs of an increasingly wealthy and urbanised population are met by hydropower, but the highly industrialised south still obtains the majority of its power from coal. In rural areas, woodfuel remains an important energy source. Growing mining, manufacturing and agricultural operations reduce water and air quality. Problems of soil acidification and nitrogen deposition appear downwind of major industrial complexes. Soil salinization becomes a problem in irrigated areas. Water purification costs increase due to higher contaminant loads, contributing to the rising price of water. Intense competition for water resources south of the Zambezi hampers economic development and creates conflict situations. Box 3.3 and Figures 3.3 and 3.4 summarise drivers, dynamics and ecosystem services under this scenario.

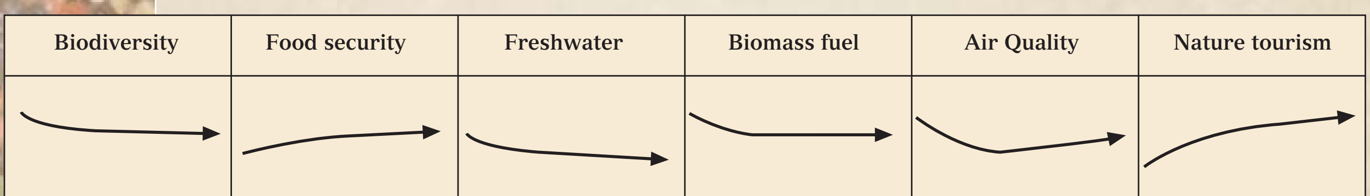


Figure 3.3: Summary of trends in the ecosystem services covered in this study under the Partnership scenario between 2000 and 2030. Most services show a decline due to increased human demands, but then stabilise as effective institutions develop to regulate resource utilisation. Nutrition and nature-based tourism show marked improvements.

Possible Interventions

Human well-being under this scenario may be compromised by inadequate consideration and management of several ecosystem services, particularly relating to food and water provision, where systemic problems are aggravated by climate change. Responding to these threats, interventions occur at the regional, national and local level, making use of the strong governance structures and the financial resources of the region. By maintaining genetic diversity within agricultural crops, and proactively implementing climate change adaptation strategies, such as selecting drought and pest tolerant cultivars, risk of crop failures is reduced. Investment of resources in agricultural research and extension help bring about good land management practices, lessening impacts on water and soil resources and biodiversity. Regional and national systems for stockpiling grain harvests in high production years help bridge years of low production.

The establishment of regionally integrated, representative water management institutions, with strongly developed mechanisms for conflict mediation, become central to the maintenance of economic growth and peace and security in the regionís southern parts, and the exploitation of the region’s hydropower potential. Global environmental health standards are adopted and enforced by regional monitoring bodies, with particular attention paid to improving water and air quality. This greatly improves access to safe water, and brings about a reduction in infant mortality. Off-grid power supplies and alternative energy sources provide affordable, clean energy for people in rural areas. Provisions within the international climate change protocols facilitate a switch to cleaner technologies that reduce air pollution and greenhouse gas emissions.

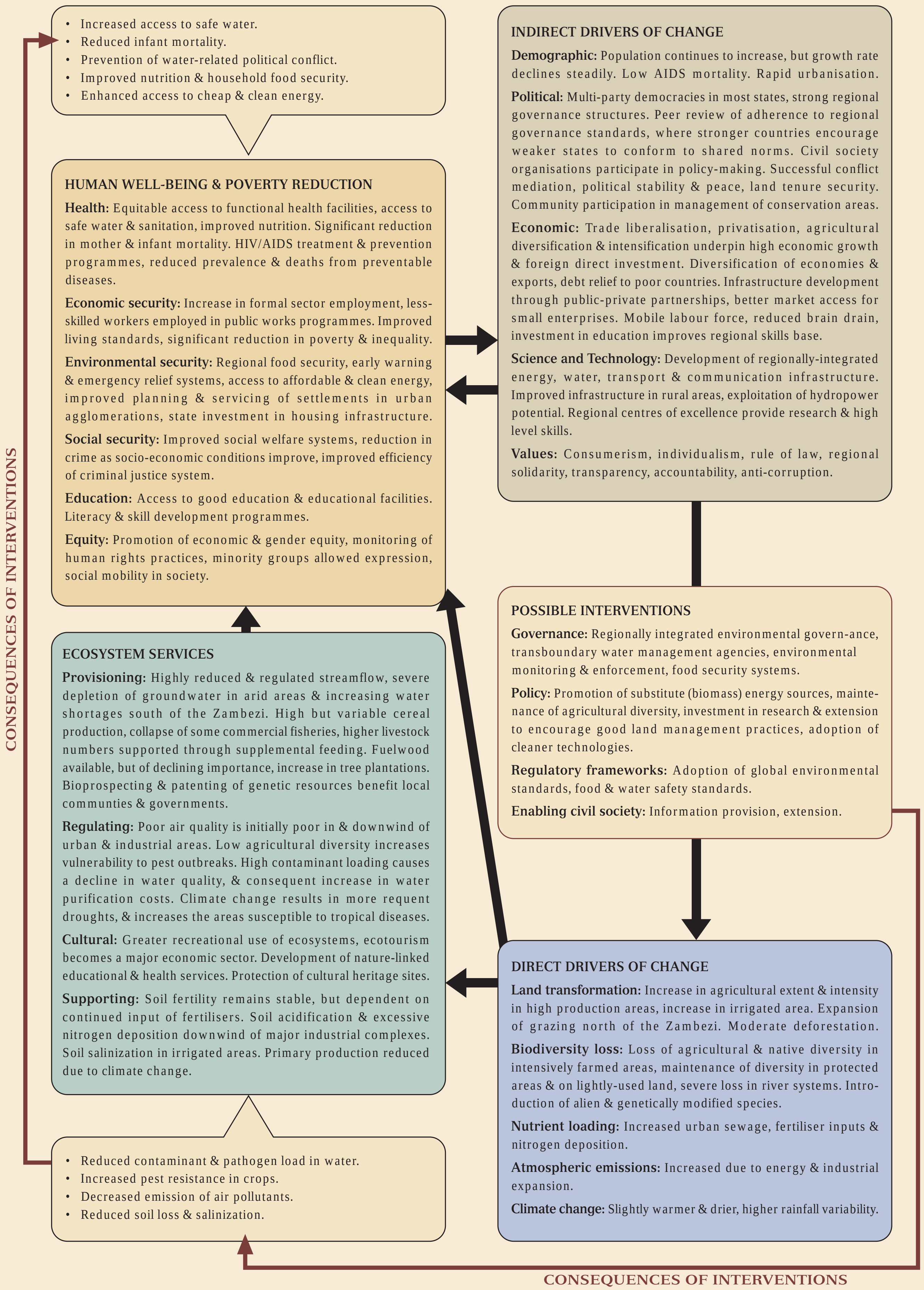


Figure 3.4: The African Partnership scenario. We used the published NEPAD goals (NEPAD 2001; NEPAD 2002) to populate the human well-being and poverty reduction box of the MA conceptual framework diagram (Figure 1.1, page 1), and related the various NEPAD action plans to the indirect drivers box. This information was supplemented with descriptions of similar scenarios (Table 3.2). By means of expert opinion, we explored the trends that the indirect drivers would induce in direct drivers, such as water use and pollution, and inferred how various ecosystem services would change as a result. Lastly, potential inconsistencies between the trends in services and the stated NEPAD well-being goals were identified, as well as interventions that could remove such inconsistencies.

4.1 THE VARIETY OF LIFE IN SOUTHERN AFRICA

Southern Africa has an extraordinarily rich biota relative to its size. This is especially apparent for higher plants, where South Africa, for instance, has 6.2% of the globally known species, despite occupying only 0.8 % of the global land surface. It is also true for other groups of relatively well-described biodiversity (the vertebrates: birds, mammals, reptiles, fish and amphibia), and probably holds for the less-studied invertebrates (Table 4.1).

The biological variety is especially high within several centres of endemism ('biodiversity hot-spots'), of which the Cape floral kingdom (Fynbos), the Succulent Karoo, the Maputoland-Pondoland-Albany and the Great Lakes (for fish) are best known (Figure 4.2). It is also more generally distributed: for instance, the woodlands and savannas that cover much of the land surface are drawn from the 'Zambezian' phytochorion (plant domain), with a richness of 8500 species, 54% of which are endemic (White 1983) and a rich diversity of mammals and birds. The equatorial forests are part of the Guineo-Congolian phytochorion with another 8000 plant species, 80% of which are endemic, and a great diversity of amphibia.

Box 4.1: What is biodiversity?

Biodiversity refers to the variety of life on Earth, but this is not simply the number of different species on the planet. Biological variation occurs at three levels: genetic, species and ecosystem. Variation at each of these levels is expressed in terms of composition (e.g. the genes of different maize cultivars), structure (e.g. ratio of tall to short trees in different ecosystems) and function (e.g. primary production). The MA regards biodiversity as an underlying condition necessary for the delivery of ecosystem services.

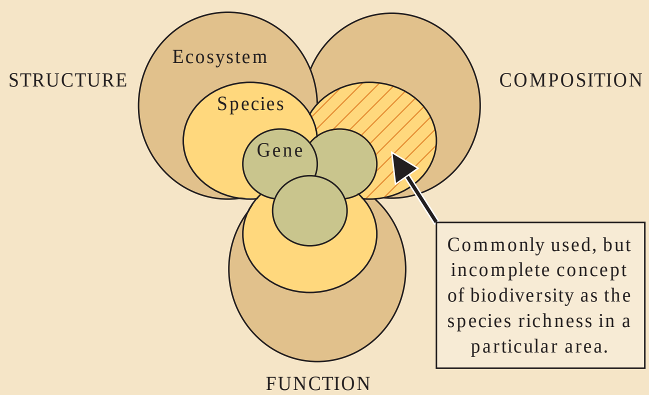


Figure 4.1 The multi-faceted nature of biodiversity (Noss 1990)

Table 4.1: Estimated richness of the major taxa in each country, together with the estimated number of species endemic to each country. The exceptional plant diversity in South Africa results from three biodiversity hotspots: The Cape Floral Kingdom (Fynbos), the Succulent Karoo and the Maputoland-Pondoland-Albany area. Source: UNEP-WCMC database.

	Plants		Mammals		Birds			Reptiles		Amphibia		Fish
	Total	*End*	*Total*	*End*	*Total*	*TotBr*	*End*	*Total*	*End*	*Total*	*End*	*Total*
Angola	5185	1260	276	7	909	765	12	-	18	-	22	-
Botswana	2151	17	164	0	550	386	1	157	2	38	0	92
Burundi	2500	-	107	0	596	451	0	-	0	-	2	-
Congo	6000	1200	200	2	569	449	0	-	1	-	1	-
Dem Rep Congo	11007	1100	450	28	1096	929	24	-	33	-	53	-
Equatorial Guinea	3250	66	184	1	322	273	3	-	3	-	2	-
Gabon	6651	-	190	3	629	466	1	-	3	-	4	-
Kenya	6506	265	359	23	1068	844	9	187	15	88	11	-
Lesotho	1591	2	33	0	281	58	0	-	2	-	1	8
Malawi	3765	49	195	0	645	521	0	124	6	69	3	-
Mozambique	5692	219	179	2	678	498	0	-	5	62	1	-
Namibia	3174	687	250	3	609	469	3	-	26	32	1	102
Rwanda	2288	26	151	0	666	513	0	-	1	-	0	-
South Africa	*18388	**11033	247	35	790	596	8	299	81	95	45	94
Swaziland	2715	4	47	0	485	364	0	102	1	40	0	40
Tanzania	10008	1122	316	15	1005	822	24	245	56	121	43	-
Uganda	5406	-	338	6	992	830	3	149	2	50	1	291
Zambia	4747	211	233	3	736	605	2	-	2	83	1	-
Zimbabwe	4440	95	270	0	648	532	0	153	2	120	3	112

Total = Total number of species recorded in country;
TotBr = Total number of breeding bird species in country;
End = Number of species endemic to country;
-No data
* Huntley (1999)
** Based on 60% endemism (Le Roux 2002)

Biodiversity underlies ecosystem services

Being custodians of such abundant biodiversity is both a blessing and a responsibility. The direct human well-being benefits that derive from biodiversity as such (in other words, from the variety of what is present, Box 4.1) include the important and growing nature-based tourism sector (covered in Chapter 9), contributions to the diet of rural people (especially with respect to protein and micronutrients, see Chapter 5) and traditional medicines, used by the vast majority of southern Africans. In addition, a great number of people, in southern Africa and outside it, and across all cultures and socio-economic conditions, regard biodiversity as having a non-financial intrinsic value, related to spiritual, aesthetic and ethical considerations.

While recognising these direct ecosystem services of biodiversity, SAfMA follows the MA guidelines in treating biodiversity not as a service itself, but as an underlying condition necessary for the sustained delivery of most other ecosystem services, such as food and clean water. This is why the tradeoffs between food, water and biodiversity are so crucial: they represent not just choices between different proportions of a 'buffet' of ecosystem services, but impact on the productive base on which some of those services depend in the long term. Climate change raises significant additional concerns in this respect (Box 4.2).

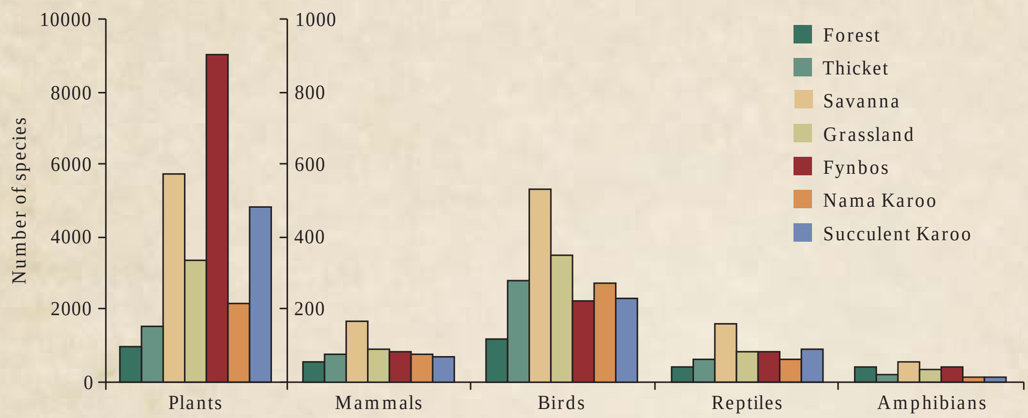


Figure 4.2: Comparative richness of different taxa in the major biomes of South Africa (Le Roux 2002). Note that plant richness is an order of magnitude greater than other taxa.

Box 4.2: Climate change and biodiversity

In many places around the world, natural ecosystems have already begun to show the effects of a changing climate (Gitay *et al.* 2002). For instance, coral reefs, including those on the east coast of southern Africa, have shown bleaching attributed to warmer oceans. Although several studies completed during the 1990s strongly indicated that the biodiversity of southern Africa was at risk (Hulme 1996, Rutherford *et al.* 1999, Erasmus *et al.* 2002), accounts of observed impacts were until recently largely anecdotal. There is now convincing evidence that *Aloe dichotoma* is dying in the northern part of its range but stable in the southern part, as predicted by global change models (Foden *et al.* 2003). There is also experimental evidence suggesting that the widely-observed expansion of tree cover into formerly open grasslands and savannas, beginning around the 1960s, may have been predisposed by the steadily-rising global CO_2 concentration (Bond *et al.* 2003).

Why is the projected change in the 21st century a matter of concern? Populations and ecosystems in southern Africa have been exposed to climatic fluctuations throughout the past 4 million years, and it is thought that this is among the factors that generated the diverse fauna and flora of the region. The present change is of concern firstly because the rate of change currently observed and projected is at least an order of magnitude more rapid than anything experienced in the past million years. Secondly, in order to stay within their climatic habitat species need to migrate, but migration is now severely hampered by a landscape fragmented and made inhospitable by human activities. Thirdly, the world is entering a 'no analog' state, unlike anything that it has experienced before in its combination of climate, atmospheric composition and other key environmental factors.

The AIACC project[1] is currently analysing response options that will protect biodiversity under changing climate and land-cover scenarios in southern Africa. The responses range from (1) do nothing, since the uncertainties and costs are too high, (2) strategically adjust the location, shape and extent of the protected area network to accommodate future species distributions, (3) modify the land use practices in the matrix between formally-protected areas to make it more accommodating to species that find themselves out of their preferred habitat, (4) facilitated dispersal, where the movement of plants and animals is deliberately accelerated by human assistance, and (5) *ex situ* conservation in zoos, gardens and gene banks. These options are not mutually exclusive.

[1] Assessment of Impacts and Adaptations to Climate Change: www.aiaccproject.org

4.2 HOW ARE WE DOING AT CONSERVING BIODIVERSITY?

Species extinction is widely used as a measure of biodiversity performance (e.g. IUCN 2002), but is a poor indicator of the changes in biodiversity that have occurred in southern Africa. Of the approximately 30 000 endemic species of plants (inferred from Huntley 1989) and 3000 endemic species of vertebrates (Olson *et al.* 2001) in southern Africa, 41 plants and 12 animals are believed, with high certainty, to have become extinct in the last two centuries (Golding 2002, IUCN 2002). This does not adequately reflect the overall extent of changes to biodiversity in its multiple aspects (see Box 4.1). For purposes of practical biodiversity measurement, extinction is a poor indicator for two reasons: Firstly, documenting extinctions is intrinsically difficult and secondly, it only records a change once it is too late to do anything about it. A more sensitive measure that aims to highlight problems in time to take action is that of threatened and endangered species (Table 4.2), although it faces similar data challenges to that of species extinction.

Another widely-used conservation index is the fraction of land that is in protected areas (Table 4.7, page 25). With 7% in parks and another 8% in formally demarcated sustainable-use areas, southern Africa as a whole exceeds the international guideline of 10% land area under formal protection. The on-the-ground reality of these protected areas varies between countries, but in general, southern Africa is acclaimed for the quality of management of its parks. However, the rate at which new state-controlled protected areas are declared in southern Africa is likely to taper off as available areas with few competing demands are used up. Where pressure for land is relatively high, such as in South Africa, the current growth in biodiversity protection is mostly in the private and communal sectors (Box 4.3, page 26), and is often on dual-use land.

The Biodiversity Intactness Index

Using 'protected area' as an index of biodiversity conservation ignores 90% of the landscape, where people live and where most biodiversity changes are occurring. For this reason, and to avoid the insensitivity of extinction-based measures, SAfMA developed a new index, called the 'Biodiversity Intactness Index' (Scholes and Biggs in prep). The BII measures the remaining fraction of the original populations of all species that occurred in a given area, integrating across all land uses and the well-described categories of biodiversity (plants, mammals, birds, reptiles and amphibians). There are three inputs to the calculation: The spatial distribution of land uses of varying intensity; the inferred pre-colonial spatial distribution of species richness within each main class of organism and biome; and the impact of differing land uses on the populations of organisms within each biome (Figure 4.3).

Based on the BII, overall 84% of the original number of wild organisms (not species) are estimated to persist in southern Africa (Table 4.3), despite greatly increased human demands on ecosystems. The impact of humans is felt very selectively, primarily by a small number of species that tend to be large-bodied (and thus easy to hunt or harvest), and either valuable or in direct conflict with aspects of human well-being (e.g. large predators, or herbivores that compete with cattle). The vast majority of species are affected primarily through loss of

Table 4.2: IUCN Redlist of Threatened Species[1] 2002. Listed are species in the critically endangered, endangered and vulnerable categories. The countries with the highest number of threatened species are Tanzania, South Africa and Kenya. The lack of reliable and complete data, particularly for taxa other than mammals and birds, present severe challenges to the consistency and completeness of these data.

	Plants	Mammals	Birds	Reptiles	Amphibia	Fishes	Molluscs	Other Inverts	Total
Angola	19	19	15	4	0	0	5	1	**63**
Botswana	0	6	7	0	0	0	0	0	**13**
Burundi	2	6	7	0	0	0	0	3	**18**
Congo	33	15	3	1	0	1	1	0	**54**
Dem Rep Congo	55	40	28	2	0	1	41	4	**171**
Equatorial Guinea	23	16	5	2	1	0	0	2	**49**
Gabon	71	15	5	1	0	1	0	1	**94**
Kenya	98	51	24	5	0	18	12	3	**211**
Lesotho	1	3	7	0	0	1	0	1	**13**
Malawi	13	8	11	0	0	0	8	0	**40**
Mozambique	36	14	16	5	0	4	6	1	**82**
Namibia	5	15	11	3	1	3	1	0	**39**
Rwanda	3	9	9	0	0	0	0	2	**23**
South Africa	45	42	28	19	9	29	10	102	**284**
Swaziland	3	4	5	0	0	0	0	0	**12**
Tanzania	235	42	33	5	0	17	41	6	**379**
Uganda	33	20	13	0	0	27	7	3	**103**
Zambia	8	11	11	0	0	0	4	2	**36**
Zimbabwe	14	11	10	0	0	0	0	2	**37**

[1]www.redlist.org

habitat to cultivated lands or urban areas, both of which are relatively small fractions of the landscape in southern Africa. Some functional groups, such as certain abundant groups of frogs, or fruit- or seed-eating birds, benefit from human activities such as the proliferation of farm dams, cereal crops or gardens; in these cases BII can assume values greater than one. Mammals are the most impacted group overall, especially in the former grasslands. This is due to a combination of direct hunting pressure and habitat loss.

The Fynbos, followed closely by the grasslands, are the biomes where the greatest impact on biodiversity has occurred. The major cause is conversion to cultivated land, followed by urban sprawl, alien plant invasion (especially in the Fynbos) and plantation forestry (especially in grasslands). The arid shrublands are least impacted overall, and will probably remain so due to the paucity of other uses to which they can be put. Note that climate change may, result in significant impacts (Box 4.2), particularly on the plant-rich Succulent Karoo. Large-scale wetlands (e.g. the Okavango) are at present apparently little affected, but are critically dependent on the future management of their catchment areas. Small-scale wetlands, including seasonal dambos, are not detected by the broad-scale approach taken in this study, but are probably highly impacted by particularly cultivation. Savannas (including woodlands) and forests are most threatened by degradation; in other words, unsustainable use that does not transform them to other forms of land-cover, but reduces the ecosystem services and biodiversity that they provide.

Policy implications

Figure 4.3 suggests that the policy action with the greatest potential to prevent further loss of biodiversity is to prevent lands which are currently used sustainably, from becoming degraded. Sustainably-used land (e.g. grazed within stocking norms, or selectively logged using low-impact methods) show almost the same level of biodiversity as protected areas (which are inferred to have basically the same biodiversity as was present prior to the colonial era, two centuries ago). Degradation, in the form of overgrazing or clear-felling, on average reduces species populations by 40-60%. As rehabilitation is uncertain and expensive, preventing degradation is the best option.

Note that some biodiversity persists under all land uses, even dense human settlements. Cultivation and human settlement have a higher impact than degradation, but a small fraction of the land is at risk. Expanded cultivation is to some degree inevitable if Africa's food needs are to be locally met (Figure 4.6), but the amount of expansion depends on the productivity gains that can be achieved on the existing land area. Enhanced production per unit land under cultivation should be a high biodiversity policy priority, as well as a food production goal (Chapter 5).

Table 4.3: The average fraction of the original population sizes of plant and vertebrate groups remaining in the major biomes of southern Africa (Scholes & Biggs in prep.). Averaged across all species and ecosystems, wild populations have declined by 16% relative to pre-colonial times, with a 95% confidence range of ±7%. Note that wetland refers only to large wetland areas (see Figure 2.1, page 3) e.g. the Okavango delta. The analysis covers the following countries (country results given in brackets): Botswana (0.89), Lesotho (0.69), Mozambique (0.89), Namibia (0.91), South Africa (0.80), Swaziland (0.72), Zimbabwe (0.76).

	Plants	Mammals	Birds	Reptiles	Amphibia	ALL TAXA
Forest	0.75	0.75	0.92	0.86	0.85	**0.78**
Savanna	0.86	0.73	0.96	0.89	0.96	**0.87**
Grassland	0.72	0.55	0.90	0.76	0.81	**0.74**
Shrubland	0.86	0.72	1.06	0.93	1.27	**0.89**
Fynbos	0.75	0.78	0.91	0.77	0.79	**0.76**
Wetland	0.91	0.83	0.94	0.92	0.95	**0.91**
All Biomes	**0.82**	**0.71**	**0.96**	**0.88**	**0.95**	**0.84**

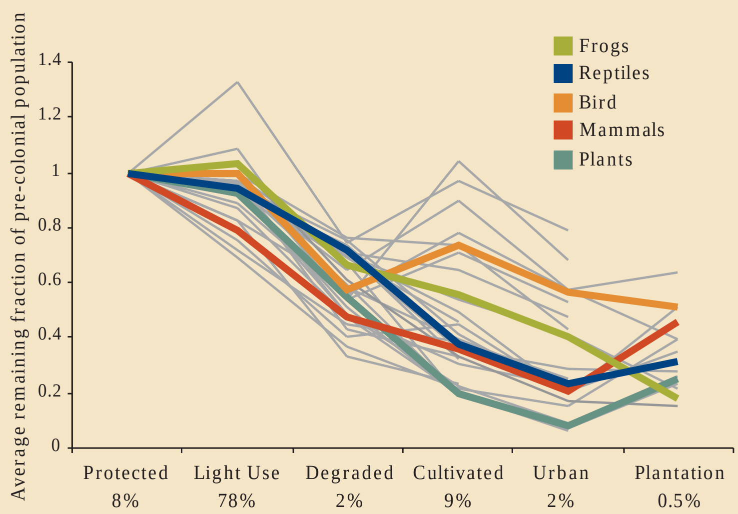


Figure 4.3: The effect of increasing land use intensity on the inferred original population. These estimates, averaged over biomes and functional types, were derived from independent structured interviews with 16 taxon specialists. Some general patterns are evident: non-mobile species such as plants are more adversely affected than mobile species such as birds. Larger organisms and predators are more affected by human activity than are smaller, non-predatory species. Mammals and reptiles tend to track (plant) habitat changes, whereas birds and frogs show marked non-linearities in their response. The x-axis percentages refer to the percentage of southern Africa under the respective land uses. Grey lines show the range of estimates.

4.3 THE CHANGING LAND-COVER

In southern Africa, land-cover is closely linked to biodiversity change (Figure 4.3) in all its levels and aspects (see Box 4.1). Therefore, monitoring and understanding land-cover change, which typically reflects an underlying land-use change, is critical to the assessment of the condition and trends in biodiversity. One of the practical problems is the disagreement between published sources, for instance of forested (Table 4.4) and cultivated area (Table 4.5). This makes date-based assessment of trends in land-cover change over time highly uncertain, since no estimates have been made more than once using the same method. Some of the variance in results is due to differences in land-cover definition, and some due to the different resolution of the methods applied.

Forest cover

Most of southern Africa has some degree of tree (woody plants taller than 2.5 m) cover. The Food and Agriculture Organisation of the United Nations (FAO), which is responsible for assessing global forest resources, defines forests as all areas with more than 10% woody cover (FAO 2001). In contrast, forest professionals and lay people in the region typically refer to areas with greater than 60% canopy cover (i.e. the canopies touch) as forests, 40 - 60% cover as woodlands and 5 - 40% as open savannas (Scholes 2004). The relationship between these cut-off points and the 'forested' area that they predict is shown in Figure 4.4. The area of 'closed forest' is clearly fairly insensitive to assumptions made about cover percentage, and is about 2 million km^2, or 18% of the land area of southern Africa. Mixed tree-grass systems (i.e. savannas in the broad sense) occupy 60% of the area, with no clear disjunction between woodlands and the more open forms. Much of the disagreement in forested area stems from how much of the savanna component is included in 'forest'. Clearly, in their submissions to the FAO (Table 4.4), none of the countries are following the FAO definitions. Neither are they following the narrower definition of forest, but in general appear to be reporting the total of forest and woodland.

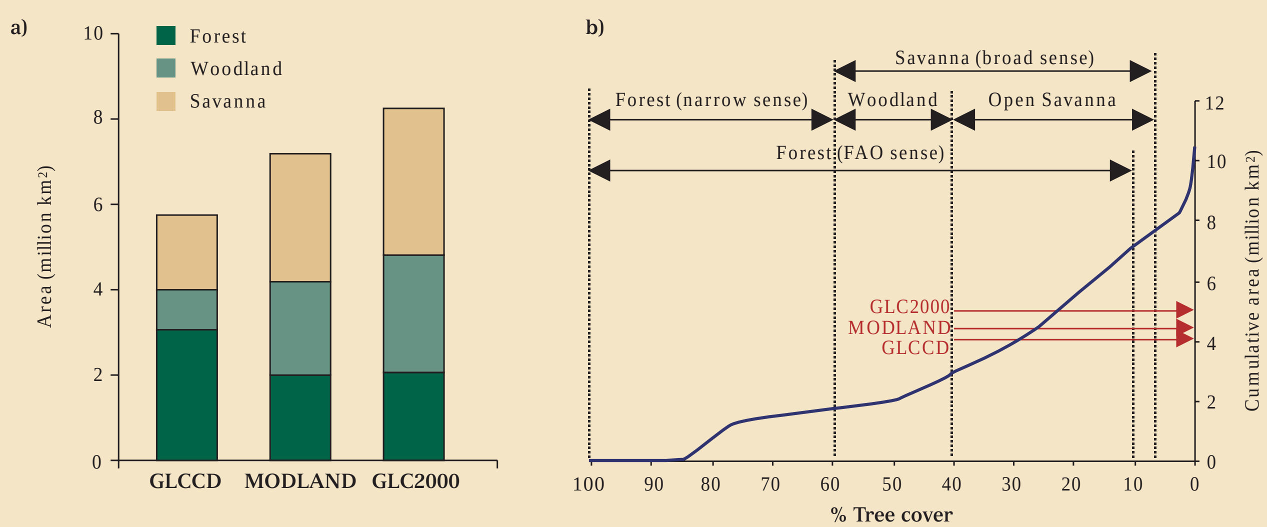


Figure 4.4: a) Comparison of the total area in southern Africa estimated to be under forest cover in the FAO sense based on three recent land-cover products. b) The total land area in southern Africa with a tree canopy cover of at least the percentage given on the x-axis; the combined forest and woodland areas recorded by three studies (Table 4.4) are shown on the y-axis. Source: DeFries *et al.* (2000), IGBP GLCCD, MODLAND, GLC2000.

Table 4.4 presents the data from all regional-scale estimates of forest cover in southern Africa undertaken for the 1990s. The Global Land Cover 2000 (GLC 2000) uses 1 km resolution vegetation data, visually interpreted. The GLCCD product is the latest version of the IGBP land-cover dataset, based on 1.1 km resolution NOAA-AVHRR data and an automated decision rule. The MODIS land-cover product (MODLAND) includes the 500 m tree cover percentage layer that was used to construct Figure 4.4b. The SADC land-cover map was constructed from high-resolution data, interpreted by local experts, and should therefore be the most accurate, for the countries which it covers. For the area covered, the SADC land-cover provides a total estimate that is almost three times higher than the ModLand estimate, and 20% higher than the submissions to FAO.

The deforestation rate in the Congo Basin rainforest, the second largest contiguous tropical forest area in the world, was about 0.6% per year in the period 1980 to 1990 (Barnes 1990), equivalent to 8000 km^2 per year in the SAfMA study area. This is slightly lower than rates recorded in South America and much lower than rates in Asia in the equivalent period. Mean rates of humid tropical forest cover change in Africa in the 1990s are estimated at 0.4% per year (Achard *et al.* 2002). The deforestation rate is spatially very variable (0.1 to 0.7% per year). As in the case of South America, the unnoticed 'deforestation' in southern Africa is largely taking place in the dry forests, savannas and woodlands regions surrounding the equatorial rainforest (Figure 4.5).

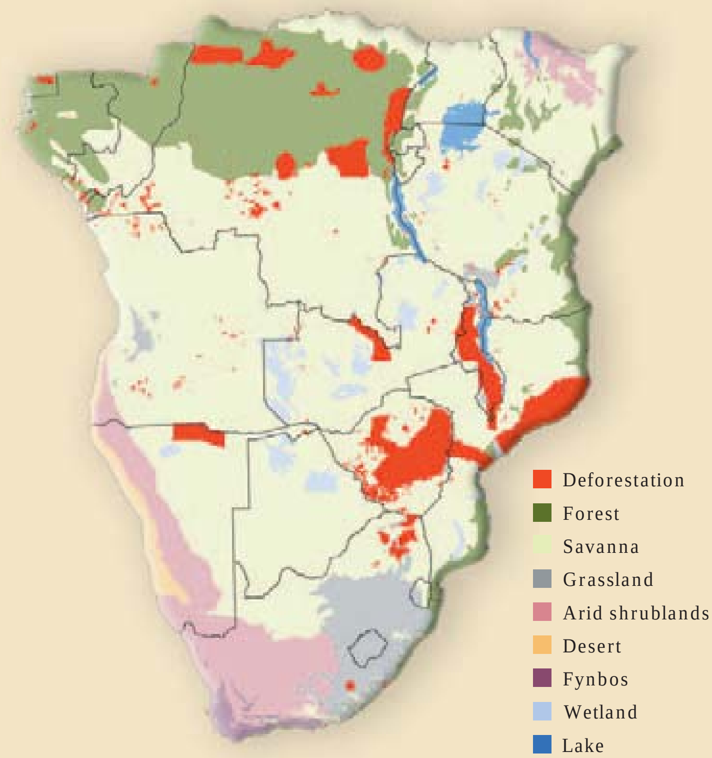


Figure 4.5: Areas of rapid deforestation during the period 1980 to 2000 (Lepers *et al.* in prep). Areas with high rates of recent and ongoing woodland loss occur in Zimbabwe, Malawi and Eastern Zambia, central Mozambique and northern Namibia, awell as in the Congo Basin rainforest in the DRC.

Table 4.4: Comparison of the total area classified as forest and woodland in southern Africa based on four satellite-derived land-cover products. FAO statistics generally correspond to the combination of these classes rather than to the broad FAO definition of forest which also includes savannas (see Figure 4.4).

	GLCCD IGBP		MODLAND		GLC 2000 Africa		SADC LC		FAO Statistics[1] 2000		
									Total		*Plantations*
	1000 km^2	*%*	*1000 km^2*	*%*	*1000 km^2*	*%*	*1000 km^2*	*%*	*1000 km^2*	*%*	*1000 km^2*
Angola	622	50	609	49	716	57			698	56	1.4
Botswana	6	1	10	2	33	6			124	21	0.0
Burundi	7	25	6	23	5	19			1	3	0.7
Congo	274	80	289	85	238	69			221	65	0.8
Dem Rep Congo	1884	80	2115	90	1832	78			1352	58	1.0
Equatorial Guinea	16	55	22	78	23	81			18	62	0.0
Gabon	200	75	208	78	234	87			218	82	0.4
Kenya	154	27	67	11	65	11			171	29	2.3
Lesotho	0	1	3	10	1	2	0	0	0	0	0.1
Malawi	19	16	14	12	32	27	26	22	26	22	1.1
Mozambique	182	23	158	20	407	51	443	55	306	38	0.5
Namibia	1	0	2	0	3	0			80	10	0.0
Rwanda	6	24	8	30	4	15			3	12	2.6
South Africa	52	4	66	5	206	17	75	6	89	7	15.5
Swaziland	2	13	3	17	14	82	3	18	5	30	1.6
Tanzania	278	29	179	19	296	31	470	50	388	41	1.4
Uganda	92	38	126	52	88	36			42	17	0.4
Zambia	209	28	265	35	448	59			312	42	0.8
Zimbabwe	21	5	25	6	154	39	209	53	190	49	1.4
REGION	**4024**	**37**	**4175**	**39**	**4797**	**44**			**4245**	**39**	**32.1**

[1]FAO Global Forest Resources Assessment 2000 (http://www.fao.org/forestry). FRA 2000 adopted a threshold of 10% minimum crown cover in defining forest. Total forest includes both natural forests and forest plantations, but excludes trees established primarily for agricultural production (e.g. orchards). Forest plantations are forest stands of introduced species or intensively managed stands of indigenous species of even age class and regular spacing.

Cultivated area

Estimates of the true area under cultivation in southern Africa vary even more than the area estimated to be under undisturbed forest cover (Table 4.5). This is partly because of the lack of resources in national government agencies responsible for agricultural data collection, and partly because the type of crop agriculture that dominates over much of the region (small-scale, non-market and shifting) is difficult to monitor by either census methods or remote sensing. A ‘best estimate’ is between 6 and 11% of the land area.

The GLC 2000 product does a reasonable job of producing estimates that match both the official FAO statistics and the detailed SADC land-cover map. The GLCCD product shows a wide variation in estimates for individual countries compared to the other products. Coarse-resolution approaches tend to classify fine-scale mosaics of cultivated and uncultivated land either entirely into a ‘cultivated landscape’ category, or as mosaics. Including these classes in the estimate of the total area under cultivation substantially increases the area, and may be used as an upper estimate of the total area affected by cultivation activities. The rate of increase in the area of permanent crops, as reported to the FAO, was 0.6% per annum during the 1990s. Virtually all of this increase occurred in the area from Zimbabwe southwards, where the arable land is now approaching its upper limit. The zone between 17ºS and 10ºS (southern Angola, Zambia, Malawi and northern Mozambique) is projected to be the ‘agricultural frontier’ in the first quarter of the 21st century.

Future agricultural expansion

The population of southern Africa is projected to nearly double over the next half century, despite the effects of HIV/Aids (Table 2.3, page 7). The food requirements of the additional people are projected to rise more than proportionately, due to the changes in diet that typically accompany increases in wealth and urbanisation. As discussed in Chapter 5, southern Africa (and particularly the zone between 17ºS and 10ºS) has more than adequate potential to meet these growing demands, either through the expansion of cultivated area (‘extensification’) or by increasing the agricultural production per unit land (‘intensification’). In reality, both processes will occur, but their relative proportions will depend on how various socio-economic factors develop in the coming decades. The balance between extensification and intensification has enormous consequences for land-cover change and biodiversity. Where extensification predominates, a much larger area of habitat is lost. Under intensification the local biodiversity impacts may be higher, but the area affected is smaller. Off-site impacts, particularly on freshwater systems, may be greater under intensive agriculture.

Table 4.5: The area estimated to be under cultivation in southern Africa varies considerably between different sources. The ‘core’ areas given for the GLCCD and GLC 2000 products are comparable to the areas given by MODLAND, the SADC Land-cover product and the FAO statistics. The ‘total’ areas additionally include areas classified as cropland/natural vegetation mosaics, and therefore represent an upper estimate of the total area affected by cultivation.

	GLCCD IGBP				GLC2000 Africa				MODLAND		SADC LC		FAO Statistics 2000	
	Core	*%*	*Total*	*%*	*Core*	*%*	*Total*	*%*	*1000 km²*	*%*	*1000 km²*	*%*	*1000 km²*	*%*
Angola	63	5	127	10	48	4	49	4	28	2			33	3
Botswana	27	5	119	21	36	6	36	6	23	4			4	1
Burundi	1	4	17	61	9	33	9	33	6	23			13	45
Congo Rep	5	1	13	4	2	1	14	4	5	1			2	1
Dem Rep of Congo	65	3	244	10	8	0	123	5	27	1			79	3
Equatorial Guinea	0	2	5	19	0	0	4	13	0	1			2	8
Gabon	6	2	20	7	0	0	12	4	3	1			5	2
Kenya	39	7	112	19	53	9	59	10	60	10			45	8
Lesotho	1	2	8	27	3	10	3	10	2	5	7	23	3	11
Malawi	23	19	29	25	31	26	31	26	12	10	59	50	22	19
Mozambique	219	27	282	35	71	9	73	9	19	2	48	6	41	5
Namibia	10	1	68	8	3	0	3	0	3	0			8	1
Rwanda	1	6	12	46	13	48	13	49	8	29			12	44
South Africa	150	12	462	38	136	11	138	11	92	8	144	12	157	13
Swaziland	11	66	12	67	0	0	0	0	5	31	4	20	2	11
Tanzania	221	23	358	38	178	19	178	19	74	8	101	11	50	5
Uganda	62	26	85	35	67	28	70	29	41	17			70	29
Zambia	114	15	256	34	64	8	64	8	59	8			53	7
Zimbabwe	160	41	211	54	119	30	119	30	26	7	107	27	34	9
REGION	**1178**	**11**	**2442**	**23**	**842**	**8**	**998**	**9**	**494**	**5**			**634**	**6**

In urban contexts, traditional starches such as millet, sorghum, maize and cassava are increasingly replaced by wheat products (bread and pasta), rice and potatoes. As household income increases, the consumption of protein also increases. Since there is little capacity for the natural fisheries of southern Africa to increase their harvest, the demand for poultry, mutton, pork and particularly beef, is projected to increase. An increased demand for poultry usually occurs first, and has a knock-on effect on the demand for grain used to feed chickens. Most meat in southern Africa is produced from natural pasturage; a relatively small amount of pork, and to a limited degree beef, is fattened using cultivated products such as forages and feed grains.

The scope for increasing the number of livestock in the arid and semi-arid lands is limited, whereas there remains considerable potential for increasing cattle in the moister areas, provided disease and nutrition constraints are overcome. The moister savanna areas are more suited to cattle than to small stock, because of the low quality of the forage, but have historically not supported large cattle numbers due to the extremely low nitrogen content of the grass in the dry season and the presence of livestock diseases. Both of these problems have been overcome in other parts of the tropics, but require improved agricultural extension and infrastructure. An increase in livestock production affects a much larger area of natural ecosystems than a proportional increase in crop production, but if the grazing remains within sustainable limits, the impact on biodiversity is relatively low (Figure 4.3, page 18).

Scenarios of land-cover change

The increased, but somewhat different, demand for food projected under the SAfMA scenarios (described in Chapter 3) can either be satisfied by within-region supply, or by imports. The Partnership scenario (strong central governance, high economic growth) is more likely to generate the trade surpluses needed for food purchases, both within the region and from extra-regional suppliers. Furthermore, the production of crops and livestock per unit land area is likely to be higher under this scenario, due to the greater affordability of inputs for intensification (fertilisers, improved crop varieties, mechanisation, pesticides). Thus the total area transformed by agriculture is projected to be smaller under the Partnership scenario than under the Patchwork scenario. Under the latter scenario, food imports are likely to be dominated by food aid. Local communities will tend to convert ever-increasing areas of land into low-input, low yielding croplands.

The projections shown in Figure 4.6, using the IMAGE land-cover change model, of dramatic land-cover changes under both scenarios in the Angola-Zambia-Malawi-Mozambique belt, bears close examination. The main cause of the agricultural expansion predicted by the model is an increase in livestock production driven by diet changes. In the southern African context this does not necessarily lead to a change in land-cover, since cattle are typically grazed in near-natural ecosystems. Such land-cover changes would occur only if ranchers follow the Australian and South American example and clear woodlands and forests to improve pasture production (possible under the Partnership scenario), or if the stocking rates are sufficiently high to cause degradation (more likely under the Patchwork scenario) (Section 4.4).

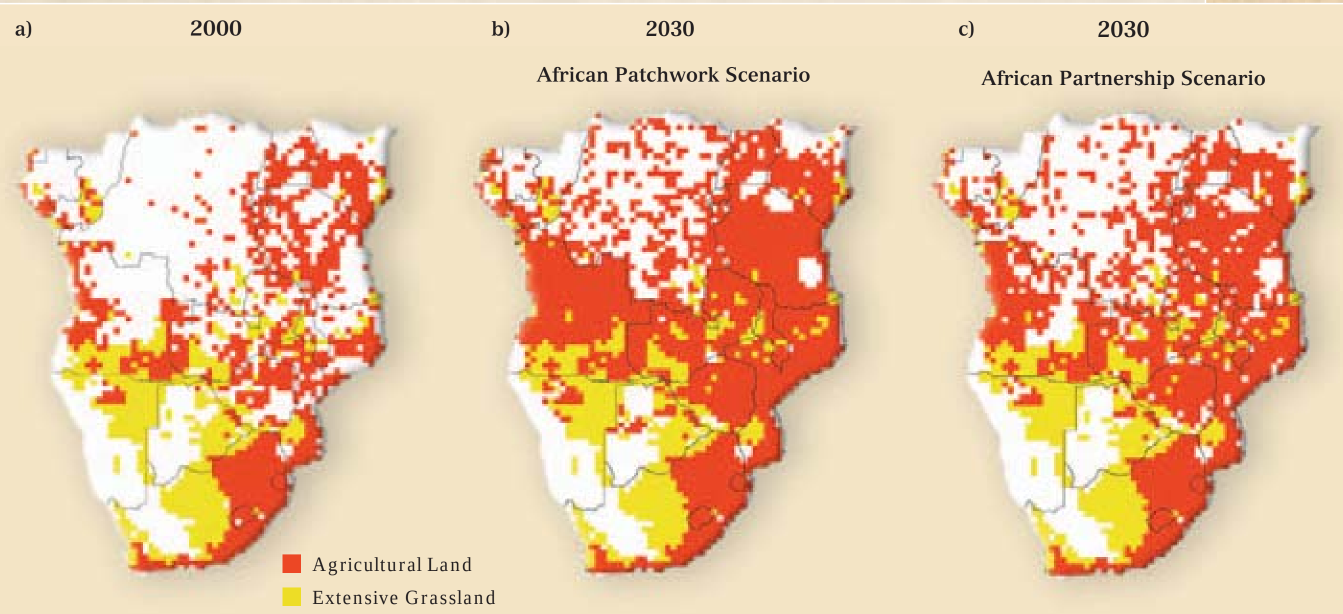


Figure 4.6: Projections of land-cover change using the IMAGE model (Alcamo *et al.* 1998). Under the Patchwork low economic growth scenario a greater area is converted to agriculture than under the high economic growth Partnership scenario. In both cases the major changes occur north of the Zambezi river, and are mainly due to increased livestock numbers rather than increased crop area. The model assumes that livestock are grazed extensively on the areas depicted in yellow, and intensively on a portion of the areas depicted in red (the remaining agricultural land being used for crop production).

4.4 DEGRADATION AND DESERTIFICATION

The UN Convention on Combating Desertification (UNCCD) defines desertification as 'degradation in arid, semi-arid and dry sub-humid lands'. This study follows the South African policy on desertification by going one logical step further, and defining degradation as a 'sustained loss in ecosystem services' (DEAT 2003). This creates a very clear link between the Millennium Ecosystem Assessment, with its focus on ecosystem services, and the UNCCD, and broadens the debate on desertification beyond its historical focus on livestock and crop-related issues.

In the drier parts of southern Africa, the main processes of degradation involve changes to the vegetation cover and composition, or changes to the soil (Hoffman & Ashwell 2001). In areas perceived to be degraded, the ground cover and productivity typically decline, palatable species may be replaced by unpalatable species, a greater fraction of rainfall is converted to storm-flow, and the sediment yield per unit area increases. Tree cover may decrease (typical of communal areas) or increase (the phenomenon of bush encroachment, typical on commercial rangeland). The main driver of desertification (i.e. degradation in dry regions) is thought to be long-term herbivory at levels greater than the productive potential of the landscape can support, generally by domestic livestock (Figure 4.7). Reich *et al.* (2001) estimate that approximately half of the sub-humid and semi-arid parts of the region are at moderate to high risk of desertification. Salinisation and soil erosion, associated with poor irrigation and cropping practices, often in marginal lands, affect a smaller area.

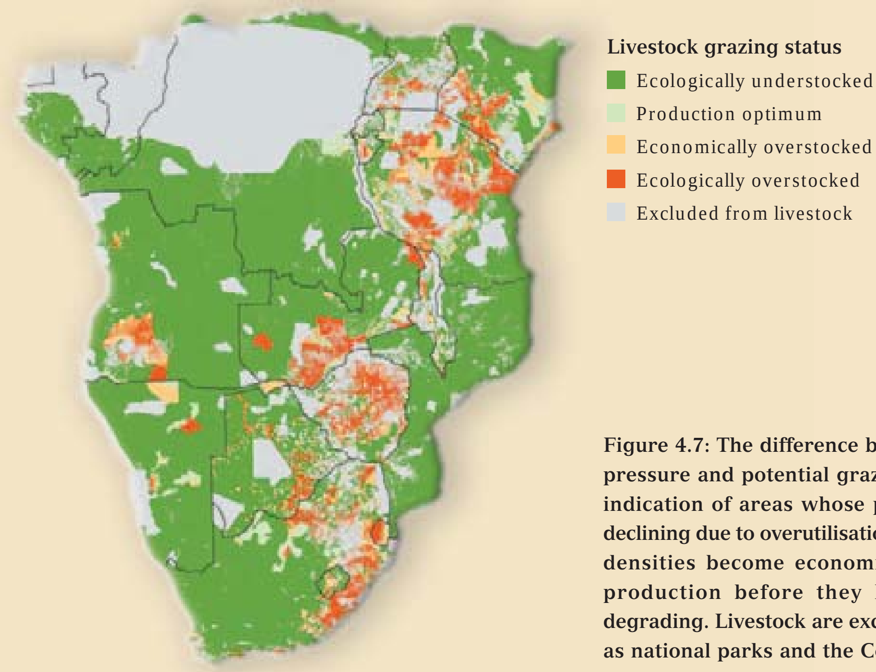


Figure 4.7: The difference between actual grazing pressure and potential grazing capacity, gives an indication of areas whose productive capacity is declining due to overutilisation. Increasing livestock densities become economically suboptimal for production before they become ecologically degrading. Livestock are excluded from areas such as national parks and the Congo Basin rainforest.

In areas too moist to fall under the ambit of the UNCCD, the main processes of degradation are:

- Deforestation, both within the humid forest, and (more extensively) within the drier woodlands;
- Over-harvesting, particularly of high-value timbers and medicinal plants, and medium-to large-bodied mammals and birds for the 'bushmeat' and collector trade;
- Soil erosion, particularly in the steep lands of East Africa; and
- Nutrient depletion, which is widespread on the infertile landscapes of the African shield.

The underlying causes of degradation are a combination of lack of alternate economic opportunities, and an absence or failure of regulatory structures. In the case of nutrient depletion, the age and origin of the soils in most of southern Africa (areas on the African shield) makes them inherently low in nutrients. This condition is accentuated by repeated crop harvest without adequate nutrient replenishment (Sanchez 2002), as infrastructure is inadequate to deliver fertilisers at a cost affordable to small farmers.

There are various other degradation processes at work in southern Africa, in more localised areas. Direct pollution impacts are documented in the vicinity of the highly industrialised parts of South Africa and the 'Copper Belt' mining centre of Zambia and the Democratic Republic of Congo (e.g. Figure 8.3, page 57). Coastal pollution is experienced around major ports and coastal settlements. The Cape of Good Hope is especially vulnerable to oilspills, given its combination of stormy conditions and high sea traffic. Freshwater quality is widely degraded by faecal pollutants, and in drier areas, by excessive water use (Chapter 6).

4.5 INVASION BY ALIEN ORGANISMS

An 'alien' organism is one that has been introduced, by deliberate or accidental human action, into an environment in which it did not previously occur. Not all alien organisms thrive in their new environments, but some do. When they spread rapidly at the expense of indigenous organisms, and cause significant change to ecosystem properties or service delivery, they become known as 'invasive aliens', or more popularly, as 'weeds' or 'problem animals'. They can occur on land, in the ocean, or in freshwater, and can be drawn from any group of organisms.

The concern regarding alien organisms is not equally distributed around the globe or within the region (Table 4.6). This may simply be due to differences in observation and recording efforts, rather than reflecting true differences in the number of alien species, or it may reflect the time for which different countries have been exposed to new species. South Africa, for instance, along with other former colonies such as Australia and New Zealand was the target of a movement that first aimed to make the colonies as reminiscent of the 'home country' as possible by deliberately introducing European species, and then became part of a general 'improvement' programme, transferring species all over the world in order to confer their supposed benefits to new locations. Some of these organisms did, in fact, become useful naturalised species, but about 6% of the introduced organisms were 'transformer species', with severe unanticipated negative consequences (Wells *et al.* 1986). In a more recent study in South Africa (Nel *et al.* 2004), 20% of listed aliens were categorised as 'major invaders', and a further 15% as 'emerging invaders'. A third possibility, still poorly disentangled from the above two considerations, is that some ecosystems are inherently more susceptible to invasion than others. Riparian ecosystems, for example, are vulnerable because water provides rapid transport for seeds. Similarly, the Cape coast is exposed to sea traffic that carries marine organisms from afar.

Table 4.6: Number of alien species of different taxa that have been identified as harmful, invasive or pests (Macdonald et al. 2003) in selected SADC countries. Alien plant data refer to the total number of alien plants recorded and is based on the SAPIA database (Henderson 1998). Category 1 alien plants are prohibited and must be controlled according to the CARA legislation in South Africa.

	Plants		Birds	Reptiles	Fish	Insects	Spiders	Molluscs	Plant Pathogens
	Cat 1	*Total*							
Angola		0	0						
Botswana	5	7			3				
Lesotho	21	82							
Malawi	18	38				4			
Mozambique	7	12	1			6			3
Namibia	15	32							
South Africa*	122	503	15	1	**58	***225	24	25	
Swaziland	35	64							
Tanzania			1			10			5

* Figures for South Africa generally refer to the total number of known alien species, not only those regarded as pests
** Includes 36 internal translocations
*** Species introduced for biological control

Alien invasive organisms can have a major impact on the endemic biodiversity of a region, as well as on other ecosystem services. Evergreen, deep-rooted alien trees are estimated to have reduced the amount of water flowing down South African rivers by 1.4 to 3.3 billion m^3 per year, equivalent to a loss of about 10% (Görgens & van Wilgen 2004). Nitrogen fixing aliens such as *Acacia saligna* have altered the nitrogen cycle in parts of the Fynbos to their own advantage, and to the disadvantage of native plants adapted to low nutrient supply. Highly combustible, fire-tolerant aliens have also altered the fire regime. Combined with competition for light, nutrients, water and space, these processes are believed to have been a major factor in local extinctions (Richardson & van Wilgen 2004). On an area affected basis, up to 70% of the remaining Fynbos is invaded to some degree, about 2.5% severely (Rouget *et al.* 2003). Comparable data are not available for grasslands, savannas or forests, but the problem is inferred to be somewhat less severe. Weed data from southern Africa, however, do not support the perception that the Fynbos is especially vulnerable. There are 30% more listed important weed species in savannas, grasslands and forests (these three systems share many weed species) than in the Fynbos. Deserts and arid shrublands respectively have about an eighth and half of the weeds listed for savannas (Richardson *et al.* 1997).

Responses to the problem of alien invader species have included regulations aimed at restricting the import of potentially invasive organisms, and various control measures to combat species already established. Introduction of natural pests or predators from the place of origin of the alien species has been successful in several cases, often in combination with direct physical control (Olckers & Hill 1999). In South Africa, the 'Working for Water' programme combines a major rural poverty-relief initiative with an effort to remove water-thirsty alien plants from catchments (van Wilgen *et al.* 1998).

4.6 RESPONSES: PROTECTED AREAS AND OTHER CONSERVATION ACTIONS

While some species are able to persist under all forms of land use (Figure 4.3, page 18), certain areas are managed with the express intention to protect and maintain biodiversity. Such areas are owned and managed by a large variety of people and institutions and with a range of objectives, including National Parks managed by state authorities, ecological research sites managed by academic institutions, private game farms managed for tourism, and sustainable use areas managed by local communities. This makes the international collation of data (undertaken by UNEP-WCMC) on the nature, extent and effectiveness of protected areas very difficult. Estimates vary over short periods of time due to differences in categorisation, data quality and frequency of update between countries. In addition, there are discrepancies between reported areas, and areas derived by GIS analysis. Table 4.7 gives current estimates of protected areas of different status.

Priority areas for conservation

In response to predictions of massive looming species extinctions (Vitousek *et al.* 1997) and faced with inadequate funding to address these, much of the conservation community has focused on identifying priority locations for conservation. Rather than emphasising the preservation of particular species, recent approaches attempt to identify areas of high biodiversity value (in terms of richness, endemism, threat, biodiversity representation, complementarity to existing protected areas, or other value), whose conservation would simultaneously preserve a large number of species as well as maintain general ecosystem health.

Two main approaches have been used to identify priority areas. Representation approaches, such as the WWF Global 200 areas (Olson & Dinerstein 2002), aim to identify a set of areas whose conservation would protect representative examples of all ecosystems (Figure 4.8a). Variations of such sophisticated systematic conservation planning techniques have been locally developed in South Africa and applied on a regional scale (e.g. Cowling & Pressey 2003). In Africa, many of these priority areas are densely inhabited, creating the potential for conservation conflict (Balmford *et al.* 2001).

Table 4.7: Estimated protected areas per country. Approximately half the countries in the region meet the international target of 10% area under protection, but note that management various greatly across the subcontinent. Data obtained from the WRI Searchable Online Database[1].

	Area of National Parks, Nature Reserves & Protected landscapes (IUCN I-V)[2] 2003		Areas managed for sustainable use & areas not classified by IUCN (IUCN VI & other)[3] 2003		All terrestrial protected areas as a % of surface area 2003	Marine & littoral protected areas (IUCN I-VI) 2003	Biosphere Reserves[4] 2003	Ramsar Wetland Sites[5] 2003	World Heritage Sites[6] 2003
	1000 km^2	%	1000 km^2	%	%	1000 km^2	No.	No.	No.
Angola	53	4.2	73	5.8	10.0	29	0	N	0
Botswana	105	18.0	70	12.0	30.2	-	0	1	0
Burundi	1	5.3	0	0.0	5.4	-	0	1	0
Congo	49	14.2	2	0.6	15.8	0	2	1	0
Dem Rep Congo	119	5.1	75	3.2	8.3	1	3	2	5
Equatorial Guinea	5	16.2	0	0.0	16.8	1	0	3	N
Gabon	1	0.3	8	3.0	3.4	3	1	3	0
Kenya	35	6.0	37	6.4	12.3	4	6	4	2
Lesotho	0	0.2	0	0.0	0.2	-	0	N	N
Malawi	11	8.9	9	7.4	16.3	-	1	1	1
Mozambique	33	4.1	12	1.6	5.7	21	0	N	0
Namibia	32	3.9	14	1.7	5.6	74	0	4	0
Rwanda	2	7.4	0	0.0	7.7	-	1	N	0
South Africa	66	5.4	10	0.8	6.2	2	4	17	1
Swaziland	0	2.0	0	1.4	3.5	-	0	N	N
Tanzania	138	14.6	236	25.0	39.6	1	3	3	4
Uganda	18	7.3	47	19.3	26.4	-	1	1	2
Zambia	64	8.5	249	33.0	41.4	-	0	2	1
Zimbabwe	31	7.9	26	6.8	14.7	-	0	N	2
REGION	**761**	**7.1**	**868**	**8.0**	**15.1**	**136**	**22**	**43**	**17**

1 www.earthtrends.wri.org
2 Marine protected areas are excluded. Additionally, about 15% of sites are excluded as they do not yet have area data.
3 Marine protected areas are excluded. Additionally, about 30% of sites are excluded as they do not yet have area data.
4 Areas internationally recognized under the Man and the Biosphere Programme of UNESCO. Available online at www.unesco.rog/mab
5 Wetlands of international importance. Available online at http://ramsar.org
6 Areas of outstanding natural or cultural value. Only sites of natural value listed here. Available online at http://whc.unesco.org
- Land-locked countries
N Countries not signatory to the convention.

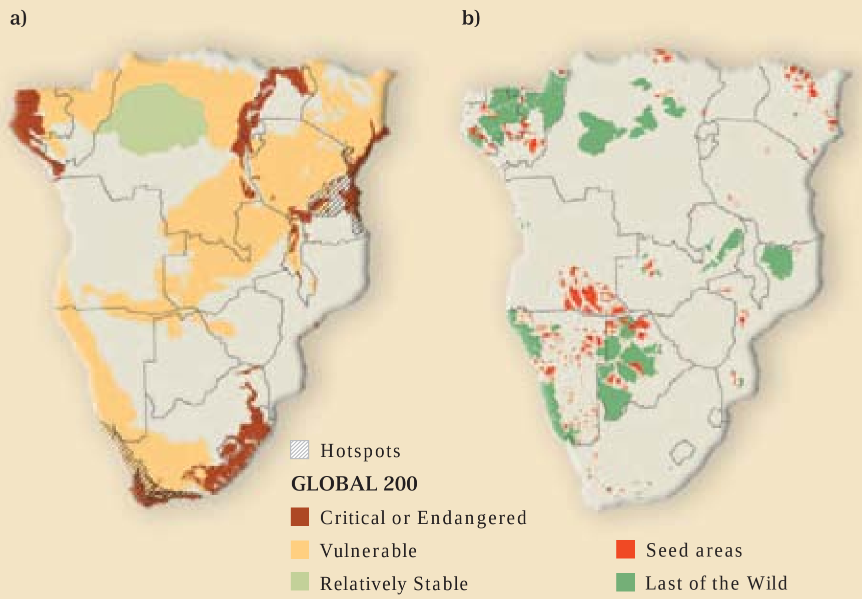


Figure 4.8: Areas that have been proposed as priorities for conservation in southern Africa. a) The WWF Global 200 identifies representative examples of all ecosystems and emphasizes biodiversity features that were in place before major human impacts. Conservation International's hotspot analyses highlight areas of high endemism that are undergoing exceptional loss of habitat. b) The Last of the Wild areas indicate the ten largest contiguous areas in each biome which fall within the 10% least impacted (wildest) areas on earth. Seed areas indicate the 1% wildest areas in each biome, regardless of size.

Hotspot approaches such as adopted by Conservation International[1] aim to highlight areas with high concentrations of range-restricted (endemic) species that are undergoing exceptional loss of habitat (Myers *et al.* 2000). At large scales, priority-setting analyses, including Birdlife International's Endemic Bird Areas (Stattersfield et al. 1998) and the IUCN/WWF's Centres of Plant Diversity and Endemism (Davis *et al.* 1994), show significant overlap (Myers *et al.* 2000; WCMC 2000). A complementary approach is to identify the remaining areas in each biome least impacted by human activity (Sanderson *et al.* 2002) (Figure 4.8b).

Other conservation activities

A substantial fraction of conservation-related activities in particularly South Africa are now conducted by the private sector (Box 4.3, also see Chapter 9). It remains an open question whether such non-government protected land is equivalent to legislated conservation areas run by government agencies. What is clear is that the state has a pivotal role to play in protecting the 'core areas' around which the non-state conservation lands can coalesce, and establishing the institutional framework in which they can exist.

Box 4.3: A revolution in natural resource ownership

The protected area in South Africa rose from about 5% of the land surface in 1980 to over 14% today, and is still rising (WDPA 2003). Most of the newly protected land is not administered by the state, but by the private sector. A similar pattern is observed in Zimbabwe and Namibia. What happened?

Historically in most southern African countries, wildlife (and many other natural resources) belonged to the state, and not to the land custodian. People were issued licences to hunt or harvest, but had little incentive to conserve or enhance wildlife stocks. Several experiments began in southern Africa during the early 1980s to transfer use rights to the landowners: In South Africa, initially to private, mostly white, individual freehold landowners, and in Zimbabwe to local communities.

In South Africa this transfer involved a simple change to the regulations in the provincial wildlife protection legislation. Owners who erected a game-proof fence around their land were freed from many (but not all) of the restrictions relating to the use of wildlife. Almost immediately, large parts of the country that were used, unprofitably, for cattle or sheep ranching began to farm wildlife as well. Initially, the small but lucrative trophy-hunting market provided the incentive. This triggered a 'bubble' in live wildlife sales to stock new areas, driving the conversion forward. The rapid expansion of the nature-based tourism market (see Chapter 9) following the democratic transition in South Africa has subsequently taken over as the major driver. At the same time, the high cost of fencing and wildlife management promoted the collaboration of adjacent landowners and the formation of new institutions, called 'conservancies'.

In Zimbabwe, the CAMPFIRE programme targeted sparsely-populated communal lands adjacent to national parks or game hunting areas. It demonstrated that the economic returns from sustainable use of the wildlife (largely through trophy hunting) exceeded the returns from marginal cultivation or cattle ranching, both of which were in increasing conflict with elephants and large predators. Schemes were devised to return the proceeds to the community as a whole. The concept spread rapidly to northern Namibia, Botswana and South Africa, and expanded to embrace other high value resources, such as timber and ecotourism. In some places it has become a victim of its own success: in cash-strapped Zimbabwe, the state has taken back ownership of what are now seen as lucrative resources, and the local communities have been invaded by people seeking to share in the spoils.

[1] www.biodiversityhotspots.org

5. Food and Nutrition

5.1 FOOD SECURITY AND HUMAN WELL-BEING

Enough food is produced in the world to provide an adequate diet for everyone (FAO 2002). Yet, in 2002, there were 840 million undernourished people, 196 million of whom were in sub-Saharan Africa. One of the Millennium Development Goals includes halving the number of hungry people by 2015[1]. At the current rate of progress, this target may only be achieved in 2150 (FAO 2002).

The production of food is one of the most basic of ecosystem services and takes place both in natural and agricultural ecosystems. A number of studies, in Africa and elsewhere (Lesotho VAC & SADC-FANR 2002, SCF-UK 2002, DFID 2002a), indicate that rural people obtain about a third of their nutritional requirements from wild foods, such as fruits, 'bush meat' and insects. This proportion rises at times of stress, such as when crops fail or employment is scarce. The ecosystem therefore acts as a food security safety-net. Wild plants and animals also have a profound indirect effect on food security, through income generation, traditional medicines and by maintaining well-functioning ecosystems and the services they supply.

In addition to the protein and the energy provided by carbohydrates and fats, human health and development requires small quantities essential elements (such as iron and iodine), and about a dozen complex compounds of biological origin, collectively known as vitamins. These 'micronutrients' come from a varied diet, including fruits and vegetables, many of which are traditionally sourced from natural ecosystems. Micronutrients may be deficient in the diet because the ecosystem has a naturally low supply, for reasons of geology or the great age of the soil. Deficiencies are also associated with narrowing diets, due to rural poverty, depletion of natural sources of fruits and vegetables, and urbanisation. Vitamin A, iron and iodine are the three most critical deficiencies in the region (USAID 1998).

Food security, vulnerability and poverty

A broadly-accepted definition of food security is that all people should have access, at all times, to sufficient food for an active and healthy lifestyle (Meissner 2002). Malnutrition is a narrower concept, meaning an inadequate food intake, which is influenced not only by availability, but also by education, culture, food preferences and disease. The World Health Organisation recommends a minimum dietary consumption of 2100 kilocalories per day, including 56 g and 48 g of protein per day for the average adult man and woman respectively. The Food and Agriculture Organisation (FAO) defines undernourishment as food consumption of less than about 1900 kilocalories per day (Scherr 2003). Undernourishment may lead to malnutrition, which reduces human well-being by impairing physical functioning, the ability to work and learn, and affecting processes such as growth, pregnancy, lactation and resistance to disease (Young 2001).

Vulnerability includes both the likelihood of exposure to stresses as well as sensitivity, which is the capacity to cope with such stresses (Watts & Bohle 1993). Vulnerability and poverty are frequently associated. One of the characteristics of the poor is that most of their resources are expended on purchasing or producing food for subsistence (Devereux & Maxwell 2001). Pursuit of food security frequently involves trade-offs, such as reduced expenditure on healthcare and education (Boudreau 1998), which further undermines the poor's capacity to improve their living conditions or increase their resilience to stress and shock, and thus increases their vulnerability. Enabling communities to find long-term solutions to breaking this cycle is the key to addressing food security at the livelihoods level.

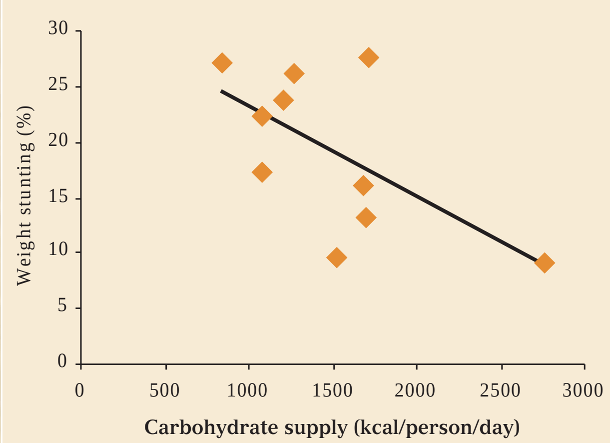


Figure 5.1: The relationship in southern Africa between national-scale per capita kilocalorie availability from cereals, and average weight stunting among children. Projection of the trend line indicates that there would need to be about 3300 kilocalories available per capita per day at a national scale for weight stunting to drop to 5% amongst children. This is a probabilistic statement, not a direct cause-and-effect relationship as many factors intervene to prevent food being evenly distributed in a population. The two data sets have a correlation coefficient of 0.56; thus other issues, such as conflict, low market access and poor infrastructure, are together nearly as powerful in deciding undernourishment in children at a local scale, as national cereal availability. Kilocalories and weight stunting are averages for 1993-2002. Sources: FAOSTAT[2], Human Development Network[3], WHOSIS[4] and Macrointernational[5].

[2] http://apps/fao.org
[3] http://devdata.woldbank.org
[4] http://who.int
[5] http://measure.dhs.com

[1] www.developmentgoals.org. This target was first set at the World Food Summit in 1996

What can regional analyses tell us about local realities?

Vulnerability and food insecurity are felt at the level of the individual household, but can be analysed at a range of spatial scales, from local to global, as well as at time scales from short to long (Watts & Bohle 1993). Reducing vulnerability at the regional scale does not necessarily translate into a reduction in vulnerability at the local level (Wisner & Luce 1994), nor do regional policy decisions always convert into successful local implementation. For example, reported national cereal availability in Zimbabwe between April and November 2002 indicated a national surplus, which directly conflicted with community level assessments indicating severe shortages (SADC-FANR 2003).

Nevertheless, food security at the household level in southern Africa needs to be considered against the background of regional trends showing an inadequate aggregate calorie and protein supply, and the macro-level political and economic failures highlighted by the recent food crisis (Box 5.1). If a rigorous study indicates food insecurity at the regional scale, there must be food insecurity in at least some local areas. An approximate calibration can be established between local undernutrition and national food balance (Figure 5.1). This indicates that a regional-scale 'overproduction' of about 30% is required before undernourishment is reduced to acceptable levels.

Box 5.1: Lessons from the 2002-2003 food security crisis in southern Africa

The 2002-2003 food shortages were the worst in the region since 1991-1992 (FAO/WFP 2002). Although the region had been affected by drought, climatic stress had not been as severe as in previous crises, and maize production during the preceding cropping season was only 5.5% below the previous five year average (Mano *et al.* 2003). Rather, the human suffering in the 2002-2003 crisis is indicative of entrenched vulnerability in southern Africa, resulting from a suite of regional and global political and economic factors (Vogel and Smith 2002). Some of the multiple stressors cited as contributing to the crisis include: High food prices (Sawdon 2002, SCF-UK 2002), the legacies of structural adjustment (Omamo 2003), government policies (Nijhoff *et al.* 2003), conflict and war, policies surrounding genetically modified foods (Mano *et al.* 2003), and the poor leadership in responding to the HIV/AIDS pandemic (Morris 2002, Holloway 2003). A moderate environmental shock was sufficient to set off the crisis, which intensified the long-term vulnerability in the region.

What causes food insecurity?

Food insecurity is one element in a cycle of entrenched socio-economic frailty, marked by unemployment, isolation from markets, lack of education, poverty and vulnerability (Box 5.1). The mix of drivers and their impacts vary across the region (Figure 5.2), but in all communities many interacting factors result in vulnerability to food shortages, the most important of which are poverty and climate. The impacts of sudden shocks, such as drought or a change in access to resources, are felt on top of ongoing, long-term stresses.

The low ability to cope with shocks and to mitigate chronic stressors means that the cost of employing coping strategies is in turn very high. Amongst the poor, approximately half their food is acquired through purchase in a 'normal' year. Typically, the reliance on food purchases increases in a year of food crisis due to losses in subsistence food production. This often leads to an increase in poverty due to the synergistic action of other drivers, such as rising food prices and unemployment. Some of the coping strategies commonly encountered include: Decreased expenditure on essential goods and services (education, staple foods, healthcare, agriculture and livestock inputs), in- and out-migration (return to the community due to retrenchment, or a search for work elsewhere), sale of assets (such as livestock at reduced prices), and a decrease in the number and dietary variation of meals.

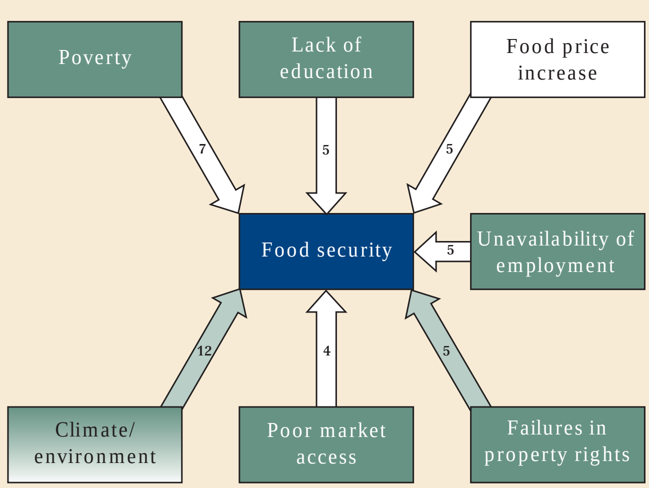


Figure 5.2: The seven most frequently cited drivers in 49 studies of household-level food insecurity in southern Africa (Misselhorn in prep). The numbers in the arrows indicate the number of citations, as a percentage of 555 citations of 33 possible drivers. The drivers shaded in green were noted as being chronic, ongoing issues, while the unshaded drivers were predominantly experienced as sudden 'shocks'. Climate/ environment was given as chronic in 57% of cases and as a shock in 43%. The shaded arrows indicate drivers that acted primarily via reductions in food production, while the unshaded arrows indicate those which acted by restricting access to food. Poverty was cited as an underlying (indirect) driver in 21% of the studies, climate and environment in 17%, and social or political unrest in 12%.

5.2 STAPLE CARBOHYDRATE CROPS

Carbohydrates (starches and sugars) are the main source of energy in the African diet. Protein is also an energy source, but is chiefly valuable for its nitrogen content. For southern Africa as a whole, the carbohydrate supply is dominated by cereals, and in particular maize (Table 5.1). Note that cereals also make a significant contribution to protein requirements (Table 5.2). There are important within-region dietary differences (Figure 5.3): Cereals are overwhelmingly dominant in the drier southern and north-eastern parts of the region, while in the wetter, more tropical northern part, root crops (such as cassava, yams, taro and sweet potato), and fruits such as bananas are important starch sources.

Within the 'cereal diet' subregion, the population as a whole is above the minimum recommended consumption of 2100 calories per person per day, but not sufficiently so as to avoid undernutrition in parts of society, especially in periods of substantially below-average rainfall. In the 'root diet' subregion, the population as a whole is below the recommended calorie intake, indicating that severe and chronic deficiencies must occur among disadvantaged subpopulations. As a result, for southern Africa as a whole, the availability of carbohydrates is just below the guidelines set for adequate nutrition (Table 5.1), but stable (Figure 5.4). The spatial distribution of cereal food balance is shown in Figure 5.5. Most of the carbohydrates consumed are from within-region production, with a minor contribution imported from global markets, and about 5% provided as food aid. We suggest that the short-fall between production, imports, food aid and nutritional needs is probably partly met by unrecorded consumption from natural ecosystems.

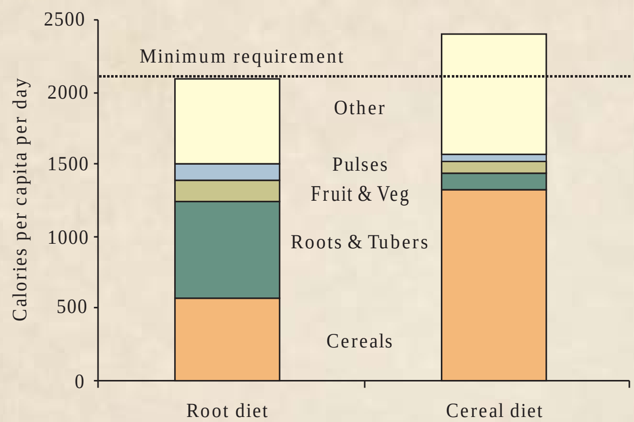


Figure 5.3: There are two distinct carbohydrate dietary patterns in the region. In the drier southern and north-eastern parts, 55% of the average total calorie intake is derived from cereals. In the more tropical central parts, including Mozambique and Tanzania, 32% of the diet consists of root crops, and only 27% of cereals. Country groupings based on FAO world diet classes (WCMC 2000): South Africa, Lesotho, Swaziland, Namibia, Botswana, Zimbabwe, Malawi and Kenya fall in cereal diet group; all other countries in root diet group. Source: FAOSTAT.

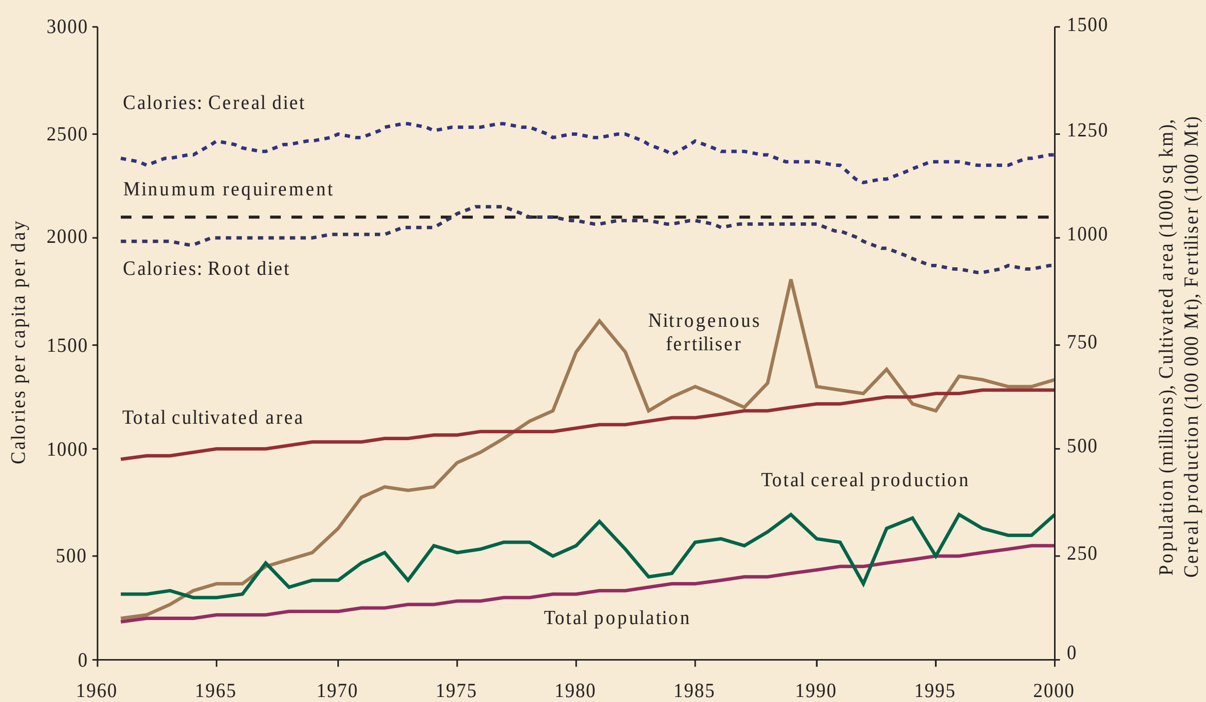


Figure 5.4: Trends in average total calorie consumption, and associated production factors. Countries relying primarily on root crops have an average calorie consumption which hovers just below the minimum recommended consumption, while countries relying primarily on cereals have an average intake slightly above the recommended minimum. Total cereal production in the region has doubled since 1960, while the area under cultivation has increased by only 30%, and the population has tripled. Total fertiliser use in the region increased sevenfold from 1960 to 1980, then leveled off. Source: FAOSTAT.

Resilience of food supply

African smallholder farmers typically plant a wide variety of crops on their land, either in mixtures within one field or separately. The genetic variation ('land races') within individual species is also high and locally-adapted, both in crops and livestock. This diversity is part of a strategy of risk avoidance, rather than production maximisation, on the part of subsistence farmers. The three key aspects of this risk avoidance strategy are crop diversity, use of natural ecosystem resources in times of stress, and the existence of strong, local-level social networks. All three are undermined by current trends, without compensatory mechanisms necessarily being in place.

What has permitted people to cope within a harsh and unpredictable environment in the past? The yields of individual crops are often very low by commercial farming standards, but even in times of drought, some yield is assured. Food from wild plants is particularly important in times of drought or food insecurity, especially in arid and semi-arid areas (Gari 2003). The trend towards monocultures of high-yielding cultivars increases productivity (provided the input conditions are met) but reduces resilience to environmental shocks. Genetically modified crops (GMOs) in southern Africa are currently largely a phenomenon of commercial farmers, and an issue in relation to imports and food aid. Some regional states feel that their neediness in times of drought is used to force them into accepting GMOs without proper debate and informed consent.

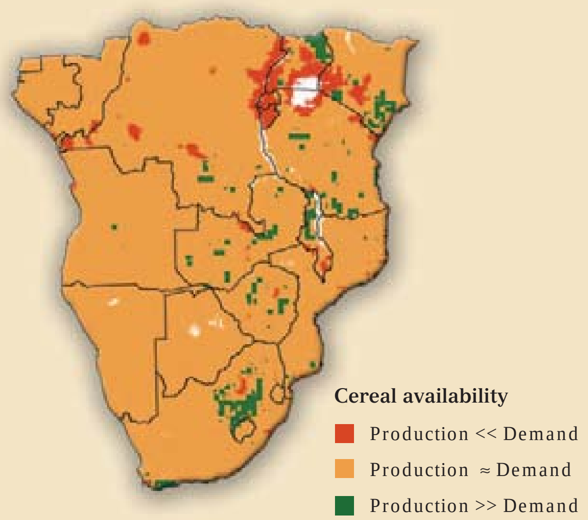


Figure 5.5: Although the region as a whole is approximately self-sufficient in staple crops (maize, sorghum and millet) in good years, the spatial pattern of food supply does not match demand, resulting in food shortages in certain areas, particularly in places where distribution networks are poor. Production was modeled at a 5km resolution based on simple crop growth models calibrated to FAO statistics and restricted to cultivated areas. A variable fraction of maize production was distributed nationally depending on the non-agricultural proportion of the population in each country; the remainder and all millet and sorghum were assumed to be distributed within an area of 50 x 50 km of where it was produced. Demand was assumed to be 2000 cal/cap/day and the food grain calorie content 3333 cal/kg. Gridded population data obtained from CIESIN.

Table 5.1: Production and nutritional contribution of major carbohydrate-supplying crops in southern Africa, averaged over the period 1998 to 2002. The cereals listed account for over 98% of total cereal production in every country. The minimum recommended daily carbohydrate consumption per person is 2100 calories, and the region as a whole falls just below this level (shown in red). Note that the production values are the harvest mass, which includes the water content, which is high in the case of roots, fruits and vegetables. Sources: FAOSTAT.

	PRODUCTION								NUTRITION				
	Maize	Wheat	Millet & Sorghum	Rice	Root	Pulses	Fruit	Veg	Total	Cereals	Roots	Pulses	Fruit & Veg
	hundred thousand metric tons per year								*Cal/ cap/day*	*% contribution to calorie intake[1]*			
Angola	4.36	0.04	1.13	0.17	46.57	0.75	4.46	2.62	1885	33	35	4	3
Botswana	0.07	0.01	0.14	<0.01	0.13	0.16	0.10	0.16	2264	47	2	5	3
Burundi	1.26	0.08	0.76	0.55	15.16	2.72	16.00	2.39	1632	16	33	24	11
Congo	0.07	<0.01	<0.01	0.01	8.75	0.08	2.13	0.40	2159	25	38	1	6
Dem Rep Congo	11.84	0.09	0.91	3.38	167.04	1.93	24.34	4.40	1616	19	58	2	4
Eq. Guinea	<0.01	<0.01	<0.01	<0.01	1.04	<0.01	0.50	<0.01	-	-	-	-	-
Gabon	0.28	<0.01	<0.01	0.01	4.41	<0.01	2.93	0.35	2569	28	18	0	16
Kenya	24.00	2.33	1.52	0.49	20.50	4.34	19.70	14.45	2020	50	7	3	6
Lesotho	1.23	0.35	0.32	<0.01	0.87	0.14	0.13	0.18	2298	78	3	3	1
Malawi	19.80	0.02	0.59	0.84	37.36	2.38	5.13	2.56	2133	60	16	5	4
Mozambique	11.12	0.01	3.60	1.73	58.01	2.00	3.26	1.38	1919	41	35	4	1
Namibia	0.25	0.06	0.64	<0.01	2.61	0.08	0.16	0.10	2650	55	12	2	2
Rwanda	0.70	0.06	1.54	0.13	24.26	2.13	25.21	2.15	1919	15	33	14	25
South Africa	89.73	21.70	3.15	0.03	16.77	1.04	47.98	21.95	2875	54	2	1	3
Swaziland	0.97	<0.01	0.01	<0.01	0.08	0.04	0.95	0.11	2529	47	2	2	2
Tanzania	26.18	0.90	9.03	7.13	80.65	4.33	13.32	11.64	1942	50	21	5	4
Uganda	10.93	0.12	10.00	1.06	76.17	6.07	101.21	5.39	2324	22	22	8	23
Zambia	7.09	0.73	0.74	0.12	9.63	0.16	0.99	2.62	1888	65	13	1	1
Zimbabwe	14.02	2.50	1.31	0.01	2.05	0.51	2.12	1.50	2080	57	2	2	1
REGION	**223.90**	**29.00**	**35.38**	**15.64**	**572.05**	**28.87**	**270.63**	**74.36**	**2088**	**42**	**21**	**4**	**6**

- No data
[1] Percentages do not add to 100, as not all sources are listed.

5.3 PROTEIN NUTRITION

Almost three-quarters of the recorded dietary protein in the region is derived from vegetable sources. Approximately 15% comes from beef, poultry, fish and small stock, with important additional contributions from milk products and eggs (Table 5.2). The proportions in the mix vary from place to place, fish being more important near the major fisheries, while meat is more important in the drier southern countries. The within-region dietary split in carbohydrates (Figure 5.3) has important implications for protein nutrition, as cereals make a far bigger contribution to protein requirements than do tubers. The contribution from small stock, poultry, milk and eggs is probably underestimated because it does not include unreported home consumption of domestic stock.

There is a downward trend in protein supply per capita over the past 25 years (Figure 5.6). Total protein intake, averaged for the region, is now 3.2% below the recommended minimum (52 g/person/day) for adequate nutrition. The average protein intake in Botswana, Lesotho, Namibia, South Africa, Swaziland and Gabon is well above the minimum, but the deficits in more than half the region's countries are serious. It is likely that a significant portion of this deficit is satisfied from unrecorded natural ecosystem sources, such as insects, small animals and birds. Estimates of their contribution to the average protein intake, based on very limited data, range from 0.1% in South Africa to 8.5% in the DRC. Subsistence hunting is estimated to provide 90% of bushmeat supply in Africa (Ntiamoa-Biadu 1997). Protein hunger-driven hunting contributes significantly to pressures on wild mammal and bird populations inside and outside protected areas.

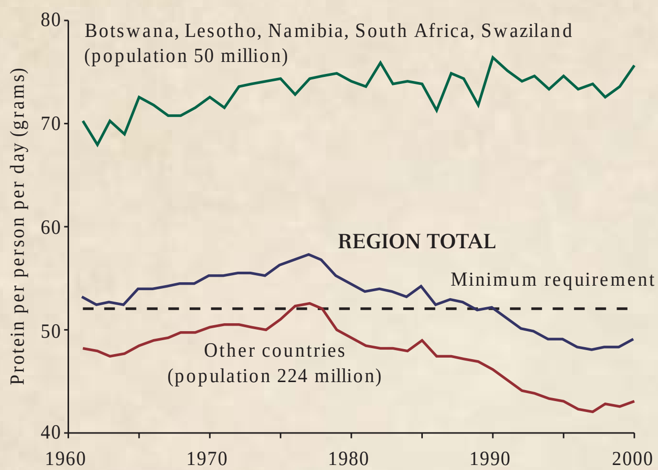


Figure 5.6: The average daily consumption of protein per person in the region. The dashed line is the average of the recommended value for men (56 g/day) and women (48 g/day). In the year 2000, the region as a whole is significantly undernourished with respect to protein. The sudden transition in 1977 from a steady improvement to a worrying decline in the northern half of the region corresponds to the plateau in nitrogen fertiliser use (Figure 5.4). The soils and ecosystems of the northern parts of the region are naturally chronically nitrogen deficient, and in the absence of replenishment, depletion occurs. We suggest that the falling protein supply is a symptom of this. Data source: FAOSTAT.

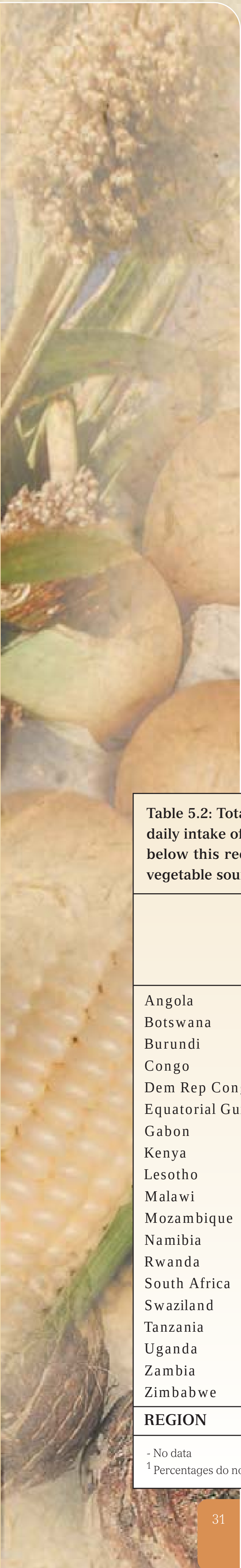


Table 5.2: Total protein consumption and main sources for the year 2000. The region as a whole falls below the recommended minimum daily intake of protein (shown in orange), which is 52 g per person. The Democratic Republic of Congo and Mozambique fall significantly below this requirement (shown in red). Cereals contribute almost half the total protein intake in the region, and together with other vegetable sources account for almost 75% of protein supply. Source: FAOSTAT.

	GRAND TOTAL (grams)	PERCENTAGE CONTRIBUTION TO PROTEIN INTAKE[1]									
		Cereals[2]	Roots	Pulses	Fruit & Veg	Bovine	Poultry	Mutton, Goat & pig	Pelagic Fish	Fresh-water Fish	Dairy[3]
Angola	41.3	39	15	11	3	8	3	3	6	0	3
Botswana	71.2	40	1	12	3	3	3	4	0	0	21
Burundi	44.1	15	14	51	9	1	1	1	0	1	1
Congo	42.8	36	13	4	5	2	4	2	7	6	3
Dem Rep Congo	24.1	32	23	9	6	1	1	2	0	5	0
Equatorial Guinea	-	-	-	-	-	-	-	-	-	-	-
Gabon	73.7	24	8	0	7	2	8	4	10	4	4
Kenya	53.2	51	3	8	4	7	1	2	0	3	14
Lesotho	63.7	77	3	6	1	3	2	2	0	0	2
Malawi	53.4	62	11	13	3	1	1	1	0	2	1
Mozambique	38.0	56	14	15	1	2	2	1	1	1	1
Namibia	77.6	48	7	4	1	10	6	4	1	0	7
Rwanda	48.1	21	18	40	9	2	0	1	0	1	2
South Africa	76.6	57	2	2	3	7	9	3	2	0	7
Swaziland	63.7	47	1	4	2	14	1	3	2	0	13
Tanzania	47.6	49	10	13	3	5	1	1	0	5	4
Uganda	56.2	20	11	22	10	3	1	3	0	7	3
Zambia	47.1	68	4	2	2	3	2	1	0	4	1
Zimbabwe	49.9	65	1	4	1	5	1	2	0	1	3
REGION	**48.8**	**45**	**11**	**11**	**4**	**4**	**3**	**2**	**1**	**3**	**4**

- No data
[1] Percentages do not add up to 100 as only major protein sources are listed. [2] Excluding beer. [3] Excluding butter.

5.4 LIVESTOCK

Grazing is an important ecosystem service in southern Africa, as virtually all livestock except pigs and poultry feed for most of their life on natural grass and shrubs. There is a trend in South Africa for cattle to be fattened ('finished') in feedlots, using grain. Commercial dairy cattle, a small fraction of the total, are often kept on pastures specifically planted for this purpose. In some peri-urban and high-human-density areas cattle and small stock are kept in 'zero-grazing' conditions, where they are fed cut forage.

Domestic livestock in southern Africa consists mainly of cattle in the areas that receive more than 450 mm mean annual rainfall (Figure 5.7), and sheep and goats in drier areas. Donkeys are important draught animals in poorer communities, but occur in much lower numbers than cattle, sheep and goats (Table 5.3). Undomesticated, but nevertheless actively ranched wildlife species are increasingly important, especially in South Africa, Namibia and Zimbabwe, but currently contribute less than 10% to the large mammal herbivore biomass in those countries.

The service provided by cattle in southern Africa is far more than food. The Bantu-speaking people of southern Africa are historically pastoralists. Especially in traditional societies living on communal lands, cattle are an important way of accumulating assets and demonstrating wealth and status. For instance, cattle are often required as part of the bride-price. Oxen provide draught power for ploughing and transport. Slaughter of livestock is ritually associated with major events, such as celebrations and funerals. Meat is not consumed on a daily basis; milk, often in a sour form, is the more important protein source, and in some ethnic groups, also tapped blood.

As people become urbanised and wealthier, their diet undergoes major changes, as do the uses and values associated with livestock. In particular, the daily consumption of animal protein increases. The expansion of cattle ranching to satisfy this demand is the major land-use change predicted in southern Africa under the Partnership scenario (Section 3.3). This projected increase in demand could equally be satisfied without increasing the herd size or grazed area, but by improving herd productivity.

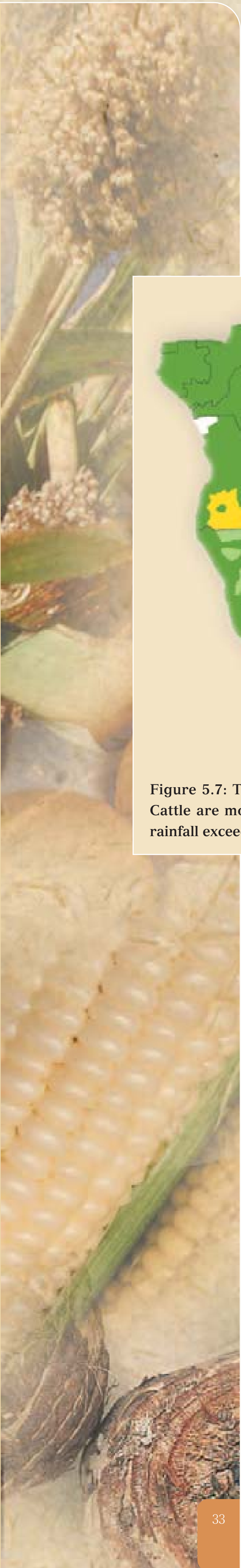
Table 5.3: The number of domestic livestock in southern African countries in the year 2000, summed to the cattle equivalent number of cattle, and expressed relative to a reference value of large herbivore biomass in cattle equivalents, as estimated to have been present before pastoralism. Source: FAOSTAT, and livestock model by Scholes (1998).

	Cattle	Sheep & goats	Horses, asses & mules	Pigs	Poultry	Cattle equivalents[1]	Grazing reference value	Actual/ reference
	millions	*millions*	*millions*	*millions*	*millions*	*millions*	*millions*	*%*
Angola	4.0	2.5	0.01	0.80	6.8	4.6	27.37	17
Botswana	1.9	2.6	0.37	0.01	3.5	2.9	4.63	63
Burundi	0.3	0.8	0.00	0.07	4.1	0.5	0.66	74
Congo	0.1	0.4	0.00	0.05	1.9	0.2	29.47	1
Dem Rep Congo	0.8	5.1	0.00	1.05	21.6	1.8	3.16	58
Equatorial Guinea	0.0	0.0	0.00	0.01	0.3	0		
Gabon	0.0	0.3	0.00	0.21	3.2	0.1	1.87	5
Kenya	13.8	16.6	0.00	0.32	31.8	17.1	8.14	210
Lesotho	0.6	1.5	0.26	0.07	1.8	1.2	1.02	122
Malawi	0.8	1.8	0.00	0.47	15.0	1.1	1.20	94
Mozambique	1.3	0.5	0.02	0.18	28.7	1.5	13.49	11
Namibia	2.5	4.3	0.24	0.02	2.3	3.7	5.75	65
Rwanda	0.7	1.0	0.00	0.18	1.1	0.9	0.42	223
South Africa	13.5	35.3	0.48	1.56	119.8	21.2	15.34	138
Swaziland	0.6	0.4	0.02	0.03	3.0	0.7	0.48	152
Tanzania	17.0	15.0	0.18	0.45	29.0	20.3	15.71	129
Uganda	6.0	7.3	0.02	1.55	25.0	7.4	4.69	159
Zambia	2.6	1.4	0.00	0.31	29.0	2.9	11.84	25
Zimbabwe	5.7	3.6	0.13	0.60	17.6	6.6	4.16	159
REGION	**72.2**	**100.3**	**1.72**	**7.91**	**345.5**	**94.8**	**149.38**	**63**

[1] For the purposes of calculating cattle equivalents, the mean mass of an African cow was assumed to be 300 kg. Five small stock (sheep and goats) were assumed to equal one cow, and 1.5 cows were assumed to equal one horse.

Carrying capacity and productivity

The concept of livestock 'carrying capacity' has come under considerable debate and revision (Behnke & Scoones 1993, Illius & O'Connor 1999). The two main criticisms are that grazing systems are intrinsically highly variable in both space and time and should not be characterised using a single number. Secondly, the concept has implicit assumptions regarding the desired state and purpose of the land. When viewed at a large enough scale, the first criticism falls away: the time-course of livestock numbers in southern Africa follows an s-shaped growth curve, levelling out at a slightly-variable plateau, much as theory suggests it should (Figure 5.8). The second point is valid, even at large scales, and must be accommodated by agreeing that a policy-prescribed target stocking rate is a joint biophysical and social concept, and not the exclusive domain of either discipline.



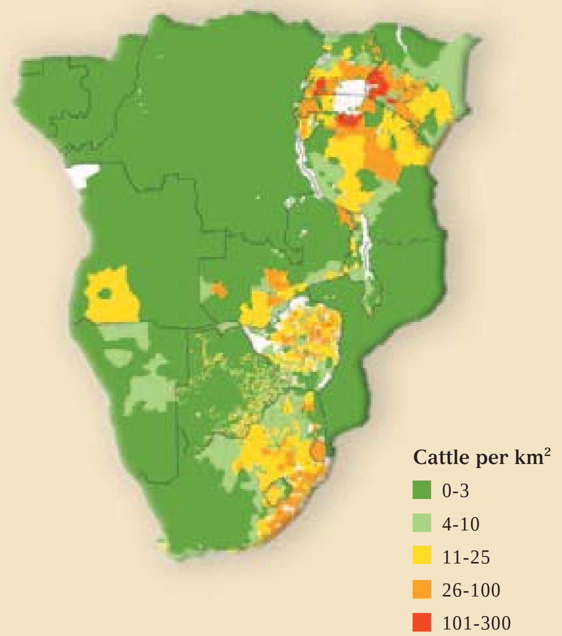


Figure 5.7: The distribution of cattle in southern Africa. Cattle are mostly found in areas where the mean annual rainfall exceeds 450 mm. Source: ILRI.

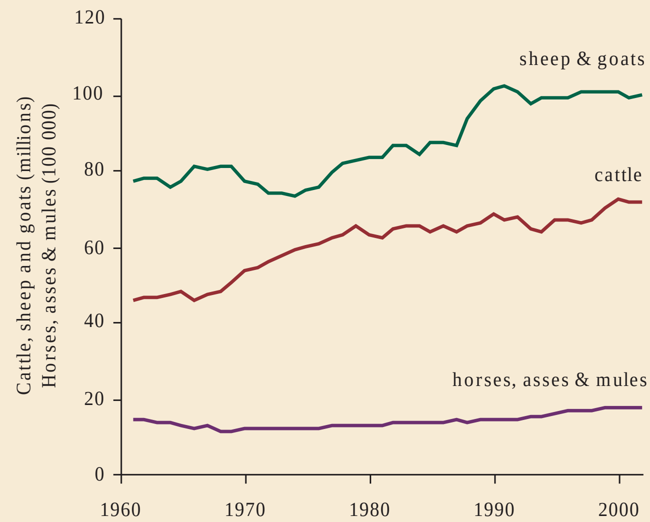


Figure 5.8: Livestock numbers in southern Africa from 1961 to 2002. Cattle numbers grew at an average of 2.1% per annum between 1966 and 1979, but at only 0.4% per annum from 1980 to 2002. Sheep and goat numbers were stable from 1961 to 1965, then rose at 1.8% per year until 1990, before levelling off. Source: FAOSTAT.

It is possible to estimate the size of the sustainable grazing service delivered by natural ecosystems in southern Africa by extrapolating from the biomass of wild mammal herbivores found in game reserves throughout the subcontinent (Scholes 1998, based on Fritz & Duncan 1993 and other sources). The 'reference grazing potential' calculated in this way is based on wild herbivores assumed to be in equilibrium with their environment, and is therefore considered to be a conservative number, demonstrated to be sustainable over a period of several centuries. Higher stocking rates are possible in the short term, and may even be sustainable in the long term, but are not optimal for animal productivity. Notwithstanding this debate, long-term stocking at rates much greater (>200%) than the reference grazing potential are widely identified as a driver of land degradation in arid and semi-arid areas in southern Africa (Hoffman & Ashwell 2001) (Figure 4.7, page 23).

Overall, the 'productivity' of livestock in southern Africa, if defined as the annual off-take of animals divided by the standing stock, is low. For cattle the average productivity is about 14% per year, whereas the potential in highly-managed herds can exceed 40%. This way of analysing animal productivity has two major flaws: Firstly, the official data seldom include off-take for home consumption, and secondly, the service provided by livestock is only partly based on slaughtering animals. When adjusted for these factors, livestock productivity is much higher than it seems (Barrett 1992). The observed productivity of sheep and goats in southern Africa is higher (29%), reflecting both the inherent higher reproduction rate of small stock, and the greater willingness of livestock owners to slaughter small stock. There is technical potential for improvement of productivity in small stock herds as well as cattle.

5.5 FISHERIES

Southern Africa has marine fisheries on both the west and east coasts, and freshwater fisheries based on three African great lakes and on several locally important rivers, dams or swamps. The fish harvested in southern Africa are currently sufficient for about one quarter of the animal dietary protein intake of the people in the region (which is about one twentieth of the total protein intake, Table 5.2). Two thirds of the fish consumed in southern Africa are caught from marine stocks. About 2% of the total catch is exported, and about a third of the west-coast marine catch processed into fishmeal for animals. All of the freshwater catch is for human consumption.

The combined freshwater and marine fish catch has been more-or-less constant since the 1960s, at around 2.2 million tons per year (Table 5.4). As in the case of fisheries elsewhere, it is not possible to conclude from the relative stability of the total catch numbers that the fish resources of southern Africa are being sustainably harvested. Virtually the entire marine and freshwater catch comes from naturally-recruiting fish populations. Aquaculture ('fish farming') is undertaken at a small scale in a number of locations, but is not yet a significant source of food at the regional scale.

Given that the population is projected to increase over the next three decades and a ceiling appears to have been reached in the quantity of fish that can be harvested, the average contribution to human nutritional welfare from fish is likely to decline. Potential exists for increasing the output of aquaculture, but care needs to be exercised that aquaculture does not increase aquatic pollution and alter the coastal, estuarine and freshwater habitats. Aquaculture based on the use of protein inputs (such as fishmeal or soybeans) does not help to address the underlying problem of regional protein shortages.

Marine fisheries

Southern Africa adjoins two 'Large Marine Ecosystems' (LME). The nutrient-rich upwelling of the cold Benguela current LME on the west coast provides about 70% of the marine catch in southern Africa, consisting of commercially important species such as hake, anchovy and pilchard. The Agulhas Current LME on the east coast is a warm, relatively nutrient-poor system, of moderate productivity. It supports fish such as Cape hake, blackhand sole, yellowfin and albacore tuna, and is characterised by a high percentage of crustacean catch (40% of the total).

The Benguela fishery is almost entirely within the exclusive economic zone of three countries: South Africa, Namibia and Angola. These countries cooperate closely in the management of the stocks, which may partly explain why the fishery has persisted while fish stocks in most places around the world are collapsing. An additional contributing factor is that the fishery is based mostly on small pelagic fish, which live for a year and recruit annually in large numbers, in contrast to fisheries based mostly on high trophic level, long-lived fish.

	Freshwater (1000 tons/y)	Marine (1000 tons/y)	**Total (1000 tons/y)**
Angola	0	134	**134**
Botswana	2	0	**2**
Burundi	17	0	**17**
Congo	26	19	**44**
Dem Rep Congo	171	4	**174**
Equatorial Guinea	1	3	**5**
Gabon	8	29	**37**
Kenya	181	5	**187**
Lesotho	0	0	**0**
Malawi	60	0	**60**
Mozambique	9	24	**33**
Namibia	0	287	**287**
Rwanda	4	0	**4**
South Africa	0	553	**553**
Swaziland	0	0	**0**
Tanzania	0	339	**339**
Uganda	223	0	**223**
Zambia	69	0	**69**
Zimbabwe	19	0	**19**
REGION	**789**	**1398**	**2187**

Table 5.4: The average catch from marine and freshwater fisheries in southern Africa for 1990-1999. Source FAOSTAT.

Notes

Statistics were unavailable in some categories for some countries. The entire reported catch for Angola and Tanzania was assumed to be marine. The freshwater portion for Mozambique was estimated using data from 1980-84.

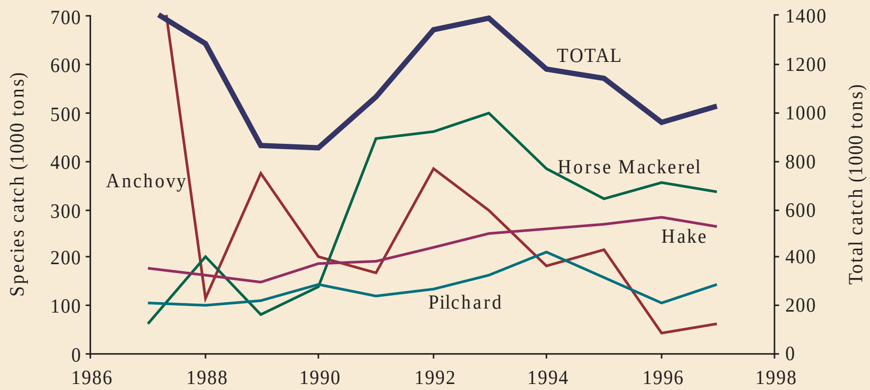


Figure 5.9: Trends in marine fish catches in the Benguela LME off the west coast of southern Africa. This system provided 44% of the total catch in the region during the 1990s. The fluctuation in stocks appears to be synchronised with stock fluctuations in other major fisheries around the world, and is therefore suggested to partly influenced by the climate system. Source: DEAT (2000).

Following the inception of commercial fisheries during the early twentieth century, and especially from about mid-century, the combined catch of the five main species in the Benguela system grew to a peak around 1970, and then declined. More recently, many of the stocks have shown a gradual recovery, although collapsed anchovy and pilchard stocks off Namibia have not recovered (Molly & Reinikainen 2003). Several of the marine fish harvested on the west coast have shown large fluctuations in their stocks (Figure 5.9), the causes of which are poorly understood. In the case of the Namibian anchovy, the increasingly frequent southward intrusion of warm tropical water, a phenomenon similar to (but apparently unconnected with) the El Niño in the Pacific Ocean, may be associated with their decline. In the case of the other species, over-fishing is the probable main factor causing the fluctuations.

Much less information is available regarding the warm-water fisheries off the east coast of southern Africa, and a significant danger of resource depletion exists. The total catch rose from 32 000 metric tons in 1990 to 40 000 tons in 1994, then declined to 20 000 tons in 1999 (FAO 2003). Non-oceanic tuna represented 40% of the catch over that period. Tuna is heavily exploited by foreign vessels, and recent indications are of over-exploitation. Local overexploitation, including the use of dynamite for reef fishing, has been documented in Tanzania and South Africa, and over-harvesting by foreign fleets (both legal and illegal) is a potential problem, given the limited fisheries regulation enforcement capacity in Mozambique, Tanzania and Kenya, and to a lesser extent in South Africa. Excessive recreational fishing of species high on the food chain is likely in the absence of strict limits.

Freshwater fisheries

The most important freshwater fisheries are located in the northern parts of the region. Lakes Victoria, Tanganyika and Malawi (Niassa) all support large fisheries, as well as a remarkable number of endemic fish species. Many of these endemic species have become part of the freshwater aquarium trade, without much benefit accruing to the region. Lake Victoria provides an interesting case study of some of the trade-offs that exist between fisheries and biodiversity (Box 5.2). The smaller rift valley lakes also supply fish, as do the extensive wetland systems of Lake Banguelu, the Kafue and Okavango, and several river systems (e.g. the Cunene). Fisheries have also been established in the reservoirs formed by the Kariba and Cahora Bassa dams on the Zambezi River.

Box 5.2: Lake Victoria: biodiversity, fisheries and unexpected resilience

Lake Victoria, the largest tropical freshwater body in the world, has more than 600 species of haplochromine chichlid fish. This is in itself an evolutionary marvel, given that much of the lake was a dry plain only 20 000 years ago. Fishing intensity increased throughout the 20th century, and non-endemic species, the Nile perch and Nile tilapia, were introduced to supplement the native fish populations. These fish are large and predatory, and while easier to catch than the native fish, resulted in the apparent extinction of many of the endemic species. At the same time, rising agriculture and human settlement in the catchment increased the flow of silt, nutrients and pollutants into the lake. The turbidity increased and primary productivity doubled, but was dominated by blue-green algae, and for a time, by water hyacinth, a floating weed. Oxygen deprived areas developed over sections of the lake floor. The combined result of these changes was that a diverse fishery changed into one based on only three species, two of which were introduced.

At present, the Nile perch fishery is exhibiting the classic signs of overfishing. This has been accompanied by a resurgence of native species, some of which were believed to be extinct. It is thought that they retreated to 'refugia', such as rocky-bottomed areas, where they were protected from the predatory fish and from the worst effects of human-induced environmental changes.

The case study illustrates that the goals of biodiversity conservation and sustainable use are not necessarily in conflict. In this case, maintaining a relatively high but regulated level of fishing pressure on the Nile perch stocks can preserve both the diversity of fish in the lake, and the livelihoods that depend on fishing.

Source: Balirwa *et al.* (2003)

5.6 FOOD SECURITY INTO THE FUTURE

Many studies predict sub-Saharan Africa to be the food crisis epicentre of the world (e.g. Rosegrant *et al.* 2001, DFID 2002b), and several indicate that projected climate change during the first half of the 21st century will make this situation worse (Fischer *et al.* 2002, Jones & Thornton 2003). The International Model for Policy Analysis of Agricultural Commodities and Trade (IMPACT), developed by IFPRI, forecasts a 'perilous' situation for Sub-Saharan Africa, with a 6 million increase in the number of children suffering from malnutrition between 1997 and 2020 (Rosegrant *et al.* 2001). The FAO estimates that per capita food supplies in sub-Saharan Africa will be at 2170 calories/day by 2010, which is low relative to the rest of the developing world (FAO 1993). These projections are consistent with trends indicated by historical statistical data (Figure 5.4, page 29), but they assume no significant interventions or changes.

Climate change

The projected combination of warming and drying at the regional scale (Box 2.1, page 4) will have serious consequences for agricultural production. More locations in the region are predicted to decrease in agricultural production potential than are predicted to increase (Fisher *et al.* 2002). Maize production is projected to be down by about 10%, while wheat production could increase by 7% (Jones & Thornton 2003). Some of the uncertainty regarding impacts on agricultural production is due to the compensating effect that the rising CO_2 concentration in the atmosphere will have on plant water use efficiency. However, the unrealised agricultural potential of southern Africa, both in terms of area available for the expansion of cultivated lands and the difference between actual yield per unit planted area and what is known to be technically possible, is far greater than either the projected impacts of climate change or the needs of the current or future population.

HIV/AIDS

The slowdown in population growth due to HIV/AIDS worsens the future food security situation, rather than making it easier. HIV/AIDS increases vulnerability to food insecurity in a number of ways: By reducing the capacity of the agricultural labour force, by reducing household assets and income through loss of earners, by interfering with the transfer of knowledge and education, and by placing pressure on household food resources through the presence of AIDS orphans (Morris 2002, Mano *et al.* 2003, USAID 2003). The feedback from malnutrition to increased and accelerated mortality is well documented (Steyn & Walker 2000, Young 2001).

Scenarios of food security

Under the **Patchwork scenario** (Section 3.2) large parts of the region would continue to have sluggish economic growth and worsening food production deficits. This may lead to increased illegal migration to areas of relatively greater food availability, and escalating conflict between increasingly polarised communities. The inherently highly variable climate, compounded by climate change, could precipitate a series of crises, without full recovery between them. Progressive failure of the 'safety net' provided by natural resources will increase vulnerability. Poor nutrition and inadequate government healthcare intervention under this scenario would allow the HIV/AIDS pandemic to cripple rural labour and drain rural assets, further holding back agricultural development already retarded by declining soil fertility and failed extension services. Fragmented, vulnerable communities and the loss of regional-level governance would undermine the institutions able to offer protection and support to the smallholder farmer, making for an increasingly powerless and poverty-stricken region unable to compete in world markets. The region would become increasingly dependent on food aid, but deteriorating infrastructure, corruption, conflict and the weakness of national and regional governance institutions would hamstring its distribution to the local level.

Under the **Partnership scenario** (Section 3.3) stronger governance could pave the way for more cohesive alliances with other developing regions of the world, which collectively present more bargaining power in World Trade Organisation negotiations and lead to world trade policies that nurture southern Africa's markets. Economic growth in the industrial, mining and service sectors, together with successful commercial cash crop production, would promote export trade, foreign investment and increased regional wealth. This would allow investment in infrastructure, research and extension, permitting the intensification of crop production (greater yields from the same area of land) and moderate expansion of cultivated land in the region north of the Zambezi River. The nations would be able to afford food imports to offset the occasional deficits caused by droughts. Food security under this scenario will be dependent on sustained investments by national governments in infrastructure, health and education, basic requirements for empowering communities to break the vulnerability cycle. Investments in research and extension would be necessary to enhance the position of the smallholder farmer, as well as an enabling environment for private or semi-private marketing institutions able to promote market access and producer incentives.

5.7 RESPONSE OPTIONS: IMPROVING REGIONAL FOOD SECURITY

The literature is replete with proposals and findings for mitigating food insecurity in southern Africa (see Devereux & Maxwell 2001). The greatest challenge for decision and policy makers is finding ways to integrate research findings into practical decisions and policies that translate into action (e.g. Omamo 2003, Holloway 2003); in other words, finding the 'how' of resolving problems and implementing change, so that strategies are realised into food security across scales, down to the local livelihoods level.

PREVIOUS INTERVENTIONS

The broad categories of historical interventions that have had deep impacts on food security include:

I Macro-economic policies and liberalization reforms, and WTO trade policies
II Early warning systems and disaster management
III Agricultural productivity enhancement
IV Research and extension
V Nutrition intervention programmes

Two interventions have been selected for brief review from the above areas, on the basis of their scale of operation and extent of impact in southern Africa.

Agricultural productivity enhancement: southern Africa's Green Revolution

Research into high-yielding varieties of maize began in southern Africa during the 1950s. In 1960, the then Southern Rhodesian agricultural service bred the famous maize hybrid SR52s, which was adopted by 90% of commercial farmers in the region within 10 years (Gabre-Madhin & Haggblade 2003). During the 1970s and 1980s national research programmes, supported by international agricultural research bodies, such as CIMMYT, began to focus on location-specific breeding and the needs of the smallholder farmer (Evenson & Gollins 2001). Today, just over one third of the maize area in southern Africa is estimated to be under high-yielding varieties.

Despite these successes, the benefits to sub-Saharan Africa of crop genetic improvement are the lowest of all developing world regions. Increases in the yields of 11 major food crops in sub-Saharan Africa between 1965 and 1999 are estimated to be just 28%, and the reduction of malnutrition amongst children only 2.5-3% (Evenson & Gollins 2001). The limited impact of the green revolution in Africa has been attributed to several factors, including the quality of the varieties (Evenson & Gollins 2001), market liberalization (Gabre-Madhin & Haggblade 2003), weak institutions and government policies (Box 5.3), poor market access, low household resources, lack of education (Peters 1999, Scherr 2003), and declines in soil fertility (Gabre-Madhin & Haggblade 2003, Kumwenda *et al.* 1996, Sanchez 2002).

Macroeconomic policies: structural adjustment and market liberalisation

The era of structural adjustment in southern Africa (mid-1980s to late 1990s) brought changes to agricultural policy that had mixed consequences (Friis-Hansen 2000a). The changes advocated by the World Bank, and applied to varying degrees by different countries, included withdrawal of government subsidies, facilitating privatisation, and removing pan-territorial pricing. The performance of aggregate agricultural production under structural adjustment was disappointing. Between 1990 and 1997 food production over the whole of sub-Saharan Africa increased by only 2.7% per annum, failing to keep pace with a 3% per annum population growth rate (Gibbon 2000). At the livelihoods level, market liberalisation, and particularly the way in which it was applied, has removed some of the institutional support that provided a safety net for the food insecure, and smallholder farmers have become more vulnerable to livelihood shocks, particularly in times of market failure (Devereux 2003, Friis-Hansen 2000b, Gibbon 2000).

Box 5.3: The political and institutional failures of Zambia's Green Revolution

Beginning in the 1970s, the government of Zambia along with donor organizations, invested in enabling smallholder agriculture through higher-yielding maize varieties, as well as by promoting agricultural credit support, and seed and fertilizer availability. Their objectives were to increase national maize supply, reduce reliance on commercial farming, and improve rural equity in remote areas. By 1992, 60% of the area planted to maize on small- and medium-sized farms consisted of high-yielding varieties. The rate of return on investments was, however, calculated as negative between 1978 and 1991, primarily due to the marketing costs of transporting inputs to, and maize from, farmers in remote areas.

There were three main flaws in these efforts to increase agricultural surplus. Firstly, the main impact of maize price controls and marketing subsidies was to redistribute rather than increase aggregate maize production, from commercial farmers to smallholders in more remote areas. Subsequent structural adjustment and reduced government subsidies led to a shift in the regions planted to high-yielding varieties to areas less reliant on subsidised market structures, and closer to markets and transport routes. Secondly, there were no incentives for the bodies implementing the maize policies to keep costs down, which led to inefficiencies in the market and a poor transition from public to semi-privatised and privatised marketing structures. Finally, when Zambia became a one-party state, the ruling party estranged itself from the support of key economic interest groups able to move the country in an economically and politically viable direction.

Source: Howard & Mungoma (1996)

IMPROVING THE SUCCESS OF RESPONSES

An analysis of the broad categories of response in terms of a number of success criteria (Box 5.4) suggests that response strategies need to be broad-based, containing significant elements of all major intervention categories. This is consistent with the understanding that food insecurity has many drivers, and response actions must simultaneously take into account issues such as employment, education and land-access.

Agriculture in southern Africa provides more than food. It contributes to livelihood strategies, markets, raw materials, and foreign exchange, and employs two-thirds of the region's labour force (Maxwell 2001). The approach of channelling resources into a sustainable increase in agricultural productivity, as part of a broad-based poverty- and food insecurity-alleviation programme, is widespread in the literature (e.g. Dixon *et al.* 2001, Paarlberg 2002, Devereux 2003, Watkins & Von Braun 2003). The emphasis is on smallholder agriculture (e.g. Friis-Hansen 2000b), partly because rural poverty still accounts for a high proportion of total poverty in the region, and about 80% of rural poor are estimated to be dependent on agriculture and farm labour for their livelihoods (Dixon *et al.* 2001).

Smallholder Agricultural Initiatives

Enhancing smallholder agricultural productivity goes hand in hand with a strong emphasis on research and extension. Promising agricultural research initiatives include the Southern African Drought and Low Soil Fertility Project (SADLF), and the Africa Maize Stress Project (AMS), both of which aim at developing crop varieties specifically for African conditions and to reach resource poor farmers (Banziger and Diallo 2000).

Another promising initiative is the soil nutrient replenishment approach championed by the International Centre for Research in Agroforestry (ICRAF), working together with national research systems and NGOs (Gabre-Madhin & Haggblade 2003). The concept is to rebuild the 'natural capital' of soil fertility, specifically nitrogen and phosphorus.

The challenge for decision makers is to create an environment that encourages the transfer of successful techniques at the community level across a broad range of geographical settings, so that their reach is scaled-up to benefit millions of smallholder farmers (Sanchez 2002).

Effective institutions, at all levels, are at least as important as technology-based production interventions. Government macro-economic policies and practices that enable the effective functioning of markets are a prerequisite for smallholder agricultural success (DFID 2002b, Diaz-Bonilla & Gulati 2003). The lessons of structural adjustment suggest a policy focus on enabling institutions that increase the power of smallholders, encourage agricultural diversification, and improve the quality of products. Structural adjustment sought to redress the tendency of cooperatives and parastatals to use their market power to the disadvantage of producers. Nevertheless, even a deregulated market system will need institutions with similar functions. One suggestion has been to make membership by producers voluntary (Friis-Hansen 2000b).

Box 5.4: Choosing response options

Seven criteria have been identified as necessary for successful responses (weighting factor in brackets):

1. Address food security by treating the causes rather than the symptoms, i.e. addressing the underlying drivers identified in the literature (7)
2. Empower communities with the tools to reduce vulnerability (7)
3. Community support for action (5)
4. Compatibility with the Millennium Development Goals (6)
5. Existing or accessible infrastructure and institutions to implement and sustain action (5)
6. Impact on the Patchwork Scenario (4)
7. Impact on the Partnership Scenario (6)

A decision analysis matrix was used to rate the five broad categories of intervention against the weighted criteria. A rating of 1 (poor) to 4 (excellent) was applied to each category against each criterion, and multiplied by the criterion's weighting.

	Category of Intervention				
	I	II	III	IV	V
Criteria	Score	Score	Score	Score	Score
1 (7)	28	7	28	28	14
2 (7)	21	7	28	28	14
3 (5)	15	20	20	20	20
4 (6)	24	12	24	18	12
5 (5)	10	15	10	10	15
6 (4)	8	4	8	8	8
7 (6)	24	24	24	24	24
Total	**130**	**89**	**142**	**136**	**107**

Notes

I – Macro-economic policies
II – Early warning systems
III – Increased agricultural productivity
IV – Research and extension
V – Nutritional intervention

6. Freshwater

Vital for human survival, water is also crucial to the maintenance of ecosystem processes and the functions of many economic sectors, such as agriculture, industry and tourism. An unsafe and unreliable water supply is the reality for millions of people in Africa south of the equator: Close to half the region's population has no access to safe water and sanitation services. The time-varying and spatially-uneven distribution of water resources, combined with the region's current state and pace of population growth and socio-economic development, pose significant challenges to meeting current and future water needs.

6.1 THE AQUATIC ECOSYSTEMS OF SOUTHERN AFRICA

Rivers are the predominant aquatic ecosystems in the region, with lakes, pans and wetlands occurring in certain areas. The largest rivers are the Gariep (formerly the Orange), Cunene, Cuanza and the gigantic Congo draining to the west, and the Rufiji, Rovuma, Zambezi, Save and Limpopo Rivers draining to the east (Figure 6.2, Table 6.1). The Okavango, a major river in the interior part of the region, does not drain into the ocean but dissipates in the Kalahari Desert. The Nile River, which eventually drains into the Mediterranean Ocean, has its headwaters in the northern part of the region.

The 'Great Lakes' of Africa, resulting from the formation of the East African Rift Valley, include Lake Victoria (68 800 km^2, the largest tropical lake in the world), Lake Tanganika (32 900 km^2) and Lake Malawi (22 490 km^2). Some of the Rift Valley lakes have no exit drainage, and are therefore high in salts, for example Lake Natron in Tanzania. Outside of the Rift Valley, the two largest lakes are the shallow, swamp-fringed Lakes Mweru and Bangweulu in Zambia. In most parts south of the Zambezi River, evaporation exceeds rainfall and therefore there are few true lakes. Clusters of coastal lakes, most of which are relict estuaries, occur on the wide coastal plains between Inhambane in Mozambique and St. Lucia in South Africa, and between the Wilderness and Agulhas Lakes on the south coast of South Africa (Day 1998).

The largest and best-known permanent wetlands are the Okavango Delta in Botswana, the Lake Bangweulu swamps in Zambia together with the Kafue and upper Zambezi floodplains, and the extensive swamp forests straddling the border of the Congo and DRC. Seasonal wetlands occur throughout the region, but are especially important in the miombo ecosystems of Zambia, Angola, southern DRC and northern Mozambique, where they are called *dambos* and in total can comprise up to one fifth of the landscape. The drier and more seasonal parts of the region support temporary waters of various kinds, from huge saltpan systems of Etosha in Namibia and Makgadikgadi in Botswana, to tiny potholes in granite inselbergs in the Namib Desert of Namibia (Day 1998).

Two major dams (artificial lakes) are located in the region, both on the Zambezi River: Kariba (storage volume 160 km^3, covering 5180 km^2, with a dam wall 128 m high) in Zimbabwe and Cahora Bassa (volume 52 km^3, covering 2660 km^2, with the highest dam wall in Africa at 171 m) in Mozambique.

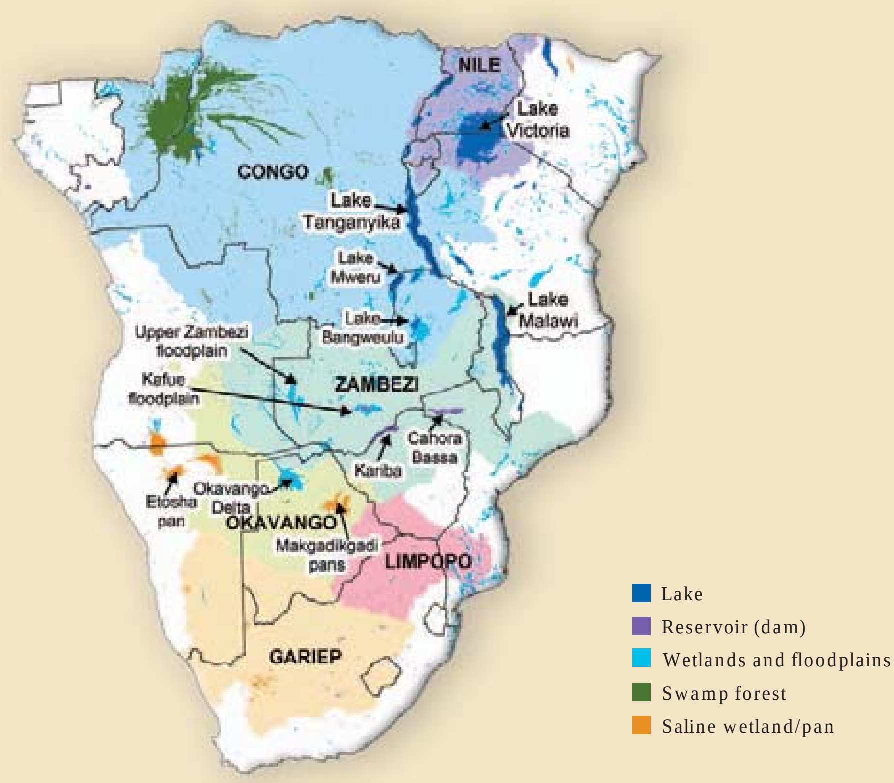


Figure 6.1: The major drainage basins and freshwater features of southern Africa. Source: UNEP-WCMC

6.2 FRESHWATER RESOURCES IN SOUTHERN AFRICA

A defining characteristic of southern hemisphere Africa is that all the major drainage systems are shared by two or more countries (Table 6.1). For example, the Zambezi is shared by eight countries, the Congo by nine, the Gariep by four, and the Okavango by three. Moreover, four of the most developed countries in southern Africa (South Africa, Botswana, Namibia and Zimbabwe) are also the most water stressed. Water availability may therefore become a major factor limiting the future economic growth of these countries, and a driver of either conflict or cooperation in the region. As such, water resource management is a key component of the New Partnership for Africa's Development (NEPAD), and other regional development initiatives (Turton 2004).

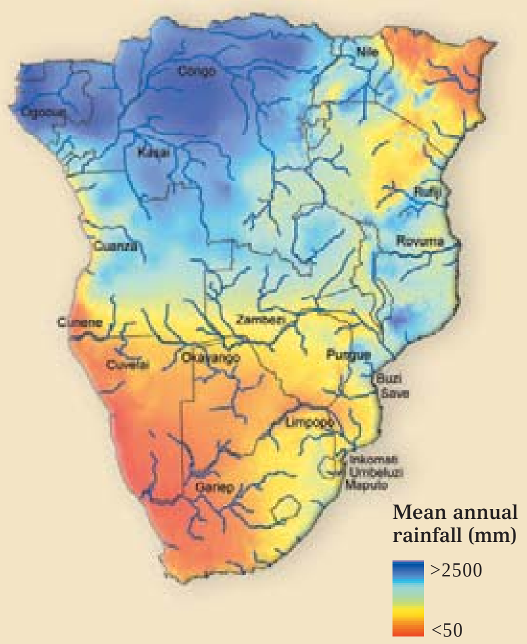


Figure 6.2: Major river systems and mean annual precipitation in the region. Precipitation broadly increases from south to north, and from west to east in the southern parts, and from east to west in the northern parts.

Uneven distribution of water resources

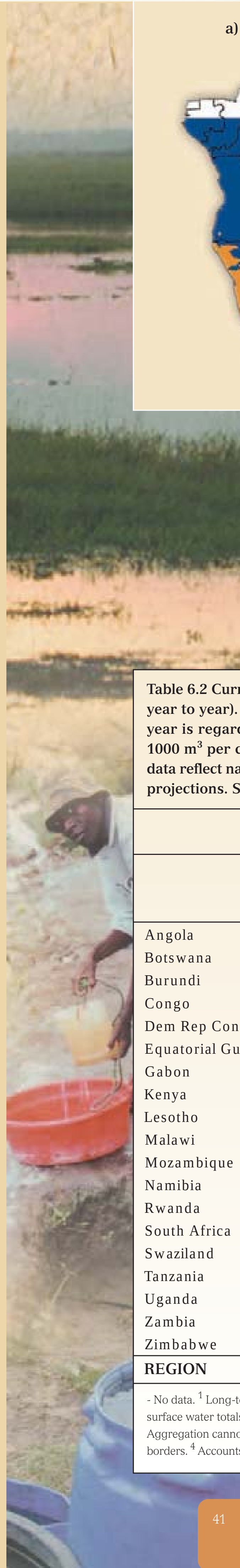
The water resources in most of the region are highly variable in both space and time. Rainfall patterns are typically very seasonal, and annual variability of rainfall is high, particularly in the semi-arid south-western parts of the region where an inter-annual coefficient of variation of up to 35% is common. The ratio of rainfall to evaporation in southern Africa is the lowest in the world (O'Keefe *et al.* 1992). In addition, southern Africa experiences decade-long cyclical periods of wetness and dryness partly associated with the ENSO phenomenon. The rainfall of the early 1990s was about 20% lower than that of the 1970s and there were intense and widespread droughts in 1983-4, 1992 and 2002 (Chenje & Johnson 1996).

Spatially, freshwater is unevenly distributed within and across the countries of southern Africa. The region divides roughly along the line of the Zambezi and Cunene rivers into a water-abundant north and a water-scarce south, with some exceptions such as the relatively wet Lesotho highlands, and the relatively dry eastern parts of Kenya and Tanzania (Figure 6.2, 6.3). The United Nations defines areas where per capita water supply drops below 1 700 m^3 per year as experiencing 'water stress', a situation where disruptive water shortages can frequently occur. 'Scarcity' is defined as a water supply below 1000 m^3 per person per year and poses challenges to human health, food production and economic development. The availability of freshwater resources in each country is given in Table 6.2.

Table 6.1: Features of the major shared river basins in southern Africa. The Congo and Zambezi Rivers together account for 95% of the total mean annual runoff (MAR) of the listed basins. The most highly developed river basin in the region is the Gariep, which supplies the industrial and commercial Gauteng Province of South Africa. The Nile, which arises in the northern part of the region, drains ten states and has a catchment area of 2800 km^2 and MAR of 86 km^3 per year. Source: Heyns (2003).

Basin	No. of states	Catchment area (1000 km^2)	MAR[1] (km^3 p.a.)	No. of dams > 12 mil m^3	Impoundments (% runoff)	Installed hydropower capacity (MW)	Present water transfer capacity (m^3/s)
Buzi	2	31	2.5	1	None	90	0
Congo	9	3800	1260.0	20	Insignificant	2500	0
Cunene	2	107	5.5	4	57	280	Out: 3.2*
Cuvelai	2	100	0.1	0	None	0	Into: 3.2*
Gariep (Orange)	4	850	10.0	31	152	613	Out: 67.7 Into: 29.4 Within: 56.6*
Inkomati	3	50	3.5	10	40	0	Out: 3.8
Limpopo	4	415	5.5	43	82	0	Into: 26.9 Within: 0.3*
Maputo	3	32	2.5	4	60	0	Out: 9.8
Okavango	3	530	10.0	1	None	0	Out: 4.0
Pungué	2	33	3.0	0	Small diversion	0	0
Rovuma	3	156	15.0	0	None	0	0
Save	2	93	7.0	17	63	0	0
Umbeluzi	2	6	0.6	1	30	0	0
Zambezi	8	1400	94.0	28	225	4734	0

[1] Natural (unaugmented) mean annual run-off at the mouth of the river. MAR of Cuvelai as measured as the ephemeral endoreic Etosha Pan; MAR of Okavango as at perennial endoreic 'panhandle' of the Okavango Delta.
* International water transfers; other transfers are within a single country.



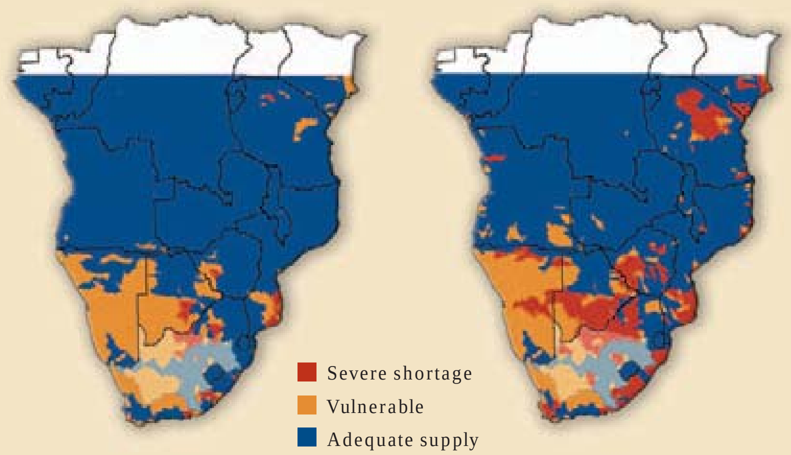


Figure 6.3: The distribution of surface water abundance and scarcity in southern Africa: (a) average over the year and, (b) in the driest month. Red areas already experience severe shortages, while yellow areas are vulnerable to deficits. The 'driest month' map is a more conservative indicator of problem areas, given the limited water storage capacity in the region. Water supply was calculated using the Water Balance Model (Fekete et al. 2002), a hydrological model which takes into account rainfall, drainage basins, topography, vegetation and soil. Annual freshwater demand was assumed to be 1000 m^3 per capita per year, the minimum target set by the United Nations, while the demand in the driest month was assumed to be 50 m^3 per capita. Gridded population data were obtained from CIESIN (2000).

In some cases, figures of average national water availability, such as presented in Table 6.2, obscure significant areas of water shortage. Averaged across the country, Namibia and Botswana both appear to have sufficient water due to the contribution of a few large rivers on their boundaries, but in fact the major part of these countries is hyper-arid and lack of water is the principle factor restricting development. In addition, the actual level at which water scarcity occurs is not absolute, since the challenges posed by water scarcity can be mitigated or adapted to through appropriate policies, institutions and technologies. In particular, differences in the type of food consumed can have an important impact on the volume of water required per person. The range of potential adaptation strategies increases if the country or community is relatively wealthy and technologically advanced, and can for instance import rather than grow foodstuffs which require large amounts of water for their production (Turton *et al*. 2003).

Table 6.2 Current and future water availability in the region, representing average annual freshwater resources (actual supply varies from year to year). Data cover both surface water and groundwater, as well as flows between countries. An amount of 1700 m^3 per capita per year is regarded as the threshold for water stress resulting in disruptive water shortages (shown in yellow), while availabilities below 1000 m^3 per capita per year (shown in red) leads to more serious problems with food production and economic development. Note that data reflect national averages, and that the completeness and accuracy of data varies between countries. See Table 2.3 (page 7) for population projections. Source: FAO AQUASTAT[1].

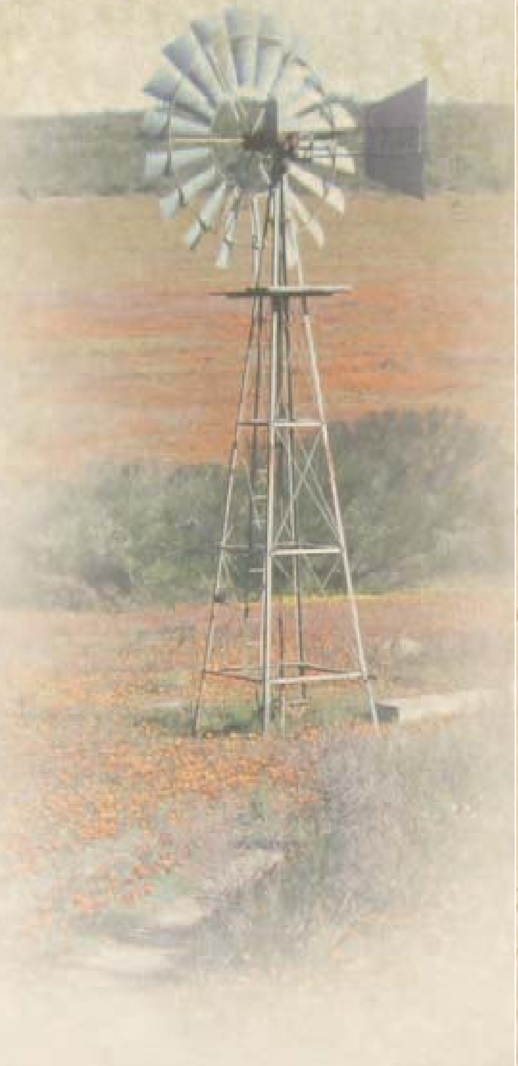
	INTERNAL RENEWABLE WATER RESOURCES[1]		NATURAL RENEWABLE WATER RESOURCES			
	Groundwater km^3 p.a.	Surface water km^3 p.a.	Actual total[2] km^3 p.a.	Dependency ratio[3] %	Water per person 2001 m^3 per capita	Water per person 2030[4] m^3 per capita
Angola	72.00	182.00	184.00	0	13620	6436
Botswana	1.70	1.70	14.40	80	8471	9219
Burundi	2.10	3.50	3.60	0	519	264
Congo	198.00	222.00	832.00	73	268387	110082
Dem Rep Congo	421.00	899.00	1283.00	30	24508	11992
Equatorial Guinea	10.00	25.00	26.00	0	55319	29279
Gabon	62.00	162.00	164.00	0	130159	80235
Kenya	3.00	17.20	30.20	33	982	734
Lesotho	0.50	5.23	3.02	0	1467	1943
Malawi	1.40	16.14	17.28	7	1641	871
Mozambique	17.00	97.00	216.11	54	11960	8118
Namibia	2.10	4.10	17.94	66	10022	7419
Rwanda	3.60	5.20	5.20	0	656	387
South Africa	4.80	43.00	50.00	10	1156	1186
Swaziland	-	-	4.51	41	4215	4422
Tanzania	30.00	80.00	91.00	10	2642	1599
Uganda	29.00	39.00	66.00	41	2896	1032
Zambia	47.00	80.20	105.20	24	10233	6910
Zimbabwe	5.00	13.10	20.00	30	1560	1566
REGION	**910.20**	**1895.37**			**11390[5]**	**6836[5]**

- No data. [1] Long-term annual average volume of water generated within a country's borders. [2] Total internal renewable water resources (corrected for the partial overlap in groundwater and surface water totals) plus or minus the natural flows of surface and groundwater entering or leaving a country, including flows secured through treaties and agreements with other countries. Aggregation cannot be done for the region as it would result in double counting of shared water resources. [3] Indicates the percentage of a country's total water resources generated outside its borders. [4] Accounts only for changes in population size (medium-variant projection), not changes in water resources resulting from changes in treaties or climate. [5] Population-weighted average.

[1] http://www.fao.org/ag/agl/aglw/aquastat/dbase/index.stm

Groundwater

Water-bearing strata underlie most of region, and are of critical importance to human welfare where surface water supplies are absent or unreliable. In particular, the arid south-western region (Botswana, Namibia and parts of South Africa), as well as parts of Tanzania and Kenya are highly dependent on groundwater. In Botswana, groundwater is the main source of water for nearly 80 per cent of the human and livestock populations (Government of Botswana 1993), while it accounts for more than 40 per cent of water supply in Namibia (Heyns 1995). In the Gariep River basin, which covers about a third of South Africa, much of the non-urban population depends on groundwater (Vegter 2000). In areas such as the Pangani Basin of Tanzania groundwater is a significant source for irrigated agriculture (World Bank and DANIDA 1995).



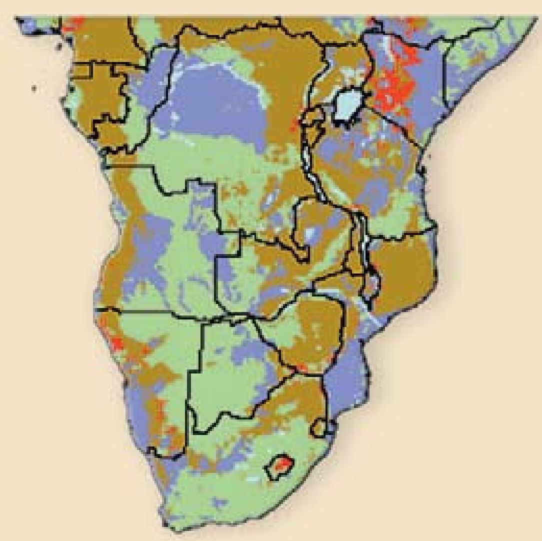
In the arid parts of South Africa and Namibia, plentiful good quality groundwater is mostly confined to the dolomitic areas (Table 6.3, Figure 6.4). Water of generally poorer quality underlies much of the remainder of the arid lands, often at great depth and in rock types that yield stored water at very slow rates. The water is frequently brack (i.e. contains dissolved salts in excess of 350 mg/l and sometimes above 3000 mg/l), which is unsafe for prolonged consumption. Some geological formations contain water with a fluoride level that is too high for normal bone and tooth development. In areas of high human density and inadequate sanitation, groundwater may be polluted by nitrates or faecal pathogens. Groundwater beneath areas of intensive agricultural development may also contain high levels of nitrates.

Most of the critical groundwater resources of southern Africa are 'fossil' supplies, created thousands of years ago when the climate of southern Africa was wetter than at present. The current rate of recharge into these aquifers is typically of the order of 1% or less of the mean annual rainfall (Beekman & Xu 2003), while the rate of extraction for human use is often substantially higher. In such cases, the use of groundwater supplies is unsustainable in the long term. The imbalance between use and recharge manifests as an increasing depth to the water table in areas of high extraction.

Table 6.3: Average groundwater yields and estimated costs of developing groundwater sources for rural domestic supply. Source: MacDonald & Davies (2000).

Hydrogeological domain	Hydrogeological sub-domain	Average yield (l/s)	Cost[1]
Basement	Highly weathered or fractured Poorly weathered or sparsely fractured	0.1 - 1 0.1	£ - ££ £££
Volcanic	Mountainous areas Plains or plateaux	0.5 - 5 0.5 - 5	£ - ££ ££ - £££
Consolidated sedimentary	Sandstones Mudstones Limestones	1 - 20 0 – 0.5 1 - 10	£ - ££ ££ - £££ ££ - £££
Unconsolidated sediments	Large basins Small dispersed deposits	1 - 20 1 - 20	£ - ££ £ - ££

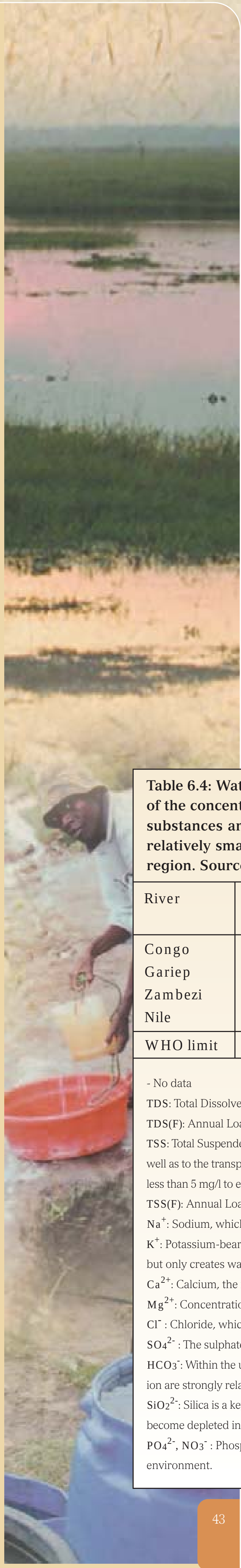
[1] Approximate cost of siting and constructing one source, including 'hidden' cost of dry sources: £ = <£1000; ££ = £1000 – 10 000; £££ = >£10 000



Hydrogeological Domains

- PreCambrian "basement" rocks *(low-moderate potential)*
- Volcanic rocks *(moderate potential)*
- Consolidated sedimentary rocks (incl. dolomites) *(low-high potential)*
- Unconsolidated sediments *(moderate to high potential)*
- Lakes

Figure 6.4: Groundwater potential according to the main hydrogeological domains of sub-equatorial Africa. Source: MacDonald & Davies (2000).



Water Quality

While the absolute quantity of available water is important, the key problems of water availability usually relate to obtaining water of adequate quality. Water quality is defined as the combined physical, chemical and biological attributes of water that contribute to its usefulness for a particular purpose. Lack of access to safe water is a leading cause of illness and death in developing countries, especially amongst children. In parts of the region such as the Zambezi River Basin, where fish are a major source of protein in low-income families, habitat degradation and pollution of freshwater ecosystems through siltation impacts on fish stocks, and has important implications for food security. Deteriorating water quality resulting from pollution can also be a barrier to the use of water for irrigation and even industrial development. Treating water that has been polluted by mining and industrial activities, industrial runoff or poor waste disposal is both difficult and expensive. Monitoring and managing water quality is therefore very important (Box 6.1).

Box 6.1: "River Health" approaches to water quality

In South Africa, the government initiated a river health programme in 1994 to gather information on the ecological state of rivers in support of improved management (Roux 1999). It uses a variety of indices, based on physical, chemical and biological measurements, to classify river reaches in five classes of increasing impact, from 'natural' to 'unacceptable' and identifies the drivers of change. In the catchments where it has been implemented, which drain the highly industrialised, populated and agriculturally-transformed north-east of South Africa, fair to poor states predominate (Ballance *et al.* 2001). Making the information publicly available in the form of regular, easily-understood 'State of the Rivers' reports aims to raise the level of awareness, compliance and water quality enforcement.

Water quality is influenced both by natural conditions and human activities. Biophysically, water quality is determined by the weathering of bedrock minerals, hydrological factors (particularly discharge), temperature (which affects the rate of chemical and biological processes), atmospheric processes of evapotranspiration, natural leaching of organic matter and nutrients from soils, and the deposition of dust and salt by wind (UNEP 2002b). In various parts of southern Africa, and particularly in the Gariep Basin of South Africa, human activities have an important impact on water quality through industrial and mine effluents, sewage and sewage return flows, runoff of soil, nutrients and pesticides from farmlands, and salinisation resulting from inappropriate irrigation (Table 6.4). Land clearance is generally not a major factor contributing to reduced water quality in the region. Although many cities, particularly in the southern parts of the region, have adequate stormwater systems and sewage plants, urbanization, particularly in the form of informal ("squatter") settlements, is rapidly becoming an important issue with respect to water quality. This is due to the unplanned nature of such settlements and their lack of infrastructure to deal with effluents.

Table 6.4: Water quality in the major water basins of the region aggregated to regional values and covering the period 1976 - 1990. None of the concentration levels listed exceed the World Health Organisation (WHO) guidelines for drinking water. The highest levels of most substances are found in the Gariep River, owing to the fact that it drains the most highly industrialised parts of the region and has a relatively small discharge. The Nile also has high levels of certain substances, but most of the affected parts of the river lie outside the region. Source: UNEP (2002b).

River	TDS	TDS(F)	TSS	TSS(F)	Na^+	K^+	Ca^{2+}	Mg^{2+}	Cl^-	SO_4^{2-}	HCO_3^-	SiO_2^{2-}	PO_4^{2-}	NO_3^-
	mg/l	Tg/y	mg/l	Tg/y	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
Congo	42.0	56.1	32.0	43.0	2.17	1.55	2.67	2.07	3.32	1.50	17.10	11.20	-	-
Gariep	183.0	2.8	1111.0	17.0	13.40	2.30	18.10	7.80	10.60	7.20	107.00	16.90	-	0.72
Zambezi	140.0	14.5	194.0	20.0	5.40	1.90	12.90	4.10	6.50	5.00	89.00	15.50	-	0.13
Nile	204.0	6.1	-	-	8.10	3.20	22.00	5.30	5.70	12.00	135.00	12.80	0.03	0.80
WHO limit						12.00			200.00	400.00				

- No data

TDS: Total Dissolved Solids (sum of major ions and dissolved silica). TDS concentrations are generally inversely proportional to river discharge.

TDS(F): Annual Load of Total Dissolved Solids to Oceans. Tg = million metric tons.

TSS: Total Suspended Sediment (calculated), comprised of organic and mineral particles transported in the water column. TSS is closely linked to land erosion and to erosion of river channels, as well as to the transport through river systems of nutrients (especially phosphorus), metals, and a wide range of industrial and agricultural chemicals. TSS can be extremely variable, ranging from less than 5 mg/l to extremes of 30 000 mg/l.

TSS(F): Annual Load of Total Suspended Sediment to Oceans. Tg = million metric tons.

Na^+: Sodium, which is tightly linked to chloride. Both originate from natural weathering of rock, atmospheric transport of oceanic inputs and a wide variety of anthropogenic sources.

K^+: Potassium-bearing minerals, mostly feldspar and mica, are abundant but poorly soluble, so that natural potassium concentrations in rivers <5 m/l. Potassium is affected by fertilizer use, but only creates water quality concerns downstream of mining areas.

Ca^{2+}: Calcium, the most common cation found in surface waters, is mainly a function of geology, particularly when carbonate or gypsum deposits are present.

Mg^{2+}: Concentrations of magnesium are not strongly influenced by anthropogenic activities and therefore is not used as an indicator of pollution stress.

Cl^- : Chloride, which is tightly linked to sodium (above).

$SO4^{2-}$: The sulphate ion ($SO4^{2-}$) is highly variable in surface waters and linked to sulphur-bearing minerals.

$HCO3^-$: Within the usual range of pH values of rivers, from 6.4 to 8.3, the bicarbonate ion ($HCO3^-$) is the most common carbonate species found in natural waters. Concentrations of the bicarbonate ion are strongly related to Ca^{2+} concentrations which reflect the weathering of limestones ($CaCO_3$) and dolomites ($CaCO_3$, $MgCO_3$). When these rocks are present the risk of acidification is low.

SiO_2^{2-}: Silica is a key nutrient in diatom production, a very common algal group, and is taken up during the early growing season. SiO_2 concentrations can limit diatom production if concentrations become depleted in the surface waters. This is particularly the case for lakes and reservoirs. In rivers, dissolved silica concentrations depend primarily on the native rock types within a river basin.

$PO4^{2-}$, $NO3^-$: Phosphorus and nitrogen, primarily in the oxidized forms of phosphate ($PO4^{2-}$) and nitrate ($NO3^-$), are used as indicators both of population and agricultural impact on the environment.

6.3 THE USE OF WATER IN SOUTHERN AFRICA

Water that supports human needs can be divided into two groups: Blue water and green water (Falkenmark 1995). 'Blue water' refers to the water flows in groundwater and surface water (rivers and lakes), and represents the water that can be withdrawn for uses such as irrigation or that is available for uses such as hydro-electric power generation. 'Green water' is defined as the fraction of water that is evapotranspired, in other words the water used by all non-irrigated vegetation: rain-fed agriculture, as well as natural vegetation. Conventionally, only blue water is regarded as an economic resource and much of the policy focus is on improving efficiency of especially irrigation systems, which account for approximately two thirds of all blue water use (Shiklomanov 2000). The substantial quantities of green water used to sustain rain-fed agriculture, as well as the natural vegetation that supplies society with services such as grazing for livestock (Section 5.4, page 32), fuelwood (Chapter 7), timber and fibre is often forgotten.

'BLUE WATER': USE OF WATER FROM RIVERS AND AQUIFERS

There are five broad categories of blue water use in southern Africa: Domestic consumption (including home gardens), industry (including mining and coal-fired electricity generation), hydroelectric power generation, irrigated agriculture and the maintenance of aquatic ecosystems. In addition, river ecosystems process and dilute wastes, help with flood control, and provide for recreation, aesthetic satisfaction and religious rituals. Blue water is generally not 'used up' when it is consumed, but its fitness for subsequent use can be reduced by contamination or relocation. Thus there is a strong interaction between water quantity and water quality: How much water there is depends not so much on the total volume, as on what fraction is deemed 'fit for use'. That in turn depends on how much the user is willing to pay to make it usable or reusable. Similarly, the degree to which the supply is degraded for subsequent use depends on how the water is treated after use.

Domestic supply and sanitation

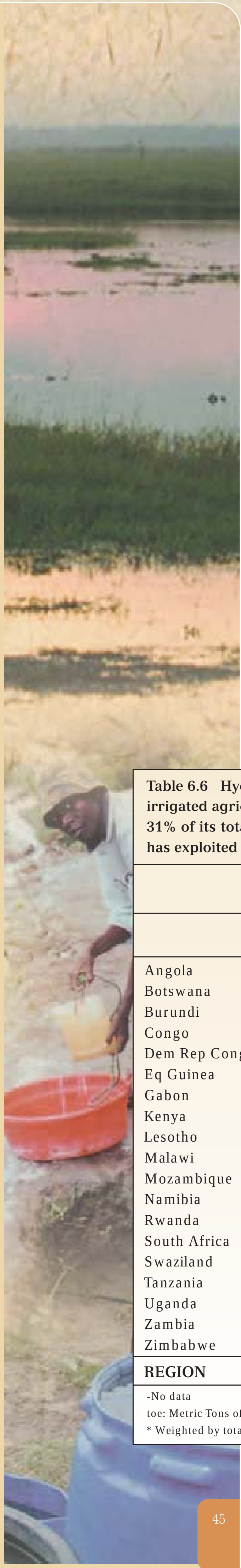
Access to adequate water supply is recognized as a fundamental need and human right, and has considerable health and economic benefits to households and individuals. Lack of access to safe water contributes to deaths and illness, especially in children (Table 6.5). The most common of these are diarrhea, intestinal worms, trachoma, schistosomiasis (biharzia) and cholera. Thus, the improvement of access to water is a crucial element in the reduction of under-five mortality and morbidity, in particular in impoverished urban areas. Access to water also means that the considerable amount of time women and children spend fetching water can be spent more effectively on other tasks, improving economic productivity, a key component in poverty alleviation efforts (UNICEF & WHO 2000).

Table 6.5: The percentages of the population with access to safe water and sanitation facilities (see Table 2.3 on page 7 for population statistics). Urban inhabitants almost always have better access than their rural counterparts. Lack of access to adequate water contributes to death and illness, especially in children. Note that diarrhoea rates are not directly comparable between countries due to seasonal differences in the timing of surveys. Sources: UN Millennium Indicators Database[1], UNICEF ORT Database[2], UNDP (2003).

	Access to improved drinking water 2000			Access to improved sanitation 2000			Under-five mortality rate	Under-five diarrhoea rate
	%Urban	*%Rural*	*% Total*	*%Urban*	*%Rural*	*% Total*	*per 1000 live births*	*% under-fives[1]*
Angola	34	40	38	70	30	44	260	28
Botswana	100	90	95	88	43	66	110	7
Burundi	91	77	78	68	90	88	190	-
Congo	71	17	51	14	-	-	108	-
Dem Rep Congo	89	26	45	54	6	21	205	23
Equatorial Guinea	45	42	44	60	46	53	153	-
Gabon	95	47	86	55	43	53	90	14
Kenya	88	42	57	96	82	87	122	17
Lesotho	88	74	78	72	40	49	132	-
Malawi	95	44	57	96	70	76	183	16
Mozambique	81	41	57	68	26	43	197	21
Namibia	100	67	77	96	17	41	67	21
Rwanda	60	40	41	12	8	8	183	22
South Africa	99	73	86	93	80	87	71	13
Swaziland[2]	61	44	48	66	37	44	149	-
Tanzania	90	57	68	99	86	90	165	12
Uganda	80	47	52	93	77	79	124	24
Zambia	88	48	64	99	64	78	202	24
Zimbabwe	100	73	83	71	57	62	123	14
REGION[3]	**88**	**48**	**61**	**81**	**53**	**63**	**155**	**18**

- No data. [1] Percentage children under-five with diarrhoea in the two weeks prior to the UNICEF survey . [2] Water and sanitation data for 1997. [3] Population-weighted averages.

[1] http://millenniumindicators.un.org. [2] www.childinfo.org



Mining and industrial use

On average, the mining and industrial sector accounts for the smallest fraction of water withdrawals in the region, well behind agricultural and domestic uses (Table 6.6). Comprehensive figures on water use in mining are not readily available for the southern African region. In South Africa's Crocodile-Limpopo and Olifants basins, mining water requirements were 8% of the total available water in 1996. This is expected to rise to 9% by the year 2030 (Basson *et al.*1997).

Hydroelectric power generation

Most of the countries in the region other than South Africa, Swaziland and Botswana rely heavily on hydropower for electricity. The largest installed hydropower capacity is in the Zambezi Basin (Table 6.1), of which nearly half is at the Cahora Bassa dam in Mozambique (Heyns 2003). A further 40 possible sites for new hydropower plants have been identified in this basin, mostly in Mozambique (Chenje 2000). The Congo River is Africa's largest potential hydroelectric resource, with a theoretical generating capacity of 100 000 MW, at present hardly exploited. Currently, the major hydropower developments on the Congo River are Inga I and Inga II, whose installed capacities are 350 MW and 1400 MW respectively. This is dwarfed by the proposed Grand Inga Dam, which will have a total installed generating capacity of 39 000 MW (Heyns 2003). Angola, the Democratic Republic of Congo, Mozambique and Lesotho have large potential to develop more hydroelectric power generation facilities.

Irrigated agriculture

Long dry seasons and unreliable wet-season rainfall have made irrigated crops an important part of agricultural production in the drier countries of the region. In the region overall about 70% of freshwater that is extracted from rivers and aquifers is used for irrigation, and in most of the region there remains a large area of land suitable for irrigation (Table 6.6). Water-use efficiency of irrigation, in terms of product value per unit water consumed is, however, low relative to competing uses (Gleick 2000). In order to reduce the volume of water consumed by irrigated agriculture and improve water-use efficiency, many countries in the drier parts of the region are introducing water demand management measures that could release water resources from irrigated agriculture for other uses (Pallet 1997, Maro & Thamae 2002). It can be anticipated that an increased cost of water will make marginal irrigated agriculture unprofitable, and cause a switch of irrigation from low value crops (such as cereals) to high value crops such as horticulture.

Table 6.6 Hydropower, irrigation and water use per sector in southern African countries for the year 2000. In the majority of countries, irrigated agriculture is by far the biggest water user. South Africa consumes more than half the total water withdrawn in the region, and 31% of its total renewable natural water resources (given in Table 6.2). Together with Swaziland, South Africa is the only country that has exploited a substantial fraction of its irrigation potential. Source: FAO AQUASTAT[1], WRI Earthtrends Database[2].

	HYDRO-ELECTRICTIY		IRRIGATION			WATER WITHDRAWALS							
			Potential	*Total*	*Exploited*	*Irrigated Agric.*		*Domestic*		*Industrial*		*Total water use*	
	toe	*%*	*1000 ha*	*1000 ha*	*%*	*km^3 p.a.*	*%*	*km^3 p.a.*	*%*	*km^3 p.a.*	*%*	*km^{3}p.a*	*% res.*
Angola	77	1	6700	75	1	0.21	62	0.08	22	0.06	16	0.34	0.2
Botswana	-	-	20	1	7	0.06	43	0.05	38	0.03	19	0.14	1.0
Burundi	-	-	185	14	8	0.19	82	0.04	17	<0.01	1	0.23	6.5
Congo	8	2.9	40	<1	1	<0.01	10	0.02	60	0.01	30	0.04	<0.1
Dem Rep Congo	489	3.3	4000	11	<1	0.11	31	0.19	53	0.06	16	0.36	<0.1
Eq Guinea	-	-	-	-	-	<0.01	1	0.09	83	0.02	16	0.11	0.4
Gabon	60	3.9	440	4	1	0.05	40	0.06	49	0.01	11	0.13	0.1
Kenya	209	0.7	352	67	19	1.01	64	0.47	30	0.10	6	1.58	5.2
Lesotho	-	-	13	3	22	0.01	19	0.02	40	0.02	41	0.05	1.8
Malawi	-	-	162	28	17	0.06	80	0.03	15	0.05	5	0.11	5.8
Mozambique	588	7.9	3300	107	3	0.55	87	0.07	11	0.01	2	0.64	0.3
Namibia	101	12.8	45	6	14	0.17	62	0.09	33	0.01	5	0.27	1.5
Rwanda	-	-	160	4	3	0.03	39	0.04	47	0.01	14	0.08	1.5
South Africa	62	0.1	1500	1270	85	11.12	73	2.58	17	1.61	10	15.31	30.6
Swaziland	-	-	90	67	75	0.76	91	0.02	3	0.05	6	0.83	18.4
Tanzania	185	1.3	828	150	18	1.85	93	0.12	6	0.03	1	2.00	2.2
Uganda	-	-	202	9	5	0.12	40	0.13	45	0.05	15	0.30	0.4
Zambia	663	10.9	520	46	9	1.32	76	0.29	16	0.13	8	1.74	1.7
Zimbabwe	254	2.6	331	117	35	2.24	85	0.25	10	0.12	5	2.61	13.1
REGION	**2696**	**1.1**	**18888**	**1980**	**10**	**19.87**	**74**	**4.64**	**17**	**2.39**	**9**	**26.87**	***0.5**

-No data

toe: Metric Tons of Oil Equivalent; Percentage data reflect contribution to total national energy supply

* Weighted by total renewable resources of each country.

[1] http://www.fao.org/ag/agl/aglw/aquastat/dbase/index.stm

[2] www.earthtrends.wri.org

Maintenance of aquatic ecosystems

Excessive abstraction or large impoundments affect the flow regimes of rivers, as well as water chemistry, sediment and temperature regimes, and consequently impact on aquatic plants and animals. To mitigate these impacts, river regulation in parts of the region make provision for environmental flows, in other words, for water to be purposefully left in a river by restricting abstraction or releasing water from an impoundment with the objective to maintain a river in a desired condition. Environmental flows vary by season, and also allow for periodic small and large floods that may be essential to stimulate fish spawning or maintain beaches. As a general rule, the closer to natural the desired condition, the greater the volume of the original flow regime that will be required as an environmental flow (Brown & King 2002).

‘GREEN WATER’: WATER USED BY VEGETATION

Policies that take into account societal dependence on green water flows, namely water required to sustain biomass growth of rainfed crops and natural vegetation, have a markedly different emphasis from those which account only for blue water flows. In conventional blue water assessments, the focus is strongly on improving irrigation efficiencies in order not to exhaust river and aquifer resources. When additionally considering rain-fed agriculture, the emphasis shifts to improving rainwater use efficiency (more crop per drop of green water) by blending irrigation and dryland cropping techniques. Also accounting for the contribution of green water to livestock production and other ecosystem services, leads to a wider emphasis on land management (Falkenmark *et al.* 2001).

Rainfed agriculture

Food production requires large volumes of water (1000 – 3000 m^3 per ton of grain produced). The majority of this is ‘green water’ used in the production of rainfed crops (Falkenmark *et al.* 2001). In most countries in southern hemisphere Africa, the dependence on green water in sustaining national food production exceeds 80% of the total annual water use in the food sector. In the hyper-arid Namibia and Botswana, there is a greater dependence on blue water, as agriculture in many parts is only feasible under irrigated conditions.

It is projected that by 2025 global demand for water, based on a per capita water need for food of 1200 m^3/person/yr and a population of 8 billion people together with increased domestic and industrial use, will roughly equal the total amount of accessible blue water (12 500 km^3/yr) in the world’s rivers and aquifers (Falkenmark *et al.* 2001). Given that irrigated agriculture accounts for two-thirds of blue water withdrawals, meeting the world’s future food demands will therefore have to rely increasingly on rain-fed agriculture and green water flows. Importantly, the vast majority of farmers in southern hemisphere Africa practise rain-fed agriculture, often sub-optimally. Improving rain-fed agriculture through dryspell mitigation by blending irrigation and dryland techniques therefore presents a huge potential for improving future food production in the region.

Plantation forestry

Plantation forestry only occurs on a significant scale in South Africa, where it is treated as a consumptive water user under the revised water legislation (Box 6.3). This is because the evergreen, deep-rooted, fast-growing species that are grown for pulp and saw timber use more water, on a per hectare basis, than the natural vegetation they replace, and the result is reduced streamflow in catchments that are extensively afforested (Tewari 2000). The magnitude of streamflow reduction increases as the plantation matures, reaching about 300 mm of rainfall equivalent at the time of harvest, 12 to 20 years after planting. Streamflow reduction from commercial forests in South Africa is estimated to be 1.4 billion m^3 per year from an area of 1.44 million ha of plantation (Tewari 2000). Because of the location of the plantations on South Africa’s eastern escarpment, conflict has arisen with the flow requirements for aquatic ecosystem health in the downstream reaches, many of which traverse conservation areas. Conflict has also arisen with downstream irrigated agriculture and neighbouring Mozambique (Hassan 2003).

Natural vegetation

Green water, in sustaining biomass growth in the world’s terrestrial ecosystems, is crucial to the production of a range of ecosystem services that support human well-being. These services include the growth of grass for grazing by livestock, the growth of trees for fuelwood and timber, as well as non-cultivated foods and fibre. Through biomass production, green water also supports less obvious services such as biodiversity, micro-climatic conditions and carbon sequestration. It has been calculated that approximately 60 000 km^3/yr or 90% of the world’s green water flow is involved in sustaining the major biomes of the world (Rockström *et al.* 1999). This green water dependency contrasts markedly with that of blue water: 4000 km^3/yr or 10% of the total blue water flow is currently withdrawn globally for human use, or 32% of the estimated total blue water accessible for societal use (Falkenmark *et al.* 2001).

6.4 FUTURE WATER SUPPLY AND DEMAND

While the central African region has adequate water supplies for the foreseeable future, many countries in the southern and eastern parts of the region either already experience shortages or will within less than three decades (Figure 6.3). In Kenya, Burundi and Rwanda, supplies already fall below the 'scarcity' level of 1000 m^3 per person per year (Table 6.2), and the situation is set to worsen in coming decades due to population growth (Figure 6.5). Malawi currently experiences water stress and by the year 2025 is projected to fall below the 1000 m^3 scarcity threshold. Tanzania and Uganda are projected to move from a situation of adequate supply to water stress by 2030. The city of Bulawayo in Zimbabwe will need to augment supplies soon. South Africa has identified that its water supplies (including imports from Lesotho) will not meet demand by 2030 (Basson *et al.* 1997).

Increased water demand in the future has two causes: One is the projected growth in the population, and the second is changes in consumption patterns as living standards rise, resulting in increased water use per person. Wealthier people, conveniently supplied with reticulated water, use up to ten times more water than impoverished rural people (DFID 2003), who often need to carry their water great distances. The total volume of water withdrawn in sub-Saharan Africa is projected to double over the next two decades, but significant shifts in sectoral allocation are expected. The share of water consumed by agriculture is projected to fall to under half of total water withdrawals, while industrial use is expected to increase to about 20% of total withdrawals and domestic use to about 40% (Cosgrove & Rijsberman 2000). The increase in water use in the industrial and domestic sectors will be a direct result of population growth and planned expansion of the industrial sector, especially under the Partnership scenario (Section 3.3). Major turning points that could alter these trend projections include whether irrigated agriculture will continue to expand, or whether there will be a greater emphasis on improving water productivity in rainfed agriculture, for example through the use of biotechnology. Related to this, is whether policies will emphasize national food security or global food security, which relate strongly to regional and global governance and trade issues.

Climate Change

There is now general scientific agreement that the mean annual temperature in southern Africa will rise by 2 to 5°C by 2050 (IPCC 2001; see Box 2.1). Increased temperatures directly affect water availability, which is the balance between input (rainfall) and losses (evaporation from water bodies and soils, and transpiration through plants). Rising temperature increases losses by raising evaporation rates by about 5% per °C increase. This will be offset, to an uncertain degree, by the reduced transpiration rates of plants under increased atmospheric CO_2 concentrations. On the input side, rainfall is projected (with great uncertainty and lack of spatial agreement between climate models) to increase in the northern and eastern parts of the region, and decrease in the southern and western parts, by up to about 15% in both cases. Therefore, the already wet areas of southern Africa are likely to remain approximately the same or become slightly wetter, while the dry areas face the combined impact of reduced rainfall and increased evaporation. River flow and the recharge of groundwater are much more sensitive to changes in water balance than, say soil water content, because they only occur once certain thresholds are exceeded (McCarthy *et al.* 2001). Thus changes in climate are greatly amplified in the hydrological system.

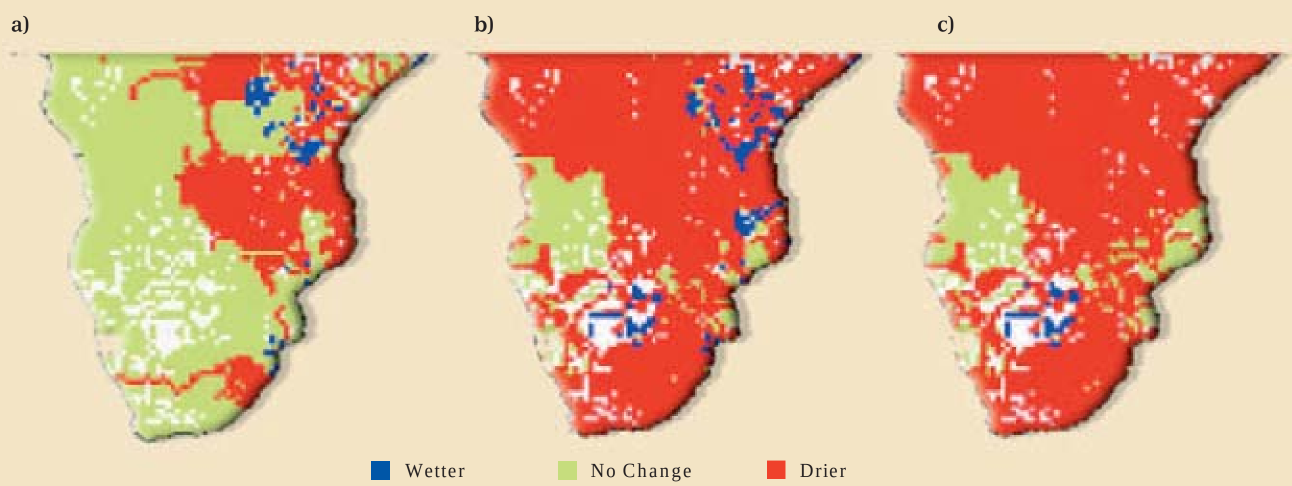


Figure 6.5: Relative change in water demand per discharge in 2025 compared to 1985 accounting for (a) change in climate only, (b) change in population and economic development only, and (c) both effects. These scenarios were produced using the Water Balance Model and the Canadian Climate Center general circulation model (CGCM1). A threshold of ±20% was used to highlight areas of substantial change. Source: Vörösmarty *et al.* (2000).

6.5 RESPONDING TO WATER SCARCITY

Although water supply is projected to fall below water demand in many southern African countries in the near future, the consequence is not that 'we will run out of water'. At every level of societal organisation, from the individual, through the household, community, local authority, province, nation and region, society has the capacity to adapt to changing levels of water availability. A wide range of factors influences society's capacity for adaptation, and some societies are much better able to adapt at particular levels of organisation than others. At the national level, several countries in the region are already subject to water scarcity and have responded substantially. Responses include revising the legal basis on which water is managed and allocated; supply-side schemes to make more effective use of the resources; demand-side management to reduce consumption, increased water conservation and recycling; and inter-national and inter-basin cooperation.

Water law reform

Many southern African countries are in the process of revising national water laws, policies, strategies and institutions. Water policies have historically treated water as a basic social good and focused on promoting water supply. Priority was given to the supply of water to communities, agriculture and industry, including mining and hydroelectric power generation (SADC 1998). New water policies and legislative measures developed during the 1990s show a marked shift in emphasis. In order to promote sustainability, environmental management principles have been embraced and stakeholder participation at community level is encouraged (Box 6.2, 6.3). The inclusion of environmental considerations into water management policies calls for close co-ordination between national environmental and water departments. HIV/AIDS raises several specifically water-related concerns, which call for coordination with health and other public service departments (Box 6.4).

Policy enforcement at both the national and regional levels is currently inadequate in most southern African countries (Chenje 2000). Effective water resources development and management is particularly difficult in shared river basins because different national laws pertaining to water resource use and management often conflict. Most regional SADC treaties are not enforced at the national level until their obligations are incorporated into national law (Mutambirwa *et al.* 2001). At a more local level, enterprises and individuals who sink private boreholes and construct dams without permission from the relevant national authorities hamper proper water accounting. Wastage through leaks, faulty equipment and other means can be addressed through enforcement of existing policies where the user pays for the water. Policy initiatives could also consider incentives for industry and domestic consumers by reducing tax for categories that comply with better water use practices (Chenje 2000).

Box 6.2: Examples of recent legislative and policy revisions in the region

- The *National Environment Policy of Lesotho* has a section on water resources management, with the objective to "develop integrated and co-ordinated effective and efficient approaches to conservation and use of water resources, and promote its conservation and availability in sufficient quantity and quality on a sustainable basis" (Government of Lesotho 1998).
- The *Malawi Water Policy* of 1994 has as one of its objectives the preservation and enhancement of aquatic and riparian environment (Government of Malawi 1997).
- In *South Africa*, the *Water Policy* (see Box 6.3) embodies the constitutional principle of the people's right to "an environment that is not harmful to their health or well-being" and the "right to have the environment protected for the benefit of present and future generations" (Government of South Africa 1998).
- *Zimbabwe* has developed new water resources legislation and a new national water resources management strategy, both of which aim at providing more equitable access to water for the majority of the population. In addition they provide for instream environmental needs; and apply economic incentives to promote efficient water use (Pazvakavambwa 1999).
- The *Zambia Water Policy* of 1994, promotes the management of water quality for the use of the resource on a sustainable basis and for the preservation of the natural environment (Government of Zambia 1997).

Box 6.3: New water legislation in South Africa

The South African National Water Act (NWA, Act 36 of 1998) is a landmark in several respects. It supersedes an outdated and complicated system of 'water rights' that had over-allocated the available supply. It gives priority in allocation to basic human needs and the needs of aquatic ecosystems, and establishes a framework for rational allocation of the remainder. It treats the entire hydrological cycle holistically instead of focussing just on in-stream flow and groundwater, recognising that they are connected and also linked to land use.

The NWA defines water inter alia as an economic good that has an underlying social component. This allows water to be used productively for the benefit of society as well as the economy. The social value of water is not tangible and depends on culture, belief system and heritage. This component has to be described in order for it to be incorporated into the water resources management process, and therefore to balance the value placed on water as an economic, social and ecological good. The NWA provides for a pricing strategy to address the issues related to the costs of water use activities, setting of tariffs and disposal of monies recovered. The strategy also allows for water to be provided without cost at certain minimum supply levels as a social development imperative.

In principle, the available resource is first allocated to the 'Reserve', then international obligations are provided for, and once those needs are satisfied, any remaining water is allocated to the most beneficial use. The 'Reserve' has two parts: the basic human needs reserve and the ecological reserve. The basic human needs reserve provides for the essential needs of individuals served by the water resource in question and includes water for personal hygiene. The ecological reserve is defined as the water quantity and quality required to protect the structure and function of aquatic ecosystems in order to secure ecologically sustainable development. The Reserve refers to both the quantity and quality of the water in the resource, and varies depending on the class or desired state of the resource.

Water licensing

Abstraction permits, licenses or water-use authorizations provide a mechanism for determining and monitoring water-use and allocation. A licensing system, in contrast to a rights-based system, is based on the notion that the state is the guardian of all water resources and therefore determines the allocation and best use of the water resources, an approach widely adopted in recent revisions of water law in southern African countries. Provided adequate capacity is available for enforcement, licenses and permits can be used as a tool for controlling water use, promoting equity and protecting aquatic ecosystems. For example, in South Africa, the reserve (Box 6.3), consisting of a human and environmental component, is a water right and all other uses are granted a permit only after the reserve has been determined and set aside for a particular river.

Water pricing

Water pricing is one tool to promote more efficient and equitable water use (Rogers *et al.* 2002). The pricing approach recommends that public authorities raise the user price of water to reflect its opportunity cost, thereby inducing water conservation and making more water available to higher value uses. Water pricing typically varies with consumer categories. In southern Africa, as elsewhere, water is generally under-priced and heavily cross-subsidised, and varies according to consumer category and region. At best, the price covers the direct use value or the production costs (Mondoka & Kampata 2000). In Zimbabwe, for instance, the main pricing mechanism is the national "blend" price, which is calculated from the historical cost of several government-constructed dams and associated works (Bate & Tren 2002). Under the framework of the revised 1998 legislation (Box 6.3), South Africa has put forward a comprehensive water pricing policy which aims to charge all significant water resource use, regardless of where it occurs. The only exception will be in respect of the reserve, which is to be provided free of charge. The price will include operating, maintenance and capital costs where appropriate as well as a water resource management levy and a resource conservation charge. The levy may include charges for effluent disposal or streamflow interception as a result of land uses such as afforestation or agriculture.

Box 6.4: Water and HIV/AIDS

Frequent exposure to parasitic and diarrhoeal illnesses associated with poor water and domestic sewerage supply can speed the progress of HIV/AIDS infection to full-blown AIDS. People with weakened immune systems are more susceptible to parasitic infections, and their water and sanitation needs require particular attention (Harvey 2003).

Several problems arise from the interaction between HIV/AIDS and water resource management (Ashton & Ramasar 2001): Inaccurate estimates of population growth and mortality rates lead to incorrect estimates of water demand; widespread difficulty to pay for water supply and sanitation services requires innovative funding and cross-subsidisation mechanisms and; loss of productivity due to water management staff members infected with HIV/AIDS. Additional productivity losses are attributable to workers having to care for sick family members and relatives, as well as due to workers attending funerals. The resultant reduced service levels can lead to inadequate water treatment, increasing public health risks, particularly for individuals with compromised immune systems, and especially where sanitation facilities are inadequate.

Interbasin water transfers

Interbasin transfers, which aim to supplement water-poor basins with water from more water-abundant basins, are already a feature of the region and likely to become more important in future (Heyns 2002), notwithstanding their cost and engineering challenges. Such transfers are of strategic importance in the region in terms of the objectives regional economic integration advocated in the SADC Treaty, particularly because the most economically developed states (South Africa, Botswana, Namibia and Zimbabwe) are also the most water-constrained. Currently, the major water transfer schemes in the region augment the Vaal River in the Gariep catchment that supplies Gauteng, the industrial and urban centre of South Africa (Table 6.1, page 40). The Lesotho Highlands project, of which the first phase has been completed, aims to further augment the Vaal. There are plans to lead water from the Okavango River to supply Windhoek in Namibia, and the possibility of carrying water from the Zambezi (or even the Congo basin) to Botswana and South Africa has been mooted.

One of the consequences of this 'continental-scale plumbing' is that the traditional concept of a drainage basin as a self-contained unit begins to disintegrate. In these cases there is a need, in addition to river basin authorities, to have institutions that deal with water issues across catchments. A further consequence is that the biota that were formerly confined to one basin have the possibility of moving into other basins, potentially accelerating the invasion of alien species (including the translocation of southern African species into catchments in which they did not previously occur) and destabilising the existing biodiversity.

Virtual water and food trade

Virtual water is a term used to refer to the water needed to produce agricultural commodities, but can also be expanded to include the water used to produce non-agricultural commodities (Allan 2003). The concept of virtual water links water, food and trade by drawing attention to the fact that serious local water shortages can be effectively ameliorated by global economic processes, in particular by food trade. Since agriculture is by far the biggest user of water in the region, requiring approximately 1000 m^3 of water to produce a ton of grain, the pressures on water resources in water-scarce regions can be significantly reduced if food is not grown locally but rather imported from water abundant areas. By focusing on a policy of national food security, partly reliant on food imports, rather than a policy of national self-sufficiency, problems with water scarcity can be significantly ameliorated. Pursuing such a policy, however, requires strong international collaboration as well as adequate national financial resources.

Transboundary basin management

Due to the shared nature of water resources in the region, water-related problems often require solutions at a higher level than that of the individual countries. As shortages increase in the region, so does the potential for disputes over water, and the need for international institutions to regulate use in an equitable and sustainable way. International decision-making processes are, however, intrinsically complicated as they involve issues of national rights, sovereignty over resources, security of economy and questions of social order (Turton *et al.* 2003). In southern Africa, it is widely recognized that governance is a key constraint to sustainable water resource management, primarily because of the weak institutional and legal frameworks in the region (Turton 2004). The establishment of institutions and processes to ensure the proper management of the region's water resources could therefore become one of the major platforms on which sustained economic growth and prosperity could be developed (Granit 2000).

The region already has several highly sophisticated international river basin organisations centred on the Gariep, Okavango, Zambezi, Komati and Nile Rivers. Over the past two decades, member states of SADC (and its predecessor SADCC) drafted a broad-based water protocol and negotiated at least nine transboundary water agreements (Giordano & Wolf 2003). At the basin-level, the focus has been on negotiating agreements to establish joint water commissions and institutions to manage individual watercourses and water development projects collaboratively. At the regional level, the SADC water protocol institutionalises and encourages basin-level agreements by offering a general framework for creating joint water-resource networks and policies based on both UN Convention principles and existing regional institutions. These developments clearly indicate an overall commitment among southern African nations to cooperate over water resources. Nevertheless, conflict resolution, public participation and regional water-use prioritisation are institutional components which require further attention (Giordano & Wolf 2003).

7. Biomass Fuel

7.1 WOOD AND CHARCOAL USE IN SOUTHERN AFRICA

Wood is to many countries in southern hemisphere Africa what oil is to the Middle East: the overwhelmingly dominant energy source. Over 80% of people in the region use wood or charcoal for domestic cooking and heating (IEA 2002). Throughout the world, dependence on wood as an energy source declines as per capita income and total energy use increases. With the exception of South Africa, most southern African countries have relatively small industrial energy sectors. South Africa has large coal reserves and a minor gas resource, and Angola, Equatorial Guinea and Gabon have productive oil fields. Mozambique has a gas field under development. Gas resources have been proven off the coast of Namibia, but not yet developed. In general, processed fossil fuels are imported and expensive to the consumer, even in producer countries. As a consequence, traditional biomass fuels make up a large proportion of the total energy consumption in most southern African countries (Table 7.1), even where electricity, paraffin, liquid petroleum gas or coal are available as substitutes. The alternate fuels are less affordable, or in some cases an open fire is preferred for cooking and domestic space heating.

Charcoal is the preferred fuel in urban areas. Wood tends to be used when the wood source is close to the place of consumption, for instance in rural situations. The energy content per unit mass of charcoal is about twice that of wood. The cost of transporting fuel from where it grows to where it is consumed constitutes a large part of the total fuel cost, making charcoal a more viable economic option in most large centres. A further reason that charcoal is favoured in urban areas is that it is relatively clean-burning, resulting in the health impacts of charcoal being four times lower than those of wood (IEA 2002). If the wood is carried by head-load, the radius over which wood is harvested shrinks to about 5 km.

In terms of total energy efficiency and global atmospheric pollution, converting wood to charcoal is a poor option. In most of the region charcoal is produced using relatively primitive methods. Trees are felled and cut into logs, which are stacked nearby and partly dried before being covered with earth and ignited. Following several days of slow, oxygen-starved combustion, which drives off water and large quantities of volatile hydrocarbons, the heap is cooled, opened and the charcoal is extracted. The mass of charcoal is typically only 7 - 22% of that of the original wood (Feinstein & van der Plas 1991). 'Improved traditional' methods can raise this to approximately 30%, and more modern techniques to close to 50%. Although charcoal itself is relatively clean-burning, the total emissions produced when the charcoal-making process is included exceeds the emissions if the wood were directly burned in a well-aerated hearth.

Table 7.1: The contribution of biomass fuels to the energy supply of southern African countries in 2000. The biomass values include only 'commercial biomass', i.e. that which is traded. Total household biomass consumption is independently estimated at 315 million tons per year. One ton of fuel oil contains about 44 700 MJ of energy, which is equivalent to about 2 tons of oven dry wood (~20% moisture), which contains about 18 200 MJ/t. Source: International Energy Agency.

Country	TPES	TPES per capita	Biomass	Electricity access
	Mtoe	*toe per capita*	*%*	*% Population*
Angola	7.67	0.58	73.6	12
Botswana	-	-	-	22
Burundi	-	-	-	-
Congo	0.89	0.30	64.7	21
Dem Rep Congo	14.89	0.29	90.6	7
Equatorial Guinea	-	-	-	
Gabon	1.56	1.27	59.2	31
Kenya	15.48	0.51	76.2	8
Lesotho	-	-	-	5
Malawi	-	-	-	5
Mozambique	6.98	0.40	87.1	7
Namibia	1.03	0.59	18.7	34
Rwanda	-	-	-	-
South Africa	107.6	2.51	11.6	66
Swaziland	-	-	-	-
Tanzania	15.39	0.46	93.6	11
Uganda	-	-	-	4
Zambia	6.24	0.62	78.8	12
Zimbabwe	10.22	0.81	56.5	40
Region (minimum estimate)	**172.47**		***34.5**	****21**

TPES = Total Primary Energy Supply, toe = Tons of oil equivalent, Mtoe = Million Tons of oil equivalent,
*TPES-weighted average, ** Population-weighted average.
- No data

Impacts on the environment and human well-being

Biomass-based fuel has some advantages over fossil fuel or electricity in terms of greenhouse gas production and general air quality (Chapter 8), but can have severe disadvantages in terms of human health if inappropriately burned. When wood fuels are sustainably harvested (i.e. the harvest rate is equal to or less than the rate of growth) then their combustion has no long-term effect on atmospheric carbon dioxide concentration, the main driver of global climate change. The carbon dioxide produced by combustion is taken up again from the atmosphere over a period of years to decades through the process of photosynthesis in regrowing trees. Unsustainable harvest of wood energy, on the other hand, does make a net carbon dioxide contribution to the atmosphere. The methane, nitrous oxide and ozone precursors emitted during combustion of biomass are not reabsorbed in the same way. Their effect on global warming is relatively small, and partly offset by the cooling effect of the smoke produced.

Given the huge amounts of wood consumed in southern Africa, the impact of smoke and its constituent gases on ambient air quality in urban areas is substantial. Biomass fuels produce some NO_x, especially when burned in ‘improved’ stoves, but very little SO_x. These two gases are the main components of ‘acid rain’, and NO_x is an important ozone precursor. The major impact of biomass fuels on human well-being is via indoor air pollution (Smith 1987). Most households light fires indoors, especially at cold times of the year, and typically in inefficient hearths or stoves with poor ventilation. The concentrations of smoke particles and carbon monoxide inside African dwellings are often many times higher than the recommended limits for human health, because of the way in which the biomass fuel is burned. More efficient combustion in stoves with chimneys greatly reduces health problems while simultaneously reducing the quantity of wood consumed. Although improved stove programmes have repeatedly been attempted in southern Africa, they have a poor rate of long-term adoption. Cost, fuel-inflexibility and lack of cultural acceptance are some of the reasons (Haider 2002).

Woodfuel shortages occur in areas where there are large populations without access to alternative affordable energy sources. Without adequate energy, food cannot be properly cooked, homes are unheated and water is not boiled to sterilize it. As a result, people become more susceptible to illness or malnutrition. Woodfuel scarcity impacts particularly on the poor, women (Tinker 1987) and children, who must walk long distances searching for firewood, leaving less time for tending crops, cooking meals or attending school. A further health impact results from carrying heavy loads of wood on the head, mostly by women.

The ‘woodfuel crisis’

Southern Africa has been predicted to be on the brink of a woodfuel crisis for decades (Eckholm 1975, FAO 1983). Wood is used for many purposes other than fuel, and the impacts are cumulative. Clearing of land for agriculture and harvesting trees for construction timber has negative impacts on woodfuel availability.’The problem of woodfuel availability has not gone away, but neither has it resulted in general, national-scale catastrophes. One of the reasons is that the early analyses of the ‘woodfuel gap’ were somewhat coarse and unsophisticated. Although widespread, wood scarcity is a relatively local-scale phenomenon and does not lend itself to large-scale averages.

As wood is a renewable resource, the correct technical analysis is to compare the local production rate to the local harvest rate. Where harvest exceeds production, the stock will inevitably decline, and despite some regrowth in the depleted area, the zone in which harvesting occurs expands until the effort required to transport the wood or charcoal exceeds its value. Initially only large, dead, fallen branches are taken, focussing on the most preferred species. As wood becomes scarce, all species are targeted, and living trees first pollarded and then felled. The price of fuel rises (either the actual market price, or the opportunity cost of the wood-gatherers, who are typically women) and per household consumption declines. Eventually all twigs, leaf litter, agricultural residues and dung are collected and the household is forced to switch partly or completely to alternative energy sources.

7.2 ESTIMATING WOODFUEL SUPPLY AND DEMAND

'Energy deficit' or gap modelling has attracted some criticism, largely because it is conducted at too coarse a scale and does not consider the potential for adaptation of demand as woodfuel supply declines. The maps of woodfuel supply, demand and deficit presented in Figure 7.1 were carried out at a fundamental resolution of 5 x 5 km, made possible by new remote sensing products and spatial population databases. This is close to the typical resolution at which local shortages are apparent.

Total annual wood production (Figure 7.1a) was calculated by scaling a maximum annual increment of 10 t/ha/yr by a function of the number of days available for tree growth (which is related to precipitation and evaporation) (Ellery *et al.* 1991) and the percentage tree cover at a particular location. Per capita demand (Figure 7.1b) was derived by adjusting average annual woodfuel consumption rates (1.3 t/person/yr in rural areas; 0.4 t/person /yr in urban areas) (Marufu et al. 1999) for regional variations in wood demand related to ambient temperature and the availability of woodfuel.

The results clearly show that woodfuel deficits in southern Africa occur in very well-defined areas, which agree with independent observations: The area surrounding lake Victoria and Lake Malawi, the Zambian Copperbelt, and the highlands of South Africa and Lesotho. The balance between supply and demand is close in all the arid parts: Kenya, Tanzania, Botswana, Namibia and South Africa. In general, harvesting for woodfuel is not associated with tropical deforestation in southern Africa, but along with land transformation for agriculture, it is strongly associated with loss of woodlands in many places.

Woodfuel demand in the future

Woodfuel is likely to remain an important energy source in Africa in the coming decades (Arnold *et al.* 2003). Although the fraction that it contributes to national energy supply is likely to decline, the absolute number of people needing woodfuel energy by 2030 is predicted to rise by 50%, and an estimated three quarters of the total household energy will still be supplied by biomass fuels (IEA 2002). As the population continues to urbanise, charcoal is set to make up an increasing share of biomass energy. The Food and Agriculture Organisation projects a 25% increase in wood consumption and a doubling of charcoal consumption in Africa during over the next three decades (Broadhead *et al.* 2001).

Woodland depletion under the Patchwork and Partnership scenarios (described in Chapter 3) was examined at the national scale by assuming identical population growth, but higher urbanisation rates and greater use of alternative modern energy sources under the Partnership scenario (Figure 7.2). The average fraction of a particular country covered by trees in a specific year was assumed to decline when the demand for woodfuel in the previous year exceeded the wood production. Total woodfuel production in a particular year was taken as the product of the total area covered by trees and the average productivity per hectare in the country under consideration (derived from Figure 7.1a), while total demand was calculated as a function of total population and average consumption per person for rural and urban areas respectively.

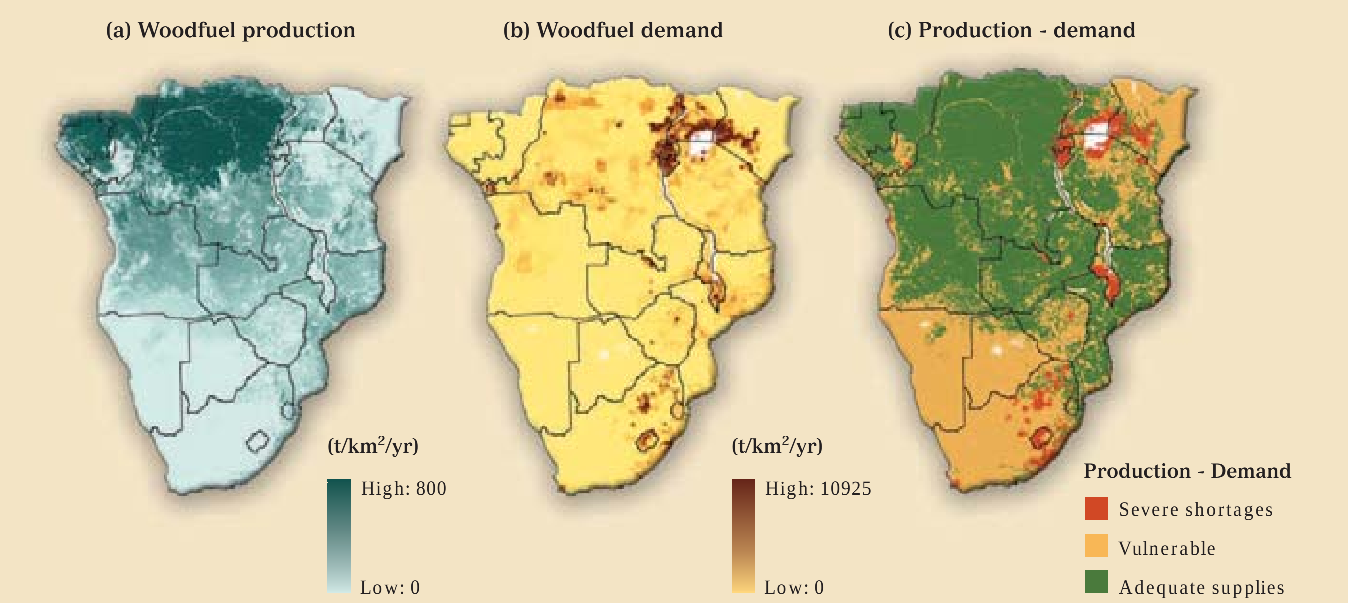


Figure 7.1: Woodfuel harvesting is sustainable when the rate of wood use is less than the rate of wood growth. The rate of wood growth (a) is mainly controlled by climatic factors. Woodfuel use (b) differs between rural and urban areas and varies with climate and woodfuel availability. Where the rate of wood use is greater than wood growth (c), people cut into the woodfuel stock, resulting in deforestation or woodland loss. All data are for 1995 and displayed at a 5 x 5 km resolution. Sources: Corbett & O' Brien (1997), CIESIN (2000), DeFries (2000), Hutchinson *et al.* (1995).

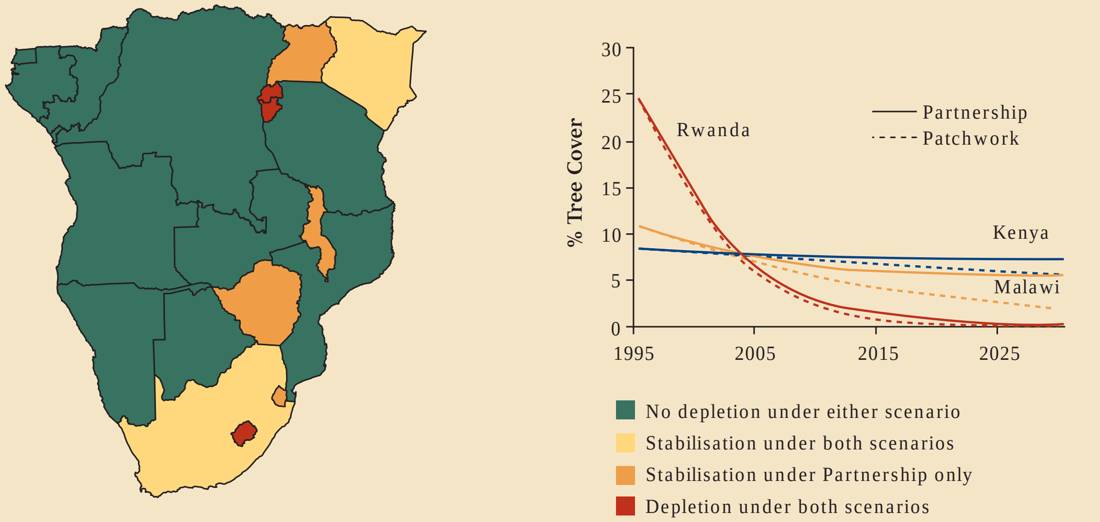


Figure 7.2: Woodland depletion under the Patchwork and Partnership scenarios modelled to 2030 at the national scale. Total population was assumed to be the same under both scenarios (UN medium-variant projection), but the urbanisation rate under the Partnership scenario 50% greater than under the Patchwork scenario, which assumed the UN medium-variant projected rate. Woodfuel consumption rates were assumed to decline linearly over time, to 80% and 70% of 1995 rates in rural and urban areas respectively under the Patchwork scenario, and to 40% and 10% respectively under the Partnership scenario. Sources: DeFries *et al*. (2000), UN (2002).

The results indicate that countries with either a large woodfuel stock (e.g. Democratic Republic of Congo) or a small population (e.g. Namibia) show no woodfuel depletion under either scenario (Figure 7.2). Burundi and Rwanda show a drastic decline in tree cover under both scenarios, dropping below 1% by 2005 and 2010 respectively. Kenya and South Africa show a continued decline and then stabilisation under both scenarios. In the case of Malawi, Zimbabwe and Swaziland, there are marked differences in woodfuel depletion under the two scenarios, suggesting that woodfuel depletion in these countries is extremely sensitive to the energy alternatives that are available and affordable.

7.3 ENERGY SYSTEM RESPONSES

The standard response to local woodfuel crises, and the deforested landscapes for which they are partly responsible, has been to establish village woodlots, usually of fast-growing exotic trees. These have had mixed success (Leach & Mearns 1988), largely because the distribution of benefits and the responsibilities for their care are not clear. In some cases the species planted are either unattractive as woodfuel, or escape to become unwanted weeds. Privately-owned household hedges of fast-growing, multipurpose agroforestry trees have been more successful. They provide a quicker, more assured return, and a nearby supply of wood of the dimensions that women can easily cut and carry.

There is technical potential for ‘demand side management’ in woodfuel consumption; in other words, reducing demand by improving efficiency. The two main options are higher-efficiency stoves and improved charcoal-making techniques. These approaches have the additional advantages of improving ambient and indoor air quality. Once again, success has been mixed. Even very cheap stoves may be unaffordable in the context of the extremely poor rural people in Africa, and the cultural preferences associated with open fires and the multiple services they provide (space heating, light, cooking) can be very persistent. Additionally, stoves are often less flexible in their fuel requirements than the traditional open hearth (Munslow *et al*. 1988). Reflecting on past failures and successes, they recommend differentiating between urban and rural households. Prospects for better stove programmes are much better in urban areas. Rural efforts could focus more on improvements to the charcoal-making process, initially using training programmes to transfer methods developed elsewhere in Africa, using local resources, before introducing more costly and complex industrial approaches.

The main response, in the long-term, is likely to be fuel switching, enabled by economic development. Greater development of hydroelectric capacity in south-central Africa (see Chapter 5), and tapping of the natural gas reserves on the west and east coasts is likely to lead to a gradual replacement of wood and charcoal as a primary fuel, starting in urban areas. Nevertheless, there remains an important role for biomass fuels, even in a ‘modern’ energy economy. They represent an abundant and renewable resource, unlike fossil fuels. The use of biomass for energy generation is a possible measure for helping reduce global carbon dioxide (CO_2) emissions. The ‘carbon benefits’ of a sustainably-harvested woodfuel resource, either a plantation, natural forest or woodland, persist indefinitely. The technical scope for increasing the efficiency with which biomass fuels are burned in small-scale industrial applications is high. Such ‘modern biomass’ energy systems produce very little pollution, and have the potential to compete with oil, gas and coal under scenarios of rising fossil fuel prices.

8. Air

8.1 THE SHARED ATMOSPHERE OVER SOUTHERN AFRICA

The climate and air circulation of the region south of about 10º S (northern Angola) is dominated by the frequent presence of a ‘gyre’, centred approximately on Botswana. A gyre is like a whirlpool in the atmosphere: the air mass rotates anti-clockwise, completing one revolution in about a week. At ground level, the centre of the gyre has a higher air pressure than the outer edge, meaning that the air mass is descending, stable and dry. The gyre is part of the Hadley circulation, a phenomenon that occurs around the world on both sides of the equator, and leads to the presence of the subtropical deserts, such as the Sahara and the Kalahari.

What makes the southern African gyre unusual is that it remains in place over the subcontinent for weeks on end, especially during the winter months. This is responsible for the sunny, dry weather in winter, but also leads to the build-up of various atmospheric pollutants trapped within the gyre. The result is gradually deteriorating visibility and air quality over a period of about a week, over large parts of the subcontinent. The air is refreshed when a ‘westerly wave’ (a front of cold air travelling from west to east across the Southern Ocean) brushes over southern Africa, causing the stale air to be vented into the South Indian Ocean and the equatorial South Atlantic Ocean. The development of one such event is shown in Figure 8.1.

The pollutants that accumulate in the southern African airmass come from a variety of sources (Table 8.1). Some of the substances that are potentially harmful to plants, animals and humans, such as ozone, are secondary pollutants produced by the chemical interaction of primary pollutants while being mixed and held in the giant cauldron provided by the gyre.

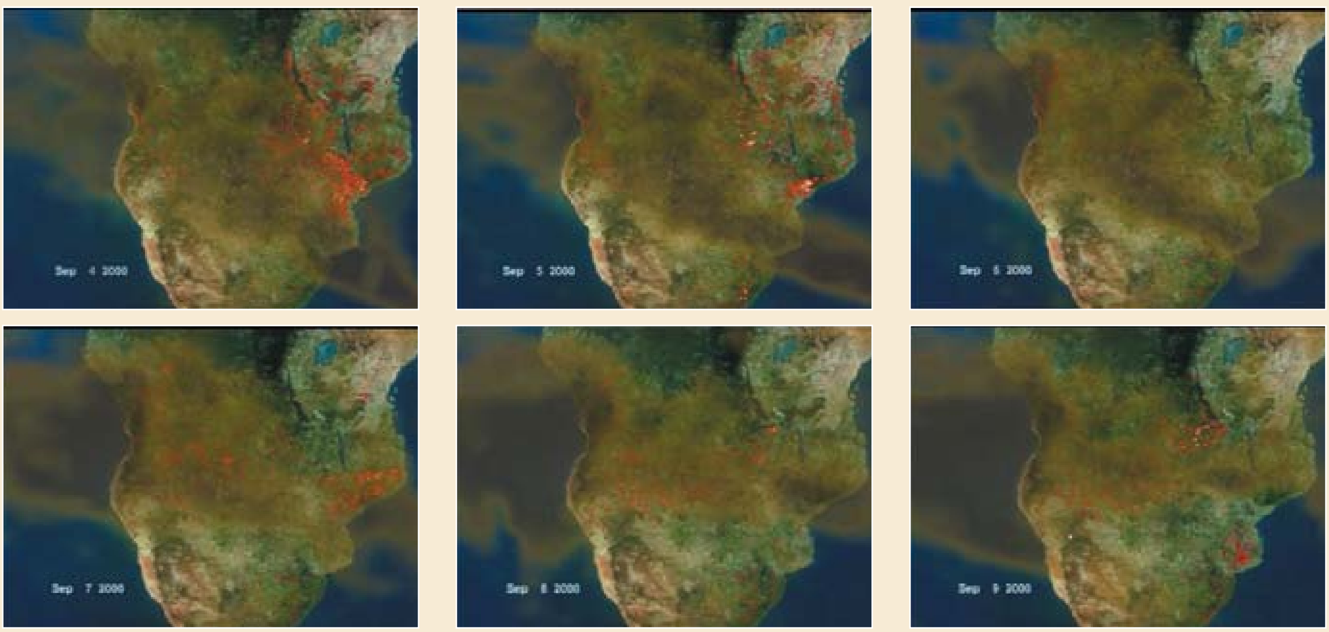


Figure 8.1: A cloud of smoke developing over southern Africa over a six day period. The active fires are coloured red. The cloud swirls around in the gyre, then exits over the Atlantic and Indian Oceans. Source: Satellite images processed by Anne Thompson, NASA.

Tropospheric ozone

Ozone in the troposphere, where we live and breathe, is harmful, and not to be confused with stratospheric ozone, which protects us from the harmful rays in sunlight. Ground-level ozone concentrations are frequently above the 60 parts per billion threshold widely used as a warning of potential harmful impacts to crops and people (Figure 8.2). To the best of our knowledge, the cloud of tropospheric ozone that builds up over southern Africa between August and October has been doing so every year for millions of years. Ozone is formed by reactions involving volatile organic compounds (VOC) and oxides of nitrogen (NO_x). VOC and NO_x mostly come from plants, soils and biomass burning, but there are also significant localised vehicle and industrial sources. Because the chemical reaction only produces ozone above certain critical concentrations and ratios of the primary pollutants, the addition of human-created pollutants during the period for which the ‘natural’ cloud exists adds disproportionately to the ozone concentration in the cloud and its duration.

What ‘service’ are southern African ecosystems providing, if they regularly generate a cloud of toxic gas? The atmosphere is self-cleansing, both through the mechanism of expelling the pollutants over the oceans, where they are diluted to non-toxic levels, and by the mechanism of destroying the dangerous gases by reactions involving the hydroxyl radical, OH- (Brasseur *et al.* 1999). The hydroxyl radical is produced by the atmosphere itself, a service we take for granted. The production rate is limited, and when the supply is exceeded by demands imposed by the combined human-caused and natural pollutant emissions, harmful reactive gases such as ozone build up.

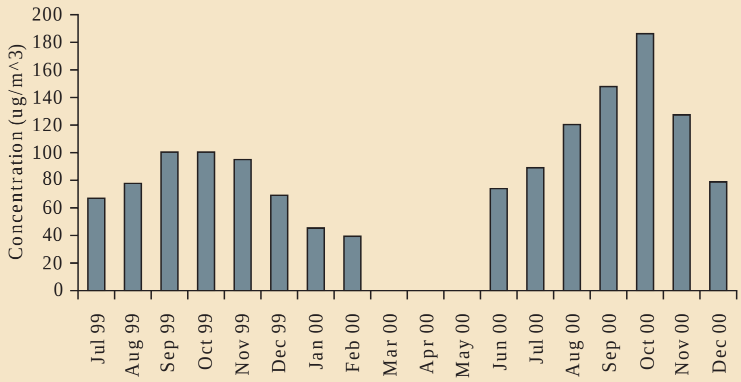


Figure 8.2: A record of near-ground ozone concentrations at Maun, in the north of Botswana (Botswana Department of Mines). Maun is far from any industrial pollution source, but close to the main centre of wildfire emissions.

The emissions of ozone forming gases in southern Africa are anticipated to increase over the next three decades, at a rate of between 2% and 6% per annum under the Patchwork and Partnership scenarios respectively (Chapter 3), assuming no special interventions. Unless steps are taken to manage the emissions into the regionally shared airmass (Box 8.1), the intensity and duration of bad air-quality days will increase.

Greenhouse gases

Most of the pollutants listed in Table 8.1 are directly or indirectly involved in the net warming of the atmosphere that has occurred over the past two centuries. Methane (CH_4) and nitrous oxide (N_2O) are direct greenhouse gases. NMVOC, NO_x and CO are all ozone precursors, and tropospheric ozone is a powerful greenhouse gas. Sulphate aerosols, formed from SO_x have a cooling effect on the atmosphere. Other particles can have either cooling or warming effects, depending on their exact nature and where and when they are injected into the atmosphere.

Carbon dioxide (CO_2) is the main human-caused greenhouse gas. It does not appear in table 8.1 as it has no toxic effects. Over 80% of the CO_2 emissions derived from fossil fuels originate in South Africa. The southern African emission of CO_2 from land cover change and the burning of fossil fuels is estimated to be around 400 Mt/y. Despite this, the region as a whole absorbs more CO_2 from the atmosphere than it emits (Gurney *et al.* 2004). This is because the extensive forest, woodlands and savannas take up a large amount of CO_2 through enhanced growth.

Table 8.1: The estimated principle pollutant emissions from the land mass of Africa south of the equator, excluding Madagascar, in an average year. Gg is a billion grams. Sources: Otter & Scholes (2000), Otter *et al.* (2001), Parsons *et al.* (1996), Schade & Crutzen (1999), Schade *et al.* (1999), Scholes *et al.* (1996, 1997), Scholes & Scholes (1998).

	Gas or particle emission (Gg/yr, whole-gas basis)						
	CO	CH_4	NMVOC	NO_x	N_2O	SO_2	$PM_{2.5}$
Natural or semi-natural sources							
Wildfires	14900						
	6700-60500	500	550	1040	446		2200
		-230 sink					
Soils & plants	500	200-10000 wetland	44200-879800	1000	~100		6000
Ruminants		320					
Human-caused or substantially human-altered sources							
Fossil fuels in boilers	400	20		1830		3339	
Vehicles	2700	40		480		85	
Domestic	14200	310	473	250			1890
Land clearing	470	110		140			500
Landfills, mining							
Agricultural soils							Significant

CH_4 (methane) is the second-most important greenhouse gas after CO_2 and can contribute to ozone formation. **CO** (carbon monoxide) is very toxic in high concentrations, such as are sometimes experienced indoors when cooking and heating are done in poorly ventilated rooms with no chimney. **NMVOC** (non-methane volatile organic compounds) include hundreds of different substances that can contribute to ozone formation. **NO_x** is a combination of NO and NO_2. At high concentrations it irritates the respiratory tract, but its main importance in southern Africa is as an ozone precursor and source of nitrates, the main part of acid deposition in the region. **N_2O** (nitrous oxide) is a powerful greenhouse gas, not toxic at low concentrations. **SO_2** (sulphur dioxide) is dangerous at high concentrations and is the source of sulphates, the second most important component of acid deposition in southern Africa. **$PM_{2.5}$** Particulate Matter smaller than 2.5μm, i.e. small enough to enter the tiniest air passages in the lungs and cause damage.

Box 8.1: Managing air quality

There are several examples of successful regional treaties for the management of air quality across national borders. For example, the Convention on Long-Range Transboundary Air Pollution has led to significant improvements in air quality in Europe. On the other hand, the Association of South East Asian Nations were unsuccessful with their plan, which was not based on a legally binding treaty. At the scale of local government, stricter and better enforced regulations on emissions from vehicles and industrial processes, using existing technology already widely applied in the developed world, can greatly reduce the level of urban pollution without reducing the level of service provided or increasing the total economic cost.

8.2 ACID DEPOSITION

Carbon dioxide and various organic compounds form weak acids in the atmosphere, even in unpolluted areas. However, downwind of major cities and industrial complexes the rainfall chemistry is dominated by human-caused emissions of NO_x, NH_3 and SO_2 (Table 8.1), which combine with water to form nitric and sulphuric acid respectively. In the relatively dry atmosphere of southern Africa, particularly in the winter months, more than three-quarters of the acid is in the form of dust-like crystals properly known as 'aerosols'. This dry deposition is trapped on vegetation surfaces and then builds up in the soil. Soil is a natural buffer, and for a period of up to several decades, the soil shows only a very slow decrease in pH. Initially, plants may even grow slightly better as a result of the fertilising effect of nitrogen and sulphur. The first acidity problems show up in rivers and lakes, when the absorptive capacity of the terrestrial ecosystem becomes saturated, and the excess enters the river system. The concentration of nitrate and sulphate, as well as accompanying H^+ and Al^{+++} (which is toxic to plants and most aquatic organisms) in the water suddenly increases. Ameliorating this impact once it has begun, for instance by treating the rivers with lime, is extremely costly and may cause more harm than good.

Figure 8.3 Areas at risk from acid deposition in southern Africa. The highest risk categories are in red and orange, intermediate risk in yellow, and low risk in grey. The circled locations are immediately downwind of large emission sources, and are at high risk. Source: Cinderby *et al.* (1998).

There are two main centres of acid-forming emissions in southern Africa (Figure 8.3). One is in the Mpumalanga highveld region of South Africa, where coal-fired electricity generating plants, petrochemical and metallurgical industries are concentrated. The other is in northern Zambia and the southern Democratic Republic of Congo, associated with the smelters of the Copper Belt. While the greatest acid deposition occurs within a few hundred kilometres of the source, the combination of very tall smokestacks and the southern African gyre means that traces of the emissions can be detected throughout the region.

Where high amounts of acid deposition coincide with soils that have a low buffering capacity, for instance because they are already naturally acid, sandy or thin, the emergence of acidification and nitrogen saturation symptoms is inevitable in the long run. The high-risk area in Zambia is vulnerable because soils are already naturally very acid. The situation in the high-rainfall grasslands on the eastern escarpment of South Africa is aggravated by the planting of eucalyptus, pine and wattle trees. The plantation system acidifies the soil by exporting the balancing 'bases' from the catchment in the form of wood, while the trees are more effective than the original grasslands in trapping dry deposition.

The ecosystem, through its buffering capacity, provides a service by absorbing acid deposition. An economic measure of the magnitude of the service is the equivalent cost of fitting SO_2 removal equipment to electricity generating plants. This was estimated to increase the cost of generation by 17 to 22%, around US$12 billion. Relying on the buffering capacity of the ecosystems instead is only justifiable if this capacity is not exceeded; thereafter the costs in terms of damage to other ecosystem services, particularly water quality, are likely to rapidly exceed the benefits of avoided electricity generation costs.

The air-quality situation that currently causes the greatest damage to human health in southern Africa is 'indoor pollution', caused by inhaling smoke from domestic fires inside poorly-ventilated dwellings. The levels of carbon monoxide and particulate matter are often many times higher than the safety limits set by the World Health Organisation. Therefore expansion of electricity generation, even if it is based on the burning of coal, will have net benefits for human health. The increase in atmospheric concentrations of harmful gases from well-managed power plants is far less than the decrease in harmful indoor gases that follow the switching from wood or charcoal braziers to electricity. Other responses to this problem are also possible. For instance, more efficient stoves fitted with chimneys improve the indoor air quality, and if the wood is harvested sustainably (see Chapter 7), do not contribute significantly to greenhouse gas emissions.

8.3 WILDFIRES AND AIR QUALITY

Africa has been termed the 'fiery continent'. About half the land area burned globally is in Africa, and much of that is in the savannas (Figure 8.4). This has been the case for millions of years, with little evidence to suggest that overall it is more, or less, frequent now than in the past. More than three-quarters of the fires in southern Africa are ignited by humans, for reasons mostly to do with managing ecosystems for grazing, honey, agriculture and other ecosystem services. These fires are termed 'wildfires', since they are largely uncontrolled once lit. Humans are likely to have been the main lighters of fires in Africa for many millennia. If the land were not ignited by humans, it would sooner or later burn as a result of lightning ignition. The combination of a long dry season every year, and wet-season build-up of grassy fuel too unpalatable to be grazed, makes frequent fires inevitable in this environment. With the exception of the moist forests and extremely dry areas, fires are a natural and required feature of southern Africa's ecology. Without fire, the ecosystems change in structure, biodiversity and function, and therefore the package of environmental services that they deliver. For instance, if fire is excluded, most savannas and grasslands become unusable for grazing.

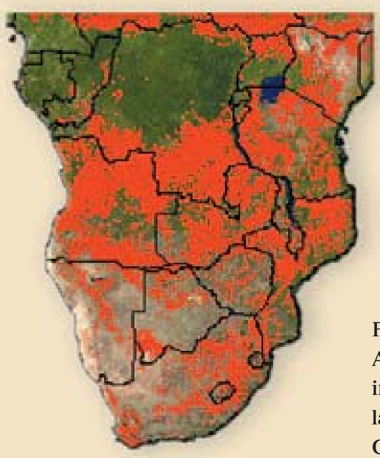


Figure 8.4: Fires detected by low-resolution satellite sensors over southern Africa during one year. The resolution of this image gives a misleading impression of the actual extent burned, which seldom exceeds a third of the landscape in any one year, even in the most extensively burned areas. Source: GBA2000.

The emissions from vegetation burning in southern Africa have a significant effect on both the regional and global atmosphere. Fires are a major source of many gases (Table 8.1). Since these ecosystems burn repeatedly without a change in the average land cover, there is no net emission of carbon dioxide from wild fires, unless the overall amount of biomass burned has increased over time. The 'gross' emission of between 0.3 and 2 billion tons of CO_2 per annum is absorbed within weeks to years by the regrowth of vegetation. The same is not true of greenhouse gases other than CO_2, such as CH_4 and N_2O; wildfires are a net source of these gases. Furthermore, the black smoke particles produced by wildfires absorb more solar energy than they reflect. Therefore fires in southern Africa act to warm the atmosphere to a small degree. Given the lack of information on fire frequency and intensity prior to the year 1750, it is unclear at this stage what fraction, if any, of this warming can be considered 'anthropogenic' in the sense of the UN Framework Convention on Climate Change.

The poor visibility and low air quality over much of the region on some occasions during the dry season is mainly a consequence of emissions from fires, often combined with dust from the dry soil. In addition, many lives are accidentally lost every year as a direct result of fires, along with damage to property and livestock. The challenge in southern Africa is to devise policies that recognise the inevitability of vegetation fires, and their benefits in terms of ecosystem health, while minimising their impacts on the climate, air quality and human well-being. Currently, most countries in the region have ineffectual laws for controlling wildfires. A new approach is needed; some of the key aspects are incorporated into the South African Veld Fire Act of 1998. The Act recognises the need for fires in managing ecosystems, but tries to limit the unintentional damage they cause. It devolves much of the responsibility for determining the appropriate fire management to self-organising local Fire Management Associations. In return, it offers a degree of legal indemnity and technical support at national level. The Act promotes the construction of firebreaks and the training of fire-fighting teams, while forbidding the lighting of fires in situations where the risk of dangerous, uncontrollable conflagrations is high.

9.1 THE ECONOMIC VALUE OF NATURE TOURISM IN SOUTHERN AFRICA

Tourism is one of the fastest-growing economic sectors in the world and in southern Africa. The part motivated by a desire to visit places of natural beauty is growing fastest of all (Fillion *et al* 1992). 'Nature-based tourism' includes a wide variety of activities, ranging from hunting to soaking up the sun on the beach, that have as a common factor a dependence on ecosystem services such as clean air and water, unspoiled scenery and attractive biodiversity. 'Ecotourism', defined as nature-based tourism that is sustainable and environmentally and culturally sensitive, is a subset of nature-based tourism (Wood 2002). 'Adventure tourism' is in many cases also dependent on natural features, and these activities form another subset.

This study estimates the aggregate value of nature-based tourism in southern Africa in the year 2000 to be US$ 3.6 billion (Table 9.1). This is based on direct tourism expenditures (i.e. what tourists spend in the country rather than what they are willing to pay for this experience) and represents approximately half the total tourism income in the region, the other half being contributed mostly by business travel and visits to family and friends (Figure 9.1). Tourism revenue is not evenly distributed around the region, nor is the proportion of nature-based tourism. The travel and tourism economy contributed 9% of the total GDP in SADC in the year 1999 (Krug *et al* 2002), varying from 5% in large, highly industrialised economies like South Africa, to 30% in Tanzania. In countries without large mineral resources, tourism is often the major source of foreign income (WTTC 1999).

Tourism arrivals and revenues in the counties for which data are available have been growing at rates between 10 and 30% per annum during the 1990s (Fillion *et al* 1992). The revenue-weighted average growth for the region is about 5% per year over the past decade. In the absence of comprehensive data, it is assumed that the fraction of total tourism arrivals and revenue contributed by nature-based tourism has been steady or increasing over this period.

Table 9.1: Measured and estimated nature-based tourism numbers and revenue for countries in southern Africa in approximately the year 2000. Where studies were not available, estimates were made by the authors of this report by extrapolating from other countries in the region.

	Nature tourism arrivals (thousands)			Income from nature tourism (million US$)			
	Non-African	*African*	*Domestic*	*Non-African*	*African*	*Domestic*	*Total*
Angola[1]	0.8	0.1	-	0.3	0.0	-	0.3
Botswana[2]	110.4	362.5	-	30.6	100.6	-	131.3
Burundi	0.0	0.0	-	0.0	0.0	-	0.0
Congo	0.0	0.0	-	0.0	0.0	-	0.0
Dem Rep Congo[3]	0.0	0.0	-	0.0	0.0	-	0.0
Equatorial Guinea[1]	0.0	0.0	-	0.0	0.0	-	0.0
Gabon	28.0	0.0	-	1.3	0.0	-	1.3
Kenya	552.8	201.6	0.2	178.2	65.0	7.5	250.7
Lesotho[1]	5.4	48.4	-	0.6	4.9	-	5.5
Malawi	18.4	91.0	-	2.2	10.8	-	13.0
Mozambique[3]	6.0	36.0	-	1.2	7.2	-	8.4
Namibia[1]	96.6	263.4	-	45.3	202.3	-	247.6
Rwanda[1]	1.7	0.0	-	2.7	0.0	-	2.7
South Africa[1]	1203.3	3425.6	5.6	504.4	1436.0	358.4	2298.8
Swaziland[1]	77.3	166.6	-	15.9	11.0	-	27.0
Tanzania[1]	203.7	0.0	-	299.9	0.0	-	299.9
Uganda	28.0	92.8	-	27.6	91.6	-	119.2
Zambia[1]	137.6	321.6	-	21.8	51.0	-	72.8
Zimbabwe[1]	358.4	1136.0	-	34.4	109.1	-	143.5
REGION	**2828.4**	**6145.6**	**-**	**1166.4**	**2089.5**	**-**	**3622.0**

- No data
Sources: Adapted from the following: (1) WTO (2001), (2) Botswana Tourism Development Programme (2000), (3) KPMG (2002).
Expenditure figures extracted from the African Development Indicators Database (Worldbank 2003).

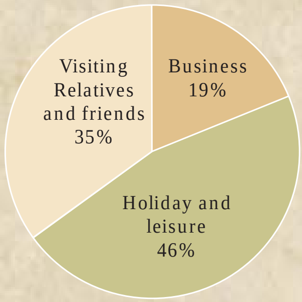


Figure 9.1: Motivation to travel. In terms of holiday and leisure travel, 'Nature-based' motivations (wildlife-viewing, hiking, scenery, flowers, beach holidays, hunting) dominate over non-nature based motivations for both domestic and international visitors in the 'holiday and leisure' category. This graphic is a synthesis of data from several countries in southern Africa.

It is useful to compare income from nature-based tourism to the income generated from other main ecosystem services-based sectors: agriculture, forestry and fisheries. Assuming that nature-based tourism is half of all tourism, and excluding the manufacturing sector knock-on effects of agriculture, forestry and fisheries, the contribution by nature-based tourism is nearly equal to the other natural resource sectors combined. Importantly, those sectors are growing slowly (1-3% per annum) while tourism is growing rapidly (5-15% per annum).

Thus the balance of policy drivers in relation to natural resources is likely to shift over the next decades, from being strongly influenced by the needs of agriculture, forestry and fishing, to being more influenced by considerations of conservation and aesthetics. The dominance of industries based on non-renewable resources, such as mining and oil extraction, must in the long-term decline, but is likely to remain high over the next quarter century. A key trade-off is between the social benefits that such sectors offer now, and the long-term benefits that may be afforded by nature-based tourism.

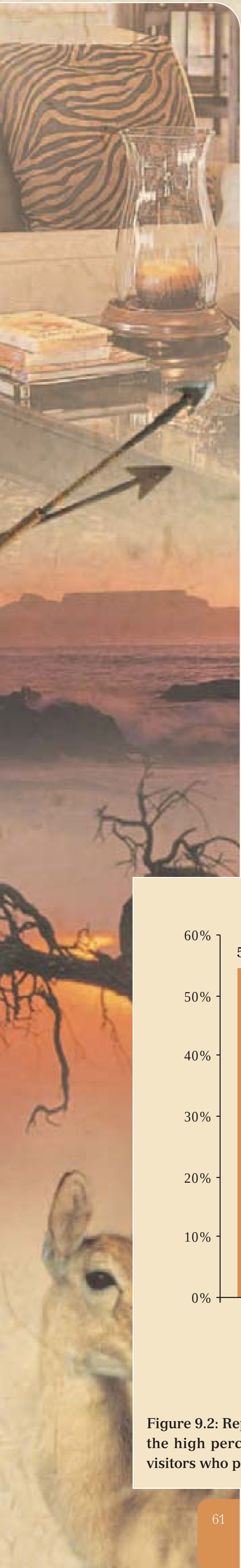
A major fraction of the nature-based tourism in South Africa is based on the domestic market, whereas in other countries in the region the foreign market (i.e. African and non-African) dominates. This difference cannot be ascribed to absolute differences in the cost of accessing national parks (Table 9.2), as the cost for citizens of a country is similar in all cases, although the cost to foreign nationals varies greatly. Affordability relative to disposable income and the other costs of reaching natural areas may be a factor, but social factors (such as the proportion of urban people, and time for which they have been urbanised) are probably equally important. It is anticipated that domestic demand for nature-based tourism will grow throughout the region, and especially under the Partnership scenario (Chapter 3), with its implied growth of middle-income, urbanised populations.

While a substantial and growing fraction of nature-based tourism, particularly in South Africa, is coupled to private conservation areas, there remains a crucial role for state-owned protected areas. National parks generally provide the nucleus around which private and community-based nature-tourism activities cluster. Non-statutory institutions cannot guarantee the stability of protection over time that state-owned protected areas offer.

Table 9.2 Costs for two people in one vehicle to enter and stay for three nights in formally-conserved protected areas in southern Africa during November 1998. Adapted from Krug (2000).

	Non-residents (US$)	Non-national residents (US$)	Citizens (US$)
Eastern Africa			
Kenya	130	22	16
Malawi	105	-	-
Tanzania	150	150	10
Uganda	86	53	10
Southern Africa			
Botswana	68	14	4
Namibia	29	29	14
South Africa	15	15	15
Zambia	112	22	17
Zimbabwe	30	30	2

-No data



9.2 WHAT DETERMINES THE NATURE TOURISM SERVICE?

It is clear that many factors are involved in determining the size of the nature-based tourism service in particular countries or regions: the quality and extent of natural assets, ease of access to these assets, and perceptions by the visitor of risk to personal safety and health are among the main ones. The countries that attract the greatest number of foreign nature tourists in southern Africa offer a diverse range of assets to visitors. Many tourists return to visit such countries on multiple occasions (Figure 9.2). Nonetheless, even countries with meagre natural assets, poor access and high perceived risk continue to attract at least some nature-based tourism.

The connection between natural assets and tourism potential is very obvious for spectacular natural features, such as the Victoria Falls on the Zambezi River, or Table Mountain in Cape Town. In other cases, the qualities of the landscape, rather than any individual feature, are crucial: the Namib and Kalahari deserts, the Okavango Delta and the tropical Indian Ocean coast are examples. Topographic variety and a sense of wilderness are often contributing factors.

The relationship between biodiversity (i.e. the variety of living things) and nature tourism is more obscure. Positive links between biodiversity, protected landscapes, and tourism do exist, but they are seldom direct and immediate. The compositional and structural aspects of biodiversity (i.e., what is there, and what it looks like - see Box 4.1, page 15) seem more important in this context than the functional biodiversity aspects that underpin most other ecosystem services.

For the great majority of visitors biodiversity is adequately represented by a small number of 'charismatic' species. For wildlife areas in southern Africa, the presence of the 'big five' (lion, elephant, rhino, buffalo and leopard) is an important factor that had its origin in the danger involved in hunting these animals, but is now perpetuated by marketing. The Serengeti is famed not for the high diversity of antelope that occur there, but for the millions of individuals of just two species: migrating wildebeest and zebra. Similarly, tourists viewing the spring flowers in Namaqualand (Succulent Karoo) are more attracted to the massed displays of a single variety of daisy than the unique variety of insignificant but rare endemic succulents and geophytes. For specialist groups such as birdwatchers or botanists, however, the variety of life itself is the attraction.

Even an unspecialised market discerns between an obviously unnatural experience (such as a zoo, or a peri-urban wildlife park) and an apparently natural experience in a larger and more remote protected area. Tourists are attracted to Africa for the latter: 61% of all tourists to the region visit at least one game or nature reserve during their stay (Spenceley 2001). Furthermore, the existence of 'flagship' species such as elephants in the wild both requires, and creates the conditions for, the existence of a wide range of other biodiversity.

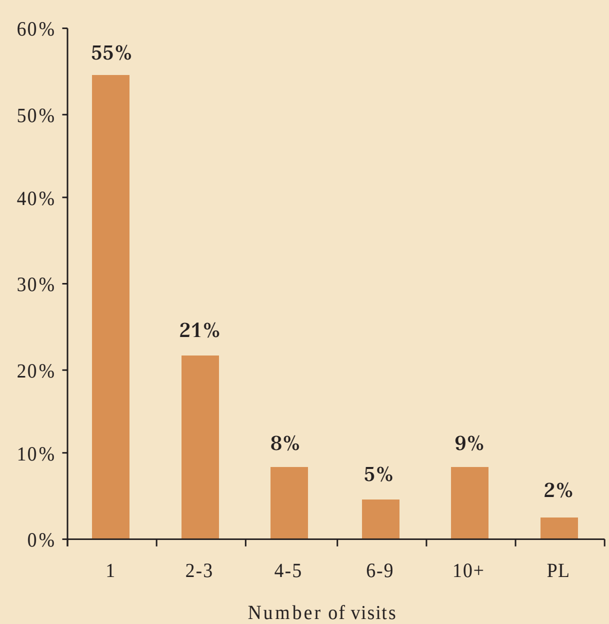


Figure 9.2: Repeat rate of foreign tourists visiting South Africa, showing the high percentage return to visit this country. PL indicates return visitors who previously lived in South Africa. Source: SA Tourism (2003).

9.3 WHO PAYS, AND WHO BENEFITS?

The gross income from tourism does not represent the net social benefit of the nature-based tourism sector to society. Firstly, the direct and indirect costs must be subtracted from the total (true) income to reveal the margin. The true income may be somewhat higher than the direct income, allowing for knock-on effects, and must be corrected for taxes and subsidies. The indirect costs include, amongst others, the costs of building and maintaining airports and roads to service the sector, the cost of establishing and maintaining a protected area system, and the externalised costs of dealing with environmental and social impacts resulting from tourism. Since the full cost and benefit of these activities cannot be ascribed solely to the tourism sector, estimating the indirect cost is difficult.

Under favourable conditions, such as are found in a number of well-documented cases in the region, it is clear that the net financial benefit to an enterprise is positive, and in these cases nature-based tourism is often the most profitable use of the land or resource (Barnes 1995, Barnes *et al.* 1999, Barnes *et al.* 2001). However, this is not always the case. Many smaller or less-attractive protected areas operate at a loss, and are cross-subsidised by more successful protected areas. The failure rate for tourism ventures in southern Africa is high. The net economic benefit, which is calculated at a scale much greater than the individual enterprise, and includes costs and benefits borne by society as a whole, is believed to be positive in many cases, especially when compared to highly-subsidised land uses in areas of low productive potential (Table 9.3).

Table 9.3: Comparative financial and economic rates of return of wildlife-based versus cattle ranching enterprises in the south-eastern Kalahari, Botswana, illustrating the effect of government subsudes (Barnes 2001). Financial rates of return give an indication of the private incentive for investment in an activity, while the economic rate of return considers the total effect on the welfare of society.

	Beef*- Subsidies	Beef*- No subsidies	Game**- No subsidies
Financial Rate of Return	8.8%	2.0%	5.9%
Economic Rate of Return	2.3%	2.3%	6.6%

* Beef breeding and rearing for production of slaughter steers
** Mixed-species game ranching for safari hunting and biltong production

Secondly, the distribution of costs and benefits between foreign and local recipients, and between local people and urban elites must be considered. In the worst cases, the brunt of the costs, such as denial of access to traditional resources such as grazing, crop lands, wild foods and water, are borne by local people, who are often relatively powerless. The bulk of the benefits are often enjoyed by foreign owners of up-market lodge facilities, middlemen in the tourism market chain (e.g. travel agents, frequently in the country of origin of the visitor), and by the foreign and domestic urban elites who are the main users of the service. The fraction of the sector turnover that accrues to local people can be as low as a few percent (UNEP 2002c, Mbaiwa 2003).

In best-practice examples, the costs to local people are minimised by negotiated access, and the benefits are spread by joint-ownership (Figure 9.3), profit-sharing, preferential employment, associated enterprises (e.g. craft industries, cultural entertainment) or outsourcing schemes (e.g. vegetable growing, transport to airports). There have been a number of more-or-less successful experiments in community-based provision of nature tourism (e.g. the Campfire programme in Zimbabwe, the Himba in Namibia, the Maluleke and Mier communities in South Africa, and Wilderness Safaris in Botswana), and probably an equal number of less-publicised failures. Key factors associated with success or failure are the mechanism for joint ownership and distribution of benefits to the community (including defining who comprises the community), the level of entrepreneurial and management skills available, and the presence or absence of supportive policies at the national level. A key constraint is the policy disconnect that often exists between biodiversity agencies and tourism authorities, at all levels from the region down to the local implementation.

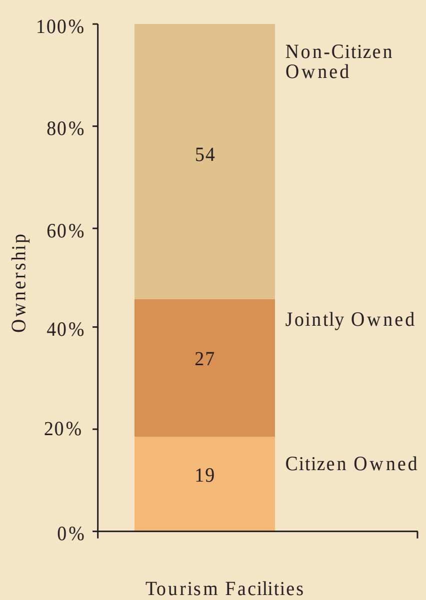


Figure 9.3: Ownership of 65 tourism facilities in the Okavango area of Botswana. Source: Mbaiwa (2003).

There is some debate regarding whether labour costs should be included or excluded from the calculation of net social benefit. In the context of high unemployment, where the support of the unemployed is a direct or indirect cost to society, it can be argued that at least this part of the labour cost should be excluded. Labour makes up a large part of the cost of nature-based tourism, and is regarded as one of its main development advantages. It is estimated that one tourist-day creates eight job-days. Jobs in tourism, while mostly not high-skill or highly-paid, are preferred to the available alternatives, which are usually either unemployment or low-paid agricultural manual labour. If the returns to labour are factored as a benefit rather than a cost, the net social benefit of nature-based tourism is greatly increased. The danger of including returns to labour as a benefit is the creation of state-subsidised tourism that is uncompetitive without ongoing support.

9.4 THE LIMITS TO NATURE TOURISM

To how many people can ecosystems provide recreational, spiritual or aesthetic services before the basis of those services is undermined? The answer is obviously dependent on the service being provided, the environment providing it and the person receiving it. At the one extreme is the small fraction of nature-based tourists who are specifically looking for a 'wilderness experience'. Such tourists require relatively large areas (in order of magnitude terms, greater than 100 km^2 and a user density of less than 0.1 persons per km^2). At the other extreme are people for whom being part of a crowd creates a buzz of excitement. Much beach or water-associated tourism fits into this category, and visitor densities of 1 to 10 persons per km^2 are common. The dependence of this type of tourism on ecosystem services is limited to having clean water, a nice view, a litter-free environment and good weather. The bulk of the nature-based tourism in southern Africa falls between these extremes.

The capacity for nature-based tourism

Several studies of nature tourism in southern Africa have indicated that a high consumer surplus is associated with visits to wildlife parks, particularly for foreign tourists. This surplus is often ignored (i.e. not captured) and thus tourists pay less for a particular experience than they would be prepared to. For example, a study undertaken by Brown et al. (1995) using the travel cost and contingent valuation method found that the consumer surplus per foreign tourist visitor to Kenyan parks amounted to between US$330 and US$850. In other words, the consumerís willingness-to-pay is significantly higher than the fees charged. Similar findings have come from studies in Namibia and Botswana (Krug *et al*, 2002; Barnes, 1996; Barnes *et al*. 1999). This is the basis for the growth of private conservation land, privatisation of service delivery in state parks, and the two-tier entrance fee structure that is now commonplace.

Our preliminary analysis suggests that nature-based tourism will be absorptive-capacity limited, rather than demand-limited in the future. Figure 9.4 can be used to estimate the 'carrying capacity' of visitors in southern African wildlife-related destinations. It is assumed that the upper envelope of this relationship, excluding clear outliers, represents the empirically-determined limit for this type of nature tourism. Multiplying this value (roughly one visitor per km^2) by the protected area in southern Africa (0.76 million km^2 of strict state conservation, and a further 0.87 million km^2 in less formal arrangements) and by 365/7 (assuming the average nature tourist spends about a week a year in nature areas) gives an approximate 'capacity' in southern Africa of 39 to 84 million wildlife-related tourists per year. The current number of tourists is about nine million (Table 9.1).

If nature-based tourism grows at 15% per annum, an upper estimate based on past experience, and consistent with the Partnership scenario (Chapter 3), the combined number of domestic and foreign tourists would exceed this notional limit in 2013, at which stage southern Africa would be the destination for about 6% of world tourism.

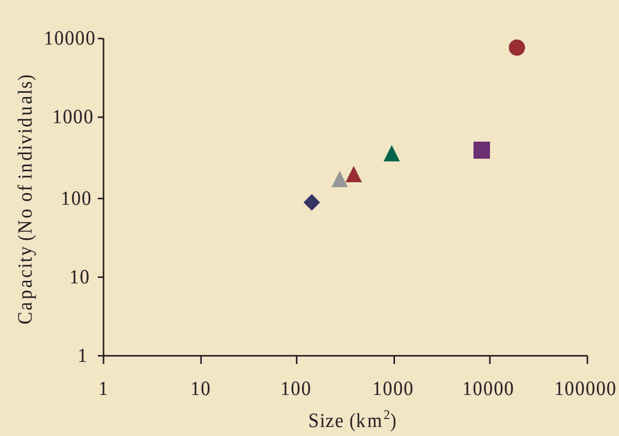


Figure 9.4: Maximum number of tourists that can be accommodated at any one time relative to the size of several wildlife parks in the region.

Scenarios for nature-based tourism

Economic growth under the Partnership Scenario (Section 3.3) is projected to be about 6% per annum. Thus by 2015, the contribution by tourism (all types) to the economy of the region would have risen from the current 9% to 28%. Assuming that nature-based tourism continues to constitute half the total tourism revenue, it would be by far the largest sector directly based on ecosystem services. For this scenario to be realised, the policy priority afforded to nature-based tourism, and the scenic beauty, biodiversity and environmental qualities that underpin it, would need to equal that given to industrial and agricultural development.

The Patchwork scenario (Section 3.2) holds a number of negatives for nature-based tourism, the main ones being the perception of risks to health and security among foreign visitors, the slow growth of the domestic market, and possible encroachment on protected areas by the rural poor. Nevertheless, nature-based tourism is likely to grow at double the rate of 2% per annum projected for the general economy under this scenario. At a growth rate of 4% per annum, nature-based tourism would reach only half of absorptive capacity of the protected area service by 2025, but would nevertheless be an important economic sector overall (8% of the economy versus the current 4.5%).

Managing for wilderness tourism

Measures of ‘wildness’ reveal few truly uninhabited areas in southern Africa, without roads or other infrastructure, except in deserts and areas of dense forest (Figure 4.8b, page 26). The desire to have areas free of human influence sometimes misses the point that the ‘wild’ landscapes of Africa are the consequence of human actions over a period of millions of years. It is hard to make an economic case for wilderness based on tourism alone, unless the access fees are extremely high, which makes wilderness a privilege of the wealthy. The wilderness concept is compatible with mountain catchments, where disturbance is minimised in order to protect water quality; areas of extremely low production potential (less than 200 mm rainfall per year); or places where areas must be set aside for the protection of disturbance-sensitive species.

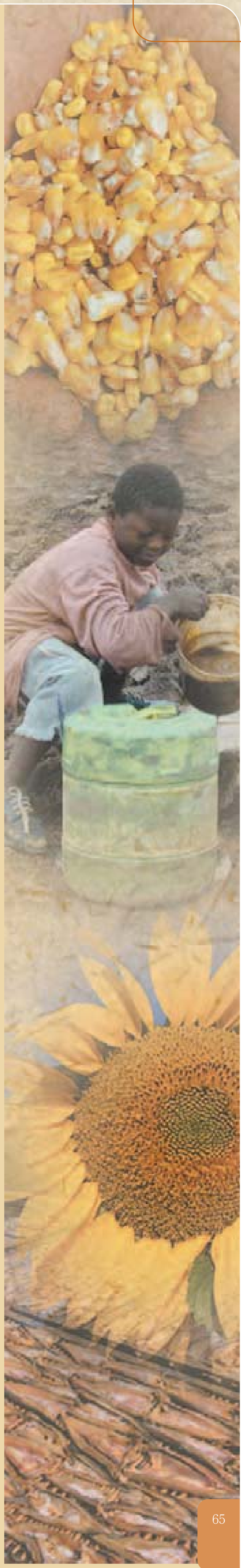
Perceptions of wilderness can be managed. For example, the Kruger National Park in South Africa rates higher in terms of standard wilderness metrics (e.g. population density or road density) than the immediately adjacent private wildlife areas, but visitor perceptions are typically the opposite. The visitor density in the Kruger National Park averaged over the year is about 0.28 persons per km^2, but the majority of visitors are confined to a network of 1863 km of roads and 21 large camps. In the immediately adjacent private wildlife areas, visitor density is three times higher, but visitors are accommodated in a large number of small facilities (15 to 30 beds each) designed to appear rustic while offering a high level of luxury. Visitors are guided in small groups over a dense network of tracks, with travel coordinated so that vehicles seldom catch sight of one another. The tourism income per unit land is one hundred times higher in the latter model (Engelbrecht & van der Walt 1996).

Negative impacts of nature-based tourism

Nature tourism is often portrayed as a ‘pollution-free industry’. While it is not as obviously damaging to the environment as mining or heavy industry, it can have negative consequences that undermine its own viability. In particular, the treatment of sewage and other wastes in sensitive environments is a key issue, requiring the setting and enforcement of strict disposal standards.

‘Visual pollution’ results from inappropriately designed and poorly-sited developments in an area where scenic beauty or a perception of wildness is a key part of the attraction. It is hard to reverse once it has occurred. The best protection is a thoughtful, participatory, pre-emptive spatial development plan, and the greatest threat is the risk of corruption of local officials responsible for the enforcement of such a plan.

More difficult to assess is the effect of large numbers of visitors on traditional cultures. The opportunity to be exposed to different cultures is an important component of foreign tourism in Africa, but has the potential to destroy its own base. Tourism can be associated with increases in prostitution and theft, but so can the lack of economic opportunity. Giving local people a meaningful say in the type and amount of tourism that occurs in their area is probably the best way to get the balance right.



10. Synthesis: Ecosystem services in southern Africa

10.1 ECOSYSTEM SERVICES AND HUMAN WELL-BEING IN SOUTHERN AFRICA

The nations of Africa south of the equator are amongst the poorest and least developed in the world. Indicators of human well-being, such as the Human Development Index (HDI), show that the people of this region are among the most disadvantaged on the planet. The average population-weighted HDI for the region is 0.46 (with a corresponding mean rank of 150 out of 175), which places southern Africa as a whole in the UNDP,s 'Low Human Development category' (see Table 2.2, page 5). Human well-being in southern Africa shows significant variation, both between and within countries, between urban and rural areas, and between different sectors of society. The highest-ranked regional country in terms of the HDI is South Africa (0.68, ranked 111th) and the lowest is Burundi (0.34, ranked 171st).

Human well-being depends on ecosystem services

There is a strong interaction between human well-being and the state of ecosystem services in the region. Many elements of human well-being are directly dependent on the products of ecosystems. Food, water and biomass energy are prime examples. Human health is reliant on adequate nutrition. The provision of food by agro-ecosystems is well documented, but the role of foods harvested from natural ecosystems is underestimated. These are critical for the well-being (and even survival) of most rural people in southern Africa, especially in times of climatic or economic hardship.

Human health furthermore depends on clean water for consumption and sanitation, clean air, and enough domestic energy for heating and cooking. The sensitivity of humans to the continued sufficient supply of these services is heightened in the face of diseases such as malaria, HIV/Aids and tuberculosis. Among other things, the ability to avoid infection, and to survive if infected, is strongly linked to nutrition and environment.

Other aspects of human well-being, such as the ability to earn an income that permits access to the basic material for a good life, are also often directly or indirectly linked to ecosystem services. The income from nature-based tourism, which is largely based on the spectacular biodiversity in southern Africa, is an example.

The dependence of people of all cultures and socio-economic standing on ecosystems for less tangible benefits, such as cultural, spiritual, recreational and aesthetic services, is strong and universal. This is demonstrated within southern Africa at all scales of analysis. At the regional scale it manifests as a seemingly insatiable demand by relatively wealthy, often urban or foreign-based people for nature-based tourism. At the local scale it is manifest, for example, as traditional protection of sacred groves and pools. The political and economic power of these 'intangibles' should not be underestimated, although they are difficult to quantify.

Sustainable development is linked to sustaining ecosystem services

While the definition of sustainable development remains ambiguous and disputed, formal declarations are converging on a minimal definition that includes meeting human needs, such as reducing huger and poverty, while preserving the life support systems of the planet (Parris and Kates 2003). Over 500 efforts have been devoted to developing quantitative indicators of sustainable development (IISD 2000), but currently no indicator sets are simultaneously universally accepted, backed by theory and rigorous data collection, and influential in policy. While indicators vary in the detail of their results, there are broad correlations between measures, at least when countries are compared within a regional context (Figure 10.1). This provides hope that it is possible to agree at least on what does not constitute sustainable development. Of the indicators presented in Figure 10.1, the highest correlation (44%) is between the Environmental Sustainability Index and the Well-being Index. The correlation is statistically significant and underscores the main point of this report: Human well-being is related, substantially but not exclusively, to the state of ecosystems.

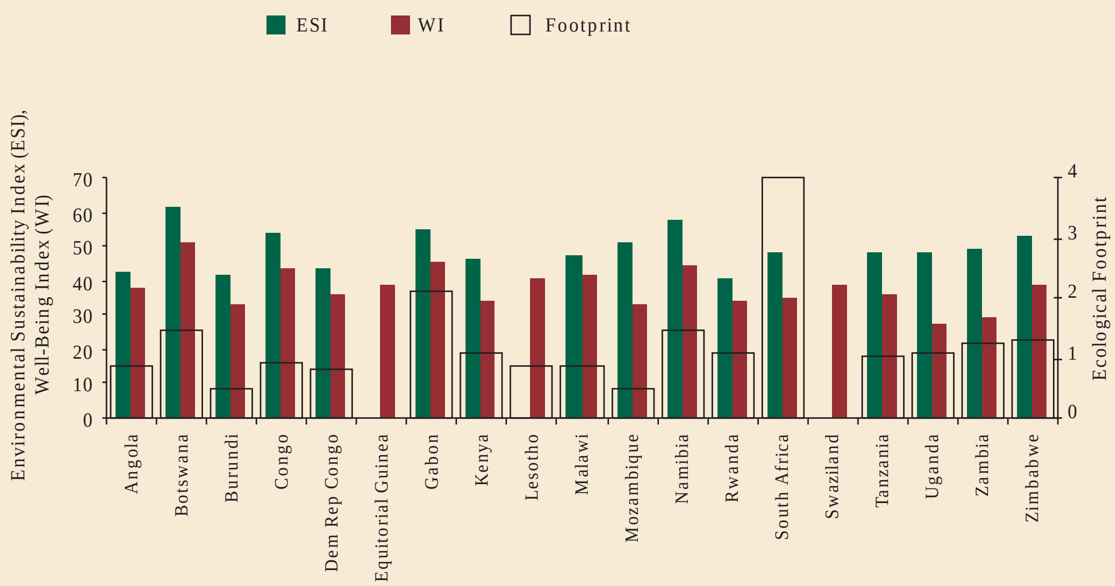


Figure 10.1: A comparison of three indicators of sustainable development, the Environmental Sustainability Index[1] (ESI) (World Economic Forum *et al.* 2002), the IUCN-sponsored Well-being Index[2] (WI) (Prescott-Allen 2001), and the Ecological Footprint[3] (Wackernagel *et al.* 2002). These indicators are generated by global groups, using globally-available data, but quantified for individual countries.

Maintaining ecosystem services requires effective institutions

There is a feedback from human well-being to ecosystem services that can cause their mutual interaction to enter either a 'virtuous' or 'vicious' spiral, depending largely on the institutions that govern the relationships between people and ecosystems. On the positive side, there is evidence that as people become materially better-off, their ability to create effective institutions to protect ecosystem services increases.

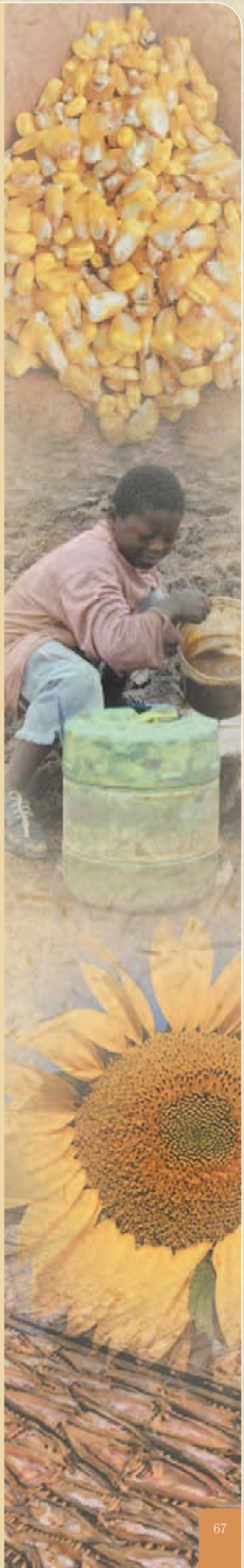
On the other hand, where people have little recourse to alternate sources of income, food, fuel or medicine, they draw on the 'natural capital' of their environment. Up to a point, this need can be satisfied without degrading its long-term potential, but beyond that point the ecosystem's capacity to deliver the service (and others that may be inadvertently impacted) is impaired, sometimes permanently.

Unless some regulating mechanism exists to keep demand within limits, the result is ecosystem degradation. Traditionally, these mechanisms were local-scale institutions that restricted access to and use of resources. Over the colonial and post-colonial period, many local mechanisms were replaced by national-scale institutions, with varying degrees of effectiveness. As novel threats arise, such as global climate change or conflict over water in internationally shared river basins, for which neither local nor national institutions have tried-and-tested responses, there is an additional need for regional-scale and international institutions. A key challenge at the regional scale is to ensure that these mechanisms are effective.

[1] Measure of overall progress towards environmental sustainability, based 20 core indicators and 68 underlying variables. Highest is Finland (73.9) and lowest is Kuwait (23.9).

[2] Average of Human Well-being Index and Ecosystem Well-being Index.

[3] Sum of cropland, grazing, forest, fishing, energy and built-up land footprints.



10.2 HOW ARE ECOSYSTEM SERVICES IN THE REGION DOING?

Viewed at the regional scale, southern Africa is in a declining, but not yet irrecoverable state with respect to ecosystem services. In places where services are in critically limited supply (such as water over the southern half of the region, and food over the northern half), the fundamental capacity to generate the service remains largely intact. Widespread, irreversible damage has not been incurred to date, but is possible under scenarios of increasing demand for ecosystem services coupled with inadequate ecosystem protection and management. There are many examples of local-scale degradation (Figure 10.2), and without focussed intervention these could spread and coalesce into a general syndrome of ecosystem service failure.

Freshwater

The region as a whole has an abundance of freshwater, mostly in an unpolluted state, but the distribution of the resource does not match that of demand: The major water supplies lie in the north of the region, while much of the demand is in the south. Many rural people, including those living in small rural towns, are dependent on groundwater, which in many places is being used at a rate that exceeds its recharge. Southern African nations are acutely aware of the problems of water availability, and have already initiated a range of national and international measures to address them. Continued and intensified coordinated action will be needed to avert deepening problems in the future, and to meet Millennium Development Goals 4 and 7 (Box 2.2, page 6).

Water quality is a critical issue throughout the region, but for differing reasons. In the southern part, heavy demands on limited water supplies means that the quantity left in the rivers is inadequate to dilute and flush away the salts, sediments, nutrients, pathogens and pollutants that drain there from industry and agriculture. In the north, non-existent or dysfunctional sanitation systems allow the water bodies to become polluted with pathogens. Uncontrolled agricultural runoff and sewage raises the nutrient levels to the point where major changes in lake ecosystems occur, including outbreaks of aquatic weeds and loss of important fisheries.

Food and nutrition

Southern Africa has sufficient biophysical potential to grow enough food for its population, even in the face of climate change and population growth, and with a generous margin to spare for export or non-food cash crops. However, the region does not currently produce enough protein or carbohydrates to meet the basic nutritional needs of its people, and the deficit is getting larger as the population grows. Meeting Millennium Development Goal 1 (Box 2.2, page 6) on hunger reduction will not occur without decisive intervention.

Biodiversity

Southern Africa has a biological diversity that is disproportionate to the fraction of the Earth's surface that it occupies. With notable and predictable exceptions, this biodiversity is largely intact. The exceptions are important, but constitute a relatively small subset of organisms that have one or more of the following attributes: they are valuable; they are perceived as a direct hazard to humans, their crops or livestock; or they occur in localised environments that are well-suited for agriculture, human settlement, or dams.

The future integrity of biodiversity, with its direct and indirect links to human well-being, is threatened by ecosystem degradation, habitat transformation, and uncontrolled harvesting. Degradation occurs through overgrazing, over-cutting of fuelwood and destructive fishing techniques, such as the use of dynamite. Habitat loss is largely due to agriculture and human settlement. The threat from climate change is potentially large, but currently poorly predictable.

Southern Africa has a relatively large fraction of its land in protected areas in comparison to other parts of the world. A key future response will be biodiversity-compatible management of the ecosystems outside protected areas; and in particular, the prevention of ecosystem degradation.

Nature-based tourism

Nature-based tourism, which in southern Africa has biodiversity and natural features as its main drawcards, is rapidly becoming a powerful economic sector. It has scope to grow much larger, but also has the potential to undermine its own basis by overcrowding, insensitive development and pollution. Ecosystem management policies, which were historically driven by largely rural-based sectors such as agriculture and forestry, will need to take into account the needs and priorities of urban (and often foreign) people if the value of this ecosystem service is to be fully realised.

Biomass fuel

Biomass fuel, in the form of wood and charcoal, is the dominant domestic energy source in the region, and for several countries, the main energy source overall. While its fractional importance as an energy source is likely to decline over time, absolute demand will rise over the next quarter century. The severe local shortages experienced in well-defined parts of the region will expand and intensify. In Africa, woodfuel harvesting is not the main driver of rainforest loss, but is in many places an important factor in woodland degradation. Traditional methods of burning fuel and making charcoal have severe negative impacts on human health and the regional atmosphere that could be addressed by modest technical interventions.

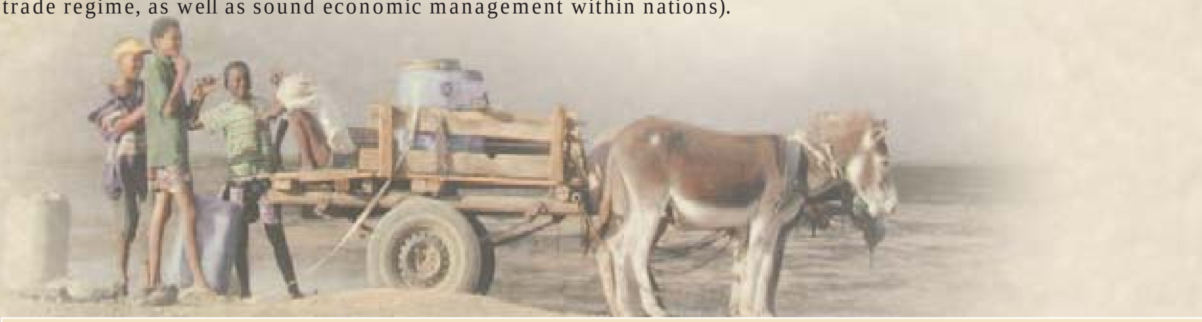
Air

The capacity of the regional atmosphere to absorb and disperse pollutants is limited by the nature of its circulation, and the seasonal naturally high concentration of lower-atmosphere ozone. Development paths that lead to the emission of large quantities of ozone-forming substances will have negative consequences for human and ecosystem health.

Trade-offs and synergies

Food, water and biodiversity have strong linkages that lead to important tradeoffs and potential for mutual benefits. Expansion of agricultural land to satisfy the region's food needs is the factor most likely to accelerate biodiversity loss in the medium term. On the other hand, intensification of agriculture on a smaller cultivated area runs the risk of using even a greater fraction of the scarce water resources than it already does, and polluting what remains with salts, sediment, fertilisers and pesticides.

A sustainable pathway to the future, in other words one that does not commit the future to being like the past, but keeps the choices and options available to future generations as wide as possible, requires careful balancing of the trade-offs between food, water and biodiversity. The capacity to strike such a balance depends strongly on policy choices outside the direct realm of ecosystem management. It requires effective and accountable governance at all levels; an educated population; and adequate economic growth (implying a fair international trade regime, as well as sound economic management within nations).



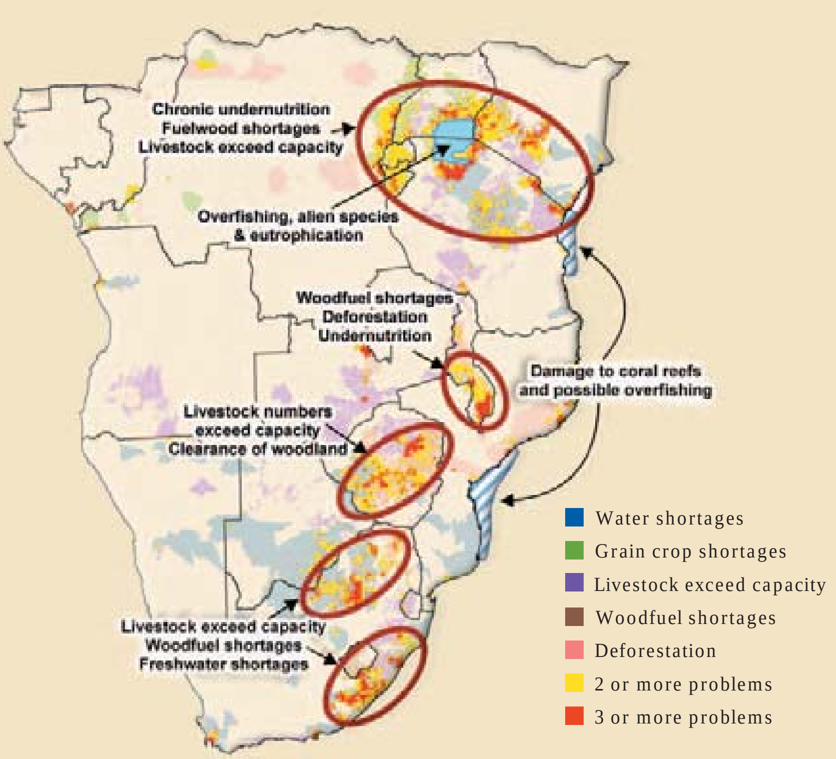
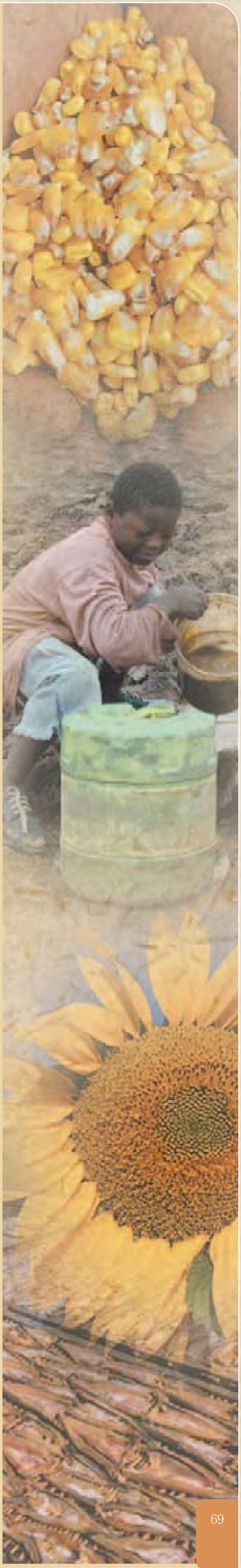


Figure 10.2: A synthesis map illustrating the main ecosystem service issues of high concern, as identified in this study. Note that in several areas there are multiple problems, often interconnected. This is a manifestation of a downward spiral of poverty, declining ecosystem services, and deteriorating human well-being. The correspondence between areas of ecosystem service loss and social conflict is suggestive of a link between these two issues, which are usually treated independently. The link could go in either or both directions: conflict creates conditions promoting ecosystem degradation, or environmental resource depletion could be a cause of conflict.



10.3 THE FUTURE OF ECOSYSTEM SERVICES IN SOUTHERN AFRICA

This study compared two scenarios spanning the next three decades. The scenarios share many features: both acknowledge that southern Africa will be affected by, but remain peripheral to global trade (but not unaffected) over this period; that the population, despite the effects of HIV/AIDS, will increase and become increasingly urbanised; and that the climate will be somewhat warmer and rainfall probably more variable. The principal difference between the scenarios centres on the degree to which cooperative governance becomes established at national and supranational levels and affects the management and use of ecosystem services.

The African Partnership scenario

In the African Partnership scenario, democratic and effective national governments are established in the majority of countries and there is a high degree of regional cooperation. Foreign investment follows, along with technology transfer and the growth of markets, leading to per-capita income growth. There is little doubt that this scenario would lead to net increases in human well-being in the region by all commonly-accepted measures. However, there are several ecosystem service-related issues that could, if not addressed, thwart this development path. The first relates to water supply: Intensified agriculture, urban growth and industrial development will all put substantially increased demands on water resources and greater loads on water quality. New institutions and regulatory frameworks will have to be established to deal with the inevitable issues of socially optimal allocation, water demand and supply management and the protection of water quality. Similarly, the threshold of unacceptable air quality is likely to be exceeded in more places, more often, and expose more people to harmful effects than in lower-growth scenarios. Applying known technologies and mechanisms to avoid severe deterioration of air quality will require international cooperation and the effective application of air quality standards at local level. The third key ecosystem service that requires attention to realise this scenario is the protection of biodiversity, which through nature-based tourism, is one of the key engines of economic growth. There is a real risk of killing the goose that lays the golden egg: Coastlines, rivers, scenic areas, forest and wildlife resources all need protection, partly from the effects of tourism itself. This can only be achieved, in the long term, if the flow of benefits to local people is effective, visible and assured.

The African Patchwork scenario

African Patchwork imagines a situation where many, but not all, national governments within the region are ineffective in delivering basic services, such as education, water, sanitation, and infrastructural linkages to the wider world, to the majority of their people. Economic growth is barely faster than population growth, and growing food needs are mostly met by clearing more land rather than increasing production on existing cultivated land. Air and water quality in urban areas is dire. In contrast, in rural areas, life is likely to continue much as it always has, with a great emphasis on local self-reliance. Food security at a regional scale remains precarious, but paradoxically could become less subject to the vagaries of international markets and the destabilising effects of pests. Land degradation through unsustainable grazing and cropping practices expands, particularly in marginal areas that have high human populations. Tropical deforestation continues, largely unlawfully, and large zones devoid of fuelwood surround many urban areas. Some elements of biodiversity notably large mammals and edible and commercially valuable species – suffer. Under this scenario, most countries in the region would remain in the bottom quarter of global human development rankings. This scenario is not desirable from either an ecosystem or human point of view, but is also not without potential for mitigation. Because of the limited capacity of national governments to either regulate or deliver services, response options in this scenario have a greater weighting towards local and non-governmental institutions, on the one hand, and responsible development assistance, market and resource extraction (for example fisheries and forests) policies on the part of the international community on the other.

Southern Hemisphere Africa's future development path

In caricature, the two scenarios can be thought of as a high efficiency, low resilience state and a low efficiency, high resilience state respectively. Each has its particular benefits and problems. A unifying feature is that both require explicit consideration of the role of ecosystem services in sustaining human well-being. It is likely that the southern African future will contain elements of both scenarios, within different countries and even between districts within single countries. Nonetheless, Africa at the beginning of the twenty-first century stands at a fork in its development path. One road promises rising living standards, but if the foundation of ecosystem services is not protected, could eventually peter out in potholes. The other road travels familiar territory, picturesque in places, but nevertheless mostly downhill in terms of both human aspirations and the opportunities to harness the rich heritage of African natural resources.

10.4 WAS A REGIONAL-SCALE ASSESSMENT USEFUL?

The regional study of SAfMA is aimed at improving decision-making at national to regional scales in southern Africa. Many policies with far-reaching implications for ecosystem services are made at these scales, by national governments and supra-national bodies. Furthermore, many ecosystem processes occur at a regional scale, such as the migration of species and the movement of water and air, and pay scant heed to national boundaries. Even ecosystem services that vary at a much more local scale (for instance, food, fuelwood and biodiversity can differ substantially over distances of less than 10 km) are influenced by processes and factors operating a much larger scales, making a wider perspective essential. Key insights regarding the relationship between ecosystem services and human well-being as contributed by the regional scale assessment are highlighted in Box 10.1.

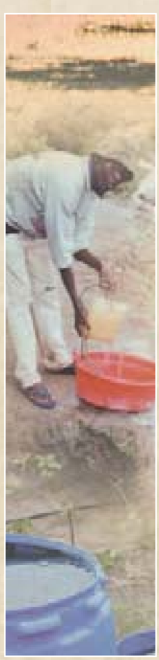
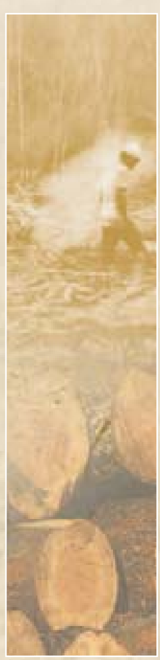
Broad-scale studies such as this have been criticised for averaging over local variation, and thus reaching conclusions that do not match realities on the ground. A distinction needs to be drawn between the scale of reporting (in this case regional, with detail at the national level), and the resolution of the observations and calculations used to reach those aggregated measures. Advances in process understanding, observing systems, databases and computational power make it possible, for some services, to estimate their condition at a resolution approaching the basic pattern on the ground, even over areas as large as the entire southern Africa. This capability does not replace the need for local assessment, but can supplement it and help to target more detailed studies.

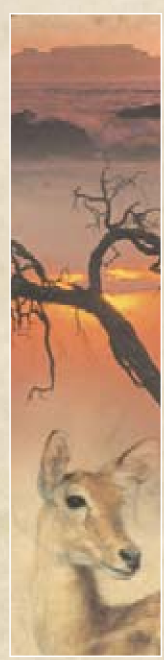
Box 10.1: What has the SAfMA regional scale study contributed in support of decision-making?

The SAfMA regional scale study has made the following original contributions to our understanding of the relationship between ecosystem services and human well-being in support of improved decision-making in southern Africa:

- It illustrates the constraints that will be placed on both the realisation of the Millennium Development Goals and the New Partnership for African Development unless issues relating to ecosystem services are explicitly addressed (Box 2.2, Section 3.3 and 10.3);
- It quantifies, for the first time, the overall degree of biodiversity loss in the region, and provides comparative estimates of the extent of forests (Section 4.2 and 4.3);
- It reveals biodiversity exists mostly outside protected areas, and that the key challenge in the next decades will be preventing the loss of this biodiversity through ecosystem degradation (Section 4.2);
- It shows that while the carbohydrate supply in southern Africa as a whole is barely adequate it is steady, but the protein supply is below accepted limits for adequate nutrition, and declining (Section 5.2 and 5.3);
- It confirms, through the synthesis of many local-scale studies, that food insecurity has several causes, most associated with poverty in general, and that the capacity of the agricultural ecosystem is seldom the dominant factor (Section 5.1);
- It shows that nature-based tourism is rapidly overtaking the traditional harvest-based sectors such as agriculture, forestry and fisheries as an economic sector based on ecosystem services (Section 9.1);
- It reveals the striking correlation between areas of social conflict and areas of ecosystem service inadequacy or degradation within the region (Section 10.2).





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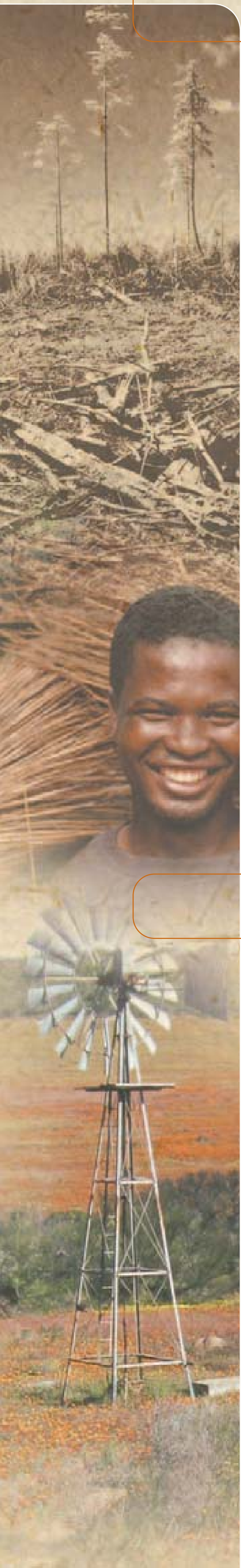

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For more information contact:
Dr Bob Scholes
CSIR Environmentek
PO Box 395
Pretoria
0001
South Africa
Tel: +27 12 841 2045
Fax: +27 12 841 2689
bscholes@csir.co.za

Report available at:

www.millenniumassessment.org

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