Chapter 3

What is affecting our environment?

The relationship between land use and all associated activities, and the natural environment or ecological systems, is complex and continually changing. The natural environment provides the basic elements that human beings need to survive such as food, water and shelter.

Chapter 3

Contents

3.1 INTRODUCTION

Population dynamics and economic development are the overarching drivers of environmental change, whilst other particular human activities exert pressures such as energy consumption, transportation, urban expansion, agriculture and mining. Understanding the drivers, pressures, connections and interdependencies amongst factors affecting our environment helps us to better address their impact on the environment and to find solutions. Thus we can ensure enhanced environmental benefits accrue to both people and the economy.

The relationship between land use and all associated activities, and the natural environment or ecological systems, is complex and continually changing. The natural environment provides the basic elements that human beings need to survive such as food, water and shelter. Most human settlements are therefore located in areas with abundant natural resources such as next to rivers, close to minerals or high potential agricultural land.

Commonly, the relationship between human settlements and the environment is considered to be linear (Figure 3.1). In this linear system, nature provides inputs to the human settlement: food, energy, goods and land. The impact or outputs of human settlements, which are organic wastes, emissions and inorganic wastes, are disposed of in the natural environment. Should the impact exceed the ability of the environment to absorb them, it will result in a degradation of the very environment that human beings depend on.

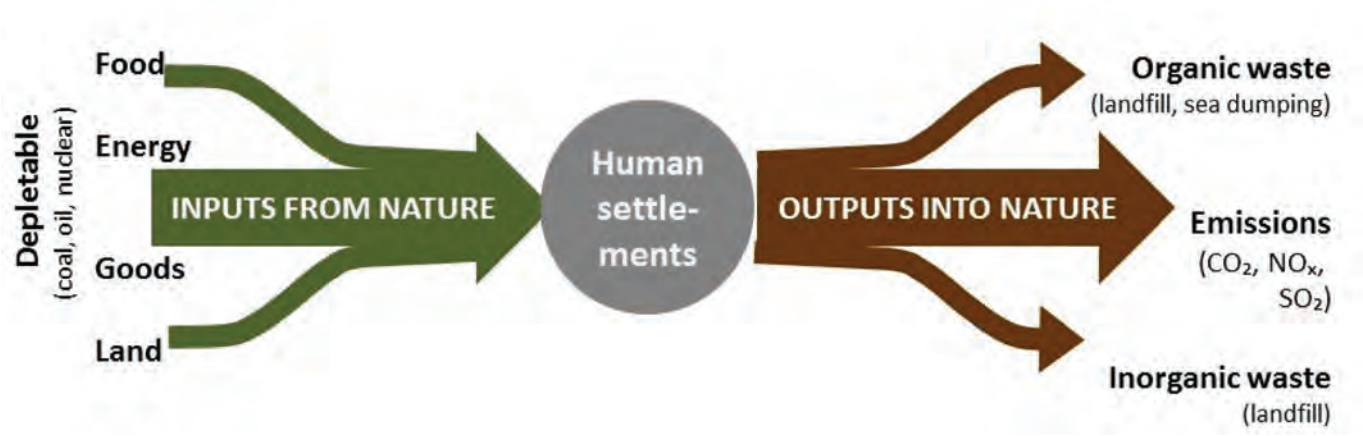


Figure 3. 1: A linear conceptualization of the relationship between humans and nature
Source: Adapted from Eaton et al. *(2007)*

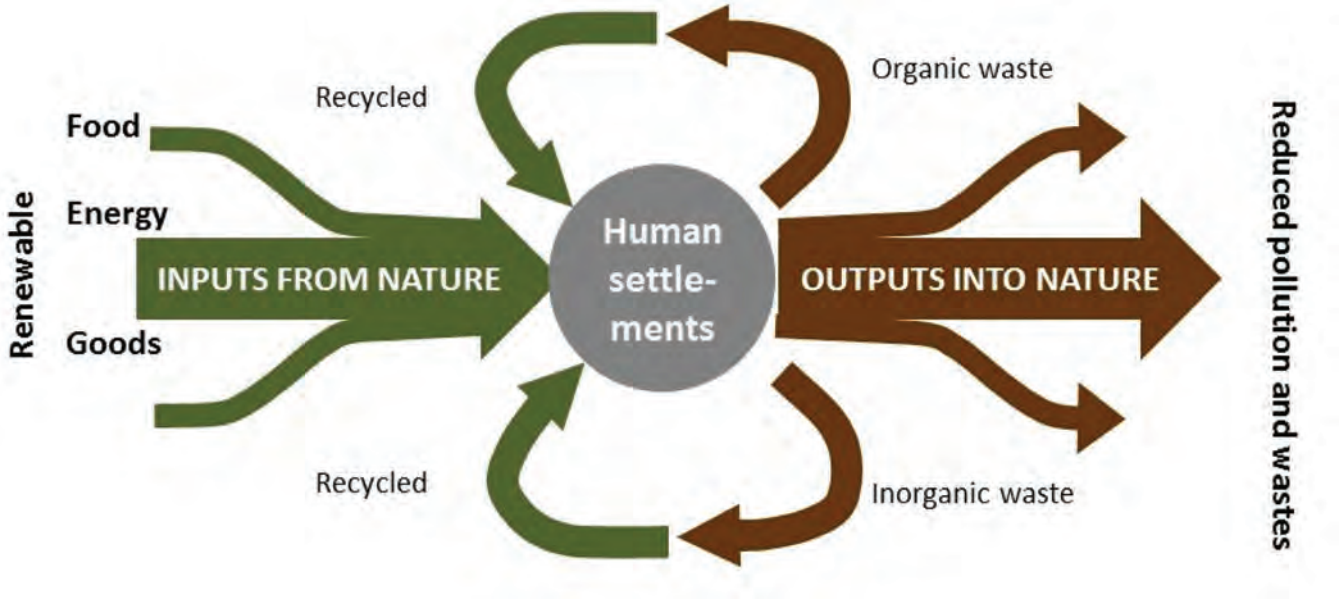


Figure 3. 2: A circular conceptualization of the relationship between humans and nature
Source: Adapted from Eaton et al. *(2007)*

In order to prevent human actions from destroying the natural environment and with it their own livelihoods and quality of life, the relationship between the natural environment and human settlements should rather be conceptualized as a more idealized circular connection as depicted in Figure 3.2. In such a circular system, only renewable resources are used and natural resource consumption is limited and controlled to prevent over-exploitation. Due to lower consumption, greater efficiencies and careful harvesting, less waste is then produced and the waste that is produced is more easily recycled.

Human actions are currently changing the natural environment to such an extent that they endanger the survival of the human species. A move towards more sustainable lifestyles, circular resource use systems and decoupling are therefore critical and human settlements and activities play a pivotal role in this. The current paradigm of economic growth and development does not take ecological thresholds into account and the South African economy is driven by a combination of continually expanding domestic consumption and exports of primary resources (Swilling 2011). Both of these have serious environmental implications, as can be seen in South Africa's current ecological footprint.

There is however a drive in South Africa towards greater sustainability and decoupling, as is reflected in national policies such as the NSSD.

In this chapter, the pressures that are placed on the natural environment through human population dynamics (including population growth, changing household sizes and increasing numbers of households, amongst others) and the patterns of resource consumption, are investigated. This provides a common reference against which the theme chapters on different aspects of the environment that follow can be measured and interpreted.

3.2 DRIVERS OF CHANGE

As explained earlier in this report, the Environment Outlook relies on a DPSIR framework to track and interpret the state of the environment. Within this framework, Drivers (human induced or natural) are defined as the primary agents driving change in the environment. These underlying socio-economic and political agents of change, such as patterns of production and consumption and population dynamics, determine where and how we use and consume natural resources.

Pressures, in terms of the DPSIR framework, are the human activities and processes that act on the environment and directly cause environmental change (for example pollution). They are distinct from the driving forces since they relate directly to the use and exploitation of natural resources, as opposed to the driving forces that determine the scope or extent of the pressures. This subtle distinction is important to understand, and is easily confused, even by environmental specialists. Pressures can be categorized into three main types: (i) use of environmental resources; (ii) changes in land use; and (iii) emissions (of chemicals, waste, radiation, noise) to air, water and soil.

3.3 DEMOGRAPHY AND HUMAN WELL-BEING

The impact of population dynamics on the environment has long been recognized. The general assumption is that population size impacts not only on the amount of natural goods consumed, but also the volumes of waste generated. This is further driven by dynamics within that population. In South Africa while population growth is slowing, the numbers of households are increasing along with the demand for goods. More affluent members of society consume a lot more and generate more waste than larger numbers of poor people. Although not a direct correlation, more people and higher incomes would mean a larger demand for environmental goods, such as food, land and water, thereby possibly depleting these resources faster than they can be replaced, or completely exhausting the resources and possibly destroying natural areas in the process. Therefore "*…it is not only the scale or quantity of the population that affects the nature of a pressure on the environment. …how human populations are organized – in cities or villages, in nuclear or extended families, as migrants or those that stay behind – makes a difference to the capacity of the environment to support them in their way of life*." (UNEP 2012). How social structure and change therefore influence the use of resources is consequently a key determinant of the extent of environmental change. A further consideration is how we produce and consume goods in a manner that many be wasteful of limited resources or generate excessive waste.

3.3.1 Population growth

A growing population naturally makes more demands on the environment if each person contributes a discrete amount of consumption to the total resource usage. Although the population growth rate is declining in South Africa, in line with international trends, the increasing number of smaller households is exerting increasing pressure on the environment. More households means a greater need for basic household goods (stoves, fridges, furniture and so on) and access to services (electricity, water etc.) which drives up the demand for resources.

Table 3.1 shows that life expectancy at birth declined between 2001 and 2005 but has since increased, partially due to the roll-out of antiretroviral treatment for those infected with HIV/acquired immune deficiency syndrome (AIDS). The increase in life expectancy at birth, which for 2011 is estimated at 54,9 years for males and 59,1 years for females, is expected to continue to increase. Although still high, infant mortality has dropped from approximately 53 per 1,000 births in 2001 to 38 in 2011. Fertility has also declined from an average of 2,92 children per woman in 2001 to 2,35 children in 2011. Crude death rates have begun to decline again in recent years, which could possibly also be traced back to increased access to anti-retroviral treatment for HIV/AIDS carriers.

Table 3. 1: Estimates for fertility, life expectancy and infant mortality levels for 2001 to 2011

Year	Crude birth rate	Total fertility rate	Life expectancy at birth			Infant mortality rate	Under 5 mortality	Crude death rate
			Male	Female	Total			
2001	26,1	2,92	52,1	57,8	55,1	53,3	78,8	11,9
2002	25,7	2,86	51,1	56,4	53,9	53,0	79,2	12,7
2003	25,2	2,81	50,3	55,2	52,9	52,4	79,1	13,4
2004	24,7	2,75	49,8	54,4	52,2	51,4	78,2	14,0
2005	24,2	2,69	49,6	53,8	51,8	50,0	76,2	14,4
2006	23,7	2,64	50,1	54,2	52,3	46,8	72,2	14,2
2007	23,1	2,58	50,9	54,9	53,0	45,1	67,8	13,8
2008	22,6	2,52	52,1	56,1	54,1	42,1	63,1	13,1
2009	22,1	2,47	53,3	57,5	55,5	40,6	59,3	12,4
2010	21,5	2,41	54,3	58,5	56,5	39,1	56,6	11,9
2011	21,0	2,35	54,9	59,1	57,1	37,9	54,3	11,7

Source: StatsSA (2011)

3.3.2 Migration

Migration is inextricably linked to urbanization and has a pronounced impact on human settlements, reshaping South Africa's environment, economy, lifestyles and livelihoods. Migration is a complex process, made more so by the role it played in the creation of the apartheid state. Although restrictions on the movement and settlement of people within South Africa were lifted 20 years ago, research suggests that patterns of temporary urban migration persist, and that significant proportions of households remain reliant on remittances sent by migrants, although this has been alleviated to some extent by the introduction of Government grants as part of extending a social welfare safety net for the poor (Casale & Posel 2006).

Migration patterns and trends have a far-reaching impact on the social, economic and environmental conditions in the areas of origin and destination and hence, the process is often mistakenly described as a problem. However, it should

be understood that migration is often a central component of households' livelihood strategies, and that it not only offers hope for the future, but also plays a vital role in redressing past inequities (DSD 2010).

Migration patterns in South Africa largely follow patterns of job creation and job losses nationally. It is thus not surprising that Gauteng and the Western Cape receive the bulk of migrants, as is depicted in Table 3.2, with a net migration of 566,760 and 192,401 respectively. The main provinces shedding migrants were the more rural Eastern Cape (325,078) and Limpopo (259,116) with smaller net outflows from the Northern Cape and Mpumalanga (StatsSA 2012a). Although migrants are still primarily attracted by employment prospects or access to other services and opportunities, which are historically located in or more accessible in metropolitan areas, high unemployment rates in these areas have slowed down movements to some cities or even diverted migration streams. Large numbers of migrants are instead moving into local smaller towns, mining areas, dense peri-urban or even rural settlements that offer the promise of access to housing, jobs and services as well as easier ties with areas of origin. These towns are often, however, even less adequately resourced than large cities to deal with migration streams, and their relatively fragile economies make finding permanent employment very unlikely (DSD 2010).

Table 3. 2: Net migration (province of enumeration by previous province of residence) as per Census 2011

Province	WC	EC	NC	FS	KZN	NW	GP	MP	LP	In-migration	Out migration	Net migration
WC	945, 853	172,628	17,868	12,844	22,010	6,004	74,619	7,295	7,761	321,029	128,628	192,401
EC	39,198	578,713	4,009	8,119	18,480	2,922	38,508	3,259	2,751	117,246	442,324	-325,078
NC	10,507	4,947	119,142	7,183	1,870	17,745	9,291	1,845	1,865	55,253	70,466	-15,213
FS	5,142	15,820	8,673	225,712	11,518	9,977	31,539	5,058	5,561	93,288	153,125	-59,837
KZN	9,132	74,906	5,707	8,944	936,435	3,750	54,658	12,234	4,632	173,963	283,852	-109,889
NW	5,094	33,167	11,623	24,308	8,609	333,789	75,750	13,239	27,298	199,088	167,367	31,721
GP	51,500	119,796	16,418	75,443	187,748	104,393	2,398,669	123,186	286,355	964,839	398,079	566,760
MP	4,687	12,039	4,215	10,942	28,943	8,499	60,982	305,290	39,472	169,779	191,528	-21,749
LP	3,368	9,021	1,953	5,342	4,674	14,077	52,732	25,412	409,687	116,579	375,695	-259,116

Source: StatsSA (2012a)

It is, however, not only migration patterns that have implications for the environment. The opposite is also true: changes in the environment can result in a movement of people. As early as 1990, the Intergovernmental Panel on Climate Change (IPCC; Laczko & Aghazarm 2009) warned that "*the greatest single impact of climate change could be on human migration*" – with millions of people displaced by shoreline erosion, coastal flooding and severe drought.

3.3.3 Human development and well-being

3.3.3.1 Human development

The Human Development Index (HDI) is a measure of human development, and is used by the United Nations Development Programme (UNDP) to measure and monitor human development across a range of indicators instead of the commonly used crude economic measure of the GDP of different countries. Its three dimensions of human development comprise a long and healthy life (health), access to knowledge (education) and a decent standard of living (income).

In 2006, the HDI for South Africa was reported to be in 'freefall', with the country ranking having dropped from number 67 out of 147 in 1995 to number 120 out of 177 countries in 2003. This was, to a large extent due to the impact of HIV/AIDS. This decline is being arrested, however, and the country currently (2011) ranks as number 123 out of 187 countries (UNDP 2011). Although the ranking is still considered 'medium', the actual score of 0.619 does represent a ten per cent improvement in the overall index since 1980. Compared to its continental peers, South Africa's HDI remains above average for sub-Saharan countries.

As in 2006, the biggest challenge remains the poor performance in the human health index, reflected in life expectancy, though this is slowly experiencing a turnaround. On the other hand, education helps to improve the rating with a marked improvement during the preceding three decades. This results as more children go to school and levels of tertiary education increases.

3.3.3.2 Health

The HIV/AIDS epidemic is projected to continue to have a significant impact on the demography of South Africa for some time to come. In 2012, there were five districts that recorded HIV prevalence above 40 per cent, all of which were located in KwaZulu-Natal; namely eThekwini (41.1 per cent), uMkhanyakude (41.9 per cent), iLembe (42.3 per cent), uMgungundlovu (42.3 per cent) and Ugu (41.1 per cent). As shown in Figure 3.3: Rates of HIV prevalence distribution by province for 2010 KwaZulu-Natal has the highest prevalence of HIV in the 15 to 49 age group, at 39.5 per cent. This is followed by Mpumalanga (35 per cent), the Free State (30.6 per cent) and Gauteng (30.4 per cent).

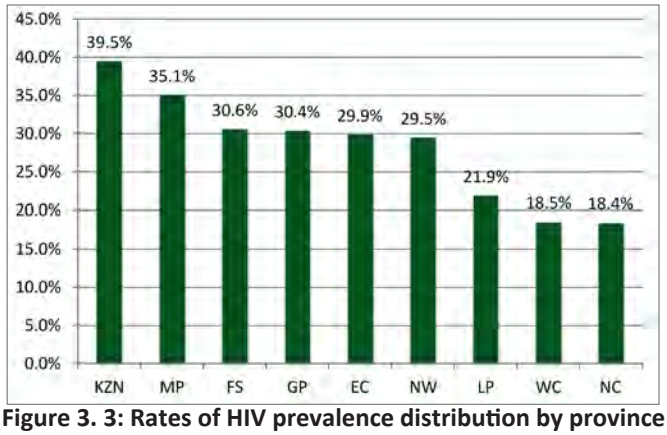


Figure 3. 3: Rates of HIV prevalence distribution by province for 2010
Source: Adapted from DoH (2010)

3.3.3.3 Poverty and inequality

According to StatsSA (2012b), 39.5 per cent of South Africans live in poor households (see Chapter 5: Human Settlements for details). In Chapter 1: Introduction, the Gini Coefficient for South Africa is shown to be high indicating a high level of income inequality. Tribal areas are identified as the poorest settlement types.

The NDP (NPC 2012), as the blueprint for South Africa's strategic development until 2030, seeks to confront poverty and inequality as the two broad obstacles on the road to successful and sustainable economic development. South Africa's issues of poverty and inequality are similar to those in many other developing countries, where unemployment levels are high, and where emphasis is placed on poverty eradication through industrial expansion (Butchart *et al*. 2010; CBD 2010).

3.3.4 Human settlements

A detailed discussion of human settlements is contained in Chapter 5: Human settlements.

Human settlements and their associated activities, as well as the general distribution of land use, drive environmental change in several ways. South Africa's model of urban development is on the whole one of low-density mono-functional sprawl, which dramatically exacerbates the environmental impacts of settlements. Middle- and high-income suburbs often have very high environmental costs. Coastal ribbon development (holiday homes, golf estates etc.), is often a serious offender when it comes to sprawl and over consumption of resources.

The potential for environmental degradation is often evident in the mushrooming informal settlements in South Africa. Because of the lack of appropriate town planning and infrastructure provision (such as waste management and sanitation services, etc.), the people in the informal settlements are forced to dispose of their biodegradable and solid waste in the vicinity of the settlement, thus threatening the surrounding ecosystems.

Most of the established formal settlements also contribute to the deterioration of ecosystems by over-use of renewable resource systems and depleting non-renewable resources. Sprawling car-dependent residential suburbs are often

realized at the expense of large areas of prime agricultural land or green open spaces. The affluence associated with such areas is often a mask for the over consumption of resources that far exceeds that of informal settlements.

Environmental impacts associated with human settlements include:

- Settlements are often located in areas with attractive natural features, such as next to coastal areas, rivers and streams. Important habitats associated with such natural features become degraded or destroyed by settlement growth;
- As settlements need to tap into natural resources such as water, those that are located in water-scarce areas can place a disproportionate pressure on the natural water sources, often far away from their location (e.g. Johannesburg);
- Water pollution caused by increased population density and settlements close to natural water sources, such as rivers and streams, is one of the major threats to the environment and the management of water quality in the country is as important as managing the available quantity;
- Settlements that are experiencing rapid expansion may threaten surrounding natural areas and high potential agricultural land;
- Fast-growing settlements often struggle to keep up with the demand for infrastructural services thus creating potential pollution problems. For example, the slow installation of engineering infrastructure may mean that water is extracted from a river or stream for human consumption and wastewater returned back to the natural environment. Polluted water is thus introduced into the natural water cycle without treatment;
- Transport can also be a major contributor to pollution, and promote the greenhouse effect. Increasing transport movements results in the growing consumption of non-renewable resources, such as diesel, oil and petrol, which are in turn manufactured from non-renewable energy sources such as oil, gas and coal. This is particularly true in low density areas where private vehicles are the main means of transport; and,
- The use of coal and firewood as the main energy sources for household cooking and heating by a major proportion of the population, especially in rural, semi-urban and informal settlement areas.

Measuring the environmental impact of human settlements, nevertheless, can be done in terms of dimensions other than absolute population numbers. Since it is often households rather than individuals that are the real units of consumption, it is worthwhile to view the intensity of the impact on the environment on a per household basis (AAAS 2000).

3.3.5 Household structure

The increasing number of smaller households in practice exerts increased pressure on the environment. If the population is rather counted as households, instead of individuals, the real environmental impact of population proves to be much greater, particularly if one considers the role of energy consumption and pollution generation per capita. Smaller households generally have higher consumption rates per person than larger households, and thus a larger impact on the environment. Each household usually consists of a separate dwelling unit with its own heating and lighting, as well as personal consumer items (such as televisions, refrigerators, washing machines, motor vehicles, etc.). It is thus often households rather than individuals that are the drivers of consumption and thus the real population units that impact on the environment (AAAS 2000). An increase in number of households will generally result in an increase in consumption as resources need to be distributed amongst a growing number of houses. In developed countries, the increase in the number of households has more than doubled the impact on growth in carbon dioxide emissions than did the increase in population numbers (Pelser & Redelinghuys 2009).

As the number of households increases, transport related environmental impacts are also likely to increase (UNEP 2012). Particularly in South Africa, an increase in the number of homes has typically occurred in suburban low-density areas (and frequently related to past spatial planning), often on the urban periphery, rather than in high density inner city areas. This results in more passenger vehicles and increased long distance commuting, which in turn adds to fuel consumption and increased air emissions and pollution (UNEP 2012).

In the nine major cities in South Africa, namely Buffalo City, Cape Town, Ekurhuleni, eThekwini, Johannesburg, Mangaung, Msunduzi, Nelson Mandela Bay, and Tshwane, the average number of households grew by 27.5 per cent (2.13 million households) between 1996 and 2001, which is more than double the growth rate of the country's population as a whole (Pillay *et al*. in FFC 2011). This has largely been attributed to declining household sizes. As with elsewhere in the world, the decline in average household size can be accounted for by, among others, ageing of the population, rising divorce rates, rapidly declining fertility rates, an increasing middle class, increasing levels of education and increasing childlessness (Pelser & Redelinghuys 2009). The average household size in South Africa decreased from 4.47 people in 1996 to four in 2001 (FFC 2011) and 3.7 in 2007 (Pelser & Redelinghuys 2009). In the Census 2011, average household size was reported to be 3.6. Household formation in South Africa can also be attributed to new housing opportunities that are being created. According to the National Planning Commission (NPC 2011), annual household formation continues at a rate of about three per cent a year, although population growth rates for South Africa as a whole are now below one per cent.

According to the Census 2011 (Table 3.3), Gauteng and North West have the highest rates of number of household growth, with 28.6 per cent and 28.4 per cent respectively.

Table 3. 3: Number of households in South Africa: Census 1996, 2001 and 2011 and Community Survey 2007

Province	Number of households (Thousands)			
	1996	2001	2007	2011
Northern Cape	218,339	245,086	264,653	301,405
Eastern Cape	1,303,287	1,481,640	1,586,739	1,687,385
Western Cape	983,015	1,173,304	1,369,180	1,634,000
Free State	625,011	733,302	802,872	823,316
KwaZulu-Natal	1,689,995	2,117,274	2,234,129	2,539,429
North West	591,240	760,588	822,964	1,062,015
Gauteng	2,069,512	2,791,270	3,263,712	3,909,022
Mpumalanga	669,801	785,424	940,425	1,075,488
Limpopo	909,371	1,117,818	1,215,935	1,418,102
TOTAL	**9,059,571**	**11,205,706**	**12,500,609**	**14,450,162**

Source: StatsSA (2012a)

3.4 ECONOMIC DEVELOPMENT

3.4.1 Decoupling economic growth and environmental degradation

Economic growth is dependent on resource availability, and its efficient use. Typically, economic activity and growth relies on ever expanding efforts at extracting natural resources and disposing of wastes without accounting for the full environmental costs of these activities. The South African economy remains largely dependent on the extraction of natural resources. The net result is a progressive deterioration in the quality and functioning of the natural processes that sustain human activities.

Sustainable means of development can only be realized if ecosystems are used in a balanced way and are not compromised beyond repair by unsustainable consumption by people, industries and cities. For this reason, a sustainable development trajectory is envisaged that will make the most of our natural resources by improving the efficiency, and reducing the carbon intensity, of our economic activities. This will include improvements to infrastructure delivery, especially with regards to addressing historic patterns of inequality, providing more affordable and reliable services (such as quality public transport) to poor communities, and creating employment opportunities in the green economy (NPC 2012).

To ensure sustainable development, the link between economic activity and environmental deterioration needs to be decoupled. This delinking is possible, despite the wide range of studies and volumes of evidence that show how humans are depleting the natural capital available to them. The decoupling approach attempts to decrease the amount of resources such as water or fossil fuels used to produce economic growth, as is illustrated in Figure 3.4.

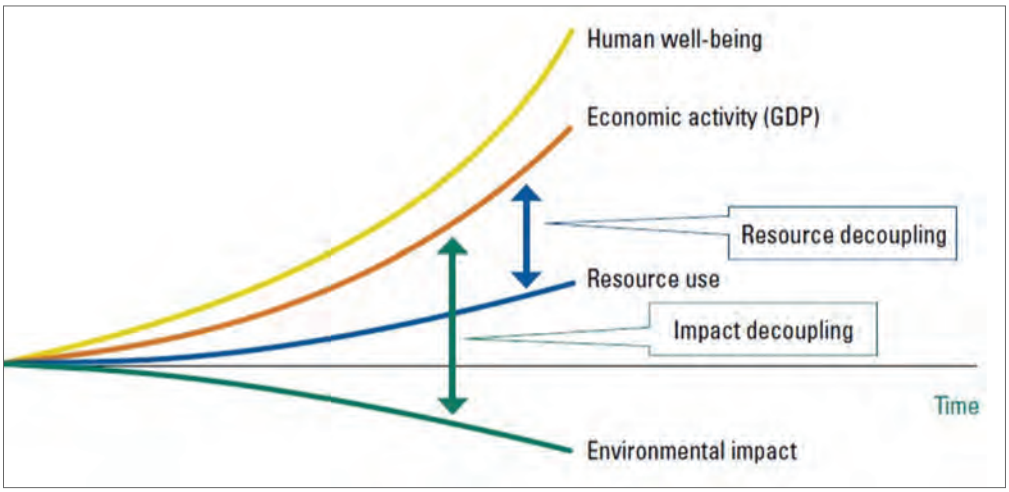


Figure 3. 4: An illustrative example of decoupling
Source: UNEP (2011)

A UNEP report on decoupling examined the relationship between material consumption within a country and GDP (UNEP 2011). Figure 3.5 shows the relationship between GDP per capita and metabolic rates for individual countries. Metabolic rates are defined as the resource use per capita. South Africa can be seen to have a relatively high metabolic rate, or use of resources, relative to its GDP (UNEP 2011). This shows high resource consumption levels per capita without a corresponding rise in income per capita, typical of an economy specialized in the extraction of raw materials. The growing services sector within South Africa may show increased resource decoupling. There is some evidence of decoupling in the 20 years leading up to 2000 where a study does suggest that a relatively minor level of decoupling is taking place and the domestic material consumption of primary materials has declined while population growth and GDP have grown (Swilling 2011).

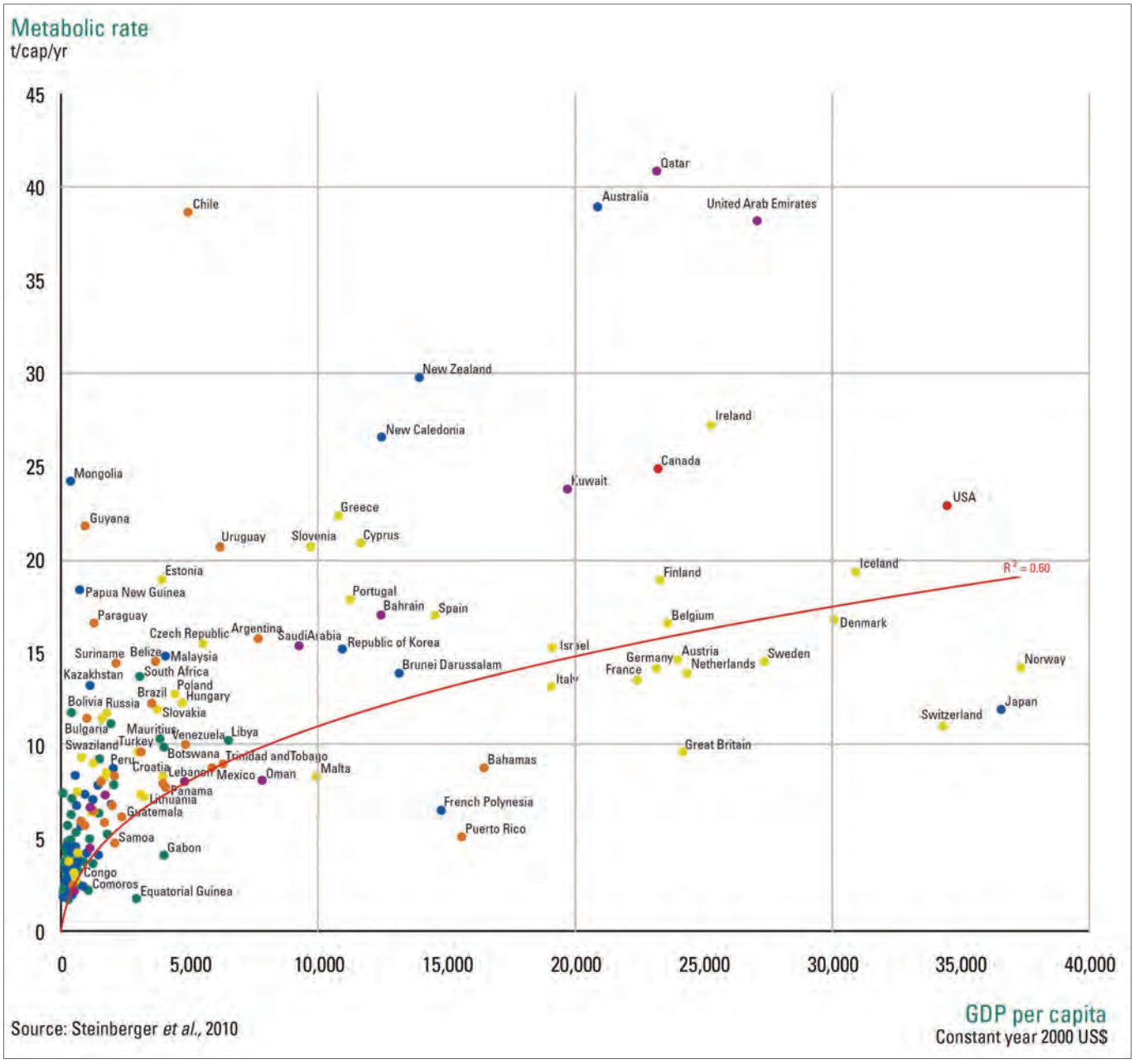


Figure 3. 5: The global interrelation between resource use and income (175 countries in the year 2000)
Source: UNEP (2011)

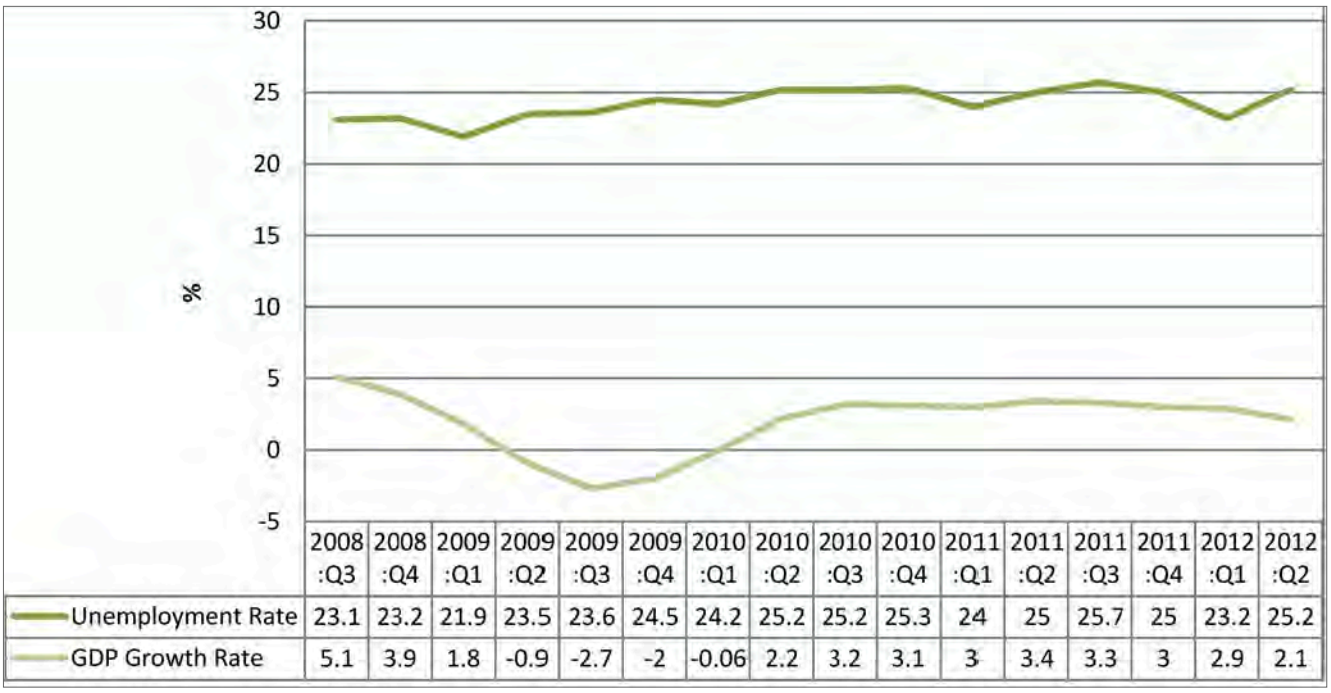
What is required, are changes to the way in which economic activities take place, rather than the amount of economic activities. These changes include:

- Less energy and resource intensive agriculture, industry and manufacturing;
- Less energy and resource intensive residential and business activities;
- A large-scale shift to renewable energy;
- Economic development that places more of a focus on improvements to the minimum level of socio-economic conditions required per person rather than an absolute improvement in GDP or similar measures; and,
- A reduction in the amount of concentrated pollution entering the natural system.

Many of the green economy approaches and strategies current being implemented within South Africa have begun to address these issues.

3.4.2 Employment and income

South Africa is currently in the unenviable situation of having to reconcile the complex and often conflicting demands of poverty reduction, economic growth, housing, health and job creation, or the 'brown agenda', as well as 'green' agenda issues, which address protection of the natural environment, conservation and sustainability. The high levels of poverty and unemployment in South Africa have resulted in a focus on economic growth in the country at various scales from a national level down to small scale economic growth for the benefit of local communities. However, as shown in Figure 3.6, economic growth does not necessarily result in a growth in employment.



	2008 :Q3	2008 :Q4	2009 :Q1	2009 :Q2	2009 :Q3	2009 :Q4	2010 :Q1	2010 :Q2	2010 :Q3	2010 :Q4	2011 :Q1	2011 :Q2	2011 :Q3	2011 :Q4	2012 :Q1	2012 :Q2
Unemployment Rate	23.1	23.2	21.9	23.5	23.6	24.5	24.2	25.2	25.2	25.3	24	25	25.7	25	23.2	25.2
GDP Growth Rate	5.1	3.9	1.8	-0.9	-2.7	-2	-0.06	2.2	3.2	3.1	3	3.4	3.3	3	2.9	2.1

Figure 3. 6: GDP and unemployment change from 2008 to 2012
Source: Adapted from Trading Economics (2012a, 2012b)

3.4.3 Trends in sectoral growth and environmental implications

Based on the consumptive nature of human settlements and the land use practices needed to sustain these growing settlements, the following trends and environmental implications have been noted:

3.4.3.1 Urban development

Urban settlements provide homes, places of business and other critical services for the majority of the South African population. Inappropriately located settlements, far from services, places of work and transport networks, as a result of past planning practices, as well as the need for decent housing and improvements to services, support the infrastructure drive currently taking place across South Africa's urban landscape (John 2012).

A total of 1.5 per cent of the land area in South Africa is covered by cities and towns (van den Berg *et al*. 2008). Urban settlements and associated developments are predominantly concentrated in the eastern and north-eastern parts of the country, along primary road networks, and along the coastal belt (DST 2010). The western half is relatively sparsely populated although the West Coast north of Cape Town is fast growing (Saldanha has been earmarked as one of several Industrial Development Zones in the country).

As at 2010, population density was highest in the Johannesburg municipal jurisdiction (2.231 people per km^2) (John 2012). The next highest on record was 1.513/ km^2 (Ethekwini) and 1.455 (Ekurhuleni). However, what is not commonly understood is that population growth in South Africa is not directly correlated to economic growth. For example, it was found that between 2005 and 2010,

the municipality with the highest economic growth was Polokwane (Pietersburg, Limpopo at 5.5 per cent), followed by Tlokwe (Potchefstroom, North West Province at 4.9 per cent) and Madibeng (Brits, North West Province at 4.8 per cent).

Recreational and residential estate development in urban landscapes and other forms of landscape modification at the coast and in the interior are becoming increasingly popular. This results not only in direct impacts on biodiversity loss and ecosystem health through land cover change, but also in the demand for scarce resources such as water. However, such areas can contribute significantly to biodiversity conservation, education and recreation in certain instances. South Africa's botanical gardens, in particular, have been shown to conserve a disproportionally high number of species, comparable, and even exceeding the achievement of some of the world's richest nations (Golding *et al*. 2010).

Solutions for 'greener' human settlements lie in managing, conserving and restoring biodiversity priority areas, and maintaining connectivity (ecological corridors) in both land and aquatic ecosystems associated with infrastructural expansion (Zeitsman 2011). This can be achieved through integrated spatial planning frameworks, where the design of 'strong' and 'hard' urban edges is promoted, where densification of development is encouraged and government services are effectively provided at the municipal level, and where biodiversity priority areas are identified and sufficiently resourced and managed. Biodiversity priority areas can function as green spaces where residents can enjoy recreational activities and learn to appreciate the value of biodiversity. These areas can also assist as source areas for the provision and maintenance of ecosystem services for low income as well as affluent areas.

3.4.3.2 Agriculture

Agriculture refers to land production and covers animal production, field crops and horticulture. It is usually segregated into a small-scale, subsistence sector and a fairly well-developed, large-scale commercial sector. Agricultural landscapes play a critical role in South Africa's economy and environment and are vital for maintaining the food security of South Africa and its neighbouring countries. Within South Africa, land area under maize, wheat and dairy has decreased significantly over the last 20 years, yet agricultural production remains relatively constant. This indicates an increasing trend in intensified production and farms have increased their irrigation, fuel, fertilizer, mechanization and genetically modified seed inputs (WWF 2011). WWF further states that: "*Poorly managed intensive farming has many negative impacts on the natural environment, on people's well-being and on a farmer's ability to adapt to change. A dependence and overuse of synthetic fertilisers, pesticides and herbicides reduces long-term soil fertility, causes soil erosion, pollutes water supplies, poisons fragile ecosystems, exposes farmers and farm workers to toxins, and contributes to climate change through greenhouse gas emissions*."

About 30 per cent of South Africa's land surface is rangeland (Milton & Dean 2011). Where rainfall or water supply for irrigation is low and too unpredictable to support crops or commercial forestry, game ranching is often dominant. The value of rangelands, and the ecosystem services they provide, is declining as a result of poor land management, and through the loss of palatable plants, soil, firewood, and the yield of potable water resources (Milton & Dean 2011). Rangeland activities, such as grazing, may be compatible with sustaining biodiversity and ecosystem functions, but only if stocking densities and resource management strategies are appropriately implemented (Milton & Dean 2011).

Cultivation activities, which cover approximately 14 per cent of South Africa's land area, alter natural habitats, and can negatively impact rivers and wetlands if buffers of natural habitat are not retained adjacent to them. The modification of soil profiles, the reduction in the quality of surface and underground water sources and food chains of the surrounding natural environment, can be adversely affected. Cultivation results in irreversible loss of natural habitat in the terrestrial environment, and often has severe negative impacts on freshwater ecosystems. Irrigation accounts for approximately 60 per cent of South Africa's water use.

Of rising concern in the agricultural arena is the yet largely unknown effect of genetically modified organisms (GMOs) on the state of ecosystems, and the potential environmental impacts associated with genetically modified (GM) crops. Genetic engineering is a new, rapidly expanding, but still poorly understood instrument being deployed to increase food yields and to boost the secure production of land-based food crops. As such, the impacts thereof have not been quantified comprehensively, leaving many risks and uncertainties. No animal biotechnology is known to be conducted in South Africa (Esterhuizen 2011).

3.4.3.3 Timber industry

Commercial timber plantations cover approximately 1.1 per cent of South Africa's land surface (DAFF 2010), equivalent to the country's indigenous forest land cover (Grundy & Wynberg 2001) (DAFF 2011), and are located mostly in Mpumalanga, the Eastern Cape and KwaZulu-Natal. Many of the areas preferred for commercial timber plantation are found in the Grassland biome. Approximately 68 per cent of the area covered by plantation estates in South Africa is planted with non-indigenous, exotic tree species. The timber industry is geographically more localized than cultivation activities. By implication, its impacts are spatially more easily managed.

The land area under plantations in South Africa has levelled off over the past decade and presently appears to be decreasing at an average rate of 0.9 per cent per annum. The reasons

for the reduction are the effects of the global economic crisis, i.e. more robust competition, pricing schemes, tariffs and exports, stricter monitoring and compliance associated with environmental regulations, changes in land use profitability and improved mapping technology (DAFF 2011). To date, close to 12,500 jobs in the industry have been shed since 2008, with significant production being lost. In areas, commercial forestry is a sector government remains committed to invest in, particularly for small scale foresters and job creation potential.

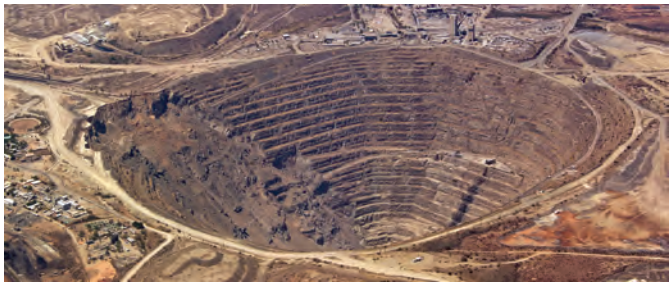
Timber plantations, as with mining, cultivation and urban development, degrade biodiversity and impact negatively on ecosystems. Fragmentation, and the loss of habitats, directly results in the significant loss and conversion of biodiverse areas, including encroachment into wetlands and water catchment source areas.

The timber industry owns or leases almost 600,000 ha of land that is currently unplanted (DAFF 2011). Approximately 100,000 ha identified in KwaZulu-Natal and the Eastern Cape has been earmarked for the establishment of plantations on land which has historically not been planted (Chamberlain *et al*. 2005). However, these areas can possibly also contribute to protected area targets.

3.4.3.4 Mining

The South African economy depends greatly on the growth and development of its extractive mining sector. Our mineral wealth is amongst the world's top five in terms of coal production, consumption and exports. South Africa's minerals represent 88 per cent of the world's reserve of platinum metals, 80 per cent of its manganese, 73 per cent of its chromium and 45 per cent of its gold. The Chamber of Mines of South Africa reports that during 2009, the mining industry contributed 8.8 per cent to the GDP and created direct employment for 491,922 people (Chamber of Mines 2011). If the dependants for these employees are included, mining is a significant contributor.

Other than job creation and contribution to the GDP, the demand for cheaply priced energy is an additional stimulus for mining. This is causing the expansion of coal mining at a rapid rate to feed the power stations and industry, particularly in the Grassland biome where large coal deposits exist (SANBI 2011).



The past few years have witnessed a rise in mining and prospecting permit applications in South Africa due to the commodities boom prior to 2008. In some cases, particularly where mining is contemplated near ecologically and socially important sites, these have been met with significant opposition, such as at the Mapungubwe World Heritage Site.

The pressures from mines on the natural environment have increased significantly over the past few years, partially due to abandonment and mine closures amidst the current global economic crisis, socially and environmentally irresponsible business practices and the use of legal loopholes in the penalty regulations. In this regard, the most recent National Environmental Compliance and Enforcement Report (DEA 2012) documents some landmark cases.

Of all the big industries, the extractives sector and especially mining, is a key driver of habitat loss in South Africa. Resource extraction has localized impacts that may occur in a relatively small footprint, but the fallout is often felt on a national scale due to wider impacts on water resources, ecosystem integrity and because environmental impacts are not fully costed. Mining impacts on biodiversity and ecosystems can be highly ecosystem-altering and can also impact human health and employment and social services once a mine goes into decline or closes. The ecological impacts of mines are diverse, and are both direct and indirect (Zietsman 2011). The extent, intensity and duration of these vary with mining type and size of the mineral deposit.

The impacts of mining increase the loss of natural habitats and impair the quality, functionality and delivery of ecosystem services inherent in those natural habitats. They characteristically include increases in nitrogen loads and those of other nutrients from manufacturing processes and wastes to ecosystems, including heavy metals such as lead and mercury which accumulate in food webs. Despite a history of mining in the country, no long-term baseline research for South Africa as a whole is available on such impacts.

Other key impacts include alterations to the water table, a decline in the functioning and quality of above-ground natural ecosystems at the mine and its surrounding areas, and visible changes to the scenery by mine dumps, slime dams and open pits (Zietsman 2011). Mine dumps are often susceptible to alien plant infestations due to a decline in ecosystem resilience, and thus also serve as source centres for dispersal to surrounding areas.

Wetlands, often underlain with coal are mined first, are severely affected, the result being a decrease or elimination in ecosystem services such as water purification, flood attenuation, erosion control and water storage.

The most costly environmental and socio-economic impact of mining in South Africa is potentially linked to Acid Mine Drainage (AMD; mine effluent containing bi-metals (including radioactive heavy metals), acids and sulphates). The impacts are multiple, and include decimation of life forms in water bodies into which mine effluent is discharged. AMD pollutants accumulate in organisms during agricultural irrigation and livestock production in the vicinity of the mines. The pollutant is then transmitted from the water table or rivers through food chains, eventually having poisonous effects at higher trophic levels, also affecting the health and wellbeing of humans. AMD impacts may continue for centuries after mine closure, and there may be a considerable time lag for detecting AMD contamination. Treatment of AMD after pollution events has increased costs for water treatment and land rehabilitation.

3.4.4 Green economy

One of the key actions for the transformation of society into a more environmentally sustainable form is to develop an economy based on green principles. Such a green economy will put sustainable development in action by marginalizing economic activities that have unsustainable environmental costs, and using environmentally responsible development activities to solve social and economic ills more effectively than business-as-usual practices.

In the report entitled Programmes in Support of Transitioning South Africa to a Green Economy (DBSA 2011), "*greening the South African economy represents a critical lever for bringing about the structural transformation needed for a more equitable and inclusive economy*". The report further states that "*co-ordinated activity is required to achieve the envisaged economic shifts to transition the country to a low-carbon and greener economy, with the ultimate objective of a carbon-neutral economy by 2050*".

3.5 VALUE SYSTEMS AND CONSUMPTION

Values and cultural systems can drive environmental change. Human decisions, value systems and beliefs (whether it be at a household or individual level) about activities and resource consumption are influenced by values and those decisions impact on the environment (UNEP 2012). Some decisions may be a formal weighing of values and beliefs, while other choices are made without much reflection, typically on the basis of emotions, experience and cultural expectations. An example is the value South Africans place on owning and driving their own vehicles as a mark of success, versus making use of public transport systems.

Changes in food consumption patterns for individuals or households (e.g. due to urbanization, population dynamics or increasing disposable incomes) are likely to have profound effects on regional food systems. Urban lifestyles consume higher amounts of water and energy and have increased carbon emissions. These changes in consumption and consumption preferences introduce increased pressures on food and energy systems (due to increased demand), and in turn forces "*compensating adjustments to take place on the supply side through market-mediated, price-driven interactions with producers*". (UNEP 2012).

Changing behaviours of individuals and households to reduce their environmental impacts lies at the core of effective policy for sustainable development. As an example, waste recycling to reduce the waste volumes to landfill. Increasing affluence and economic growth in urban areas also increases the volumes of waste produced. If the waste is not separated and reduced or recycled, the volumes of waste sent to landfills can create negative environmental and social consequences.

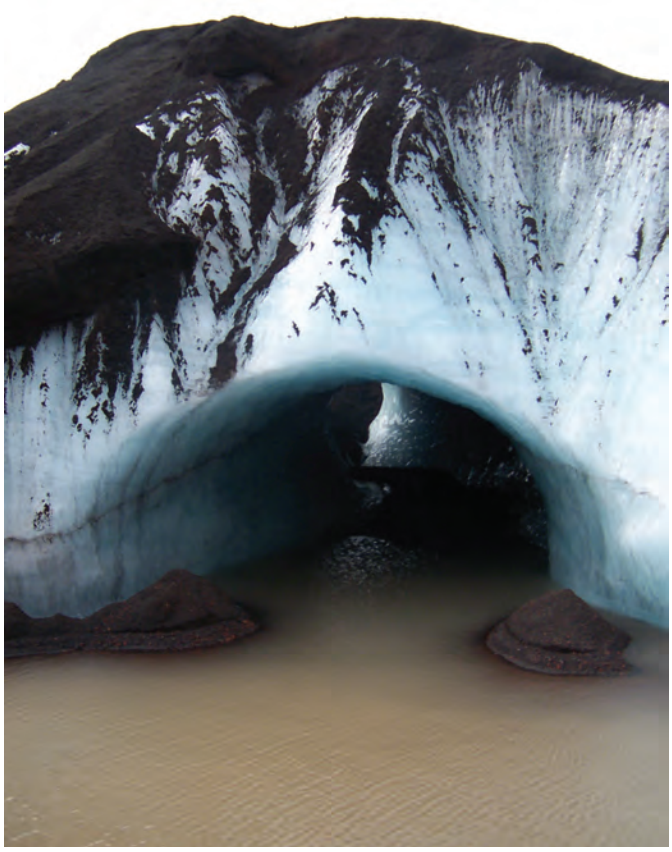
3.6 FEEDBACKS IN NATURAL SYSTEMS

The South African Risk and Vulnerability Atlas (DST 2010) and Observations on Environmental Change in South Africa (Zeitsman 2011) are two primary research works that illustrate how South Africa is challenged by an intensification of drivers, pressures and impacts on its biodiversity and ecosystems.

The concern that arises is that changes to the natural systems, initially caused by pressures such as economic activities, can in turn become drivers and pressures themselves. Two prime examples of this are climate change and the spread of invasive alien species. In both cases, the changes forced on the natural system by irresponsible or unsustainable human activities become pervasive enough that the natural system begins to influence the nature of human activities. Effectively, the changes themselves therefore become pressures that are driving change.

3.6.1 Climate change

There is a need for healthy natural ecosystems to help humans adapt to climate change i.e. ecosystem-based adaptation. Intact ecosystems, as well as humans optimising the efficient use of natural resources, both play an important role in mitigating climate change impacts (DEA 2011; Driver *et al*. 2012).



The functioning and scale of marine ecosystems makes it inherently difficult to predict the impacts of climate change and yet the marine environment is intimately connected to weather formation. On account of their large geographic ranges, their position at the top of the food chain and their vulnerability to ecosystem changes, seabirds, for example, are considered useful indicators of marine health. Recent shifts in the distribution of seabirds have been found to track the distributions of fish species (Crawford & Altwegg 2009). Additional examples are that in the first decade of the 21st century, more than half the global population of African penguins *Spheniscus demersus* have declined (Crawford *et al*. 2011) and severe decreases in bank cormorant *Phalacrocorax neglectus* populations have been observed (Crawford *et al*. 2008). Both these flagship species are endemic to southern Africa and currently have a Red List status of Endangered.

Sea-level rise is a significant result of climate change in South Africa and levels on the West Coast are rising by 1.87 mm per annum, on the South Coast by 1.47 mm per annum and on the East Coast by 2.47 mm per annum (DEA 2011).

South Africa's Second National Communication on Climate Change (DEA 2011) explains that the aim of adaptation and mitigation efforts is to increase the resilience of species and ecosystems by reducing existing or new threats. These include managing invasive species, reducing rates of habitat loss and fragmentation, minimizing levels of exploitation, restoring habitat area and connectivity, and expanding and consolidating protected area networks.

Knock-on effects caused by elevated carbon dioxide levels and changes in wildfire regimes are cause for concern, particularly in the winter rainfall biomes during hot, dry conditions. The majority of such studies have been undertaken in the Fynbos, Grassland and Savannah biomes, and to a lesser extent, in the Succulent Karoo. Based on analyses done for the NBA 2011, the Grassland biome seems to be most at risk from climate change (Driver *et al.* 2012).

Increased atmospheric carbon may also result in increased cover of shrubs and trees in rangelands, causing bush encroachment and the spread of invasive alien species (possibly beneficial for carbon sequestration) (DEA 2011). Increased temperatures may, in addition, result in population growth spurts of pests and pathogens that may harm cultivation activities.

Ecologically, vegetation composition and community structure will be influenced, which will have implications for protected area planning and resource availability. Summer rainfall biomes (Savannah, Nama Karoo, Grassland and Forest) are likely to experience changes in the competitive balance between woody and herbaceous plants (grass-tree and grass-shrub cover) which, in turn, will have implications for the functioning and delivery of ecosystem services (Midgley & Thuiller 2010). This will certainly affect wildlife populations, and will consequently have financial implications for the eco-tourism sector (Turpie *et al*. 2008).

The potential impact of climate change on productive terrestrial landscapes has received massive attention, largely in the form of food security studies and agri-conservation practices. In recent years, significant declines in fish catches at sea have occurred as a result of over-fishing, poaching and illegal fishing (Zeitsman 2011). The likely impacts of climate change on marine stocks are multiple and complex, and may increase in range and influence, affecting small scale sustainable livelihoods to commercial off-takes. Range shifts in marine populations and population migrations are likely, as are disruptions in important chemical processes at sea as a result of rising water temperatures, circulatory up-welling, sea level rises, acidity and storm frequencies, which may in turn alter habitats requirements for the normal growth and reproduction of marine life. Consequently, coastal systems already under human development pressure are predicted to be the worst affected by climate change.

Rising sea levels are not expected to have detrimental impacts on most coastline species, however, as most can migrate higher up the shore, with the exception of intertidal species associated with micro-habitats on rocky platforms (Griffiths *et al*. 2010). The greatest impact is likely on the East Coast where a rise in water temperature may cause a southward range expansion of tropical species. Interestingly though, satellite readings (1987 to 2007) unexpectedly show temperature declines along the West and South Coast (Griffiths *et al*. 2010).

3.6.2 Invasive alien infestations

Invasive alien trees and shrubs have major impacts on the surface water resources in South Africa. Not all invasive plants consume more water than the natural vegetation that they displace, but dense stands dominating high-rainfall grasslands or shrublands do. For example, invasive woody aliens are thought to utilize 3,300 million cubic metres per annum. This is considerably more water than what is used by indigenous vegetation, and accounts for about 7 per cent of the runoff of the country (Richardson *et al*. 2011). If invasive alien plants are left to spread to their full potential, the carrying capacity for large stock units (grazing) could be reduced by 71 per cent (van Wilgen *et al*. 2008).

Alien fish impacts in our waters include the transfer of associated parasites, changes in aquatic invertebrate communities and the extinction of indigenous fish by predation and competition, and the possibility for hybridization. On the other hand, some alien fish (e.g. trout) are valuable contributors to the economy as they are major target catches for recreational anglers, provide food security to local communities and drive a growing trade in the pet and table-fish industry.

The ecological costs of invasive alien impacts caused by plant and animal invasions are estimated to be more than R6,500

million annually (van Wilgen *et al*. 2012). The main costs are associated with losses in agricultural yields caused by crop pests, mainly arthropods, as well as a decline in ecosystem services such as water and grazing (Reyers *et al*. 2009; van Wilgen *et al*. 2008). Of the 40 top crop pests in South Africa, 42 per cent have been introduced (Picker & Griffiths 2011).

Of concern too, is that introduced parasites and pathogens and their vectors, may in fact represent the transfer of virulent forms of invasive species that cause infectious diseases (Cumming *et al*. 2011; Gaidet *et al*. 2012). Disease epidemics such as chestnut blight, black sigatoka virus, frog Chytrid fungus, white-nosed disease in bats, and so forth, can have widespread effects on ecosystems, food production and human health.

Biodiversity and livestock and poultry farming in South Africa, and our adjacent border countries, is potentially threatened by a range of diseases that can be imported with avifauna or livestock. For instance, rinderpest, anthrax, and tuberculosis are relevant to mammal conservation, particularly in regard to planning for veterinary fencelines, maintaining migration routes, and transfrontier conservation areas (TFCAs). For birds, Avian Influenza, Newcastle Disease, and West Nile may all be or become problems for conservation.

About half of all major plant weed species have been successfully impacted on by biocontrol agents. Approximately 21 per cent of the weed species on which biological control agents are established have been completely controlled, and another 38 per cent are under a substantial degree of control. Seventy-five (71 per cent) of the 106 biocontrol agents released in South Africa became established on 48 invasive alien plant species (Klein 2011). These agents generally include mites, insects and pathogen species or biotypes thereof.

3.7 GAP BETWEEN POLICY AND IMPLEMENTATION

South Africa has, on the whole, good environmental policies but, like many other countries often faces challenges in implementing policy for a range of reasons. Reasons include the fact that we currently have a complex spectrum of policies and strategies that do not always speak clearly to each other and cause overlapping mandates, confusion around responsibilities for implementation and monitoring needs.

In an Africa-wide survey of sustainability and performance of cities, none of the South African cities performed well on quantifiable metrics such as electricity consumption, waste generation and water consumption (Siemens Economist Intelligence Unit 2011). Added hereto, they have among the highest carbon dioxide emissions from electricity, mainly because South Africa's electricity is produced mostly from coal. The survey did however find that South African cities "*more than make up for drawbacks on consumption with consistently strong environmental policies*."

The following sections outline sectoral examples indicating the gap between the sustainability policy environment and the actual implementation on the ground.

3.7.1 Housing

Sustainable housing/ settlements are not being created with the exception of a few developments - mostly outside of the mainstream, namely:

- Pilot projects such as Cosmo City, Midrand;
- NGO-driven developments such as Thlolego in the Rustenburg area; and,
- Private developments for the higher-income market, such as Crossways (Eastern Cape), Southdowns (Irene, Gauteng) and Verkykerskop (Eastern Free State).

Conventional Reconstruction and Development Programme (RDP) and speculation houses in mono-functional townships are still the main housing type being provided due to the need to provide affordable housing at a rapid rate. Passively designed houses (designed according to passive architectural principles, whereby high levels of insulation, appropriate room orientations and high thermal-performance materials are used to ensure climatically sound buildings) are not built for the mass market, being the choice rather of some ecologically-concerned few. In most cases, the total life-cycle costs of providing housing are not considered. In the mass property development market, green-washing creates a false impression: many developers misuse the terms sustainable and eco for marketing purposes.

3.7.2 Infrastructure

Demand-management is yet to play a significant role in the provision of electricity and wet services (potable water supply and sanitation). Renewable energy technologies have yet to take hold on any substantial scale and ecological stormwater management is the exception rather than the rule. Roads are designed and built for commuter traffic; cyclists and pedestrians are rarely catered for. Waste management activities still largely follow the 'cradle to grave' approach.

3.7.3 Land use management

Land use is still being largely regulated by the old Provincial Ordinances and Town Planning Schemes. These are outdated, with no mention of issues of sustainable development. Current land use schemes could be amended to reflect more sustainable approaches, but such amendments can be onerous and ad hoc. Guidance is needed to get land use schemes on a sustainable footing, but unfortunately the guidance needed is not provided by the Spatial Planning and Land Use Management Act (No 16 of 2013) (SPLUMA). It is too early to say if the NSSD will have any positive influence on land use schemes and municipal by-laws.

3.7.4 Spatial planning

The same assessment with regards to land use management also applies to wider spatial planning. In most cases, sustainability is only given lip-service in Integrated Development Plans (IDPs) and Spatial Development Frameworks (SDFs). Principles and norms for sustainability do not find expression in these plans because many (if not most) planners and officials do not understand the concept, nor do they know which principles to formulate and which norms and metrics to apply.

3.7.5 Resource use

Environmental issues are not well integrated with spatial and developmental problems. There are assessments or evaluations (EIAs and Environmental Management Frameworks (EMFs)) of terrains or environments' suitability for certain developments and the probability of impacts and possible mitigating measures are determined. What is not being done however, is the accurate measuring and follow up of impacts, especially the downstream latent or indirect impacts (which are actually required by NEMA through the precautionary principle). Consequently, there is seldom, if ever, consideration of cumulative impacts (also required by NEMA) on environmental systems and services. Relentlessly, there is eroding of natural capital (environmental services).

3.8 SKILLS AVAILABILITY IN THE ENVIRONMENTAL SECTOR

All of the chapters within Part II of this SAEO identify some level of skills shortages to deal with environmental issues. The most pressing shortages in current skills are the ability to collect and interpret data, monitor important changes and thresholds, as well as the ability to implement policies. Most government departments and municipalities have recognized the shortage of skills as a key constraint and invest heavily in skills development programmes. SANBI has undertaken extensive research relating to the major challenges associated with skills shortages and human capital development in the environment sector as a whole. Skills development and capacity building is elaborated on as an important cross-cutting issue in Part IV: Options for Action.

3.9 SCIENCE AND TECHNOLOGY

Science and technology drive both positive and negative effects on the environment. They can drive the development of new technologies that allow more efficient resource use, enable recycling, improve food production, clean water, develop pharmaceuticals, prevent disease and so on. Innovation and scientific advances can also accelerate urbanization, land transformation and increase pollution and waste. Technological advances can also enable the greater exploitation of natural resources (DEAT 2006).

The Departments of Environmental Affairs and of Science and Technology have signed a Memorandum of Understanding (MoU) to collaborate on joint initiatives. In contributing to the 2002 national research and strategy and the global change research plan, the environment sector research, development and evidence (R,D&E) framework was approved by MINMEC in June 2012. The framework aims to enhance the sector science-policy interface and evidence-based policy making. The objective is to implement a common sector framework that ensures joint scoping and joint interpretation among researchers and policymakers.

Further information is outlined in Part IV: Options for Action where Science and Technology is identified as an important cross-cutting issue.

3.10 CONCLUSION

The primary drivers of change in the environment are population dynamics, the patterns of production and consumption, an unsustainable urban development model and patterns of economic development. Population dynamics (including population growth, migration, household size, age profiles, skills and income levels) and economic trends consumption and production both have a compounded effect on environmental pressures. Particularly within the last decade, South Africa has realized that while equitable economic growth and development are absolutely necessary, these must be done in a manner that does not drive environmental change beyond recoverable thresholds. As an example, recognition of the need to supply electricity for economic growth along with a dependence on a coal supply for electricity has led to ambitious targets being set for energy efficiency and a move to alternative and renewable energy options.

Policy responses to environmental change mostly concentrate on reducing pressures and often do not address directly the drivers of change. Policy interventions targeted directly at the drivers of population dynamics and economy, however, may not be practical or, politically viable, and may raise moral and humanitarian concerns (UNEP 2012). There are nevertheless options that can reduce a driver indirectly, for example, policies that target improving education, creating employment or incentivising environmentally favourable behaviour.

3.11 REFERENCES

1. AASA (American Association for the Advancement of Science), (2000). *Atlas of population and environment*. University of California, Berkeley.

2. Butchart, S.H.M., Walpole, M., Collen, B., van Strien, A., Scharlemann, J.P.W., Almond, R.E.A., Baillie, J.E.M., Bomhard, B., Brown, C., Bruno, J., Carpenter, K.E., Carr, G.M., Chanson, J., Chenery, A.M., Csirke, J. and Nick, C. (2010). Global Biodiversity: Indicators of Recent Declines. *Science* 328: 1164-1168.

3. Casale, D. and Posel, D. (2006). *Migration and remittances in South Africa: Background document on migration and first set of draft questions for inclusion in the National Income Dynamics Study*. South African Labour and Development Research Unit, University of Cape Town, Cape Town.

4. Chamber of Mines of South Africa (2011). *Introduction to the Chamber of Mines of South Africa 2011*. Chamber of Mines of South Africa. http://www.bullion.org.za/ Viewed 2 November 2011.

5. Chamberlain, D., Essop, H., Hougaard, C., Malherbe, S. and Walker, R. (2005). *G:ENESIS: Part II Market Analysis*. Final Report 29 June 2005.

6. Crawford, R.J.M. and Altwegg, R. (2009). *Seabirds and Climate Change in southern Africa - Some Considerations*. In: Harebottle, D.M., Craig, A.J.F.K., Anderson, M.D.,

Rakotomanana, H. and Muchai, M. (eds). Proceedings of the 12th Pan-African Ornithological Congress, 2008. Cape Town, Animal Demography Unit.

7. Crawford, R.J.M., Altwegg, R., Braham, B.J., Barham, P.J., Durant, J.M., Dyer B.M., Geldenhuys, D., Makhado, A.B., Pichegru, L., Ryan, P.G., Underhill, L.G., Upfold, L., Visagie, J., Waller, L.J. and Whittington, P.A. (2011). Collapse of South Africa's Penguins in the 21st Century: a Consideration of Food Availability. *African Journal of Marine Science* 33: 139–156.

8. Crawford, R. J. M., Cockroft, A. C., Dyer, B. M. and Upfold, L. (2008). Divergent, Trends in Bank Cormorants *Phalacrocorax neglectus* Breeding in South Africa's Western Cape Consistent with a Distributional Shift of Rock Lobsters Jasus lalandii. *African Journal of Marine Science* 30: 161–166.

9. Cumming, G.S., Caron, A., Abolnik, C., Cattoli, G., Bruinzeel, L.W., Burger, C.E., Cecchettin, K., Chiweshe, N., Mchotlhoane, B. and Mutumi, G.L. (2011). The Ecology of Influenza A Viruses in Wild Birds in Southern Africa. *Ecosystem Health* 8(1): 4-13.

10. DAFF (Department of Agriculture, Forestry and Fisheries), (2010). *Forest policy, governance and institutional arrangements in a changing environment*. Presentation by Ms S Chipeta, DAFF, Forestry Indaba, Mpumalanga.

11. DAFF (Department of Agriculture, Forestry and Fisheries), (2011). *State of Forest Report*. Department of Agriculture, Forestry and Fisheries, Pretoria.

12. DEA (2012). *National Environmental Compliance and Enforcement Report*. Department of Environmental Affairs. https://www.environment.gov.za/sites/default/files/.../necer2011.

13. DEA (Department of Environmental Affairs), (2011). *National Strategy for Sustainable Development and Action Plan (NSSD) 2011-2014*. Department of Environmental Affairs, Pretoria.

14. DoH (2010). *The National Antenatal Sentinel HIV and Syphilis Prevalence Survey in South Africa*. http://www.hst.org.za/sites/default/files/hiv_aids_survey.pdf. Viewed 25 July 2012.

15. DSD (Department of Social Development), (2010). *Progress Review of the Implementation of The White Paper on Population Policy for South Africa (1998) and The ICDP Programme of Action (1994)*. Department of Social Justice, Pretoria.

16. DBSA (Development Bank of Southern Africa Limited), (2011). *Programmes in support of transitioning South Africa to a green economy*. Development Planning Division Working Paper Series No. 24, DBSA, Pretoria.

17. Driver A., Sink, K.J., Nel, J.N., Holness, S., Van Niekerk, L., Daniels, F., Jonas, Z., Majiedt, P.A., Harris, L. & Maze, K. (2012). *National Biodiversity Assessment 2011: An assessment of South Africa's biodiversity and ecosystems. Synthesis Report*. South African National Biodiversity Institute and Department of Environmental Affairs, Pretoria.

18. Eaton, R.L., Hammond, G.F., and Laurie, J. (2007). Footprints on the landscape: An environmental appraisal of urban and rural living in the developed world. *Landscape and Urban Planning* 84 (1): 13-28.

19. Esterhuizen, D. (2011). *South Africa Biotech Annual Report*. United States Department of Agriculture. Foreign Agricultural Service.

20. FFC (Financial and Fiscal Commission), (2011). *The economic and fiscal costs of inefficient land use patterns in South Africa*. Unpublished research report.

21. Griffiths, C.L., Robinson, T.B., Lange, L. and Mead, A. (2010). Marine Biodiversity in South Africa: An Evaluation of Current States of Knowledge. *PLoS ONE* 5(8): e12008. Doi: 10.1371/journak.pone.0012008.

22. Grundy, I. and Wynberg, R. (2001). *Integration of biodiversity into national forest planning programmes: The case of South Africa*. Presentation at the Integration of Biodiversity in National Forestry Planning Programme, 13-16 August 2001, CIFOR Headquarters, Indonesia.

23. Golding, J.S., Güsewell, S., Kreft, H., Kuzevanov, V.Y., Lehvävirta, S., Parmentier, I. and Pautasso, M. (2010). Species-richness Patterns of the Living Collections of the World's Botanic Gardens: a Matter of Socio-Economics? *Annals of Botany* 105(5): 689-696.

24. John, L. (2012). *Secondary Cities in South Africa: the Start of a Conversation*. South African Cities Network, Pretoria.

25. Klein, H. (2011). A Catalogue of the Insects, Mites and Pathogens that have been Used or Rejected, or are Under Consideration, for the Biological Control of Invasive Alien Plants in South Africa. *African Entomology* 19(2):515–549.

26. Laczko, F and Aghazarm, C. (eds). (2009). *Migration, Environment and Climate Change: Assessing the Evidence*. International Organization for Migration, Geneva.

27. Midgley, G.F. and Thuiller. W. (2010). *Potential Responses of Terrestrial Biodiversity in Southern Africa to Anthropogenic Climate Change*. Regional Environmental Change. DOI 10.1007/s10113-010-0191-8.

28. Milton, S.J. and Dean, W.R. (2011). *Changes in Rangeland Capital. Trends, Drivers and Consequences*. In: Zeitsman, L. (ed.) Observations on Environmental Change in South Africa. Sun Media, Stellenbosch.

29. NPC (2011). *Diagnostic report on material conditions*. Unpublished report. http://www.npconline.co.za/MediaLib/Downloads/Home/Tabs/Diagnostic/Diagnostic_Material_Conditions.pdf. Viewed 21 May 2012.

30. NPC (National Planning Commission), (2012). *National Development Plan 2030: Our future – make it work*. National Planning Commission, Pretoria.

31. Pelser, A. and Redelinghuys, N. (2009). *Population, environment and development. Towards a 10-year review of the population policy implementation in South Africa (1998 – 2008)*. Department of Social Development, Pretoria. http://www.population.gov.za/pop_dev/index.php/Population-Policy-+-10-Review/View-category.html?dir=DESC&limit=5&limitstart=5&order=name. Viewed 21 May 2012.

32. Picker, M. and Griffiths, C.L. (2011). *Alien and Invasive Animals*. Struik Nature, Cape Town.

33. Richardson, D., Wikson, J.R., Weyl, O.L.F. and Griffiths. C.L. (2011). *South Africa: Invasions*. In: Simberloff, D. and Rejmánek, M. (eds). Encyclopaedia of Biological Invasions. University of California Press, Berkeley and Los Angeles.

34. Reyers, B., O'Farrell, P. J., Cowling, R. M., Egoh, B. N., Le Maitre, D. C. and Vlok, J. H. J. (2009). Ecosystem services, land-cover change, and stakeholders: finding a sustainable foothold for a semiarid biodiversity hotspot. *Ecology and Society* 14(1):38.

35. SANBI (South African National Biodiversity Institute). (2011). *Grasslands Factsheet*. http://www.grasslands.org.za/phocadownload/grasslands%20fact%20sheets%20new.pdf Viewed 2 November 2011.

36. StatsSA (2011). *Mid-year population estimates 2011*. Statistical release P0302. Statistics South Africa. http://www.statssa.gov.za/publications/P0302/P03022011.pdf. Viewed 27 July 2011.

37. StatsSA (Statistics South Africa), (2012a). *Census 2011*. Statistics South Africa, Pretoria.

38. StatsSA (Statistics South Africa), (2012b). *Subjective Poverty in South Africa: findings of the living conditions survey 2008/2009*. Statistics South Africa, Pretoria.

39. Siemens Economist Intelligence Unit (2011). *African Green City Index: Assessing the environmental performance of Africa's major cities.* A research project conducted by the Economist Intelligence Unit, sponsored by Siemens. http://www.siemens.com/entry/cc/en/greencityindex.htm.

40. Swilling, M. (2011). *Growth Resource Use and Decoupling: Towards a 'Green New Deal' for South Africa*? Working paper series no. 14. March 2011.

41. Trading Economics (2012a). *South Africa GDP Annual Growth Rate*. http://www.tradingeconomics.com/south-africa/gdp-growth. Viewed 27 July 2012.

42. Trading Economics (2012b). *South Africa Unemployment Rate*. http://www.tradingeconomics.com/south-africa/unemployment-rate. Viewed 27 July 2012.

43. Turpie, J.K., Menayas, A., Dures, S., Shaw, J.M., Meek, C., Cordingley, J., Hamann, M., Mzumara. T., Musvuugwa, T., Louw, A., Bewana, A., Quayle, T. and Ditlhobolo, T. (2008). *The nature, distribution and value of ecosystem services in South Africa*. Unpublished report. Percy FitzPatrick Institute, University of Cape Town.

44. UNDP (United Nations Development Plan), (2011). *Human Development Report 2011*. United Nations Development Programme. New York.

45. UNEP (2011). *Decoupling natural resource use and environmental impacts from economic growth*. A Report of the Working Group on Decoupling to the International Resource Panel. Fischer-Kowalski, M., Swilling, M., von Weizsäcker, E.U., Ren, Y., Moriguchi, Y., Crane, W., Krausmann, F., Eisenmenger, N., Giljum, S., Hennicke, P., Romero Lankao, P., Siriban Manalang, A., Sewerin, S. United Nations Environment Programme. http://www.unep.org/resourcepanel/decoupling/files/pdf/decoupling_report_english.pdf. Viewed 19 June 2012.

46. UNEP (United Nations Environment Programme), (2012). *Global Environmental Outlook 5: Environment for the future we want*. United Nations Environment Programme, Nairobi.

47. van den Berg, E.C., Plarre, C., van den Berg, H.M. and Thompson, M.W. (2008). *The South African National Land Cover 2000*. Agricultural Research Council (ARC) and Council for Scientific and Industrial Research (CSIR), Pretoria. Report No. GW/A/2008/86.

48. van Wilgen, B.W., Reyers, B., Le Maitre, D.C., Richardson, D. & Schonegevel, L. (2008). A Biome-scale Assessment of the Impact of Invasive Alien Plants on Ecosystem Services in South Africa. *Journal of Environmental Management* 89: 336–349.

49. van Wilgen, B.W., Forsyth, G.G., Le Maitre, D.C., Wannenburgh, A., Kotzé, I., van den Berg, L. and Henderson, L. (2012). An Assessment of the Effectiveness of a Large, National-scale Invasive Alien Plant Control Strategy in South Africa. *Biological Conservation* 148:28–38.

50. Ward, C.D., Parker, C.M. and Shackleton, C.M. (2010). The Use and Appreciation of Botanical Gardens as Urban Green Spaces in South Africa. *Urban Forestry and Urban Greening* 9(1):49-55.

51. WWF (2011). *Agriculture: Facts and Trends: South Africa, awsassets*. World Wide Fund for Nature. http://www.wwf.org.za/downloads/facts_brochure_mockup_04_b.pdf.

52. WWF (World Wide Fund for Nature), (2012). *Living Planet Report 2012: Biodiversity, biocapacity and better choices*. World Wide Fund for Nature, Gland.

53. Zeitsman, L. (2011). *Observations on Environmental Change in South Africa*. (Ed.) Sun Media, Stellenbosch.