



Part III

Human vulnerability to environmental change

Chapter 10

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At a glance

The chapter starts by defining vulnerability in the context of environmental change. It notes that people's levels of vulnerability are determined by the interaction between environmental change, natural disasters, and prevailing socio-economic conditions such as increasing poverty, unemployment, and HIV and AIDS. By featuring several case studies, the chapter demonstrates that vulnerability is wide-ranging and has a profound impact on our country's economically and socially marginalized communities. The chapter proposes several responses, including improving people's capacity to cope with change by creating social networks and groups to fight poverty and HIV and AIDS, changing patterns of land use, and avoiding inherently hazardous areas.

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10.1 INTRODUCTION: UNDERSTANDING VULNERABILITY

The 1997 Human Development Report emphasized the dramatic economic and environmental changes during the last decades of the 20th century:

The world is rapidly changing, with the globalization and liberalization of the world economy, with the rise of new conflicts, with the spread of HIV and AIDS, with the steady deterioration of environmental resources, with demographic changes, with the failures of economic growth in sub-Saharan Africa, Latin America and the Caribbean and the Arab States, and with the transition to free market economic systems and democratic government¹.

The New Partnership for Africa's Development (NEPAD) has reiterated these concerns, and in particular, recognized that "natural disasters, such as floods, droughts, earthquakes and landslides cause considerable human suffering and economic damage"². Natural disasters and environmental degradation will continue to undermine prospects of fighting poverty, economic growth, and sustainable development.

This chapter defines vulnerability and indicates how environmental change is affected by and affects human activity. The following section elaborates on this understanding by presenting five place-bound case studies, which highlight various dimensions of human vulnerability

to environmental change. The chapter concludes by considering areas of possible intervention.

10.1.1 Defining vulnerability

The *Global Environment Outlook 3* report defines vulnerability³ as the "the interface between exposure to the physical threats to human well-being and the capacity of people and communities to cope with those threats"³. Vulnerability, therefore, has two sides: an external side of risks, shocks, and stresses to which an individual or household is subject, and an internal side, which offers the means for coping, without causing damage or loss⁴ (see Figure 10.1).

Although vulnerability is often considered in relation to a particular stressor or hazard, such as drought, it is becoming increasingly clear that it is generated and shaped by interacting biophysical and socio-economic factors (see Figure 10.2). These include not only physical changes in the environment, such as deforestation, erosion, desertification, infilling of flood plains, and dwindling surface and ground water, but also economic, social, and political changes brought about by socio-economic processes such as economic globalization, urbanization, migration, and political conflicts⁵.

The causes and impacts of environmental change and natural disasters are the result of both physical and socio-economic factors. Vulnerability is strongly linked to the complex make-up of society, including class, gender and

"Only when the last tree has died and the last river has been poisoned and the last fish has been caught will we realize that we can't eat money."

Cree proverb

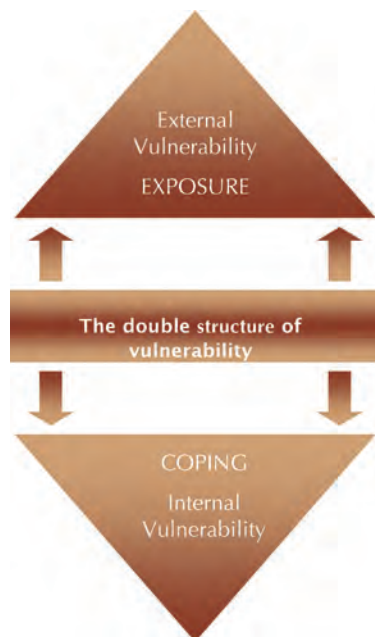


Figure 10.1: A conceptual model for vulnerability

Source: after Bohle (2001)⁷

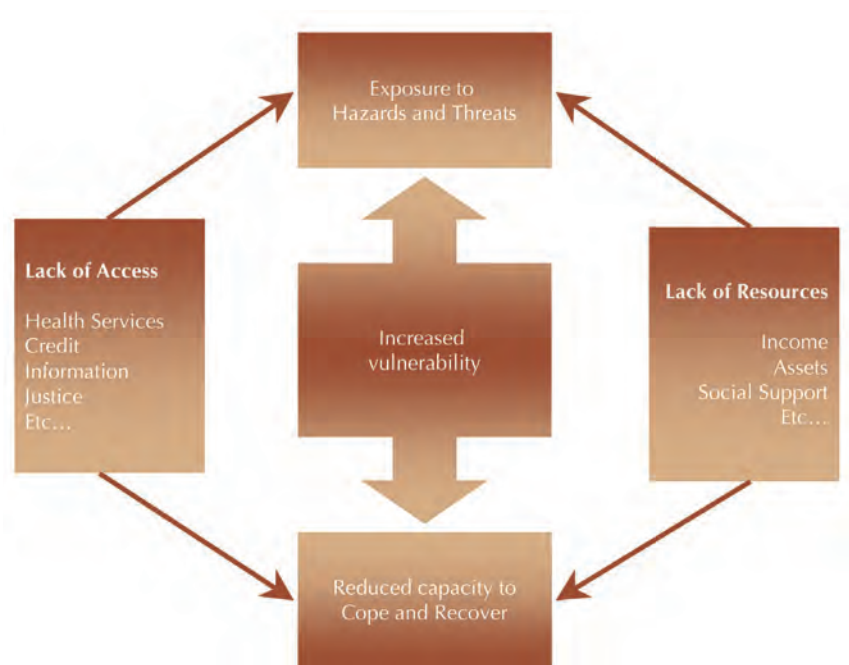


Figure 10.2: Schematic outline of vulnerability

Source: Wisner (2003)⁶



age, past loss and misfortune, and susceptibility to future losses⁶. Human vulnerability may be compounded by several factors⁷:

- Livelihood circumstances – position and status in society, which in turn are normally related to wealth, gender, race, ethnicity, health, and other conditions
- Location – the geographical proximity to a hazard or potential hazard
- Self-protection – the capacity to protect oneself from harm, including access to materials, knowledge, and information
- Social protection – the extent of assistance and support, including resources and technical expertise, that the society or group of individuals can provide.

Vulnerable populations have limited capacity to protect themselves from current and future environmental hazards, such as polluted air and water, catastrophes, and the adverse consequences of large-scale environmental change, such as land degradation, biodiversity loss, and climate change⁸. These factors can be used as variables to gauge vulnerability within a country.

A set of national level indicators of vulnerability and capacity to adapt to climate hazards is shown in Box 10.1. Although these indicators are specific to climate change, they still provide a useful entry point to analysing vulnerability in South Africa.

10.1.2 Environmental change

Most environments are in a constant state of natural flux. Human modifications for food production, settlements, and infrastructure, or to produce and store goods³ can accelerate these rates of change outside the range of natural disturbance and fluctuation.

Change is the norm rather than the exception, but most natural ecosystems maintain themselves in a state of 'dynamic equilibrium', in which the system is resilient and adapted to withstand perturbations and disturbances caused by limited magnitude or range of change.

Extreme events can occur naturally (such as earthquakes, hurricanes, floods, and droughts), which 're-set' a system or change it into a new one. Ecologists have established that floods and droughts are necessary 're-sets' in systems that are prone to them. These extreme events occur in particular locations, which are therefore inherently unstable, such as floodplains, steep slopes, and the intertidal zone of the coast. South Africa has always been known as a drought prone region, and its major rivers are subject to violent floods.

Humanity's ability to modify, manipulate, and control natural processes has increased as engineering and technology have developed, to the point where many

people now believe nature to be completely controllable, and they underestimate the role of natural dynamics. They erect barriers to sea-water in coastal areas, for example, build on steep slopes that are subject to land slides, canalize rivers, fill in floodplains, and build cities on tectonic faults. South Africa has developed livestock densities and a grain industry that underprovides for drought years, leading to disaster when drought reappears.

Vulnerability to natural events that lead to human disasters is inevitable where human settlement coexists with and attempts to control and modify inherently unstable natural landscapes. There is now evidence that this vulnerability may increase with human attempts to manipulate natural hazards. Canalization of rivers promotes development on floodplains, for instance. Urban development in floodplains increases both the volume and rate of runoff into rivers, thus increasing the flood peak volume beyond the designed flow capacity of canals. Flooding from the canal becomes catastrophic to adjacent urban development, partly because of the assumption that an engineered solution will protect people from harm. The 2005 devastation of New Orleans, which lies below sea level in a major river delta or floodplain, is a relevant example. So our patterns of land use make everyone vulnerable to natural hazards.

Environmental changes caused by human activities often set in motion a chain of events that increases human vulnerability. Desertification (loss of vegetation cover), for example, reduces soil moisture (which lowers agricultural productivity), and increased soil erosion and runoff leads to



N2 highway destroyed by floods. *Photography: Trace Images / Brenton Geach*

Box 10.1 Vulnerability indicators

The table below presents a set of national level indicators of vulnerability and capacity that have been adapted to climate hazards. Although these indicators are specific to climate change, they nevertheless provide a useful entry point for analysing vulnerability in South

Africa. Particular emphasis is placed on the categories of health, education, and governance. Education and health underpin human capability and well-being, and governance facilitates the ability to cope through the provision and support of institutions. Participation in

the political process, for example, leads to the development of social capital. Education indicators can be used to assess whether or not non-manual employment is contributing to resilience through diversified livelihoods and access to information.

Potential proxies for national level vulnerability to climate change

Category	Variable	Proxy
Economy	National wealth Inequality	Gross domestic product (GDP) per capita (US\$ PPP)** Gini coefficient
Health	State support for health General health Healthcare availability Removal of economically active population	Health expenditure per capita (US\$ PPP) *Life expectancy at birth *Maternal mortality per 100 000 HIV prevalence rate (% of adults)
Food & nutrition security	Nutritional status General food availability Food access/access to nutrition	*Calorie intake per capita Food production index Food price index
Education	Educational commitment Educational commitment Entitlement to information Entitlement to information Entitlement to information Participatory decision making	Education expenditure as % of Gross National Product (GNP) Educational expenditure as % of government expenditure *Literacy rate (% of population over 15) *Literacy rate (% of 15–24 year olds) *Literacy ratio (female to male) *Voice and accountability
Infrastructure	Isolation of rural communities Commitment to rural communities Quality of basic infrastructure	Roads (km, scaled by land area with 99% of population) Rural population without access to safe water (%) *Population with access to sanitation (%)
Governance	Effectiveness of policies Influence of political process Influence of political process Ability to deliver services Willingness to invest in adaptation	Control of corruption *Civil liberties *Political rights *Government effectiveness Political stability
Geography / demography	Resource pressure Coastal risk	Population density Population within 100 km of coastline (%)
Agriculture	Agricultural self-sufficiency	Agricultural production index
Ecology	Environmental stress Environmental stress Sustainability of water resources Sustainability of water resources	Protected land area (%) Unpopulated land area Groundwater recharge per capita Water resources per capita
Technology	Commitment to and resources for research Capacity to undertake research and understand issues	Research and development (R&D) investment (% GNP) Scientists & engineers in R&D per million population

Proxies marked with an * indicate key indicators of vulnerability as per Brooks *et al.* (2004).

**Comparing GDPs of different countries is done by using the purchasing-power parities (PPPs) instead of market exchange rates.

Source: (adapted) from Brooks *et al.* (2004)⁹



Koue Bokkeveld farmer has sunk a borehole on his land because his dams are dry.

Photography: Trace Images / Andrew Ingram



Many residents lost all their possessions in a fire that demolished 300 shacks in Khayelitsha, outside Cape Town.

Photography: Trace Images / Lulama Zenzile

increased flood volumes and poor water quality because of increased levels of suspended solids. Poorly treated wastewater entering rivers degrades water quality, making communities downstream vulnerable to waterborne infectious diseases. Global human migration has spread infectious diseases into new regions and continents. Attempts to eliminate disease by developing super-drugs have bred 'super-resistant' bacteria such as Vancomycin-resistant *Enterococci*, *Streptococcus pneumoniae*, and *Escherichia coli* (*E.coli*). High levels of pollution can cause the development of widespread, life-threatening health conditions that can increase people's risk of contracting lethal diseases.

The following recorded changes in South Africa's environment are important for understanding vulnerability:

- Climate scenarios generated from global atmospheric models indicate that southern Africa could experience increased frequencies and magnitudes of extreme events such as droughts and floods¹⁰. The most recent projections for South Africa show that its east coast regions will experience wetting while the west will become drier. The Western Cape will face a shorter rainfall season¹¹.
- Increasing atmospheric pollutant concentrations, in general, currently exceed recommended health limits across the country, while indoor air pollution from the burning of coal and wood for cooking and heating is considered to be one of the most critical environmental health issues^b.
- The lower reaches of rivers and those in urban areas are in poor health. Many rivers suffer deteriorating water quality, particularly with respect to salinity, and most primary river ecosystems are threatened^d.
- There is increased conversion and fragmentation of natural land and habitat to urban and agricultural use^{d,e}.
- There is lack of access to land, and there is also poor

planning, particularly on the fringes of urban centres^d where high density informal settlements are developing.

- There is increasing exploitation of coastal resources by fisheries, particularly on the west coast^f.

There are growing signs that the earth system is 'fragile' and that the changes now occurring throughout the global environment, their magnitude and their rate, are unprecedented in human history. These changes pose significant challenges for southern Africa, where rapidly evolving socio-economic conditions compound the problem.

10.2 POVERTY AND HUMAN VULNERABILITY IN SOUTH AFRICA

In a developing country such as South Africa, poor people tend to be the most vulnerable to environmental disturbance, because they have fewer resources to help them to cope with disaster. They have low incomes, restricted choices regarding location and employment, are less able to afford food or to save and accumulate assets, and are often powerless. Both global and local consequences of environmental damage impact upon poor people.

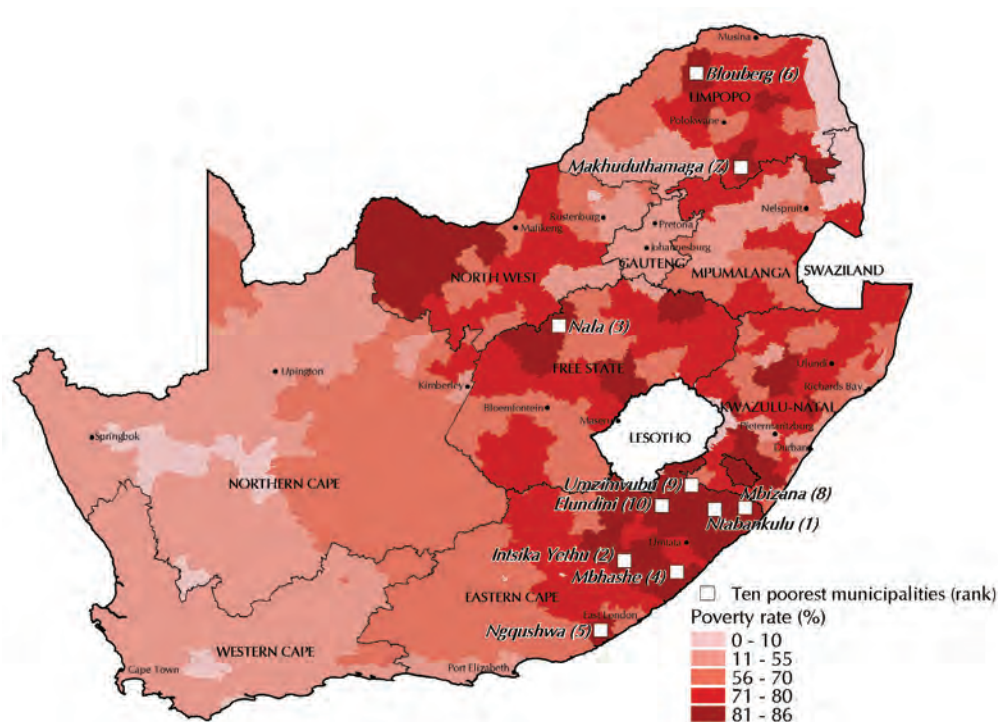
Vulnerability is, however, not the same as poverty¹². Rising poverty certainly contributes to rising vulnerability, but poor people may not necessarily be vulnerable if they live in relatively stable circumstances, with good infrastructure, communications, and social support systems (see Figure 10.2)¹³. Poverty in this context may be a state of deprivation (lack of adequate access) to key resources needed for full participation in an economic and social life. Wealthier people can also be vulnerable when they live in unstable and uncertain environments, such as, for example, those who bear the extreme fire risk to thatched cottages on the fynbos coast of the South-western Cape.

Table 10.1: Poverty indicators by province

Province	Number of poor person (millions)	% of population in poverty	Poverty gap* (R billions)	Share of poverty gap (%)
Eastern Cape	4.6	72	14.8	18
Free State	1.8	68	5.9	7
Gauteng	3.7	42	12.1	15
KwaZulu-Natal	5.7	61	18.3	22
Limpopo	4.1	77	11.5	14
Mpumalanga	1.8	57	7.1	9
North West	1.9	52	6.1	8
Northern Cape	0.5	61	1.5	2
Western Cape	1.4	32	4.1	5
South Africa	25.5	58	81.4	100

*The poverty gap measures the required annual income transfer to all poor households to bring them out of poverty.

Source: Adapted from Human Sciences Research Council (2004)¹⁵



Map 10.1: Distribution of poverty across South Africa showing the ten poorest municipalities

Source: Human Sciences Research Council (2004)¹⁵

As indicated in Chapter 2 of this report, the absolute number of people living in poverty in South Africa increased between 1995 and 2002¹⁴. Furthermore, those households living in poverty have fallen deeper into poverty, and the gap between rich and poor has widened¹⁵.

The spatial distribution of the poor across municipalities is shown in Map 10.1. Seven of the ten poorest municipalities are located in the Eastern Cape, two in Limpopo, and one in the Free State. These rural areas correspond with the former 'homelands', and a disproportionate number of South Africa's poor reside there.

The poverty gap indicates how far below the poverty line poor households live. It has grown from R56-billion in 1996 to R81-billion in 2001. It indicates that poor households have not shared the benefits of economic growth. In 1996 the total poverty gap was equivalent to 6.7% of gross domestic product (GDP). By 2001 it had risen to 8.3%.

10.2.1 Rural poverty

Poor rural households do not have the resources (land, finances, tools, training) to progress as agriculturalists, and land-based livelihood strategies fail to provide enough to accumulate sufficient of these resources to make it possible for them to reduce their vulnerability over time (see Box 10.2¹⁶).

Several of the poorest municipalities in South Africa are

densely populated and situated in 'deep' rural locations (see Map 10.1). Typically under communal tenure, these communities have the largest historical backlogs in terms of service delivery. It is here that vulnerability in South Africa is greatest (see case study on Umkhanyakude in section 10.3.2).

South Africa is experiencing urbanization without proportionate economic and income growth (see Chapter 9) resulting in the nine major cities accommodating a disproportionate share of the country's unemployed. If nothing is done about the situation in the rural areas – including land reform and building more diverse farming communities around revitalized rural towns – then the urban areas will fail to cope with the continuing influx of migrants who seek employment that is not available to them.

Education in rural areas underpins resilience and reduces susceptibility to stresses such as environmental change. The general standard of educational attainment has improved throughout South Africa since 1996: the proportion of individuals without schooling has decreased, and the proportion of people with Grade 12 or higher education has increased significantly (for statistics, see Chapter 2, section 2.2.4).

Rural women remain one of the most marginalized and vulnerable groups, in spite of improvements in education. Most women (52–74%) in the Makhuduthamaga municipality, for instance, have little or no primary school education. Makhuduthamaga falls within the Sekhukhune District Council, which is one of the Integrated Rural Development nodes selected as an area requiring concerted effort to meet backlogs¹⁵ in the provision of access to basic services. Map 10.1 indicates that the Makhuduthamaga municipality is one of the country's ten poorest municipalities (see case study on food insecurity in Sekhukhune).

10.2.2 Urban poverty

The city poor have become conspicuous in the urban landscape. Between 1996 and 2001, the population of the largest 21 urban centres in South Africa rose from 18.4



After the fire at their squatter camp, these boys are left destitute. *Photography: IMAGES24.co.za / Beeld / Siddique Davids*



A little boy from Rustenburg is outside his classroom flooded by water. *Photography: IMAGES24.co.za / City Press / George Mashini*

million to 21.1 million, an absolute increase of 14.2% or an annual growth rate of 2.7%¹⁷.

Unemployment underlies poverty in urban areas, with a substantial number of potential workers lacking the required education and relevant skills (see Chapter 2). At the same time it is the poor in cities who are commonly exposed to degraded urban environments and who are unable to afford a safer environment or pay for essential services.

Box 10.2 Marginalization of the rural poor

"They appreciated that I came to visit them because no one visits their house. What touched me is that four members of the family were sick. One had TB, one had HIV, one woman had a breast problem, and her baby had diarrhoea. They have never been treated because they could not pay for transport. The baby is fed on thin porridge diluted with water and breastfed on the

healthy breast. I had to help them with money. There is no food at all, they depend on anyone who comes in and gives food... The family is tired of them, they do not want to assist any more, because they are always hungry. There are no blankets except one, which is shared between the baby with diarrhoea and the person with HIV. The roof is leaking during the rainy season and it gets

flooded sometimes. The house belongs to a family member who died of TB. No-one in this family has an ID, and they have no money to apply for IDs, or even to come to town."

Source: Mount Frere Fieldworker, Chronic Poverty Research Centre, University of Western Cape. Translated from isiXhosa in De Swardt (2003)

Table 10.2: HIV prevalence by locality in South Africa

Locality type	% HIV positive	95% confidence interval	Sample size
Urban formal	12.1	10.3–14.0	5 098
Urban informal	21.3	16.2–26.5	841
Tribal	8.7	6.5–10.9	1 906
Farms	7.9	4.8–11.1	583
Total	11.4	10.0–12.7	8 428

Source: Shisana and Simbayi (2002)¹⁸

Informal settlements are often located on the banks of streams or against steep hills, where dangers of flooding and mudslides are greatest. People living in these settlements often do not have access to safe water, stormwater management, or sanitation services, which increases their vulnerability to infectious diseases. Housing is a key necessity for the poor, and indicators of dwelling quality reveal the vulnerability of impoverished households to adverse weather conditions¹⁷. Of the dwellings in South Africa, 19% have been classified as being in poor repair. Nationally, nearly half of all informal dwellings, and more than one-third of traditional dwellings can be classified as vulnerable to environmental factors.

Disease in informal settlements compounds vulnerability, with HIV and AIDS a major development issue in South Africa. The loss of family members to AIDS-related death; productivity losses due to illness, caring for the sick, and funerals; the direct costs of medication, as well as other burdens, have forced poorer households to the very brink



Residents of informal settlements such as Diepsloot are vulnerable because of poor infrastructure. *Photography: Janet Peace*

of survival. (See Chapters 2 and 9 for estimated HIV prevalence rates in South Africa, and Table 10.2 for the HIV prevalence by location of the individual respondents in the research undertaken by the Human Sciences Research Council¹⁸.) Prevalence, compared with the national average, has almost doubled among residents of informal settlements.

10.3 LOCAL-LEVEL CASE STUDIES

This section looks in greater detail at particular 'hot spots' of human vulnerability to environmental change by using case studies to illustrate particular examples of human vulnerability to environmental change.

- Case study 1: Climate variability and food security in communal areas in South Africa
- Case study 2: Health issues in Umkhanyakude District Council, KwaZulu-Natal
- Case study 3: Floods in Alexandra (Gauteng) and Montagu (Western Cape)
- Case study 4: Climate change in the Western Cape
- Case study 5: Air pollution in South Durban, KwaZulu-Natal.

These case studies do not cover all the vulnerability 'hot spots' in the country, but only illustrate broad patterns of response. Furthermore, it is unreliable to attempt to extrapolate from local dynamics to regional interactions, as a stressor for one individual can represent an opportunity to another. This said, the case studies that follow highlight various dimensions of human vulnerability to environmental change.

10.3.1 Case study 1: Climate variability and food security in communal areas in South Africa

Food price increases are not the only feature of food insecurity in South Africa that is linked to environmental change. As indicated above (see also Chapter 4), droughts are frequent in South Africa and the region. They lead to regional livelihood losses that severely aggravate the plight of many of the rural poor.

Rural conditions make it difficult for households to cope with adverse environmental events. Population densities in rural communal areas tend to be high, which, over time, contribute to over-grazing and severe soil erosion. In the event of drought, the production of even a small amount of grain or other food is diminished and livestock is lost. Productive people migrate to the cities in search of work, leaving behind women and the elderly as heads of the rural households. Rural household income falls in the face of

Table 10.3: The prevalence of stunting per age category in Sekhukhune

		Age category (n=1025)				Total
		13–23 months	24–71 months	72–119 months	12–215 months	
Stunted	Count	17	70	79	200	366
	% within age group	43.6	36.6	33.5	35.8	35.7
Normal	Count	22	121	157	359	659
	% within age group	56.4	63.4	66.5	64.2	64.3
Total	Count	39*	191	236	559	1 025
	% within age group	100.0	100.0	100.0	100.0	100.0

Source: Food Insecurity and Vulnerability Information and Mapping System Consortium (2005)²⁴

limited opportunity for employment and the capacity to farm the land is lost. The main source of income in many rural households comes from social grants and remittances from employed family members.

Research conducted at several locations in diverse communal areas⁹ across South Africa shows how environmental impact has influenced community livelihoods, particularly in the case of more intense and variable climatic events^{19, 20, 21}. In the uThukela District, for example, communities reported great climate variability: they had snow, hail, and frost in 2001; heavy rain and flooding in 1996 and 1998; and drought in 1983, 1990, 1991, 1994, and 2002–2003, all of which caused loss of crops and livestock, as well as damage to property. The relationship between these phenomena and a complex socio-political structure elevates the livelihood risks experienced by these communities. Environmental factors cited by respondents involved in this research include:

- Regular risk of drought (all study sites)
- Unpredictable rainy season (all study sites)
- Weak 'wetting' trend for agriculture (KwaZulu-Natal)
- Water shortages (all study sites)
- Poor quality rangeland, with an increase in unpalatable grasses (KwaZulu-Natal, North West)
- Land degradation and bush encroachment (KwaZulu-Natal, North West).

Long-term erosion of livelihoods and food insecurity among vulnerable communities in South Africa, particularly in rural areas, has caused malnutrition, with its severe impact on children's physiology. Malnutrition has worsened in the country, with the prevalence of underweight children increasing from 9.3% to 10.3% during the late 1990s²². The prevalence of stunting also rose, from 22.9% of children aged 1–6 in 1994 to 23.3% in 1999²³. A recent



Hundreds of cooks providing the community with food at Rylands Primary School in Cape Town. *Photography: Trace Images / Brenton Geach*

study in 2005 in Sekhukhune has highlighted the serious nutritional situation of the poor in South Africa, with a high prevalence of underweight children per age category²⁴. According to the World Health Organization (WHO) classification²⁴, in the category of children two years and older, the severity of the prevalence of underweight was medium (10.0–19.9%) for children aged 24–71 months and 72–119 months, and high (20.0–29.9%) for children aged 120–215 months. Stunting, as an indicator for chronic malnutrition, was also found to be prevalent in Sekhukhune. For children two years and older, the severity of stunting was high (30.0–39.9%) in all three age categories (see Table 10.3).

The physiological outcome of chronic food insecurity is clearly evident in Sekhukhune. It characterizes a population



Table 10.4: Percentage shocks experienced by households in the last year, by municipality, Sekhukhune

Type of shock	Groblersdal	Marble Hall	Tubatse	Makhu-duthamaga	Fetakgomo	Sekhukhune Total
	%					
Death of an adult	36.1	15.3	10.2	26.0	22.1	22.5
Drought	21.4	6.2	8.1	32.3	28.2	18.9
General joblessness in the household	4.8	20.3	12.6	32.6	6.7	16.8
Death of a child	27.3	7.8	4.5	23.0	4.2	15.2
Increase in food prices	7.9	1.2	8.2	36.1	2.2	14.2
No access to clean water	1.6	5.0	4.4	27.5	17.3	11.1

Source: Food Insecurity and Vulnerability Information and Mapping System Consortium (2005)²⁴

that is highly susceptible to a range of shocks. The same study has revealed that after the recent death of an adult, experienced by 23% of households interviewed, drought was regarded as the second severest household shock (see Table 10.4).

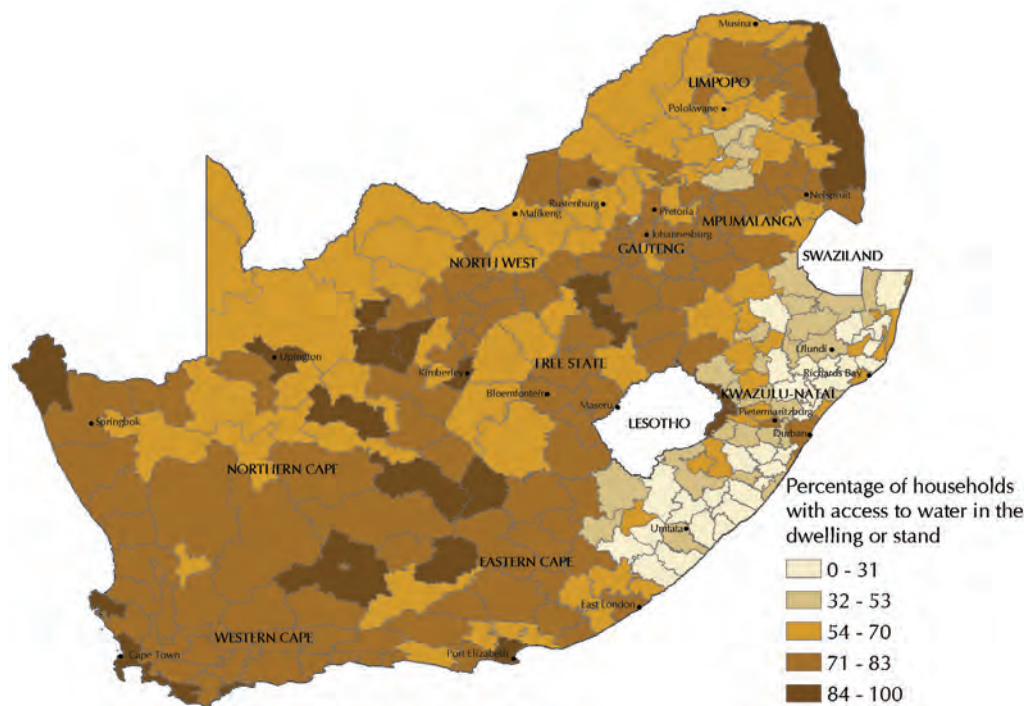
Together with a lack of access to potable water, drought has undermined livelihood options available to communities

in Sekhukhune, particularly the small number previously engaged in agriculture. Most households rely on household gardens or small plots to supplement their diets, as well as utilizing seasonally available natural resources, which are affected by drought. The most important constraint to agriculture in Sekhukhune is access to water. Anecdotal reflection has indicated that water tables have recently been far lower, and that mountain streams and springs, along with other sources of water, have been drying up. With a large number of mines planned for the district, water stress is likely to remain a major source of future vulnerability and potential conflict in Sekhukhune.

10.3.2 Case study 2: Health issues in Umkhanyakude District Council, KwaZulu-Natal

Human vulnerability to environmental change is exacerbated by poor health, which predisposes people to disease. Contributing factors are malnourishment and under-nutrition, as well as weak public health institutions and interventions. Poor health has an adverse effect on economic activity and production, as individuals feel ill or are bed-ridden. This effect is amplified where illness requires other individuals to take care of the sick instead of being involved in gainful activity. Illness also involves direct costs, such as use of health care services and the purchase of medicines, with their associated transport costs and payments. Poor health also contributes to negative emotional and psychological effects. It can arise from exposure to environmentally related risks (such as vector-borne diseases or air pollution), and can, in turn, exacerbate vulnerability and undermine resilience against other shocks.

Access to clean drinking water and sanitation services provides a fundamental basis for promoting good public



Map 10.2: Percentage of households with access to water in the dwelling or stand

Source: Human Sciences Research Council (2004)¹⁵, Census 2001



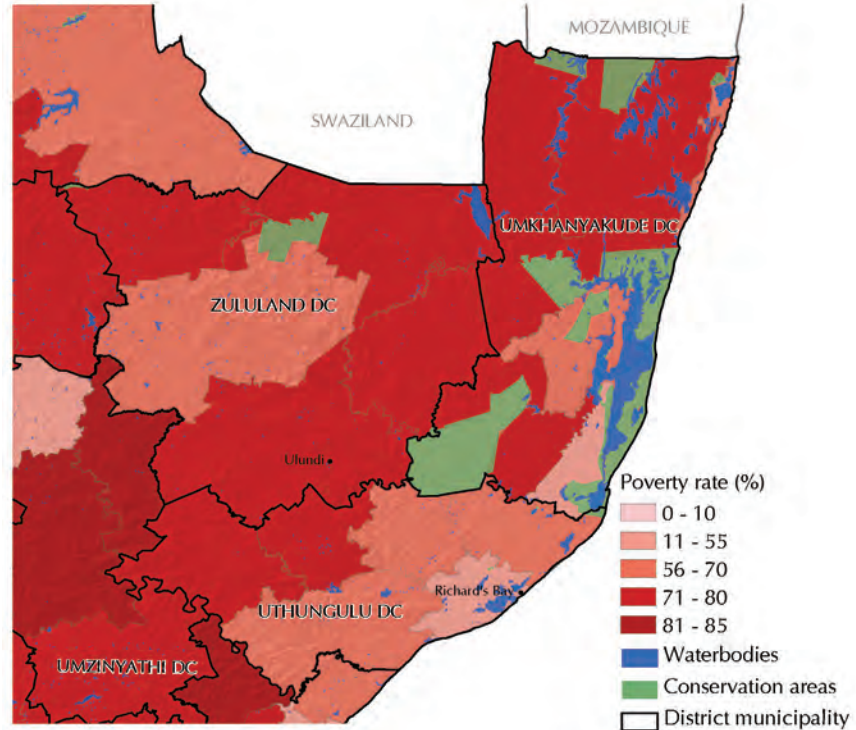
health and reducing human vulnerability. Poverty in South Africa tends to have a negative association with basic services, with poorer households having less access than those less poor to safe drinking water and adequate sanitation²² (compare Maps 10.1 and 10.2). Overlapping vulnerabilities tend to be the dominant feature in regions of extreme poverty.

Although provision of access to water and sanitation remains a challenge within South Africa, significant progress has been made nationally with respect to water provision, with greater access now than before to piped water in dwellings, yards, and public taps (see Chapter 9).

The Umkhanyakude District Council in north-eastern KwaZulu-Natal has been chosen for a case study to determine the interrelationships between human vulnerability, health, and environmental change. The district is situated in a remote rural area, with a high poverty rate (see Map 10.3), limited access to services (see Map 10.4), a vulnerable population (see Map 10.5), lying in a subtropical zone in close proximity to Mozambique and Swaziland. Umkhanyakude is the poorest district in KwaZulu-Natal with a scattered rural population of 542 953 people. The Health Systems Trust has reported large numbers of orphans and households cared for by young children because of the high incidence of HIV and AIDS in the area²⁵. The province has estimated the HIV and AIDS prevalence rate to be 37.5%, which is the highest in the country²⁶. The district has an unemployment rate of 54% and more than half of the households lack potable water and sanitation, which contributes to frequent cholera outbreaks. These overlapping factors have contributed to a range of environmental factors that affect human vulnerability in Umkhanyakude.

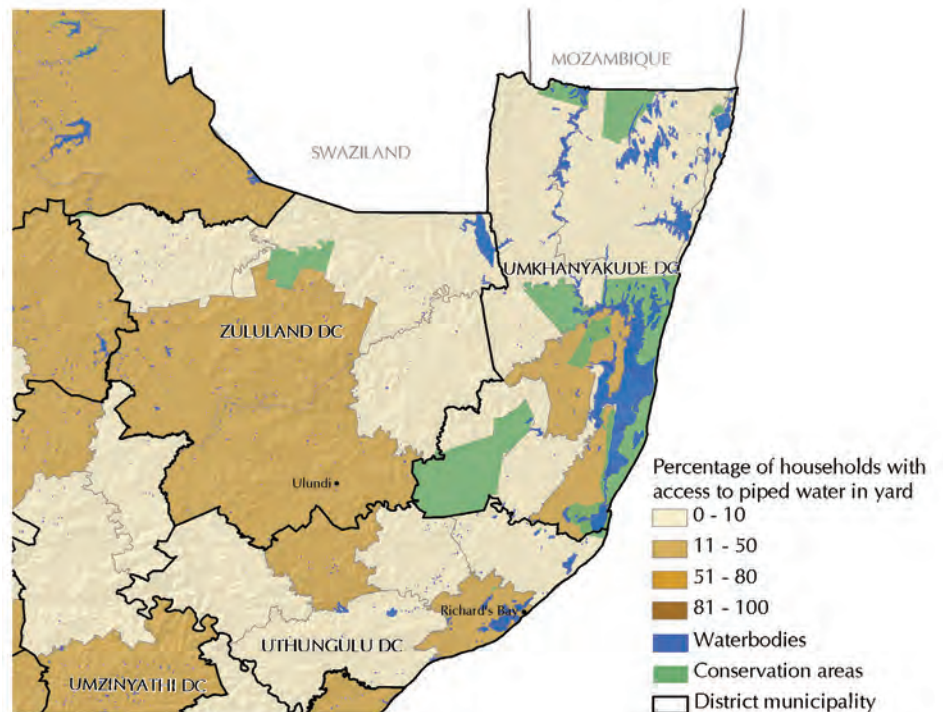
Among the poor, there is a disproportionate number of women, and also of households headed by women. The problem is commonly rural, where poverty is concentrated, with fewer adults of working age, higher unemployment rates among women, and a persistent wage gap between the earnings of men and women²⁷. The usual reason offered for this higher population of women is the fact that so many of the men are temporary residents because they migrate in search of work elsewhere. Gender plays a significant role in human vulnerability. Women tend to be more vulnerable than men to HIV infection (see Chapter 2), for instance. It has been estimated that 1.2 women in southern Africa contract HIV for every man who is infected¹³.

Umkhanyakude is thus vulnerable to a number of possible shocks including those that are health related and those derived directly or indirectly by environmental change. The World Health Organization has estimated that about one million people die from malaria every year, with 90% of these deaths occurring in Africa, mostly children under the age of five²⁸. The *Anopheles* mosquito, the host carrier of malaria, thrives in tropical and sub-tropical conditions such



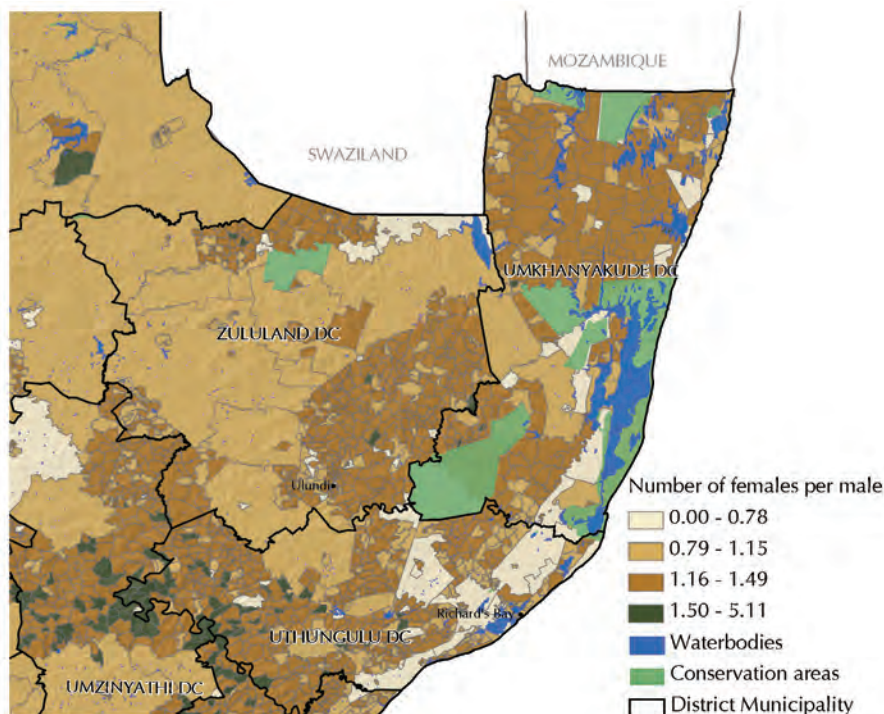
Map 10.3: Poverty rate in Umkhanyakude District Council, KwaZulu-Natal

Source: Human Sciences Research Council (2004)¹⁵, Census 2001



Map 10.4: Percentage of households with access to piped water in yard, Umkhanyakude District Council, KwaZulu-Natal

Source: Human Sciences Research Council (2004)¹⁵, Census 2001



Map 10.5: Proportions of people by gender, Umkhanyakude District Council, KwaZulu-Natal

Source: Human Sciences Research Council (2004)¹⁵, Census 2001

as that of Umkhanyakude. The district is well known for having the highest malaria incidence in South Africa²⁵, aggravated by poor control of malaria in neighbouring Mozambique.

Climate change, as well as human activities that transform habitats and create conditions suitable for parasites and disease organisms to breed, have a significant impact on the distribution and prevalence of vector-borne diseases (VBDs). Climate change affects vector survival primarily through minimum temperatures, regulating the latitude and elevation of distribution, as well as the duration of season permissive to transmission of vector-borne diseases.

Seasonal variation of rainfall may result in some of the inhabitants of Umkhanyakude experiencing transitory vulnerability during the onset of rains, increasing the likelihood of water borne diseases and malaria. If predictions about increasing levels of rainfall in the eastern parts of South Africa become a reality for the future, then vulnerability to malaria could increase, despite efforts to mitigate its spread through pesticide control. Owing to various malaria control programmes (including spraying with DDT, which if used improperly, has a deleterious environmental effect), malaria was effectively under control in South Africa by the 1980s (see national trends in cases of notifiable diseases in Chapter 2).

The rapid increase in tuberculosis (TB) has compounded

these problems in north-eastern KwaZulu-Natal, increasing human vulnerability in Umkhanyakude. As indicated in Chapter 2, tuberculosis is now strongly associated with HIV infection, because the virus reduces immunity to disease, making it easier to contract tuberculosis. This reality, coupled with the fact that tuberculosis thrives in conditions where people live in poor housing, has contributed to KwaZulu-Natal being the most affected province.

Health and economic stresses, such as those outlined in Umkhanyakude, influence the social networks and relationships that enable household subsistence and social cohesion²⁹. Poverty, lack of access to natural resources, and unemployment all impact adversely on dependency ratios within households. A saturated labour market has led to the collapse of the role of the traditional male breadwinner, exacerbating exploitative and abusive gender dynamics. Absence of men from household subsistence structures severely stresses care chains. Poverty, lack of access to social services, and the inability to claim citizens' rights encourage abusive and exploitative patron-client relationships. Constructive social institutions are vital for creating resilience to environmental change and other shocks. Intersecting cycles of vulnerability severely undermine poor people's ability to develop livelihood strategies, adaptive behaviours, and coping strategies that can give them long term sustainability and an escape from poverty.

10.3.3 Case study 3: Floods in Alexandra (Gauteng) and Montagu (Western Cape)

When assessing local vulnerability it is necessary to determine the relevant suite of factors, both social and biophysical, that drive risk and vulnerability. The first case study in this section explores the complex dynamics of an environmentally induced disaster in Alexandra in Gauteng; the second explores an extreme weather event in the South-western Cape.

In the first case study, the flooding of Alexandra Township in Johannesburg is examined, and, to understand vulnerability more fully, a sensitive understanding is required of the local context and setting in which potential risks unravel. Dealing with the flood event of 2000, vulnerability in Alexandra is indicated as a product of political action (or inaction), lack of access to resources and information, compounded by a failure to enhance active community resilience⁷. Exposure to hazards, flooding in this instance, has a physical and socio-economic consequence that can increase or decrease the ability of the community to cope and adapt to changes wrought by flood.

Alexandra Township had an estimated population of 350 000 in the year 2000, living in an area that was originally designated for 70 000 people. The crowding of people, estimated in 1998 to be 34 000 people/km²,

contributed to serious environmental degradation. The historical interplay of colonialism, capitalism, and apartheid helped significantly to shape the social, political, and economic setting that underpins local vulnerability, and augmented the disaster risks in Alexandra. Alexandra has been one of the poorest and most impoverished black townships in South Africa, a situation exacerbated by Johannesburg's rapid growth and urbanization. Overpopulation and high urban unemployment rates prevail there. Accommodation shortages, people living in hostels, backyard shacks, numerous informal dwellings close to the Jukskei River (see Map 10.6) have characterized the 'lived' space of Alexandra⁷.

Torrential rains fell in January 2000, causing devastating floods in mid-February across most of southern Africa. Climatic extremes in several locations of the world were attributed to the global La Niña phenomenon. La Niña, a weather pattern arising from cooler than normal sea-surface temperatures in the central and equatorial Pacific, much like its opposite counterpart El Niño, can trigger a host of weather-related impacts around the planet. Heavy rainfall across Alexandra (twice the typical monthly precipitation) resulted in extensive flooding, particularly in the wider Johannesburg City area. The Jukskei River rose, spilling over its west bank in particular, and devastating informal settlements, many of them located below the 1:100 year flood-line (see Map 10.6). Property damage was considerable, with several hundred homes swept away. A number of other flood impacts are shown in Table 10.5.

Emergency response interventions during such disastrous events are soon stretched and overwhelmed, compounded by weak social networks, despite a rich history of community activism in Alexandra. These networks are usually a key form of adaptation, noted in poor communities facing similar risks. The case study reconfirms that squatter households, with their lack of infrastructure, inadequate sanitation, overcrowded conditions, and generally limited access to economic resources, are often most vulnerable to environmental and other changes⁷. A lack of effective institutions and organization (either formal or informal) heightens vulnerability to risks associated with global environmental change. The lack of a government risk-reduction strategy before and during the heavy rains has resulted in an escalating survival problem for many of the residents.

The second case study in this section examines an extreme weather event that swept across the South-western Cape in March 2003. It brought heavy rain and strong winds, triggering flooding and excessive storm-water runoff. The impact upon poor and marginalized communities triggered by this extreme event was diverse, with the greatest loss endured by residents in low-cost housing that had been inadequately designed and constructed³¹. The research undertaken in the areas affected has underlined the critical importance of both local institutions and informal networks in mediating the impact of extreme weather



Rand Water pipe burst, causing flooding in the suburb of Meredale, south Johannesburg.

Photography: IMAGES24.co.za / Beeld / Johann Hattingh



A man trying to sweep the water out of his house after flooding.

Photography: IMAGES24.co.za / Rapport / Roger Sedres

events. Significant shortcomings have been highlighted, particularly with respect to the institutional arrangements required for the support of poor households and communities affected by the event. While some communities received evacuation assistance, and social, and material relief, many of them received no assistance. This haphazard response of key local institutions and community members included failure to provide any formal warnings to residents that an extreme weather event was imminent. No monitoring was made of the impacts that were triggered by rain, flooding, or storm-water runoff.

A consequence of the lack of a formally coordinated

Table 10.5: Classification of impacts of the Alexandra floods in 2002

Impact type	Example
Direct impacts	<ul style="list-style-type: none"> • Destruction of infrastructure, especially roads. • Four deaths were reported. • Loss of domestic animals, mostly chickens. • Damage to vegetable gardens, loss of livelihood. • Loss of food and clothing.
Indirect impacts	<ul style="list-style-type: none"> • Loss of income, people could not go to work. • Children could not go to school, as some had to cross the river. • Living with the fear, anxiety, and misery of not knowing what is going to happen next. • Injuries as a result of collapsing shacks. • Sewage being washed away and possibly causing diseases such as cholera and diarrhoea.

Source: Various interview respondents, Mgquba and Vogel (2004)⁷



Map 10.6: Aerial photograph showing the proximity of informal settlements to the Jukskei River in Alexandra, Johannesburg. The 1:100 year floodline is indicated in white.

Source: Taken from Steffen Robertson and Kirsten (2000)³⁰

emergency response has been that no standardized approach to assistance or evacuation of households has existed within the declared disaster area. This has resulted in significant shortcomings in the formal identification of households and communities that have been affected by the weather event. The reliance on informal social networks for relief and assistance in the recovery phase was a feature of this crisis, reflecting a strategy employed by residents of poor communities on a daily basis and has been internalized within households and communities as a survival strategy.

This case study emphasizes that early warning and



People being rescued from their flooded squattercamp in Gugulethu.

Photography: IMAGES24.co.za / Die Burger / Mlandeli Puzi

monitoring are essentials in pre-disaster planning and emergency response, so as to minimize the impact of an extreme weather hazard. Communities are otherwise caught unaware, with a limited scope to avert loss.

10.3.4 Case study 4: Climate change in the Western Cape

A South African Country Study on Climate Change (2004) has identified the Northern and Western Cape provinces as being at greatest risk from projected climate change-induced warming and rainfall change³². The future climate of the Western Cape is likely to be warmer and drier than at present. This has compelled the Western Cape provincial government to commission a major study, entitled "A Status Quo, Vulnerability and Adaptation Assessment of the Physical and Socio-economic Effects of Climate Change in the Western Cape". It deals with the vulnerability of the Western Cape to climate change impact and considers results from a range of climate models for a range of sectors. It also considers various hazards associated with climate change that would affect the livelihoods of people living in the region. These range from the prospect of deteriorating health from air pollution³¹, heat stress³¹, and the possibility of increased flooding³¹.

Three key groups have been identified to be the most vulnerable to climate change impacts in the Western Cape. These are people living along the coast, people living in informal settlements, and marginal groups living in rural areas. This case study examines the effects of increased flooding as an example that illustrates human vulnerability.

An increase in intensity of heavy rainfall events, particularly in late summer³², would lead to increased flooding that could threaten large areas of the province. Many of Cape Town's informal settlements are particularly vulnerable, being on the Cape Flats, where a high water table and inadequate infrastructure render them vulnerable to flooding. Poor housing quality in informal settlements exacerbates this vulnerability, because these structures are easily destroyed or washed away during a flood event.

Landslides have become more frequent during flooding, because settlement areas have typically been cleared of natural vegetation to create space to meet demand for building new dwellings and to provide fuel wood. As with Alexandra in Gauteng, poor access to services leads to an inability to cope and recover from such an event. The lack of tarred roads increases flood vulnerability in informal settlements. Unpaved roads wash away, hindering access. Other related vulnerabilities include inadequate sewage and storm-water infrastructure, creating stagnant pools of foul water that are a source of disease.

An increase in temperature is also significant to informal settlements, as it predisposes fires³². Two types of fires have been identified in informal settlements. Large fires destroy

many dwellings, while smaller ones may affect a small group or family but still lead to livelihood loss. Abnormally high housing density in informal settlements contributes to the unacceptable frequency and intensity of fires. This is a similar vulnerability to that endured by those on the densely populated banks of the Jukskei River in Alexandra.

In analysing such case studies, it is necessary to assess what resources exist or are needed to enable vulnerable people to cope with and respond to the shock of having their homes washed away or burnt. Access to finance or to social networks is often important, to allow people to respond effectively during a disaster and then to recover. The Western Cape provincial government's *Status Quo* report, for instance, identifies limited social networks arising from the large and diverse numbers of people who originally come from other countries or provinces to the Western Cape. The Cape Flats have experienced a population increase from cross-migration from the impoverished Eastern Cape Province, which can limit the social networks to which people have access, particularly in the event of a disaster.

10.3.5. Case study 5: Air pollution in South Durban, KwaZulu-Natal

There are vulnerable communities that are adversely affected by the low-level, long-term risks of living in close contact with the environment⁶. There are also less obvious risks that arise directly from processes of economic progress, including industrialization, that involve risks linked to the global environmental system, such as global warming, climate change, and ozone depletion³³ (see Chapter 8).

South Durban provides an important example of human vulnerability to these environmental factors. Durban is the largest industrial centre of the eThekweni Metropolitan Area, where working class communities live in close proximity to chemical and other 'dirty' industries. These communities are exposed to the health risks of living near this type of industry, including the nation's largest petroleum refinery, the second largest petrochemical factory, and a total of 180 smokestack operations in this industrial region (see Map 10.7).

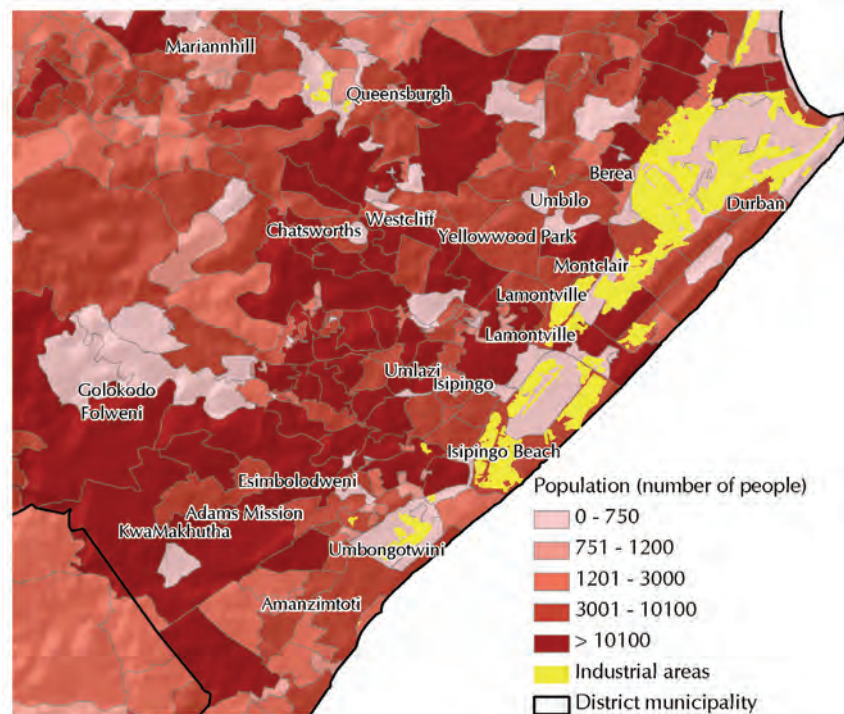
The complex land-use mix is compounded by the geography of the area, the topography being a basin, with frequent inversion layers and poor air circulation that cause aggravating air pollution problems. Experience of social injustice, together with the environmental injustice imposed on these communities from such pollution levels, have resulted not only in severe resentment on the part of residents, but have also created serious constraints on future industrial development. The scale and scope of the air pollution problem in South Durban has been fiercely contested over the years abetted by a shortage of reliable information on the true extent of the problem.

Until now, little incentive or coercion exists for

companies in South Durban to adhere to environmental emission standards. Despite a comprehensive framework of environmental legislation, enforcement in the area has been weak due to a lack of external monitoring and enforcement capacity. As mentioned elsewhere, this is currently being addressed. There was only one air pollution officer for the whole of the province of KwaZulu-Natal in 1999. The local communities and the media have challenged ineffective legislation on air pollution on several occasions.

The Durban South industrial basin has seen intensifying environmental activism since the early 1990s, particularly from organizations such as the South Durban Environmental Alliance, an umbrella organization. It has been at the forefront of campaigns for corporate responsibility and has put pressure on local refineries and other problem factories such as the Mondi paper mill to reduce their air pollution of Durban South.

Government initiated a Multi Point Plan (MPP) in an effort to find a sustainable solution to the poor air quality problem in the South Durban Basin. The South Durban Basin Multi Point Plan received multi-stakeholder endorsement in May 2000 and Cabinet Approval in October 2000. Key project areas of the MPP include establishing a modern air quality management system, undertaking a health study to measure exposure levels, setting air pollution standards,



Map 10.7: Proximity of population to industrial zones, eThekweni, KwaZulu-Natal

Source: Census 2001, National Land-cover Database (Thompson 1996)



and phasing out polluting fuels, in an effort to reduce sulphur dioxide and fugitive gas emissions.

The air pollution-monitoring network is an integral component of the MPP that was deployed in early 2004. This network comprises eleven air quality monitoring stations that measure a variety of air pollutants, and five meteorological stations, placed at various strategic locations in the South Durban Basin and environs. Data from the monitoring stations are used to check compliance with legislation and compared with standards for priority air pollutants. These air pollution data are available online¹ allowing for the forecasting of episodes of high air pollution. They provide a useful tool for air pollution officers responding to complaints, and allow them to carry out short-term abatement actions to minimize episodic high concentrations.

A further component of the MPP is a health study to determine how industrial air pollution is affecting communities in the Basin and its surrounding areas, to assess the severity of the exposure, and most important, to determine the steps that should be taken to ensure that people living in the area are guaranteed a safe and healthy environment. The results of the study were not available at the time when this report was prepared.

One of the remarkable achievements of the MPP has been a 45% reduction in sulphur dioxide emissions, attributed to the phasing out of fuels of excessive sulphur content. The MPP has also initiated an investment of over a billion rand from the industries that contributed to the sulphur dioxide reduction plan. It is anticipated that there will be further reductions in sulphur dioxide emissions over the next few years through continuing regulatory intervention.

The Durban South case study is a good example of the way in which participatory processes, involving stakeholders, the local community, government and industry, formed the pivotal component in making MPP a reality and, most important, in delivering quantifiable results. One of the outcomes of the MPP is that government is considering other potential pollution 'hot spots' in the country, such as the Vaal Triangle (see Chapter 8). These could be declared Priority Areas under the new Air Quality Act, and therefore deemed suitable for the MPP approach in dealing with air pollution, which in turn could help to address human vulnerability.

10.4 AREAS OF POSSIBLE INTERVENTION

"Vulnerability can be reduced by promoting empowerment, investing in human resources, and fostering participation in public affairs and decision-making."⁸

The interplay between environmental change and socio-political and economic issues, operating at different

scales, is a critical area requiring more research³⁴. There is a need to understand what generates vulnerabilities and what improves resilience in people's livelihoods in both 'normal' and 'stressed' conditions.

The dimensions of human vulnerability that have been analysed include poverty, food security, health, education, and economic factors. These can act either as the constituent elements of vulnerability or, depending on the coping capacities and resilience of an affected population, can result from or be exacerbated by environmental change. Responding to human vulnerability in South Africa requires building on people's own responses, providing a range of institutional support, and promoting resilience and adaptive capacity among vulnerable people.

10.4.1 Building capacity through social capital and environmental justice

Social capital³⁵ arose as an essential element in many of the case studies for building resilience in coping with environmental change. Numerous forms of social capital include relationships of trust, reciprocity and exchange, common rules, norms and sanctions, social connectedness, and social networks and groups^{35, 36}. The drivers of poverty, conflict, and HIV and AIDS, in particular, link to decreasing social coherence and social capital, which is one of the fundamental determinants of escalating vulnerability across the region³⁷.

The two cited case studies exploring human vulnerability to flooding (see section 10.3.3) illustrate clearly the importance of informal networks and the role of social capital in underpinning resilience. Social capital provides a base upon which an enabling institutional framework can be built. "People's own inventive solutions need to be released from the tyranny of a public sector institutional environment that often preoccupies itself more with hampering and blocking people's efforts to devise new livelihood sources than encouraging and facilitating them to do so"³⁷.

In the South Durban case study, access to environmental justice arose as a key prerequisite for protecting and realizing environmental human rights. The main problem is the lack of legal aid services to vulnerable communities. These could enable them to claim their rights in terms of environmental justice. Enforcement and the protection of the rights of the poor are constrained by limited state resources, poor quality services, and limited access. These all provide challenges for reducing human vulnerability through a rights-based approach. Meeting such challenges would facilitate the establishment of a norm whereby conditions involving a lack of clean water, exposure to hazardous pollution, or inadequate early warning would be regarded as an abnormality and a threat to personal security.



10.4.2 Building resilience and adaptive capacity

The huge costs and impacts associated with environmental change and its interaction with underlying human vulnerability highlights risk management as a potential key priority for South Africa. Focusing only on improved adaptation to and mitigation of environmental change is not viable in a context where there are multiple stresses, high incidence of poverty, and the high mortality and reduced life expectancy associated with HIV and AIDS. The cumulative evidence for increasing human vulnerability to environmental change calls for a significant policy response and action on several fronts.

Social responses have frequently focused on a reactive mode of mitigating the impacts of environmental change or natural disaster, rather than on a pre-emptive mode, which addresses issues ahead of a potential crisis. The onset of conditions that create threats and vulnerability may be gradual or inconspicuous. A need exists to find ways to associate environmental change risk-reduction and management with other risks, as well as to link these activities to ongoing development agendas.

Two types of policy response are possible. One can reduce a threat with prevention and preparedness initiatives, or one can improve the capacity of vulnerable groups to cope with the threat when it becomes a reality. By reducing the risk or probability that damage will occur, exposure to threats can be minimized. Improving the capacity of groups to cope, when they are at greatest risk, can do much to reduce the damage caused by extreme events or environmental degradation. The capacity to cope with threats includes the ability to absorb impacts by guarding against them or by adapting to them. It also includes measures taken in advance to cover for potential damage through insurance, or by accumulating savings or contingency reserves. Where a threat cannot be reduced or eliminated, adapting to it can be an alternative response.

South Africa is committed to fighting poverty and improving the lives of the most vulnerable. Interventions that address human vulnerability to environmental change should be translated into integrated responses that reflect the intersectoral nature and dynamics of the origins and states of vulnerability. Because human well-being depends on the effectiveness of sustainable environmental management and the reduction of human vulnerability to environmental change and threats, responses aimed to address the negative impacts of environmental change should be rapid, effective, and coordinated.

10.4.3 Vulnerability assessments and early warning

A key goal of vulnerability analysis is to identify the opportunities arising from processes of change, including

the ways that stressors can be transformed into opportunities for improving human security. Environmental change needs to be viewed as both a physical and social phenomenon. One of the most effective responses to reduce human vulnerability to environmental change, is to strengthen mechanisms for early warning. Institutional preparedness can be decisive in reducing vulnerability, as indicated in the Alexandra study (see section 10.3.3).

Famine and periods of food shortage require not only technical solutions, such as better early warning systems and meteorological analysis, but also substantial political will⁵⁸. Addressing vulnerabilities within the global change context will take time, for it is normally the underlying circumstances of a situation that determine vulnerability, and these conditions and interactions are only beginning to be understood. It is thus essential for a constant commitment to be made to achieving rigour in vulnerability assessments, paying particular attention to such issues as context, history, capacities, 'normal' conditions, training needs, and community involvement.

Effective disaster management, with a strong emphasis on risk reduction, is an imperative for South Africa. It requires careful assessment of past disaster losses and their implications for development. South Africa's Disaster Management Act (No. 57 of 2002) provides for an integrated and coordinated disaster management policy that focuses on preventing or reducing the risks of disasters, mitigating



An old man sifts through his burnt belongings and is left homeless after shacks burnt down. *Photography: IMAGES24.co.za / City Vision / Bomba Chauke*

the severity of disasters, emergency preparedness, rapid and effective responses to disasters, and post-disaster recovery. With the ultimate establishment of national, provincial and municipal disaster management centres, South Africa will be in a stronger position to implement the requirements of the Act. This Act is considered to be one of the finest pieces of disaster management legislation in southern Africa and provides for integrated and coordinated disaster management policies and plans.

Linked to such a policy, vulnerability assessment can measure the severity of potential threats on the basis of known hazards and the level of vulnerability of societies and individuals. It can be used to translate early warning information into preventive action, and is necessary for early warning and emergency preparedness. Results should ideally be integrated into the long-term planning policies of institutions and governments, and should promote institutional responsiveness to increasing vulnerability as well as action for disaster preparedness and mitigation. A recent exercise to map vulnerability in South Africa in a Food Insecurity and Vulnerability Information and Mapping System has revealed a discontinuity between the 'science' of risk reduction through vulnerability assessments and the 'institutional capacity' that can begin to implement and effect changes²⁴. The political will for changes (such as twinning vulnerability and development efforts and enhancing resilience to various stresses including climate variability) is present; the actual institutional design and architecture that may be required are still in the formative stages.

10.5 CONCLUSION

The case histories in this chapter support the view that accelerating environmental change and continuing erosion of human capability increase the threats to human well-being and put South Africa's sustainable development agenda at risk. The complexity of these changes makes it difficult to assess human vulnerability to both short-term impacts and long-term environmental change, and demand concerted effort from a range of sectors. Better understanding of the interplay of social and physical factors that determine human vulnerability needs to be pursued in South Africa, improving the ability to mitigate the potentially harmful impacts that might arise from environmental change.

NOTES

- a. The term 'vulnerability' most commonly refers to 'exposure to contingencies and stress and the means for coping with them.'
- b. Refer to Chapter 8, "Atmosphere".
- c. Refer to Chapter 6, "Inland Water".
- d. Refer to Chapter 4, "Land".
- e. Refer to Chapter 5, "Biodiversity and Ecosystem Health".
- f. Refer to Chapter 7, "Marine and Coastal Resources".
- g. The Centre for Climate Change Research Project at the University of Sheffield has undertaken research in uThukela District in KwaZulu-Natal, Lehurutshe in North West Province, and Dzanani in Limpopo.
- h. The projected increase in the number of inversions will trap pollutants in the atmosphere close to the ground.
- i. The number of very hot days may increase.
- j. Rainfall events may become fewer but heavier.
- k. The risks attached to close interface with the environment include ongoing problems associated with poor drainage, poor waste management, social violence, and inaccessibility to economic, educational, and social opportunities.
- l. For air pollution data see <http://www2.nilu.no/airquality/>
- m. Social capital refers to the degree to which a community or society collaborates and cooperates (through such mechanisms as networks, shared trust, norms and values) to achieve mutual benefits.

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*When we were children,
we used to think that
when we were grown-up
we would no longer be vulnerable.
But to grow up is to accept
vulnerability...
To be alive is to be vulnerable.*

Madeleine L'Engle

