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Chapter 7: Freshwater and Sanitation

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AFRICA ENVIRONMENT OUTLOOK 3

UNEP

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Our Environment, Our Health

UNEP

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Our Environment, Our Health

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Foreword

The quality and integrity of the environment are two main factors that influence human health and the disease burden in Africa. Indeed, Africa continues to grapple with environment related health issues, which continue to affect life expectancy, the ability to invest in children and the youth and negatively impinge on commercial productivity, investment in business at all levels, social cohesion, education and macroeconomic stability. In order for countries in Africa to meet the Millennium Development Goals, as well as to stay on the trajectory to achieve sustainable development, governments will have to better manage challenges associated with the environment-health nexus.

It has become increasingly evident that immense opportunities exist to manage the environment in order to achieve better health outcomes in Africa. Furthermore, it is clear that efforts directed at preventive, rather than curative, aspects of health must largely focus more on environmental interventions. For countries to take strategic steps to seize these opportunities, there must be a shared and common understanding, as well as awareness of the interlinkages between health and the environment, underpinned by credible data and information.

The African Ministers of the environment are committed to implement the Libreville Declaration on Health and Environment. This will be achieved through the Health and Environment Strategic Alliance (HESA) now being coordinated with assistance from UNEP and WHO. Indeed, as part of this effort, a number of countries have completed their Situation and Needs Assessments, and are in the process to identify national priorities, develop National Plans of Joint Action, and formulate cross-sector activities to deliver health and environmental benefits to communities.

The third Africa Environment Outlook (AEO-3) report has been prepared in response to the call by African Ministers and the outcome of the Libreville Declaration on Health and Environment. Its objective and scope is to provide a comprehensive, reliable and scientifically credible assessment of the state and outlook of the environment in Africa, with a focus on its impact on human health. It aims to improve the understanding of a wide audience on the interlinkages between health and the environment. It also goes further to identify areas where data and information are still lacking, thus providing suggestions for research and data collection. Actions resulting from the findings of this report are especially poignant as the region strives to develop and implement programmes and activities that are aligned to decisions made at the United Nations Conference on Sustainable Development held in Rio de Janeiro in June 2012.

AEO-3 is a product of collaboration between the United Nations Environment Programme (UNEP), the World Health Organisation (WHO), African institutions and experts. I would like to commend all those who have been involved in preparation of this report and urge them to continue the valuable collaboration to unravel the linkages between health and environment and encourage the elaboration of policy options to address the related challenges. The findings of this report point to a number of areas where focus is necessary to achieve benefits in the environment and health sectors.

It is my ardent hope that the report will trigger actions by policy and decision makers at all levels in Africa as they continue to make their contributions in pursuit of sustainable development. I wish you all good reading.

Hon. Dr. Terezya L. Huvisa

Minister of State–Environment, Tanzania and President of the African Ministerial Conference on the Environment

PREFACE

The health of Africa's population is central towards the aims of the Continent to make a transition towards an inclusive Green Economy and a sustainable century.

Africa's natural resources will play a pivotal role in these aims.

About 28% of the region's disease burden, largely dominated by malaria, respiratory infections and diarrhoea, is driven in large part by environmental factors and environmental change.

The third Africa Environment Outlook (AEO-3) report focuses on these issues and makes the case that human health and a healthy environment are inseparable.

Furthermore, the report demonstrates how investments in improved environmental management can lead to beneficial health outcomes which in turn have economic and social benefits. It also highlights how the rich diversity in species and ecosystems that the continent holds have both historically and currently played a vital role in the health and wealth of Africa's people.

Conversely, the Outlook underlines that environmental degradation challenges efforts to reduce the disease burden and thus the achievement of the poverty-related Millennium Development Goals.

The Outlook also points to the wealth of Africa—from its lands, lakes, rivers, oceans, forests and grasslands—in terms of biodiversity as a treasure trove of potentially untapped breakthroughs in natural substances that in turn could be the new pharmaceutical for the global medical market.

AEO-3 builds and explores scenarios about the future under a number of different environmental management regimes, and how these are likely to manifest themselves in the realm of human health.

The report, prepared with support of the United Nations Environment Programme (UNEP), and with input from the World Health Organisation (WHO), responds to recommendations made by African Ministers of Health and Ministers responsible for the Environment at their meeting held in Libreville, Gabon, in 2008. It provides some of the pathways along which the health and the environmental communities can work together to achieve their mutual goals as also outlined in the decisions taken at Rio+20 in June 2012 in the outcome document the Future We Want.

Above all, this report represents an analysis and directions upon which policy and decision makers in the Africa region, as well as the other stakeholders in the health and environment arena, can sharpen and catalyze the kinds of institutional and collective action that can assist in delivering an ever more sustainable future.

The environment and its health are fundamental to the lives and livelihoods of this vibrant Continent and it is incumbent upon all nations to make the informed and transformational decisions that can assist in keeping it that way.

Achim Steiner

United Nations Under-Secretary General and Executive Director, United Nations Environment Programme

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Health and Environment in Africa

Introduction

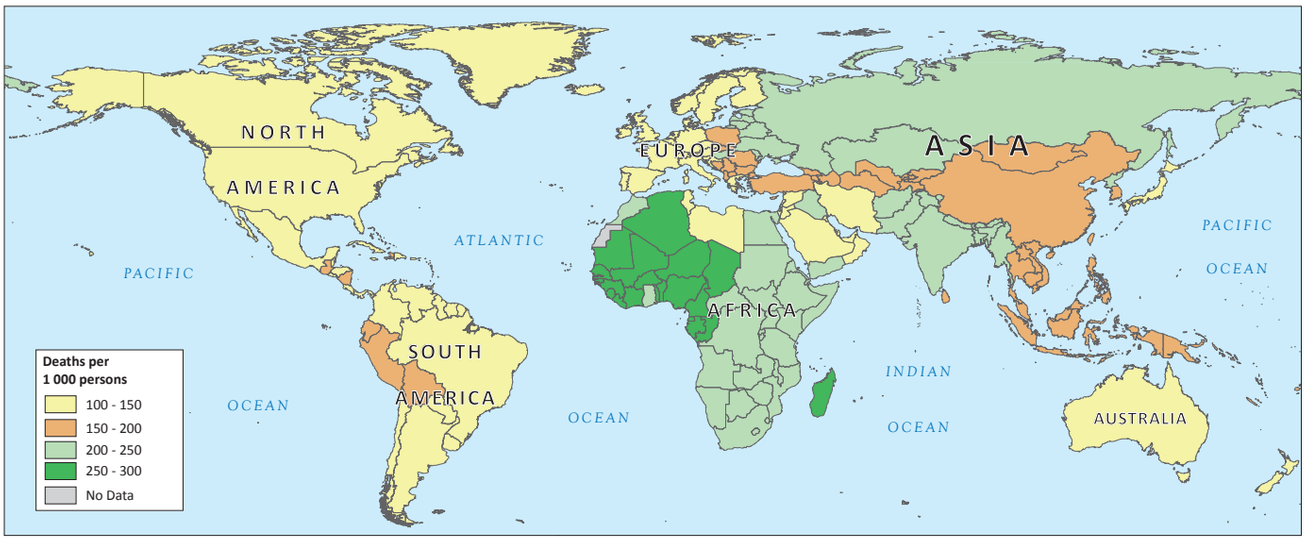
Environmental risks are blamed for about 28 per cent of Africa's disease burden (WHO and UNEP 2010). Diarrhoea, respiratory infections and malaria collectively account for 60 per cent of known environmental health impacts in the region (WHO and UNEP 2010). In 2008, Africa's ministers of environment and of health, through the Libreville Declaration on Health and Environment in Africa 2008, underscored the importance of using multi-sectoral actions on health and environment linkages to achieve substantial health and environmental improvements and their co-benefits, as well as the Millennium Development Goals (MDGs). This was reiterated in 2010 through the joint Luanda Commitment on the implementation of the Libreville Declaration.

Deaths resulting from this exposure to environmental risks indicated that Africa bears a relatively greater environmental disease burden compared to other regions of the world (Figure 1.1). Africa's burden is linked to exposure to unsafe water, poor sanitation and hygiene, and over dependence on solid fuels. An estimated 1.3 million avoidable child deaths attributable to the environment occur in the region each year (WHO and UNEP 2010).

The Libreville Declaration and the Luanda Commitment seek to enhance inter-sectoral actions and co-benefits for human health and the environment in order to achieve the MDGs, especially Goals 4, 5, 6 and 7 which relate to child health, maternal health, communicable diseases and environmental sustainability respectively. The priority areas as indicated in the Luanda Commitment are:

- Provision of safe drinking water
- Provision of sanitation and hygiene services
- Management of environmental and health risks related to climate change and variability, including sea level rises particularly in the Small Island Developing States (SIDS)
- Sustainable management of forests and wetlands
- Management of water, soil and air pollution, and biodiversity conservation
- Vector control and management of chemicals (particularly pesticides) and wastes, including biomedical, electronic and electrical wastes
- Food safety and food security including the management of genetically modified organisms (GMOs) in food production
- Environmental health of women and children
- Health in the workplace, and
- Management of natural and human-induced disasters.

Figure 1.1: Environmental disease burden



Source: Modified from Prüss-Ustün and Corvalan 2006.

Cognizant of the ministers' priority areas of focus in implementing a multi-sectoral approach to deriving benefits from environment and health interventions, an expert consultative meeting was convened in Johannesburg on 29-31 March 2011. During this meeting, consensus was reached to produce the third Africa Environment Outlook (AEO-3) with a focus on environment and health linkages. The identified areas were clustered around the themes of: air quality; biodiversity; chemicals and wastes; climate change and variability; coastal and marine resources; freshwater and sanitation; and land.

This assessment will complement the knowledge generated and shared through the Situation Analyses and Needs Assessments (SANAs) and the planned National Plans for Joint Action (NPJAs). It is envisaged that this will result in meeting the 2014 Luanda Commitment target of establishing and strengthening national core capacities in order to:

- Forecast and prevent communicable and non-communicable diseases, reduce their incidence and the associated morbidity and mortality especially in children and vulnerable populations
- Ensure continued delivery of ecosystem goods and services in support of human health and wellbeing, taking into account climate change.

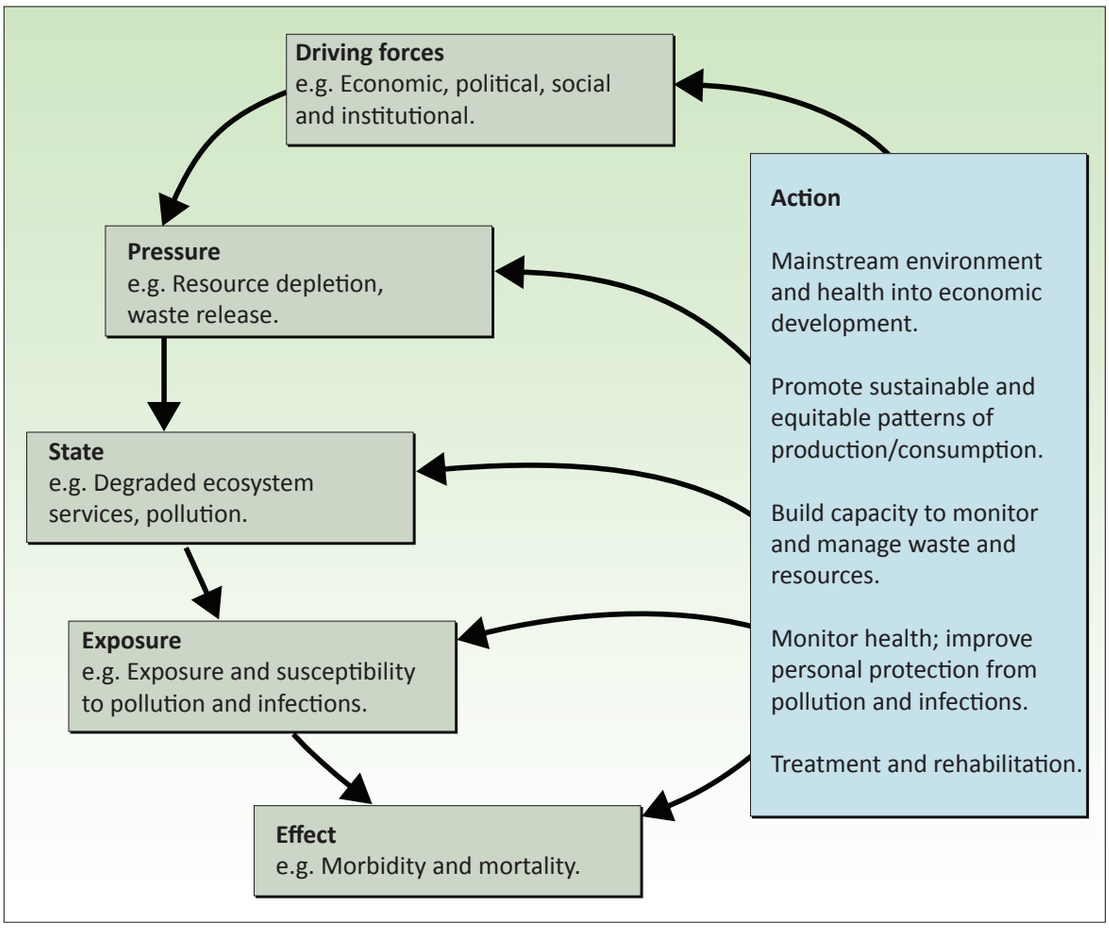
Analytical framework

An integrated analysis of the state and trends covering the themes of: air quality; biodiversity; chemicals and waste; climate change and variability; coastal and marine resources, freshwater and sanitation; and land is used in this report. The Drivers, Pressures, State, Exposure, Effects and

Safe drinking water

Global Water Partnership/ Flickr/CC BY NC SA 2.0

Figure 1.2: The DPSEEA framework



Source: WHO 1999

Actions (DPSEEA) analytical framework (Figure 1.2) is used. The DPSEEA framework is employed to give a comprehensive linkage between health and environment, and to illustrate how socio-economic driving forces can generate environmental pressures, leading to altered ecosystem states, personal exposure to risks, and eventual health impacts.

The DPSEEA model adopts a linear or chain approach to mapping a spectrum of environment and health issues from higher level cultural and political **Drivers** of environmental change to **Pressures** which modify the physical environment to produce an environment with defined characteristics – **State**. A particular environmental state will impact humans through varying amounts of **Exposure**, resulting in certain health **Effects**. Society's responses to these effects constitute **Actions** that are applied at the drivers, pressures, exposure and effects levels as part of the management efforts. The actions are aimed at reducing the magnitude of the driving forces, the impact of the pressures, alterations to the state of environment, as well as exposure and effects.

The AEO-3 report discusses drivers as key triggers of environmental change with significant implications on human health. This is because various policy interventions targeted at the pressures only provide temporary relief. It is generally argued that by addressing the drivers, long-term solutions may be found to not only Africa's but also the world's pressing environmental challenges.

Drivers

The state and trends of Africa's environment are largely driven by the region's demographic dynamics, economic development, poverty, technology, and

systems of governance and accountability. These together place several pressures on the continent that include high urbanization rates, little uptake of clean renewable energy technologies, and the negative effects of globalization.

Population

Africa's population reached one billion in 2009 and is projected to double by 2050 (AfDB 2011). Between 2000 and 2100, Africa's share of the world's population is expected to steeply rise from 13.1 to 24.9 per cent (UN 2004) with East, Central and West Africa experiencing the fastest population expansion. Africa's population is not only the fastest growing in the world, but also the most youthful. As at 2006, sub-Saharan Africa had 44 per cent of the world's population under the age of 15, making the sub-region the youngest in the world (Ashford 2007).

Sub-Saharan Africa's population is growing at an annual rate of 2.4 per cent (UNFPA 2011) which presents both challenges and opportunities for the region. A rapidly growing population stresses ecosystems by raising demand for food, energy, medicines and water, while bringing distortions to land tenure arrangements, as well as accelerating environmental degradation through soil erosion, deforestation and biodiversity loss (World Bank 2008). In extreme cases, competition over scarce resources leads to conflict.

Happy and healthy women and children in Sudan

A rapidly growing population also presents financial and logistical challenges in service provision, especially in the areas of education, health, safe drinking water and sanitation. Tellingly, it is partly because of the rapid population growth that many African countries are not on course to meeting a number of MDGs. For example, as at 2008, only nine countries in Africa had reached more than 90 per cent coverage of safe drinking water, while only four had over 90 per cent of their population with access to improved sanitation facilities (UNECA and others 2010). This is despite a near doubling in the Sub-Saharan population using an improved drinking source from 252 million in 1990 to 492 million in 2008, with safe water coverage increasing from an average 49 per cent in 1990 to 60 per cent in 2008 (UN 2011).

Although it is often argued that population growth contributes to environmental degradation, it is worth noting that Africa's young population provides opportunities for economic growth. Africa is set to have more working adults per child in 2030 than was the case in 2006 (Ashford 2007). The region's institutions and economies will need to be strengthened to take advantage of the increase in the working population.

The anticipated demographic dividend is expected to result in greater savings on health and social services, and a switch to sustainable livelihoods. For example, expected higher incomes may result in reduced deforestation as more people will have capacity to switch from fuelwood to cleaner energy sources. It may also lead to the use of modern high yielding agricultural techniques that reduce the demand for agricultural land. Similarly as household incomes grow, sanitation and waste-water treatment may improve.

Economic development

Africa's average economic growth rate for 2012 was estimated at 4.8 per cent, maintaining the momentum from the 4.9 per cent growth registered in 2011 (World Bank 2012). This is an improvement from the previous years in which Africa's average economic growth rate was 3.7 percent in 2003 and 2.6 per cent per year between 1990 and 2002 (UNEP 2006). This improved growth increases opportunities to meet key MDGs and to enhance human well-being, with positive spin-offs for the environment. Between 2001 and 2010, six of the 10 countries with the world's fastest economic growth rates were in Africa: Angola, Chad, Ethiopia, Mozambique, Nigeria and Rwanda.

Despite the positive economic growth trends, poverty remains a major challenge in Africa, and its linkage with environmental degradation is a persistent concern. According to UNEP (2006), Sub-Saharan Africa's annual economic growth rate must average 7 per cent if income poverty is to be halved by 2015.

Carrying water—a burden for women

UNAMID Photo/Flickr/CC BY NC ND 2.0

Poverty is more widespread in Africa's rural areas than its urban counterparts. Rural people depend on the environment for various goods, including food, medicines and energy, and regulating services such as water purification. Given their direct dependence on the environment, Africa's largely rural population, which constitutes 60 per cent of the region's total population (UN-HABITAT 2010), is also vulnerable to environmental disasters and risks, some of which expose them to insect-borne diseases such as malaria, and water-borne diseases such as cholera.

Inappropriate policies and weak institutions can limit the value poor people derive from environmental resources, forcing them to harvest or use more in meeting basic needs (UNEP 2006). For example, policies and laws that only permit use of natural resources for subsistence needs may unwittingly encourage the poor to unsustainably exploit the resources with a view to generating more income. Similarly, bureaucratic hurdles and inefficient economies may limit access to markets and financial resources, resulting in post-harvest crop losses or general lack of investment in the natural resources sector.

Technology

Technological innovations can influence the environment in both positive and negative ways by increasing resource use efficiency or by placing unsustainable demands on the environment. New technologies may also result in new risks to human and environmental health (UNEP 2006). For example, Genetically Modified Organisms (GMOs) are not widely accepted in Africa mainly because of biosafety concerns. Only South Africa uses GMOs on a commercial basis. Only a few African countries use genetic modification technology. These are Burkina Faso, Egypt, Kenya, Malawi, Mauritius, Uganda, South Africa and Zimbabwe. However, only Burkina Faso, Egypt and South Africa have reached the commercialization stage (ASSA 2010).

A review of the pace of technological advancement in Africa presents a mixed picture. Besides the biosafety concerns highlighted above, uptake of biotechnology and hybrid seed which could have seen higher agricultural yields in Africa has been slow due to high costs of improved seed and

The use of ICT in Africa is continuing to grow

related inputs, such as fertilizers. As a result, Africa continues to witness low cereal yields averaging less than one tonne per hectare (ICRAF undated), a situation that demands more land to be cleared for agriculture, including ecologically fragile land such as forests and wetlands.

Nevertheless, information and communications technology (ICT), especially mobile telephony, has significantly expanded in Africa in recent times. There are wide applications of mobile phones in Africa, including mobile banking, information sharing and general communication.

Positive benefits of ICT in Africa include telemedicine, which has been successfully used in the delivery of healthcare in Ethiopia, Ghana, Mali, Mozambique, Rwanda, the United Republic of Tanzania and Uganda (Mbarika 2004). Other applications of ICT have been in the area of agricultural marketing. For example, the Social Enterprise Foundation of West Africa has successfully linked rural soybean producers to mills through the use of satellite, databases and mobile phones. This has helped to ensure a fair income for producers and a steady supply of raw materials for the mills (IICD 2007). The successful application of ICT has largely been driven by the rapid penetration of mobile telephones in Africa. In 2011, there were more than 500 million mobile phone subscribers in Africa, up from 246 million subscribers in 2008 (Rao 2011).

Governance

The state and trends of Africa's environment are to a large extent shaped by the systems of governance which range from command and control to participatory which allow for the sharing of benefits. These arrangements include policies, legislation, institutional and financial arrangements, and partnerships, some of which promote central control while others support the devolution of authority to local levels. Non off-take systems of environmental management, including Marine Protected Areas (MPAs) and some of the traditional national parks are crucial for the conservation of biodiversity and the sustainable use of natural resources. While there are more than 1 100 national parks and reserves in sub-Saharan Africa, of which 36 are designated World Heritage Sites (WCMC 2004 in Newmark 2008), there is a growing recognition that protected areas are isolated and pose a serious threat to the long-term viability of many wildlife populations and migrations in Africa (Newmark 2008). This has influenced the amalgamation of protected areas into Marine Managed Areas (MMAs) and trans-frontier conservation, which is credited with opening up migration routes and dispersal areas and reducing the risk of in-breeding.

Protected areas covered 15.9 per cent and 10.1 per cent of the total land surface in the East/Southern African and West/Central African regions, respectively (Chape and others 2005 in Newmark 2008). The small ratio of the area under protection led to the realization that this was unsatisfactory, given that the remainder of the land provided vast opportunities for habitats and biodiversity (Child 2005). This led to private conservation, which later also evolved

into Community Based Natural Resources Management (CBNRM). Much of the success of CBNRM in conservation comes from the way benefits and costs are shared, as well as the fact that power is devolved to lower structures of society, which allows for consultative management of environmental resources.

Structure of AEO-3

The third Africa Environment Outlook (AEO-3) report has two main parts. The first part provides details about the health and environment linkages, following a thematic approach. The priority themes are presented as chapters in alphabetical order as follows:

- Air quality
- Biodiversity
- Chemicals and wastes
- Climate change and variability
- Coastal and marine resources
- Freshwater and sanitation
- Land

The second part deals with

- Scenarios of future health-environment linkages, and
- Enhancing implementation of environmental and health policies

While efforts were made to cover the entire Africa region in the report, there were limitations due to paucity of scientific data.

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PART I
Health and Environment Linkages

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2

Air Quality

Opposite page: ISS / NASA

Air quality in Africa

Good air quality is essential for human health. Although Africa's air quality is generally within acceptable limits, there are cases where outdoor and indoor air quality is rapidly deteriorating due to increasing levels of urbanization, motorization and economic activity (UNEP 2006).

Major air quality issues in Africa include outdoor and indoor air pollution, as well as an increasing contribution towards greenhouse gas (GHG) emissions which cause climate change (which is discussed in detail in Chapter 4). Outdoor air pollution from motor vehicles, thermal power stations and industry is mainly due to increasing economic development and lack of pollution control (Larsen and others 2008). Outdoor pollution is particularly a challenge in Africa's rapidly urbanizing countries. In 2010, 395 million people, constituting 40 per cent of Africa's total population, lived in urban areas, and the region's urban population will expand to one billion, making up 60 per cent, by 2040 (UN-Habitat 2010).

Air pollution levels are rising in many countries in Africa, with carbon dioxide (CO_2), carbon monoxide (CO), particulate matter, sulphur dioxide (SO_2), oxides of nitrogen (NO_x) and lead (Pb) constituting some of the major indoor and outdoor air pollutants. Piketh and Walton (2004) identified three main sources of pollution in Africa, namely windblown dust, biomass burning and anthropogenic activities. Windblown dust comes from the Sahara Desert and to a lesser extent the Namib Desert. Biomass burning in the region, which makes up approximately 30 per cent of the global total, comes from the dense forests of central Africa and the savannah grasslands of southern Africa. Anthropogenic sources of pollution are generally spread out on the continent, with the largest being in South Africa's Gauteng Province, the most industrialized part of the continent.

Dust and smoke from forest fires are important outdoor air pollutants in both rural and urban areas. Indoor air pollution is common in the rural areas, as well as in the low and middle income urban areas where solid fuels are used for cooking and heating. In such cases wood, biomass, charcoal and coal are often burnt on open fires or in traditional stoves with low combustion efficiency and in rooms with poor ventilation, resulting in high concentrations of air pollution, often 10-30 times higher than the World Health Organization (WHO) limits (Larsen and others 2008). Although Africa's greenhouse gas emissions are low, they are growing. The region's GHG emissions were estimated at 2.2 per cent of global totals in 1970, and 3.6 per cent of the global totals since 2000 (UNEP undated; Kifle and others 2008; Agyemang-Bonsu 2009).

Air quality-health linkages

Air pollution is associated with acute respiratory infections (ARIs), among other health concerns. These ARIs rank fourth in the share of total burden of diseases in Africa (UNEP 2005). These ARIs kill 1.6-2.2 million children under the age of 5 years globally with 22 per cent of these deaths occurring in Africa (Zar and Mulholland 2003). Some country studies demonstrate the seriousness of air pollution as a cause of respiratory diseases in sub-Saharan Africa where indoor respirable suspended particles were found to range between 1 000 and 9 000 $\mu g/m^3$ with peaks as high as 21 000 $\mu g/m^3$ (Wafula and others 2000). This range is far higher than the 100 to 150 $\mu g/m^3$ limit recommended by WHO (UNEP 2005). The particulates in smoke from wood, a key source of biomass fuel in Africa, are mostly less than 5 µm in diameter, and as such they are respirable and can easily penetrate into the lungs (UNEP 2005).

Outdoor air pollution and health

Outdoor pollution is predominantly an urban problem in Africa. With the region's urban population doubling every 20 years (UNEP 2007), a corresponding increase in health impacts due to outdoor air pollution is expected. Outdoor air pollution kills an estimated 800 000 people per year in the world, mainly in the urban areas, and 40 000 of these deaths occur in Africa (WHO 2008). The impact of outdoor air pollution on health includes respiratory illnesses, heavy metal-related illnesses, and allergies and skin diseases, which are experienced mostly by children (WHO and UNEP 2008). Specifically, SO_2 contributes to acid rain, and affects the health of ecosystems. High concentrations of SO_2 affect breathing and may aggravate existing respiratory and cardiovascular diseases. Carbon monoxide reduces the delivery of oxygen to the body's organs and tissues, and at high exposure levels, it can cause visual impairment or even death.

A high occurrence of cough, morning phlegm, nasal catarrh, chest pain and reduced lung function was observed in Bacita, Kwara State, Nigeria, due to exposure to air pollution from the process of sugar production (Tanimowo 1995), and similar conclusions were drawn from sawmill workers in Nigeria (Fatusi and Erhabor 1996). In East Africa,

The smog in Cairo is an example of outdoor air pollution

a high prevalence of chronic cough, chronic bronchitis and bronchial asthma was observed among workers in yarn, cement and cigarette factories (Mengesha and Bekele 1998). It has also been shown that people who are exposed to air pollution from vehicular and machinery fuel combustion had high blood lead levels (Ogunsola and others 1994) as is the case in Cotonou (Box 2.1). In South Africa high average blood concentrations of lead, ranging from 3.8-12 µg/dl (UNEP 2005) were observed in the industrial and commercial areas of Durban, much higher than those recorded in the residential areas (Nriagu and others 1996 in Tanimowo 2000).

Studies have noted that as a result of atmospheric lead due to leaded fuels, vegetables that are grown in urban and peri-urban sites are exposed to fine particulate lead matter. Since lead does not dissipate, biodegrade or decay, lead pollution deposited into soil and dust will always remain a potential source of illness (UNEP 2005). Studies show that 10-15 per cent of dietary lead intake can bio-accumulate to 63 per cent in fasting conditions or in poor diet patterns, with children under the age of six being more susceptible to health deficiencies caused by elevated levels of lead exposure (UNEP 2005). Health deficiencies due to lead exposure include delayed puberty in

Box 2.1: Outdoor air pollution and diseases: The case of Cotonou

There are high levels of air pollution in Cotonou, a city with a population of 844 000 (UN-Habitat 2010). Daily emissions of carbon monoxide amount to 83 tonnes, while emissions of hydrocarbons are estimated at 36 tonnes, reaching maximum levels of 2 000 µg/m^3 (MEHU 2000 in Boko 2003). The city's transport network has high levels of lead pollution averaging 13 µg/m^3 against the accepted limit of 2 µg/m^3.

The high levels of air pollution in Cotonou are principally due to the city's transportation system, especially the two-wheeled taxis known as zemidjan (literally meaning take me quickly). The zemidjan is a response to the socio-economic crisis of the 1980s in most West African countries, which resulted in high unemployment levels. As a result the motor cycles became sources of jobs and facilitated easy and quick passenger transport. In 2002, there were 160 000 zemidjan in Benin, of which 72 000 were in Cotonou. The number of the zemidjan continues to increase as there is little capacity to expand the public common transportation system to meet the demand for urban mobility. In addition this means of transport is very popular because the zemidjan can manoeuvre the poor road infrastructure. The motor cycles are responsible for 59 per cent of the daily emission of carbon monoxide and 90 per cent of daily emission of hydro-carbons in Cotonou. The motor cycles are old second-hand European and Asian imports, averaging 15 years. The levels of pollution are worsened by the poor quality fuel, which is sold illegally on the black market.

Zemidjan transport, Cotonou

The pollution exposes the public to respiratory health problems, with the zemidjan drivers directly affected. A study by Gounongbé (1999in Boko 2003) noted that 62 per cent of zemidjan drivers suffer from respiratory diseases; 26 per cent from eye diseases, 11 per cent from larynx infections and 71 per cent from muscular and bone infections.

Source: Boko 2003

Figure 2.1: August 2011 sulphur levels in diesel fuels in Africa

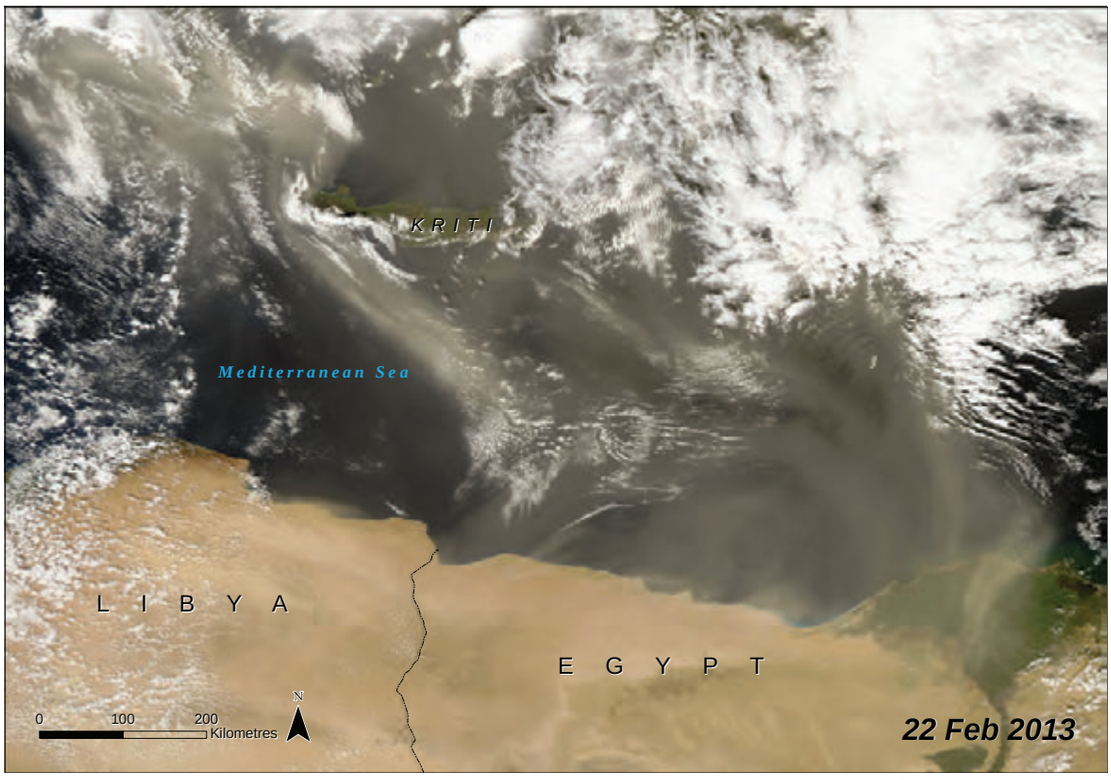
Source: UNEP and PCFV 2012.

girls, abnormal deliveries in women, low sperm count in men, lowered IQ, reading and learning disabilities in children, impaired hearing, reduced attention span and hyperactivity in children (UNEP 2005).

The use of lead-free gasoline in Africa has significantly contributed to the elimination of vehicle-related lead pollution. UNEP (2010) reports that 49 countries in Sub-Saharan Africa had put in place mechanisms for the phasing out of leaded-petrol by February 2006. Worldwide, there are also growing calls for the gradual phase out of sulphur in diesel, and as shown in Figure 2.1, Africa still has to make significant progress in reducing sulphur content in its diesel fuels.

Dust storms from the Sahara and Namib Deserts have been noted to cause or worsen respiratory infections. Tanaka and Chiba (2006)

Figure 2.2: Dust from the Sahara Desert blowing over the Mediterranean Sea



Source: MODIS; visualization by UNEP/GRID

estimate that the Sahara accounts for 58 per cent of the total global dust emission. In Africa the dust from the Sahara is transported to the Gulf of Guinea (Sunnu and others 2008) where the dry, dusty wind is one of the predominant atmospheric phenomena in West Africa known

Dust storm in the Namib Desert

jriggert / Flickr / CC BY NC ND 2.0

as the Harmattan (Afeti and Resch 2000). The dust emissions from the Sahara also cross the Atlantic Ocean into the United States of America, the Caribbean and South America (Kellogg and others 2004), as well as into the Mediterranean and Europe (Kellogg and others 2004), the Middle East and the eastern Mediterranean region (Middleton and others 2008). Figure 2.2 shows the dust from the Sahara blowing over the Mediterranean Sea. Airborne dust particles affect human health, by contaminating local and regional air quality (Anuforom and others 2007), with studies suggesting that persons with advanced cardiovascular and respiratory diseases are sensitive to dust storms (Kwon and others 2002). Other studies have established a significant link between dust events and pneumonia infections (Cheng and others 2008) as well as asthma (Perez and others 2008).

Indoor air pollution and health

Exposure to indoor air pollution is associated with chronic obstructive pulmonary disease, lung cancer, nasopharyngeal cancer, tuberculosis and eye infections in adults, as well as low birth weight and acute lower respiratory infections (ALRI) such as pneumonia amongst children under the

Table 2.1: Estimated national burden of disease caused by indoor air pollution

Country	Percentage of population using solid fuels	ALRI deaths attributable to solid fuel use (<5 years)	COPD deaths attributable to solid fuel use (≥30 years)	Lung cancer deaths attributable to coal use (≥30 years)	Total deaths attributable to solid fuel use	Total DALYs attributable to solid fuel use	Percentage of National burden of disease attributable to solid fuel use
Angola	>95	21 170	870	-	22 000	747 000	6.9
Botswana	65	100	90	-	200	4 600	0.4
Lesotho	83	260	180	-	400	10 500	0.8
Malawi	>95	12 240	1 060	-	13 300	431 300	5.2
Mozambique	80	8 450	1 230	-	9 700	300 200	2.4
Namibia	65	80	150	-	200	4 000	0.5
South Africa	18	450	560	20	1 000	20 800	0.1
Swaziland	64	320	60	-	400	11 300	1.4
United Republic of Tanzania	>95	25 050	2 410	-	27 500	885 600	4.4
Zambia	87	8 160	470	-	8 600	285 400	3.8
Zimbabwe	72	1 380	510	-	1 900	50 900	0.6

Source: Bruce and others 2000

age of five (Bruce and others 2000). The ALRIs are the single leading cause of death amongst children under 5 years old worldwide (Murray and Lopez 1997). In homes where coal is used as a source of fuel, the risks of lung cancer are high (Hosgood III and others 2010). As Table 2.1 shows, the national burdens of disease estimates for 11 southern African countries are a close reflection of the ratio of the population using solid fuels (WHO 2007). Sources of indoor air pollution include combustion sources (cook stoves and fuel based lighting), building materials and furnishings, household cleaning, maintenance, central heating and cooling systems and humidification devices (Wang and others 2010; Weschler 2009).

An estimated 1.5 million people globally die annually from indoor air pollution (WHO 2006). Reliance on polluting solid fuels and inefficient household energy practices were blamed for 396 000 deaths in Africa in 2002 (WHO 2006). In most homes in Africa, woodfuel, charcoal or kerosene or a combination of these is used for cooking. To demonstrate the link between indoor pollution and health, Femi-Pearse and others (1973) found the use of woodfuel for cooking to be associated with early morning expectoration and persistent phlegm. Indoor air pollution was also found to contribute to the development of asthma in children in Kenya (Mohamed and others 1995), and to acute respiratory infections in Ugandan children (Tumwesigire and Barton 1995). In Mozambique, women who use woodfuel for cooking were also found to have a high prevalence of respiratory symptoms, especially coughs (Ellegard 1996).

Improved wood- or charcoal-burning stoves without flues which are popular in East Africa, can reduce kitchen pollution by up to 50 per cent, although pollution levels would still remain high (Bruce and others 2006). Charcoal gives off less particulate matter than woodfuel, while improved

Clay inserts for improved cookstoves

aamhc / Flickr / CC BY NC SA 2.0

Table 2.2: Interventions for reducing exposure to indoor air pollution

Act on Source of Pollution	Improve the Living Environment	Change User Behaviour
Improved cooking devices	*Improved ventilation*	*Reduced Exposure*
• Improved biomass stoves without flues • Improved stoves with flues	• Hoods, fireplaces and chimneys built into the structure of the house • Windows and ventilation holes, which may have cowls to assist extraction	• Dry fuel • Use pot lids to conserve heat • Properly maintain stoves, chimneys and appliances
Alternative fuel and/or cooker combinations	*Kitchen design and placement of the stove*	*Avoiding smoke*
• Briquettes and pellets • Charcoal • Kerosene, Liquid Petroleum Gas, Biogas, Solar cookers	• Kitchen separate from the house to reduce exposure of the family • Stove at waist height to reduce direct exposure	• Keep children away from smoke – for example, in another room (if available and safe to do so)

Source: Bruce and others 2006

cook stoves, such as the Kenyan jiko, yield levels of particulate matter that are around 10 per cent of those from wood fires (Ezzati and others 2000). As shown in Table 2.2, interventions to reduce indoor air pollution are not only targeted at the improvement of cooking devices, but also improvement of the living environment and reduction of exposure.

In South Africa, the Clean Air Act of 2004 and the Integrated National Electrification Programme (INEP) were designed to address indoor air pollution, among other environmental problems. Under INEP, over 2.5 million households were electrified between 1994 and 2000. As a result, the proportion of households with access to electricity increased from 33 per cent to 63 per cent during that period. By the end of 2006, 73 per cent of South African households had access to electricity. However, about 50 percent of the households continue to use wood for cooking and heating for economic reasons, lack of information and knowledge, and cultural considerations (WHO 2000; and Barnes and others 2009).

In addition to cooking stoves and lighting, smoking of tobacco is another common source of indoor air pollution in Africa. By inhaling tobacco smoke, people are exposed to adverse health outcomes, such as cancer, as well as cardiovascular and pulmonary diseases. Most countries in Africa, including the island states of the West Indian Ocean sub region have taken bold measures to ban tobacco smoking in public places. For example, the Seychelles Tobacco Control Act of 2009 imposes a smoking ban on all public transportation and in all enclosed public places and workplaces, although smoking is permitted in hotel guestrooms. Similar laws are in force in Mauritius, Mozambique, Uganda and Zambia although exceptions are made for specially designated smoking areas in some of these countries. Laws prohibiting the sale of tobacco to minors are also in force in Madagascar and South Africa. However, enforcement of these laws remains rather weak.

Sources of air pollution

Carbon dioxide is a major pollutant in Africa and is emitted by the industrial, mining and transport sectors, as well as through biomass burning.

Industrial emissions

Industrial emissions tend to be localized, and there are wide disparities between emissions by countries. For example, industry in Morocco generates 2 million tonnes of CO_2, while in South Africa 306.3 million tonnes of CO_2 are emitted from coal consumption, and this constitutes 90.6 per cent of Africa's energy-related carbon emissions and 3.4 per cent of world energy-related CO_2 emissions (UNEP 2005). A further 1.8 million tonnes of SO_2 are also emitted annually from electricity generation in South Africa alone, where the average annual ambient SO_2 concentration is approaching the 20 ppb WHO limit in many areas in the country (UNEP 2005). Reliance on

coal-based energy sources explains South Africa's proportionally larger CO_2 and SO_2 emissions in comparison to other industrializing countries.

Petrochemical refineries and mining

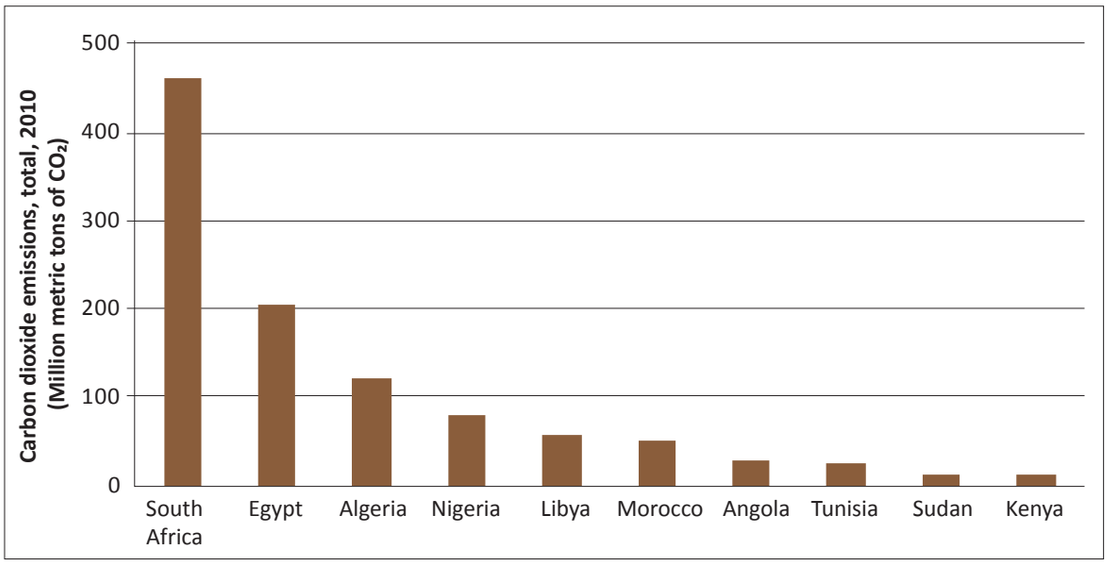
Petrochemical refineries in Egypt and South Africa are the other major sources of SO_2 emissions. A petrochemical refinery near Cape Town, South Africa, was found to emit 18 tonnes of SO_2 daily (Norman and others 2007), while in Egypt 27 µg of SO_2 were recorded per m^3 of air, a level that is lower than Egypt's legal limit of 60 µg/m^3 but higher than regional averages (EEAA 2011). Zambia's Copper-belt area also has high SO_2 emission levels, with the copper smelters being the main sources and estimated to release between 300 000 and 700 000 tonnes of SO_2 per year (ZCCM Investment Holdings Plc. 2002). In Nigeria's Niger Delta, about 70 million m^3 of natural gas is flared daily (Tawari and Abowei 2012), releasing SO_2, dioxins and benzene, and causing skin and respiratory complications and killing plants and animals (Tawari and Abowei 2012). Mining and cement production in countries such as Morocco, Zimbabwe, Zambia and South Africa contribute significantly to the region's air pollution mainly through dust and CO_2 emissions from coal combustion.

Transport

Globally, the transport sector contributes about 20 per cent of greenhouse gas emissions, with the transport sector responsible for about 25 per cent of world energy demand and using 55 per cent of total oil consumed per year (UNECA 2009). In Africa, road transport accounts for 80 per cent of the goods traffic and 90 per cent of the passenger movement (UNECA 2009). In addition, maritime transport is the most dominant mode of transport for moving freight to and from Africa, accounting for 92 per cent of region's external trade (UNECA 2009). Africa has 90 major ports, which handle only 6 per cent of global traffic, and of these, only six ports, three each in Egypt and South Africa, handle about 50 per cent of Africa's container traffic (UNECA 2009). Africa's share of global air transport remains modest at about 5.2 per cent of the passenger traffic, and carries about 3.6 per cent of the global freight (UNECA 2009).

Traffic in Cairo, Egypt

Figure 2.3: Key emitters of CO_2 in Africa in 2010



Source: UNSD 2013

The contribution of the transport sector to air pollution is also increasing in big cities such as Addis Ababa, Cairo, Dakar, Johannesburg, Kinshasa, Luanda and Nairobi. In 1999, Africa had 20.9 cars per 1 000 people and this increased to 24.9 cars per 1 000 people in 2009 (Davis and others 2011), and the average age for the cars is more than 12 years (Harrington and McConnel 2003). These result in significant emissions of CO_2 (Figure 2.3).

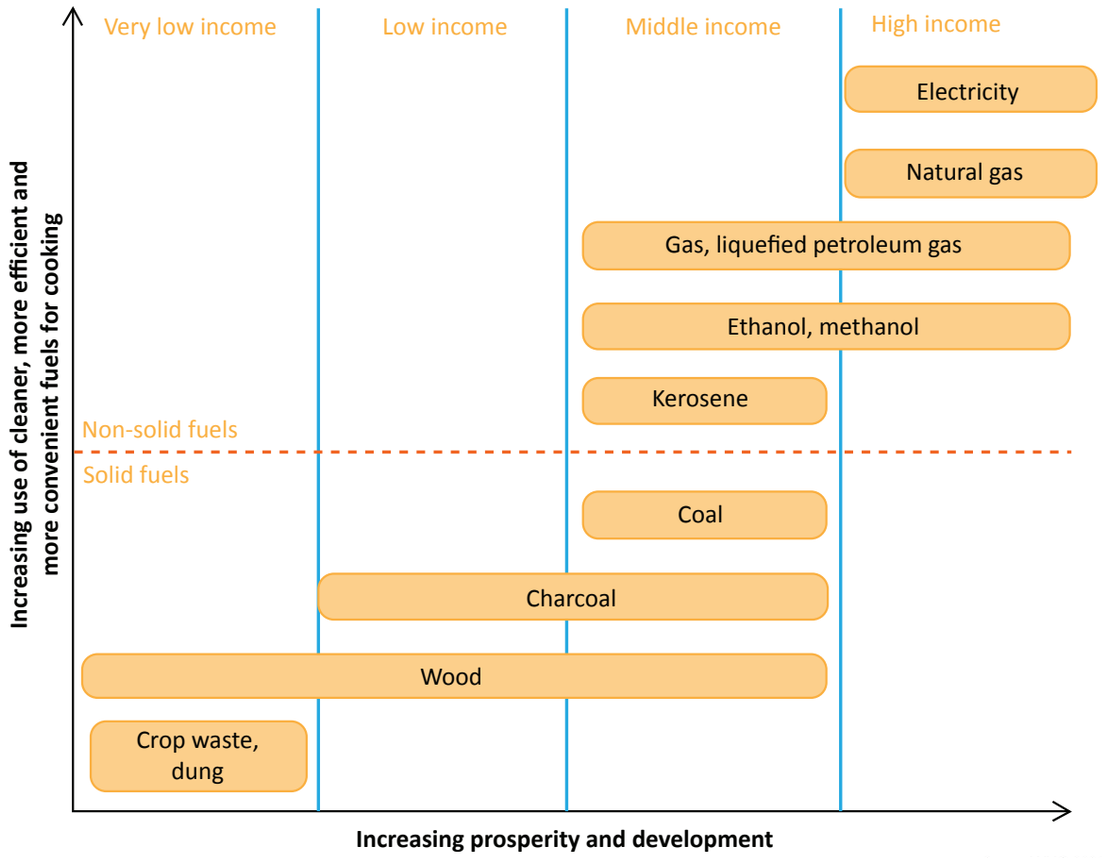
The rapidly growing number of second-hand cars and poor road infrastructure often lead to traffic congestion in most African cities, resulting in fuel wastage, air pollution and road traffic accidents. For example, about 50 million vehicle hours were lost in Nairobi in 2002 owing to congestion at peak hours, translating to about 63 million litres of fuel worth US$ 25 million (Republic of Kenya 2004 in UNEP 2005). This is in addition to 300 fatalities annually due to road traffic accidents blamed on ageing cars and poor roads (IAPT and AAPT 2010).

Household energy

Fire from household energy, mainly from woodfuel, charcoal and kerosene use, and fire from land use sectors, including forest fires and agro-wastes, are the most important GHG emission sources in Africa, contributing about 4 per cent to the global CO_2 levels (Kituyi and others 2005). Southern Africa's savannas and grasslands contribute 86 per cent of the total biomass burned annually in Africa (van Wilgen and Scholes 1997). The emissions from biomass sources are a significant source of global photochemical ozone formation, contributing as much as 35 per cent (Marufu 2000). In West and Central Africa, forest fires emanate from the rich biomass. In Cote d'Ivoire, forest fires are considered a national disaster since the drought of 1983 when wildfires destroyed 60 000 ha of forests and 108 000 ha of coffee and cocoa plantations (IFFN 1996). Between 1983 and 1994, forest fires also destroyed homes of more than 70 000 people and killed 77 people in Cote d'Ivoire (IFFN 1996).

Over 70 per cent of domestic energy needs in most sub-Saharan Africa countries are met by biomass fuels, which is equivalent to 161.4 million tonnes of oil. An additional 575 000 tonnes of liquid petroleum gas, 1.6 million tonnes of coal, 54 265 GWh of electricity and 3.78 million tonnes of kerosene are consumed in the region every year (International Energy Agency 2003 in UNEP 2005). All these fuel combustion processes emit a wide range of air pollutants and particulate matter. For example, in South Africa, more than 20 million

Figure 2.4: The energy ladder



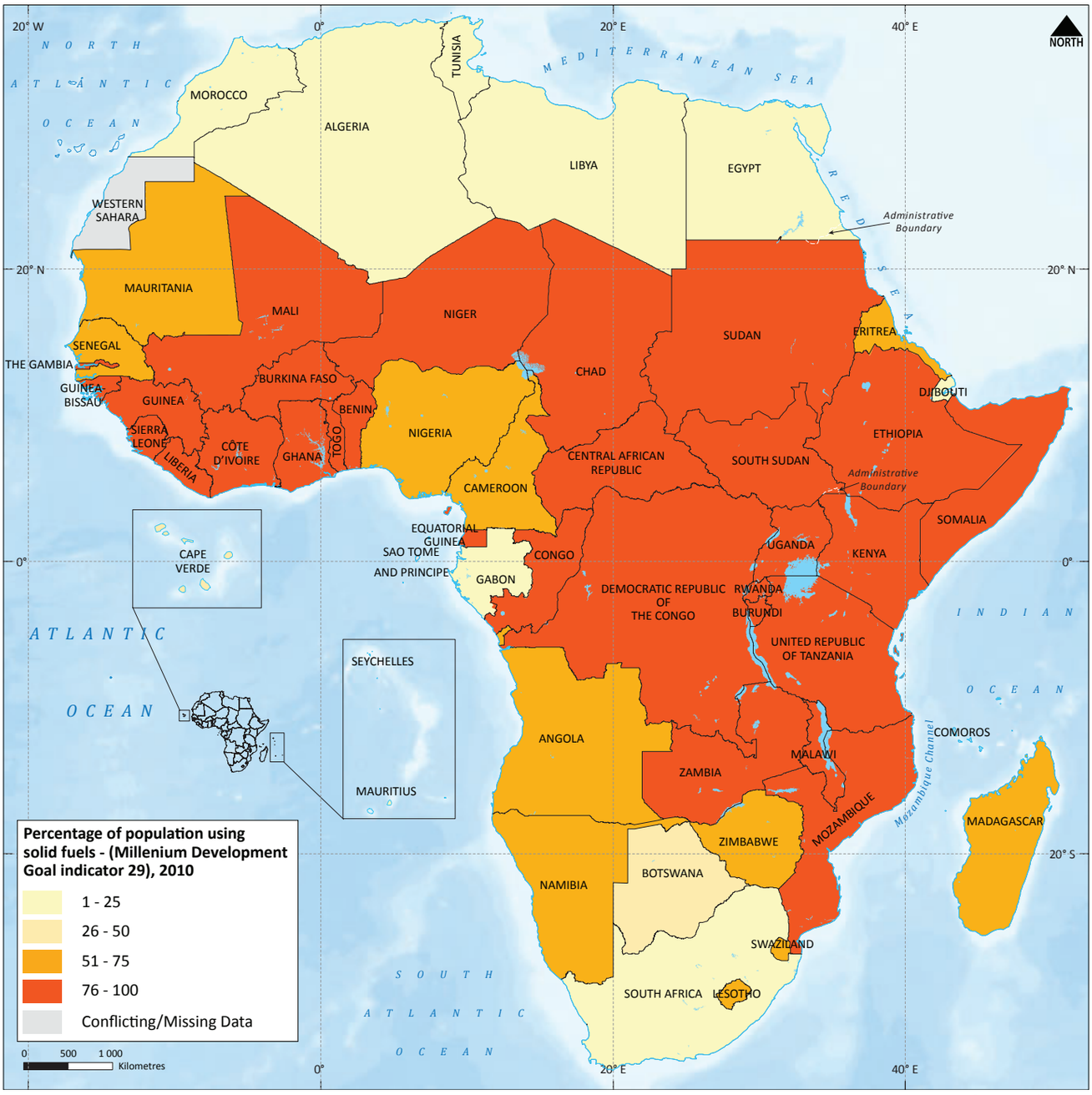
Source: WHO 2006

people are said to rely on woodfuel, coal and kerosene for their basic energy needs such as cooking and heating. These people are exposed to high concentrations of particulates in the range of 294 to 2304 µg/ m^3 compounded by the daily 12-hour exposure to the pollutants (Tanimowo 2000). The demand for biomass sources of energy is correlated with poverty as is evident from the energy ladder depicted in Figure 2.4.

Cooking over a wood fire, Burkina Faso

TREEAID / Foter / CC BY

Figure 2.5: Percentage of Africa's population that relies on solid fuels



Source: WHO undated

The demand for biomass fuel is also linked to population growth, which in Africa expanded from 118 million in 1900 to 469 million in 1980 (UNEP 2006) before reaching 1 billion in 2011 (UNDESA 2013). The percentage of the region's population that relies on solid fuels is depicted in Figure 2.5.

Outdoor activities and processes

Dust is an important source of air pollutants, especially in North Africa and the Sahelian countries. For example, average outdoor concentrations of PM10 in Egypt, Morocco and Sudan exceed 25 μg/m^3 (UNEP 2006), above the WHO permissible limit of 20 μg/m^3. Figure 2.6 illustrates the PM10 concentrations for Egypt. The PM10 pollutants result in smog. Wind-blown dusts from mine dumps in places such as Soweto in South Africa and other places near mining industries in southern Africa are also important sources of outdoor air pollution (UNEP 2005).

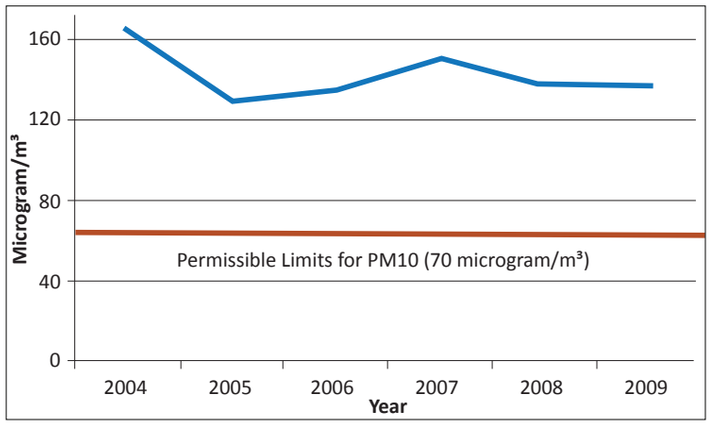
Other sources of outdoor pollutants include biogenic processes and lightning (UNEP 2005).

Clean air for healthy living

Efforts to ensure clean indoor and outdoor air in Africa include setting and enforcing quality standards, regulations and laws and using more efficient technologies.

Indoor air pollution poses serious health problems for Africa due to the heavy use of solid fuels. Consequently, a number of interventions have been proposed to reduce indoor air pollution. These include acting on the source of pollution through improved cooking devices; improving the living environment through better ventilation and kitchen design and placement of the stove; and changing user behaviour to ensure reduced exposure and avoidance of smoke (Bruce and others 2006). This ultimately reduces exposure to indoor pollution the prevalence of ARIs, especially among the vulnerable groups especially women and children. However, cultural and economic impediments constrain the uptake of interventions targeting the source of indoor air pollution. Slow progress in the construction of rural and peri-urban housing due to widespread poverty undermines efforts to improve the living environment.

Figure 2.6: Egypt, record of PM10 2004-2009



Source: EEAA 2009

Venting cooking smoke helps to reduce indoor air pollution

UNICEF Ethiopia / Flickr / CC BY NC ND 2.0

Renewable energy: rows of solar panels, Morocco

There is scope for further improvement through adoption of improved cooking devices, tapping solar energy, uptake of less polluting fuels such as liquefied petroleum gas (LPG), changes in user behaviour and expansion of national electrification programmes. With regard to the later, the region should position itself to benefit from the Power Africa initiative announced by President Barack Obama during his July 2013 visit to Africa. The initiative, worth US$ 7 billion seeks to double access to electricity in six of the region's countries (Kenya, Ethiopia, Ghana, Liberia, the United Republic of Tanzania and Nigeria) by 2018.

With regard to outdoor air pollution, Africa has successfully phased out leaded gasoline (save for Algeria) and has progressed well in lowering the sulphur content in diesel. Initiatives by some countries such as Kenya to set age limits for imported used vehicles hold promise as they are associated with reduced vehicular emissions that cause a range of diseases. Despite these efforts, outdoor air pollution remains a major challenge which needs to be addressed in order to harness the health benefits of clean air.

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3

Biodiversity

Africa's biological diversity

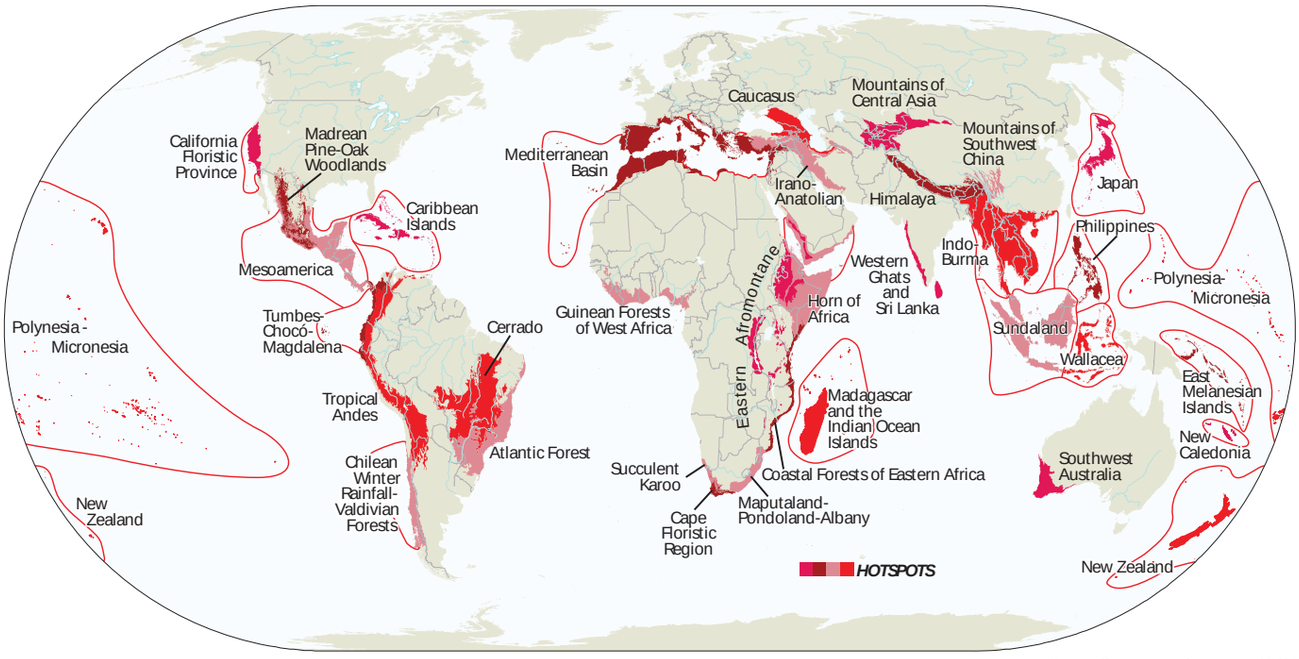
Biodiversity supports human health in many ways, including being a major source of food and medicine. The dependence of 80 per cent of Africa's rural population on traditional medicine attests to the importance of biodiversity to human health (WHO 2008). In addition, Africa's rich biodiversity provides critical social, cultural, economic and environmental services, and offers aesthetic enjoyment.

Eight of the world's 34 biodiversity hotspots are in Africa (UNEP 2008). These are the Cape Floristic Province; the Coastal Forests of Eastern Africa; the Eastern Afromontane; the Guinean Forests of West Africa; the Horn of Africa; Madagascar and Indian Ocean Islands; Maputaland-Pondoland-Albany; and Succulent Karoo (Conservation International 2005). Africa has three of the world's most biologically diverse countries. These are Madagascar (Figure 3.1), South Africa and the Democratic Republic of Congo (DRC), while the Ethiopian Highlands are one of the world's

Figure 3.1: A satellite image of coastal Madagascar, a biodiversity hotspot

Source: Landsat; visualization by UNEP/GRID

Figure 3.2: The world's biodiversity hotspots



Source: Conservation International 2006

eight major centres of crop diversity (Shikongo 2005). Figure 3.2 contains the world's biodiversity hotspots while Table 3.1 contains the key features of Africa's eight centres of crop diversity. The Congo Rainforest, covering 301.8 million ha (FAO and ITTO 2011), is the second largest rainforest in the world after the Amazon, and is very rich in biodiversity. Other important habitats in Africa include the Atlas Mountains in North Africa. These shelter rich pine and oak forests, provide prime habitats for migratory birds, offer refuges for threatened wildlife, and also host a number of endemic and rare species such as the wild olive and the Saharan myrtle (Duruigbo 2013). Many of these habitats offer goods and services with diverse human health values.

The continent is nonetheless rapidly losing its biodiversity wealth due to uncontrolled exploitation and fragmentation of natural habitats owing to rapid population growth and agricultural expansion. Increasing rates of deforestation,

Table 3.1: Key features of Africa's eight biodiversity hotspots

Hotspot	Key features
Cape Floristic Region	Evergreen fire-dependent shrublands characterize the landscape of the Cape Floristic Region.
Coastal Forests of Eastern Africa	Though tiny and fragmented, the forest remnants that make up the Coastal Forests of Eastern Africa contain remarkable levels of biodiversity.
Eastern Afromontane	The mountains of the Eastern Afromontane hotspot are scattered along the eastern edge of Africa, from Saudi Arabia in the north to Zimbabwe in the south.
Guinean Forests of West Africa	The lowland forests of West Africa are home to more than a quarter of Africa's mammals, including more than 20 species of primates.
Horn of Africa	The arid Horn of Africa has been a renowned source of biological resources for thousands of years.
Madagascar & The Indian Ocean Islands	Madagascar and its neighbouring island groups have an astounding total of eight plant families, four bird families, and five primate families that are endemic to the region.
Maputaland-Pondoland-Albany	Maputaland-Pondoland-Albany, which stretches along the east coast of southern Africa below the Great Escarpment, is an important centre of plant endemism.
Succulent Karoo	The Succulent Karoo of South Africa and Namibia boasts the richest succulent flora on earth, as well as remarkable endemism in plants.

Source: Conservation International 2005

overgrazing, soil erosion and desertification threaten biodiversity of medicinal and food security value. Overharvesting and climate change also contribute to biodiversity degradation and lead to imbalances in predator-prey relationships that may create conditions for disease outbreak.

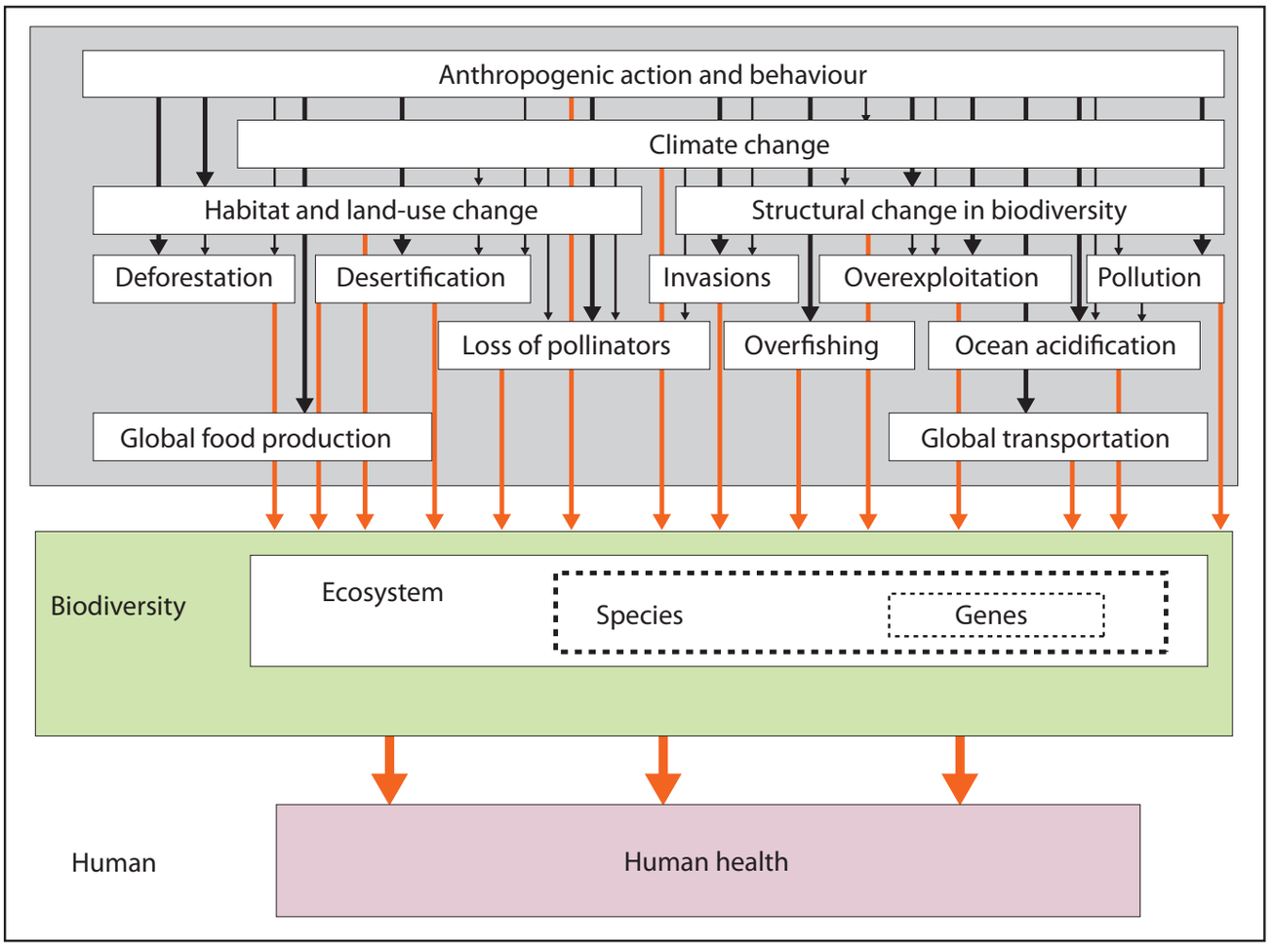
Biodiversity and human health linkages

Africa's biodiversity offers opportunities for the development of pharmaceutical products that would yield both health and financial benefits for the region. It also provides possibilities for crop and livestock improvements, especially in enabling the breeding of varieties that are resistant to drought, pests and diseases that are projected to increase with climate change. These collectively expand the food supply and medicinal value of the continent's biodiversity. The biodiversity-human health linkages are illustrated in Figure 3.3.

Food supply

A variety of fruits, vegetables, honey, spices, oils, bushmeat, fish, edible worms and mushrooms found in Africa's biodiversity-rich ecosystems contribute to food and nutrition security on the continent. For example, in Zimbabwe, 50 mushroom, 25 fruit and 50 vegetable species are harvested from the wild (MENRM 2010; Jumbe and others undated) while in Mozambique, marine invertebrates are an important food source (MCEA 2009). In the United Republic of Tanzania, there are 79 indigenous species of fruit and 40 indigenous vegetables (URT 2009). Loss of genetic diversity

Figure 3.3: Biodiversity-human health linkages



Source: Hammen and Settele 2011

in staple crops threatens human health when the potential of the crops for resistance against disease, pests, drought and other natural or human caused disasters is compromised (EC 2011). Similarly, the integrity of ecosystems is important in ensuring food security and facilitating healthy living, with ecological imbalances causing diseases (Chivian and Bernstein 2008).

Medicinal benefits

Both conventional and traditional medicines derive many active ingredients from the region's flora and fauna. In South Africa's Eastern Cape Province, about 525 tonnes of medicinal plants are harvested each year (Dold and Cocks 2002). Between 2001 and 2009, African exports of wild medicinal plants to China alone were estimated at US$ 23 million (Olsson and Ouattara 2013). Global exports of these medicinal plants are much higher.

Traditional medicines include oils of cedar, cypress, licorice, myrrh and poppy. Modern day antibiotics come almost exclusively from microbes, including penicillin, which is isolated from the Pencillium fungus (Chivian and Bernstein 2008). Other examples of medicinal plant species in Africa include *Prunus Africana* and *Aloe vera* which are abundant in Nyungwe Forest in Rwanda. *Prunus Africana* is said to treat prostate cancer while *Aloe vera* is also used in the pharmaceutical and cosmetic industries (REMA 2009).

Aloe vera plant in Rwanda

Medical research

Biodiversity provides resources for medical research. Studies of wildlife anatomy, physiology and biochemistry can lead to important developments in human medicine (CBD 2010). A great deal of medical discoveries has been made through a better understanding of biodiversity. Loss of biodiversity may therefore limit the discovery of potential medicines for many diseases and other health problems.

Regulation of infectious diseases

Biodiversity loss and ecosystem change can increase the risk of emergence or spread of infectious diseases in animals, plants and humans (CBD 2010). Human activities disrupt both the structure and functions of ecosystems and alter biodiversity. There has in the recent past been an increase in the rate of emergence and re-emergence of infectious diseases due to intensified human encroachment on natural habitats and loss of biodiversity.

Infectious disease risks are affected by destruction of, or encroachment into wildlife habitat, changes in distribution and availability of surface waters, land-use changes, and uncontrolled urbanization, among others. Intact biodiversity therefore plays a role in the regulation and control of infectious diseases.

Social, cultural and spiritual importance

Ecosystem changes can result in disconnection of populations from open spaces or the wider countryside with negative implications for physical and mental well-being. This has been linked to an

increased prevalence of the 'diseases of affluence' (diabetes, obesity, cardio-pulmonary illness) and psychological disorders in many communities (CBD 2010).

Biodiversity provides opportunities for recreation, tourism, aesthetic enjoyment (MA 2005; Lloret 2010) and education. These services can improve mental health, enhance the understanding of local culture and enrich the knowledge of local communities. Access to green spaces is associated with better health outcomes and shorter hospital visits.

Adapting to climate change

Climate change will have a range of significant impacts on human health, many of which are directly associated with climate impacts on ecosystems (CBD 2010). Loss of biodiversity services places communities at risk of severe climate change impacts, such as extreme weather events (EWEs), drought and crop failure. Climatic conditions are to a large extent influenced by changes in biodiversity ecosystems and landscapes, especially deforestation and desertification which in turn affect the health of human populations. Conservation of biodiversity is therefore essential for adapting to climate change.

Reduction of disasters

Disasters such as droughts, floods and landslides have impacts on human health through deaths and injuries. Other indirect impacts include damage to infrastructure, displacement of people and disruption of economic activities. Floods may lead to increased incidences of communicable diseases due to lack of clean water and shelter while droughts may lead to food insecurity and hence poor nutrition. Communities that have been displaced as a result of disasters are more prone to sickness and will tend to rely more on biodiversity systems for medicine and food.

Biodiversity and healthy ecosystems can provide important natural buffers against natural disasters (MA 2005). Sustainable management of biodiversity can help to provide essential resources for promoting health and rebuilding livelihoods in post-disaster situations (CBD 2010).

Flamingoes taking off in Amboseli National Park, Kenya

Threats to biodiversity

Although there is paucity of data on biodiversity loss, it is generally agreed that there is a consistent decline in average species abundance, with global losses estimated at as high as 40 per cent between 1970 and 2000 (CBD 2006). Left unchecked, the decline will continue to erode the health benefits of the region's biodiversity. In Africa, loss of biodiversity is expected to continue at an increasing pace in the coming decades due to rapid population growth, overexploitation, pollution, habitat disturbance, deforestation, illegal logging, infrastructure development, invasive alien species and climate change (which is discussed in Chapter 5). Figure 3.4 depicts Africa's relatively stable, vulnerable and critically endangered biological hotspots.

Unless drastic measures are taken, the relatively stable biodiversity habitats mapped in Figure 3.4 are likely to be quickly transformed into vulnerable or critically endangered biological hotspots. Left unchecked, the decline will continue to erode the health benefits of the region's biodiversity.

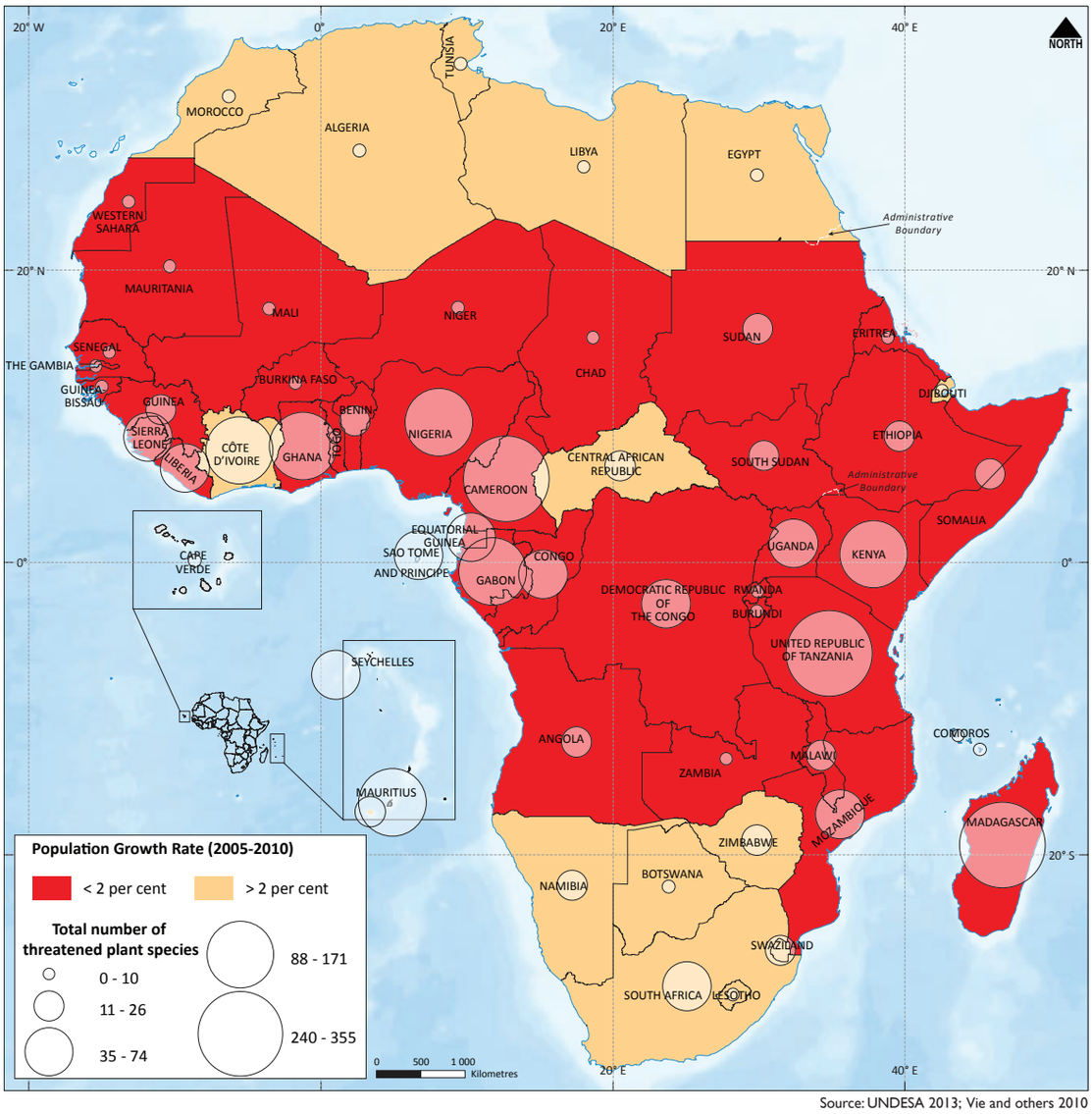
Rapid population growth

By 2030, the African population is expected to have doubled from 2007 levels (UNFPA 2007). Rapid population growth in situations where there

Figure 3.4: Classification of Africa's relatively stable, vulnerable and critically endangered biological hotspots

Source: UNEP-GRID

Figure 3.5: Rapid population growth in areas with many vulnerable species



Source: UNDESA 2013; Vie and others 2010

are limited employment opportunities in the service and industrial sectors is likely to exacerbate population pressure on natural resources. The consequences of this are likely to be deforestation, overgrazing, rapid urbanization, soil erosion and desertification which will endanger traditional medicine and food security. Biodiversity loss is exacerbated by the increasing fragmentation of natural habitats, including large river systems which are affected by damming. The increasing human population may lead to settlement expansion and encroachment on natural ecosystems. This exposes humans to greater contacts with wildlife, raising the risk of outbreaks of zoonotic and other diseases. Figure 3.5 highlights the threat of rapid population growth on vulnerable species and that this problem is especially severe in Africa.

Overexploitation

Overexploitation of the natural resources in the region mostly affects fisheries, forests and woodlands. This is blamed on uncontrolled resource extraction, hunting, poaching and collection of medicines as well as illegal, unregulated and uncontrolled (IUU) fishing in both the oceans and freshwater resources. Africa will need an additional 1.6 million tonnes of fish a year by 2015 just to maintain current consumption (WorldFishCentre 2009). This is projected to increase by a further 2.6 million

Deforestation in Burundi

tonnes a year by 2030. This demand will exceed most wild capture fisheries, most of which have reached their production limit or are over-fished (WorldFishCentre 2009), with serious implications for human health. For example, evidence from Lake Malawi indicates that overfishing and the increased use of fine-mesh beach seines caused a decrease in density of the snail-eating cichlid Trematocranus placodon (Evers and others 2011). The decline of these predators in Lake Malawi appears to have been responsible for the rise in transmission of the schistosomiasis parasites in the lake since the 1980s (Evers and others 2011), causing a rise in bilharzia (Box 3.1).

Between 2000 and 2005, Africa accounted for a net loss of 4.0 million hectares of forests per year and an average annual negative change rate of -0.62 per cent over the same period. Africa suffered the second largest net loss in forests per annum with Burundi having the second largest deforestation rate in the world, followed by Togo and Mauritania. Based on annual net loss, other hotspots include the DRC, Nigeria, Sudan, the United Republic of Tanzaniaand Zambia (FAO 2007).

Box 3.1: The impact of overfishing in Lake Malawi on the spread of bilharzia

Schistosomiasis, also known as bilharzia, is a disease caused by parasitic worms (schistosomes) that are hosted in some snail species. It is the second most devastating parasitic disease after malaria, with over 200 million infections worldwide. Since the 1980s, Lake Malawi's open shores were considered free from human schistosomes (Stauffer and Madsen 2012). A six year study on this lake discovered that a prevalent species of fish in the lake known as the cichlid devours these snails that are an intermediate host for the schistosomes that cause bilharzia, thus helping in controlling or reducing bilharzia's spread. The decline of these fish species is a direct result of people over-fishing. It is evident that densities of some cichlid species are now significantly lower than they were during the early 1980s (Stauffer and others 2006 in Stauffer and Madsen 2012). This has essentially led to more reported cases of bilharzia as more snails carrying this parasite are now prevalent in the lake.

Source: Stauffer and others 2006

Box 3.2: Pollution from oil spills in Niger Delta

Situated in the southern region of Nigeria, the Niger Delta is renowned for its massive oil deposits. However, it is continually faced with the risk of environmental disaster from oil spills. The delta is home to over 31 million impoverished villagers living in many states. The ecosystem is made up of marshland, creeks, tributaries and lagoons which drain into the Atlantic at the Bight of Biafra. It contains the world's largest mangrove forest, as well as diverse plant and animal species, including many exotic and unique species. The Niger Delta provides approximately 40 per cent of all the crude oil imported by the US. Several major oil companies including Royal Dutch Shell, Chevron, ExxonMobil, Total, ENI and Addax run oil extraction operations in the delta. Since 1958, between 9 and 13 million barrels of oil have leaked into the Niger Delta, an amount estimated to be triple the spillage in the Gulf of Mexico. The Niger Delta is now heavily polluted with severe consequences on its biodiversity. For instance, large purple slicks cover the once fertile fields while many rivers are clogged with oil from decades of leaks. In addition, previously abundant fish and bird species have dramatically disappeared from the swamps which are now silent. This festering pollution over a long period of spillage requires massive clean-up and political attention similar to that recently witnessed during the Gulf of Mexico BP oil spill.

Remnants of an oil spill in the Niger Delta

Sosialistisk Ungdom-SU / Flickr / CC BY ND 2.0

Source: Adapted from Pringle 2010

Pollution

Pollution poses a major risk to the region's biodiversity. Box 3.2, which summarizes the risks associated with oil spillage in the Niger Delta, illustrates this point. Pollution causes losses of biodiversity in both terrestrial and aquatic habits. Harmful algal blooms have been linked to nutrient loading from the catchment area. Pollution from anthropogenic activities is threatening Lake Victoria, causing eutrophication and low dissolved oxygen levels. The pollution is due to phosphorous and nitrogen originating from atmospheric deposition and land runoff as a result of increased human activities in the lake's surroundings, mostly from agriculture and forest burning (Scheren and others 2000). Blue-green algae that are forms of cyanobacteria, cause dizziness, fevers, and allergenic diseases such as asthma and may have been behind an outbreak of these diseases in Homa Bay on the shores of Lake Victoria in 1998 (Stewart and others 2006).

Habitat disturbance

Habitat disturbances occur either naturally or anthropogenically. When this happens, the associated loss of biodiversity and the emergence of new ecosystems may create conditions for new health challenges. In 2003, about 49 per cent of

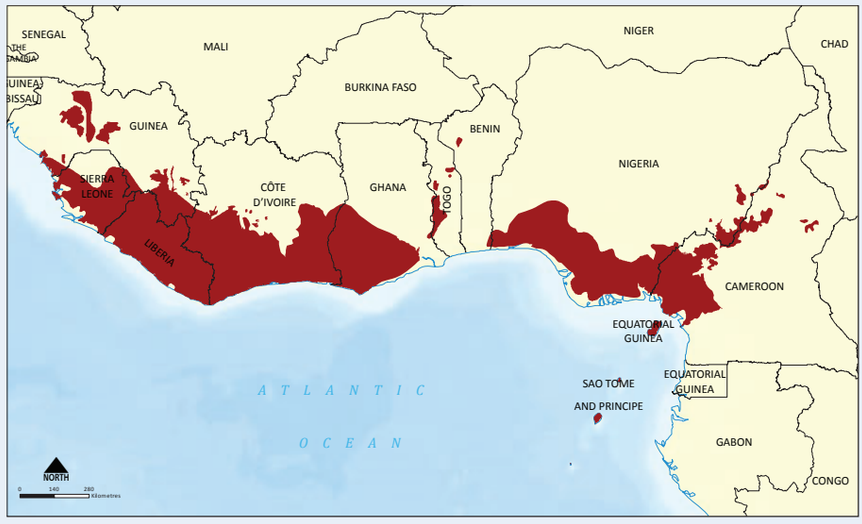
Africa's land was believed to be undisturbed (Hens and Boon 2003) and the biodiversity of such areas thought to be intact. However, recent trends suggest increasing disturbance. With these changes, incidences of host changes for pathogens are linked to the spread of, for instance, H5N1 from migratory birds to poultry (Hammen and Settele 2011).

The impoundment of rivers, as was the case in the Kafue Flats in southern Zambia where two large dams that are 270 km apart (Mumba and Thompson 2005), has altered the associated hydrological regimes. Backwater from the downstream Kafue Gorge Dam and releases from the upstream Itezhi-tezhi Dam create a permanently flooded area in the floodplain. The hydrological and vegetation changes have affected the habitat for important wildlife communities including the endemic lechwe antelope (*Kobus lechwe kafuensis*). The other dramatic change in vegetation is the colonization of parts of the floodplain by the invasive alien plant, *Mimosa pigra* (Mumba and Thompson 2005). Other common forms of habitat disturbance in Africa are destruction of coral reefs through dynamite fishing, and the conversion of natural forests and grasslands into agricultural fields.

Biodiversity loss is also due to the loss of co-evolutionary partner species. For example, as a result of the declining elephant population the numbers of the Moabi tree (*Baillonella toxisperma*), one of the largest tree species in the Congo Basin, are falling in Cameroon, Gabon Equatorial Guinea and the Republic of Congo. For its reproduction, the Moabi tree depends on elephants to swallow and disperse the seeds. The reduction in numbers of elephants in countries such as Benin, the Cote d'Ivoire and Ghana has had an important impact on the distribution of the tree (Hens and Boon 2003). Moabi fruits are edible and remedies for

Diverse wildlife in Amboseli National Park, Kenya

Box 3.3: Guinean Forests of West Africa



The Guinean Forests found in lowland West Africa (stretching from Guinea and Sierra Leone eastward to the Sanaga River in Cameroon) are home to more than a quarter of Africa's mammals, including more than 20 species of primates. The hotspot includes two distinct sub-regions, which incorporate several important forest refugia created by the retraction and fragmentation of forests during the Pleistocene Epoch. The first sub-region, Upper Guinea, stretches from southern Guinea into eastern Sierra Leone and through Liberia, Côte d'Ivoire and Ghana into western Togo. The second sub-region, Nigeria-Cameroon, extends along the coast from western Nigeria to the Sanaga River in south western Cameroon. Human activities like logging, mining, hunting and human population growth are placing extreme stress on the forests. Species such as Jentink's duiker, pygmy hippopotamus, and western chimpanzees are already threatened. The hotspot covers an extent of 620 314 sq. km with the vegetation cover currently at 93 047 sq. km. There are 1800 endemic plant species while some 31 endemic bird species are threatened. A forested area of over 100 000 sq. km is protected.

Source: Adapted from Conservation International 2013

dental and back problems can be extracted from the bark of the tree (Forest Monitor 2001).

As shown in Box 3.3, human pressure is a major stress on the Guinean Forest of West Africa. The tree species is important in economic, cultural and medicinal terms.

Biodiversity protection has largely been made possible through the designation of protected areas. Sub-Saharan Africa has more than 1 100 national parks and reserves, of which 36 are designated World Heritage Sites (Newmark 2008). Since 1970, the total protected area in the region has doubled, covering nearly 3.06 million sq. km of terrestrial and marine habitats (Newmark 2008). Protected areas cover about 15.9 per cent and 10.1 per cent of the total land surface in the East/Southern African and West/Central African regions, respectively (Chape and others 2005 in Newmark 2008). Through protected area management, Africa has scored successes such as the discovery of some new plant and animal species and their subsequent protection. For example, new discoveries in Madagascar since 1999 have included 385 plant species, 41 mammals, 61 reptiles, 69 amphibians, 17 fish and 42 invertebrates (WWF 2011).

Better protection is also credited for the recent recovery of the mountain gorilla and elephant populations in East and Southern African reserves, respectively. In addition, the interlinking and enlargement of selected protected areas, including transboundary natural resources management, have resulted in growth of wildlife populations due to opening up migration routes. The increased participation by local communities in managing

Box 3.4: The *Ngitili* system of community-based forest management in the United Republic of Tanzania

Ngitili (which means enclosure) is an indigenous resource management system used by agro-pastoralists in the United Republic of Tanzania to provide dry season food and fodder. It involves the conservation of fallow and rangelands by encouraging vegetation regeneration through controlled livestock grazing during the wet season for use in the dry season. The concept was developed in response to acute and frequent droughts. The is viewed as an easier and better option than planting trees, many of which are exotic and not preferred by the local people. Recorded benefits of the Ngitili include the restoration of forest biodiversity, including 152 tree, shrub and climber species in over 500 000 hectares of an area previously known as the Desert of Tanzania. Average incomes in participating villages doubled as a result of better livestock management, as well as increased sale of forest products such as honey and timber. The health of communities also improved through the availability of medicinal plants and fruits. Communities were also empowered in the governance of their resources.

Shinyanga, United Republic of Tanzania

chmoss / Foter / CC BY NC ND

Source: Slingenberg and others 2009

natural resources adjacent to the reserves (Box 3.4), and the increase in the number of institutions offering training in conservation biology and wildlife and protected-area management has also resulted in the improvement of wildlife management (Newmark 2008).

Biodiversity and habitat complexity affect the composition and distribution of animals that may play important roles in the transmission cycles of some human diseases. The loss of predators causes changes in ecosystem processes and functioning.

Species diversity: chameleon on a branch

CaMiLo11 / Foter / CC BY ND

Box 3.5: Pathways through which deforestation can affect malaria infection and disease

Malaria medication

World Bank Photo Collection / Foter / CC BY NC ND

(i) Deforestation changes the ecology of a disease vector and its options for hosts

Whereas the forest floor in primary growth tends to be heavily shaded and littered with a thick layer of organic matter that absorbs water and renders it quite acidic, cleared lands are generally more sunlit and prone to the formation of puddles with more neutral pH which can favour specific anopheline larval development (Patz and others 2000).

(ii) Deforestation can change local climate and thereby affect the spread of disease by reducing moisture held by the vegetation, and raising ground temperatures

Higher temperatures can increase the rate at which mosquitoes develop into adults, the frequency of their blood feeding, the rate at which parasites are acquired, and the incubation of the parasite within mosquitoes (Walsh and others 1993).

(iii) Deforestation is often the beginning of a variety of land use changes

These changes may include agriculture and livestock, plantations, human settlement, increased use of regenerating forests, construction of roads, and water control systems (dams, canals, irrigation systems, and reservoirs).These habitat changes may not only result in mosquito populations that have higher rates of malaria transmission, they may also lead to increased human contact and transmission (Petney 2001). And, use of insecticide in follow-up agriculture can increase vector resistance (Wilson 2001).

(iv) Deforestation is accompanied by migration that may enhance the spread of malaria

Migrants typically have little previous exposure and therefore lower natural immunity (Castilla and Sawyer 1993). Moreover, migrants introduce the additional complication associated with administering health services to transient populations such as inadequate medical follow up and possible side effects. Although incomplete treatment can relieve fever, the underlying malarial infection persists as the migrant moves and potentially transmits the disease to other locations on the deforestation frontier.

Sources: Walsh and others 1993; Patz and others 2000; Petney 2001; Wilson 2001; and Castilla and Sawyer 1993

Deforestation

Africa has the world's highest level of deforestation. While the global annual rate of forest loss was 0.13 per cent between 2000 and 2010, Africa recorded an annual forest loss of 0.49 per cent (FAO 2011). Changes in biodiversity, through habitat fragmentation and deforestation, increase the risk of malaria transmission by affecting the survival, density and distribution of mosquitoes (Yasuoka and Levins 2007). Box 3.5 contains the pathways through which deforestation can affect malaria infection and disease.

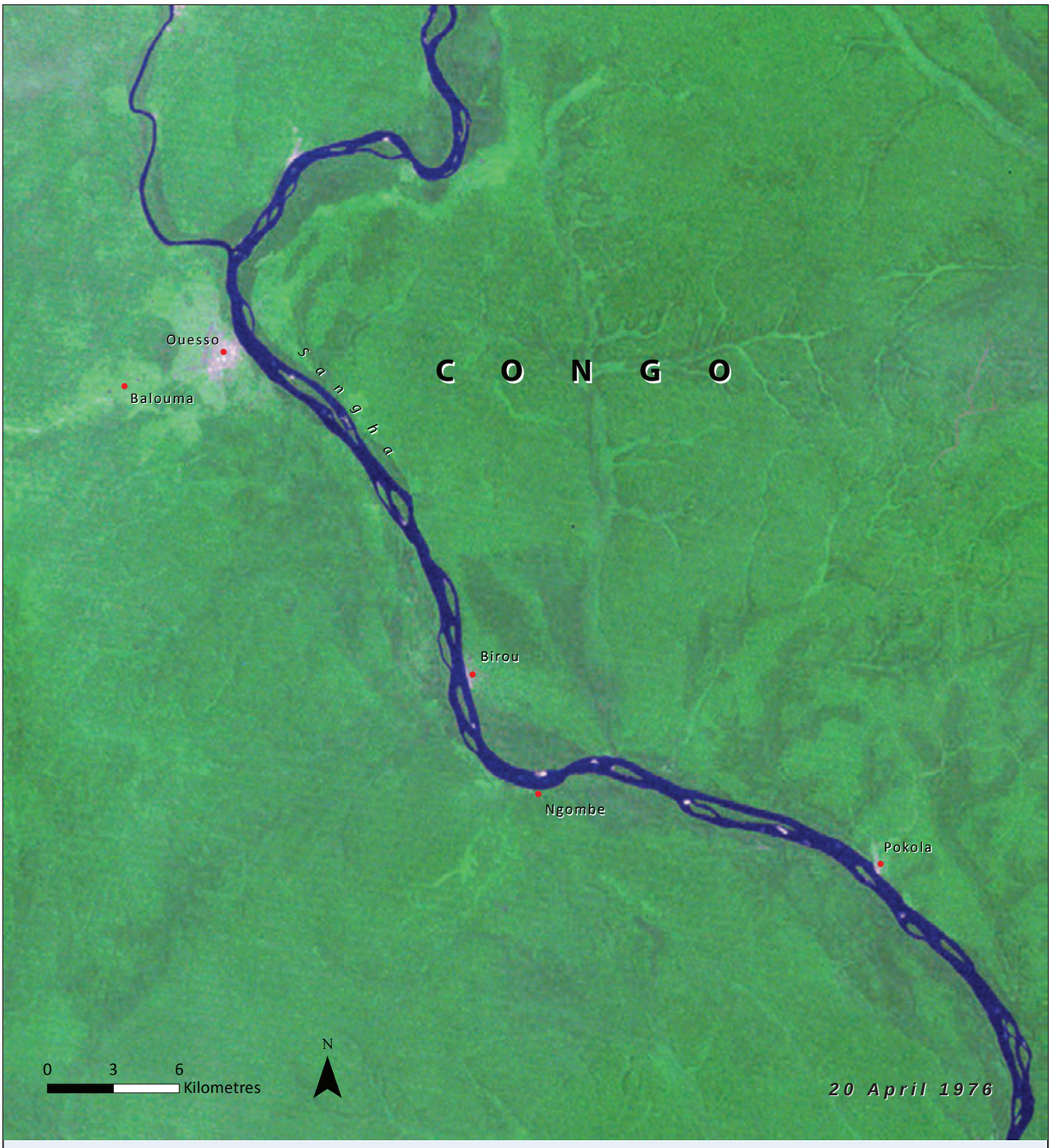
Deforestation also increases transmission of malaria by raising surface-water availability and creating new breeding sites for some *Anopheles* mosquitoes (Kondrashin and others 1993 in Yasuoka and Levins 2007). Deforestation also affects the local microclimate, including sunlight and temperature. Mosquito larval habitats may be exposed to more sunlight, rising water temperatures and changing community dynamics, which can increase the survival of larval mosquitoes (Tuno and others 2005). A warmer microclimate can cause mosquitoes to digest blood meals more quickly, leading them to feed and lay eggs

Mountain gorilla in the Impenetrable Forest (Bwindi National Park, Uganda)

more often, resulting in higher rates of vector development and reproduction (Afrane and others 2011). For example, in the western Kenya highlands the capacity for vector development is estimated to be almost 80 per cent higher in deforested sites than in forested ones (Afrane and others 2008).

Through deforestation and other anthropogenic changes to forest habitats such as encroachment of agricultural land into forests, biodiversity is not only reduced, but people are also brought into closer contact with wildlife, increasing the risk of zoonotic disease transmission (Pongsiri and others 2009). Non-human primates are an important human disease reservoir, not only because of their physiological similarity to people but also because of their ecological responsiveness to habitat disturbance (Chapman and others 2005 in Pongsiri and others 2009). Habitat disturbance such as road construction results in people encroaching into forests, and is linked to the consumption of bushmeat and the spread of zoonoses such Ebola (Wolfe and others 2005) and monkey pox (Wolfe and others 2005).

In Central Africa, about 3.4 million tonnes of bushmeat are consumed annually, while in West Africa, a large share of protein in the diet comes from bushmeat (Karesh and others 2005 in Chomel and others 2007). Some of the earlier cases of Ebola were recorded in 1976 in Sudan and Congo where 284 and 318 cases were recorded, respectively. These resulted in mortality rates of 53 per cent in Sudan and 88 per cent in Congo. In 2003, Gabon and Democratic Republic of Congo recorded 302 cases, with a mortality rate of 84 per cent (Rivera 2010). Transmission across species also goes from humans to wildlife as was the case with the parasitic disease Giardia,



Ouesso, Republic of the Congo

Ouesso, the largest town in northern Republic of the Congo with roughly 30 000 people, is surrounded by relatively intact tropical rain forests with a range of fauna including elephants, gorillas, chimpanzees, and bongos. Bushmeat accounts for the vast majority of protein in the diet of local people. Hunters largely ignore laws governing the taking of wild game; the harvest is only limited by accessibility and technology.

Inaccessibility of the area around Ouesso has also limited timber exploitation. Of seven companies logging in the area in the 1990s, four went bankrupt under the

burden of high transportation costs. However, the area's inaccessibility appears to be changing. In the 1976 image few roads are visible and towns in the area are quite small, with little visibly disturbed forest surrounding them. By 2013, roads have penetrated throughout the area, towns have grown significantly, and, particularly near Pokola and Ngombe, the area of disturbed forest has grown (yellow arrows).

Logging, roads, vehicles and increased job opportunities have been shown to dramatically increase the range in which bushmeat hunting takes place. It also changes hunting from a subsistence activity to a commercial activity with meat being transported as far away as Brazzaville. There is a proposal to build an Ouesso-Brazzaville rail line. Improved transportation at lower cost would likely bring more roads, increased logging, and accelerated bushmeat trade.

which was introduced to the Ugandan mountain gorilla by humans through ecotourism activities (Nizeyi and others 1999 in Patz and Confalonieri 2005).

In addition to bushmeat, wild plant and animal products are also collected for food and medicines. In Swaziland, about 200 wild plant species are routinely collected for food and medicine (Tarr and Tarr in SAIEA 2013), while in Namibia, it is estimated that 33 per cent of total household consumption in rural areas comes from wild foods, including game meat and fish (Ashley and La Franchi 1997 in SAIEA 2013). In sub-Saharan Africa, at least 60 species of wild grass are harvested for food (UNEP 1999 in SAIEA 2013).

Commercial logging and the development of infrastructure

In many parts of Africa where forests biodiversity is threatened, other than general deforestation, commercial logging and timber production is closely connected to development of infrastructure. Logging is mostly carried out by large international companies, which normally buy or rent the land in order to harvest the timber required for infrastructural development. These companies are also responsible for creating new roads in the areas they operate in (as the Ouesso change pair demonstrates). Though the extension of these transport networks is not directly aimed at promoting human settlement, road construction creates easy access for illegal settlers, who encroach on the areas around the new roads as soon as logging is finished. The closer proximity of settlers to the forested areas exposes them to a range of zoonoses.

Invasive alien species

An important link between biodiversity and human health is manifested through the spread of invasive species and pathogens, driven largely by globalization and the transfer of exotic organisms. The exotic species can cause extinction of local species, resulting in the loss of diversity at many levels, from genetic variation to species numbers. Insect vectors can disperse into new habitats by one organism transporting another, or thorough flight, or wind. However, development of transport infrastructure has been responsible for the arrival and spread of the most invasive vectors, such as fleas, lice, and mosquitoes. Yellow fever, dengue, malaria, and West Nile encephalitis are some of the diseases that have breached bio-geographic barriers through human movement (Lounibos 2002 in Pongsiri and others 2009).

Roadside firewood for sale

jacashgone / Foter / CC BY-NC-ND

Water hyacinth on Lake Victoria

Africa has a growing problem of invasive alien species. According to UNEP (2006), all countries in the region are affected by invasive alien species, including South Africa where there are 81 identified invasive alien species, Mauritius which has 49, Swaziland with 44, Algeria and Madagascar with 37 each, Egypt with 28, Ghana and Zimbabwe with 26 each, and Ethiopia with 22 (IUCN/SSC/ISSG 2004). Many of the invasive alien species found in Africa are among the 100 worst invasive alien species (IUCN/SSG/ISSG 2004). These include the widespread water hyacinth (*Eichhornia crassipes*); economically important species such as the Nile perch, Mozambique tilapia (*Oreochromis mossambicus*) and black wattle (*Acacia mearnsi*); species introduced for biological control, such as Indian myna (*Acridotheres tristis*) and cane toad (*Bufo marinus*); and ornamentals such as *Lantana camara* (UNEP 2006).

The disappearance or threat of extinction of two thirds of the more than 300 haplochromine cichlid species in Lake Victoria is due to predation by Nile perch, an introduced predator (Goldschmidt and others 1993). 36 species in the fynbos region of South Africa are also now believed to be extinct (Maneveldt 2010). Other recently recorded extinctions include the Rodrigues Blue-pigeon, Mauritius Blue-pigeon (*Alectroenas nitidissima*) (BirdLife International 2013), Mauritian Shelduck (*Alopochen mauritianus*), Mauritius Duck (*Anas theodori*) (BirdLife International 2013), the bluebuck (*Hippotragus leucophaeus*) (IUCN SSC Antelope Specialist Group 2008a) the Quagga (*Equus quagga quagga*) (Hack and others 2008), the Zanzibar leopard (*Panthera pardus adersi*), and the Bubal Hartebeest (*Alcelaphus buselaphus ssp. Buselaphus*) (IUCN SSC Antelope Specialist Group 2008b).

In North Africa there are 551 invasive alien species, 100 of which are classified as a threat to native fauna and flora, while 10 million hectares of South Africa's land surface area are currently infested by invasive alien plants (Le Maitre and others 2000). In Zambia, the giant mimosa (*Mimosa pigra*), a

Box 3.6: Some invasive alien species which threaten Africa's biodiversity

In Africa in recent decades, concern has been rising over the following invasive alien species:

Lantana camara

Nemo's Great Uncle / Flickr / CC BY NC SA 2.0

The shrub *Lantana camara* which is present and invasive in many countries in Africa. In Uganda, for instance *Lantana camara* invasions cover vast areas particularly around Hima in Western Uganda. The allelopathic capacity of *Lantana* prevents all other plants from growing under and near it. As such, it forms single-species stands that exclude all other plants and any land uses. *Lantana camara* continues to invade more land each year, affecting agriculturally productive areas as well as rural and urban settlements.

Parthenium hysterophorus

Forest and Kim Starr / Flickr / CC BY 2.0

The weed *Parthenium hysterophorus* has been noted to spread fast and has invaded the Queen Elizabeth National Park in Western Uganda, endangering populations of animals and native plant species. In Ethiopia, the weed has invaded large areas of agricultural land, forcing farmers to abandon their land. It is also choking wetlands like Lake Awassa. There is evidence that the weed is spreading to Kenya and the United Republic of Tanzania as well as Mozambique and South Africa.

Mimosa diplotricha

IRRI Images / Flickr / CC BY NC SA 2.0

Mimosa diplotricha has been detected in Ethiopia where it invades roadsides, rock outcrops and road excavations. It has been recognized as a threat in the Indian Ocean island states and is currently spreading in Burundi.

Source: IUCN undated

spiny shrub native to Latin America, established itself on the Kafue flood plain in the early 1980s and now covers 3 000 hectares of prime floodplain habitat. It is fast displacing important indigenous animals, birds and plants from their natural environment (Beilfuss 2007). The socio-economic impacts of invasive alien species can be enormous, and include both direct costs for their control and eradication as well as indirect costs due to the loss of ecosystem services. In the fynbos biome of South Africa, it is estimated that invasive alien species cause losses of about R700 million (approximately US$ 100 million) per year. It is further estimated that the eradication of all invasive alien species currently in South Africa would cost R600 million (US$ 86 million) per year for the next twenty years (DEAT 2009). The cost of invasion of waterways by the water hyacinth in Zambia and Zimbabwe is estimated at US$71.4 million per year (SADC and others 2008), while in Uganda the average cost of not managing *Cymbopogon* is estimated at US $175 per hectare (NARO quoted in NEMA-U 2011).

Box 3.7: The impacts of the invasion of *Prosopis juliflora* in Afar, North east Ethiopia

Prosopis juliflora was introduced in the 1970s by Ministry of Agriculture to high quality pasturelands and irrigable areas, including the Awash River basin in the Afar National Regional State of North east Ethiopia. Local people were not informed about the invasive nature of the tree at first and were not advised on management practices to minimize its spread. As a result, the plant rapidly invaded vast areas of agro- and silvo-pastoral lands, affecting both the biodiversity and socio-economic environment. Over 700 000 hectares of prime grazing land and cultivable land along the Awash River is currently invaded or at risk of invasion from Prosopis in the Afar Region. This accounts for 15 per cent of the region's productive land excluding wetlands, water bodies, and sandy and rocky areas.

The *Prosopis* invasion has resulted in multiple negative effects on food security, livelihoods and the region's environment. The local people are dependent on livestock as a source of food, income, and savings. The invasion has caused considerable declines in livestock production and productivity due to the loss of dry season grazing areas to Prosopis plants. Palatable indigenous pasture species such as *Chrysopogon plumulosus, Cenchrus ciliaris* and *Setaria acromelaena* have been reduced. Indigenous trees such as *Acacia tortilis, Acacia senegal* and *Acacia nilotica* have also declined in the rangelands due to the invasion. Yet the pods and branches of these trees are the main dry season feed sources for livestock. Feeding livestock exclusively on *Prosopis* pods for extended periods, due to lack of pasture in the invaded areas, has resulted in health problems to animals such as constipation, dental disfiguration and reduced overall productivity.

People and livestock suffer from injuries from the sharp and poisonous *Prosopis* thorns. With the decline of grazing and cultivable land, coupled with recurrent droughts, people in the Afar region became highly food insecure and dependent on government food aid for survival. In highly invaded areas, people now rely on food aid for 5-6 months in good years and for up to 10 months in the drought years. As a coping strategy, households have had to diversify their livelihood base to better cope with food insecurity. Alternative livelihoods include charcoal production and sales.

Source: Admasu 2008

In Egypt, about 487 sq. km is covered by the water hyacinth (*Eichhornia Crassipes*), resulting in the loss of 3 500 million cubic m/annum of water through transpiration, an amount sufficient to irrigate 432 sq. km annually (EEAA 2007).

African forest biodiversity is under threat from alien invasive species such as Tick berry (*Lantana camara*), Coypu rat (*Myocastor coypus*), Speckled mousebird (*Colius striatus*), Ring-necked pheasant (*Phasianus colchicus*) and Mute swan (*Cygnus olor*), Mathenge (*Velvet mesquite*) (*Prosopis juliflora*), Mauritius thorn (*Caesalpinia decapelata*) and Senna spectabilis. Others include Striga which reduces cereal yields and Cybopogon nardus that diminishes the productivity of grazing lands. Other invasive species of economic importance in Africa include *Acacia hockii, Mimosa pigra, Chromolaena odorata* among others. Kenya has documented 34 invasive alien animal and plant species (Kedera and Kuria 2005), while in Ethiopia *Prosopis juliflora* is a major invasive plant. Some of the invasive species that pose a threat to Africa's biodiversity are enumerated in Box 3.6 while the impacts of the colonization of *Prosopis juliflora* are discussed in Box 3.7.

The Irish potato famine of the 1840s, caused by a fungus introduced from North America, had devastating impacts on the health of the local people (McNeely and others 2001), and is probably one of the earliest examples of the health impacts of invasive species on human livelihood. In Africa, rinderpest, a viral disease, was introduced in the 1890s via infected cattle, and it subsequently spread into both domesticated and

Box 3.8: *Lantana camara* and human health

Besides cattle, *Lantana camara* also affects horses, sheep, goats, and rabbits (Morton 1994). Cooper (2007) also observed that *Lantana camara* poisoned ostriches at a farm on the outskirts of Harare, Zimbabwe. If the plant is ingested in sufficiently large amounts it causes photosensitization and liver damage. It also causes the accumulation of phylloerythrin in the blood, which sensitizes the animal's skin to ultra-violent light. It severely affects the nasal and facial areas, where the skin peels away leaving these areas reddish and inflamed. Due to this, these areas are susceptible to secondary bacterial infections. In South Africa, *Lantana camara* is one of the top 10 most invasive alien plant species (Le Maitre and others 2000).

While Lantana camara negatively affects the livestock protein base, especially for pastoral communities, the plant is also widely used as a herbal medicine in East Africa. It also has other uses such as providing a source of firewood, mulch, making hedges, and use as a source of microbicides, fungicides, nematicides and insecticides (Jimenez-Arellanes and others 2003 in Kirimuhuzya and others 2009). In Uganda, the leaves of *Lantana camara* are chewed with salt and the extract swallowed for treatment of cancers, asthma, high blood pressure, fevers and malaria. Extracted Lantana oil is used as an ointment for the treatment of skin itches, including chicken pox, measles, eczema, leprosy and scabies as well as an antiseptic for external wounds (Jimenez-Arellanes and others 2003 in Kirimuhuzya and others 2009).

Source: Compiled from the publications cited above

wild herds of bovids throughout the savannah regions of Africa, affecting about 25 per cent of cattle-dependent pastoralists some of whom may have starved to death in the early 20th century (McNeely and others 2001). Recently, the Nile perch (*Lates niloticus*) was intentionally introduced into Lake Victoria for economic reasons, but has led to the extinction of some species of cichlid fish that were endemic to the lake. It has also caused deforestation around the lake as a lot of firewood is needed to dry the oily perch. This in turn leads to siltation and eutrophication, adding additional pressure to the productivity of the lake, which is also infested with the invasive water hyacinth (Lowe and others 2000). While the Nile perch catches from Lake Victoria generate up to US$400 million per year in export income, few of these economic benefits trickle down to the local people living around the lake (Revenga and others 2000 in Kadigi and others 2007).

According to UNEP (2006), invasive alien species affect agriculture and livestock production systems, potentially threatening food security. For example, weeds affect the productive capacity and increase agricultural labour time, while some invasive alien species such as Lantana camara transform succulent grasslands into poisonous fodder (IUCN/SSC/ISSG 2004). Agricultural and grazing land are also threatened by rapidly growing species of plants such as *Parthenium hysterophorus* (congress weed), which spreads quickly and is not only allelopathic (Patel 2011), but also unpalatable to livestock, as is detailed in Box 3.8.

Conserving biodiversity for human health benefits

Stemming degradation of biodiversity requires taking actions that motivate communities whose health and incomes are highly dependent on these resources to engage in their sustainable use and conservation. Two main actions in this regard are improved access to biodiversity resources that are basic to meeting their health and income needs and fair sharing of the benefits that accrue from conservation. Protection of biodiversity is also key to helping Africa tap into the opportunities

provided through bio-prospecting, biotechnology, and climate change mitigation.

Community Based Natural Resources Management (CBNRM), which is practised across the region, has demonstrated some benefits such as community empowerment, and economic and environmental rewards (Binot and others 2009 in Roe and others 2009). For example, in the Luangwa Valley in Zambia, Dalal-Clayton and Child 2003 (in Roe and others 2009) noted tangible benefits that included organizational capacity and empowerment effects created by the process of revenue distribution. These involved regular elections, managing bank accounts, carrying out regular audits, and a high level of participation in decision-making by villagers. In the United Republic of Tanzania, the village council budget of Ololosokwan village, Ngorongoro District, increased from US$ 2500 in 1995-1997to US$ 60 000in 2003 through development of village-based private sector tourism initiatives (Nelson and Ole Makko 2005in Roe and others 2009). This resulted in a greater capacity of the village to invest in social services and provide local benefits to village residents (Binot and others 2009 in Roe and others 2009), including health. In West Africa, CBNRM led to decentralization and gave power to locals, and this protected community borders from outside resource use and economic immigration (Stamm 2000 in Roe and others 2009) and susceptibility to communicable diseases.

However, deriving health and income benefits from CBNRM initiatives requires paying special attention to some of the factors that have undermined the flow and sharing of these benefits. For example, in Botswana, there have been instances of local trusts mismanaging revenue from wildlife-based enterprises, which Rihoy and Maguranyanga (2007) attribute to the lack of long-term investment in building local capacity. In Kenya, pastoralist group ranches failed as collective resource governance institutions, leading communities to individualize formerly communal pastures and seek new, generally smaller collective landholding arrangements (Mwangi 2007 in Roe and others 2009). In West Africa, mapping and enforcing community boundaries for land registration were not supported by the national infrastructure for implementing decentralization policy, and this caused confusion to an already pluralistic system and potentially further weakened traditional community management. This was also the case in Cote d'Ivoire (Stamm 2000 in Roe and others 2009) and Gabon (Starkey 2004 in Roe and others 2009).

Through its biodiversity, Africa's role in climate change mitigation is gaining prominence, with locals deriving value for their efforts in conservation. Importantly, there is a growing recognition that some forest resources have higher value when used for climate change mitigation than other purposes. For example, Cameroon's forests are estimated to provide about US$560 per hectare per year through timber; US$61 for woodfuel and between US$41 and US$70 for non-timber forest products. A much higher value, estimated between US$ 842 and US$ 2 265 per hectare per year is derived through the contribution of Cameroon's forests to climate regulation (Lescuyer 2007). This yields double benefits in terms of continued access to biodiversity resources that promote health and, averted climate-related diseases.

With its vast biodiversity resource base, Africa provides opportunities for bio-prospecting. Central to bio-prospecting in Africa is the recognition of indigenous knowledge systems, and the need to dispel mistrust and suspicion among knowledge holders, bio-prospectors and the private sector. In a globalizing economy, Africa's biological resources continue to be attractive to the world market, with medicinal plants being of particular interest due to the growing desire for natural products in the industrialized world (Rutert and others 2011).

Unless urgent measures are taken to stem the decline of biodiversity, African countries may not meet internationally agreed goals and targets on its conservation. The application of available knowledge and technologies, enforcement of current biodiversity policies, and implementation of conservation strategies and agendas should be more effective. The protection of conservation areas will require adequate enforcement. Of great importance to this will be long-term public education on the importance of biodiversity. Especially important will be teaching the next generation the complexities of ecosystem services, ecological footprints and how biodiversity enhance human health.

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4

Chemicals and Wastes

Chemicals and wastes in Africa

Chemicals are used in everyday life, playing a central role in health, agriculture, infrastructure, mining, education, research and industrial processes. These chemicals include pesticides, persistent organic pollutants (POPs), mercury and lead. An estimated 248 000 chemicals are in commercial production (CAS 2011) and account for a global chemical industry that is worth US$ 4.1 trillion each year (UNEP 2013a). 45 per cent of these chemicals are traded internationally (Perenius 2009). Africa's share in this industry is 1.7 per cent for imports and 0.7 per cent for exports (Perenius 2009). Between 1997 and 2007, chemical sales in the region grew at an annual rate of 3.4 per cent per year (Perenius 2009). The use of chemicals has contributed to improvements in agriculture, health and manufacturing, and is a major source of employment. However, the growth of the chemical industry in Africa poses challenges related to production, transportation, storage, use and disposal.

A related challenge for Africa is the growing problem of wastes, including municipal and electronic wastes (e-waste). According to Schwarzer and others 2005 (in UNEP 2012), e-waste is a major environmental challenge of the 21st century, as 20–50 million tonnes of this category of waste is generated globally each year. Africa has the added challenge of poor waste management and illegal dumping of toxic wastes, and accumulation of obsolete pesticides.

A child standing in a trash pile in Burkina Faso

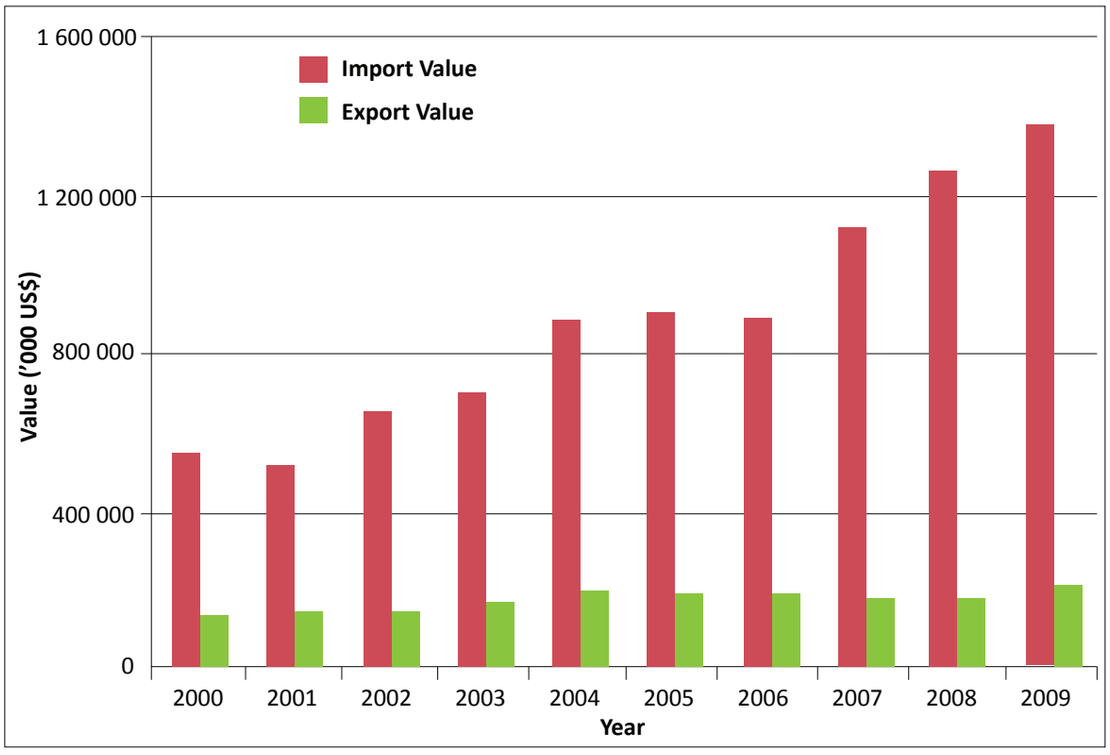
Marco Bellucci / Foter / CC BY

Health linkages of chemicals and wastes

With a growing population, Africa will in the foreseeable future be in urgent need of increasing agricultural production and accelerated industrial development. This trend is likely to necessitate more use of chemicals especially fertilizers and pesticides to promote food security and pest and disease control (UNEP 2006). The increased prevalence of insect-borne diseases such as malaria, in the era of climate change will also require greater use of chemicals (UNECA 2009). In addition, the observed trend in urbanization across the region is likely to contribute to increased consumption of industrially manufactured goods, with a greater consumption of household chemicals and increased generation of waste (UNECA 2009).

Chemical pollution and poor waste management are serious threats to human health and ecosystem integrity. Global estimates indicate that three per cent of agricultural workers suffer from acute pesticide poisoning every year (EJF undated), while 90 per cent of water and fish samples from aquatic environments are contaminated by pesticides (UNEP 2012). Chemical pollutants are released into the environment through various pathways, including discharges, spillages, leakages and runoffs. These often lead to contamination of groundwater, surface water and the soil. Chemicals are also emitted into the air through combustion and waste incineration.

Figure 4.1 Value (US $ '000) of pesticides imported and exported from Africa, 2000-2009



Source: FAO 2012

Chemicals and health

Agrochemicals

Agrochemicals used in Africa are of different varieties, including fertilizers, and pesticides such as insecticides, herbicides, acaricides, fungicides, rodenticides, nematicides and avicides. In addition, there are other pesticides that are used for non-agricultural uses such as turf and ornaments in public health and in houses.

The global pesticide industry is worth over US$30 billion per year, and Africa accounts for about 4 per cent of this trade (IAMC 2007). This amounts to about 75 000-100 000 tonnes of pesticide active ingredients used per year on the continent compared to around 350 000 tones in Europe. Even compared with other developing countries, average pesticide use per hectare of cultivated land in Africa is very low, where it is estimated at 1.23kg per hectare, compared with 7.17kg and 3.12kg for Latin America and Asia, respectively (PAN undated). According to Figure 4.1 the value of pesticides imported into Africa over the period 2000-2009 increased. For example, in the United Republic of Tanzania, between 2000 and 2003, pesticides imports increased from 500 to 2500 tonnes per year. However, due to unfavourable weather conditions, not all of the pesticides were used, worsening the stockpiles problem (PAN 2006).

Agro-pesticides

In Africa, the likelihood for contact with pesticides is very high given poor handling and lack of training. In addition, although the use of pesticides in the region is relatively low, it is growing among the large proportion of people who depend on agriculture. In Mali, for instance, out of a population of 13 million, about 70-80 per cent lives in rural areas and depends on agriculture. About a fifth of the population is dependent on cotton and this is the crop where pesticide use is highest (PAN AP 2010).

Pesticides can cause undesirable side effects on workers, consumers, community health workers

Table 4.1: Pesticides poisoning in selected countries in Africa

Country	Example of pesticide poisoning
Togo	More than 500 cases of poisonings linked to endosulfan have been recorded each year by the Toxicology Division of the Public Hospital of Lome-Tokoin (Kodjo 2007).
Ivory Coast	The National Centre for Agronomical Research in Abidjan estimates that 65% of the illnesses suffered by market gardeners, the cotton growers, mango producers, as well as consumers in Ivory Coast, are due to pesticides (Hala, Kehe, 2009).
Morocco	2 609 cases of poisoning recorded at the Moroccan Anti-Poison Centre over the period 1992-2007 (Rhalem et al. 2009).
Mali	In 2000, the FAO estimated that acute pesticide poisoning affected 329 people a year with 30-210 deaths and from 1 150-1 980 chronic poisonings (FAO/CILSS 2000).
Burkina Faso	100 producers spraying cotton crops in the area of Gourma, experienced severe headaches (92%), dizziness (83%), trembling hands (54%), nausea or vomiting (21%), troubled vision (21%), excessive sweating (13%), blackouts (8%) and hypersalivation (8%). The 2006 study found that the most serious incidents (13%) occurred during pesticide use and other symptoms occurred hours or days after use. The pesticide responsible was not positively identified, but was most likely endosulfan. (Glin et al. 2006)
Kenya	350 000 people (7 per cent of people in agricultural sector) suffer pesticide poisoning every year (Saoke 2005); and in 1985 the major hospitals treated on average 2 cases of pesticide poisoning each week; in 1996, the Kenyan Ministry of Health estimated that 700 died due to pesticide poisoning (Shivoga undated).

Source: PAN AP 2010

and safety, groundwater, surface waters, and non-target wildlife organisms. Some pesticides persist and accumulate in food chains that are far from the original point of use. They may also cause reproductive failure and endocrine system abnormalities in both wildlife and humans and other species that are not their intended target. (Department of Agriculture and Fisheries South Africa 2010).

Symptoms of exposure to pesticides includes headaches, dizziness and staggering, blurred vision, excessive sweating, nausea, diarrhoea, insomnia, skin irritation, hand tremors, excessive salivation, narrowed pupils, palpitations and convulsions. There is a network of Poisons Information Centres that is supported by the World Health Organization (WHO). These have been set up to provide expert information on treatment of suspected poisoning and antidotes for health workers. There are only seven of these poison centres in Africa. These are in Algeria, Egypt, Ghana, Kenya, Senegal, South Africa and Zimbabwe. Table 4.1 highlights some examples of pesticide poisoning in selected countries in Africa. Box 4.1 highlights one of the high risk sectors, the flower industry.

Workers at a flower farm

Box 4.1: Pesticide use in the flower industry in Naivasha, Kenya

Flowers make up a major part of Kenya's horticultural industry. It is the fastest growing sector of the economy with growth in recent years estimated at between 12-15 per cent per annum. Kenya is Africa's leading exporter of cut flowers and the sixth in the world. Kenya controls about 60 per cent of the African flower trade with most of its exports going to the European market. For example, approximately 25 per cent of flowers imported into the EU come from Kenya. It is a US$200 million/year business employing about 2 million people directly and indirectly. About 500 000 people (50 000 flower farm workers and their dependents) gain their livelihoods from the flower industry directly. Most of the workers are young and 75 per cent are women.

Export volume and value 1980 – 2009 selected years

Year	Volume	Value (USD)
1980	7 422.00	3
1985	10 000.00	5
1990	14 425.00	11
1995	29 374.00	43
1996	35 212.00	51
1997	35 853.00	58
1998	30 221.00	57
1999	36 992.00	85
2000	38 757.00	102
2001	41 396.00	125
2002	52 106.00	174
2003	60 982 885.36	194
2004	70 666 260.72	220
2005	81 217 831.59	269
2006	86 480 002.13	278
2007	91 192 726.00	499
2008	118 626 644.00	404
2009	120 394 968.00	436

*The decline in 2009 was due to the drought and EU recession

Flower production is done on 2 000 ha of land, mostly around Lake Naivasha which is part of the Great Rift Valley and has increased over the years as shown in the table. Even though Lake Naivasha is designated as a Ramsar site, it is shrinking and its southern shores are devastated with an algal bloom, there is excessive abstraction of water for irrigation, industrial and domestic use, pollution from pesticides and fertilizers run-off, and change in fish species from predominantly Tilapia to Common Carp.

Some of the occupational risks include the fact that more than 100 chemicals are used in the cut flowers industry. Some of these chemicals such as methyl bromide is banned, but continues to be used in Kenya because of market demands for aesthetic perfection and also because of ineffective regulation in the country. For instance although the Kenya Flower Council developed a Code of Practice for its members, it has no specific policy to phase out the use of methyl bromide. It is estimated that Kenya uses 5 per cent of its foreign exchange earnings on the importation of this chemical.

The Kenya Flower Council Code on Pesticides says that members will:

- Provide protective clothing to workers spraying pesticides and ensure that this is worn
- Reduce pesticide use through good practices such as regular crop inspection, scouting to determine pest levels rather than calendar spraying, trapping pests and use of rotations
- Under no circumstances use products banned in Kenya, and will use only pesticides which are registered in the country
- Only in justified circumstances use pesticides categorized by the World Health Organization as 'extremely' and 'highly' hazardous
- Avoid reliance on continued use of a single chemical so as to minimize pest resistance.

Production of flowers is mainly in greenhouses. As such, workers are exposed to chemicals when transplanting, pruning, cutting, packing, spraying/fumigation and dusting. There is also the reuse of discarded pesticide-saturated greenhouse plastic for domestic purposes such as covering houses. Exposure is increased because protective clothing is not provided to those workers handling chemicals; non observance of recommended greenhouse re-entry periods after fumigation; exposure of pregnant women to chemicals (mothers breast-feed their babies before washing or changing farm clothes) low awareness among workers about the risks and a lack of disclosure by medical personnel.

Sources: Shivoga 2009; McGill 2011; and Kargbo and others 2010

Box 4.2: Chemical safety amongst farmers in Africa: Impacts on health and incomes

The manner in which chemicals are handled in Africa is a matter of concern. Some of the issues include poor storage, application and disposal; and lack of protective equipment. For example in Senegal, only 44 per cent of cotton farmers and 14 per cent of vegetable farmers use protective clothing when spraying insecticides. Most ill health episodes are felt after spraying with insecticide. Symptoms include migraine, stomach upsets, skin and eye irritation, sore throats, coughing and general weakness.

Even those who do not directly handle pesticides are affected. It is not unusual for children to play with pesticides; or for chemicals to be mistaken for other products; or to be used inappropriately such as for treating head lice or ticks. In Benin, children under 10 years old made up 20-30 per cent of poisoning cases recorded between 2000 and 2001. In Ethiopia, pesticides are almost solely sprayed by men. But the Amhara Regional Health Bureau in 2001 reported that women made up 51 per cent of the cases of pesticide poisoning.

There are health, livelihood and income implications of exposure to chemicals. Where fatal poisonings occur, livelihoods are negatively impacted. In the case of recurrent ill health, the drain on the income of farming households, as well as time off work and lost productivity can be severe. Cases of fatal poisoning have also resulted from contaminated food or where empty pesticide containers have been re-used. In Benin, for example, deaths from contaminated food and from the domestic re-use of empty containers accounts for 57 and 86 per cent of all cases of fatal poisonings respectively. The average time off work for farmers in Ghana and Benin is 15-20 days per season and it is estimated that this recurring ill health translates into losses of about US $90 per household. Furthermore, malnutrition, poor sanitation and widespread infectious diseases, including malaria and HIV/AIDS, all combine to make them more vulnerable to the impacts of pesticide exposure.

Source: PAN undated

Cocoa bean, Ghana

dotguy_az / Foter / CC BY NC

The populations most vulnerable to exposure to agricultural pesticides include workers on farms and their families. But the impacts are not confined to large scale commercial farms, but equally impact the local small scale farmers; especially given that many cash crops such as cotton, coffee, cocoa, oil palm, and vegetables are sustained by small out-grower schemes. There are various pathways (indoors and outdoors) through which exposure can occur with food and drinking water being the important routes. The impacts of exposure leading to illness can have a substantial impact on incomes due to time off work and lost productivity. For instance farming households in Ghana and Benin have been estimated to lose up to US $90 per household each growing season due to pesticide exposure (PAN undated). Box 4.2 highlights the issue amongst farmers in Africa.

Fertilizers

The single largest threat to Africa's agricultural sector and food security is declining soil fertility. Indeed reports have indicated that this decline was approaching crisis dimensions, fuelled by the disappearance of fallow land, deforestation, land degradation and low soil nutrient levels (UNDP 2012).

The inability of farmers to intensify agricultural production in a manner that maintains soil productivity is viewed as a key driver of all these problems. Improvements in soil fertility are needed

to stimulate agricultural productivity, improved food security, and increases in rural incomes. These will require substantial investment in fertilizer use (both organic and inorganic) in combination with improved land management practices.

The average intensity of fertilizer use throughout Sub-Saharan Africa (SSA) remains much lower than elsewhere (roughly 9 kg/ha versus 86 kg/ha in Latin America, 104 kg/ha in South Asia, and 142 kg/ha in Southeast Asia) and has been virtually stagnant during the past decade (Crawford and others 2005). The low fertilizer usage explains the comparatively low maize yields of 1.7 tonnes per hectare relative to the global average of 5 tonnes per hectare (FARA 2009). The 2006 Abuja Declaration on Fertilizer for African Green Revolution resolved to accelerate access of farmers to both inorganic and organic fertilizers. It proposed to increase the amounts of fertilizer used to about 50 kg per hectare by 2015 (NEPAD 2006).

Although agricultural yields may increase, the chemicals in fertilizers can have adverse health impacts. For example, water with high concentrations of nitrites and nitrates can result in blue-baby syndrome or cause miscarriages in pregnant women (Criss and Davisson 2004). Fertilizers that contain heavy metal contaminants such as uranium, lead, mercury and cadmium, arsenic, chromium (Jiao and others 2012) are associated with negative health effects.

Persistent Organic Pollutants (POPs)

Persistent Organic Pollutants or POPs, as they are frequently known, are chemicals that have properties that allow them to spread over a long range and to persist in the environment. POPs include a wide range of chemicals, but most attention is focused on 12 chemical classes that include the industrial PCBs, polychlorinated dioxins and furans (unwanted by-products of various industrial processes), and the pesticides DDT, aldrin, chlordane, dieldrin, endrin, heptachlor HCB, mirex, and toxaphene. POPs bio-magnify and bio-concentrate under normal environmental conditions and can thus reach toxic concentrations (Ritter and others 1995).

Many POPs are still manufactured in some developed nations for export and remain widely used in developing countries even though their use is restricted or banned in most developed countries. A number of African countries still use some of these substances. For example, although Endosulfan is banned, it is still used in Benin (Badarou and Coppieters 2009 in PAN AP 2010; Agbohessi and others 2013); while polychlorinated biphenyls (PCBs), chlordane and DDT are still in use in Zambia (Mundiaand Mwangala 2005). Furadan is also still widely used in many countries with adverse human health and biodiversity implications.

A number of POPs have been implicated in a range of adverse human health and environmental effects including cancer, impaired reproduction, immune-system suppression and endocrine dysfunction. Examples include toxaphene (UNEP Chemicals 2002) and endosulfan (IPEN 2004) which have been identified as carcinogenic in humans; and chlordane which shows evidence of being an endocrine disruptor (UNEP Chemicals 2002).

Dichlorodiphenyltrichloroethane (DDT) is a POP commonly used in Africa for the control of the vectors of malaria, a leading cause of illness in Africa. The statistics indicate that of the 216 million estimated cases of malaria in 2010, 81 per cent (175 million cases) occurred in Africa (WHO 2011a). A global prohibition on the use of DDT came into force under the Stockholm Convention on Persistent Organic Pollutants in 2004. By this time, its persistence in the environment, growing resistance amongst target species and effects on human health were of grave concern. Its continued use was allowed in the control of malaria-causing mosquitoes. DDT remains the most effective and low-cost prevention against mosquito-borne malaria (Lubick 2010). In 2010, 73 countries,

Table 4.2: Annual use of DDT in selected African countries (in 10^3 kg of active ingredient)

Country	2003	2005	2007	Comment
Cameroon	0	0	0	Plan to pilot in 2009
Eritrea	13	15	15	Epidemic-prone areas
Ethiopia	272	398	371	Epidemic-prone areas
Gambia, The	0	0	NA	Reintroduction in 2008
Madagascar	45	0	0	Plan to resume use in 2009
Malawi	0	0	0	Plan to pilot in 2009
Mauritius	1	1	<1	To prevent malaria introduction
Morocco	1	1	0	For occasional outbreaks
Mozambique	0	308	NA	Reintroduction in 2005
Namibia	40	40	40	Long-term use
South Africa	54	62	66	Reintroduction in 2000
Sudan	75	NA	0	No recent use reported
Swaziland	NA	8	8	Long-term use
Uganda	0	0	NA	High court prohibited use in 2008
Zambia	7	26	22	Reintroduction in 2000
Zimbabwe	0	108	12	Reintroduction in 2004

NA = not available.
Adapted from van den Berg 2009.

including 36 in the African region, recommended indoor residual sprays for malaria control and 13 countries reported using DDT for indoor residual sprays (WHO 2011a). Table 4.2 shows the annual use of DDT in Africa.

Exposure to DDT has been linked to a number of health problems. Ignorance, poverty and weak environmental legislation compound the problem. For example, it has been associated with a variety of urogenital deformities in male babies born in an area of South Africa where DDT is still used (BJU International 2009 in Lubick 2010). In Ethiopia, DDT and other chemicals are sometimes used as 'home remedies' to treat head lice, fleas and bedbugs, and even cure open wounds, sometimes with fatal consequences (PAN undated).

But apart from the harmful effects on humans and the environment, the use of these chemicals can also negatively impact the economy. For instance, between 1997 and 2000, Europe imposed a ban on imports of fish products from the Lake Victoria region due to elevated insecticide residues. As a result, in early 2003, the Kenyan Minister of Environment and Natural Resources banned the use of DDT (PAN-Germany 2010). Integrated Vector Management (IVM)has been adopted by many African countries and is promoted by WHO as one of the strategies of reducing dependence on DDT and other toxic chemicals for disease vector control (Box 4.3).

One of the goals of the Stockholm Convention is to eliminate the use of DDT. Parties that request exemption to use DDT must actively promote research and development of safer and affordable alternatives. There are thus opportunities through research for the development of ecologically-friendly alternatives to DDT.

The existing alternatives to DDT such as the organophosphates, carbamates and pyrethroids are more expensive and shorter-lived. To an extent, this contributes to the continued use of DDT. Pyrethrins, being organic products, are currently considered the safest alternatives

A canister of DDT

Jonas B / Foter / CC BY

Box 4.3: Integrated Vector Management (IVM)

New strategies for prevention and control of vector-borne diseases are emphasizing 'Integrated Vector Management' (IVM) as an approach that reinforces linkages between health and environment, and optimizes benefits to both. IVM is an integrated strategy that, by combining many different methods and resources, aims to be more efficient and effective at vector control thus reducing dependence on DDT.

Malaria, the most deadly vector borne disease, kills over 1.2 million people annually, mostly African children under the age of five. Dengue fever, together with associated dengue haemorrhagic fever (DHF), is the world's fastest growing vector borne disease. IVM strategies are designed to achieve the greatest disease control benefit in the most cost-effective manner, while minimizing negative impacts on ecosystems and adverse side-effects on public health from the excessive use of chemicals in vector control.

Rather than relying on a single method of vector control, IVM stresses the importance of first understanding the local vector ecology and local patterns of disease transmission, and then choosing the appropriate vector control tools, from the range of options available. These include environmental management strategies that can reduce or eliminate vector breeding grounds altogether through improved design or operation of water resources development projects as well as use of biological controls (for example, bacterial larvicides and larvivorous fish) that target and kill vector larvae without generating the ecological impacts of chemical use. At the same time, when other measures are ineffective or not cost-effective, IVM makes judicious use of chemical methods of vector control, such as indoor residual sprays, space spraying, and use of chemical larvicides and adulticides; these reduce disease transmission by shortening or interrupting the lifespan of vectors.

IVM provides a framework for improved personal protection/preventive strategies that combine environmental management and chemical tools for new synergies; e.g. insecticide-treated nets (ITNs). Trials using insecticide-treated bed nets in some malaria-endemic African countries have shown very substantial reductions in child and infant mortality. IVM also supports effective, accessible and affordable disease diagnosis and treatment within the framework of a multi-disease control approach.

IVM requires a multi-sectoral approach to vector-borne disease control. For instance Health Impact Assessments of new infrastructure development, such as water resource, irrigation and agriculture, can help to identify potential impacts of major policy decisions on vector-borne disease upstream so that effective action can be taken.

Source: WHO 2011c

to DDT. Development of new more effective pyrethrins is on-going. For example, the Pyrethrum Board of Kenya has recently produced pylarvex, pymos and pynet to be used to control malaria vectors. The residual action of some second generation pyrethroids such as lambda-cyhalothrin seems not to be as effective as originally thought (UNEP 2010a). Despite this, there have been some successes with their use as part of an IVM strategy.

Lambda cyhalothrinis, a second generation pyrethroid with extended residual control which has been used in countries such as Kenya, Mali, Mozambique, Rwanda, the United Republic of Tanzania and Uganda. Zanzibar's Malaria Control Programme, supplemented their indoor residual spraying programme with ICON (lambda cyhalothrin) in 2006, in combination with other methods, and succeeded in reducing the malaria burden. In 2002, malaria prevalence was 39 per cent, now it is below 1 per cent. Zanzibar is now at the pre-elimination stage of malaria (PAN-Germany 2010). But no matter how safe they are stated to be, they are still pesticides and are thus likely to pose hazards to human health and the environment. Furthermore, their efficacy is eventually compromised by the development of

Table 4.3 Hazards associated with some of the pesticides recommended for malaria control

WHO recommended pesticides	Reasons for listing at PAN International List of Highly Hazardous Pesticides
Alpha-cypermethrin (pyrethroid)	• Highly toxic to bees – affects food security
Bendiocarb (carbamate)	• Highly toxic to bees
Bifenthrin (pyrethroid)	• Highly toxic to bees • US EPA: Possible human carcinogen • EU: At least one study providing evidence of endocrine disruption in an intact organism • Highly bioaccumulative • Very persistent in water/sediment
Cyfluthrin (pyrethroid)	• Highly toxic to bees
Deltamethrin (pyrethroid)	• Highly toxic to bees • EU: At least one study providing evidence of endocrine disruption in an intact organism
DDT (organochlorine)	• EU: At least one study providing evidence of endocrine disruption in an intact organism • US EPA: Probable human carcinogen • IARC: Possibly carcinogenic to humans • EU (Directive 67/548): Substance which causes concern for humans owing to possible carcinogenic effects • POP pesticide • PIC pesticide
Entofenprox (pyrethroid)	• Highly toxic to bees
Fenitrothion (organophosphate)	• Highly toxic to bees • EU: At least one study providing evidence of endocrine disruption in an intact organism
Lambda-cyhalothrin (pyrethroid)	• Highly toxic to bees • EU: At least one study providing evidence of endocrine disruption in an intact organism • EU: (Directive 67/548) – very toxic by inhalation
Malathion (organophosphate	• Highly toxic to bees • US EPA: suggestive evidence of carconogenicity • EU: Potential for endocrine disruption (ED), in vitro data indicating potential for endocrine disruption in intact organisms, also includes effects in vivo that may or may not be ED-mediated, may include structural analyses and metabolic considerations
Pirimiphos-methyl (organophosphate)	• Not listed as highlight hazardous pesticide according to PAN International
Propoxur (carbamate)	• US EPA – Probably human carcinogen

Source: PAN-Germany 2010

vector resistance, vector behavioural adaptations as well as logistical and funding problems.

WHO has compiled a list of recommended pesticides to use for indoor residual spraying and insecticide treated nets to control malaria. However, PAN has cautioned of the environmental hazards of some of these (PAN-Germany 2010), as shown in Table 4.3.

While Africa is yet to phase out DDT, the region is further challenged by the need to find alternatives to the recent additions to the POPs. The Stockholm Convention provides a comprehensive scientific process through which extra chemicals with POP-like characteristics can be added to the treaty. Five chemicals have recently been added to the list by the Persistent Organic Pollutants Review Committee

Table 4.4: The 'New' POPs and their health and environmental impacts

Cluster	Name of POP	Health and environment impact	Use	Exposure
Brominated Flame Retardants	Pentabromodiphenyl ether (Penta BDE)	It alters thyroid hormone levels in mammals and affects learning in mince. It may also adversely affect the immune system. It is a widespread contaminant in wildlife.	Used mainly in polyurethane foam filled furniture and car interiors, cot mattresses and in the production of packaging.	It is widespread in the global environment. Potential exposure through food, and through use of products and contact with indoor air and dust.
	Octabromodiphenyl ether (OctaBDE)	It is toxic for reproduction and a possible developmental neurotoxicant in mice.	Octa-BDE is used as an additive in polymers for use in plastic housings for office equipment and business machines	Mainly through food.
	Hexabromobiphenyl	Hepatotoxicity, effects on the thyroid, and endocrine disruption including effects on reproductive capacity in rats, mink and monkeys. Evidence of hypothyroidism in workers exposed to polybrominated biphenyls and increased incidence of breast cancer in exposed women.	Hexabromobiphenyl (HBB) is an industrial chemical that was used as a flame retardant, mainly in the 1970s.	Concentrations are confined to areas near former manufacturing facilities
Perfluoro-chemicals	Perfluorooctane sulfonate (PFOS)	Toxic to bees and studies in rats and monkeys raise serious concerns. Linked to various cancers in humans.	The current intentional use of PFOS is widespread and found in products such as in electric and electronic parts, fire fighting foam, cleaning products, commercial and consumer floor polishes, photo imaging, hydraulic fluids and textiles.	High concentrations have been found in Arctic animals, far from anthropogenic sources.
Pesticides, Insecticides, Biocides, Fungicides	Chlordecone	Highly toxic to aquatic algae and invertebrate species. In mammals causes reproductive impairment, liver damage, and neurological symptoms. It is carcinogenic. Their ability to kill unwanted organisms also has the potential to harm wildlife and people.	Majorly used as an agricultural pesticide. Pesticide formerly used on banana root borer, fly larvicide, apple scab, powdery mildew, Colorado potato beetle, rust mite, wireworm, and household ant and roach traps. The insecticide chlordecone (Kepone) has already been banned in many countries.	
	Alpha and Beta hexachlorocyclohexane	Alpha-HCH has been shown to be neurotoxic, hepatotoxic, and to cause immunosuppressive effects and cancer in laboratory animals. Possible carcinogen. Beta-HCH has similar effects and also fertility, reproductive and immunosuppressive effects.	Although the intentional use of alpha- and beta-HCH as an insecticide was phased out years ago, these chemicals are still produced as an unintentional by-product of lindane.	Human exposure to alpha-HCH mainly from ingestion of contaminated plants, animals and animal products. Human exposure to beta-HCH mainly from ingestion of contaminated plants, animals and animal products. High exposure in contaminated areas due to extensive use, former production, disposal sites and stockpiles.
	Lindane	Lindane is neurotoxic and can adversely affect reproduction, the liver, and the immune system. It is highly toxic to fish, bees and aquatic invertebrates.	Lindane was used as a broad-spectrum insecticide for seed and soil treatment, foliar applications, tree and wood treatment and against ectoparasites in both veterinary and human treatments.	Found in air, water, soil sediment, aquatic and terrestrial organisms and food worldwide. Passes through the placental barrier. Direct exposure from the use of pharmaceutical products for scabies and lice treatment. Exposure from high animal lipid content diets. Occupational exposure at manufacturing facilities.
Other chlorinated chemicals or groups	Pentachlorobenzene	Highly toxic and is a possible carcinogen. Affect the immune and endocrine systems It can be released from waste incinerators where it is produced during the combustion of plastics and chlorinated waste	Used as a biocide and wood preservative. Also used in PCB products, dyestuff carriers, as a fungicide, a flame retardant. It is also produced unintentionally during combustion in thermal and industrial processes. It appears as an impurity in products such as solvents or pesticides.	PeCB has been detected in breast milk and found to accumulate in human Placenta. Occupational exposure. Found in some arctic marine animals such as polar bears, seals, whales and arctic foxes.

Source: WWF 2005

(POPRC). These include Pentabromodiphenyl ether (Penta BDE), Octabromodiphenyl ether (OctaBDE), Perfluorooctane sulfonate (PFOS), Pentachlorobenzene, Chlordecone, Hexabromobiphenyl, Lindane, and Alpha and Beta hexachlorocyclohexane (IPEN 2009). Table 4.4 lists the use of the chemicals, their health and environmental impacts and major routes of exposure.

Box 4.4: What are obsolete pesticides?

Obsolete pesticides are pesticides that can no longer be used for their intended purpose or any other purpose, have become hazardous waste and require safe destruction. They include:

- Pesticides and technical formulations well below their original specification
- Banned pesticides
- Damaged and degraded products
- Unwanted formulations and packages
- Contaminated empty containers and application equipment
- Buried pesticides and containers, and
- Heavily contaminated soils

Source: ASP 2010

Chemical stockpiles

Toxic chemical stockpiles and wastes, including, persistent organic pollutants (POPs) and obsolete pesticide stocks, are of major concern to Africa, threatening human health and ecosystems (BAN 2001). Africa has more than 27 300 tonnes of obsolete pesticides, the disposal of which will cost the region US$ 82-137 million (FAO 2012 in UNEP 2012). For example, hazardous waste is often mixed with municipal or solid wastes and then either dumped or burned in the open air (UN-Habitat 2010 in UNEP 2012).

Obsolete pesticides, which are defined in Box 4.4 are found all over Africa, mostly in aged containers that leak into the soil and water (World Bank 2010). The last 40 years have seen the buildup of obsolete pesticides estimated at over 50 000 tonnes, with large areas of land getting contaminated (ASP 2010).

The chemical stockpiles problem has been aggravated by the advent of new generation insecticides, unsuitable products, inadequate capacity of governments to procure appropriate pesticides, dumping of expired pesticides and lack of institutional capacity to detect this and, handling, storage and disposal. Inappropriate donation of pesticides by some donor agencies has also been blamed for the accumulation. In many countries, storage sites that were once located far from residential areas are now surrounded by fast-growing urban communities. Wherever these pesticides are stored, they can pose serious threats to the health of both rural and urban populations. Much of this population consists of vulnerable segments such as children, pregnant women or the elderly. For instance a study in Tunisia showed a high concentration of organophosphates stockpiles co-located with vulnerable populations (children under the age of five) especially in northern Tunisia (World Bank 2010).

Preparing obsolete pesticides for proper disposal

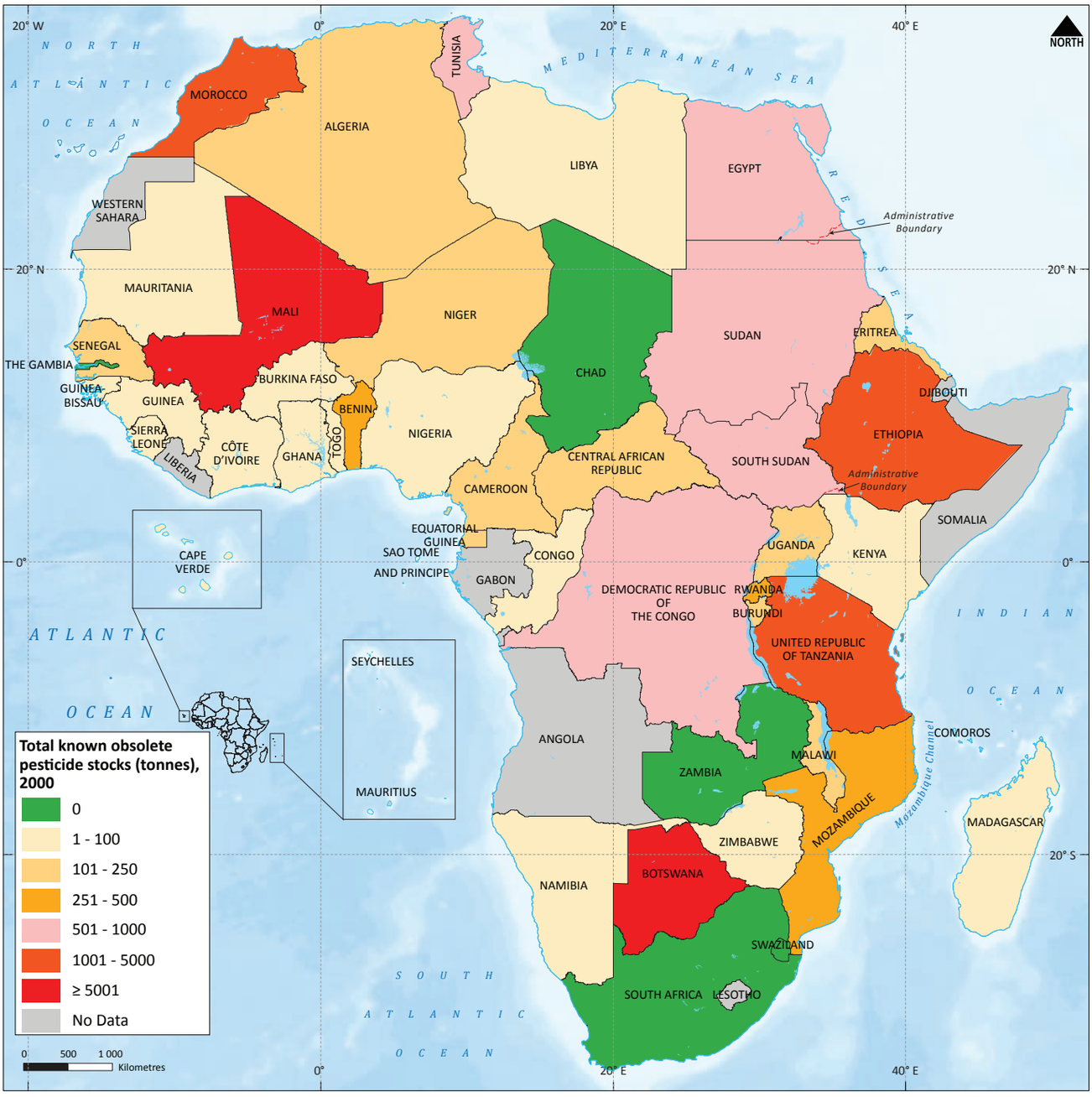
Global Environment Facility / Flickr / CC BY NC SA

With about 15 per cent of Africa's population below 5-years (UNDESA 2010) and thus very vulnerable to the impacts to obsolete pesticides, reducing these risks is imperative.

Many African governments lack both the human resource capacity and the facilities to dispose of these stocks safely. Urgent action is needed to reduce the risk to the environment and communities by safely collecting and disposing of known stockpiles, and putting in place measures that ensure that this dangerous situation does not occur again (ASP 2010). Stockpiles of obsolete and waste pesticides around Africa are depicted in Figure 4.2.

The removal of these obsolete chemicals is a necessity for sustainable development as communities, especially in the rural areas, cannot hope to develop if the soil and water are contaminated. Neither can the people hope to thrive if they are suffering ill health due to

Figure 4.2: Pesticide stockpiles in Africa



Source: Adapted from UNEP/GRID-Arendal 2006

Box 4.5: The African Stockpiles Programme

The Africa Stockpiles Programme (ASP) is a multi-stakeholder partnership formed to address the accumulation of obsolete pesticide stockpiles across the African continent. It involves African countries, international agencies, Non-Governmental Organizations (NGOs) and the private sector. An Implementing Committee is responsible for the design and development of the ASP. It is made up of CropLife International, FAO, Pesticide Action Network (PAN), World Bank and WWF.

The goal of ASP is to to clean up and dispose of existing pesticide stockpiles throughout Africa within the next 15 years, and to help prevent future accumulations, at a total cost of US$ 300 million. Through the Global Environment Facility (GEF) a foundational amount of $25 million has been raised, and co-financing from donor governments raised over $50 million for the first phase of activities in 15 countries. Currently seven countries are involved in the ASP. These are Ethiopia, Mali, Morocco, Nigeria, South Africa, the United Republic of Tanzania and Tunisia.

In Mali an inventory of 1 100 tonnes of obsolete pesticides, emergency safeguarding of high risk sites and implementation of prevention activities such as the review of the 2002 Pesticides Management and Control Bill, and various awareness-raising activities have taken place.

In South Africa, the Department of Environmental Affairs (DEA) and Association of Veterinary and Crop Associations of South Africa (AVCASA) are working with the industry association for manufacturers and retailers of agro-vet products in South Africa on ASP activities. So far, 100 tonnes of unwanted pesticides have been collected from farmers in a DEA pilot project. These activities will continue in two more provinces, and thereafter AVCASA will undertake the country wide collection of farmer held stocks.

Source: ASP 2010

pesticide poisoning. FAO's Programme on the Prevention and Disposal of Obsolete Pesticides is creating awareness about the hazards of obsolete pesticide stocks. Through this programme, developing countries are assisted to put a stop to the further accumulation of obsolete pesticides and to dispose of existing stockpiles.

A Pesticides Stock Management System, one of the tools produced during the implementation of ASP Phase I, was launched in April 2006 to collect and share information on pesticide stocks. It assists in providing data for environmental risk assessments for Obsolete Pesticide Sites and Stores and as an inventories database.

The simple disposal of obsolete pesticides will not suffice and a framework to prevent the future buildup of pesticide stocks needs to be established even as disposal and clean up actions continue. Specific recommendations include better management of stocks, improving the legal framework for pesticide management, as well as promoting alternatives to pesticide usage such as Integrated Pest Management (IPM).

Mercury

Mercury, a heavy metal, may be found naturally in the environment in several different forms. It has differing neurotoxic effects depending on the levels and form exposed to (EPA 2012). The impacts are particularly severe on key human organs and systems, such as the kidneys, and the cardiovascular and immune systems (ATSDR 1999).

There are several pathways through which exposure to mercury can occur including through the food chain, accidentally (such as by breaking products like thermometers that contain mercury) or during work processes that use mercury, such as gold mining, dental clinics or refineries. Contact with the skin may also take place during disposal of waste contaminated with mercury or when handling amalgam (ILO 2006).

Gold mining and processing at artisanal level is a significant source of mercury. For instance studies in Zimbabwe and the United Republic of Tanzania estimate that nearly 1.46 g of Mercury is lost to the environment per gram of recovered gold, and 70–80 per cent of these releases are to the atmosphere (van Straaten 2000 in Nweke and Sanders III 2009). This mercury is typically the vaporized form (Savornin and others 2007 in Nweke and Sanders III 2009) and the greatest exposure happens at the burning stage when separating the gold from the gold-mercury amalgam. The vaporized mercury is easily inhaled by the miners who in most cases do not have the required protective gear. Individuals who may not be directly involved in the mining activities, but who are in close proximity to these artisanal activities are also at risk of exposure.

When inhaled, mercury vapour damages the eyes, the central nervous and immune systems, gums, kidneys, lungs, skin and thyroid. Other signs of its contamination may be manifested in form of behavioural and neurological disorders. Symptoms of these disorders include cardiovascular problems, cognitive and motor dysfunction, headaches, insomnia, memory loss, neuromuscular effects and tremors (McKelvey and Oken 2012 in UNEP 2013b). In the young it can cause neurological damage resulting in symptoms such as mental retardation, seizures, vision and hearing loss, delayed development, language disorders and memory loss.

Exposure to mercury in artisanal mining is an especially important public health issue because of the demographics of the sector. A large section of the artisanal miners are women and children. The data indicates a range from a low of 5 per cent in South Africa to a high of 50 per cent in Mali (Hentschel and others 2003 in UNEP 2013b). Both women and children go to work in gold mines and are involved in all aspects of gold mining including those with very high risks of mercury exposure. In the Senegalese region of Kedougou, for instance, women and children are involved in

Panning for gold

Program on Forests / Flickr / CC BY

all aspects of mining; from the extraction of ore to the burning of amalgam (Savornin and others 2007 in UNEP 2013b). In the United Republic of Tanzania, it is estimated that over 3 000 children, some of whom are very young, work in artisanal mines. In Burkina Faso, Gueye (2001 in UNEP 2013b) estimated that out of 500 children working in such mines, 50 per cent were under the age of 12.

The Global Mercury Project (GMP) is a five-country project coordinated by UNIDO. It seeks to reduce the negative human health and environmental aspects of the use of mercury in artisanal gold mining. Some of the activities include introduction of cleaner technologies and building technical and regulatory capacity. The countries in Africa that are implementing the GMP are Sudan, the United Republic of Tanzania and Zimbabwe (UNIDO 2004). Artisanal and small scale mining in these regions represents an important and growing source of livelihood. However the impacts on health and the environment with respect to pollution generated are also worrying. For example, the Kadoma-Chakari region which has the highest density of small scale gold miners of all of Zimbabwe's gold belts is located in the Zambezi Basin which is shared by 8 countries (UNIDO 2004).

Lead

Following the phasing out of leaded petrol from the region, the sources of lead with the highest risk of exposure to people in Africa include mining operations, contaminated foods, cosmetics and polluted water (Nriagu and others 1997); contaminated dust and soil (Liggans and Nriagu 1998); contaminated crayons, ceramics and piped water (Okonkwo and Maribe 2004 in Nweke and Sanders III 2009). Others are lead-acid battery manufacturing and disposal (Kimani 2005); lead-containing paints (Montgomery and Mathee 2005 in Nweke and Sanders III 2009); and leaded toys that find their way into Africa from countries where such products are banned (UNECA 2009). Policy research on effectively regulating these sources of lead needs to be carried out (Mathee and others 2007).

Leaded fuel used to be a major source of exposure to people living in the urban areas of Africa. Although this was addressed with the elimination of leaded fuels in 2007 (Partnership for Clean Fuels and Vehicles 2007 in Nweke and Sanders III 2009), scientists are now concerned about the legacy of residual lead in the soil and dust. Communities that live in the vicinity of mines are also at risk of high exposure to lead, as is the case in Kabwe, Zambia (Blacksmith Institute 2013).

Lead exposure is associated with several adverse effects. There is a dearth of data from Africa. However, studies from elsewhere indicate effects on neuro-development and, in particular, its negative consequences on the intelligence quotient (IQ) (Lanphear and others 2005 in WHO 2010) and behavior (Chen and others 2007 in WHO 2010, Needleman and others 1996 in WHO 2010). Lead has also been associated with increased risks of attention-deficit hyperactivity disorders in children (Braun and others 2006 in WHO 2010) and cardiovascular mortality in adults (Schober and others 2006 in UNEP 2010b).

Waste and health

Municipal waste

Urbanization is on the rise in Africa and this trend is expected to continue in the future. The growth of urban areas is estimated at 3.3 per cent annually, the highest in the world (UN-Habitat 2008). The volumes of wastes generated are expected to rise in tandem with the projected population increases. The major problem is that the infrastructure and land use planning for waste management is not

An open dump in Lusaka City, Zambia

sama sama - massa / Foter / CC BY NC

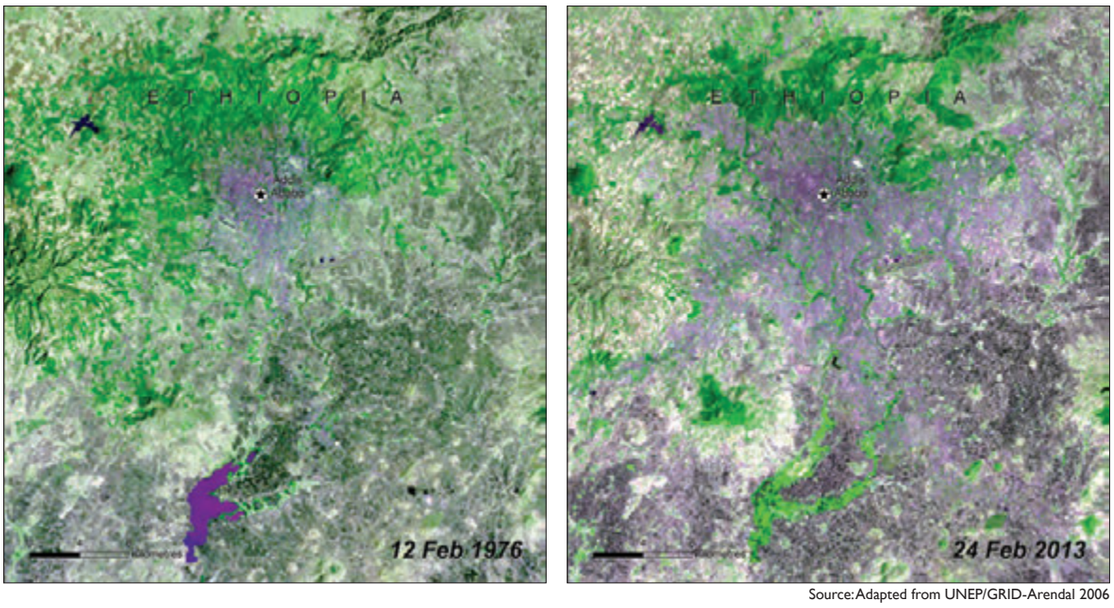
coping with this growth. In many cities in Africa, less than 50 per cent of the waste is collected. For example, in Nairobi, under 6 per cent of household waste is collected by the municipality, compared with 30 per cent in Luanda and 45.5 per cent in Addis Ababa (Figure 4.3) (UN-Habitat 2008). This has implications for human and environmental health because uncollected waste is disposed of in storm water drains, by roadsides, in valleys or is burnt in the open, in close proximity to human settlements (Onibokun 1999 in Baabereyir 2009). Even where the waste is collected, its disposal is not well managed. For example, in Egypt and Morocco, 83.5 and 62 per cent of the solid wastes collected respectively end up in open dump sites (UN-Habitat 2008). In Tunisia, only 60 per cent of the waste generated goes to dumpsites, which, in any case, lack sanitary infrastructure (UN-Habitat 2008).

Municipal solid waste varies in quantity and quality, depending on the characteristics and conditions of each community, consumption patterns and attitudes, and standards of living. It also varies between rural and urban areas. In Egypt, for example, the average solid waste generation rate in rural areas ranges from 0.4 to 0.5 kg per person per day; while in urban areas the daily per capita generation rate varies from 0.7 to 1.0 kg, especially in the richer and larger cities (UN-Habitat 2008).

Municipal or urban waste consists of various substances including waste food, plastic, electronics, glass, paper and even industrial waste. The volumes of industrial waste are usually much larger and they typically contain hazardous materials including heavy metals, volatile organic compounds, pesticides, and radionuclides. Heavy metals such as lead in landfills can originate from solid waste materials, such as batteries, paints, electronics or medical supplies. The process of decomposition at the dumpsites produces gases, for example methane which can explode, and toxic substances that may seep out and contaminate both soil and water systems.

Apart from this environmental pollution, exposure to toxic chemicals may also occur when people scavenge or live on top of dumpsites. Large and uncontrolled dumpsites can potentially impact huge numbers of people. In Africa, examples of this exist in the Mtoni dumpsite in Dar es Salaam, the United Republic of Tanzania (Shemdoe 2010); and at the 45-acre Dandora dumping site which has been the sole waste dumping site for Nairobi in Kenya for the last 35 years (Box 4.6, NEMA Kenya 2011).

Figure 4.3 Addis Ababa has urbanized quickly, but still manages to collect 45.5% per cent of municipal waste



Source: Adapted from UNEP/GRID-Arendal 2006

Box 4.6: Exposure to chemicals around Dandora in Kenya

A study in Nairobi, Kenya at the Dandora landfill site showed that the people in the neighbourhood are exposed to high levels of environmental pollutants, resulting in adverse health effects. A large proportion of children and adolescents had symptoms ranging from asthma, bronchitis, fungal infections and other skin conditions and infections of the upper respiratory tract. About half of the children who live and school in the vicinity of the dumpsite had respiratory illnesses. Further, the levels of lead in their blood equalled or exceeded the international threshold (10 µg/dl of blood); while another 30 per cent had abnormal red blood cells, confirming heavy metal poisoning.

This satellite image change pair of the area of the Dandora landfill shows that it has remained in close proximity to residences and streams over the past 10 years, creating health and environmental issues. It appears to have remained rather similar in area, but appears to have grown denser with waste.

PAN undated; image: DigitalGlobe, visualisation by UNEP/GRID

A roadside dump site in Kenya

A large proportion of solid waste is organic. Organic material is often used as fodder for animals, such as goats and pigs. In other cases, organic material is composted to produce soil conditioner and fertilizers. Non-organic solid wastes, such as plastics, metal, cardboard, and glass can be of economic value and are attractive to scavengers who recover the cost of collection by selling these materials for re-use or recycling. Sometimes, non-organic materials, such as tyres, are sold as a cheap fuel. Burning tyres can release thick black smoke that contains particulates, sulphur oxides, carbon monoxide, oxides of nitrogen (NOx), and volatile organic compounds. They also include hazardous air pollutants, such as polynuclear aromatic hydrocarbons (PAHs), dioxins, furans, hydrogen chloride, benzene, polychlorinated biphenyls (PCBs); and metals such as nickel, arsenic, cadmium, mercury, chromium, zinc, and vanadium which are carcinogenic (Khlifia and others 2013).

The waste management issue needs to be urgently addressed, particularly in the urban informal settlements where 46 per cent of Africa's urban population lives. These settlements are characterized by overcrowding, poverty and poor service delivery, such as inefficient waste collection and management facilities (UN-Habitat 2008).

A pile of used plastic water bottles

Plastics

Plastics are a major nuisance in municipal areas. They degrade the environment by spoiling the landscape, choke animals and soils, act as mosquito breeding grounds, block drainage channels and in turn cause floods during heavy rains. The increase in the use of plastics in cities has concomitantly led to an increase in the plastic component of what is disposed of as municipal solid waste. Plastic bags are among the top three marine litter items that account for 13 per cent of the debris collected in South Africa (Girum Bahri 2005). In Ghana, there is a similar trend in plastic waste generation. In 1979, the percentage of the plastic waste component was 1.4 per cent but by 1999/2000, this had increased to 8 per cent (Fobil and Hogarh 2000).

The plastic industry is one of the fastest growing in Africa. Plastics owe their wide acceptance to properties such as low density, low cost, versatility for a wide range of applications, and durability. But durability is the main reason they are a major environmental hazard. The chemical additives that give plastic products their desired properties also include harmful ecological and health effects such as direct toxicity (from lead, mercury and cadmium), carcinogens and endocrine disruption (Ecology Centre 2012). Exposure to these chemicals may occur during the manufacturing process, and when using plastic packaging as some chemicals migrate to the foods contained therein. Table 4.5 highlights some of the common types of plastics used and their health impacts.

Countries have taken various policy measures to address this issue ranging from a levy system and minimum thickness standard in South Africa; to an outright ban in Eritrea in 2002 and Somaliland in 2005. Rwanda has implemented an import ban on plastic bags with gauges of less than 100 microns (Girum Bahri 2005).

Electronic waste (E-waste)

Electronic waste (e-waste) constitutes waste from electronic or used electric equipment like computers, mobile and static phones, refrigerators, television sets, radios and other digital appliances. The Information and Communications Technology (ICT) sector is expanding rapidly and is characterized by high innovation and replacement of technology which leads to a high turnover of products such as computers and cell phones. This contributes to a rapidly increasing e-waste stream. The current challenge is the lack of capacity to manage this emerging waste stream. In the absence of proper management capacity, this e-waste is co-disposed with municipal waste in regular dump sites.

Table 4.5: Common plastics and their health and environmental impacts

Plastic	Common uses	Adverse health or environmental effects
Polyvinyl chloride (#3PVC)	Food packaging, plastic wrap, containers for toiletries, cosmetics, crib bumpers, floor tiles, pacifiers, shower curtains, toys, water pipes, garden hoses, auto upholstery, inflatable swimming pools	Can cause cancer, birth defects, genetic changes, chronic bronchitis, ulcers, skin diseases, deafness, vision failure, indigestion, and liver dysfunction. PVC releases dioxins and other persistent organic pollutants.
Phthalates (DEHP, DINP, and others)	Softened vinyl products manufactured with phthalates include vinyl clothing, emulsion paint, footwear, printing inks, non-mouthing toys and children's products, product packaging and food wrap, vinyl flooring, blood bags and tubing, IV containers and components, surgical gloves, breathing tubes, general purpose labware, inhalation masks, many other medical devices	Endocrine disruption, linked to asthma, developmental and reproductive effects. Medical waste with PVC and pthalates is regularly incinerated causing public health effects from the release of dioxins and mercury, including cancer, birth defects, hormonal changes, declining sperm counts, infertility, endometriosis, and immune system impairment.
Polycarbonate, with Bisphenol A (#7)	Water bottles	Scientists have linked very low doses of bisphenol A exposure to cancers, impaired immune function, early onset of puberty, obesity, diabetes, and hyperactivity, among other problems.
Polystyrene	Many food containers for meats, fish, cheeses, yogurt, foam and clear clamshell containers, foam and rigid plates, clear bakery containers, packaging "peanuts", foam packaging, audio cassette housings, CD cases, disposable cutlery, building insulation, flotation devices, ice buckets, wall tile, paints, serving trays, throw-away hot drink cups, toys	Can irritate eyes, nose and throat and can cause dizziness and unconsciousness. Migrates into food and stores in body fat. Elevated rates of lymphatic and hematopoietic cancers for workers. PS releases toxic chemicals when burned.
Polyethelyne (#1 PET)	Water and soda bottles, carpet fiber, chewing gum, coffee stirrers, drinking glasses, food containers and wrappers, heat-sealed plastic packaging, kitchenware, plastic bags, squeeze bottles, toys	Suspected human carcinogen
Polyester	Bedding, clothing, disposable diapers, food packaging, tampons, upholstery	Can cause eye and respiratory-tract irritation and acute skin rashes
Urea- formaldehyde	Particle board, plywood, building insulation, fabric finishes	Formaldehyde is a suspected carcinogen and has been shown to cause birth defects and genetic changes. Inhaling formaldehyde can cause cough, swelling of the throat, watery eyes, breathing problems, headaches, rashes, tiredness
Polyurethane Foam	Cushions, mattresses, pillows	Bronchitis, coughing, skin and eye problems. Can release toluene diisocyanate which can produce severe lung problems
Acrylic	Clothing, blankets, carpets made from acrylic fibers, adhesives, contact lenses, dentures, floor waxes, food preparation equipment, disposable diapers, sanitary napkins, paints	Can cause breathing difficulties, vomiting, diarrhea, nausea, weakness, headache and fatigue
Tetrafluoro- ethelyne	Non-stick coating on cookware, clothes irons, ironing board covers, plumbing and tools	Can irritate eyes, nose and throat and can cause breathing difficulties

Source: Ecology Centre 2012

The quantities of e-waste generated are huge. Globally, UNEP estimates that up to 50 million tonnes of e-waste are generated annually (SBC 2011). For example in the five countries of Benin, Côte d'Ivoire, Ghana, Liberia, and Nigeria, it is estimated that between 650 000 and 1 000 000 tonnes of domestic e-waste are generated each year (SBC 2011). It is thought to be the fastest emerging waste stream that is increasingly being seen in dumpsites around most African countries.

Some of the hazardous chemicals found in e-waste include lead which is found in the Cathode Ray Tubes (CRTs) of computer and television monitors and mercury used in the flat-panel display screens. Cadmium is also contained in circuit boards and batteries; and Polyvinyl Chloride (PVC), a synthetic polymer used for the insulation of wires and cables of electronic equipment. PVCs emit chlorinated dioxins and furans which pollute the air when exposed to heat. Cadmium is known to be a carcinogen as it is directly implicated in the promotion of various types of cancer (NEMA Kenya 2011). Toxic pollutants are generated especially when e-waste is burned or recycled in an uncontrolled manner (Orisakwe and Frazzoli 2010).

Opportunities to improve e-waste management

Inappropriate disposal of e-waste not only leads to significant environmental problems but also to loss of secondary materials (Hagelüken and Meskers 2008 in UNEP 2009). So a systematic programme to handle e-waste can prevent damage to the environment and human health and assist in the recovery of valuable materials. Some researchers estimate that nearly 75 per cent of old electronics are in storage in backyards and garages due to ignorance on how to manage them. It is predicted that between 2007 and 2020 e-waste from old computers in South Africa will have doubled (SBC 2011).

There are opportunities to improve e-waste management. They provide economic opportunities for recycling and recovery of

Electronic waste

Curtis Palmer / Foter / CC BY

certain types of wastes which generate secondary raw materials with a market value. E-waste is a tradable commodity and its recycling offers opportunities for job creation and subsequent poverty reduction in Africa. For example in 2007, Ghana generated 3000 tonnes of waste mobile phones, estimated to contain about 130 kg of copper, 3.5 kg of silver, 340 g of gold and 140 g of palladium. The market value for these metals was estimated to be US$ 6 155 000 (UNU 2009).

Other toxic chemical wastes

As many African countries have strived to transform their industrial sectors over the last 10 years, exposure to different types of chemicals for people involved in the manufacturing sector has increased significantly. For example, the proportion of heavy metals and poisons is increasing from products such as cadmium and lead from used batteries. Table 4.6 lists some

Table 4.6: Common chemicals used in Africa

Chemical	Sources	Impacts
Chromium	Combines easily with other metals to form alloys such as stainless steel. Used as a rust-resistant coating on other metals, a pigment in paint, and in wood preservatives and liquids for tanning hides.	Chromium (VI) is the main hazard for people working in the steel and textile industry. Breathing it in can cause nose irritations and nosebleeds. Other health problems include stomachs ulcers, respiratory problems, kidney and liver damage, alteration of genetic material, lung cancer and death.
Cadmium	Used in batteries, pigments, metal coatings, and plastics. Exposure risks include workplace activities, cigarette smoke and contaminated foods. Industrial facilities waste disposal and wash off from areas where cadmium containing fertilisers are used can contaminate waterways.	Damages the lungs, causes kidney disease, and irritates the digestive tract.
Asbestos	Once widely employed in construction primarily for insulation. Still used in gaskets, brakes, roofing and other materials.	When inhaled can cause lung cancer and mesothelioma.
Arsenic	Used as an alloy in lead shot and electrical circuits, as a pesticide, and as a preservative for wood.	Highly toxic and carcinogenic.
Strong acids & alkalis	Highly corrosive liquids used in industry	Can corrode metals and destroy tissues of living organisms.
POPs	Persistent organic pollutants are a class of chemicals and pesticides that persist for many years in the environment, are transported great distances from their point of release,	Can bioaccumulate (thus threatening humans and animals at the top of the food chain), and cause a range of health effects.
Cyanide	Compressed hydrogen cyanide gas is used to exterminate rodents and insects on ships and to kill insects on trees.	A poison that in large doses can cause paralysis, convulsions and respiratory arrest. Chronic exposure to low doses can cause fatigue and weakness.
Lead	Used in the production of batteries, ammunition, paints, metal products such as solder and pipes, and devices to shield X-rays.	If ingested or inhaled can harm the nervous system, kidneys, and reproductive system.
Mercury	Used to produce chlorine gas, caustic soda, thermometers, dental fillings, and batteries. Exposure occurs through contaminated air, water and food and through dental and medical treatments.	High levels may damage the brain, kidneys, and developing foetuses.
PCBs	Compounds used in industry as heat exchange fluids, in electric transformers and capacitors, and as additives in paint, carbonless copy paper, sealants and plastics.	Pose risks to nervous systems, reproductive systems, immune systems, and livers.

Source: WWF 2005

Box 4.7: Toxic waste dumping in Abidjan

A Greek ship, the Probo Koala, arrived at the Port of Abidjan in August 2006, after being denied docking permission at several other African ports. It was carrying about 528m^3 of highly toxic waste. Analysis by the Ivorian Anti-Pollution Centre revealed that the liquid sludge contained large quantities of hydrocarbons, contaminated with hydrogen sulphide, mercaptans and caustic soda, among others. This was disposed of around the city of Abidjan.

Hydrogen sulphide and mercaptans are both toxic chemicals. Hydrogen sulphide, a gas, is a potent poison to the respiratory system. Mercaptans are highly volatile, strong smelling chemicals which cause nausea and irritate the eyes and respiratory system. The dumping caused a public health crisis. The gases released are believed to have led to the deaths of 17 and the injury of over 30 000 Ivorians with complaints ranging from mild headaches to severe burns of the skin and lungs.

As a result of this catastrophe, the government developed the Hazardous Waste Management Plan for Abidjan district in October 2009. National capacity was also strengthened to control the transboundary movements of hazardous chemicals and wastes and national legislation revised and regulations developed to address the obligations related to hazardous waste and chemicals management as specified in the Basel Convention and other associated international agreements.

Furthermore, enforcement agencies and environmental authorities have been strengthened and now work in a coordinated manner to implement the Stockholm, Basel and Rotterdam conventions as well as other relevant MEAs. These activities are also being replicated in other countries including Djibouti, Ethiopia, Gabon, Kenya, Madagascar, Morocco, Mozambique and the United Republic of Tanzania with the aim of strengthening the capacity of the countries to monitor and control the transboundary movement of chemicals and hazardous wastes and guarantee their sustainable management.

Source: ASP 2010

of the common chemicals commonly used in manufacturing processes in Africa and their impacts on human health.

The problem of toxic waste in Africa also arises from the dumping of waste from developed countries as was seen in Abidjan in 2006 (Box 4.7).

Healthcare waste

The major sources of healthcare waste are institutions that provide healthcare services, human and animal research centres and testing laboratories, mortuary and autopsy establishments, blood banks and collection services and nursing homes for the aged. Every year, thousands of tonnes of waste are generated by the myriad of healthcare facilities throughout the continent. It includes blood, body parts, various medical devices, sharps, non-sharps, chemicals, pharmaceuticals and radioactive materials. Of the total amount of waste generated by healthcare activities, about 80 per cent is general waste comparable to domestic waste. The remaining 20 per cent is considered hazardous material that may be infectious, toxic

or radioactive (WHO 2011b). Box 4.8 describes the different types of healthcare wastes.

Waste generation from these healthcare establishments varies according to the development status of the countries. Low-income countries generate on average 0.2 kg of hazardous waste per hospital bed per day while developed countries generate about 0.5 kg of hazardous waste per bed per day (WHO 2011b). Even within countries, there are variations. For example, the amount of biomedical hazardous wastes generated in Ethiopia in 2006 was estimated to be 430.7 tonnes (FGE 2010). However these wastes tend to be confined to the more urban areas where most healthcare facilities are located.

Poor management of healthcare wastes exposes workers at all levels and the communities to infections, toxic effects and injuries. Some of the health impacts include injuries from sharps; poisoning and pollution through the release of pharmaceutical products, radiation, waste water or toxic chemicals such as those released during incineration (WHO 2011b).

Lack of proper disposal facilities is the key driver for indiscriminate dumping of medical waste. In 2002, an assessment conducted in 22 developing countries demonstrated that between 18-64 percent of healthcare facilities do not use appropriate methods to dispose of their waste (WHO 2005). Medical waste must be separated from municipal waste, but in many parts of Africa, it tends to be collected along with other waste streams (Abor 2007). For instance only 23.1 per cent of tertiary health centres in Benin City, Nigeria segregate their medical waste (Bassey 2007). The lack of segregation practices means that healthcare waste finds its way onto landfills, down wastewater drains or may be illegally dumped or buried. This presents serious health hazards to the environment and the public. For example, it is estimated that about 45 per cent of healthcare waste generated in the Province of KwaZulu-Natal in South Africa may be illegally dumped, buried or burnt in unknown locations (Abor 2007). In Addis Ababa, a lack of proper handling and disposal systems for medical wastes means that liquid wastes for example are channeled into streams without any treatment (FGE 2010).

The dumping of healthcare wastes in an unlined pit, or one that is too close to a water body could lead to contamination of water. Furthermore, if healthcare waste (especially that with chlorine) is burned openly or in an incinerator with no emission control, dioxins and furans and other toxic air pollutants may be produced (Abor 2007). This is the case in many developing countries. Dioxins, furans and metals are persistent, bio-accumulate and therefore should not be incinerated. Only

Box 4.8: Description of healthcare waste

Healthcare waste constitutes:

- Infectious waste: waste contaminated with blood and its by-products, cultures and stocks of infectious agents, waste from patients in isolation wards, discarded diagnostic samples containing blood and body fluids, infected animals from laboratories, and contaminated materials (such as swabs and bandages) and equipment (such as disposable medical devices)
- Pathological waste: recognizable body parts and contaminated animal carcasses
- Sharps: such as syringes, needles, disposable scalpels and blades
- Chemicals: for example mercury, solvents and disinfectants
- Pharmaceuticals: expired, unused, and contaminated drugs; vaccines and sera
- Genotoxic waste: highly hazardous, mutagenic, teratogenic or carcinogenic, such as cytotoxic drugs used in cancer treatment and their metabolites
- Radioactive waste: such as glassware contaminated with radioactive diagnostic material or radiotherapeutic materials
- Heavy metals waste: such as broken mercury thermometers.

Source: ASP 2010

modern incinerators operating at 850-1100°C and fitted with special gas-cleaning equipment are able to comply with the international emission standards for dioxins and furans (WHO 2011b).

If poorly handled, treated or disposed of, the impacts of healthcare waste can effect humans, living organisms and even ecosystems (ENCAP 2009). The major threats from improper healthcare waste handling include:

- Disease transmission, through contact with infectious waste and sharps, and contaminated water; and
- Chemical and toxic threats, through exposure to chemicals and pharmaceuticals.

Policy interventions vary across the continent. In Kenya, for example, there have been attempts at greater regulation with the finalization of the National Healthcare Waste Management Plan and Guidelines by the Ministry of Public Health and Sanitation in 2007, and the enforcement of the Environmental Management and Coordination (Waste Management) Regulations 2006 by the National Environment Management Authority. In other parts of Africa, the legal framework is still lacking. For instance in Ethiopia, the Public Health Proclamation of 2000 does not clearly address the health and environment issues of hospital wastes, hazardous wastes such as obsolete chemicals as well as industrial and radioactive waste (FGE 2010).

Small-scale healthcare facilities are crucial to providing health services to the population. However many cannot afford to implement the modern methods of handling healthcare waste. The result is that they may unintentionally pollute the environment through poor design and management of their wastes. And given their number, the cumulative effects are significant. According to ENCAP (2009), it is common for healthcare waste to be buried together with the general solid waste in urban areas. In peri-urban and rural areas, such waste is generally buried in an unlined pit without treatment. Although some hospitals have incinerators, it is not uncommon for them to fail to work properly. Many times, left over pharmaceuticals and chemicals may be emptied down pipes or drains and enter the sewer system. These can accidentally leach into the soil contaminating ground and surface water with pathogens and pollutants. Chemical and pharmaceutical wastes can also be toxic, flammable or corrosive, especially in large quantities. Burns, poisonings and negative health effects from inhalation are some of the effects.

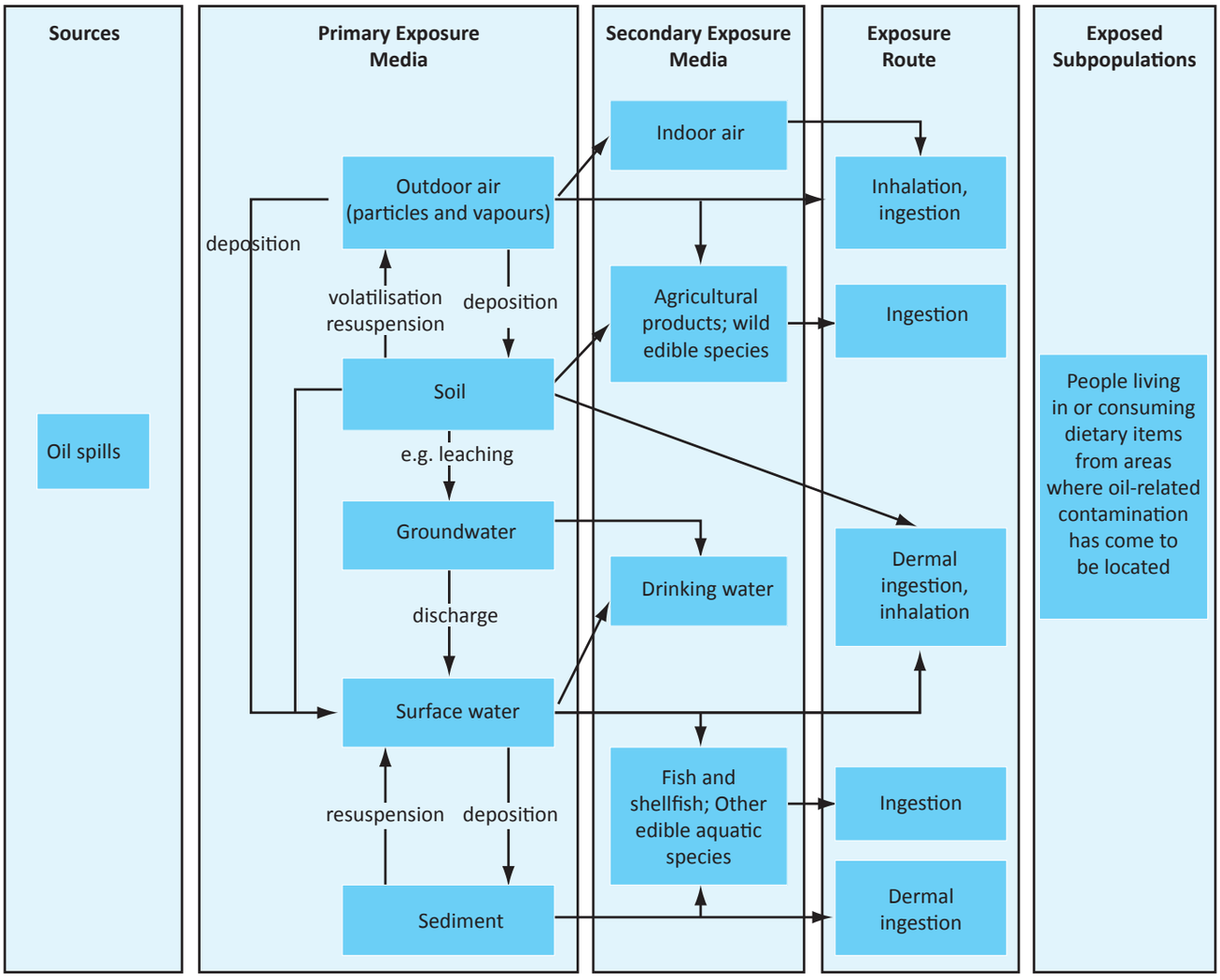
There is room for improvement in healthcare waste management in Africa. Financing programmes to manage healthcare waste should be prioritized and should include procedures that reduce the health risks at least cost. Simple actions could include replacing mercury thermometers with non-mercury ones.

There are a number of other options for safe management of healthcare waste. These include chemical disinfection, shredding, microbial inactivation using sterilization technologies, autoclaving or steam sterilization and microwave irradiation. At a more local level, practical activities such as waste minimization, promoting alternative waste treatment technologies that do not require burning, segregation of waste and technology conversions could safely and cheaply enhance the management of healthcare waste.

Petrochemical waste

Exploration and extraction of petroleum, refining and consuming fuels all have severe impacts on the environment. The processes of extracting and refining petroleum are responsible for polluting air, lake shores and the marine environment, and for generating industrial solid wastes. The solid waste and sludge from petrochemical plants and refineries are made up of organic and inorganic compounds including heavy metals such as lead, zinc and chromium. Waste water released by oil

Figure 4.4: Conceptual model of human exposure to oil spills



Source: WWF 2005

extraction industries also contains huge quantities of polycyclic and aromatic hydrocarbons, phenols, metal derivatives, sulphides, naphthylenic acids and other chemicals (Uzoekwe and Oghosanine 2011). The volumes of waste water will depend on the state of exploration or production.

Some oil exploration activities have been linked to illegal waste dumping, for instance in the Delta States of Nigeria (Nduka and Orisakwe 2009). Such activities can contaminate potable water supply with adverse impacts on human health. In fact, surface waters in the communities neighbouringsome of the exploration sites in the Delta have been shown to have levels of lead, cadmium, manganese and chromium in excess of the WHO limits for drinking water (0.01, 0.003, 0.4 and 0.05 mg/l respectively) (Nduka and Orisakwe 2009).

Petroleum hydrocarbons can come into contact with humans through the air they breathe, dermal contact or through the food chain, especially if this is contaminated with oil (UNEP 2011). Figure 4.4 shows a conceptual model of human exposure to oil spills.

Managing chemicals and wastes for better health

Exposure to chemicals and wastes remains an important source of environmental health hazard

especially where poverty, lack of investment in new technologies and weak environmental legislation combine to create and sustain high pollution levels; and where the costs of restoration are prohibitive. Many of the pressures are driven by the rising population, urbanization, disease prevalence, modernization of agriculture and industrial development. Measures and systems need to be developed to help decrease exposure to the negative human health effects of chemical use and to better manage waste generated.

Governments in Africa should be commended for their efforts to better manage chemicals through their commitment to implementing international laws such as the Basel, Stockholm and Bamako Conventions, as well as their adoption of the Strategic Approach to International Chemicals Management (SAICM). Such efforts are likely to yield health benefits through reduced exposure to poisonous chemicals such as pesticides, lead and mercury, while appropriate use of agro-chemicals will result in food security through increased agricultural productivity. However, such benefits are only possible through stringent implementation of polices and laws, including accelerated domestication of international laws. In addition, the region needs to actively participate in the negotiations on the nascent mercury convention.

Poor management of wastes poses risks to human health, the environment and the economy. Improperly designed landfill sites, uncontrolled dumping, and poor waste handling expose waste handlers and communities to harmful substances which affect their health. Waste management initiatives in Africa have tended to be fragmented across government departments, hence making enforcement and compliance difficult. Instituting robust control and monitoring measures and implementing integrated waste management programmes can help to address these problems. In addition, national policies and laws need to be strengthened to address issues related to e-waste, toxic wastes as well as second-hand goods. There is also need to ensure the effective implementation of the polluter-pays principle.

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5

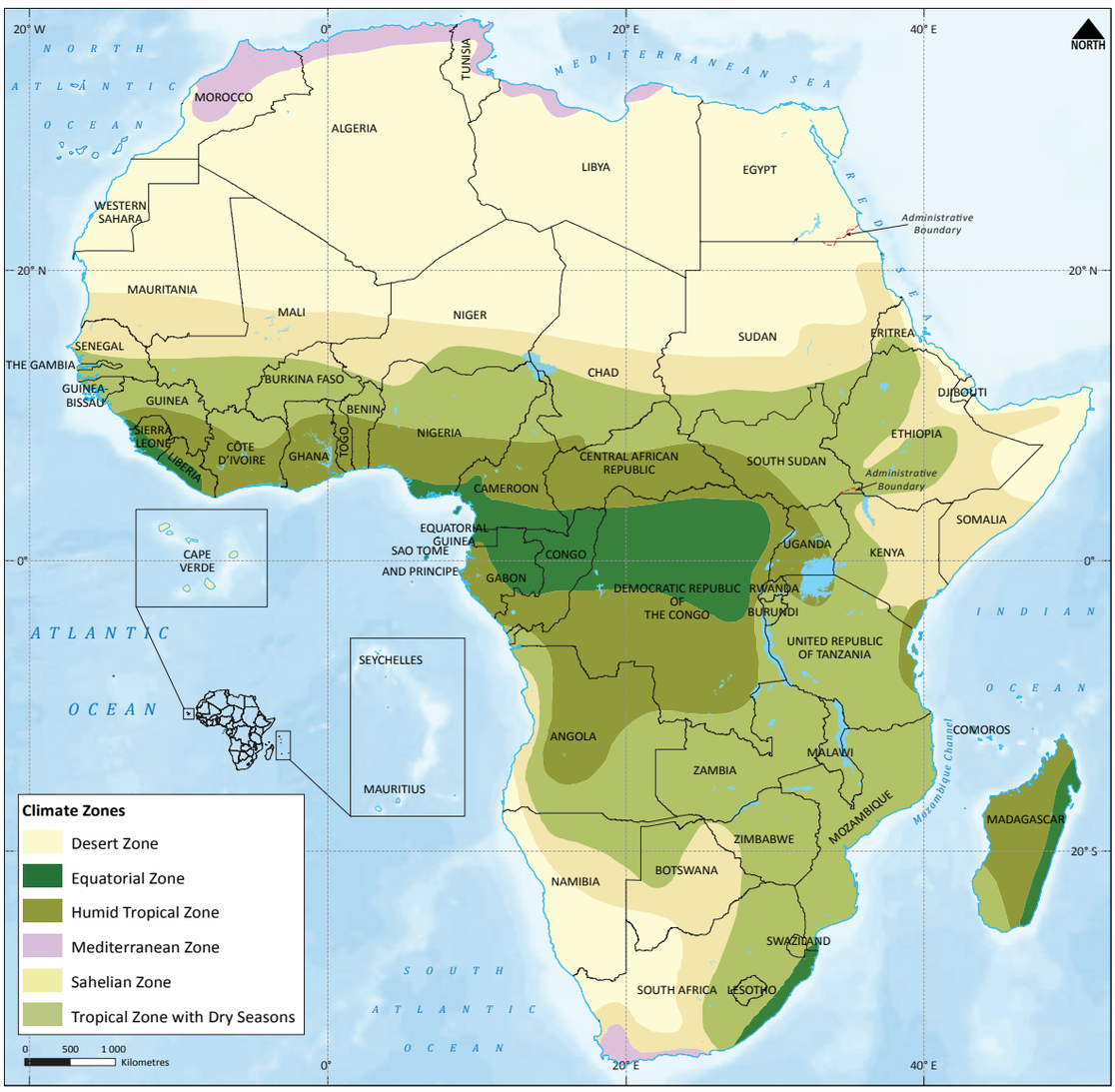
Climate Change and Vulnerability

Africa's climate regimes

Africa's diverse climate (Figure 5.1) supports various ecosystems that form the basis for varied socio-economic activities that are important for food production and health provisioning. The region's climate regimes range from humid equatorial, through seasonally-arid tropical, to sub-tropical Mediterranean-type (Hulme and others 2001). Rainfall in particular is highly variable over much of the Sahel, as well as parts of eastern and southern Africa, making these parts of the region susceptible to drought events. In East Africa, rainfall ranges from about 100 mm/year in north-eastern Ethiopia to about 2 500 mm/year in parts of northern United Republic of Tanzania.. Large parts of East Africa are arid or semi-arid. In West Africa, the climate ranges from humid equatorial along the coast to arid in the northern Sahelian countries, with a wide precipitation range that decreases from the coast inland. Central Africa's climate varies from tropical-dry to humid equatorial. Southern Africa's climate also exhibits variation in climate zones, from warm desert (arid and semi-arid areas) to humid subtropical and equatorial (Hulme and others 2001).

The warm climate of Africa makes it attractive as a tourist destination, and some of the income earned is spent on health. The rich biological diversity in the continent's aquatic and terrestrial systems is also linked to the relatively conducive

Figure 5.1: Africa's climate regimes



Source: World Book 2009

and varied climate. Africa's diverse ecosystems provide habitats for a proliferation of vectors and pathogens that are associated with many human diseases.

Africa is also vulnerable to a number of climate-sensitive diseases, which climate change and variability are likely to exacerbate (WHO 2012). These diseases include the Rift Valley Fever (RVF), which affects both people and livestock; cholera, associated with both floods and droughts; and malaria, where warming climate has resulted in the extension of its range, including to the highlands of Kenya, Rwanda and the United Republic of Tanzania. Africa has a high diversity of vector-specie complexes, which can change their habitat range as a consequence of changing climate and ecosystems, thus resulting in new disease patterns (Githeko and others 2000).

Africa's vulnerability to climate change and variability

Most parts of Africa have experienced a temperature increase of about 0.7°C in the last century (IPCC 2007). And, while Africa has generally been drier in the last few decades (Nicholson 2001; L'Hóte and others 2002; Oguntunde and others 2006), significant regional differences have been witnessed. The Horn of Africa and some parts of southern Africa (Botswana, Zimbabwe, the Transvaal of South Africa), for instance, saw significant decreases in rainfall between 1961 and 1990 (Hulme and others 2005). Other rainfall decreases have been recorded in the Volta Basin (Oguntunde

Decrease in rainfall has been recorded in the Volta Basin

CPWF Basin Focal Project / Flickr / CC BY 2.0

Box 5.1: Factors that exacerbate Africa's vulnerability to climate change and variability

The key factors that increase the vulnerability of Africa's population to the impacts of climate change and variability include:

- Heavy reliance on agriculture and other natural resources for livelihoods. These are expected to be negatively affected by changes in weather conditions.
- Limited technologies to cope with the impacts of climate change, such as irrigation technologies that would make farmers less reliant on rain-fed agriculture.
- The prevalence of drylands, which may experience reduced yields or be pushed out of production by changes in rainfall patterns or shorter growing seasons. Changes in rainfall patterns may also transform additional productive land into dryland, compounding the problem.
- Already water-poor countries may become water-stressed as weather patterns become more erratic.
- Limited capacity of governments and institutions to deal with the impacts of climate change and to strengthen resilience of the population, in particular of vulnerable groups, who are less resourced to deal with the impacts of climate change. The brain drain of qualified people further limits the ability of governments and institutions to respond to the needs of the population.
- Lack of access to capital, insurance cover and safety nets, in particular following disasters, and limited savings of the majority of the population that would enable them to weather crises.

Source: ASP 2010

and others 2006), Congo Basin (Boko and others 2007) and the Sahel (UNEP 2002). Heavy rainfall events were nevertheless noted in parts of southern Africa (Angola, Malawi, Mozambique, Namibia, and Zambia) between 1931 and 1990 (Boko and others 2007). Extreme weather events (EWEs), such as droughts and floods are also likely to occur more frequently.

Africa's economies and livelihoods are heavily dependent on natural resources, agriculture and other sectors that are particularly sensitive to the impacts of climate change and variability. These compound the already significant development challenges faced by the continent, such as widespread poverty, a variety of health challenges, weak governance, insecurity, limited access to capital, poor infrastructure, and ecosystem degradation.

Bean farmer in Rwanda

The region is susceptible to severe impacts of climate variability and extreme events such as droughts and floods (IPCC 2007). This exacerbates existing vulnerabilities in key economic sectors such as agriculture, tourism and infrastructure. The factors that exacerbate Africa's vulnerability to climate change and variability are set out in Box 5.1.

Health linkages of climate change and variability

The impacts of climate change on health can be both direct and indirect, with the latter predominating in Africa. Although limited, direct impacts such as the cyclones have had devastating impacts, including fatalities, on the West Indian

Table 5.1: Potential health impacts of climate change: Examples of interlinkages between climate change impacts and health vulnerabilities in Africa's sub-regions

Sub-region	Climate change and human health interlinkages
Northern Africa	• Sea level rises lead to salt intrusion, flooding and destruction of human settlements and water stress • Over-abstraction of scarcer water leads to deteriorating water quality and higher incidences of water borne diseases • Unpredictable weather conditions lower food yields and quality • Depleted fish stocks lower food security and household incomes • Temperature rises affect the health of vulnerable populations e.g. children, the sick and elderly.
Western Africa	• Higher frequency of EWEs results in increased mortality and morbidity • Prolonged dry spells threaten food and nutrition security and access to medicinal herbs • Warmer temperatures encourage the spread of weather-sensitive diseases e.g. malaria, meningitis, dengue fever and parasites like hookworms and ascaris • More frequent EWEs increase the vulnerability of HIV/AIDS affected persons.
Eastern Africa	• Rising numbers of EWEs lead to severe food shortages and malnutrition • Rising numbers of EWEs lead to higher morbidity and mortality • Warmer ambient temperatures extend weather-sensitive diseases e.g. malaria and Rift Valley Fever to previously disease-free zones such as the highlands of Ethiopia, Kenya, Rwanda and the United Republic of Tanzania • Frequent flooding favours the spread of waterborne diseases e.g. cholera, Rift Valley Fever and parasitic infections • Severer drought leads to conflicts over scarcer natural resources e.g. water, forests and pastures.
Central Africa	• Frequent occurrence of EWEs increases human injuries from collapsing buildings and infrastructure, landslides and heat waves • Intensified flooding increases incidences of water-borne diseases e.g. cholera and typhoid • Warmer temperatures lead to the proliferation of diseases vectors e.g. ticks, mosquitoes and rodents while scarcer resources lead to increased human-wildlife contact and increased exposure to zoonotic diseases such as Ebola • Unpredictable weather patterns disrupt food and livestock production.
Southern Africa	• Water stress leads to land degradation and lower food and livestock yields • Frequent occurrence of EWEs increases human injuries from collapsing buildings and infrastructure, landslides and heat waves • Intensified flooding increases incidences of water-borne diseases e.g. cholera, typhoid and schistosomiasis • More frequent EWEs increase the vulnerability of HIV/AIDS affected persons. Western
Western Indian Ocean Islands	• Sea level rises disproportionately affect SIDS such as Seychelles and Mauritius • Salt water intrusion leads to freshwater scarcity • Higher temperatures lead to reduced fisheries and marine biodiversity and the concomitant erosion of medicinal value • Intensified flooding increases incidences of water-borne diseases e.g. cholera, typhoid and schistosomiasis • Higher frequency of EWEs particularly floods lead to inundation and erosion of coastal areas, human injuries and loss of life.

Source: Adapted from Boko and others 2007

Ocean. For example, in Mozambique, tropical Cyclone Eline killed 700 people in 2000 and led to a loss of 20 per cent of the country's GDP (GFDRR 2012).The potential impacts of climate change on health in Africa are explained in Table 5.1.

Existing human health problems especially in communities that are ill-prepared to address them are exacerbated. These health problems may be in the form of malnutrition and alterations in pathogen lifecycles (UNECA 2011). The impacts of climate change in Africa are expected

Table 5.2: Health-related impacts of climate change

	Climate changes	Adverse health impacts
Direct	Extreme Weather Events	High levels of mortality and morbidity, changes in disease prevalence and patterns, health delivery infrastructure and access to health
	Temperature	Thermal stress, skin cancer, eye diseases
	Air quality	Cardio-respiratory diseases, allergic disorders, asthma, airway diseases
Indirect	Temperature	Food availability, malnutrition, famine, infectious diseases of migrants and droughts
	Precipitation	Water-borne, vector-borne and zoonotic diseases, droughts, food and water availability
	Extreme Weather Events, rainfall, temperature, ecosystem changes	Faster spread of contagious diseases due to migration, natural resource conflicts, food and water scarcity, famine , malnutrition, limited access to health services
	Ecosystem composition and function	Food yields and quality, aeroallergens, vector-borne, water-borne and zoonotic diseases

Source: Modified from UNECA 2011

to be severe with reductions in crop yields and livestock productivity, shortages of drinking water, malaria and other diseases (Table 5.2), an influx of 'climate refugees' and a possibility of civil conflicts. Increases in temperature and a higher incidence of droughts are likely to reduce the area suitable for farming and the length of the growing seasons, particularly in semi-arid and arid areas. This would result in food insecurity and malnutrition (Boko and others 2007). Conway (2009) reports that the production of maize crops over most of southern Africa, including Zimbabwe and South Africa, will be severely impacted by increasing droughts in the sub-region.

The Nile delta is vulnerable to sea level rise

Landsat 8

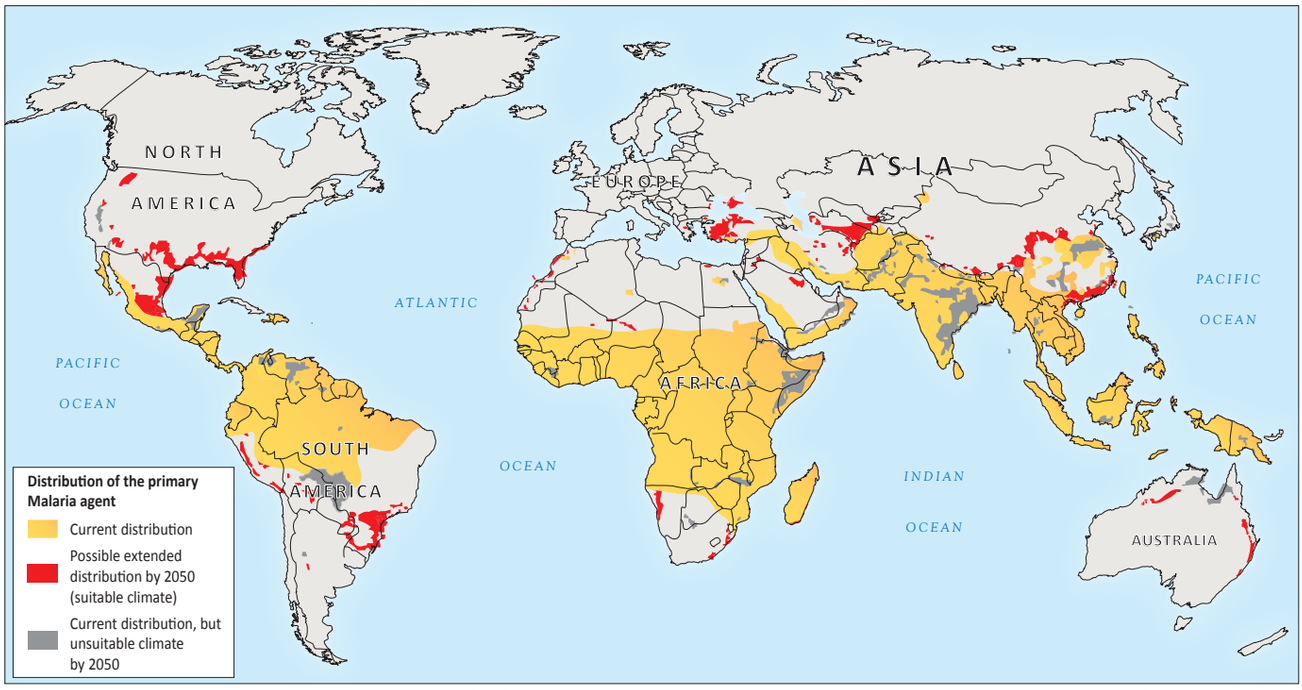
Drought affected maize

Africa's ecosystems, including biodiversity, are also likely to be affected, with ecosystems in dry and sub-humid areas, where even small changes in temperature and rainfall patterns may impact on the viability of plants and animals, particularly at risk. These increasing pressures on ecosystems are likely to affect the availability of environmental goods and services, including medicinal plants that are used by communities to treat several ailments. East Africa may see an increase in the frequency and severity of EWEs, particularly droughts and floods. According to DFID (2009), climate models show that while the short rain period is likely to become wetter, East Africa will almost certainly become warmer, and droughts are likely to continue, particularly in northern Kenya. The IPCC Fourth Assessment Report predicts a sea level rise of 18-59 cm and this is expected to have a significant impact on coastal populations. The most affected area in Africa is likely to be the Nile delta, where a one metre rise would affect over 6 million people. West Africa would also be severely affected. In Ghana, for instance, where over 25 per cent of the population resides in coastal areas, even small sea level rises would have significant consequences on the economy (Conway 2009).

Further, climate change is exacerbating the pressures on an already strained health sector. According to the Boko and others (2007), social and economic factors such as poverty levels, education, quality of and access to healthcare services, public health initiatives, infrastructure and economic development as well as adaptive capacity will be critical in determining the magnitude of the impacts of climate change on health.

Climate change exacerbates many diseases particularly malaria, meningitis, cholera and other diarrhoeal diseases, Rift Valley Fever (RVF) and Dengue fever.

Figure 5.2: Distribution of primary malaria agent in Africa compared to other regions, including projections for 2050



Note: Current distribution represents maximum extent of the distribution of the falciparum Malaria parasite. For the 2050, areas within the current maximum extent have been excluded from the map. The scenario is based on the high scenario from the HadCM2 experiment

Source: UNEP/GRID 2005

Malaria

The geographic distribution and level of transmission of malaria is determined by changes in temperature, rainfall and humidity. Plasmodium falciparum, one of the species that causes malaria, cannot complete its development in a vector if the ambient temperature is below 18°C (Craig and others 1999 in Alemu and others 2011) while most of the malaria vectors die at 40°C (UNECA 2011). *Anopheles gambiae*, one of the malaria vectors, is most abundant in humid environments while Anopheles arabiensis is dominant in the more arid environments (Lindsay and others 1991). Furthermore, each of the malaria vectors has its own ecological niche which is controlled by a number of parameters such as humidity, salinity, land cover and the presence of swamps. Each species also has different infection rates, affecting the level of malaria transmission and endemism. The level of transmission of the diseases may also be affected by the coexistence of species that have similar habitat requirements.

Climate change is expected to expand and contract the geographic range of malaria transmission (Figure 5.2), depending on prevailing temperature, rainfall patterns, and humidity. The 'Mapping malaria risk in Africa' project shows,

Mosquito nets help to protect against malaria

Gates Foundation / Foter / CC BY NC ND

Box 5.2: Changing patterns of malaria infection in Africa

Rising temperatures and changes in rainfall patterns are already thought to be affecting the life cycle of pathogens and their range, leading to variations in infections rates, as well as the spatial and temporal distribution of malaria vectors. The recent spread of malaria to the Central Kenya highlands is an example of this phenomenon. Available data indicates a highly significant warming trend in western Kenya highlands of 0.21°C, 0.24°C and 0.21°C in the monthly mean, maximum and minimum temperatures per decade. In the mid-1990s the temperature in the central Kenya highlands exceeded the 18°C mean annual temperature, resulting in the addition of about 4 million people to the malaria-susceptible population (Githeko 2009).

The effects of observed climate change on the geographical distribution of malaria and its transmission intensity in highland regions in Africa remains however an area of debate. For example, the incidence of malaria has increased in the apparent absence of climate trends in some parts of East Africa (Wandiga and others 2010). The proposed driving forces behind the malaria resurgence include drug resistance of the malaria parasite and a decrease in vector control activities. In southern Africa, long-term trends for malaria were not significantly associated with climate, although seasonal changes in case numbers were found to be linked to a number of climatic variables (Craig and others 2004).

The northern limit of Plasmodium falciparum malaria in Africa is the Sahel, where rainfall is an important limiting factor in disease transmission (Ndiaye and others 2001). Malaria has, for instance, decreased in pace with long-term decreases in annual rainfall in Senegal and Niger (Egbendewe-Mondzozo and others 2011).

UNECA (2011) has noted that between 2050 and 2080, malaria is expected to decline in the western Sahel and southern central Africa as these areas are likely to become unsuitable for malaria transmission (Thomas and others 2004). However, these projections are contradicted by conclusions by Caminade and others (2011).

Boko and others (2007) reported that by 2050, previously malaria free areas in Burundi, Ethiopia, Kenya and Rwanda may suffer 'modest incursions' of malaria. The projected higher rainfall could lead to increased malaria transmission in East Africa, and possible spread to new areas, especially in South Africa (Boko and others 2007).

for instance, that by 2050 and continuing into 2080, a large part of the western Sahel and much of southern central Africa would likely become unsuitable for malaria transmission (Thomas and others 2004 in Boko and others 2007). Hartmann and others 2002 (in Boko and others 2007) show that changes in temperature and precipitation could alter the geographical distribution of malaria in Zimbabwe, with previously malaria-free areas that are populated by humans becoming suitable for transmission (Box 5.2). Strong southward expansion of the transmission zone will probably continue into South Africa.

Meningitis

Meningitis is an air-borne disease caused by the bacterium Neisseria meningitides. Most epidemics of meningitis start during the dry and dusty season and stop with the rains (Cuevas and others 2008). Epidemics are associated with humidity levels of below 30 per cent for a continuous period of at least five days, and are also linked to the speed of the Harmattan winds (Yaka and others 2008).

The meningitis belt has expanded outside its traditional limits, most likely due to climate change (Chippaux 2008). This now includes Algeria and Tunisia to the north as well as Kenya, Rwanda, Somalia, the United Republic of Tanzania, Uganda and Zambia to the east and south (Hart and Cuevas 1997 in Boko and others 2007; Molesworth and others 2002). Epidemics have also been reported in Angola, Botswana, the Democratic Republic of Congo, Mozambique and Namibia in the last decade (WHO 2010a). Benin, Cameroon, Cote

d'Ivoire and Togo have also experience recent outbreaks, which have been linked to expansion of hotter and drier conditions (Savory and others 2006). The frequency and intensity of droughts are said to be increasing in East Africa and the Sahel. Droughts are associated with low humidity and high temperature, conditions that favour the transmission of meningitis. The traditional and expanding zones of meningitis are depicted in Figure 5.3.

Cholera and other diarrhoeal diseases

Most of the diarrhoeal diseases are either water or food borne. Their transmission is closely linked to climatic conditions. For example, flooding can cause the contamination of public health water supplies with the infecting agents and cause illnesses of a large number of people (Ahern and others 2005). Populations with poor hygiene are particularly at risk. As a result of changing

Figure 5.3: Changes in the risk of meningitis epidemics after 1975

Source: Cuevas and others 2007.

climatic conditions leading to increased frequency of floods, and growing populations, Africa is witnessing increasing cases of cholera and other diarrhoeal diseases. Cholera is associated with temperature and rainfall anomalies (de Magny 2007). Between 1970 and 1979, 19.7 per cent of global cholera cases were reported from Africa, and by 2005, Africa's contribution had increased sharply to 94.8 per cent (Gaffga and others 2007; Kebede and others 2010).

Diarrhoea affected 32.2 million people in 2008 (WHO 2008). The potential rise in food poisoning with higher daily temperatures may be the root cause of increased diarrhoea incidences while the increased coastal and inland flooding due to sea level rise and intense rainfall may also precipitate the transmission of vector-borne diseases and also lead to additional deaths from drowning (McMichael and others 2006 in Boko and others 2007).

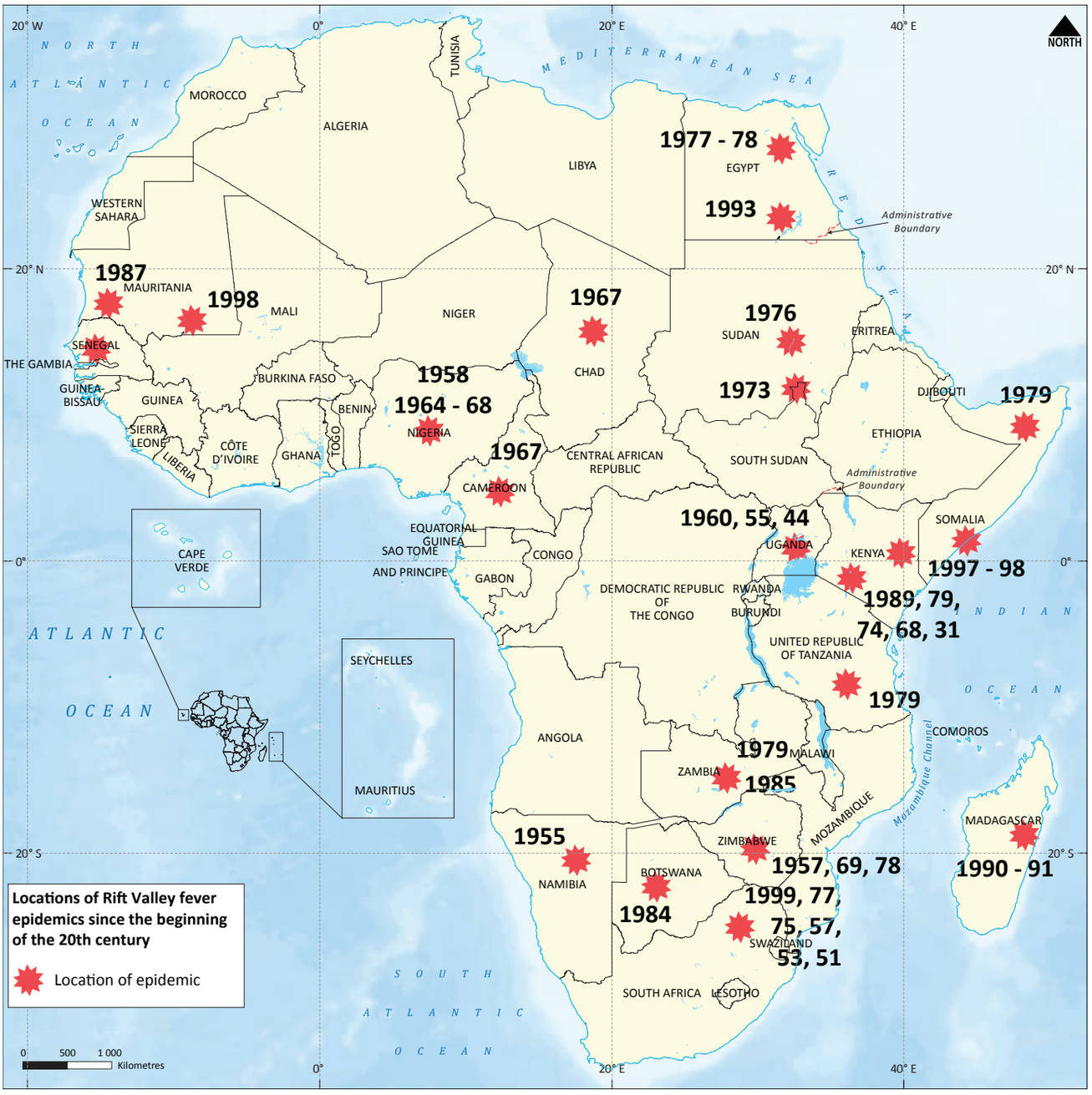
Droughts can reduce the sources and amount of safe drinking water and increase the risk of contamination in the few available sources, such as unprotected wells (Sabwa and Githeko 1985). In Zanzibar it was shown that a 1°C increase in temperature at 4 months lag resulted in a 2-fold increase of cholera cases, and an increase of 200 mm of rainfall at 2 months lag resulted in a 1.6-fold increase of cholera cases (Reyburn and others 2011). Cholera epidemics in East Africa have also been associated with the El Nino Southern Oscillation (ENSO) (Olago and others 2007).

Rift Valley Fever

Rift Valley Fever (RVF) is a serious human and animal health threat, and an economic burden. The disease is widespread in Africa, with the disease belt extending from Egypt to South Africa (Davies 2010). In West Africa, the virus has been isolated since 1974 in Kedougou (Fontenille and others 1998). The virus was first identified in 1931 during an investigation into an epidemic among sheep on a farm in the Rift Valley of Kenya. Since then, outbreaks have been reported in sub-Saharan and North Africa (WHO 2010b). One of the most recent RVF outbreaks in West Africa occurred in Mauritania in 2010 (El Mamy and others 2011). Based on rainfall, Figure 5.4 depicts the RVF risks over the period 1990-2007. An outbreak in Egypt in 1977-79 infected more than 200 000 people,

Severe drought in East Africa

Figure 5.4: Locations of Rift Valley Fever epidemics over the 20th century



Source: Clements and others 2006

causing 600 deaths and losses in livestock valued at over US$100 million (Weaver and Reisen 2010).

Rift Valley Fever is closely related to heavy rainfall, which is predicted to increase with climate change in some parts of Africa, including East and Central Africa. In 1997-1998, an RVF outbreak associated with heavy rainfall as a result of El Niño Southern Oscillation (ENSO) in eastern Africa affected Kenya, Somalia and the United Republic of Tanzania, infecting an estimated 27 500 people, and causing 170 deaths (Woods and others 2002).

Rift Valley Fever epidemics are associated with a sudden increase of Aedes mosquitoes caused by extensive flooding (WHO 2010b). In East Africa, RVF epidemics have also been associated with heavy flooding caused by the warm episodes of ENSO and the Indian Ocean Dipole (Anyamba and others 2009).

Dengue fever

Dengue fever is also likely to increase as climate change and variability gather pace (UNDP 2007). Transmitted by the *Aedes* mosquito, dengue fever is a fast growing challenge, particularly in tropical cities in developing countries. Cases have risen dramatically in the last 40 years, as unplanned urbanization with standing water in waste and other receptacles have created mosquito breeding sites, and the increased movement of people and goods has spread both mosquito vectors and infections.

The distribution of dengue fever is also highly dependent on climate. In the absence of changes in other determinants, studies suggest that climate change could expose an additional 2 billion people to dengue transmission by the 2080s. In Africa, the disease's geographical range is likely to expand considerably as a consequence of changing climatic conditions, particularly in Central and East Africa (Conway 2009).

Effects of extreme weather events (EWEs)

There is evidence that Africa has been suffering from an increase in the frequency and intensity of extreme weather events (EWEs), such as droughts and floods in recent decades, and that this trend is projected to continue (Boko and others 2007). Droughts have increased in frequency and intensity in East Africa, with droughts occurring in each decade over the past 50 years (AMCEN 2011). The 2011 drought in Eastern Africa is one of the worst Ethiopia has faced in 50 years. In Central Africa and the Sahel, droughts have become more frequent since the late 1960s. An increase in rainfall extremes has also been observed in southern Africa and the Guinean coast. Devastating flooding events in southern Nigeria has been linked to the progressive increase in August rainfall over the region in the last five decades (Adefolalu 2001).

Table 5.3: Number of people killed or affected by EWEs in Africa (1993-2003)

Type	Killed	Affected
Flood	9 642	19 939 000
Drought/Famine	4 453	110 956 000
Windstorms	11 335	5 687 000
Extreme temperatures	147	8 000
Total	15 713	136 590 000

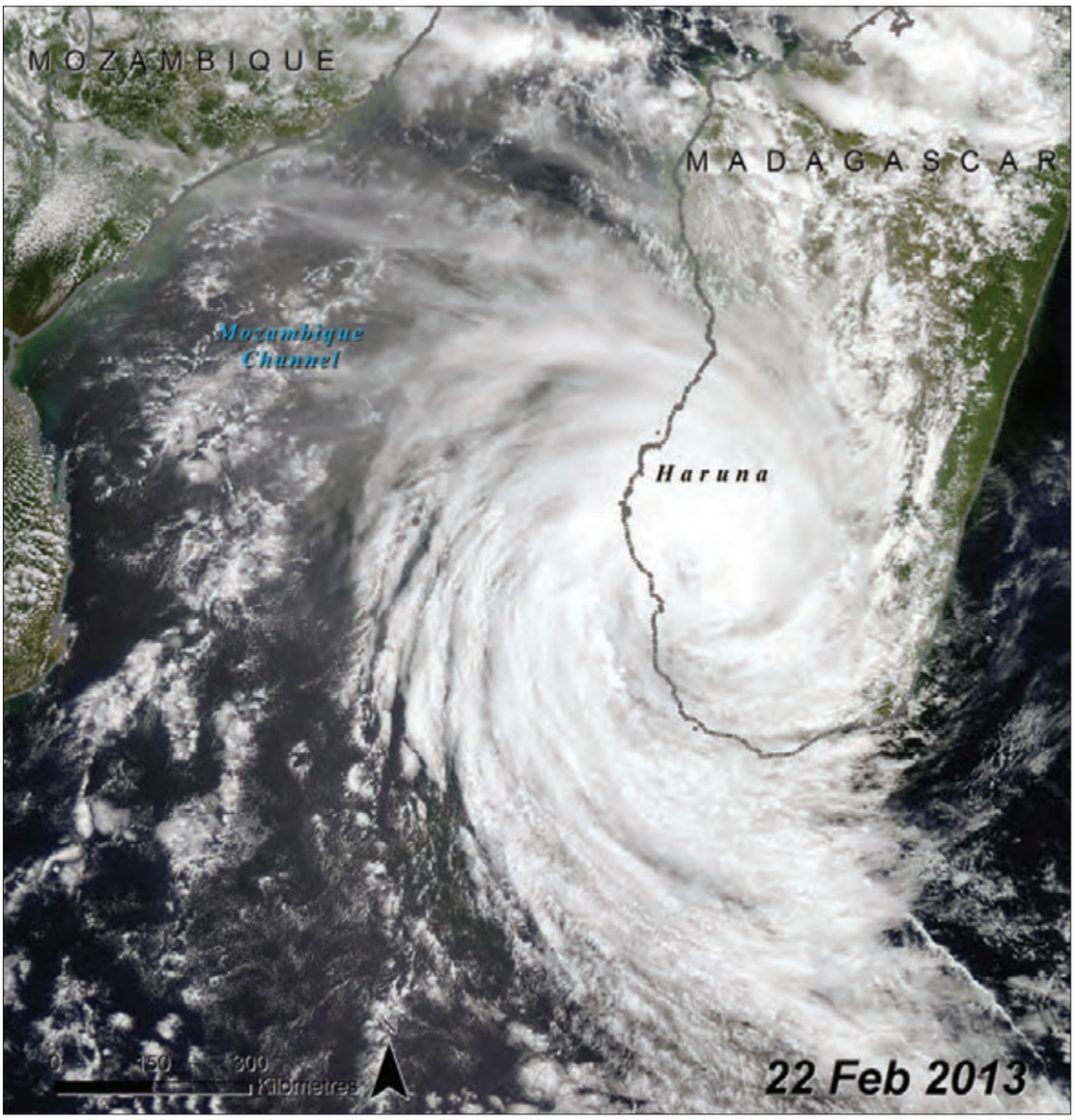
Source: EM-DAT data set quoted in Conway 2009

As is evident in Table 5.3, EWEs can cause death and injuries, as well as contaminate water sources. They also lead to intense incidences of water-borne diseases, and damage property, impede movement of people and goods and communication, and disrupt the supply of essential medical and health services. Droughts can increase food insecurity and malnutrition, increase the risk of outbreaks of diseases such as meningitis, or diseases spread by contaminated food and water.

Increases in EWEs associated with climate change are expected to lead to additional deaths and injuries, and population displacement. They are also expected to have adverse effects on food production leading to increases in malnutrition and on freshwater availability, increasing the risk for infectious disease outbreaks. This is particularly the case in low-income countries with lower climate change resilience and adaptive capacities (Confalonieri and others 2007).

In the Indian Ocean, tropical cyclones with storm surges and flooding have both short and long term effects on human health including drowning, injuries, increased disease transmission, and an increased incidence of common mental disorders (Hajat and others 2003). The islands of the western Indian Ocean witness an average of 12.5 cyclone formations between November and April (Mavume and others 2009). They are frequently influenced by tropical cyclones accompanied with very high winds and torrential rain. This is

Figure 5.5: Tropical Cyclone Haruna spinning over Madagascar

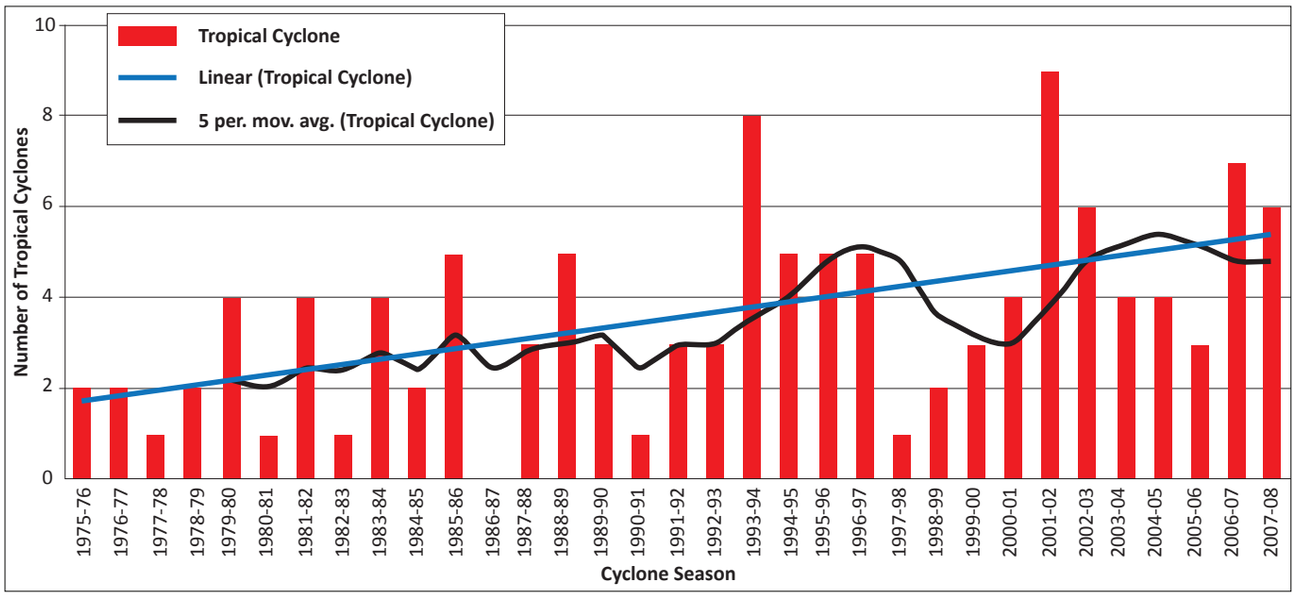


Source: MODIS; visualization by UNEP/GRID

particularly true of Madagascar, which lies on the path of almost all cyclones which form to the east of the country and move towards the west as well as others (Figure 5.5). Considerable losses to life and property occur with additional pressure on the national economy. In the South West Indian Ocean, an increasing trend in the number of intense cyclones (winds above 165 km/hr.) has been noted over the 32 year period spanning 1975-2008 (Figure 5.6).

EWEs have adverse effects on human health. But they also have indirect effects through a compounding effect of damages to infrastructure and health systems. For example, it was difficult for HIV anti-retroviral drugs to be delivered to Northern Namibia due to the floods there in early 2011 (UNECA 2011). Lack of food, shelter and safe water may also arise as a consequence of EWEs, especially in developing countries with low resilience (Shultz and others 2005) with potential consequences on the pattern of communicable and non-communicable diseases. Factors that can increase the risk of populations contracting respiratory, diarrhoeal and communicable diseases following an EWE include overcrowding, limited or no access to safe water, food insecurity as well as exposure to pollutants, pathogens and waste

Figure 5.6: Trend in number of tropical cyclones with gusts above 165 km/hr. (1975-2008) in the South West Indian Ocean



(del Ninno and Lundberg 2005 in Confalonieri and others 2007). The risks are particularly high in urban areas, where poor drainage and storm-water management increase the rates of infectious disease transmission (Confalonieri and others 2007). In addition to immediate impacts, EWEs can also lead to long term health issues, such as increases in susceptibility to infectious diseases and mental stresses, losses of infrastructure and territory, and displacement. The health effects of droughts, which are some of the most pervasive EWEs, are contained in Box 5.3.

Effects of sea level rise

Africa's coastal and estuarine areas are the most densely populated, and host highly productive ecosystems that comprise mangroves, estuaries, deltas and coral reefs. These ecosystems contribute significantly to local economies through tourism and fisheries. For example, 40 per cent of the population of West Africa currently lives in coastal cities, and it is expected that by 2020, more than 50 million people will live within 500 km of the coastline between Accra and the Niger Delta (Hewawasam 2002 in Boko and others 2007). By 2015, Abidjan, Alexandria and Lagos, three of the region's coastal megacities will each have a projected population of at least 8 million (Klein and others 2002 in Boko and others 2007; Armah and others 2005 in Boko and others 2007; Gommes and others 2005 in Boko and others 2007).

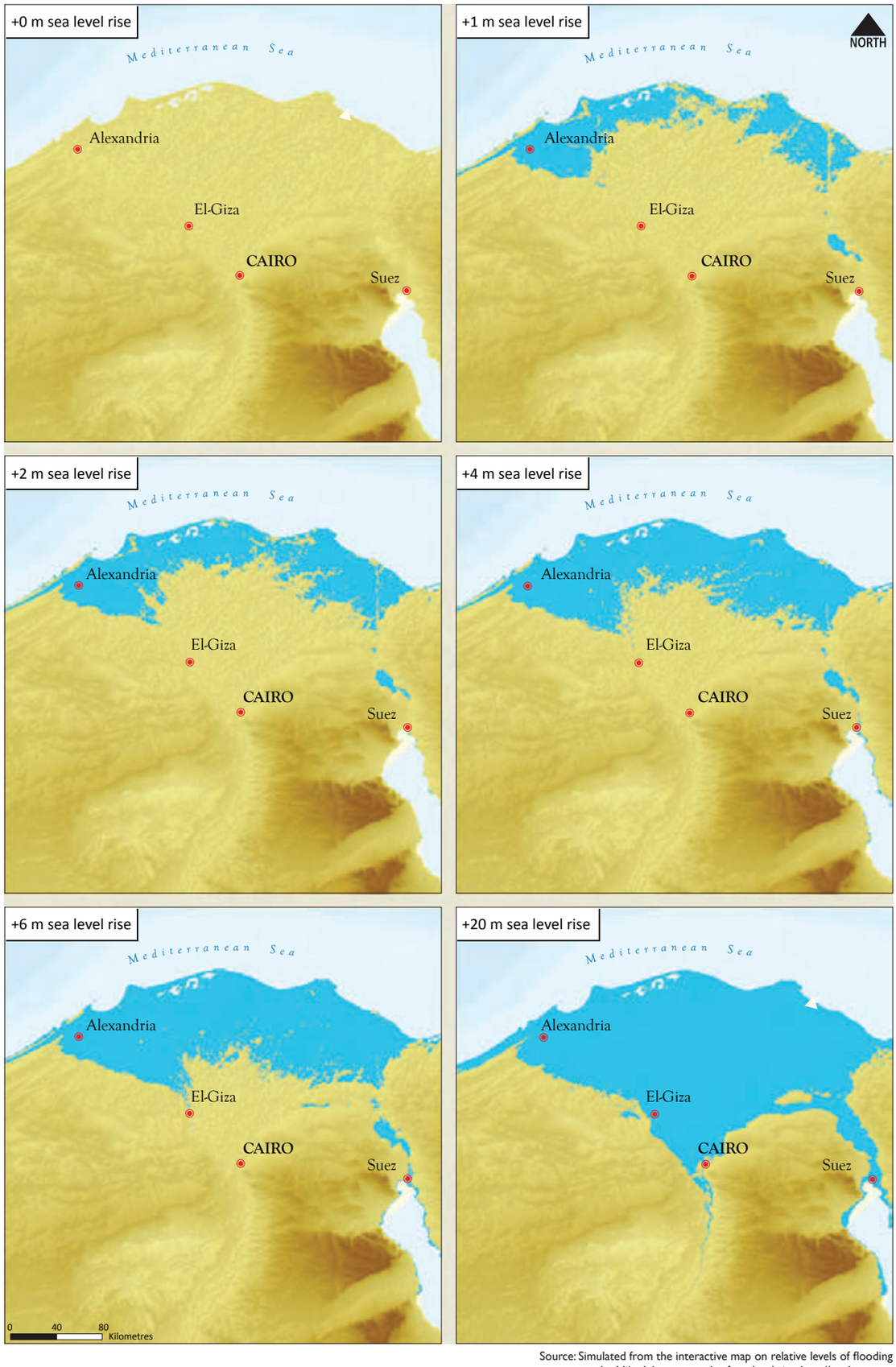
Box 5.3: Health effects of droughts

Droughts impact health through many channels, and may lead to deaths, malnutrition, as well as the spread of infectious and respiratory diseases (Menne and Bertollini 2000). Droughts may also increase food insecurity, and reduce the quality and quantity of food consumption, leading to micronutrient deficiencies. Malnutrition increases the risk of both acquiring and dying from an infectious disease.

Droughts and loss of livelihoods can lead to internal displacement or migration, particularly rural to urban migration (Confalonieri and others 2007). This in turn could lead to the spread of communicable diseases resulting from overcrowding, and lack of safe water, food and shelter (del Ninno and Lundberg 2005 in Confalonieri and others 2007).

Compounding effects such as poverty and HIV/AIDS exacerbate the negative impacts of droughts on health. For instance, a study in southern Africa suggests that HIV/AIDS amplifies the effects of drought on nutrition (Mason and others 2005 in Confalonieri and others 2007).

Figure 5.7: Scenarios showing the impacts of different sea level rise (0, +1, +2, +4, +6 and +20m) scenarios on the Nile delta



Source: Simulated from the interactive map on relative levels of flooding on the Nile delta as a result of sea level rise; http://geology.com.

Lagos, Nigeria

Even if Africa is expected to be less affected by sea level rise than other regions, the projected rise will still impact a significant number of people, particularly the poor and most vulnerable, who live in ecologically fragile areas (Klein and others 2002 in Boko and others 2007; Nicholls 2004 in Boko and others 2007). Cities such as Lagos and Alexandria will probably be impacted most. Three coastal deltaic areas likely to be significantly affected by sea level rise by 2080 have been identified in North Africa, West Africa and southern Africa (see Nicholls and Tol 2006 in Boko and others 2007; Warren and others 2006 in Boko and others 2007). For example, Figure 5.7 presents the impacts of different sea level rise scenarios on Egypt's Nile delta coastal area.

Other potential direct impacts arising from sea level rise include permanent connection of lagoons to the sea, salinization of inland waters, freshwater lagoons and aquifers, and destruction of wetlands (Conway 2009). In Cameroon, for example, indications are that a 15 per cent increase in rainfall by 2100 would likely decrease the penetration of salt water into the Wouri estuary (République de Côte d'Ivoire 2000 in Boko and others 2007). Alternatively, with an 11 per cent decrease in rainfall, salt water could extend up to about 70 km upstream. In the Gulf of Guinea, sea-level rise could induce overtopping and even destruction of the low barrier beaches that limit the coastal lagoons, while changes in precipitation could affect the discharges of rivers feeding them. These changes could also affect lagoonal fisheries and aquaculture (République de Côte d'Ivoire 2000 in Boko and others 2007).

Minimizing adverse health impacts of climate change and variability

A better understanding of the health implications of climate change and variability, as well as related development choices can lead to improved policies in all sectors, and increased resilience of the population to the negative impacts of climate change. This calls for integrated planning and considering the climate change-induced health impacts of sectoral policies and plans. Actions such as controlling vector-borne diseases, providing clean water and sanitation, and reducing reliance on energy sources that pollute the environment and harm human health will need to be scaled up.

To address the potential negative impacts of climate change on human health and increase the adaptive capacity of the population, public health planning and decision making need to adopt a long term perspective. This will enable them to take into account projected long term risks and changes associated with the impacts of climate change (in Boko and others 2007). In this context, integrated planning would promote the inclusion of climate change considerations in the health sector, by linking policy responses to strategic planning in related sectors such as agriculture, water and disaster management. In order to build resilience to climate change's negative impacts, it will be critical to build the capacity of African countries to understand and to use climate/health information for making decisions.

Addressing the underlying social and economic determinants of human vulnerability would also help to increase resilience of the population, thus reducing the magnitude of the impacts of climate change on human health. In this regard, initiatives aimed at education and raising awareness, strengthening health systems, ensuring adequate water and sanitation for all, and promoting disaster risk preparedness and response would build resilience into the national planning systems.

Early warning measures ensure that communities are better prepared for climate change related disasters such as drought, floods and even disease outbreaks. Existing surveillance systems should be reviewed in order to identify indicators that could be used for identifying and assessing climate-related health risks and the effectiveness of actions. The Famine Early Warning Systems Network has been used over the years to prepare countries for food shortages caused by droughts. The warnings provided by the Meningitis Environmental Risk Information Technologies (MERIT) project helped countries in East and West Africa prepare for the likely outbreak of meningitis by stocking the required vaccines. Scaling up early warning systems across the region will improve capacity for preparedness and responsiveness.

Better disaster preparedness at all levels is critical in minimizing the negative impacts of EWEs. So are early warning systems that are specially adapted to local circumstances and needs. Underlying vulnerabilities also need to be reduced through actions such as education as well as improving water and sanitation infrastructure, health systems and building designs.

Mitigation actions may also lead to co-benefits in terms of improved health through, for instance, lower air pollution levels. In this regard, cleaner energy sources, and safe public transport can bring important health gains to Africa's population. These co-benefits may provide significant incentives to undertake climate change mitigation and offset some of its costs.

In order to ensure better human health amidst climate change and variability, policy actions should be directed at:

- integrating climate-related scientific findings into decision-making
- empowering vulnerable communities to better cope with changes in their environments by encouraging them to engage in alternative livelihoods, and
- climate-proofing investments in climate sensitive sectors such as infrastructure, agriculture, water and health.

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6

Coastal and Marine Resources

Africa's diverse coastal and marine resources

Africa is bounded by the Mediterranean Sea to the north, the Atlantic Ocean to the west, the Indian Ocean towards the central and south east, and the Red Sea to the northeast. The Red Sea connects to the Mediterranean through the Suez Canal (Brown and others 2011). The 45 650 km coastline (Vafeidis and others 2008) is shared by the region's 48 mainland countries, as well as six island nations (Brown and others 2011). A myriad set of economic activities such as shipping, transportation and recreation depend on the resources that occur along Africa's coastline. The region's rich coastal and marine resources include mineral deposits, oil and gas as well as biodiversity, all of which have direct and indirect implications for human health.

To a large extent, the sustenance of life and human health is dependent on the oceans, coasts and seas which provide food, energy, climate regulation, transport and even recreation services (UNEP 2011). A significant proportion of Africa's population lives within 121 km of the coast and the density of human coastal populations is increasing annually. Up to 50 per cent of the population in northern Africa lives in coastal areas while along the Nile Delta, the population density reaches 500 to 1 000 people per sq. km (Brown and others 2002 in Creel 2003).

Coastal and marine ecosystems, including coral reefs, mangroves, sea grass beds, lagoons, inter-tidal systems and the oceans, are some of the most productive resources, providing goods and services that support human health. For example, in the Cape Floristic region of South Africa, the harvest of marine resources such as line-fish, rock lobster, abalone and bait species is worth

Satellite view of the coral reefs surrounding southern Zanzibar

Landsat 8

over R1 300 million per year (US$ 186 million at current exchange rate) (Turpie and others 2003). In addition to supplying food and medicines, as well as facilitating opportunities for bio-prospecting, coastal and marine resources are also important in regulating storms and detoxifying polluted waters and waste. They also have cultural and amenity values which drive tourism and recreation, and provide habitat for a wide range of biological resources (UNEP 2006b).

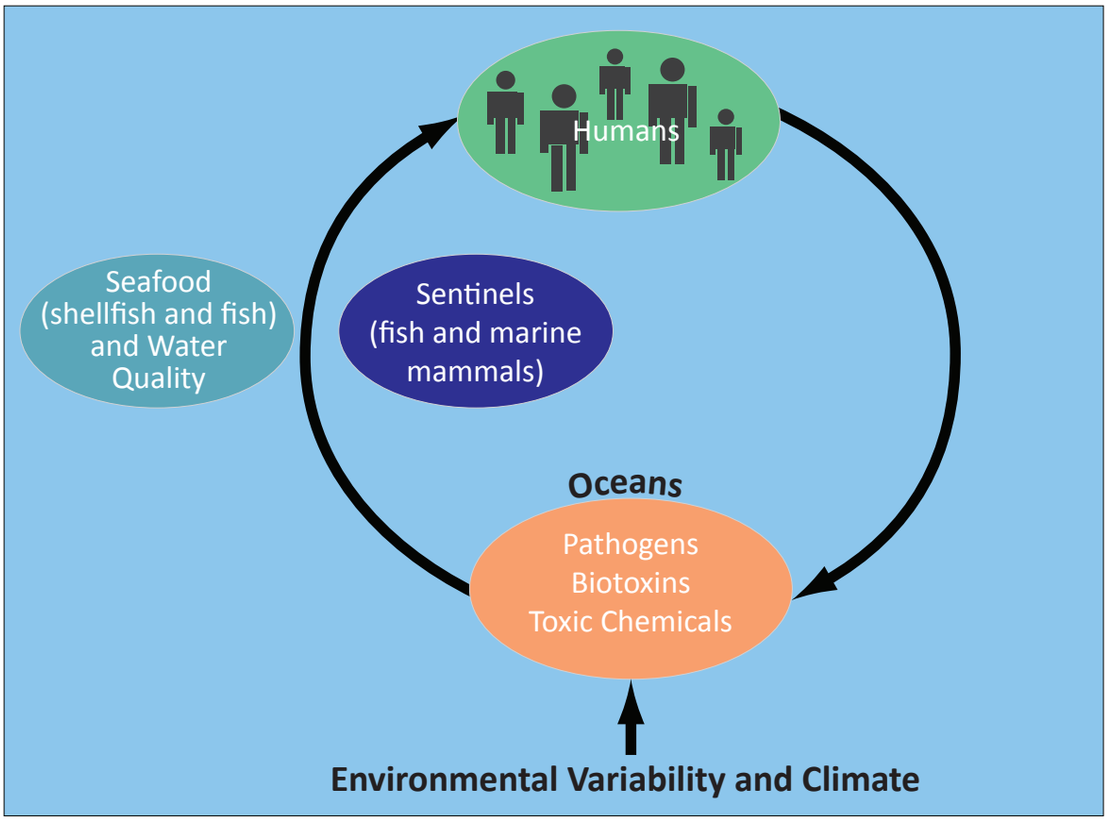
Coastal and marine resources are also important sites for human settlements and infrastructure such as undersea cables, harbours and ports. Some coastal countries in the region such as Angola, Gabon and Nigeria are large players in the world's oil industry, while in countries such as Sierra Leone and the United Republic of Tanzania, coastal resources are important sources of construction materials, including sand, gravel and limestone. Phosphate mining and salt extraction are also key coastal activities in Africa. These vast and rich coastal and marine resources of Africa portend both positive and negative implications on human health.

Coastal and marine resources link to human health

There is growing research and policy interest in the interaction between oceans, seas and coastal resources, and human health. Coastal and marine resources on the one hand, and humans on the other, are inextricably linked through activities on land, sea, and in the air with clear impacts on the health of both humans and living marine resources. These resources have both direct and indirect links to human health (Figure 6.1), such as the production of drugs (Abed and others 2011).

The direct impacts of oceans on human health are both detrimental and beneficial (Fleming

Figure 6.1: Linkages between coastal and marine resources and human health



Source: NIOSH 2003 in Fleming and others 2006

Box 6.1: The medicinal value of mangroves

Mangrove extracts have medicinal properties. For example, the leaves of the *Bruguiera* species reduce blood pressure, while *Excoecaria agallocha* treats leprosy and epilepsy. Seeds of *Xylocarpus* species and the bark of *Rhizophora* species are used to treat diarrhoea, while leaves of *Acrostichum* can be used as a vegetable. In addition to their medicinal value, mangrove forests also protect coastal communities from cyclones and storms as well as their adverse health effects.

Bruguiera species of mangrove in Mozambique

Source: Kathiresan 2000

and others 2006). Earlier, many of the reported harmful effects were death and injury, which were linked to occupations such as marine fishing and maritime transport (NIOSH 2003 in Fleming and others 2006). Emerging issues that link coastal and marine environments to human health now include: global climate change, harmful algal blooms (HABs), microbial and chemical contamination of marine waters and seafood, and marine models and natural products from the seas (Fleming and others 2006). Generally, marine products have a wide range of applications as key ingredients of pharmaceuticals, cosmetics and nutritional supplements. Sharks and horseshoe crabs, for instance, contain essential compounds for the treatment of certain forms of cancer, muscle diseases, and chronic pain (Chivian and Bernstein 2008). Mangroves, which constitute coastal forests, are not only important for fish spawning, but also for their medicinal value (Box 6.1).

People living in coastal regions risk exposure to the cumulative burden of environmental stress on coastal and marine ecosystems emanating from the human activities and overcrowding of the coast and from upstream and inland development. Burdens of pollution, deforestation, and inadequate management of soil, water, pesticides, and fertilizers increasingly pose greater threats to human health. Sewage remains the largest source of coastal environmental contamination (Doney and others 2012) as discharges from expanding cities and settlements are fast increasing.

The coastal and marine resources links to human health are related to their fragility and the implications of degraded oceans, coasts and seas. Diseases such as cholera and other waterborne ailments are common in coastal areas as a result of declining water quality, climate change, and eutrophication-driven algal blooms. Human neurological disorders and even death have also been blamed on algal blooms (including red tides) that contaminate seafood. Red tides contain toxins which can accumulate in marine organisms which if consumed or handled by humans can cause gastrointestinal, neurological and respiratory disorders (UNEP 2006b).

Other diseases which are on the increase, such as ciguatera, are linked to toxin accumulation in marine organisms and emergence of new pathogens. The diseases have considerable impacts on human well-being by directly affecting morbidity and mortality rates. In addition, import bans on fish and other sea food from coastal areas with infectious disease outbreaks have economic implications for countries and the communities affected. Important tuna producing countries such as Mozambique have been recently affected by such bans due to cholera outbreaks. This was expected to lead to substantial loss of export income and thousands of jobs.

Pollution of near shore waters and other marine

ecosystems also affects human health through consumption of fish and other marine products that contain heavy metals, PCBs, POPs, and other toxins that have bio-accumulated in the food chain. The contamination is also linked to sewage from coastal cities and poorly serviced human settlements which are on the increase. Chronic exposure to such pollutants has the cumulative effect of causing infertility. Globally pollution of coastal waters resulted in US$ 12 billion in public health costs (Shuval 2003). Africa has been reported to bear over 30 per cent of this burden (UNEP 2011).

Many diseases are associated with marine phytoplankton proliferation due to consumption of toxin-contaminated seafood such as shellfish (Faulkner 2000). According to Fleming and others (2006), these diseases include amnesic shellfish poisoning, diarrheic shellfish poisoning (DSP), neurotoxic shellfish poisoning (NSP), azaspiracid shellfish poisoning (AZP), and paralytic shellfish poisoning (PSP). Other less common ailments include ciguatera fish poisoning caused by consumption of fish contaminated with ciguatoxins emitted by phytoplankton (Backer and others 2005 in Fleming and others 2006). Other health complications result from human exposure to HAB. For example, both upper and lower respiratory symptoms and decreased respiratory function are common among people who frequent contaminated beaches with active blooms (Fleming and Laws 2006 in Fleming and others 2006). HAB toxins primarily affect the neurologic system while other toxins, for example those from the blue green algae (cyanobacteria), can cause dermatotoxicity, hepatotoxicity, immunotoxicity, and respiratory toxicity. In addition, some are carcinogenic (Backer and others 2003 in Fleming and others 2006).

There is evidence of increase in the incidence and prevalence rates of these diseases particularly in coastal areas where seafood constitutes a significant portion of subsistence food. In Africa, the segment of the population most exposed and at greatest risk of these diseases consists of those who are occupationally involved in seafood harvesting, shipping and processing. Others are consumers of seafood, environmental workers, and individuals who live, work and play on or near coastal waters. Local communities such as indigenous peoples who rely on seafood for a substantial proportion of their diet are also at risk (Fröcklin and others 2012).

There is a subtle link between the health of marine fauna and flora and that of human beings. For instance, marine mammal mortalities and poor health continue to raise concerns about the

Polluted canal in Egypt

runintherain / Foter / CC BY NC SA

Table 6.1: Marine mammal species caught and used for human consumption by country (or dependency) during the period 1970-2009

Sub-region	Country	Marine mammal species
Northern Africa	Egypt, Arab Rep.	Dugong
	Sudan	Dugong
Western Africa	Benin	West African manatee
	Cape Verde	(Humpback whale), common dolphin, melon-headed whale, bottlenose dolphin
	Côte d'Ivoire	Unspecified delphinids, west African manatee
	Gambia, The	Atlantic humpback dolphin, bottlenose dolphin, west African manatee
	Ghana	Humpback whale, sperm whale, dwarf sperm whale, common dolphin, short-finned pilot whale, Pygmy killer whale, Risso's dolphin, Fraser's dolphin, melon-headed whale, false killer whale, pantropical spotted dolphin, Clymene dolphin, Atlantic spotted dolphin, spinner dolphin, rough-toothed dolphin, bottlenose dolphin, Cuvier's beaked whale, west African manatee
	Guinea	(Common minke whale), Bryde's whale, pygmy sperm whale, Atlantic humpback dolphin, bottlenose dolphin, west African manatee
	Guinea-Bissau	Unspecified delphinids, west African manatee
	Liberia	West African manatee
	Mali	West African manatee
	Mauritania	Atlantic humpback dolphin, unspecified other delphinids
	Niger	West African manatee
	Nigeria	Bottlenose dolphin, west African manatee (Saint Helena) (pantropical spotted dolphin), (bottlenose dolphin)
	Senegal	Common minke whale, Bryde's whale, harbor porpoise, common dolphin, (pygmy killer whale), short-finned pilot whale, (Risso's dolphin), Atlantic humpback dolphin, pantropical spotted dolphin, (rough-toothed dolphin), bottlenose dolphin, west African manatee
	Sierra Leone	Unspecified delphinids, west African manatee
	Togo	Antarctic minke whale, humpback whale, west African manatee
Central Africa	Cameroon	Humpback whale, sperm whale, unspecified delphinids, west African manatee
	Chad	West African manatee
	Congo, Dem. Rep.	West African manatee
	Congo, Rep.	Atlantic humpback dolphin, bottlenose dolphin, west African manatee
	Equatorial Guinea	Humpback whale, west African manatee
	Gabon	Common dolphin, false killer whale, bottlenose dolphin, west African manatee
	São Tomé and Principe	Unspecified delphinids
Southern Africa	Angola	West African manatee
	Namibia	(Heaviside's dolphin), Cape fur seal
	South Africa	(Common minke whale), (Bryde's whale), (fin whale), humpback whale, (sperm whale), (Heaviside's dolphin), (common dolphin), Risso's dolphin, Fraser's dolphin, dusky dolphin, (killer whale), (bottlenose dolphin), strap-toothed whale, (Cape fur seal)
Eastern Africa	Comoros	Dugong
	Djibouti	Dugong
	Eritrea	Dugong
	Kenya	Dugong
	Madagascar	Humpback whale, sperm whale, dwarf sperm whale, Fraser's dolphin, killer whale, melon-headed whale, Indo-Pacific humpback dolphin, spinner dolphin, bottlenose dolphin, dugong
	Mayotte	Dugong
	Mozambique	Indo-Pacific humpback dolphin, dugong
	Seychelles	Spinner dolphin, bottlenose dolphin
	Somalia	Unspecified delphinids, (dugong)
	United Republic of Tanzania	Humpback whale, Risso's dolphin, Indo-Pacific humpback dolphin, pantropical spotted dolphin, spinner dolphin, rough-toothed dolphin, bottlenose dolphin, dugong

Note: Species in parentheses were only reported after 1990.

Source: Robards and Reeves 2011

associated degradation of coastal and marine ecosystems. Most marine mammals share similar prey with humans. It therefore means that understanding marine mammal health and disease dynamics can lead to a better understanding of current and potential impacts to human health, especially emerging diseases. Human beings tend to occupy the top of food chains that include marine mammals. Table 6.1 summarizes some important mammal species caught and used in African countries.

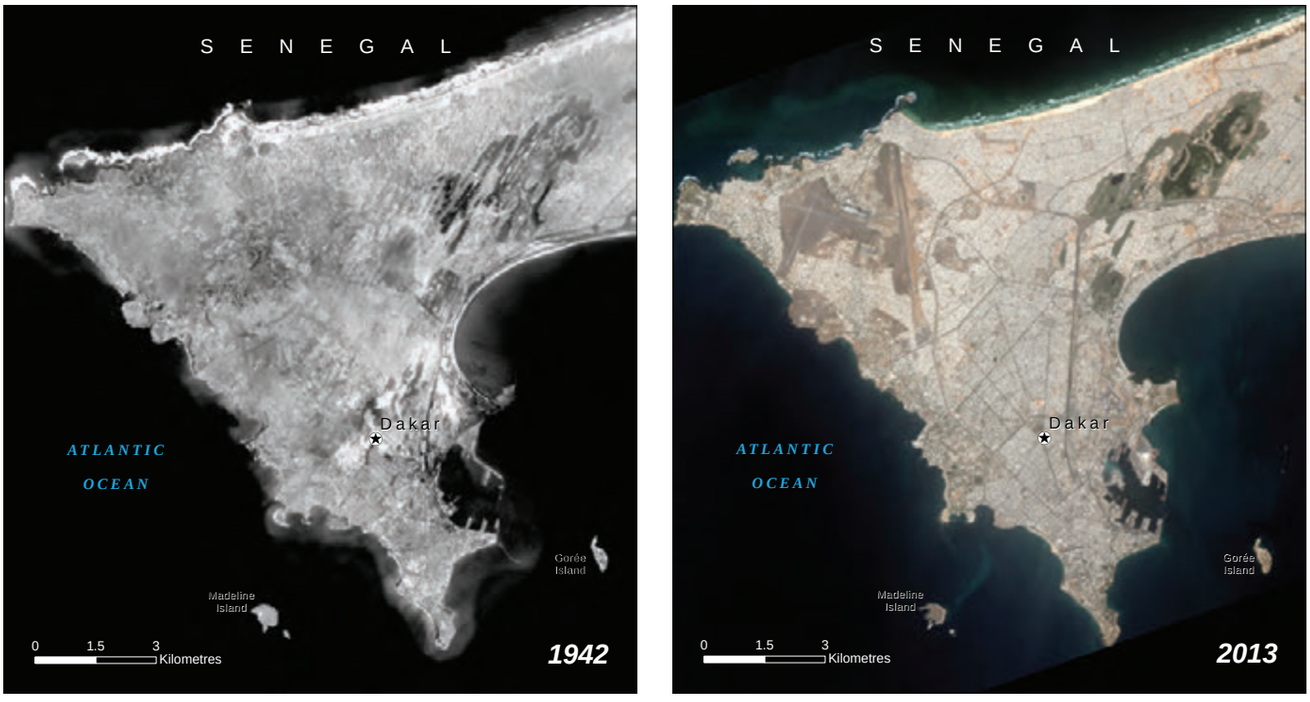
Threats to Africa's coastal and marine resources

Urbanization, population growth and other human activities

There are 320 coastal cities in Africa, and about 60 per cent of the region's coastal population lives in these urban areas (UN-HABITAT 2008). For example, in Senegal, 61.6 per cent of the country's population that lives in the Dakar coastal area is at risk (Figure 6.2) (Watson and others 1997). According to Ibe and Awosika (1991 in Brown and others 2011), there is a high concentration of residential, industrial, commercial, agricultural, transportation, tourist, educational and military facilities along Africa's coastline, and these could be affected by sea level rise. Owing to the large coastal population in Africa, there are significant fisheries activities. While these activities are artisanal and based in the coastal zone, population pressures resulting in increased demand are leading to the use of destructive methods such as dynamite fishing, which affects coral reefs.

In addition, due to weak systems for monitoring, the region faces the problem of overfishing mainly from poaching by foreign vessels. As a result, tuna in the western Indian Ocean is heavily exploited and on the Atlantic coast, foreign fishing fleets are said to have depleted deep water prawn and shrimp resources (Ibe 1996). High levels of urbanization along the coast also imply that there is a lot of economic activity in Africa's coastal zones. These include mining of sand and gravel from

Figure 6.2 Satellite imagery showing the change in population density on the coastline of Dakar, Senegal



Source: 1942 image: Corona data; 2013 image: DigitalGlobe; visualisation by UNEP/GRID

estuaries, beaches and the near-shore continental shelf (Ibe 1996). As such coastal erosion is a challenge in the region, particularly in Cote d'Ivoire, Kenya, Liberia, Mauritius, Mozambique, Nigeria, Seychelles, Sierra Leone and the United Republic of Tanzania(Bryceson and others 1990 in Ibe 1996), as well as in Benin, The Gambia, Ghana, Guinea Bissau, Guinea, Senegal and Togo (UEMOA 2011).

Besides the increased threat of coastal erosion, mining from the coastal zone also disrupts fragile ecosystems such as coral reefs and mangroves and affects their productivity (Ibe 1996). The exploration, exploitation, refining, and transportation of oil and gas in Africa's coastal areas, although contributing to economic development, also cause pollution. This is because of hydrocarbon pollution from occasional spills and from low-level releases associated with leaking valves, corroded pipelines, ballast water discharges, and production water effluents. Marine pollution also comes from raw or insufficiently treated domestic sewage and from untreated toxic wastes from industries.

By bathing or swimming at coastal beaches contaminated with pathogenic micro-organisms from domestic wastewater, people are exposed to enteric and respiratory diseases (Bartram and Rees 2000), with the rates of infection and disease increasing with the level of contamination (Prüss 1998). Fish supplies 17 per cent of the animal protein consumed in the region in 1995 (FAO undated). Seafood, particularly molluscs that are normally eaten uncooked, provides another route for transmission of infectious diseases caused by pathogens that enter the marine environment through untreated domestic wastewater (Hernroth and others 2002). Human health risks also stem from severe storms such as tropical cyclones, which due to their violent nature, have the potential to cause morbidity, mortality, and property loss. Sea level rise also has the potential to directly affect people through inundation. In Africa, coastal populations are vulnerable due to high densities of people living in unprotected floodplains, lack of proper and accessible shelter, and inadequate credible early-warning systems (Patz and others 2000).

The escalation of human developments in coastal watersheds is putting more environmental pressure on downstream fragile estuarine and coastal ecosystems (Bouvy and others 2010). The estuarine and coastal ecosystems are consequently increasingly experiencing declining water quality and eutrophication (Philomene 1997) resulting from increasing anthropogenic activities. Human activities like agriculture, fisheries, tourism, expansion of urbanization and industry as well as transport are leading to accumulation of more quantities and new types of pollutant inputs causing decline in the quality of natural habitats in these areas (Aswani and Furusawa (2007). Urban sewage pollution with high nutrient loads and a diversity of pollutant inputs leads to proliferation and abundance of microbial communities in estuaries which are in turn exposed to rapidly changing environmental conditions (Lozupone and Knight 2007). Bathing in or ingesting sewage-contaminated water can cause infections and transmit diseases such as cholera, particularly among children under five (Philomene 1997).

Likewise, the other human livelihood support systems such as settlements, infrastructure development (like undersea cables, pipelines, oil rigs, harbours and ports), oil production, harvesting of aggregates and extractive tourism along the coastline and in the open ocean risk degrading these fragile ecosystems. Vector control actions such as the periodic spraying of the sea ports and airports with DDT for the control of malaria vectors, as is done in SIDs such as Mauritius (WHO 2007), have similar effects.

Overfishing

For many people in Africa, fish represents a low cost source of protein and subsistence income. However, per capita fish consumption in the

region is low, estimated at an average of 7 kg per year compared to the annual global average of 16 kg (Agnew and others 2010). The low levels of fish consumption are partly due to low fish catches which result from use of poor fishing gear by local fisher folk, as well as overfishing in some of Africa's waters.

The rising demand for fish globally occurs at a time when fish stocks are declining, with FAO (2007) estimating that three-quarters of the world's available fisheries are either being fished at their maximum or are being overfished, and only 1 per cent are classified as recovering from overfishing. Since the 1980s, global fish landings are decreasing at a rate of 700 000 tonnes a year, resulting in the targeting of smaller species (Standing 2008). However, in Africa, the total reported marine fish capture continues to increase, with about 4.6 million tonnes recorded in 2003 (World Bank 2012). The increasing tonnage is partly due to the fact that Africa's marine resources are gaining strategic and financial value (Standing 2008). This is aided by technological improvements in fishing such as sophisticated boats that have better devices for attracting fish and access to digital maps and powerful sonar systems which make it easier to explore much of the ocean.

Much of the improved fishing gear is foreign owned, and operates in Africa illegally or under license. For example, much of the fisheries of the Somali Current upwelling is captured by illegal fisher folk, while in the West Indian Ocean, much of the tuna is exploited under license by foreign fleets (UNEP 2006a). This illegal, unreported and unregulated (IUU) fishing is blamed for food insecurity among coastal communities where most people depend on the fishing industry.

West Africa, which is one of the world's richest fisheries grounds, loses up to US$ 1.5 billion worth of fish annually to vessels fishing in protected zones or without proper equipment or licences (Anyimadu 2013). While most of the illegal catches are unaccounted for, West Africa's recorded total fish landings rose from 600 000 tonnes in 1960 to 4.5 million tonnes in 2000, making it one of the most important sources of foreign exchange in Africa (NEPAD 2012). The fisheries sector also makes a significant contribution to the national Gross Domestic Products (GDPs) of many countries. For example, in Madagascar, Mozambique and Sierra Leone, the contribution of the fisheries sector to national GDP is 9.5, 8 and 7 per cent, respectively (AfDB 2008). In Namibia and Senegal, marine fisheries exports contributed 6 per cent to the national GDP in 2005 (FAO 2007). The annual export value of fish from Africa is estimated at US$ 3 billion (NEPAD 2012). Worldwide, fisheries and fish products provided direct employment to nearly 38 million people in 2003 (FAO 2004). In Seychelles, the fisheries sector accounts for 15 per cent of direct formal employment (Robinson and others 2006), while in Senegal, the marine fisheries sector employs 125 300 people in direct and indirect employment (Agnew and others 2010).

While it is nutritious, fish from the sea can also be poisonous. For example, ciguatera poisoning caused by eating contaminated fish is endemic in tropical and subtropical regions (Boada 2010), and is the most commonly reported marine seafood toxin poisoning. Ciguatera toxins accumulate in predator fish such as the barracuda and other carnivorous reef fish, because they eat other fish that consume toxin-producing algae (dinoflagellates) that live in coral reef waters. Ciguatera toxin is harmless to fish but poisonous to humans. Incidents of ciguatera fish poisoning have been reported in Madagascar, Mauritius and Seychelles (Habermehl and others 1994).

In view of the threat of disrupting food supply and the livelihoods of the people that directly depend on the fisheries industry, the Johannesburg Plan of Implementation encourages the establishment of Marine Protected Areas (MPAs) to conserve

marine resources. This would ensure sustainable economic development and improve food security by mitigating overexploitation of fisheries and halting marine biodiversity loss. However, weak governance and institutional capacities affect the establishment and effectiveness of MPAs in some regions (Abdulla and others 2009). MPAs often tend to be smaller and wider apart than is ecologically viable (Abdulla and others 2008). Marine Managed Areas (MMAs) offer an effective alternative, as they include multiple management zones and protected no take zones (UNEP 2012). Africa's widest network of MMAs stretches over 23 sites in six countries of West Africa – Cape Verde, The Gambia, Guinea Bissau, Guinea, Mauritania and Senegal. The MMA concept has been successful in ensuring that fisheries, tourism, and oil and gas development do not adversely impact the marine ecosystem and its biological resources (Karibuhoye 2008 in UNEP 2012).

Marine pollution

An estimated 38 per cent of Africa's coastal ecosystems, including mangrove swamps and coral reefs, is at risk of pollution from marine transportation, industry and domestic sources (UNEP 2002). Over 80 per cent of the marine

Box 6.2: Collaborative transboundary marine pollution management in the Guinea Current Region of West Africa

Covering 16 countries and extending from Guinea Bissau to Angola, the Guinea Current Large Marine Ecosystem (GCMLE) has unique characteristics that make it prone to marine pollution. The region is an important centre of marine biodiversity and marine food production owing to its productive coastal and offshore waters. Pollution problems emanate from domestic and industry sources. There is persistent over-exploitation of fisheries as well as an escalation of ill-planned and ill-managed coastal developments. These, plus other near-shore activities continue to cause degradation of the already vulnerable coastal and offshore habitats, putting the economies and health of the human inhabitants at risk.

Recent studies in the GCMLE confirm identified four broad multiple coastal and marine environmental problems and issues:

1. Decline in GCLME fish stocks and unsustainable harvesting of living resources
2. Uncertainty regarding ecosystem status, integrity and yields in a highly-variable environment including effects of global climate change
3. Deterioration in water quality
4. Habitat destruction and alteration including the modification of the seabed and coastal zone, degradation of coast capes and coastline erosion.

There is a buildup of catastrophic and chronic water quality deterioration from land and sea-based industrial and agricultural activities as well as urban and domestic sewage run-off. Mining activities especially in the oil sector form the other major source of marine pollution. Incidences of eutrophication and harmful algal blooms are increasing and are transboundary in nature.

To address the environmental problems of the region, the 16 member countries have adopted Transboundary Diagnostic Analysis (TDA) with a holistic, multi-sectoral and regional approach to managing the ecosystem. The approach is embodied in the Strategic Action Programme to be implemented by the Guinea Current Commission.

The main management actions adopted to reverse the transboundary pollution in GCLME include joint policy actions to combat coastal and marine pollution, adoption of priority investment actions such as periodic assessments of the water quality and trends; household level sewage treatment infrastructure; and provision of secondary sewage treatment to targeted coastal urban populations. There are also a number of cross-sectoral investment actions in place.

Source: Ukwe and Ibe 2010

Fresh fish ready for sale in Senegal

pollution in Africa comes from land-based activities (WWF undated), including fertilizers, oil spills, and untreated sewage. Some pollutants are directly introduced into the marine and coastal environment. For example, in Mauritius the port and airport are sprayed twice yearly with DDT for the control of malaria vectors (Tatarsky and others 2011), and this constitutes a potential health threat to the marine environment.

Pollution of marine and coastal resources is also driven by growth in coastal urbanization (Guyonnet and others 2003), expanding maritime transportation (Galdies 2008), and oil spills (Galdies 2008; Golik 1988). As a result of rapid coastal urbanization, an estimated 85 per cent of the sewage that flows into the Mediterranean Sea in North Africa is untreated, creating risks of outbreaks of diseases such as dysentery and typhoid (Miller 2006). Box 6.2 illustrates the case of transboundary marine pollution and efforts to manage it collaboratively in West Africa.

Maritime transportation is another cause of marine pollution. The coastal waters of the Red Sea and Western Indian Ocean, which are major sea routes for large petroleum and oil tankers that supply the world with products from the Middle East, are at high risk of oil spills. In addition, tankers often discharge ballast water and wash engines on the high seas, and residues of degraded oil are consolidated and washed ashore by winds, currents and waves (UNEP 2006a). In West Africa, the oil producing countries in the GCLME alone discharge about 4 million tonnes of waste oil yearly into the coastal and marine environment (GEF and others 2011). Widespread oil pollution, in the Niger Delta also results in ecological, public health and security problems (Badejo and Nwilo 2010). Other sources of marine pollution include waste water discharges, and effluents from logging, manufacturing industries and oil refining (Box 6.3).

Infrastructure development, intensive agriculture, urbanization and unplanned coastal developments are some of the processes that increase the flow of sediments and sewage into the coastal and marine environment. Urban and tourist developments along the East African coast, for example, do not have the requisite infrastructure for wastewater treatment. The increasing flow of sewage into coastal waters poses a direct threat to human health and the environment (Moynihan and others 2012). Ingestion of sewage contaminated water increases the incidence of gastroenteritis whose symptoms include nausea,

Box 6.3: Pollution of the Lagos Lagoon

Wastewater discharge from the University of Lagos campus treatment plant into the Lagos lagoon resulted in high levels of biological oxygen demand of 73 per cent, 65.8 per cent for chemical oxygen demand, 26 per cent for total dissolved solids and 72 per cent for total nitrogen, which are higher than national limits (Longe and Ogundipe 2010). In the Cameroon Gulf of Guinea, which incorporates Idenau beach, Mudeka/Tiko creeks, Limbe estuary and Douala Lagoon, there are high levels of salinity averaging 20 per cent and 12 per cent during the dry and rainy seasons, respectively, while levels of organic nutrients range from 825 to 1 671 ppm (Oben and others 2007). These high levels of pollutants from logging, manufacturing industries and oil refining, promote the occurrence of harmful cyanobacterial blooms, including Lyngbya which causes dermatitis. Through the consumption of fish and shellfish, residents of the Cameroon Gulf of Guinea report cases of sudden abdominal cramps, headaches and diarrhoea (Oben and others 2007).

Figure 6.3: Shipwreck sites around Africa

Source: WRECKSITE 2012

vomiting, fever, diarrhoea and dysentery (Moynihan and others 2012). Sewage-polluted waters also spread severe diseases such as typhoid fever, dysentery, hepatitis and cholera (Moynihan and others 2012). In addition to diarrhoeal diseases, sewage contaminated water also causes eye and skin infections, such as trachoma. Schistosomiasis is also a water-related disease.

In addition to pollution by pesticides and oils, the coastal waters of Africa are also littered with ship wrecks, including oil tankers (Figure 6.3). Some of these ship wrecks date as far back as World War I and are beginning to disintegrate. The ship wrecks pose a high risk due to the large quantities of oil that ships usually carry on board. In addition, the oil pollution such as that caused by such shipwrecks and other maritime accidents, imperils the health of coastal populations and contaminates the marine ecosystem.

The Abidjan and Jeddah Conventions and associated Protocols provide important regulatory mechanisms for the control and management of marine pollution (UNEP 2012). Local initiatives such as the GCLME-initiated waste exchange

programmes, waste reduction and ecosystem recovery are also important in the control of marine pollution (Ukwe and Ibe 2010).

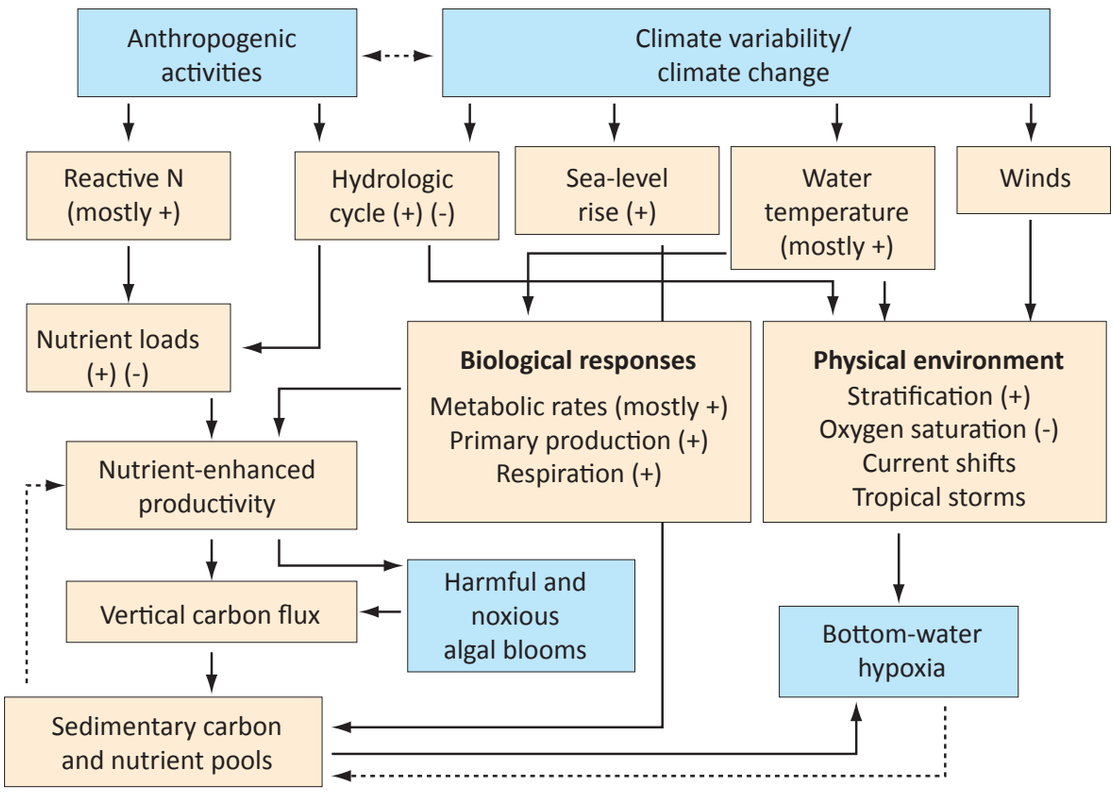
Climate change

According to IPCC (2007), climate change will exacerbate existing physical, biological, and socio-economic stresses on the African coastal zones. Evidence abounds about the extent to which sea level rises may lead to inundation and erosion of low-lying areas or increase flooding caused by storm surges and intense rainstorms (Tobey and others 2010). The coastal nations of west and central Africa such as Senegal, the low-lying lagoonal coasts of the Angola, Cameroon, Gabon, The Gambia, Nigeria and Sierra Leone are vulnerable to erosion and threats of sea-level rise. This is principally because most of the countries in this area have major and rapidly expanding cities along the coast (IPCC 1996 in Watson and others 1997). A conceptual diagram of the interaction between human health and climate change in coastal regions is shown in Figure 6.4. Climate

Shipwrecks threaten coastal and marine resources

Tristam Sparks / Flickr / CC BY NC ND 2.0

Figure 6.4: Conceptual diagram of human and climate interactions on nutrient-enhanced productivity, harmful and noxious algal blooms, and formation of hypoxia



Notes:

- Positive (+) interactions designate a worsening of conditions related to algal blooms and hypoxia, and negative (−) interactions designate fewer algal blooms and lessening of hypoxia symptoms.
- Dashed lines indicate negative feedback processes to nutrient-enhanced production and subsequent hypoxia.
- Dotted line between anthropogenic activities and climate change and variability indicates that while current climate change is driven largely by humans, it also impacts human activities.

Source: Doney and other 2012

Box 6.4: Climate change induced effects on ecosystems services from seas

Climate change puts at risk many of nature's benefits, or ecosystem services, that humans derive from the coastal and marine ecosystems. In Africa, where many people rely on such services with direct influence on health, it is expected that the impacts will have repercussions on society's dependence on the coastal and marine resources for wild-caught and farmed food, recreation, nutrient cycling, waste processing, protection from natural hazards, climate regulation, medicine, and other services. For example, climate-induced sea-level rise could put added pressure on coastal infrastructure and thus the health and safety of human communities. Natural habitats such as wetlands, mangroves, coral and oyster reefs, and sea grasses buffer coastlines from erosion and inundation, providing important protective services.

One of the many advantages of nature-based protection is that those habitats also provide other benefits, including nursery grounds for commercial and recreationally valued species, filtration of sediment and pollutants, and carbon storage and sequestration. The social values of these services are broad and include those reflected in markets, avoided damage costs, maintenance of human health and livelihoods, and cultural and aesthetic sustenance. Understanding how human activities and a changing climate are likely to interact to affect the delivery of these ecosystem services is of the utmost importance to science, policy and practice for sustainable management of African coastal and marine resources. Decisions on these activities affect the health of marine and coastal systems and their ability to sustain future human generations.

Source: Modified from Doney and others 2012

change induced effects on ecosystems services from seas are highlighted in Box 6.4.

Sea level rise

Africa is one of the continents that are most vulnerable to the impacts of sea level rise arising from ocean thermal expansion and glacial melt. Projections of global mean sea level rise over the period 1980-2099 are expected to be in the order of 0.18-0.59 m (Solomon and others 2007). Sea level rise is expected to worsen coastal erosion and enhance salt water intrusion. Coastal erosion reached 23-30 m annually in some parts of coastal West Africa in the 1980s (Ibe and Quelennac 1989 in World Bank 2006). In Cote d'Ivoire, high erosion rates occurred around the Abidjan harbour. Damming of rivers deprives coastal zones of sediment, leading to widespread coastal erosion. For example, in West Africa, damming of the Upper Niger, Benue and Volta Rivers altered the flow reaching the Niger Delta (World Bank 2006), while in Ghana, the construction of the Akosombo dam in 1965 accelerated coastal erosion west of Accra (UNEP 1999 in UNEP 2002). With sea level rise, the problem of coastal erosion is set to worsen. Coastal erosion is most severe in sparsely forested areas which are mostly inhabited by mangroves.

One of the African countries that are expected to be particularly affected by climate change and sea level rise due to its relatively low elevation at its Mediterranean shoreline is Egypt. A one-metre

Alexandria, Egypt

dungodung / Foter / CC BY SA

Figure 6.5: African cities that are at risk due to sea level rise

Source: UN-HABITAT Global Urban Observatory 2008 in UN-Habitat 2008

sea level rise will possibly submerge Alexandria (Thomas 2008b in Elsharkawy and others 2009). African cities that are at risk due to sea level rise are displayed in Figure 6.5.

A sea level rise of 0.43 m will result in the flooding of coastlines inhabited by approximately 16 million people by 2100, while another 10 million people will be forced to migrate during the period 2000 to 2100. The cost of damage to infrastructure over the century is projected to US$38 billion (Brown and others 2011). However, with adaptation, the projected impacts could be significantly reduced. For people-based impacts due to flooding and forced migration, the most vulnerable countries are Mozambique, Cameroon, the United Republic of Tanzania, Morocco and Egypt, while for economic damages, Algeria, Cameroon, Egypt, Libya, Morocco, South Africa, Tunisia are the most vulnerable (Brown and others 2011). According

Table 6.2: Population and asset exposure of African port cities due to socio-economic factors, 2070s climate change and natural and human-induced subsidence

Population Ranking		Asset Ranking	
City	Population (000s)	City	Exposed Assets (US$ billion)
Alexandria, Egypt	4 103	Alexandria, Egypt	528.2
Lagos, Nigeria	3 229	Abidjan, Côte d'Ivoire	142.0
Abidjan, Côte d'Ivoire	3 110	Lagos, Nigeria	117.3
Lomé, Togo	858	Banghazi, Libya	48.8
Conakry, Guinea	496	Lome, Togo	42.0
Maputo, Mozambique	384	Conakry, Guinea	30.1
Dar es Salaam, United Republic of Tanzania	351	Algiers, Algeria	14.4
Banghazi, Libya	143	Casablanca, Morocco	12.1
Dakar, Senegal	131	Durban, South Africa	11.6
Mogadishu, Somalia	115	Maputo, Mozambique	10.7
Casablanca, Morocco	88	Dakar, Senegal	7.7
Douala, Cameroon	78	Cape Town, South Africa	6.8
Algiers, Algeria	67	Douala, Cameroon	5.4
Accra, Ghana	51	Dar es Salaam, United Republic of Tanzania	5.3
Durban, South Africa	42	Rabat, Morocco	4.9
Rabat, Morocco	35	Accra, Ghana	4.0
Cape Town, South Africa	25	Tripoli, Libya	3.3
Luanda, Angola	18	Mogadishu, Somalia	2.1
Tripoli, Libya	10	Luanda, Angola	1.1

Source: Nicholls and others 2008

to Nicholls and others (2008) more than 2.6 million people and assets worth US$ 42 billion in Africa's coastal cities were exposed to flooding in 2005 with three cities: Abidjan, Alexandria and Lagos being at the highest risk (Brown and others 2011). This list is projected to grow considerably in the coming decades (Table 6.2).

Managing coastal and marine resources for better human health

As demonstrated in this chapter, contaminants and activities that destroy coastal and marine habitats and ecosystems also contribute to the loss of the marine flora and fauna upon which many African populations rely for food and income. It is therefore critical to maintain a healthy coastal and marine environment in order to safeguard human health and other socio-economic benefits. Some of the avenues for achieving this include Integrated Coastal Zone Management (ICZM) and Marine Protected Areas (MPAs).

Part of a coral reef in the Red Sea off the coast of Egypt

Moon Fish / Foter / CC BY NC SA

Box 6.5: Integrated Coastal Zone Management: An approach to climate change adaptation for human health improvement

Integrated coastal zone management (ICZM) embodies a futuristic strategy for coastal areas based on well thought-out plans that benefit all sectors of society. It is practised using a combination of sectoral laws and regulations. In the Western Indian Ocean (WIO) region, the interest in ICZM started in the 1990s through several regional and national initiatives (e.g. the Arusha process and Resolution, and national workshops), many of which were supported by multilateral organizations and international donors. Governments in WIO have shown significant political commitment to the implementation of ICZM (Ngoile and Linden 1997) as evidenced by the 1993 Arusha Resolution; the 1996 Seychelles Second Policy Conference on ICZM in Eastern African and Island States and the 1998 Maputo declaration from the Pan-African Conference on Sustainable Integrated Coastal Management. The signatories to the Arusha Resolution are Kenya, Madagascar, Mauritius, Mozambique, Seychelles and the United Republic of Tanzania.

ICZM plays a role in climate change adaptation with the potential to positively reduce exposure of humans to the health effects of environmental changes in coastal and marine areas. As a potent and balanced planning and management process, it constitutes an important precautionary response, and facilitates successful adaptation to climate change (Nicholls and others 2007). It enhances the ability of local systems and governments to implement plans to enable adaptation to climate change, sea-level rise and other current and long-term challenges related to coastal degradation that are detrimental to human wellbeing including human health. The ICZM approach does this by addressing the multiple pressures on coastal zones, including those occasioned by climate change.

In addressing the climate change and human health challenges of coastal zones, ICZM adopts:

- the use of best available knowledge to inform adaptation decisions
- the inclusionary and participatory processes to ensure public support for adaptation
- building linkages and improving coordination between different actors and institutions at different levels
- avoidance of functional fragmentation and overlap, and
- the use of adaptive and strategic management based on evaluation of ecosystems and health outcomes.

Further, climate change related disasters such as cyclones, tsunamis and flooding are mitigated by ICZM. WIO governments are adapting their own policies and activities to the impacts of climate change and facilitating stakeholders and local communities to develop their own adaptation responses including enacting legislation to reduce the vulnerability of people, ecosystems and activities and exposure to particular climate change risks. Elaborate national policies now exist in Mozambique and South Africa.

Source: Celliers and others 2013

Integrated Coastal Zone Management (ICZM)

Integrated Coastal Zone Management (ICZM), also referred to as Integrated Coastal Management (ICM) is a multidisciplinary process for promote sustainable management of coastal zones and includes data collection, planning, decision making as well as monitoring of the implementation of projects (EC 2013). Its objectives are set out in Box 6.5.

Marine Protected Areas (MPAs)

The implementation of Marine Protected Areas (MPAs) will create ecosystems that straddle maritime boundaries. As such, international cooperation through implementation of

Box 6.6: Examples of legal frameworks for Marine Protected Areas (MPAs)

Examples of global and regional legal frameworks for managing MPAs in Africa include:

Global instruments

- United Nations Convention on the Law of the Sea (LOS)
- Convention on Biological Diversity (CBD)
- Convention on Wetlands of International Importance Especially as Waterfowl Habitat (Ramsar Convention)
- Convention on the Conservation of Migratory Species of Wild Animals (CMS)
- Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES)
- International Convention for the Regulation of Whaling (ICRW)
- Convention Concerning the Protection of the World Cultural and Natural Heritage (WHC)
- International Convention for the Prevention of Pollution from Ships, 1973 and 1978 (Marine Pollution – (MARPOL 73/76)

Regional instruments

- African Convention for the Conservation of Nature and Natural Resources (ACCNNR)
- The Nairobi Convention for the Protection, Management and Development of the Marine and Coastal Environment of the Eastern African Region, together with its two protocols (The Marine Pollution Protocol and The Protected Areas Protocol).

the requisite international and regional legal frameworks (Box 6.6) is important.

Sustaining the health benefits

Africa's marine and coastal resources will continue to support livelihoods through subsistence fisheries and trade, while also playing a central part in the urban and industrial growth of the region. This is because they are increasingly becoming centres of exploration for natural resources such as oil, gas and minerals. The region's oceans and seas, such as those highlighted in Figure 6.6 will have a growing role in supporting communications as they provide the medium for internet access through undersea cables. Natural coastal resources will continue to play a significant role in supporting tourism, thereby benefiting local livelihoods through revenues and job creation. These in turn ensure health care provision for coastal families.

In spite of offering direct benefits to coastal countries, oceans and seas also benefit landlocked countries as they are a medium for international trade and they offer opportunities for bio-prospecting for new food sources and medicinal drugs. Oceans and seas contain more than 200 000 known species of invertebrates and algae (Winston 1988 in Pomponi 2001) some of which are used in bio-products that have wide applications for pharmaceuticals, cosmetic and nutritional supplements. For example, some

Fish is a main food source for many Africans

WorldFish / Flickr / CC BY NC ND 2.0

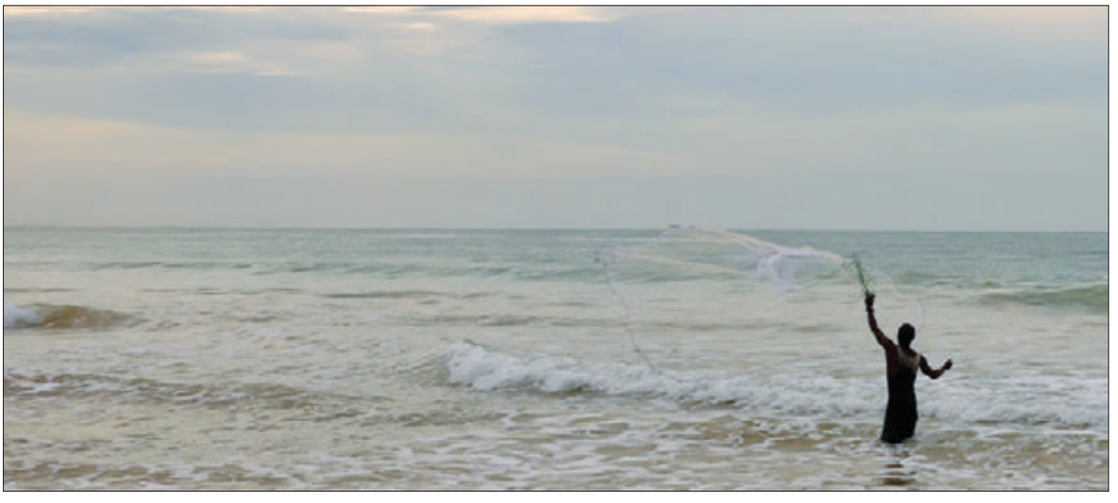
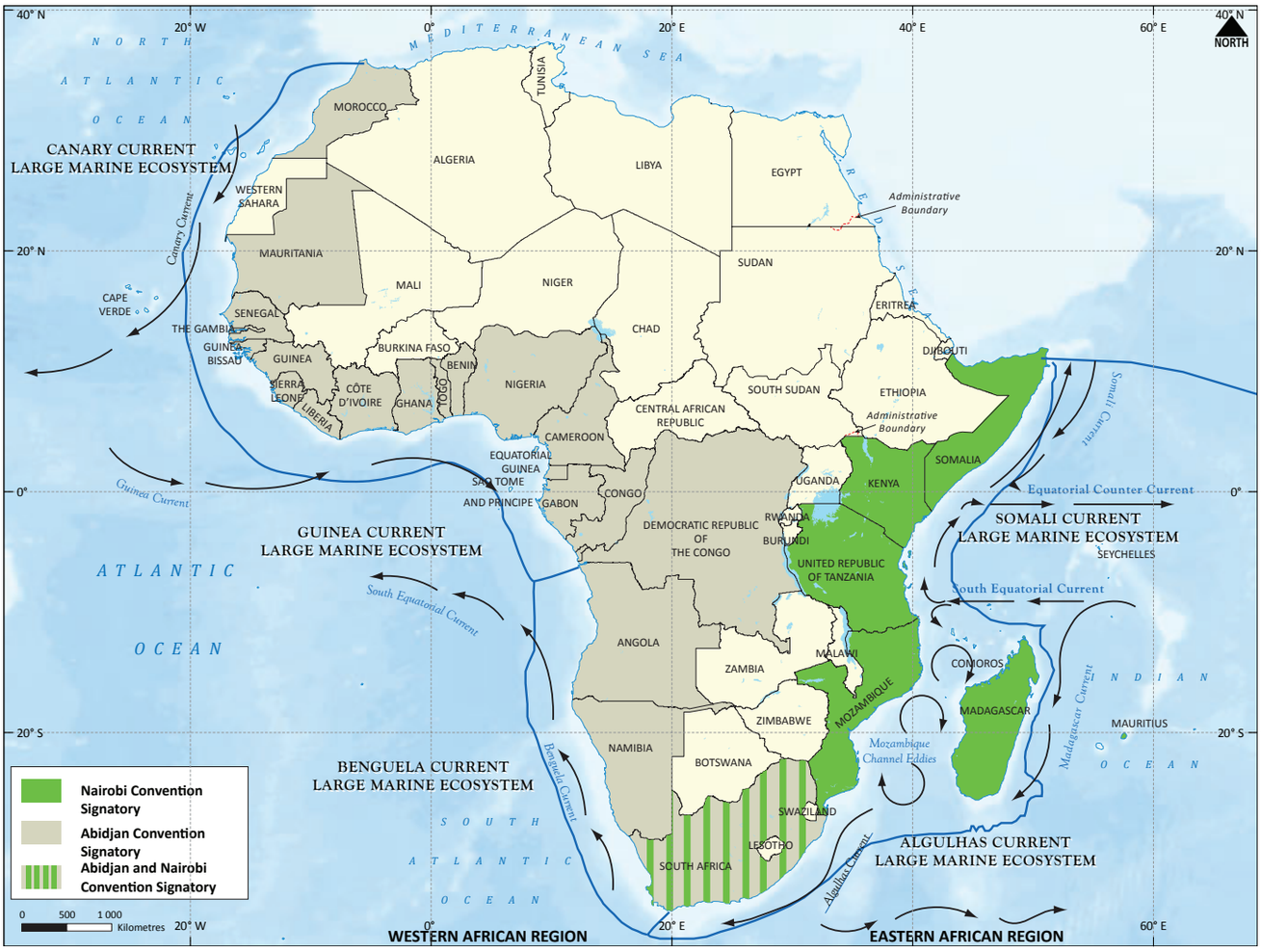


Figure 6.6: Western and Eastern African regions covered by the Abidjan and Nairobi Conventions



Source: Diop and others 2011

anti-cancer compounds have been discovered from oceans and seas, with some promising ones including Yondelis and discodermolide. Sharks and horseshoe crabs have also been proven to contain essential compounds for the treatments of cancer, muscle diseases, and chronic pain (Chivian and Bernstein 2008).

The Marine and Coastal Strategy (UNEP 2011) stipulates how to 'improve coastal water quality through addressing land based pollution, strengthen ecosystem management of marine areas within and beyond national jurisdictions, equip countries with tools for reconciling the different demands on marine and coastal resources, in particular small islands and other vulnerable places.'

A beautiful beach in Ghana

Erik Cleves Kristensen / Flickr / CC BY 2.0

There is need to invest in proactive measures to curb the threats to human health that emanate from Africa's coastal and marine resources. While national efforts to promote Marine Protected Areas (MPAs) and Integrated Coastal Zone Management (ICZM) are contributing to curbing coastal resource depletion and to controlling coastal pollution, there is need to reinforce them with the concerted implementation of the Abidjan, Bamako and Nairobi Conventions. The main policy options for sustainably enhancing the management ofcoastal and marine resources to benefit human health include:

- scaling up ICZM and consolidating MPAs into the more effective MMAs (UNEP 2012)
- accelerating ratification, domestication andimplementation of the Abidjan, Bamako and Nairobi Conventions
- replicating ecosystem-wide management approaches such as that which underpins the Western Indian Ocean Marine Eco-region (WIOMER), and
- scaling up participatory and transboundary management models.

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7

Freshwater and Sanitation

Freshwater and sanitation in Africa

Safe drinking water and adequate sanitation are vital to human health. Human beings use water for drinking, food production, sanitation, maintaining health, recreation and industrial processes. And, access to safe drinking water has been declared a human right (UN General Assembly 2011). Sanitation services help to preserve the integrity of water sources and improving sanitation is known to have a significant beneficial impact on human health.

Africa is endowed with immense freshwater resources that are largely replenished by rainfall. This varies from near zero in parts of Namibia in Southern Africa and the Sahara desert of Northern Africa, to over 2 500 mm per year in the central Democratic Republic of Congo and in the Guinea forests (UNEP 2010). The continent's freshwater resources (Figure 7.1) include 63 transboundary river basins that are home to 77 per cent of the continent's population, as well as 38 shared aquifers (UNEP 2010). Some of the world's longest rivers are found on the continent and include the Nile, Niger, Congo and

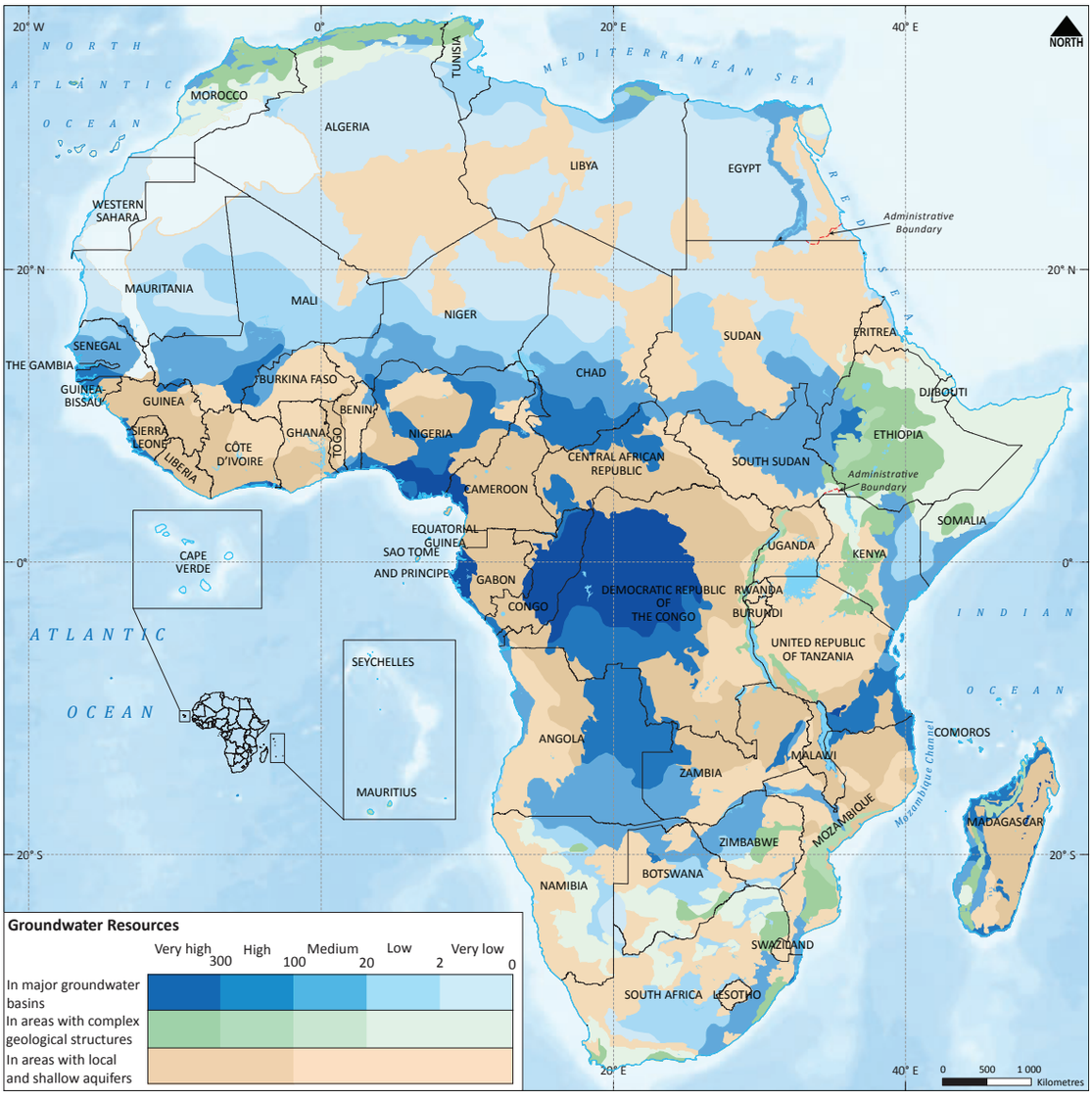
Figure 7.1: Distribution of major natural lakes, rivers, wetlands and reservoirs across Africa

Source: UNEP 2010

the Zambezi. Africa's large natural water bodies include Lakes Victoria, Tanganyika and Malawi. Many high altitude areas in several watersheds referred to as 'water towers' are the remote sources of these rivers and lakes.

A large number of multipurpose dams have also been constructed across the continent, with Southern Africa being the most dammed sub-region. Groundwater storage in Africa is estimated at 660 000 cubic km, which is more than 100 times the estimated annual renewable freshwater resources (MacDonald and others 2012). The region's largest groundwater reserves are found in large sedimentary aquifers in Algeria, Egypt, Libya and Sudan. The region's groundwater resources (Figure 7.2) are especially important for the relatively dry Northern and Southern sub-regions, where aquifers, in some countries such as Botswana, provide 80 per cent of water needs for both rural and urban communities (SADC and others 2008). These aquifers include the Nubian Sandstone, shared by Chad, Egypt, Libya, and Sudan (IAEA 2010).

Figure 7.2: Groundwater resources in Africa



Source: BGRM/ UNESCO Paris 2008 in UNEP 2010

Water, sanitation and health linkages

Maintaining freshwater quality is essential to preventing its contamination with infectious agents, toxic chemicals, and radiological hazards. Water also plays a key role in the prevention of disease. Since water is an important component of human physiology, its quality is just as important as its quantity. In order to ensure proper health and wellness, it is especially important that drinking water is clean and free of contaminants. Therefore, safe water supplies, hygienic sanitation and good water management are fundamental to global health.

Access to safe water and adequate sanitation is one of the most effective ways of improving human health. Primary health care includes the provision of adequate supplies of safe water and sanitation. There is a positive relationship between the provision of safe water and the health of the population supplied, including children (Isely 1985).

Situations where a source of safe water is more than 1 km away or where the round trip takes more than 30 minutes are regarded as 'no access' (WHO and UNICEF 2000). The majority of Africa's population still lacks safe drinking water, with Sub-Saharan Africa accounting for 330 million of the 884 million people who have no access worldwide (WHO and UNICEF 2000).

Although the actual number of people using improved drinking water sources has increased by 11 per cent since 1990, only 60 per cent of the Sub-Saharan Africa population has access to safe water (UNICEF and WHO 2010). Moreover, the growth pace is lower than that required to attain the MDG targets on drinking water and sanitation by 2015. Inadequate sanitation is a major cause of diseases worldwide and improving sanitation is known to have a significant beneficial impact on human health. In 2008, 76 per cent of people without sanitation facilities in Sub Saharan Africa are found in rural areas, compared to 70 per cent for both rural and urban areas (WHO and UNICEF 2000).

Unclean water and inadequate sanitation and hygiene rank among the top 10 causes of disease worldwide (UNDP 2011). Globally, more than 5 million deaths result from water-related and water-borne diseases and 84 per cent of these fatalities occur in children below 5 years from Africa (Dunbar and Emsley 2009; Eneh 2011). Selected health effects of lack of access to improved water and sanitation facilities and their impacts are summarized in Box 7.1.

Water is a medium for the spread of disease vectors such as mosquitoes. Water-related and water-borne diseases with high incidences in Africa include malaria, cholera, Chikungunya, Schistosomiasis (bilharzia), typhoid and dysentery. While Africa continues to battle many water-related

Box 7.1: Health effects of lack of safe drinking water and adequate sanitation and their impacts

Selected health effects	General impacts of these diseases
Intestinal diseases spread through unsafe drinking water: • Diarrhoea; • Cholera; • Typhoid; • Guinea worm; • Dysentery. Diseases caused by inadequate sanitation and hygiene: • Intestinal worms (including ascariasis, trichuriassis and hookworm); • Schistosomiasis (bilharzia); • Trachoma.	• Loss of productive time for workers and school children due to illness; • Loss of time and energy spent on collecting water from distant sources; • Loss of productive time attending to the sick • Premature deaths; • Increased numbers of orphaned children; • Persistence of poverty and; • Poverty and stress-induced criminal activities and conflicts.

Source: Compiled by the authors

diseases, the region has recorded some success in eradicating some water-related diseases, including river blindness (onchocerciasis) in West Africa (Yaméogo and others 2004). Success has also been documented in dramatically reducing the incidence of Guinea Worm Disease (GWD).

Table 7.1: Trends in reported cases of GWD in selected African countries

Country	2007#	2008@	2009*	2010*	2011^	2012
South Sudan	5 815	3 618	2 733	1 698	1 028	521
Mali	313	417	186	57	12	7
Ethiopia	0	41	24	21	8	4
Chad	0	0	0	10	10	10
Ghana	3 358	501	242	8	0	0

Sources: *WHO 2011a, #CDC 2009, @CDC 2010, ^CDC 2013

The control of river blindness was based on the use of insecticides to control the aquatic, larval stages of black flies in the *Simulium damnosum* complex. This was complemented with the distribution of drugs to reduce the incidence of the filarial worm, *Onchocerca volvulus* that may ultimately result in blindness. The control efforts were long-term, covering the period 1974-2003, and extensive with nearly 50 000 km of river stretches being treated weekly for 12 years (Yaméogo and others 2004).

Guinea Worm Disease (GWD)

Guinea worm disease (GWD) also known as dracunculiasis, is caused by drinking water contaminated by water fleas that are infested with guinea worm larvae. GWD is unique in that it is the only communicable disease that is transmitted exclusively through contaminated water. Therefore, it is the only disease that can be prevented entirely by protecting supplies of drinking water (Callahan and others 2013). Africa is moving fast towards eradicating incidences of GWD. At the end of 2012, Chad, Ethiopia, Ghana, Mali and South Sudan still had endemic transmission (Table 7.1). In particular South Sudan reported 96 per cent of all cases in 2012.

By improving water supplies, the eradication of the disease is feasible. In Africa, the number of cases declined from 3.5 million in 1986

A safe water pump in Mozambique

Gates Foundation / Foter / CC BY-NC-ND

Figure 7.3: Uganda's journey to eradicating Guinea Worm Disease

1992:

- 2 677 endemic villages in 16 districts
- Total of 126 369 cases reported

1997:

- 327 endemic villages in 6 districts
- Total of 1 455 cases reported

2003:

- 1 endemic village in 1 district
- Total of 13 cases reported

Source: Rwakimari and others 2006

to 35 000 in 2003 (van der Hoek 2006). The disease has been eradicated in most countries in Africa. Uganda, for instance, reported its first GWD-free year in 2004 (Rwakimari and others 2006). Uganda's remarkable journey to eradicating GWD is summarized in Figure 7.3. There is, however, a risk of resurgence of the disease as a result exposure of communities to contaminated drinking water in especially poor rural and informal settlement. The risk of cross border transfers from countries still affected also still remains.

Malaria

The continent accounts for 70 per cent of total morbidity from the global malaria health problem (Snow and Marsh 2010). Further, according to WHO (2012), there were an estimated 219 million cases of malaria in 2010, 660 000 of which resulted in death. About 90 per cent of these deaths occurred in Africa, with children under the age of five years being the main victims (WHO 2012). Mozambique is among the 10 countries in the world most affected by malaria, causing between 44 000 and 67 000 deaths annually in all age groups (INGC 2009 in Kulima and others 2013). A study on the economic analysis of malaria in Africa shows that patient treatment costs of malaria are set to increase by more than 20 per cent as a result of climate induced factors (Egbendewe-Mondzozo and others 2011). The disease is also a major concern in the island states of Comoros and Madagascar. Children below five years and pregnant women are the most vulnerable to malaria. An increase in water temperature increases larval development. This in turn increases the risk of contracting malaria as mosquito bites are the primary mode of transmission of the disease.

Cholera and other diarrhoeal diseases

Cholera is a persistent threat in sub-regions such as Southern Africa (Box 7.2). It now claims more lives in Africa than Asia where the disease originated during the late 1880s and was introduced into Africa through trade and travel (Sow and others 2011).

Box 7.2: Case study: Cholera outbreak in Zimbabwe in 2004

A cholera outbreak in 55 of Zimbabwe's 62 districts between August 2008 and May 2009 resulted in more than 4 000 fatalities. The following factors were responsible for the cholera outbreak:

- Consumption of contaminated underground water from wells
- Drinking water from unprotected sources (river; wells)
- Being in contact with someone with diarrhoea at home
- Absence of a toilet at home.

In response to the outbreaks the following measures were taken:

- Rehabilitation of boreholes
- Distribution of non-food items, including water urns, aquatabs, oral rehydration sachets, soap and awareness pamphlets on cholera prevention.

The following extra measures were also recommended:

- Boiling water before using it for drinking
- Treating water with aquatabs before drinking
- Practicing good personal hygiene.

Sources: WHO 2008; WHO 2011b; Zimbabwe Health Cluster 2008

Schistosomiasis (bilharzia)

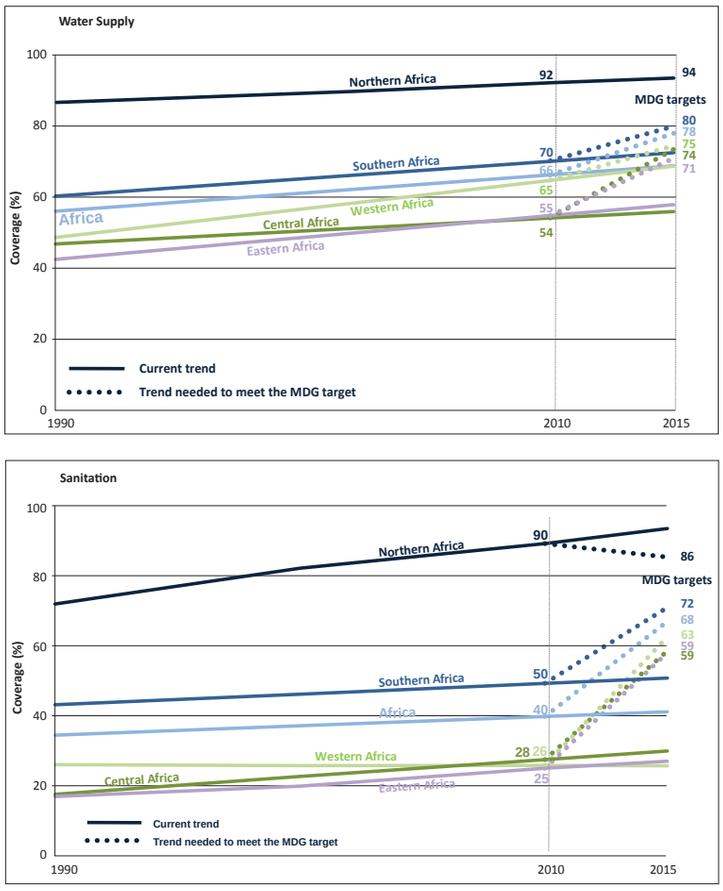
About 200 million people are infected with Schistosomiasis (bilharzia) in the world every year. An estimated 80-97 per cent of these people live in sub-Saharan Africa (Southgate and others 2005; Stothard and others 2009) making the disease prevalent across the continent. The main factors that exacerbate the spread of the disease include unsanitary living conditions, large-scale migrations of people and rapid urbanization (Southgate and others 2005). The disease commonly affects adult workers in the agriculture and freshwater fishing sectors. Although in some cases, these workers usually have only light infections and do not exhibit

any symptoms. In other cases however, such as Egypt and Sudan, bilharzia seriously affects the productivity of agricultural workers and fisher folk. When children are infected, the disease can substantially affect their growth and school performance; those between the ages of 10 and 14 are the most affected by this disease (Barnabus and others 2012).

Chikungunya

Chikungunya is another common water-borne disease in East Africa and the West Indian Ocean sub-region. The disease was first isolated in the United Republic of Tanzania in 1953 although Chikungunya epidemic outbreaks are common in the Kenyan coastal towns of Lamu and Mombasa where unsafe water storage and high temperatures during an unusually dry period created conducive conditions for the spread of the disease (Pialoux and others 2007). Between January and April 2006, more than 270 000 people in Comoros and Mauritius were infected with Chikungunya fever, transmitted to humans by the virus-carrying Aedes mosquito. The outbreak led to more than 1 000 deaths. The large-scale epidemic outbreak was preceded by a minor episode in early 2005 (Ramchurn and others 2007).

Figure 7.4: Improvements in water supply and sanitation coverage in Sub-Saharan Africa



Source: AMCOW 2012

Progress towards safe water and adequate sanitation

There is steady but insufficient progress towards improving access to safe water and sanitation in Africa. Progress towards increasing the number of people with access to improved water supply and sanitation has been made, although this is uneven among countries. An Africa-wide survey showed that improved water supply had risen by 10 per cent since 1990, from 56 per cent to 66 per cent of the total population in 2010 (AMCOW 2012). On the other hand, improved sanitation had risen to 40 per cent in 2010, an increase of only 4 per cent since 1990 (AMCOW 2012). Figure 7.4 compares improvements in water supply with improvements in sanitation coverage.

However, access to safe drinking water is still low, with only 26 of the African countries reported to be on track to meeting the drinking water MDG target (UNICEF and WHO 2008) as is evident in Figure 7.5. According to AMCOW (2012) projections, Africa will not attain its water and sanitation MDG targets. Figure 7.6 illustrates the region's progress towards improved sanitation. Current trends also indicate that the MDG drinking water target will only be reached in around 2040 and the sanitation target around 2076 (UNDP 2006). Moreover, the safe drinking water and sanitation sector is generally underfunded. For example, only US$ 7.4 billion (4.7 per cent) of the total of US$ 158 billion in development aid commitments reported for 2008 was committed

A raised pit toliet

Sustainable Sanitation / Flickr / CC BY 2.0

to water and sanitation. This is much lower than allocations for other social sectors such as health, education, energy and agriculture (WHO 2010). Therefore, the provision of safe water remains a fundamental challenge across the whole of Africa, especially in the rural areas where the majority of the population lives. The 75 and 70 per cent reduction targets for drinking water and sanitation, respectively, outlined in the Africa Water Vision (UNECA and others 2000) seem rather optimistic, based on current trends (Box 7.3).

A significant portion of ill health in informal settlements originates from lack of clean drinking water (Ramin 2009). Between 1990 and 2006, the urban population in Africa without access to an improved drinking water source increased by 28 million people to 57 million, even though coverage increased to 85 per cent for the same period (AMCOW 2012). Even where it is available, the urban poor often cannot afford the charges levied for accessing clean drinking water. This contributes to their exposure to disease from unsafe water. For example, it is estimated that informal settlement dwellers in East African cities pay 5-7 times more for a litre of water than the average North American (Ramin 2009). About

Box 7.3: Africa Water Vision 2025 - Freshwater and sanitation and environmental targets

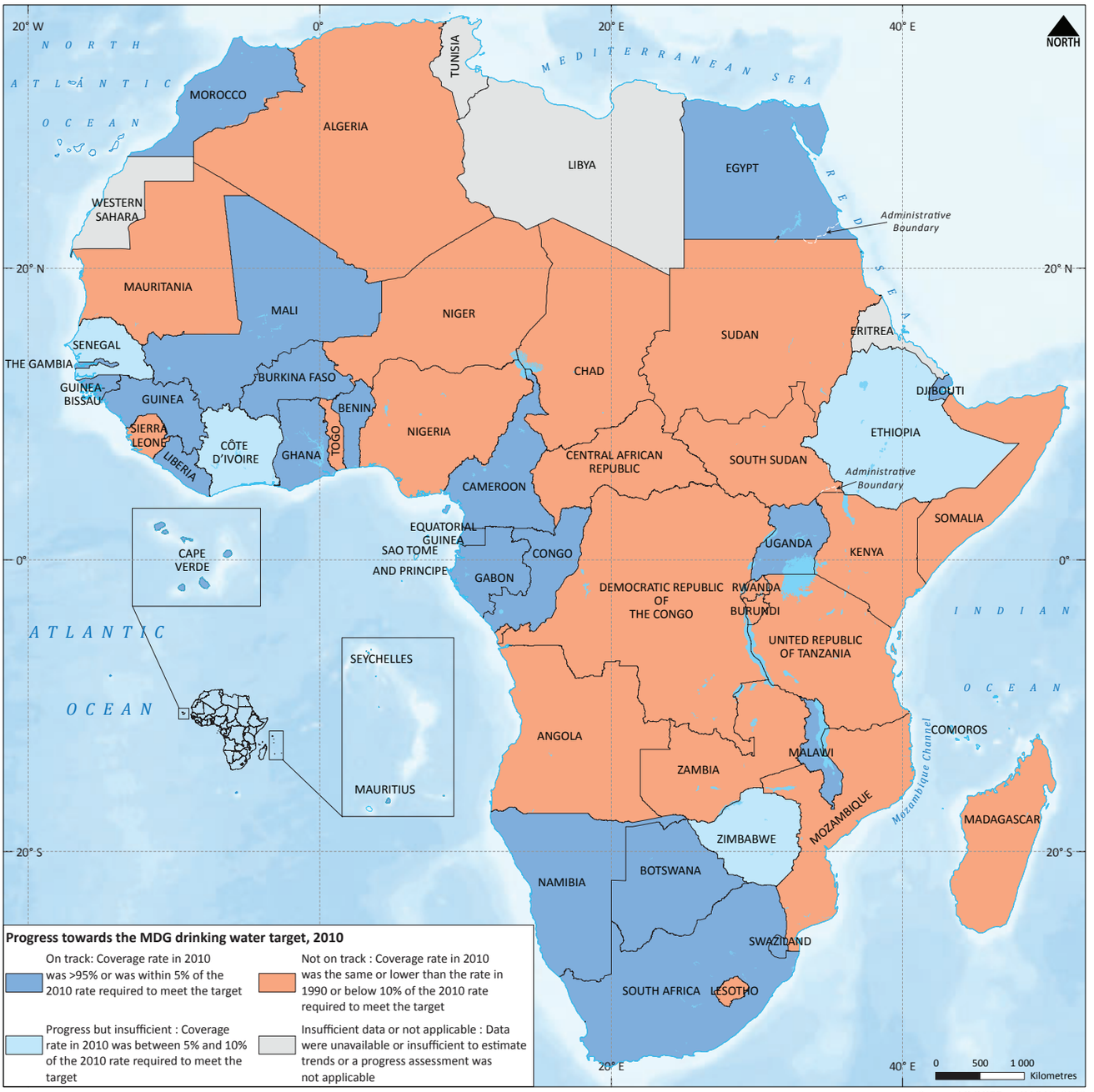
- Reduce by 75 per cent the proportion of people without access to safe and adequate water supply by 2015
- Reduce by 70 per cent the proportion of people without access to safe and adequate sanitation by 2015
- Implement measures in all countries to ensure the allocation of sufficient water for environmental sustainability by 2015
- Implement measures in all countries to conserve and restore watershed ecosystems by 2015
- Reduce by 95 per cent the proportion of people without access to safe and adequate water supply by 2025
- Reduce by 95 per cent the proportion of people without access to safe and adequate sanitation by 2025
- Implement measures in all countries to ensure the allocation of sufficient water for environmental sustainability by 2025
- Implement measures in all countries to conserve and restore watershed ecosystems by 2025.

Source: Modified from UNECA and others 2000

56 per cent of the residents of Nairobi currently live in 46 informal settlements along the banks of the Nairobi River, occupying about 5 per cent of the total land area of the city (GOK 2009). These informal settlements have encroached on the river reserve and the residents hardly have adequate sanitary facilities. As such, all domestic effluent is discharged into open drainages and ends up in the river, causing considerable pollution.

More than 80 per cent of Africa's people who don't have access to improved drinking water sources live in rural areas, compared to 41 per cent globally (UNEP 2010). Between 1990 and 2008, the safe drinking water coverage rate in all ECOWAS countries increased gradually with the exception of Sierra Leone where there

Figure 7.5: Progress towards improved drinking water



Source: UNICEF and WHO 2012

was a decline between 2000 and 2008 (from 55 per cent to 49 per cent). According to WHO and UNICEF 2010, a coverage rate of at least 50 per cent was experienced for all countries except Niger (48 per cent), Mauritania (49 per cent), and Sierra Leone (49 per cent). According to the same publication, the highest access rates were achieved in The Gambia (92 per cent), Cape Verde (84 per cent), Ghana (82 per cent) and Côte d'Ivoire (80 per cent). The pace in the expansion of drinking water coverage for the period 1990-2007 was however slowed by population growth, estimated at 2.7 per cent (WHO and UNICEF 2010) during the same period, and deteriorating water supply infrastructure that was not being rehabilitated or replaced.

According to WHO and UNICEF (2010), considerable progress in improving provision of safe drinking water to rural areas was made

Figure 7.6: Progress towards improved sanitation

Source: UNICEF and WHO 2012

between 1990 and 2008 in Benin (47 to 69 per cent), Burkina Faso (36 to 72 per cent), Ghana (37 to 74 per cent), and Guinea (38 to 61 per cent) (WHO and UNICEF 2010). Sierra Leone, Niger and Nigeria had particularly low coverage in rural areas with 26 per cent, 39 per cent and 42 per cent, respectively. In Niger, only 48 per cent of the total population has access to an improved source of drinking water. Of these, only 7 per cent of the population has a private tap while 41 per cent get their water from other modern water points such as standpipes (WHO and UNICEF 2010).

Between 1990 and 2008, there were improvements in the coverage of safe drinking water, for most countries in East Africa. However, coverage in most of the countries still falls short of the progress needed to achieve the MDG target of 75 per cent coverage by 2015. Only Uganda and Eritrea are on track to meet their MDG safe drinking water targets (WHO and UNICEF 2010).

The period 1990 to 2008 saw an increase in improved drinking water coverage in the rural areas in most Southern African countries. Namibia (51 to 88 per cent) and Malawi (33 to 77 per cent) recorded higher rates of change compared to other countries, whereas Angola, Botswana, Mozambique and the United Republic of Tanzania experienced moderate growth or slight decline in improved safe drinking water coverage in the rural areas. Most Southern African countries also experienced an increase in the urban population using improved drinking water sources. The lowest urban drinking water coverage in southern Africa was experienced by Angola, but its percentage of urban population using improved drinking water sources doubled from 30 to 60 per cent between 1990 and 2008. Positive trends were also experienced in Lesotho, Malawi, Mozambique and Swaziland, while the United Republic of Tanzania experienced a decline in the population using improved water sources in urban areas from 94 to 80 per cent for the same period (WHO and UNICEF 2010).

The sub-optimal progress in the delivery of safe drinking water and sanitation is linked to low levels of investment in infrastructure, capacity building, education and awareness, as well as governance challenges. Africa's declining water resource base occasioned by population growth, climate change and increased withdrawal rates are also blamed for the slow progress in meeting Millennium Development Goals (MDGs) relating to freshwater and sanitation (UNEP 2010).

With a rapidly growing population, the need to secure water for drinking, food production, and other economic activities has never been greater. Around 40 per cent of Africa's population lives in arid and semi-arid areas where rainfall is unreliable (UNEP 2010). Estimates show that Africa's annual per capita water availability was 4 008 CBM in 2008, compared to the global average of 6 498 CBM (UNEP 2010). In East Africa, only three countries – Burundi, Ethiopia and Uganda – were above the 1 000 CBM per capita per year threshold in 2007. Water stress and scarcity is

People in search of safe drinking water in Ghana

Gates Foundation / Flickr / CC BY NC ND 2.0

A woman carrying water in Ethiopia

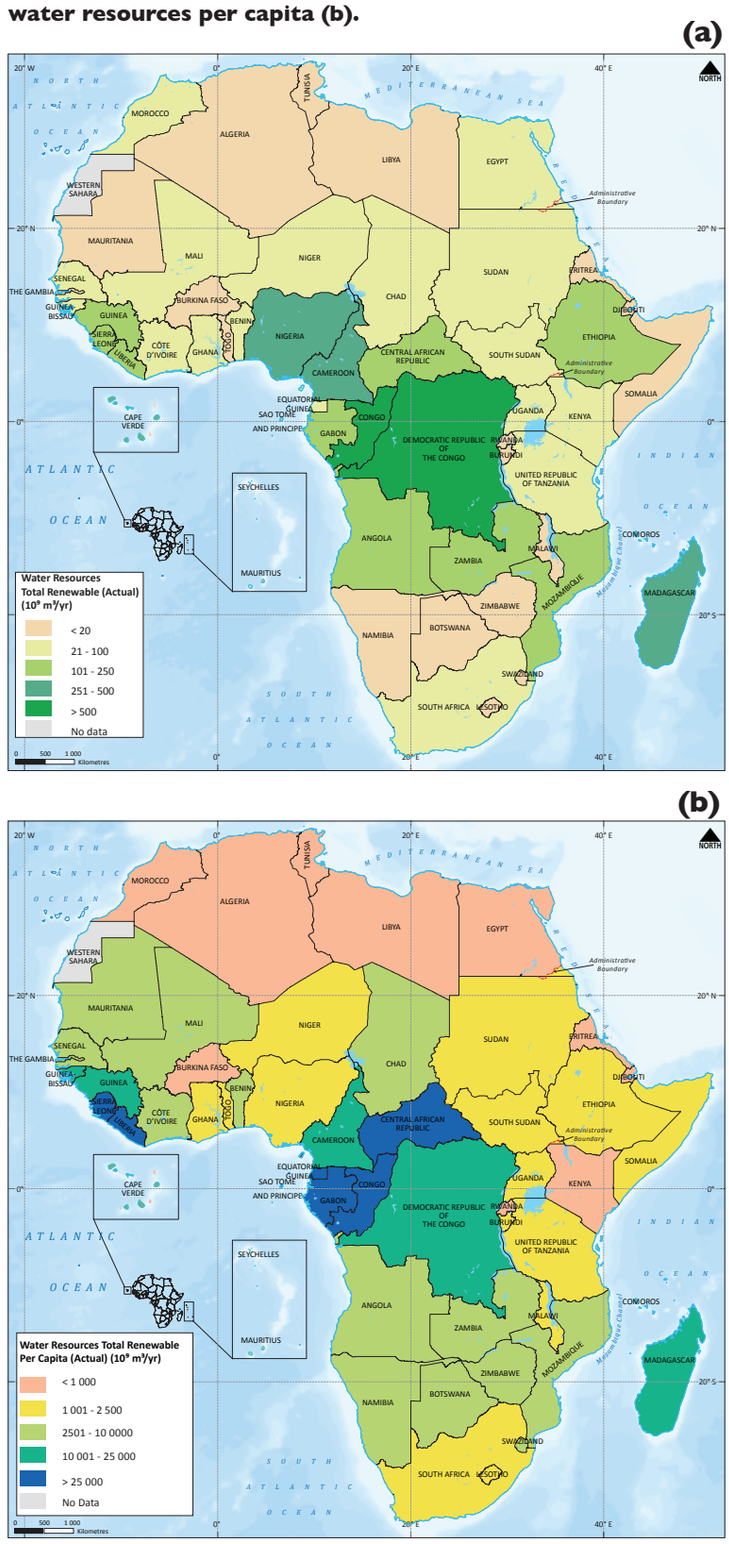
waterdotorg / Flickr / CC BY NC SA 2.0

expected to affect 18 countries in Africa, while the continental population at risk of water stress and scarcity is projected to increase from 47 per cent in 2000 to 65 per cent in 2025 (Ashton 2002 in Bates and others 2008). Figure 7.7 illustrates the region's total renewable water resources (a), and the renewable water resources per capita (b).

Water pollution due to anthropogenic factors also affects the quality and availability of water. Human-induced pollution in the Maghreb countries includes pathogenic contamination of water resources as a result of untreated municipal wastewater effluents, nitrate pollution of groundwater by fertilizers, cadmium-rich water releases from phosphate mines, and eutrophication of dam reservoirs as a result of organic pollution. In Egypt, the Nile River experiences increased oxygen depletion downstream due to human factors (CEDARE and AWC 2004).

A growing population, inadequate funding, governance challenges, low levels of investment in infrastructure and maintenance, and increasing competition for water between sectors are some of the factors constraining progress in the delivery of water to people in many countries. Major

Figure 7.7: Total renewable water resources (a) and renewable water resources per capita (b).



Source: FAO 2009 (data from the Aquastat database)

freshwater issues in Africa are water availability, including the supply of water as a resource from wetlands and other ecosystems, lack of access to safe drinking water, and inadequate sanitation coverage. These are exacerbated by water

pollution and limited financial and human capacity, as well as governance and institutional constraints.

Enhancing access to safe water and sanitation for health benefits

According to WWAP (2009), almost a tenth of all the diseases in Africa can be prevented by improving the supply of water, sanitation, hygiene and management of water resources. Improving access to safe water and sanitation is one of the least expensive and most effective means to improve public health and save lives (Montgomery and Elimelech 2007). Current efforts to expand networks of safe water supplies especially in the peri-urban and rural areas are laudable. However, it is necessary to ensure that sources such as boreholes and protected wells and springs are located in places that are not vulnerable to pollution from pit latrines and other land-based sources and activities and that they are well-maintained. In addition, sensitizing individuals on Total Sanitation (TS) using a combination of information, education and communication (IEC) that target households, schools and communities will help to change attitudes and behaviour towards hygiene.

In Africa, enactment and implementation of progressive national water and sanitation policies have helped to improve water availability and water use efficiency although this has been more prevalent in urban than rural areas. However, much more needs to be done to better manage watersheds, including Africa's water towers, in order to protect water sources and ensure their sustainability.

It is important to map the region's groundwater resources to determine their overall availability and quality in the various countries. This will better prepare them to cater for the growing human population and also avert climate induced shortages. Freshwater delivery can greatly be enhanced by exploiting the region's many transboundary aquifer systems. In North Africa, desalination may be worth exploring. There is also need to institute water-use policies and tariffs that consider the resource to be an economic good but also ensure its equitable availability. This will better ensure water use efficiency without compromising the health of the poor by jeopardizing their access rights. It is also important to enforce laws that provide for environment and health impact assessments of development projects that have the potential to expose people to water-borne diseases.

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8

Land

Africa's land resources

Land is central to human health as it is the main resource base around which ecosystems services such as food, fibre and medicines are produced. Africa has a land area of 30 million sq. km, making the region of 54 countries the second largest continent in the world after Asia (FAO 2002 in UNEP 2006). Africa's landscape is a mosaic of resources, including forests and woodlands, grasslands, arable land, mountains, drylands and deserts, coastal lands and freshwater ecosystems. These are interspaced with urban areas, which are expanding at an annual rate of 3.5 per cent (UNEP 2006). An estimated 6.7 million sq. km of Africa's total land area is covered by forests and woodlands (FAO 2011), while arid zones and deserts cover 66 per cent (IFAD 2010). The Sahara, which is the largest desert in the world and the Kalahari (or Kgalagadi) are key land

Figure 8.1: Africa's arable land

Source: FAO 2010b

features in Africa. About 8.07 million sq. km in the region is arable land, of which 1.97 million sq. km is under cultivation (Cotula and others 2009). As Figure 8.1 shows, much of the region's potential arable land is not under cultivation, and together, Africa and South America have an estimated 80 per cent of the world's reserve agricultural land (Cotula and others 2009).

Africa's arable land has the capacity to produce adequate food for the majority of the continent's population (FAO 2002 in UNEP 2006). The region produces a range of crops for the domestic and export markets, including maize, sugar cane, cassava, groundnuts, coffee, cocoa and tea. About 23 per cent of Africa's population is dependent on agriculture for its livelihood (Reich and others 2001 in UNEP 2006). While the contribution of agriculture to the Gross Domestic Product (GDP) varies from country to country, it is generally very high. For example, in Ethiopia and the United Republic of Tanzania agriculture contributes 43-47 per cent of GDP (Salami and others 2010).

Table 8.1: Percentage of household income spent on food for some sub-Saharan African countries

Country	National	Urban	Rural	Poorest quintile	Richest quintile
Benin	56	54	57	59	52
Burkina Faso	62	52	65	74	45
Burundi	57	60	57	54	53
Cameroon	63	55	68	68	53
Cote d'Ivoire	55	56	54	58	45
Ethiopia	70	57	75	82	52
Gambia, The	68	67	69	69	67
Ghana	62	58	64	66	58
Guinea-Bissau	70	64	72	69	64
Kenya	73	57	77	83	56
Madagascar	84	76	86	84	77
Malawi	59	57	59	58	56
Mali	62	54	66	64	55
Nigeria	72	70	75	84	62
Rwanda	56	57	56	77	31
Senegal	57	53	61	62	48
South Africa	40	34	50	58	16
United Republic of Tanzania	85	86	85	90	76
Uganda	65	44	69	70	50

Source: Chauvin and others 2012

Land-health linkages

Using land, people can enhance their health through increased access to ecosystem services. The greatest contribution by land to human health is through the provision of food and nutrition. Sixty per cent of Africa's population that lives in rural areas (UN-HABITAT 2010) derives its livelihood mainly by producing food from land or through agriculture-based employment. Agriculture is a major source of income in Africa, a significant proportion of which is spent on staple food (Table 8.1). On average, an African family spends 50-70 per cent of its income on staple food (Diao and others 2008).

The health of people and ecosystems can however be affected by inappropriate land use practices that lead to land degradation. Land degradation arises from misuse of chemical pesticides and fertilizers, salinization, contamination by heavy metals, and soil depletion (Lebel 2003). Land use may alter ecosystem services, and this changes the ecology of diseases, which may make people more vulnerable to infections (Collins 2001). A direct impact of reduced agricultural productivity is malnutrition which caused an estimated 159,000 deaths among low and middle income people in Africa in 2004 (WHO 2008).

Land degradation

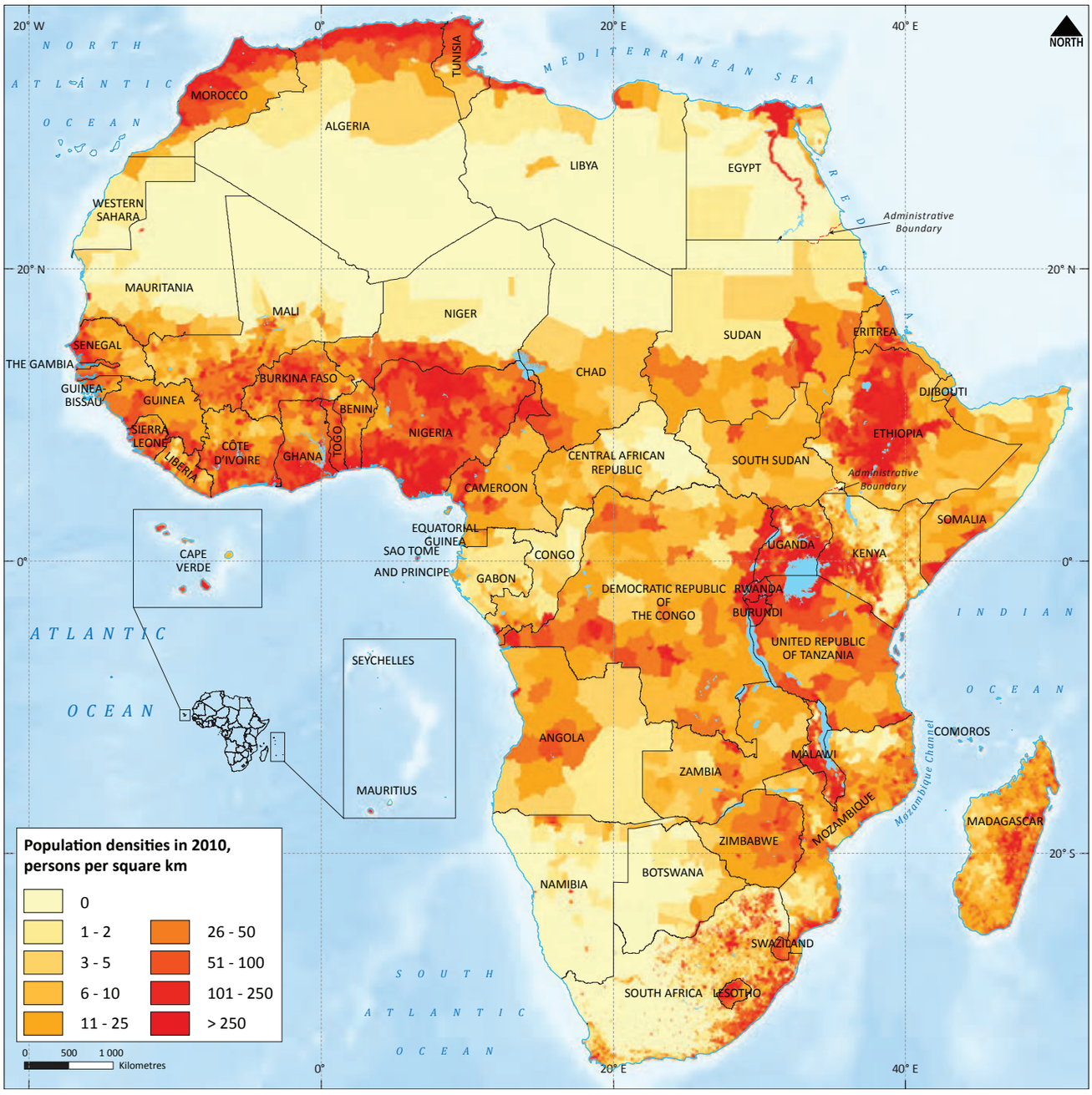
Land degradation is a major issue in Africa where an estimated 500 000 sq. km of land have undergone soil degradation since 1950, and this includes 65 per cent of the region's agricultural land (IFAD and GEF 2002). Caused by a range of factors such as over-cultivation, overgrazing, deforestation and inefficient irrigation practices, land degradation leads to reduced agricultural productivity. Agricultural productivity is also affected by land tenure as this affects access to land and working capital. Other land tenure issues that affect food security include unequal

distribution of land, sub-optimal utilization of land and insecure tenure (UNECA 2004). Land degradation is also driven by population pressure, which as Figure 8.2 shows varies across the region, with some areas being densely populated while others are sparsely populated.

Land degradation and desertification affect human health through complex pathways. Generally, as land is degraded and deserts expand in some places, food production is reduced, water sources dry up and populations are pressured to move to more hospitable areas (WHO 2013). Other potential impacts of land degradation and desertification on health include:

- higher threats of malnutrition from reduced agricultural productivity and water supplies
- the spread of infectious diseases as populations migrate

Figure 8.2: An overview of Africa's population densities



Source: CIESIN and others 2005

- more water- and food-borne diseases that result from poor hygiene and a lack of clean water which is further discussed in Chapter 7 on Freshwater and sanitation, and
- respiratory diseases caused by atmospheric dust from wind erosion and other air pollutants which are discussed in detail in Chapter 2 on Air quality.

People living in rural subsistence economies are generally at risk from nutritional deficiency (Reutlinger and Selowsky 1976), and the large rural population partly explains the comparatively higher levels of malnutrition in Africa. Between 1990-1992 and 2001-2003, the number of undernourished people in Africa increased from 169 million to 206 million (FAO 2006). Sustained growth in agriculture is crucial to reducing hunger and poverty in the region, and this is reflected in recent increases in the overall GDP growth rates in Africa which coincide with similar growth trends in the national agricultural sectors (World Bank 2007).

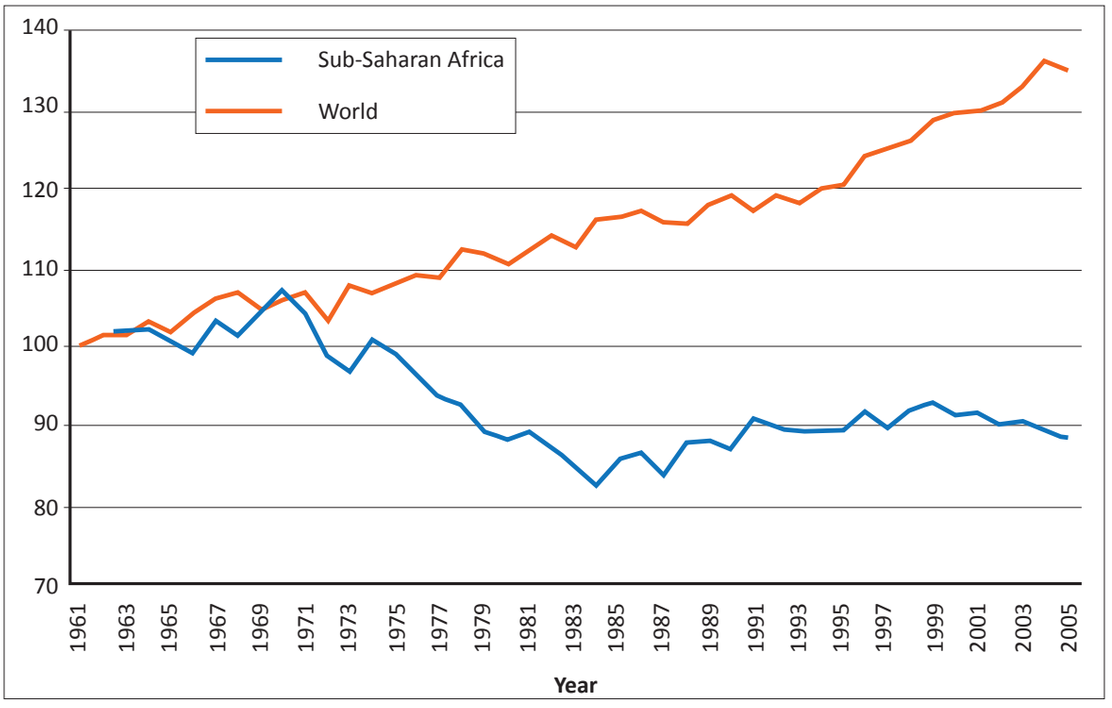
Africa's food security is largely a reflection of the productivity of the land. According to Mwaniki (2003), besides land degradation, other major challenges to food security in Africa include underdevelopment of the agricultural sector. This is characterized by over-reliance on primary agriculture, low soil fertility, minimal use of external farm inputs, significant pre- and post-harvest food crop losses, minimal value addition and product differentiation, and inadequate food storage and preservation that result in significant commodity price fluctuation. In addition, the increasing commoditization of the agricultural sector exposes the poor to food-deficiency illnesses.

Falling agricultural productivity

Africa has the highest population growth rate in the world, and since this growth has not been matched by food production for the past 45 years, per capita food production in Africa has been declining (AU 2008) as shown in Figure 8.3.

The declining per capita food production caused by land degradation, among others, and the

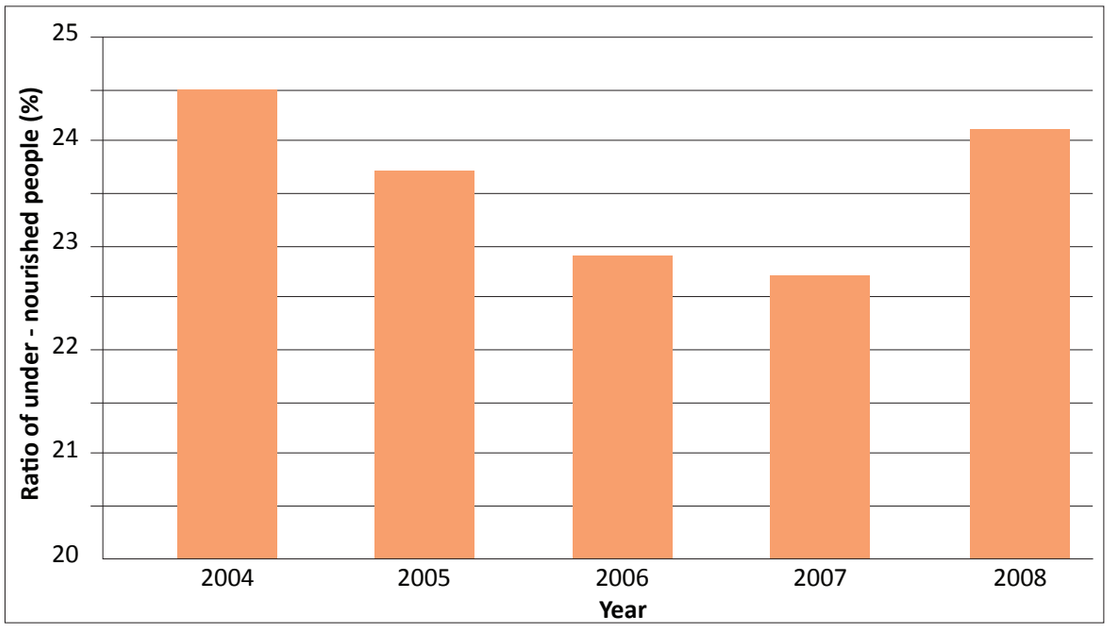
Figure 8.3: Per capita food production index



*Note: Index base 100 in 1961

Source: AU 2008

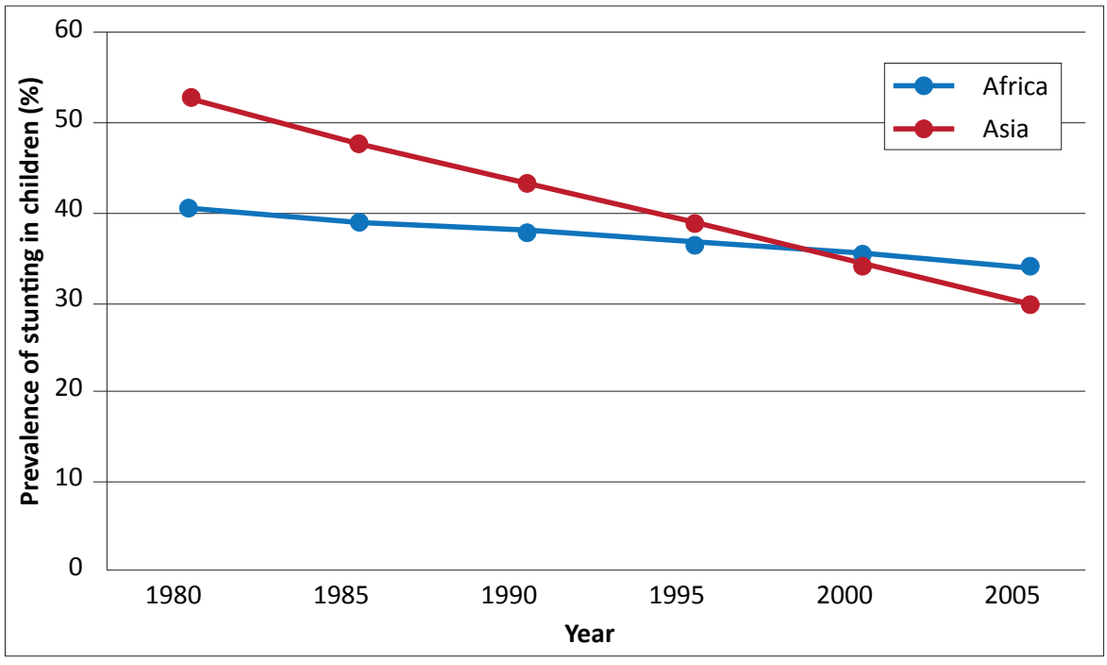
Figure 8.4: Malnutrition levels in Africa



Sources: FAO 2011; AfDB 2011

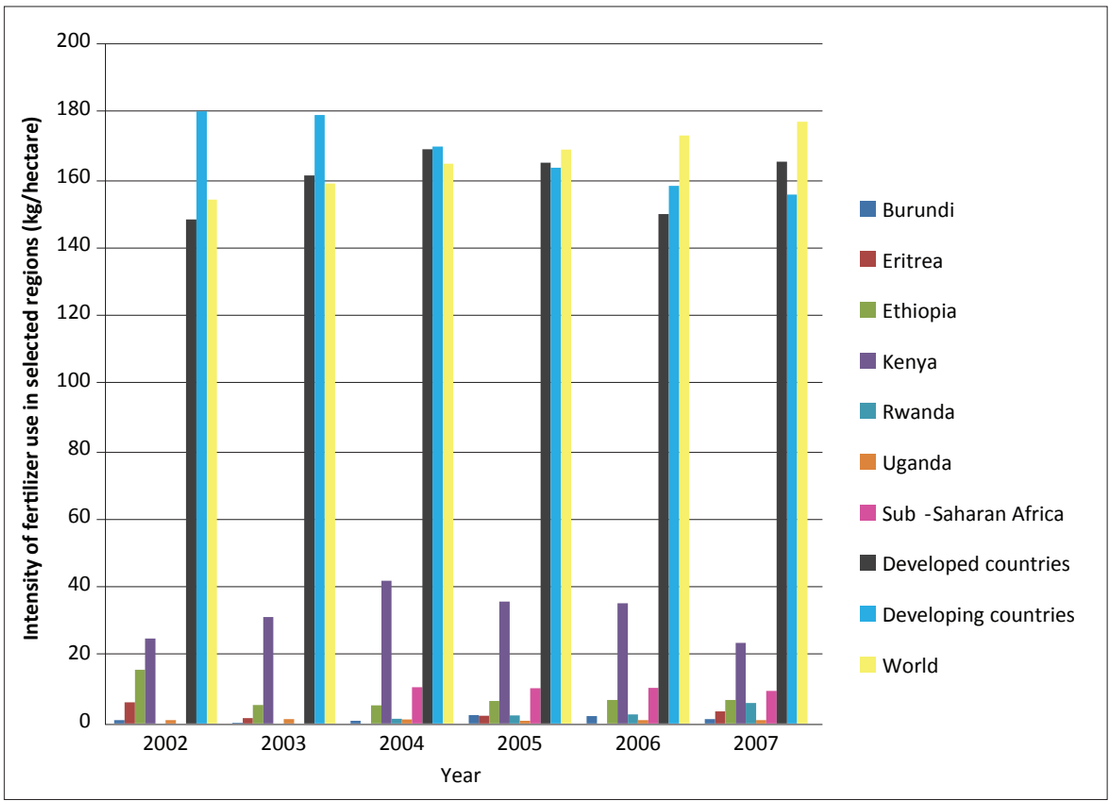
general low capacity to purchase food, are some of the reasons for the high (although declining) malnutrition levels in Africa as shown in Figure 8.4. According to Boussard and others (2005), about 20 per cent of North Africa's population is malnourished although the average daily calorie intake per capita is above minimum requirements; average calorie intake in West Africa is above 2 100 kcal per capita but the share of malnourished is above 20 per cent, and there is a high prevalence of micro-nutrient deficiency. In Central and Eastern Africa daily energy supply is insufficient, and malnutrition and food deficiencies affect more than 40 per cent of the population. In the Democratic Republic of Congo, Burundi, Eritrea and Somalia, the mean calorie availability per capita is below 1 800 kcal, which is considered the minimum intake level (Boussard and others

Figure 8.5: Prevalence of stunted children in Africa and Asia (%)



Source: de Onis and others 2000

Figure 8.6: Intensity of fertilizer use in the East African sub-region (kg/hectare)



Source: Rakshit 2011

2005). In Botswana, Burundi, the Democratic Republic Congo, The Gambia, Liberia, Madagascar, Senegal, Sierra Leone, Somalia, the United Republic of Tanzania and Zambia, the nutrition situation has been deteriorating over the last 10 years, while in Ghana, Malawi and Nigeria, there is a trend towards sustained recovery (Boussard and others 2005).

The insufficient aggregate food availability in some countries is shown by the increasing malnutrition, as measured by the prevalence of stunted growth in children (Figure 8.5). Although the rates of stunting in children are falling, this is not as fast as is happening in Asia, where until recently there were more stunted children than in Africa. The situation in Africa is attributable to economic stress, frequent droughts and the high prevalence of HIV/AIDS (UNSCN 2010). Food deficiency can also result in Kwashiorkor, marasmus, nutritional anaemia, osteomalacia and scurvy, among others. Undernourished children are also unable to sustain concentrated attention (Rotimi and Ola 2007), and this affects their school performance.

About 26 per cent of the world's under-nourished people live in Africa (FAO 2010b), where average cereal yields have stagnated for the past 45 years, averaging less than one tonne per hectare (AU 2008). This is partly due to low farm mechanization and low fertilizer use which averages 20 kg/hectare compared to 150 kg/hectare in Asia and 90 kg/hectare in Latin America (FAO 2005 in AU 2008). As Figure 8.6 shows, fertilizer use in East Africa is lower than the comparable figures for Asia and Latin America cited above.

Low adoption of biotechnology

In addition to a greater uptake of fertilizers, agricultural productivity could be increased through genetic modification. In Africa, the uptake of Genetically Modified Organisms (GMOs) is still low and is largely resisted on account of political, ethical, biosafety and religious concerns. South Africa has fully authorized the commercial cultivation and importation of GMOs for food, feed and processing (Moola and Munnik 2007), while Egypt and Burkina Faso planted genetically

Figure 8.7: Policies on genetically modified organisms (GMO) and genetically engineered foods

Source: Centre for Food Safety 2005

modified crops for the first time in 2008 (Omanya 2010). The various policies on genetically modified organisms (GMO) and genetically engineered foods in the region are illustrated in Figure 8.7.

As Africa gradually embraces innovative techniques, the development and implementation of biosafety policies and laws will be key to guiding the commercialization and use of biotechnology. It is argued that the anticipated cereal shortfall in sub-Saharan Africa of 88.7 million tonnes by 2025 could be met by reducing post-harvest losses, through value addition and embracing technological innovations, including genetic modification (Thomson 2003). There is no recorded medical condition that is directly associated with a diet that includes approved GM crops (Paparin and Romano-Spica 2004), although possible risks include allergic reactions and potential gene transfer from

modified plants to bacteria and humans (Perr 2002). For example, Bacillus thuringiensis, from which genes are extracted and widely incorporated into GM crops for its pesticide properties, is a close relative of the anthrax bacterium, B. anthracis. Potentially, this can generate more pathogens (Altieri 2002 in UNEP 2006), and cause toxic or allergic reactions in humans (ISP 2003). Concerns have also been raised over the effect of GM crop production on the environment, especially its impacts on non-targets, crop-to-weed gene flow and pest resistance build-up (Omanya 2010).

In West Africa where iron deficiency is common in food, bio-fortification is encouraged. For example, in Benin and Burkina Faso a sorghum variety was bred for its high iron and moderate phytic acid contents, and together with soil organic amendments and phosphorous fertilization, and improved food processing to remove phytic acid, crop yields increased (Slingerland and others 2005).

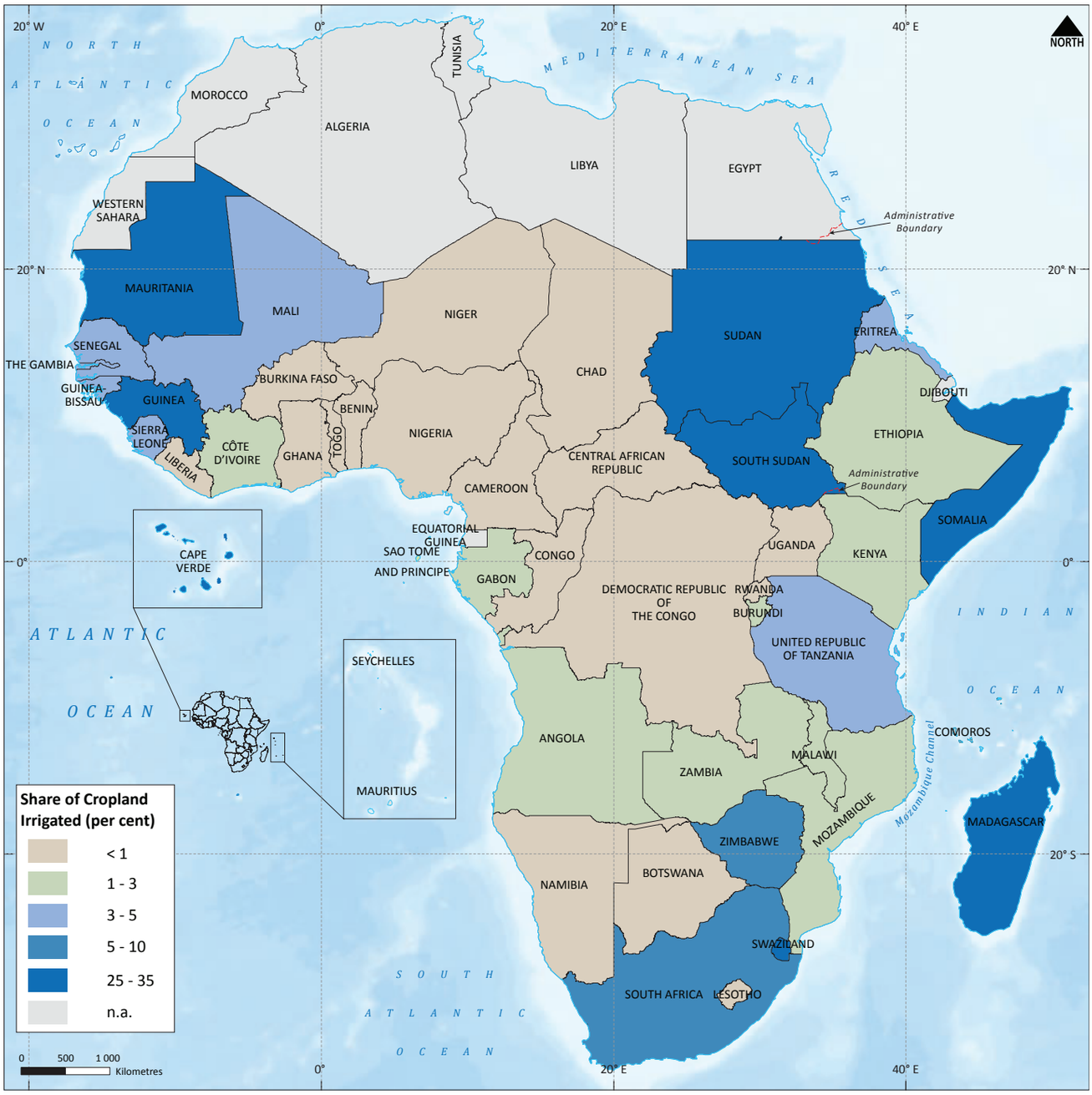
High dependence on rain-fed agriculture

Despite receiving variable and inadequate rainfall, and a high incidence of drought, food production in Africa is largely rain-fed. National and regional solutions that improve land productivity, including placing more arable land under irrigation need to be scaled up. As Figure 8.8 demonstrates, the ratio

The proportion of irrigated crops in Africa remains low, but future development of irrigation is important

IFPRI-IMAGES / Flickr / CC BY NC ND 2.0

Figure 8.8: Share of irrigated cropland



Source: FAO 2010a

of cropland under irrigation in Africa is very small. About two-thirds of the existing irrigated area is concentrated in five of the region's 54 countries, and these are Egypt, Madagascar, Morocco, South Africa and Sudan (You and others 2011). Given that in Africa, irrigated crop yields are double the rain-fed ones, irrigation development is considered to be an important cornerstone for agricultural development in Africa. This view led the Commission for Africa (2005) to call for a doubling of the area of irrigated arable land by 2015, hoping that this would lead to a sustained average annual growth rate of 6 per cent in agriculture (NEPAD and AU 2009). However, irrigation only boosts agricultural productivity when complemented with a suit of other strategies, including better fertilizer products, high yielding and nutritious seed, good postharvest processing facilities and easy access to markets (You and others 2011).

Growing competition for land from

non-food agriculture

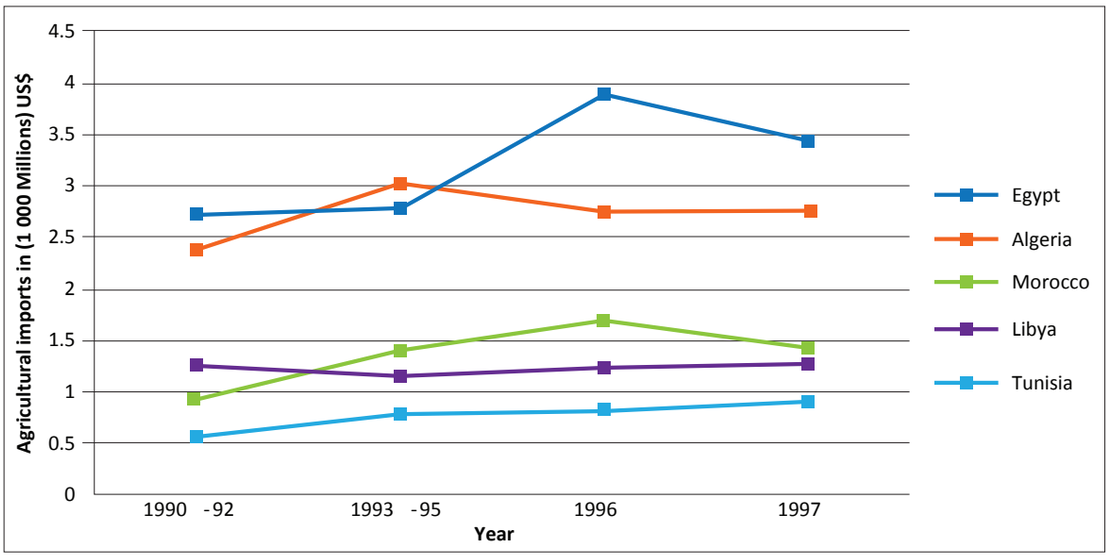
The transformation of the agricultural sector from subsistence to commercial farming could result in increased productivity, but there have been mixed results on household incomes, food security and nutritional health. In some cases, the production of cash crops has not only failed to achieve the expected economic benefits but has also had a negative impact on food consumption and nutritional status. For example, in the 1980s Kenya was concerned that in areas with increased cash cropping, particularly increased sugarcane production, household food security and therefore individual nutritional health had been jeopardized. Studies at that time showed deterioration in the nutritional status of pre-school children (Kennedy and Cogill 1988). Earlier, this concern had been reflected in the country's 1981 National Food Policy Paper which called for the safeguarding of the diet of small scale farmers who were switching from maize to sugarcane production (GoK 1981).

The common assumption with commercial agriculture is that the extra income earned facilitates the purchase of food and therefore boosts nutritional health. This is a plausible assumption given that Africa provides a huge market for agricultural products. For example, Figure 8.9 shows a growing trend of agricultural imports into North Africa in the 1990s and this is a market that the regional countries with surplus yields could tap into. However, households don't always spend income earned from agriculture on food. This is especially the case where men are the custodians of the income earned and women and children only provide the labour required for the production of the crops (Gladwin and others 2001).

Large-scale land investments and food insecurity

Due to insecure land tenure arrangements, many locals have lost vast tracts of land through lease or sale arrangements with foreigners who then grow food for export. China, India and Saudi Arabia are among the countries that have recently leased vast tracts of land (Ossevoort 2011), with the primary aim of growing food using the region's water that most African countries do not have the infrastructural capacity to exploit. For example, between 2004 and 2009, Saudi Arabia leased 376 000 hectares of land in Sudan to grow wheat and rice for the Saudi Arabian market (Ossevoort 2011). The issue that brought this phenomenon to the fore was the former Madagascar government's decision to lease 1.3

Figure 8.9: Growing demand for agricultural imports into North Africa



Source: Kurizig 1999 in AUC and others 2009

million hectares (half the country's arable land) to a South Korean company for 99 years for biofuel plantations under a barter deal for infrastructure projects. It is estimated that Africa contributes 70 per cent (45 million hectares) of the global land leased or bought to produce agricultural crops for food and biofuels (Deininger and Byerlee 2009), with adverse impacts on local food security and livelihoods (Cotula and others 2008). Yet the expected benefits of these land investments – more jobs, new technology, better infrastructure and extra tax revenues – have not always been realized (Locher 2011).

The land deals may have future negative impacts on local food security and nutritional health. The deals are viewed by some as a form of neo-colonialism (Williams 2009), especially given that the arrangement is between partners with vastly unequal power (Mackenzie 2008 in Allouche 2011). However, others argue that this development could provide more security and predictability for poor farmers than selling crops on open, often volatile markets (Mackenzie 2008 in Allouche 2011).

Land use changes and human health

Changes in land use have a bearing on the ecology of diseases, as well as on the capacity of the region to produce food, especially in cases where the use is changed from food crops to biofuels. Besides the expansion of arable agricultural land, deforestation and mining, urbanization is another major pressure for land use change.

Land use changes affect the distribution of fauna and flora, and also cause changes to the local climate. Changes in land use can also lead to land degradation, cause changes in the ecology of human diseases (Collins 2001), and increase risks to human health through the bioaccumulation of toxic substances (Darnerud 2003). For example, the eradication of the tsetse fly (*Glossina spp*) has resulted in significant land use changes in Ethiopia (Reid 1999 in Swallow 1999), Kenya (Muriuki and others 2005) and Zimbabwe (Govereh 1999 in Swallow 1999), with both positive and negative human health effects. Tsetse fly eradication enabled the beneficial use of land for food production in parts of these countries. The eradication opened up new settlement areas which has become free of the sleeping sickness disease.

However, in Zimbabwe, tsetse fly control was made possible through the use of DDT over the period 1946-1982 (Mpofu 1986). High levels of DDT averaging 25.26 mg/kg were later found in the milk of breast-feeding mothers (Chikuni and others 1997). In addition to being persistent, DDT can be transported over long distances, and it increases in concentration as it moves up the food chain. By being at the top of the food chain, human beings tend to magnify the concentration of DDT. Health effects of DDT are debatable, although it is suspected that it can affect the reproductive system and cause cancer (Dalvie and others 2004).

Land use changes can significantly affect local weather, including temperature, evapo-transpiration and surface runoff (Patz and Olson 2006). Such changes affect the survival of disease vectors such as mosquitoes. For example, in Kenya and Uganda, higher temperatures were recorded in communities bordering cultivated fields compared to those adjacent to natural wetlands, with the number of *Anopheles gambiae,* the malaria-carrying mosquito, increasing with minimum temperatures rises (Patz and Olson 2006). Deforestation and cultivation of natural swamps in the African highlands are known to create conditions favourable for the survival of *A. gambiae* larvae (Patz and Olson 2006).

Similarly, the changes in local conditions due to an increase in soil moisture associated with irrigation development in the southern Nile Delta following the construction of the Aswan High Dam was said to have caused a rapid rise in the population of the mosquito *Culex pipiens*, and consequential increase in the filarial disease *Bancroftian filariasis*

Small scale farming

(Patz and others 2003). In Sudan, Himeidan and others (2005) found a pattern of two peaks of malaria cases during the rainy and irrigation seasons, while in Zimbabwe, Senzanje and others (2002) established that malaria contributed up to 38 per cent of labour days lost each year on large-scale irrigation projects. Similar associations between malaria rates and irrigated areas have been reported by Ng'ang'a and others (2008) in Kenya. The irrigated area as a share of total cultivated area is estimated at only 6 per cent for Africa (You and others 2011), although the area has been expanding over the past 30 years, growing at an average annual rate of 2.3 per cent (You and others 2011).

Urbanization

Growing at an annual average of 3.5 per cent, Africa's pace of urbanization is the fastest in the world (UNEP 2006). About 40 per cent of Africa's population of over one billion lives in urban areas (UN-Habitat 2010). In 2010, Africa had 47 cities with populations exceeding one million (UN-Habitat 2010). The region's largest cities then were Cairo with a population of 11 million, Lagos with 10.5 million people, Kinshasa with 8.7 million, Khartoum with 5.1 million and Luanda with 4.7 million people (UN-Habitat 2010).

If current trends continue, urbanization will have significant implications for biodiversity and ecosystems with knock-on effects for human health and development (CBD 2012). The report states that urban expansion is occurring fast in areas close to biodiversity hotspots and coastal zones. In rapidly urbanizing regions, such as large and mid-sized settlements in sub-Saharan Africa, resources to implement sustainable urban planning are often lacking. The report notes that 'Africa is urbanizing faster than any other continent, and most population growth will occur in cities of less than 1 million people. These cities often have weak governance structures, high levels of poverty and low scientific capacity regarding biodiversity.' The low levels of formal employment in cities places high dependence on ecosystem services (for water and food production) from areas either within or close to city limits (CBD 2012).

Making biofuels in Mali

Cultivation of biofuels

The growing demand for biofuels, is forcing large-scale land use changes in Africa. The biofuels sector offers both promises and challenges for Africa's food security. Supporters argue that if profitably managed, biofuels can stimulate rural economic growth while opponents argue that biofuels production will threaten food supplies for the poor (Jumbe and others 2009). Von Braun (2007) noted that biofuel production will create demand for energy crops such as sugarcane and soybeans that are grown by rural farmers. Farmers can also increase incomes by growing *Jatropha curcas* on marginal land that is not suitable for food crop production.

Electricity co-generation is another benefit from biofuels. Energy co-generated from biofuels, as is the case in Mali, the United Republic of Tanzania and Zimbabwe, may lead to improved livelihoods, health and nutrition of rural households (FAO 2008 in Kgathi and others 2012; Sanga and Meena 2008 in Kgathi and others 2012). For example, 18.5 MW of electricity is generated at Zimbabwe's bio-ethanol plant in Chisumbanje as a by-product of ethanol production, and it is expected that when the project is fully commissioned, it will produce 120 MW which is enough to meet the electricity needs of over 80 000 households (Mutambo 2011). This can also potentially boost food processing and storage at the household level.

It is often asserted that the alienation of land for energy crops can threaten food security especially if the land in question is arable and is needed or used for food crops. The sustainability of biofuel developments depends on the type of biofuel feed-stocks used and the subsequent impacts on land-use change. Food availability could be affected if food crops or productive resources such as land, labour and water are switched from the production of food to that of biofuels. This may aggravate the problem of food insecurity (Kgathi and others 2012). For example, the increased interest in biofuel development resulted in the United Republic of Tanzania setting aside over 700 000 hectares of land for biofuel production, and of this about 100 000 hectares is estimated to already be under biofuel production (Sosovele 2010).

Due to lack of a national policy to guide biofuel production, most of the energy projects in the United Republic of Tanzania are situated on land that is suitable for food production and this is likely to expose the country to food insecurity. the United Republic of Tanzania has experienced shortages in supply of food in the past which resulted in the distribution of food aid (Sosovele 2010). Other countries which produce biofuel in Africa include Kenya, Malawi, Mauritius and Zimbabwe where bio-ethanol is produced, and those which produce biodiesel include Ghana, Mozambique, South Africa and Zimbabwe (Jumbe and others 2009; Amigun and others 2011).

There is a general concern that biofuel development is responsible for soaring commodity prices which have aggravated food insecurity in developing countries (FAO 2008). The contribution of biofuels to the global increase in food prices over the period 2002-2008 is estimated to be between 3-30 per cent (FAO 2008). The increase in commodity food prices affects net-food buyers negatively and net food sellers positively (Lustig 2009).The impact on net-food importers is severe in countries such as Ghana and Malawi where households spend as much as 73 per cent and 64 per cent, respectively, of the family budget on food. In southern Africa, most countries are net food importers and would be vulnerable to the impacts of price increases of agricultural food crops (Amigun and others 2011). North Africa also imports much of its food, and the sub-region's food import bill continues to grow.

Exposure to zoonotic diseases

In the quest to maximize land use and productivity, Africa is witnessing significant growth in livestock production, as well as encroachment of livestock and crop production into wildlife areas. Livestock is an important sector in Africa, even though animals attain slaughter weight at advanced ages of 3-5 years and annual milk yields are generally low ranging between 600 and 1 500 litres per cow (AU 2008).

It is estimated that 75 per cent of human diseases are zoonotic, implying that they are linked to wildlife and domestic animals (Taylor and others. 2001). For example, pig production has increased significantly in East and Southern Africa, especially in rural, smallholder communities. The growth

Farmers and their livestock in western Zambia

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Box 8.1: Foot-and-mouth disease in Botswana

In Botswana, the foot-and-mouth disease was first reported in 1930, when it spread from Zimbabwe (then Rhodesia) and South Africa. The disease was eradicated in 1934, only to reappear sporadically throughout the 1940s and in the second half of the 1950s. Other well-documented outbreaks occurred in 1977 and 1978.

Cattle-wild animal contact, especially with the buffalo, at drinking points was also strongly suspected as the main source of transmission. The country did not experience any further outbreaks of foot-and-mouth until 2002, when an outbreak of the disease was confirmed in north eastern Botswana. Illegal transboundary movement of animals between Zimbabwe and Botswana was suspected. In 2005, 2006 and 2007, three separate outbreaks of the disease were recorded in the eastern and western areas of the Chobe District and in Ngamiland District. The control policy adopted in these three cases was vaccination rather than destruction. Essentially, destruction aims to remove the virus so that exports can resume. However, since the area has a high buffalo population, technically the virus cannot be eradicated.

Source: Mapitse 2008

in pig production is partly the result of lack of grazing land for ruminants and the realization by farmers of quicker and higher returns on pig investments. This has resulted in the emergence of porcine cysticercosis, caused by the zoonotic tapeworm *Taenia solium*, and this has become a public health concern in Africa (Phiri and others 2003). A prevalence rate of 17 per cent of porcine cysticercosis was recorded in Mbulu district of the United Republic of Tanzania, while in Tete province of Mozambique, the prevalence was 15 per cent (Phiri and others 2003). The cysticerci of *T. solium* may lodge in the brain, causing cerebral cysticercosis (neurocysticercosis), resulting in headaches, epileptic seizures, blindness, mental disturbance and even death (White 2000; Phiri and others 2003).

Livestock keeping and consumption of livestock products exposes people to zoonotic tuberculosis or brucellosis, caused by *Mycobacterium bovis* and *Brucella* species. Symptoms in livestock include abortion, increased calving intervals, weight loss (Ameni and others 2007), and morbidity in wildlife, with negative effects on the tourism industry (Michel and others 2006). Trade in livestock and animal products is also affected. Human brucellosis is mostly an occupational hazard of herdsmen, veterinarians and butchers but also affects people who drink raw milk products, a common practice among children in Africa (Acha and Szyfres 2003). In humans, *Brucella* species cause influenza-like symptoms that are rarely correctly diagnosed or reported (Jennings and others 2007). Sero-prevalence rates of *Brucella* species as high as 2.5 per cent in Ethiopia; 8 per cent in Zambia and 15 per cent in Kenya have been recorded (Marcotty and others 2009), and this indicates a high level of exposure of people to human brucellosis.

Avian flu is another zoonotic disease that has affected some African countries in recent years. Nigeria detected the avian flu virus in 1996 at a commercial poultry farm in Kaduna (Fasina and others 2011). About 711 000 birds of various species died, while over 1.26 million were culled as a precautionary measure. One human fatality was reported (Fasina and others 2011). Large populations of birds within farm premises, poor biosecurity and the presence of wild birds, especially the Egyptian geese, increased the risk of infection of domesticated birds such as ostriches and chickens to the influenza virus (Fasina and others 2011).

Cattle diseases such as foot-and-mouth rarely affect humans, but can cause death or permanent disability in the animals they affect, and can cause losses in the production of meat and milk. Humans rarely contract the disease and it causes few or mild symptoms when it occurs. The major risk factor in the spread of foot-and-mouth disease is the lack of effective boundaries to separate cattle from buffaloes, which are known carriers of the disease. Commercial cattle production in Zambia declined between 1997 and 2005 largely

due to outbreaks of foot-and-mouth, anthrax and contagious bovine pleura-pneumonia (CSO 2000 in Kanema 2009). In Botswana, beef is the fifth largest export commodity (Jefferis 2005), and the most important rural economic sector. As a result, disease outbreaks such as those of foot-and-mouth have significant livelihood impacts on the country (Box 8.1).

In view of the importance of the livestock sector to the livelihoods and economic wellbeing of society, various initiatives are in place to stop the spread of the disease. These include the isolation of game conservancies from livestock areas using a double electrified fence, a defoliated strip of about 7.5m wide and the clearance of vegetation for 1m on either side of each fence-line (Sutmoller and others 2000). Other control measures include vaccination and destruction of infected cattle.

Strengthening land-health linkages

Adequate land management and enhanced agricultural productivity can make Africa self-sufficient in food and nutrition thereby strengthening the positive link between land and human health. Efforts to increase land productivity and improve food security have included expansion, intensification and diversification of land uses. While there is still room for expanding the area under agriculture, a rapidly growing population and growing demand for land, including by large-scale investors, imply that agricultural intensification, diversification and sustainable management hold the future to unlocking the potential health benefits that lie buried in Africa's land resources. This will be possible by addressing the factors which currently hamper better yields by improving access to, as well as the affordability, of fertilizers and improved seed varieties. Diversified farming systems that incorporate various crop farming, livestock keeping, agro-forestry, intercropping, and crop rotation will enable farmers to reduce the risk of failure, while also promoting a better and balanced diet. While agricultural intensification will result in higher yields per unit area, the region

Conservation farming has helped to improve the nutrition situation in Malawi

continues to be wary of biosafety challenges in the event that GM technology is used.

In view of the growing global demand for land for biofuels and food, Africa is at a more vulnerable position of dispossession than before due to weak and unclear land tenure arrangements. In many cases, these have few safeguards to ensure the protection of vulnerable groups such as the poor, elderly and pastoralists. Although the implications of the land rush to Africa are not yet fully understood, locals are bound to either benefit from increased agricultural productivity and employment opportunities or to lose following dispossession.

As a resource, land cannot be productive on its own. Water is central to land productivity, with irrigation expansion being one of the central areas of focus by the African Union through its Comprehensive Africa Agriculture Development Programme (CAADP). Irrigation will only enhance agricultural productivity with improved crop varieties, pest and disease control, and sustainable land management. Sustainable land management practices help to replenish soil nutrients through

the improvement of fallow-systems, good management of crop residues; tapping nutrients through mixed cropping and agro-forestry systems; and minimizing soil disturbance through reduced or zero tillage systems.

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PART 2

Scenarios for the Future: Enhancing Implementation of Environmental and Health Policies

9

Scenarios of Future Health and Environment Linkages

Opposite page: NASA

Scenario analysis and environmental challenges

The uncertainty about how the future will play out calls for focus on how to manage the environment for improved human health outcomes. Environmental challenges like climate change, biodiversity loss and natural resource use have long-term implications which require long-term policy solutions (Zurek and Henrichs 2007). In order to make informed natural resource choices and strategic decisions, anticipatory thinking that reveals what lies ahead is desirable. Scenarios analysis requires thinking in alternatives as the future is liable to many uncertainties (Wilkinson and Eidinow 2008). Scenarios are neither predictions nor forecasts and are plausible descriptions of how the future may unfold for our organizations, our issues, our nations and even our world, based on 'if-then' propositions (Alcamo and others 2005). Scenarios have been applied in many specific issues such as biodiversity, land, agriculture, health, water and sanitation, forestry, conflicts and climate change. Environmental scenarios, outlooks and other types of forward-looking studies help in addressing discontinuity and uncertainties of future developments and in designing robust policies that can withstand the test of time (EEA 2011).

The scenario analysis contained in this chapter is underpinned by the assumption that in order to understand the many ways in which environmental management may impact human health in the future, it is necessary to explore the current trajectories based on internationally agreed goals and gauge the effort needed to tilt the balance towards such goals. Borrowing from UNEP'S (2012) Fifth Global Environment Outlook (GEO-5), AEO-3 adopts two sets of scenarios, the Conventional World Scenario (CWS) and Sustainable World Scenario (SWS). The two groups of scenarios represent broad

Farming in the highlands of Ethiopia

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collections of other scenarios and projections that show current trends and desirable futures respectively. This is a departure from the First and Second Africa Environment Outlook reports (AEO-1 and AEO-2) that explored four scenarios (Markets Forces, Policy Reform, Fortress World and Great Transitions). The adoption of the two extreme alternatives is aimed at exploring the current trajectories in comparison to selected agreed health and environment targets with the ultimate goal of elucidating the policies and practices needed to steer environmental management towards these goals. CWS depicts trends without major policy changes while SWS depicts the options for change and transformation as well as required shifts to enable realization of long-term goals and targets.

The environment, which sustains human life, is expected to remain a profound source of both ill and good health. Africa is home both to some of the fastest industrializing economies such as Ethiopia, which has averaged 10.7 per cent economic growth over the past decade (World Bank 2013), and the world's poorest countries. As such, it has to contend with the paradox of the co-existence of good and ill health depending on environmental and health policies. The goal of this chapter is to explore the many ways in which environment and health could co-evolve and the implications of this for Africa's vulnerable populations and ecosystems. The chapter assesses the effect of current trajectories of environmental management on various drivers and pressures in order to illustrate the gaps to realizing specific health and environment goals.

The two scenarios

Conventional World Scenario

The Conventional World Scenario (CWS) depicts plausible future environmental developments along a trajectory representing a continuation of current trends without major policy shifts. In the context of health-environment linkages, CWS explores the potential health risks and benefits associated with a world that continues to develop in a business-as-usual pattern. No explicit policies to address main environment-health challenges are in place. The scenario features a strengthening of market mechanisms and corporate capitalism with emerging technological waves in the form of ICT, and the rapid economic growth in some sub-regions and countries. The scenario projects a continuing increase in extractive industries which require access to environmental goods and services and are largely driven by the same entrepreneurial and market dynamics which have been witnessed over the past few decades.

As is already happening, this scenario is characterized by a plethora of innovations and high-tech productivity but with limited, if any, consideration for environmental provisioning for human health. Under this scenario, population size and related demographic dynamics follow the UN medium scenario, increasing gradually to 2 billion by around 2050 (AfDB 2011). In terms of economic growth, if current expectations are realized, economic growth, in general, will be higher in low-income countries than in high-income ones. This does not, however, result in an income and health benefit convergence.

Sustainable World Scenario

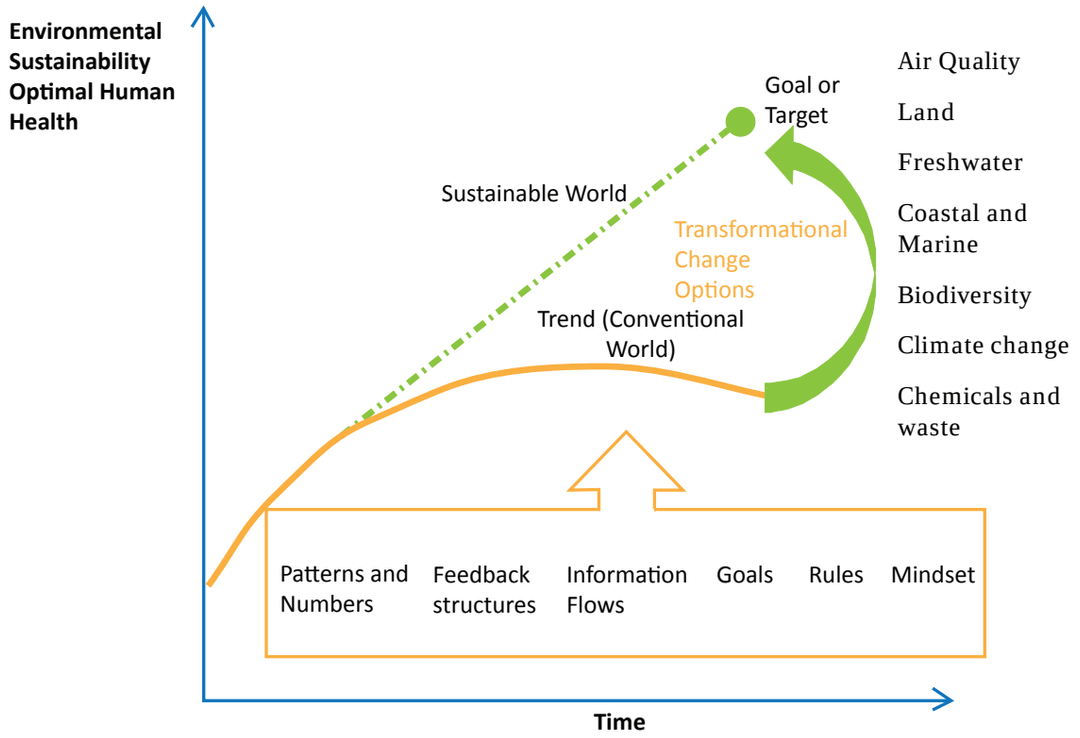
The Sustainable World Scenario (SWS) depicts a future where deliberate attempts are made to manage the environment in ways that meet internationally agreed development goals with clear targets for associated health benefits. Some of these goals relate to protocols, targets and specific milestones mentioned in the MDGs as well as those relating to biodiversity, global warming, forestry, land degradation and other sustainable development outcomes. The scenario explores the transformative actions required to bring about a more environmentally sustainable future. SWS is based on the assumption that environmental management will proceed in a manner that limits degradation and associated deleterious health outcomes. The main objective of the scenario is to reveal the choices of policies and programmes that would ensure the attainment of both the desired environmental and related human health outcomes.

With the strong momentum already started by the drivers playing out in current trends (CWS), the force to deflect such trends to meet environmental targets is expected to remain a daunting challenge. This is largely due to population dynamics, social changes, cultural inertia as well as technological and economic growth. Realizing this attractive route to the future would require considerable investments, coupled with mindset and behavioural change of individuals, communities, institutions and nations. The scenario reveals 'what it would take to overcome barriers to meeting sustainability goals' (UNEP 2012).

Scenario analysis approach

The achievement of long term policy goals by African countries remains a challenge. The goals are interrelated through the antecedent factors that cause them and must therefore be addressed in coherence to tap possible synergistic benefits to human health and the environment. The necessary trade-offs will make achieving them a challenge. It is prudent to explore through integrated scenario analysis how these goals will be realized in relation to health benefits. SWS explores plausible pathways that could lead to meeting key health and sustainable development

Figure 9.1: The Conventional World and Sustainable World Scenarios



Source: UNEP 2012

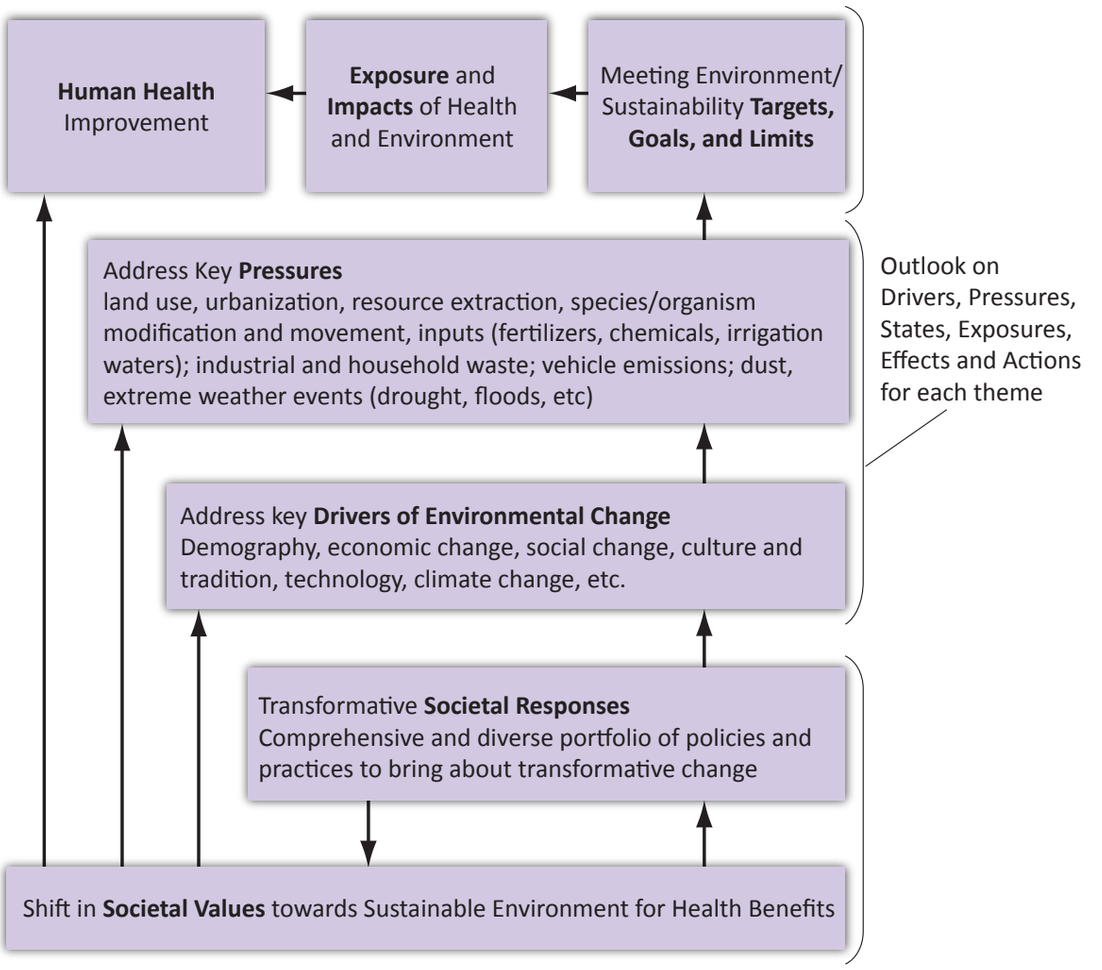
goals simultaneously as the continent manages its land, biodiversity, forest, coastal and marine and freshwater resources towards 2050.

The effort needed to realize these long-term goals constitutes the 'transformative change' alluded to in UNEP's Fourth Global Environment Outlook (GEO-4) report (UNEP 2007). The assumption is that current policies will not be sufficient to bring about the transformation. SWS adopts a back casting approach to storytelling and simulation through defining health and environment outcomes under each thematic issue and sub-regional priority. The outcomes are then used as starting points from which transformation, uncertainties, and policy actions are tracked using various modelling approaches. SWS has been adopted because it allows a consistent analysis of thematic, regional, sub-regional and national processes in order to construct a pathway envisioning complete halting of unsustainable trends and getting the region onto a sustainable development trajectory that converges with health and environmental sustainability goals (Figure 9.1).

The scenario analysis sought to transform the current CWS pathway into the desirable SWS one is detailed below and illustrated in Figure 9.2:

- Selection of themes consistent with health and environmental focus of the report and findings from the thematic chapters.
- Selection of relevant models or results from existing scenario analyses in order to provide qualitative and quantitative trends and storylines for each of the thematic areas: air quality; biodiversity; chemicals and waste; climate change and variability, coastal and marine resources; freshwater and sanitation; and land.
- Identification of long term goals including internationally agreed goals (for example 2°C temperature rise target, and MDGs and their anticipated successors), as well as environmental limits consistent with the scenario time line of 2050. Note that 2050 is the maximum long range scenario time limit. Each theme/goal might have a different time horizon and any future explorations will then be guided by the

Figure 9.2: Elaboration of the Sustainable World Scenario



Source: UNEP 2012

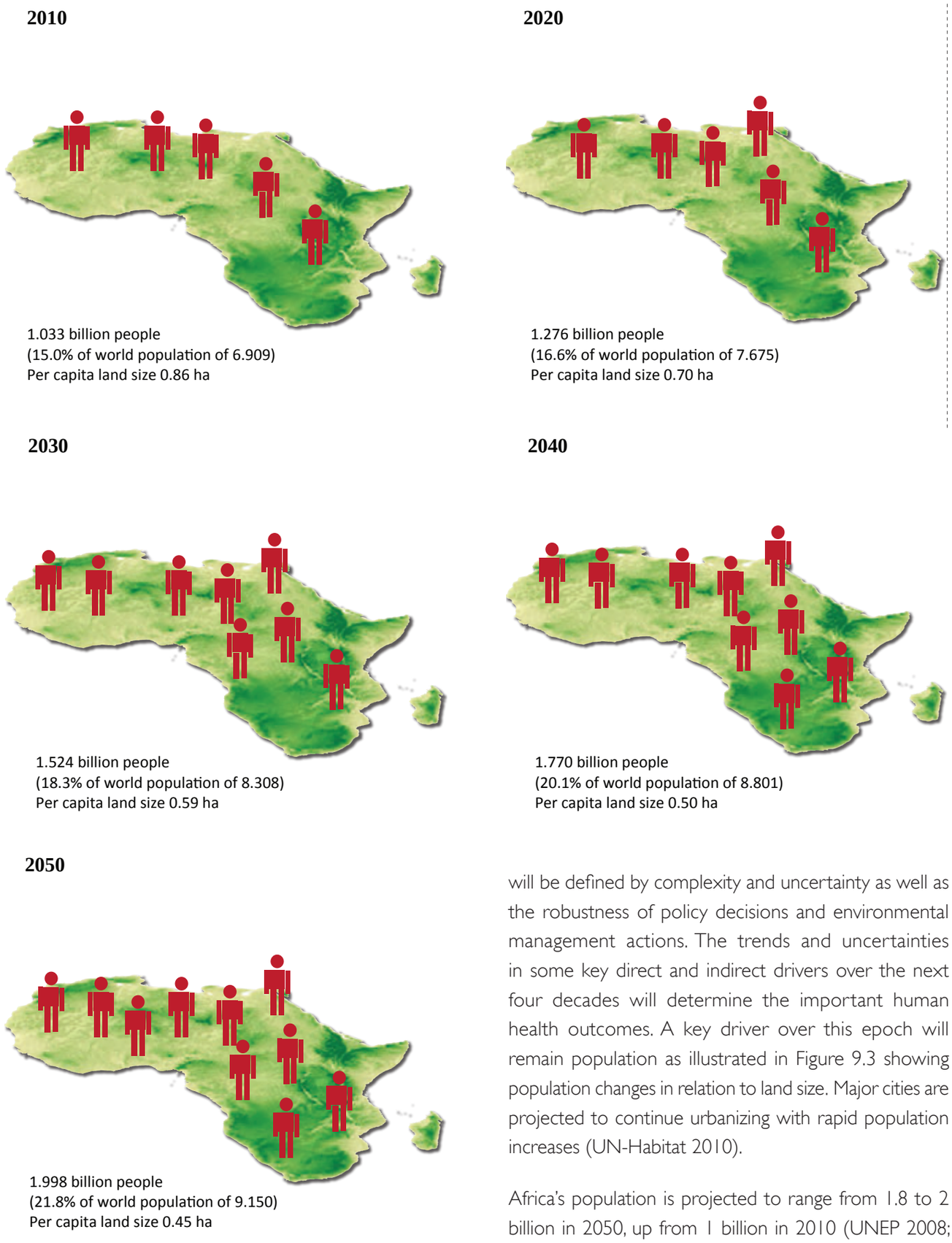
specific target milestones, for instance, the MDGs target date is 2015.

- Analysis of possible synergies and trade-offs between the goals and targets in different health and environment domains by linking the different models/scenario findings with the goals and health targets in order to construct the narrative.
- Identification and analysis of possible alternative strategies (wedges) that are sub-regionally differentiated but regionally consistent. These alternative strategies should also have the capacity to close the gap between the current trend and the identified goals for 2050 through policy changes, technological solutions, tried good practices and lifestyle and behavioural changes. The associated risks, health and environment benefits are appropriately flagged along the way to complete the storyline.
- Identification and analysis of transformative policies necessary to realize long term goals. The identified goals would build on promising initiatives that are already underway. The analysis also points out where desirable outcomes cannot be met in order to influence further research and policy interventions.

Drivers of change

If the recent trends offer some inkling of how the future might play out, then what is likely to be around the next corner is an increasingly volatile environment, where health benefits and outcomes

Figure 9.3: Projected trends in Africa's population and per capita land size to 2050

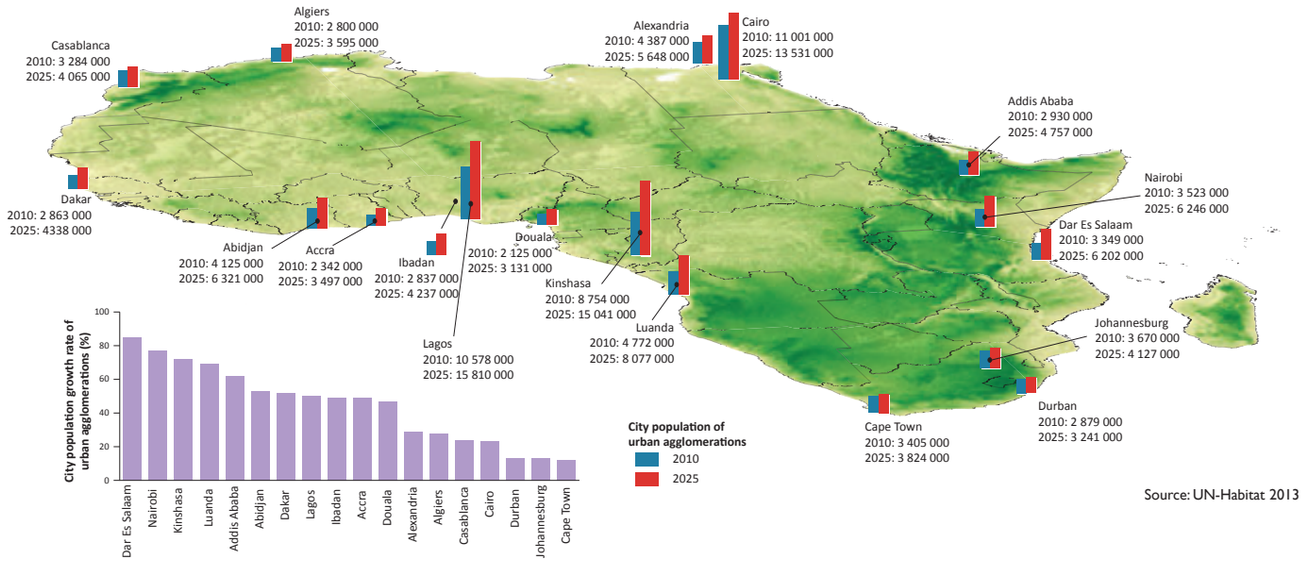


Source: UNEP 2008

will be defined by complexity and uncertainty as well as the robustness of policy decisions and environmental management actions. The trends and uncertainties in some key direct and indirect drivers over the next four decades will determine the important human health outcomes. A key driver over this epoch will remain population as illustrated in Figure 9.3 showing population changes in relation to land size. Major cities are projected to continue urbanizing with rapid population increases (UN-Habitat 2010).

Africa's population is projected to range from 1.8 to 2 billion in 2050, up from 1 billion in 2010 (UNEP 2008; AfDB 2011). Projections show the population growth rate

Figure 9.4: Populations of major African cities in 2010 and 2025



Source: UN-Habitat 2013

declining although population size will continue to increase, eventually overtaking that of China and India. A fast constant population growth rate of 2.3 per cent, such as that recorded by Africa in 2010 would cause the population to double in about 30 years. With the decrease in the total fertility rate, the annual growth rate of the population of Africa as a whole will decelerate to 1 per cent after 2050. Almost all the sub-regions of Africa would witness the same dynamics in population growth except North Africa, where annual population growth will decline rapidly to just 0.3 per cent by 2050 (AfDB 2011).

The rate of urbanization will continue and by 2050, 60 per cent of Africans will be living in cities while the population of African cities is set to triple over the next 40 years (UN-Habitat 2010). Cairo, for instance, is set to grow by 23 per cent over the next 15 years with a projected 13.5 million inhabitants by 2025. Lagos and Kinshasa rank second and third respectively among Africa's highest urban agglomerations (Figure 9.4).

All Africa's sub regions will continue to face the threat of climate change and other global environmental changes with varied immediate and long-term health effects. Despite considerable effort in addressing environmental problems, environmental degradation will still pose a huge threat to human health. The exact nature and scale of environmental risks to health will likely vary by sub-region. Factors that will influence exposure and vulnerability will largely be premised on policies and environmental management actions. It is instrumental therefore to explore how such policies and actions may play out in future in order to map a desirable pathway and the associated transformative changes required.

Busy coast of Sierra Leone

IHH Insani Yardim Vakfi TURKEY / Flickr / CC BY NC ND 2.0

Table 9.1: Projections of key indicators of health and environment change in Africa under CWS and SWS

INDICATORS		2010	Conventional world scenario 2050	Sustainable world scenario 2050
Population	Million inhabitants	940	2,015	1,970
Settlements: urban society	% of people living in cities	46%	67%	62%
Rural land Overexploitation	cropland (% of total land)	7.2%	9.7%	9.2%
	Rangeland/pasture (% of total land)	24.0%	28.1%	28.0%
	Forest (% of total land)	21.2%	18.4%	18.5%
	Natural vegetation (% of total land)	47.0%	42.9%	43.5%
	Others (% of total land)	0.6%	0.9%	0.9%
Technology (% of GDP dedicated to R&D/S&T investment)		0.5%	1.4%	2.5%
GDP (2010 = 100)		100	150	450
Wealth disparities (GDP per capita dispersion relative to mean)		4.3	2.3	1.2
Energy (MTOE=201*100)		100	200	120
Climate change (Cost of adaptation – US$)		Up to 5% of GDP	Up to 10% of GDP	Under 5% of GDP
Biodiversity (% yearly change in biodiversity loss, species change)		-0.12	-0.065	0.01
Governance (forms of government and natural resource management systems approaches)		Increasing integrated NRM and stakeholder involvement and devolution of management of NRs, co-management and improved transboundary resource management. Several resource based conflicts including cross border ones	54 democracies, mixed integrated NRM models with some level of stakeholder involvement. Reduce level of conflicts	54 democracies and full adoption of integrated and adaptive NRM. Stakeholder including PPP models in place at all scales. Transboundary resource management in place

Source: Compiled by the authors from various sources

The projections of key indicators of health and environment change in Africa under CWS and SWS are detailed in Table 9.1.

Thematic scenario analysis

This section explores the anticipated changes under both CWS and SWS. The evaluation, based on key indicators of environmental change and human health outcomes, presents future trends in air quality, biodiversity, chemicals and wastes, climate change, freshwater and sanitation, and land. The narrative under CWS uses the forecasting approach while the SWS storyline has been created using the back casting approach.

Air Quality

Africa and the rest of the world are working towards the goal of reducing and preventing air pollution through, especially limiting the concentration of pollutants (such as $PM_{2.5}$, PM_{10}, SO_2, NO_2, O_3, CO, Pb) in line with WHO guidelines (WHO 2006). This is also articulated in Article 2 of the 1979 Convention of Long-range Transboundary Air Pollution (CLRTAP). The Johannesburg Plan of Implementation (JPOI) calls for states to enhance cooperation at the international, regional and national levels in order to reduce air pollution, including transboundary air pollution, acid deposition and ozone depletion (UNDESA 2002). This is also in line with the Rio principles on the reduction of respiratory

diseases and other health impacts resulting from air pollution, which particularly affect women, children and the elderly.

Conventional World Scenario

The health effects of both outdoor and indoor pollution worsen over the years on account of developments in mining, cement production, and increased use of biomass as a household fuel source, as well as the burgeoning transport industry and associated vehicular emissions. The Sahelian countries continue to suffer dust pollution. To mitigate the effects of outdoor pollution, attention has been on reducing the effects of combustion of petroleum products, coal and controlling other industrial processes that lead to suspended particulate formation. Indoor pollution, on the other hand, is largely caused by using unclean cooking and heating energy sources such as wood and agricultural waste (WHO 2011). Unless tamed, these two forms of air pollution continue to expose vulnerable African inhabitants to many health risks.

Although comparatively insignificant, Africa continues to contribute to global warming largely through biomass burning (Thouret and others 2009), biogenic emissions by soil and vegetation (Stewart and others 2008) and lightning NOx (Schumann and Huntrieser 2007). Urban transport and long distance transport including the increasing air-transport network likely worsens the situation. This trend is likely to be maintained even in West Africa, where natural sources of air pollution such as the Harmattan (dry dust-laden atmosphere) phenomenon remain recurrent episodes virtually on a yearly basis. Whatever the source, the projected suspended particulate matter (under current trends) affects human health depending on the levels of exposure. As projected by Silva and others (2013), about 77 500 people in Africa are dying annually from PM2:5-related outdoor air pollution related diseases.

Africa's energy consumption continues to grow, with fossil fuels maintaining the largest share. By 2030, over half a billion Africans will still live without access to electricity and rely largely on the traditional use of biomass for cooking (Karekezi and others 2012). According to Mery and others (2010) the inefficient combustion of this source of energy in inadequately ventilated buildings leads to adverse health effects, especially for the rural poor and those who live in densely populated urban areas. Further, these forms of energy will lead to ecosystem degradation with indirect links to air pollution.

West Africa remains by far the most exposed and affected sub-region from dust storms. Megacities like Cairo and Lagos are likely to remain under choking air pollution due largely to growing vehicular and industrial emissions. Respiratory infections continue afflicting the vulnerable with increasing rates of mortality among infants and the elderly. GHG emissions resulting from land use change and forest cover loss will also have negative implications for carbon sequestration. Other trends that are likely to continue complicating air quality management include wild fires and continued reliance on biomass and fossil fuels for energy. Incidences of bush fires continue due to escalating human activities. Climatic factors play an important role in bush burning with drought periods witnessing more bushfires.

Sustainable World Scenario

By 2050, many African governments are effectively implementing air pollution regulations that have seen indoor and outdoor air pollution contained with minimal human health implications. Cases of respiratory tract infections linked to air pollution have been reduced greatly as particulate matter and concentration of pollutants is within WHO standards.

The challenge of reversing the detrimental effects of air pollution trends on human health

and other development objectives had involved instituting measures to prevent and manage the various forms and sources of indoor and outdoor pollution. The decisions made and actions taken between 2010 and 2050 for monitoring ambient air quality kept levels of air pollution below critical thresholds. The right to a clean, healthy environment is now provided for in many national constitutions and this provision is construed to include the right to clean and safe ambient air. Laws regulating air quality had been systematically reformed and effectively implemented in order to protect human health and the environment.

To address the challenge of exposure in rural and urban settlements as well as industrial and work places, objective-based approaches to air quality management were adopted by most countries by 2030. Standards of air quality as well as measurement and compliance procedures were inbuilt in the laws to cover the automotive and industrial sectors, and indoor energy use. Most countries also ratified and effectively implemented atmospheric pollution related conventions. The use of ozone-depleting substances such as chlorofluorocarbons (CFCs) and carbon tetrachloride were phased out by 2025.

The policies put in place by many governments in 2014 enabled the desired transformation to sustainable air quality management over the next decades. These included the enactment of anti-bushfire legislation and management regimes coupled with regional and local early warning systems. Sub-regional cooperation in preventing and managing all forms of air pollution and their causes also helped to realize the targets. All countries had by 2025 adopted lead-free gasoline policies. Other policies targeted the fossil fuel market and standards were formulated for petroleum products. The generation, dissemination and use of state-of-the-art technologies in indoor and outdoor air pollution monitoring and control were also fast tracked. There were obvious trade-offs along the way, including decisions and investments in bio-energy and related clean energy systems as well as housing and land use plans in relation to forestry management.

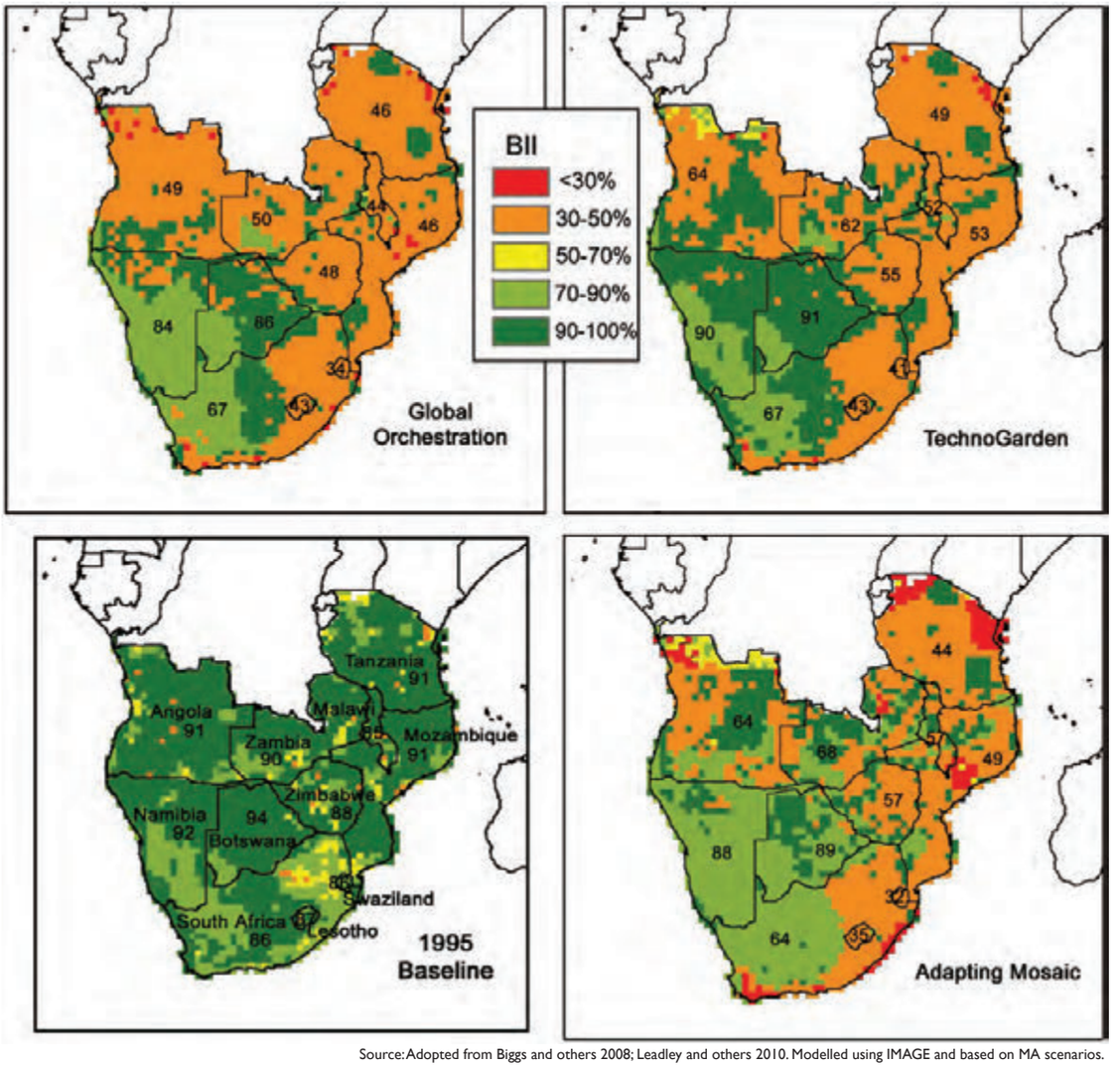
Biodiversity

Biodiversity conservation in Africa is a priority given the general failure to meet the Aichi Biodiversity Targets. Target 5 stipulates that governments should improve the status of biodiversity by safeguarding ecosystems, species and genetic diversity and promote its sustainable use and fair and equitable benefit sharing. Specifically, by 2020, the goal is to halve and where feasible bring close to zero the rate of loss of all natural habitats, including forests as well as to significantly reduce degradation and fragmentation. The targets also include preventing the extinction of known threatened species, and improving and

Colorful tree frog

Nick Hobgood / Foter / CC BY-NC

Figure 9.5: Projected declines in biodiversity by 2050 in Southern Africa



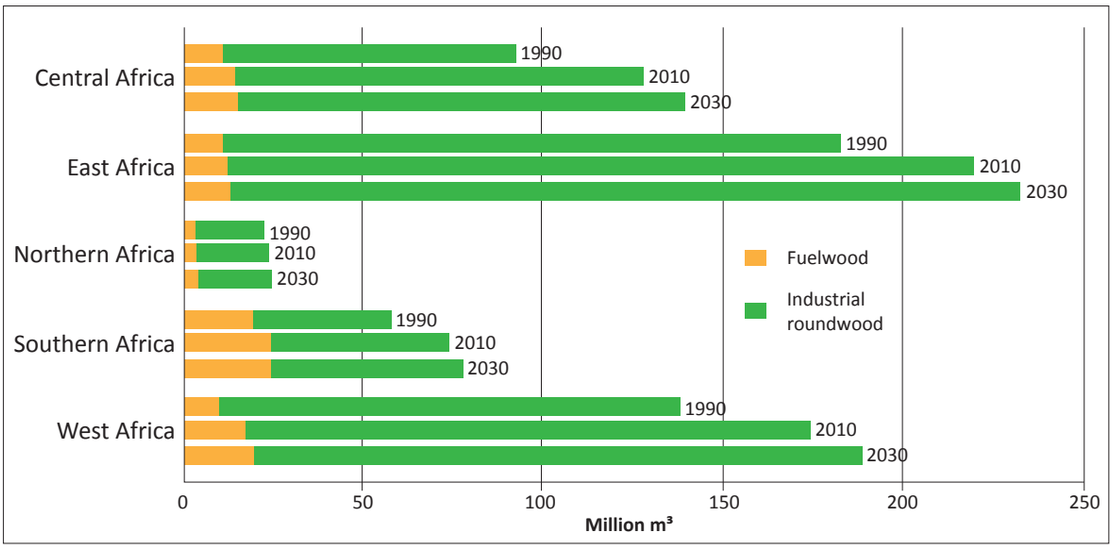
Source: Adopted from Biggs and others 2008; Leadley and others 2010. Modelled using IMAGE and based on MA scenarios.

sustaining their conservation status. For aquatic biodiversity, the 1982 UNCLOS and the 1995 Jakarta Mandate aim to protect and preserve the marine environment by promoting the conservation and sustainable use of the coastal and marine ecosystems as well as their natural resources. The promotion of the maintenance of the quality, diversity and availability of fishery resources in sufficient quantities for present and future generations is envisioned in the 1995 FAO Code of Conduct for Responsible Fisheries.

Conventional World Scenario

Current trends in biodiversity loss continue because little or no corrective action is taken (CBD 2010; UNEP 2006). A continuation of past and present trends leads to loss and possible extinction of species, changes in forest extent, habitat degradation and loss as well as changes in the distribution of hotspots. Habitat loss and consequently biodiversity loss continue at current rates with the potential of erosion of benefits to human health by 2050. Loss of mangroves, wetlands and tropical forests (CBD 2010) as well as the decline in the extent of tropical forests remains both rapid and varied. Loss in forest cover slows down in some countries particularly Rwanda and The Gambia. Corrective actions are not considerable enough to deflect the worrying trend towards the targets mentioned above. For instance, Biggs and others (2008) and Leadley and others (2010) project substantial biodiversity

Figure 9.6: Projections for wood extraction for energy by sub-region for 1990, 2010 and 2030



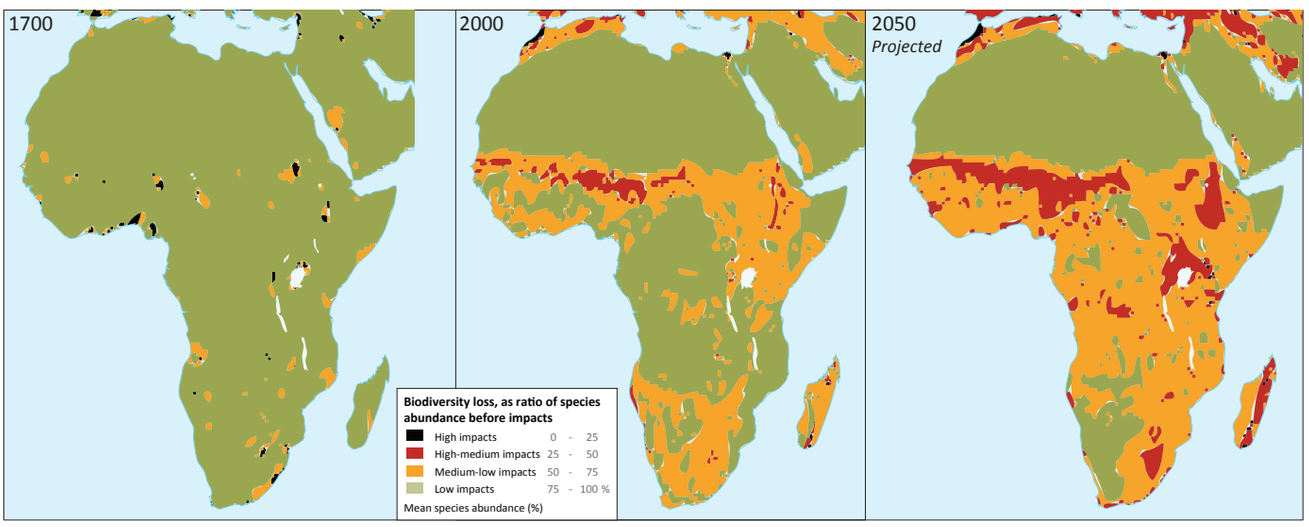
Source: FAO 2007 in FAO 2008

losses in Southern Africa by 2050 (Figure 9.5).

Although protected areas increase, the net loss of forests increases largely due to wood extraction in all sub-regions (Figure 9.6). Figure 9.7 shows the long-term pattern of Africa's biodiversity loss.

Biodiversity in aquatic ecosystems also suffers degradation owing to pressure from increasing water scarcity, climate change, invasive alien species, pollution and over exploitation. Modification of ecosystems continues due to both natural and anthropogenic forces. This may lead to reduction or unavailability of services such as the medicinal and nutritional value of plant and animal species (Spangenberg 2007). Continued attrition of native species' genetic resources is likely to jeopardize food security and lead to loss of their medicinal value. While many countries are ratifying the UN Convention on Biological Diversity (CBD) and its Nagoya Protocol, they are not adequately embedding health concerns in national biodiversity conservation strategies. The prevention of extinction of at least some critically endangered species may be unlikely to be achieved. Increased demand for agricultural land remains the single

Figure 9.7: Loss of biodiversity with continued agricultural expansion, pollution, climate change and infrastructure development in Africa



Source: GLOBIO in UNEP 2011, Alkemade and others 2009 in UNEP 2011

most critical threat to biodiversity. Pollution in freshwater systems and destruction of marine systems as well as intensive fisheries and oceanic acidification still prevail, adversely affecting aquatic biodiversity. Overfishing continues to occur with illegal, unreported and unregulated fishing (IUU) depleting stocks in the seas and oceans.

Sustainable World Scenario

Biodiversity is valued, conserved and wisely used by communities and nations by 2050. This is in accordance with the biodiversity vision espoused in national biodiversity conservation strategic plans and the global frameworks, such as the Strategic Plan for Biodiversity 2011-2020, and the Aichi Biodiversity Targets. This has led to the maintenance of underlying ecosystem services that sustain a healthy population and deliver equitable benefits. Along this sustainability pathway, many intermediate targets had been met and even surpassed in some countries and sub-regions. For example by 2020, the rate of habitat loss was halved. Protection of habitats such as terrestrial (20 per cent), inland waters (15 per cent) and coastal and marine ecosystems (25 per cent) stopped the extinction of threatened species including amphibians, plants, mammals and birds. There was an increase in the creation of transboundary protected areas and wildlife corridors.

This was possible due to technical and policy measures including reforestation policies, integrated ecosystems management, conservation policies and behaviour shifts including changes in consumption and production patterns. The strong political will facilitated these changes and the expansion of protected areas supported the reduction in the rate of habitat loss and other direct pressures on biodiversity. Regional knowledge sharing and information exchange in regions significantly aided biodiversity conservation. Although the problem of invasive alien species persisted, their management enabled limitation of their effect on human health and ecosystems integrity in wetlands, marginal dry lands and other ecosystems.

Efforts targeting reduction of over exploitation of marine and freshwater fisheries to the level of maximum sustainable yield made the all-important difference. As a trade-off, the increase in protected areas both on land and sea significantly reduced the availability of suitable land for food production. Governments circumvented this by coupling conservation with more efficient production methods on land and the establishment of sustainable fisheries. Reduced fish landing that occurred over the 2030-2050 period was addressed by increased aquaculture, crop and livestock production that provided alternatives to fish protein. By 2025, IUU fishing had been reduced to levels that no longer threatened fish stocks.

Biodiversity conservation and health had been fully integrated into international conventions, regional initiatives and other national strategies. Biodiversity, food security and poverty reduction initiatives were also integrated at all levels by 2020. This helped to stem degradation from especially the rural population that depends on biodiversity for food and medicine. The promotion of effective monitoring, assessment and reporting of biodiversity benefits and application of appropriate biotechnology to ensure food security and human and environmental integrity were part of this strategy. All along a strong political will was sustained through consolidation of leadership by African institutions such as AMCEN that had been demonstrated as early as 2010.

Chemicals and wastes

The main goal is the management of chemicals (POPs, fertilizers, heavy metals and agrochemical stockpiles) through sound management. Many international agreements on chemicals and waste management draw from Chapter 19 of Agenda 21 as the first global consensus surrounding the concept of sound management of chemicals (SMC).

There are many other legally binding Multilateral Environmental Agreements (MEAs) that reflect African countries' interest in SMC including the Bamako Convention; Basel Convention; ILO Convention No. 170; and Montreal Protocol on Ozone Depletion Substances and the Stockholm Convention on POPs. JPOI also elaborates strategies for reducing chemical pollution to protect human health and the environment by 2020 (UNDESA 2002).

Conventional World Scenario

Current trends in chemicals and waste management including associated challenges and attempts at sound management are expected to continue. The goal of eliminating or restricting the production and use of all intentionally and unintentionally produced POPs are projected to continue to feature on many national governments' strategies for SMC. However the stockpiles of wastes containing POPs remain a challenge as strategies for managing them remain largely unachieved even though many African countries continue ratifying the relevant conventions. Towards 2050, Africa still lacks disposal capacity, and the costs associated with providing infrastructure for chemicals management escalates beyond the technological and financial means of governments and municipalities. National implementation plans for managing POPs such as pesticides are in place. The projections of financial needs for implementation of plans for the first 12 POPs under the Stockholm Convention in Africa rise to over US$ 500 million after 2015 (UNDP 2010). This figure increases steadily towards 2050.

By 2015, all African countries have ratified the Basel Convention on the Control of Movement of Hazardous Wastes, their Environmentally Sound Management and Disposal, and Prevention of Illegal Waste Trafficking. AMCEN continues to provide policy guidance for preventing future accumulation of unwanted stocks of pesticides (including DDT), PCBs, and used oils. Stakeholder partnership is promoted in environmentally sound management of unwanted chemical stocks. However owing to the costs involved and capacity inadequacies, African countries suffer the health burden of the ever accumulating chemical stock piles.

As the continent intensifies agricultural production, concerns mount over the use of agro-chemicals and there arises an increasing need for financial and technological investment to reduce risks from pesticide use in agriculture targeting largely smallholder farmers. However, these and the other challenges enumerated in Box 9.1 persist.

Box 9.1: Persisting challenges of chemicals management

- Need for coherent information on chemicals
- Cooperation in development and transfer of technology of safe chemical substitutes and in development of capacity for their production
- Harmonization of policies
- Institutional and policy constraints.

Source: ECOSOC and UNECA 2009

All countries phase out leaded petrol. However, these efforts are futile in the long run in the fight against lead exposure in general because other sources of lead are not being addressed. The trend in oil and gas exploration continues in many parts of Africa exposing the environment to drilling waste, including drilling cuttings. This is because policies, technologies and capacities are not adequate to ensure effective drill site cleaning, drilling waste treatment, and proper transportation and containment of toxic by-products.

Sustainable World Scenario

More African countries increase importation of chemicals and products containing chemicals. A sustainable pathway towards 2050 sees African countries harmonizing their trade and environmental policies especially to ensure sound management of chemicals. Chemicals legislation,

similar to the European Union's Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH) Regulations had come into full force. The trend towards sub-regional and regional integration helped to harmonize policies and strategies for environmentally sound management of chemicals. By 2020 NEPAD, the African Union Commission (AUC), the African Ministerial Conference on the Environment (AMCEN) and, the African Ministerial Conference on Water (AMCOW) were fully contributing to strengthening policies and strategies for implementation of environmentally sound management of chemicals. Towards 2030, the intensification of the following actions and policies helped African countries to realize objectives of health benefits from chemicals management:

- Life cycle approach to chemicals management through integrated policies and institutions in accordance with Agenda 21
- Promotion of the ratification and implementation of international instruments on chemicals management
- Implementation of the Strategic Approach to International Chemical Management (SAICM)
- Strategic partnerships through regional cooperation on chemicals and waste management

Successful interventions over the years included the implementation of policies that address reduction of sulphur levels in diesel. Efforts to reduce mercury exposure from artisanal mining and use in energy saving bulbs through research and innovation were also put in place. The intensification and scaling up of already successful policies and actions in the continent enhanced the transformation to proper chemical use. Other transformative arrangements involved the adoption of the UNEP for Strategic Approach to International Chemicals Management (SAICM). This entailed the integration of sound chemicals management priorities into national environmental and poverty reduction planning. Setting up National Cleaner Production Centres (NCPCs) supported the introduction of better chemicals management practices and techniques to the business sector. The NCPC Programme is a joint initiative of UNIDO and UNEP and had been established in Egypt, Ethiopia, Kenya, Morocco, Mozambique, Rwanda, South Africa, the United Republic of Tanzania, Tunisia, Uganda and Zimbabwe by 2010. It began delivering dedicated services for environmentally sound management of chemicals, including new business models like chemical leasing and many other countries in the region replicated this.

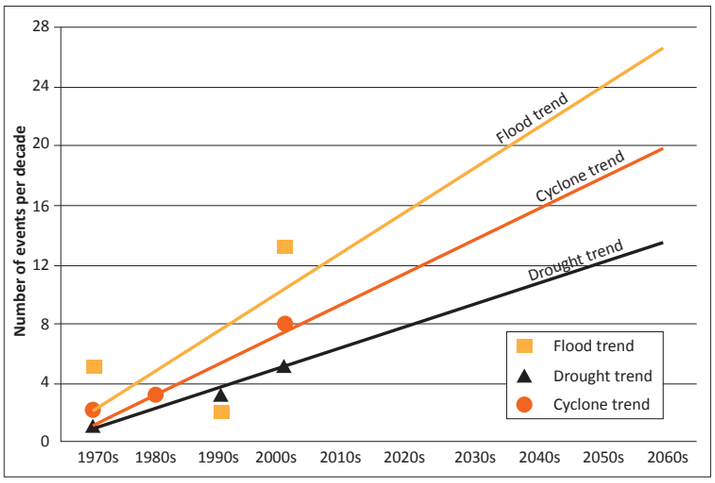
Climate change and variability

The goals of addressing climate change impacts on the African environment and also human health remain those that largely address adaptation in relation to vulnerability, exposure and the effects of climate change and variability. There is therefore need to move towards goals that aim at preventing dangerous anthropogenic interference with the climate system. The later includes the UNFCCC one of whose goals is to limit the average global temperature increases to 2°C above the pre-1990 levels. The successor to the Kyoto protocol would provide strategies for actualizing this.

Conventional World Scenario

According to IPCC (2007), accelerated climatic changes are expected to lead to potentially large impacts across Africa in the future. The scale of climate change in Africa is likely to increase with high greenhouse gas (GHG) emissions, and rising average global temperatures. While the temperature thresholds for large-scale disruptions to social and environmental systems – so called tipping-points – are not known, a global mean temperature rise of more than 2°C above pre-industrial levels will make such events more likely. Over the years, climate induced health problems will intensity. Detailed impacts and costs of climate

Figure 9.8: Modelled frequencies of climate related disasters in Mozambique based on IPCC's SRES scenarios

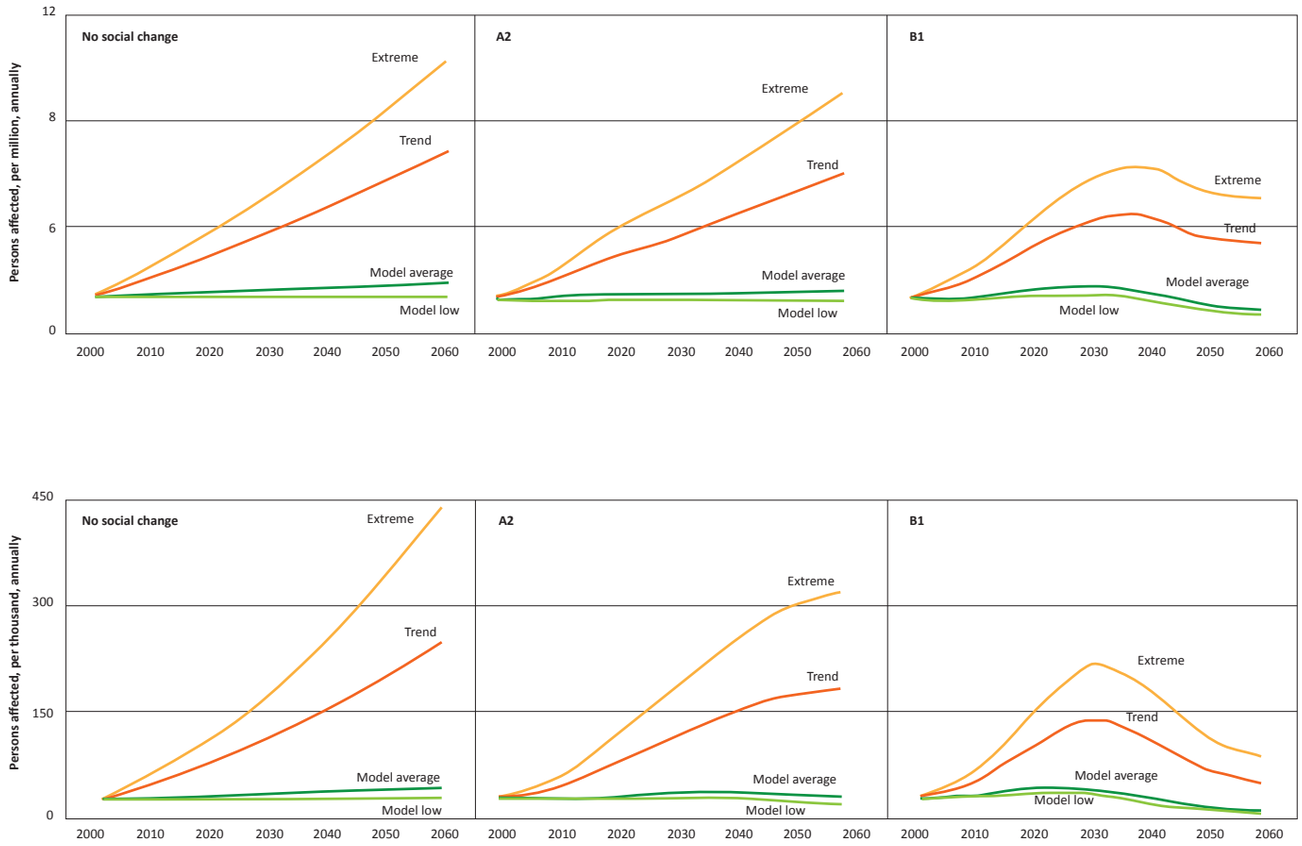


Source: INGC 2009

change under different global temperature rise scenarios are presented in Table 9.2 while Figures 9.8 and 9.9 illustrate projections of climate change related disasters in Mozambique.

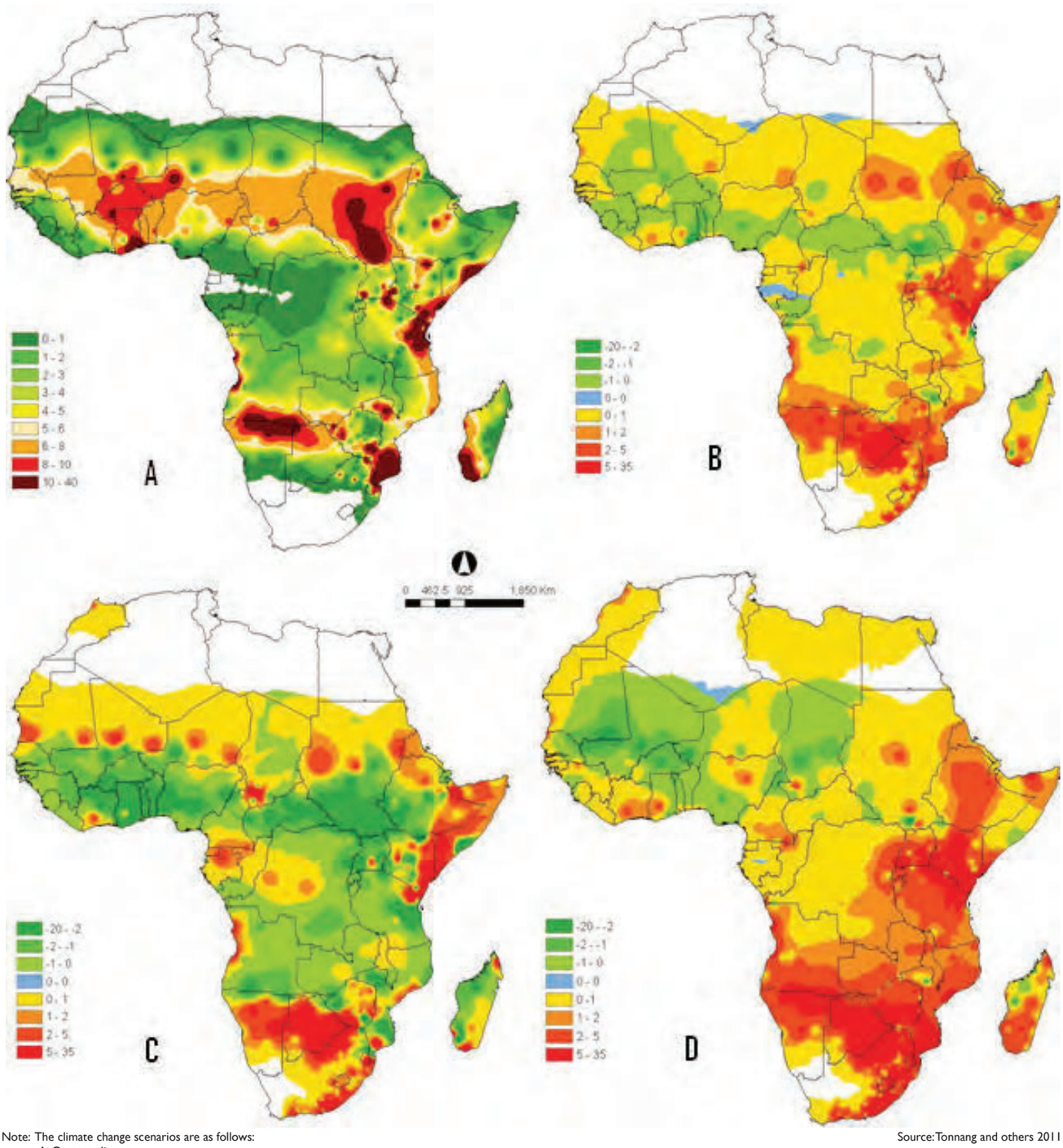
Projections by IPCC (2007) indicate that by 2020, between 75 and 250 million people in Africa are likely to be exposed to increased water stress due to climate change and that by 2020, yields from rain-fed agriculture could reduce by up to 50 per cent in some countries. Agricultural production, the mainstay of many African economies, is projected to be severely compromised (IPCC 2007; Ziervogel and others 2008) further adversely affecting food security and exacerbating malnutrition. The current trends translate to expansion of arid and semi-arid lands by 5-8 per cent before 2030. Even low-lying coastal areas are not going to be spared the effects of sea level rises including salt intrusion, degradation of coral reefs and flooding. In Southern Africa, in particular, there is a high likelihood that up to 25 per cent of the population living in lowlands will be affected by the projected increase in flood frequency and severity. In Mozambique, for instance, the Conventional World Scenario sees the number of droughts increasing by 1.37 each year, generating an expectancy of 25.39 droughts

Figure 9.9: Scenarios of vulnerability and risk of being killed by climate related disasters in Mozambique based on downscaled IPCC A1 and B1 scenarios



Source: INGC 2009

Figure 9.10: Distribution of *Anopheles* mosquito species: (A) - *A. gambiae* under current climate; (B) *A. gambiae* species ranges shifts under climate change scenario 1; (C) *A. gambiae* species ranges shifts under climate change scenario 2; (D) *A. gambiae* species ranges shifts under climate change scenario 3



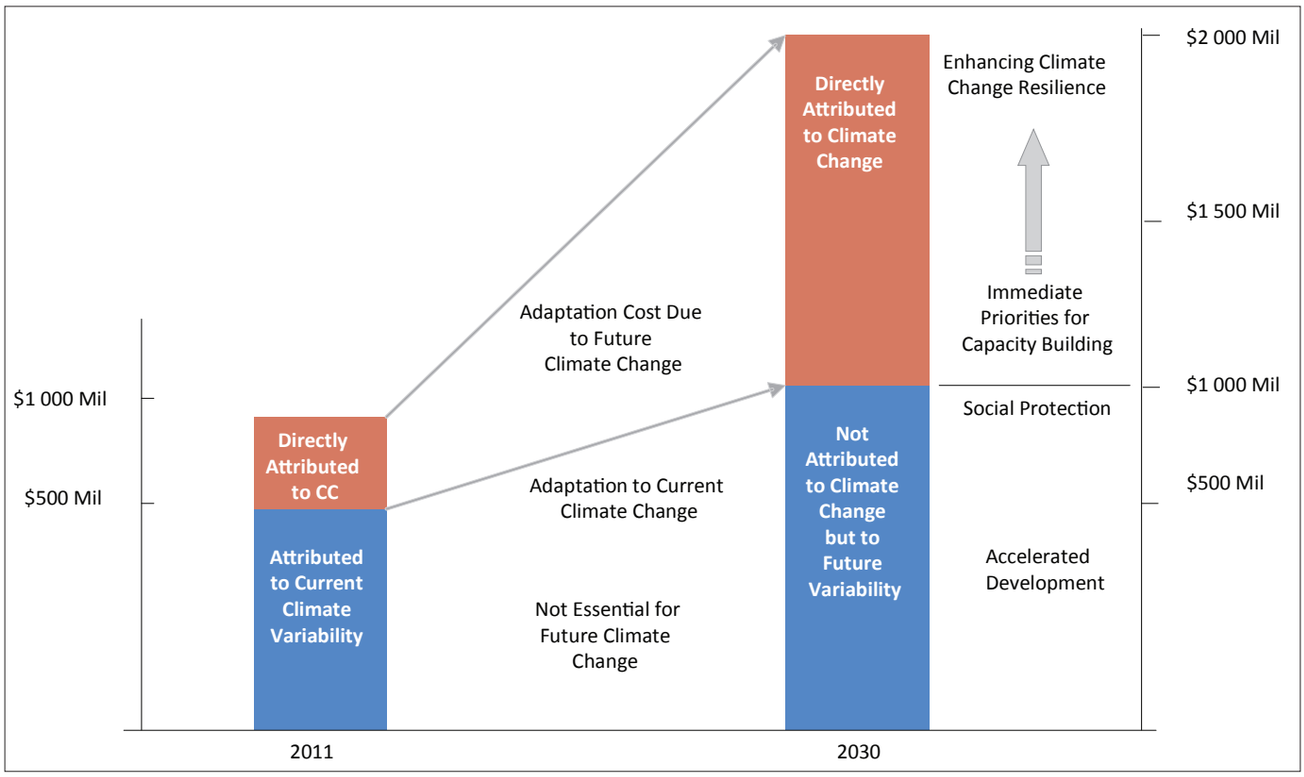
Note: The climate change scenarios are as follows:
A. Current climate
B. Scenario 1: A rise of 2°C Africa wide temperature, and 10 per cent increase of summer rainfall and 10 per cent decrease in winter rainfall.
C. Scenario 2: A 0.1°C rise in summer and winter maximum and minimum temperatures per degree of latitude, and a 10 per cent increase in rainfall in summer, and 10 per cent decrease in winter.
D. Scenario 3: A rise of 4°C Africa wide temperature, and 20 per cent increase of summer rainfall and 20 per cent decrease in winter rainfall.

Source: Tonnang and others 2011

over the 20-year period centred on 2060 (INGC 2009). According to Tonnang and others (2011), the spread of the malaria transmitting mosquito (*Anopheles gambiae*), will vary as indicated in Figure 9.10.

The cost of adaptation could amount to at least 5-10 per cent of GDP. Africa's potential adaptation financing needs to address these costs though highly uncertain, are likely to constitute a minimum of US$10 billion a year by 2030 rising to

Figure 9.11: Indicative future costs of adaptation to climate change in Kenya



Source: SEI 2009

over 30 billion by 2050. Adaptation only managed to reduce the costs of climate change by one third. The remaining economic costs and residual damages continued to affect GDP contributions to social services including health provision. Around 6 per cent of Africa's GDP by 2050 is eroded by adaptation costs. At the current trends, the cost of adaptation may double (see Figure 9.11 for projections from Kenya).

Rainstorm in South Africa

Ibontxo / Flickr / CC BY NC SA 2.0

Table 9.2: Summary of key climate change impacts and cost implications under different global mean temperature rises

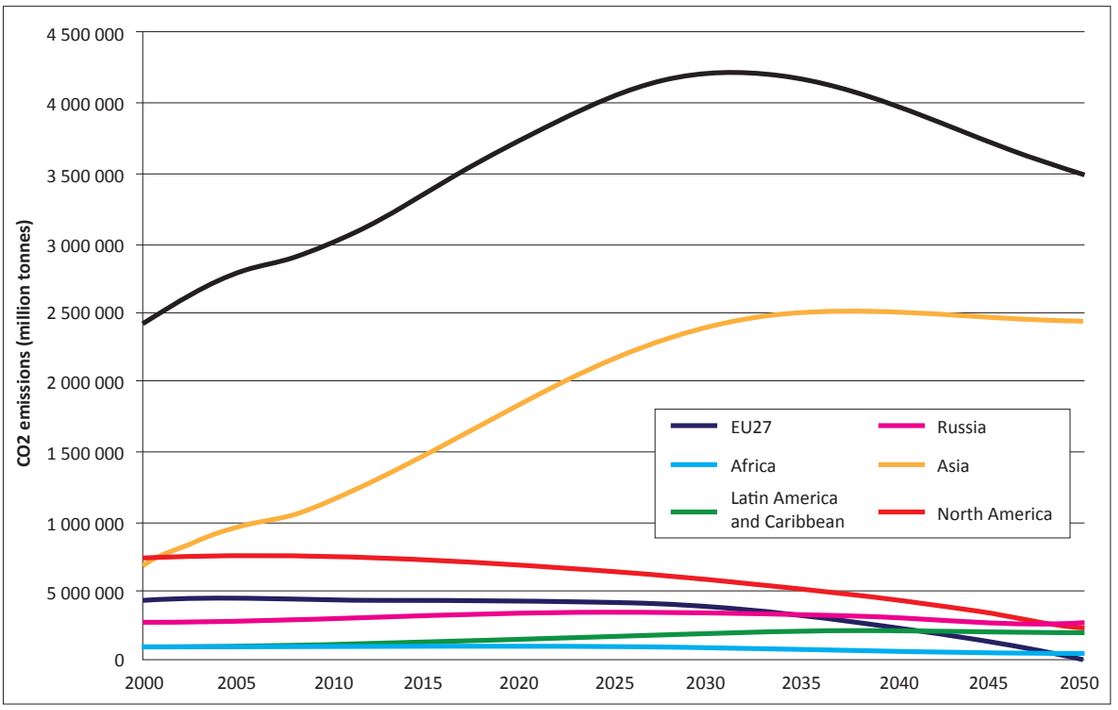
^{0}C rise	1.5^{0}C	2^{0}C	4^{0}C
Key Impacts	• Potential yield increases in East Africa and the highlands; reductions in the Sahel. • Potential increases in net revenue for small livestock farms; losses for large farms. • Twelve million people could be at risk from hunger. • Widespread coral bleaching could occur on Indian Ocean coasts. • Possible increases in exposure to malaria of 0-17 per cent; diarrhoea by -0.1-16 per cent and increased inland flood deaths by 0-127 per cent. • Increased flooding resulting in damage to infrastructure and property. • Water stress increases, particularly in North Africa. • Up to 15 per cent of sub-Saharan species could be at risk of extinction	• Potential crop yield increases in highland areas; significant reductions in Southern Africa. • Net revenue loss to agricultural sector could be as much as US$133 billion, about 4.7 per cent of Africa's total GDP. • An additional 55 million people could be at risk from hunger. • Water stress could affect between 350-600 million more people. • Increases in malaria transmission and exposure are possible. • Up to 40 per cent of species in sub-Saharan Africa could be at risk from extinction. • Flooding in coastal areas could cause around US$50 billion worth of damage.	• Increased risk of hunger among up to 128 million more people. • Higher risk of flooding in low-lying areas. • Malaria transmission area could double by 2100 in South Africa. • Increased water stress, particularly in northern and southern Africa. • Rainfall could increase in eastern Africa.
Adaptation Strategies	• Regional agreements to enforce environmental and animal protection laws. • Promoting agro-ecological approaches to farming. • Support to smallholders, including microcredit finance, improved seed varieties, drought-tolerant stock and fertilizers, veterinary services, access to appropriate technologies for irrigation systems and training in improved soil and water management. • Reforestation schemes. • Regulations on fossil fuel intensive chemical inputs. • Improving water storage and distribution technologies, • Disaster prevention and response plans. Coastal protection measures. • Retrofitting or relocating infrastructure, development of building guidelines. • Investments in health services, including education programmes, surveillance systems, staff training, and preventative measures. • Introducing energy efficiency policy and decentralised off-grid renewable energy systems for rural areas.	• Support to the agriculture sector, particularly smallholders, including improved crop varieties, drought-tolerant livestock, fertilisers and farming technology measures, such as irrigation. • Additional water stress may require larger-scale interventions, such as water basin transfers and exploitation of groundwater supplies. • Coastal protection measures. • Explicit conflict mitigation efforts and peace-building where necessary. • Energy efficiency and on-grid power extension to build human and industrial resilience in urban areas. • Capacity building in the health sector. • Biodiversity rehabilitation and conservation efforts scaled up with tighter regulations on natural resource use.	• Building the resilience of the agricultural sector still crucial. • Reinforcement or relocation of industries, infrastructure and human settlements via coastal protection measures
Cost Range with Adaptation	Minimum US$10 billion a year by 2030, and up to US$30 billion a year, directly in response to climate change.		
Cost Range without Adaptation	1.7 per cent of Africa's total GDP	3.4 per cent of total GDP	10 per cent of total GDP

Source: PACJA 2011

Sustainable World Scenario

By 2050, African countries have instituted changes in environmental management, biodiversity conservation, water and land-use systems that meet the objectives for climate change and human health benefits. By 2030, African countries had already electrified their production and household processes through considerable investments in national power grid and regional cross country distribution including production from other cleaner alternatives. More small scale clean energy schemes were adopted while the investment climate was made conducive to attract private

Figure 9.12: SWS projections for CO_2 emissions of Africa in relation to global trends (million tonnes)



Source: NEAA 2009

sector participation. All these initiatives helped to stabilize the region's CO_2 emissions (Figure 9.12).

Adequate commitment by UNFCCC Annex I countries in providing mitigation of more than 45 per cent by 2020 led to full coverage of costs of adaptation in Africa between 2020 and 2050. African countries had also taken significant mitigation actions through afforestation and harnessing the benefits of the clean development mechanism (CDM). Up to US$ 675 billion was required for low-carbon development growth in Africa and was secured from developed country commitments and internal revenue. Significant reforms were made to the CDM process that ensured environmental integrity, strengthened social safeguards and improved community access to the funds. Due to renewed emphasis on comprehensive development programming, the UNREDD+ initiative offered countries strategic policy advice. Investment in the forest sector targeted also the small and medium forest enterprises (SMFEs) through capacity building aimed at improving local livelihoods including health related benefits.

Many countries deployed the farm forest concept with working models of community based forest management (CBFM). A low-carbon economy could be achieved with currently identifiable technologies. This would entail improved energy savings, increased use of renewable energy and carbon capture and storage, reduction of deforestation, and reduction of non-CO_2 emissions. A number of past and new policies and actions bore fruit after their incorporation into Nationally Appropriate Mitigation Actions (NAMAs) and National Adaptation Programme of Action on Climate Change (NAPAs). Initiatives such as the Forest Carbon Partnership Facility (FCPF) created an enabling environment and a body of knowledge and experience to support global REDD+ initiatives. Other strategies included climate resilient development; increased awareness of health related climate vulnerability and increased capacity to incorporate adaptation in to the health care system; and investing in disease vector control systems as well as in increased surveillance of existing and emerging threats.

Coastal and marine resources

The health dimension of the ecosystems services in the coastal and marine theme hinges on coastal wetlands, mangrove swamps, coral reefs; estuaries, sandy beaches and rocky shores. The JPOI targets on coastal and marine resources include encouraging the application of the ecosystem approach for the sustainable development of the oceans, and establishing a regular process under the United Nations system for global reporting and assessment of the state of the marine environment (UNDESA 2002). The Africa Chapter of JPOI specifically states that achieving sustainable development includes developing projects, programmes and partnerships with relevant stakeholders and mobilizing resources for the effective implementation of the outcome of the African Process for the Protection and Development of the Marine and Coastal Environment (UNDESA 2002). The NEPAD environmental action plan also acknowledges the role of sharing best practices for optimally protecting and utilizing coastal resources.

Conventional World Scenario

Trends reported in both AEO-1 and AEO-2 concerning rapid population growth, industrial expansion and infrastructure development continue. Increased human activity puts pressure on resources with challenges like coastal erosion and land based and sea pollution. Coastal erosion exceeds the highest historical levels of 30 m/yr in Western Africa mainly due to continued river damming. Climate change continues to increase sea temperatures, sea levels and the incidences of hazards like cyclones. Fisheries productivity is on a steady decline despite many efforts for integrated management. The prevailing health issues and outcomes continue to be linked to siltation, sea level rise, coastal erosion and urbanization, hazardous waste dumping, illegal and overfishing, destruction of coral reefs and clearing of mangroves, conversion of coastal wetlands, invasive alien species, and inadequate management and enforcement of legislation. IUU fishing remains a challenge because of weak monitoring and enforcement systems.

Due to the attraction of the Small Island Developing States (SIDS) of the Western Indian Ocean as tourist destinations, human diseases such as malaria and HIV/AIDS are emerging. These tourism activities and services threaten the extensive mangrove ecosystems with specific effects on mollusc and crustacean communities, sea turtles, birds, and dugongs. Competition for energy resources especially oil and gas worsens the scenario as prospecting activities precipitate pollution and damage to natural ecosystems. Pollution from human activities including sewage discharges from cities, agricultural chemicals and other challenges like seafood poisoning, toxic metals such as tributyltin, cadmium and arsenic continue to jeopardize human health.

Sustainable World Scenario

The integrated coastal and marine ecosystems management approaches in place in 2050 have been the result of long-term gains from instituting national, regional and international policy frameworks. Most of the region's coastal countries had become signatories to most of the MEAs that deal with marine and coastal management issues including the Barcelona, Jeddah, Nairobi and Abidjan Conventions, as well as UNCLOS and the International Convention for the Prevention of Pollution from Ships, 1973 as modified by the Protocol of 1978 (MARPOL 73/78).

The conventions on marine and coastal resources to which many African states including Western Indian Ocean Island states are signatories laid the foundation, albeit with challenges for trends to 2050. Policy, legislation and management plans continued to embrace concerted sub-

Box 9.2: Seeds of change – IOC Regional Marine Protected Areas Project

The Indian Ocean Commission (IOC) is implementing the Western Indian Ocean Marine Eco-region (WIOMER) project for the coastal and marine waters of Comoros, French Reunion, Madagascar, Mauritius and Seychelles. The project aims to contribute to the maintenance of the biodiversity and marine and coastal resources of the WIOMER Eco-region through implementation of a coherent regional network of effectively managed Marine Protected Areas (MPA). The project designs a regional strategy for biodiversity and marine resources management, coordinates a regional forum of MPA managers and an awareness and communication programme related to the importance of MPAs. The project has seen the creation of a biological inventory in Mauritius, a system of control and surveillance in Seychelles and design of MPA plans in Madagascar.

Source: WWF undated

regional action (see Box 9.2 for the Western Indian Ocean Marine Eco-region (WIOMER) initiatives) and the concept of Integrated Coastal Zone Management (ICZM). Other arrangements like the Pan African Conference on Sustainable Integrated Coastal Management (PASICOM) and the Cape Town Conference on Cooperation for the Development and Protection of the Marine and Coastal Environment in sub-Saharan Africa, added impetus to these improvements. The ecosystems management approach adopted by all actors remained crucial with current Large Marine Ecosystems programmes such as Benguela Current Large Marine Ecosystem (BCLME) programme in Angola, the Guinea Current Large Marine Ecosystem (GCLME) project being scaled out around the continent. Many of these new initiatives were supported by international funding partners. Wider designation of Marine Managed Areas (MMAs) and Marine Protected Areas (MPAs) was also witnessed.

The starting point to addressing the challenge gaps in the African coastal and marine resources remained comprehensive capacity building to facilitate their sustainable utilization in tandem with conservation and health goals. Integrated coastal and marine resources management was a necessity and addressed even transnational issues. It also encouraged the adoption of the ecosystem-wide approach to catchment as well as coastal and marine resource management in the formulation and implementation of national policies, legislation and management plans.

Freshwater and sanitation

JPOI articulates the goal of sustaining water resources, protecting water quality and other aquatic ecosystems and aims at intensification of water pollution prevention in order to reduce health hazards and protect ecosystems. JPOI also calls for efficient and well-balanced use of freshwater resources and for safeguarding drinking water quality (UNDESA 2002). All African countries have endorsed the goal of improving access to safe drinking water and improved sanitation with the goal of halving, by 2015, the proportion of the population without sustainable access to safe drinking water and basic sanitation and ensuring full access by 2050. The full implementation of the African Water Vision (AWV) under the AfDB's Africa Water Facility (AWF) will require strengthening water governance, scaling up investments to meet water needs, strengthening the financial base and improving water knowledge management.

Conventional World Scenario

Water continues to be the most crucial natural resource in sustaining livelihoods. The current situation where more than 40 per cent of Africa's population lives in arid, semi-arid and dry sub-humid areas (UNEP 2010) continues through to 2050. Variability in water resource distribution is maintained with central Africa holding 50 per cent of the continent's total inland water reserves. Challenges of water resource management and provisioning continue while the paradox of the African water system characterized by both surplus and scarcity, under developed and over-exploited water resources persists (UNEP 2010).

The amount of water available per person, currently 4 008 CBM (UNEP 2010) remains below the global average through the next four decades. The amount actually declines especially due to the challenge of climate change and failure of current adaptation and mitigation measures to reverse the trends. Water systems provisioning is affected by falling aquifer levels, declining and unreliable rainfall, an inadequate water resource base and distorted prices as well as institutional inefficiencies. Although the ground water system currently supplies over 75 per cent of Africa's population, it continues to represent only 15 per cent of total renewable water resources on the continent (UNEP 2010). According to UNEP (2010), only 26 of the region's countries are on track to attaining the water-provision MDG target of reducing by half the proportion of the population without sustainable access to drinking water by 2015.

Many recent scenario assessments show large variations in terms of projected water withdrawals, taking into account changes in climate, population, the economy, electricity generation, irrigated area, and technology. There is a substantial net regional increase in withdrawal but significant sub-regional variations exist with North Africa accounting for the largest share of total water withdrawals on the continent. This worsens the regional water stress picture. According to UNEP (2010 and 2006) the proportion of people living in water stressed environments increases by over 45 per cent largely due to climate change impacts that exacerbate the worsening withdrawal picture. Management of transboundary water systems remains a mirage with consequent conflicts and distortions in the availability and quality of water resources for various water users.

With climate change, significant fluctuations in runoff regimes are predicted for Africa (Boko and others 2007). Over the past decades, extended droughts and increased frequency of floods and dry spells (UNEP 2007) have been observed. The mean annual runoff in the main river basins could decline by as much as 32 per cent by 2050 (IPCC 2007). Climate change is expected to exacerbate the current stress on water resources from population growth, development and land-use change, including agricultural expansion. The changes in precipitation and temperature are already affecting runoff and water available for different needs including domestic and agricultural.

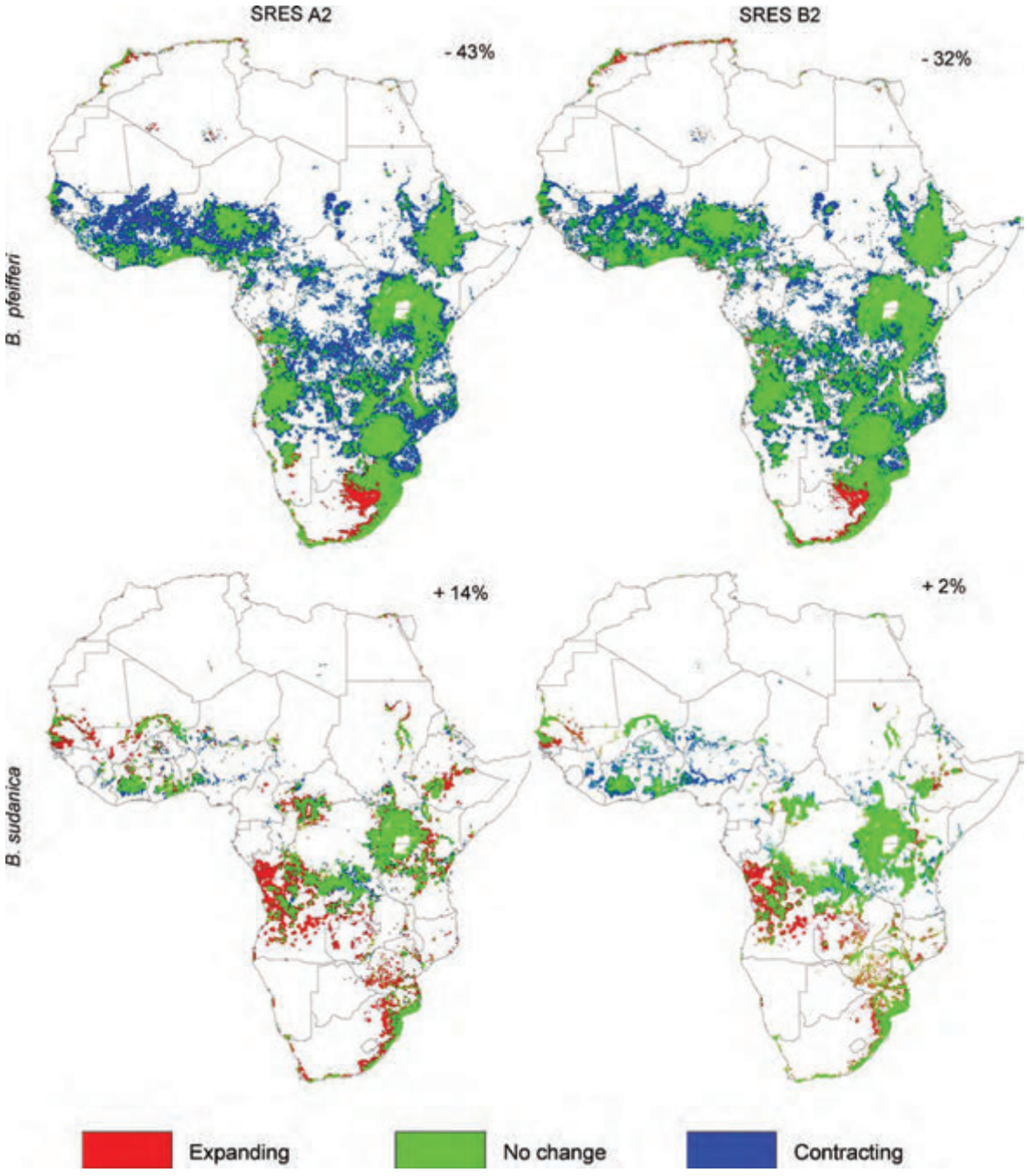
Gathering water from an open source

Jeff Attaway / Foter / CC BY

Boko and others (2007) project declines of 25 per cent in many parts of the region. Even in the coastal regions, water resources are constrained due to sea level rises that exacerbate salinization of groundwater supplies.

According to WHO and UNICEF (2010 in UNEP 2012), by 2050 more people live in water-stressed areas and half a billion people would lack access to clean drinking water while another 1 billion lack access to improved sanitation facilities. This exposes a substantial majority to unsafe water supply and sanitation and the associated pathogenic micro-organisms that are responsible for over 1 million deaths and over 10 per cent of regional disability adjusted life years (DALYs). Some studies project a decrease in lack of access to safe drinking water from 35 per cent in 2010

Figure 9.13: Potential future expanding and contracting ranges of *Biomphalaria pfeifferi* and *Biomphalaria sudanica* under the A2 or B2 emission scenarios (for 2080) of IPCC



Note: Red indicates new potential distribution by 2080, green shows areas of status quo between current and future climate scenarios and blue illustrates areas predicted to be unsuitable for the snails by 2080. The change in percentage (negative or positive) is given in the top right corner of each map.

Source: Stensgaard and others 2011

to 24 per cent by 2035 and 15.8 per cent by 2060 (Hughes and others 2011). This is not adequate to improve sanitation and as a direct result, child deaths due to diarrhoeal diseases will not decrease significantly (Hughes and others 2011). This is not adequate to improve sanitation and as a direct result, child deaths due to diarrheal diseases will not decrease significantly (Hughes and others 2011). The geographical ranges of many infectious disease agents, their vectors and intermediate hosts, are assumed to be constrained by climatic tolerances, mainly temperature (Stensgaard and others 2011). Global warming continues to cause an expansion of the areas potentially suitable for infectious disease transmission. In this regard, Figure 9.13 illustrates the distribution of two snail species (*Biomphalaria sp*) under SRES A2 and B2 scenarios.

Sustainable World Scenario

It is 2050 and the various global and regional goals on water and sanitation have been met through efforts to ensure that fewer people live with severe water stress. The reduction in water withdrawals mainly due to behavioural and technological changes has been largely responsible for this achievement.

Although by 2015, Target C of MDG 7 was not met by over half of the region's countries, 2050 witnessed substantial gains in access to safe drinking water and sanitation. Improved access to safe drinking water and sanitation came with social, economic and health returns. Depending on the sub-region and technology used in water access, economic returns of between US$ 5 and US$ 15 for every US$ 1 spent in water provisioning had been realized. This was largely due to decrease in the time spent collecting water and the reduction of water-borne diseases and death. Total avoidable deaths attributable to water-borne diseases reduced from around 45 000 in 2030 to 24 000 in 2050. The biggest gain under SWS was the deployment of the previously untapped renewable water resources across the sub-regions (Table 9.3).

A number of policy levers enabled the transformation of the region's water resources. Specifically, there had been improved funding for water and sanitation infrastructure and new technologies for developing and managing a network of water and sanitation infrastructure to keep up with an increasing population, and the related maintenance issues. These specifically targeted improvements in water use efficiency

Table 9.3: Projected CWS and SWS based proportions of inland renewable water resources in Africa's sub-regions

Southern Africa	Population (millions)	Area (1000 km²)	Inland renewable water resources					
			2010 (km³/yr)	2010 (%)	CWS 2050 (km³/yr)	SWS 2050 (km³/yr)	CWS 2050 (%/yr)	SWS 2050 (%/yr)
North Africa	174	9 259	99	1.10	108.90	326.70	1.20	3.50
Western Africa	224	6 139	1 059	17.30	1 164.90	2 329.80	19.00	38.00
Central Africa	82	5 366	1 743	32.50	1 917.30	2 875.95	35.70	53.60
Eastern Africa	144	2 758	187	6.80	205.70	514.25	7.50	18.60
Southern Africa	150	6 930	539	7.80	592.90	1 482.25	8.60	21.40
Western Indian Ocean Islands	19	594	345	58.10	379.50	948.75	63.90	159.70
TOTAL	793	30 045	3 949	13.10	4 343.90	10 859.75	14.50	36.10

Source: Adapted from UNEP 2006

Box 9.3: Seeds of change – ICT deployment

ICT access (mobile phones, PCs, and community radio) is increasing in both the urban and rural parts of Africa. And it is potentially a tool for disseminating information tools for water prospecting, gauging and withdrawal control, source mapping, service provision, pollution tracking and control, and systems management. Over the last few years, a new wave of ICT development has led to modernized infrastructures like broadband fibre optic cables and data centres, added value services and IT innovations. Emerging ICT applications range from systems and tools for:

- *Observation* (e.g. environment information circulation and monitoring system of ITU and UNITAR in Sahel and the Sahara implementing an Information System on Desertification (ISD) and the H2.0 initiative of UN-Habitat with pro-poor systems using the Google platform and embedding *MajiData* for use in urban slums in Nairobi and parts of Zanzibar
- *Analysis and planning* to enable data use by water and agricultural scientists and policy makers
- *Implementation and management* through forecasting, early warning systems and water resource management systems
- *Training and capacity building* for raising awareness, advocacy and training to enhance skills and competencies of water users to anticipate climate change induced water stress and apply various adaptation strategies
- *Collaboration, partnerships and networking* in producing, storing, analysing, retrieving, sharing and comparing information that allows cross-community, cross-institutional and multi-country knowledge management and collaboration
- *Monitoring and evaluation* for enhancing learning for improved water systems management to track the relevance, quality, effectiveness, efficiency, sustainability and overall performance of any climate change adaptation initiative.

Other scalable applications include widespread community radio media involving mainly the internet and mobile phones e.g. Madagascar's 'Survival Strategies' project. Implementation of digital monitoring systems for water regulation is underway in Kenya, the United Republic of Tanzania and Zambia. Recent innovations also include the Africa Water Atlas (UNEP 2010), the FLOW (Field Level Operations Watch) smartphone application, and the Water Point Mapper which shows the status of water supply services.

Source: Ochola and Ochola 2012

and water quality maintenance including water pollution control and waste management, management of and reduction of exposure to water-related and waterborne diseases as well as improved personal and environmental hygiene. Cholera and typhoid were significantly reduced. Water governance including management of related conflicts over resources, shared water resources, transboundary cooperation, gender and health strategies in water governance as well as coordination of water withdrawals was also improved. The deployment of emerging technologies including ICT (Box 9.3) to improve response and resilience of water resources and communities to climate change were particularly useful in promoting wider adoption.

Because human health and wellbeing cannot be achieved by implementing piece-meal and isolated measures, there is already increased cooperation in the management of transboundary rivers and aquifers. Also underway is the revision of national water resource policies as well as the adoption of holistic programmes of action such as Integrated

Water Resources Management (IWRM) and Integrated Vector Management (IVM).

Land

Key land management targets focus on reduction of salinity, combating desertification, reducing cropland expansion and preventing soil pollution and other forms of soil degradation. The 1996 World Food Summit Plan of Action (FAO 1996) and Agenda 21 (UNCSD 1992) form the basis of the various goals related to land use and forest conservation. Closely linked with the above land use goals are the MDG goals of halving, between 1990 and 2015 (UNEP 2006), the proportion of people who suffer from hunger and to eradicate hunger by 2050. JPOI provides for developing and implementing integrated land management and water use plans as well as integrated assessments of the socio-economic and environmental benefits (UNDESA 2002).

Conventional World Scenario

Many scenario studies and projections point to a strong increase in food consumption levels worldwide and in Africa up to 2050, mainly driven by population growth (FAO 2010; IAASTD 2009 in UNEP 2012). Demand for food grows and occasions expansion of agricultural land. This threatens forest cover and coupled with effects of climate change, may exacerbate land degradation. Moreover, external factors including rising world food demand and natural resource competition are expected to lead to land degradation and a slowdown in yield improvement or even declines (UNEP 2012). There is continued pressure from factors such as environmental degradation, lack of investment and land use competition. According to IAASTD (2009 in UNEP 2012) these would have far reaching effects on especially the poor with resultant incidences of malnutrition and a likelihood of failure to eradicate it by 2050. Projections of prevalence of child malnutrition for 2050 fall by only between 13-25 per cent.

Box 9.4: Contemporary land-related issues in Africa

- Hunger amidst adequate overall supplies leading to nutrition and health inequities
- Lack of income opportunities for the poor and absence of effective social safety nets
- Climate change which will affect agriculture and forestry systems
- Increase in biofuel production based on agricultural commodities which would pose a real risk to food security.

Source: Kgathi and others 2012

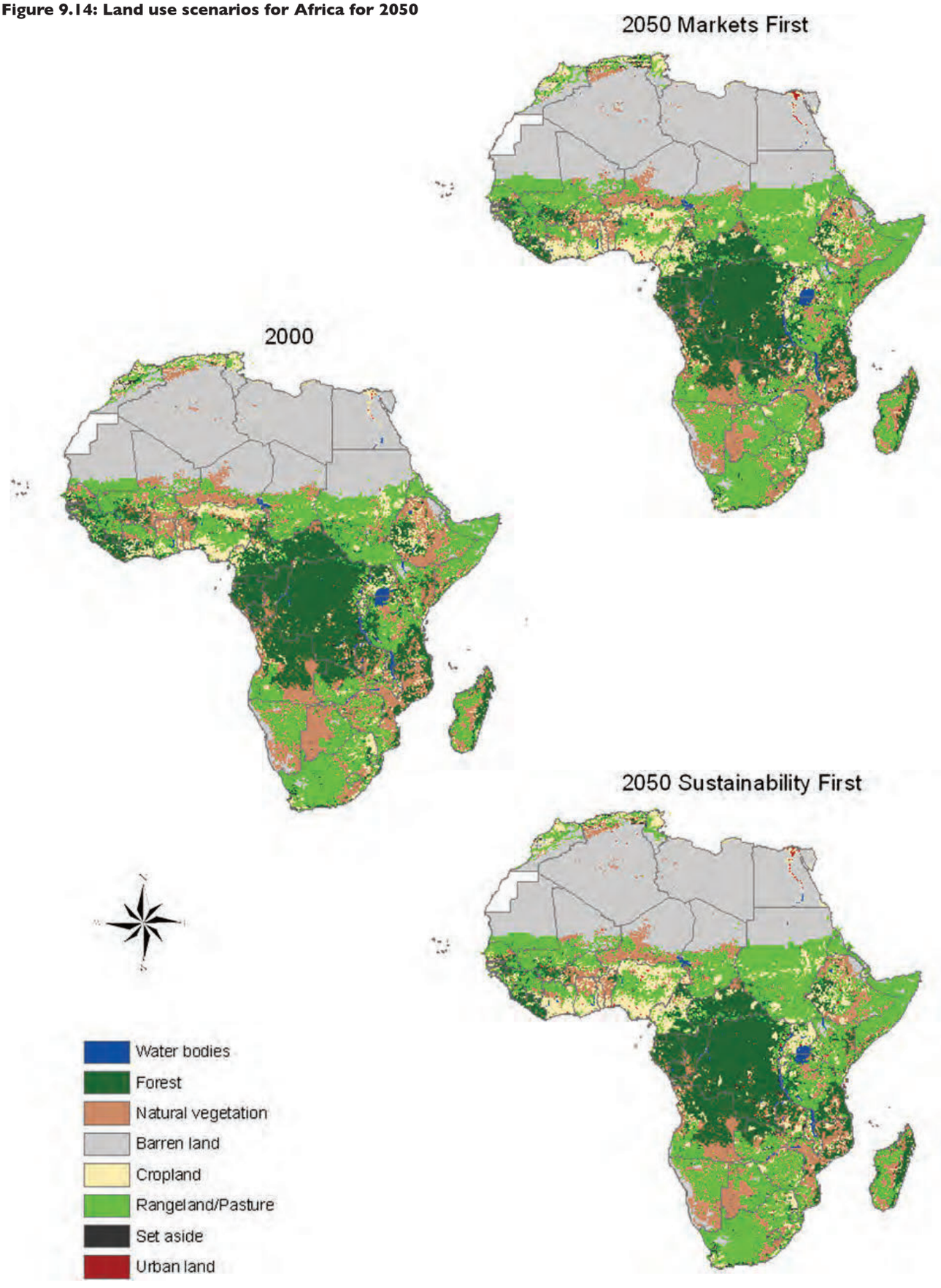
Box 9.4 lists some of the contemporary challenges associated with Africa's land resources.

Pressure on land that unequivocally induces negative land use change including loss of forest cover emanates from increased cropping intensity. Crop yields are constrained with only about 34 per cent of rise in output coming from yield increases while the rest comes from expansion of agricultural area as is the current trend (Smith and others 2010). Trends of these factors continue

Mother and child carrying water

IHH Insani Yardim Vakfi TURKEY / Flickr / CC BY NC ND 2.0

Figure 9.14: Land use scenarios for Africa for 2050



Note: The map for 2000 is computed by the model based on the 1992 initial conditions. In order to better visualize the trend of total cropland expansion, the 11 modelled crop types are aggregated to the land use type 'cropland.'

Source: Alcamo and others 2011

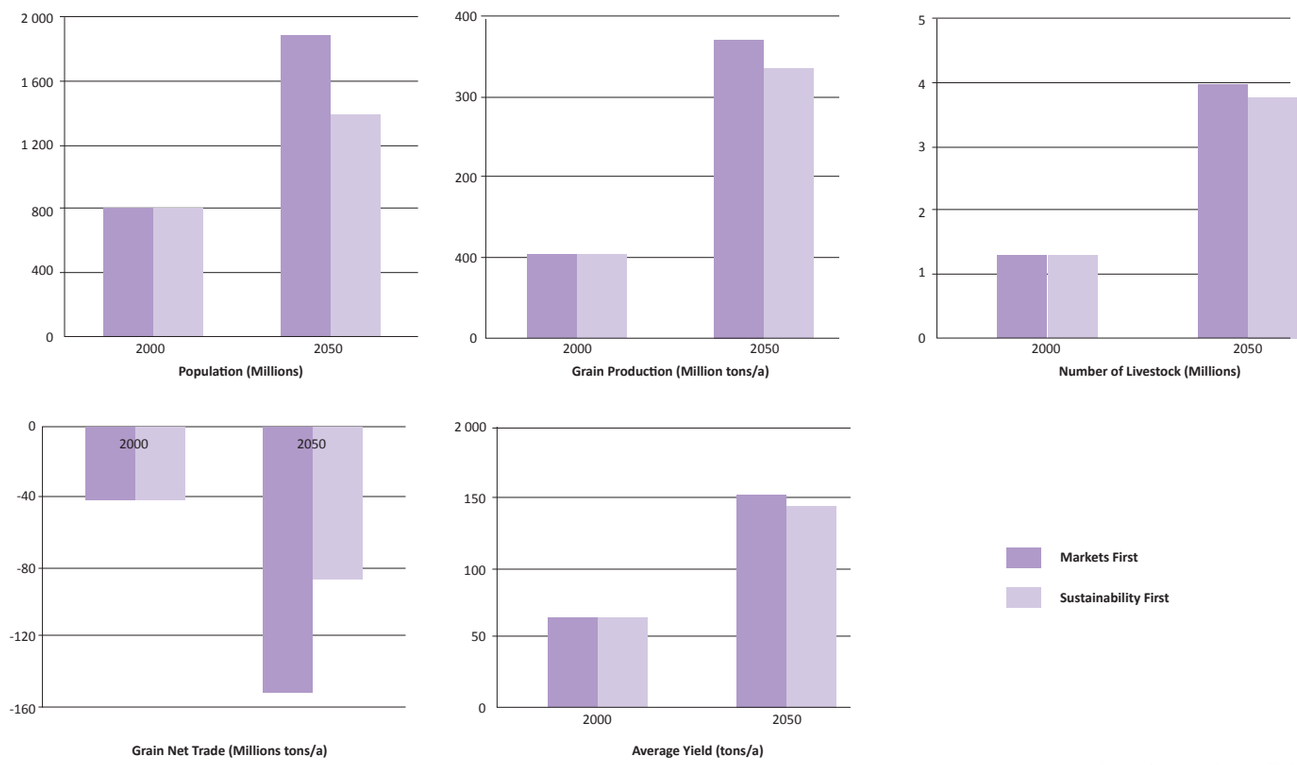
into the future but with variations across regions and seasons. Some regional scenarios show a much larger variation in expected land use (see Figure 9.14). Land degradation continues to negatively impact agricultural production leading to an even greater need for agricultural land expansion. The effect is also reflected in animal production with pastures and range lands suffering due to increased livestock numbers and other climate induced degradation. FAO scenarios point to less growth of confined grazing systems in Africa and a general 10 per cent increase in pasture land by 2050.

Sustainable World Scenario

Many projections under SWS including the Greats Transitions in AEO-2 (UNEP 2006) maintain that achieving sustainable development with respect to agriculture and land resources requires an integrated approach which considers the interlinkages between land use goals and policy outcomes from different sectors. Some principal drivers of land use change are presented in Figure 9.15 based on GEO-4 scenarios of Markets First (which parallels CWS) and Sustainability First, which parallels SWS (Alcamo and others 2011). Within a sustainable land use world, by 2050, Africa witnesses improved food production with a fitting balance between rural food production and urban demand.

Several factors were responsible for the increased food production while reducing adverse impacts on biodiversity. These included policies that set the scene for continued investment in agricultural research and productivity per unit of water, land and energy use. In addition, research and development (R&D) resulted in lower food wastage and losses during and after production. The food security targets realized after 2025 have resulted in tangible gains in nutrition security, eradication of hunger, increased life expectancy and significantly lower child mortality resulting

Figure 9.15: Principal driving forces of land use and land cover change in Africa projected to 2050 under Markets First Scenario (CWS) and Sustainability First Scenario (SWS)



Source: Alcamo and others 2011

from malnutrition. Conditions along the scenario pathway that led to this positive trend included political stability, good governance, and strong economic growth largely based on agriculture.

Actualizing the Sustainable World Scenario for sustainable land management on a wider scale requires upscaling of programmes and policies that target mindset change as well as information and knowledge flows using holistic and integrated approaches to land management (ECOSOC 2009; Nelson 2010; Taylor 2007). Land management initiatives that encouraged replication and addressed the challenge of land and health towards 2050 were supported by investment plans under the CAADP country compact processes. CAADP target countries, such as Ethiopia, Rwanda and Tunisia have designed strategic investment frameworks for sustainable land management that define mechanisms and approaches for integrated planning and coordination. The plans also focus on models for participatory land use planning and management to address degradation and water conservation through multi-stakeholder dialogue and investment. All along, land reforms remained a critical stability and security issue and were the bedrock for economic development. The SADC Land Reform Facility, for instance, facilitated the development of regional guidelines for the formulation and implementation of land reform policies. Regional lessons on redistribution, tenure, utilization, administration and adjudication were shared across the sub-region.

Summary of the transformational gaps and policy windows

The foregoing scenario analysis has explored two possible future worlds – a Conventional World Scenario depicting trajectories of past and present trends and the Sustainable World Scenario that paints sustainability pathways with major policy changes that would deflect current trajectories towards internationally agreed goals under each theme. Existing scenario studies and literature on environmental futures have been used to provide evidence for plausible gaps that are likely to become evident towards 2050. It is certain that moving forward with current trends will not help Africa to realize appropriate targets, such as the MDGs which should be met by 2015 and the 2020 mid-term goals set out in country visions and the NEPAD environment action plan. A comparison of the two worlds reveals an expanding gap (wedge) for which specific transformative policies and actions need to be urgently instituted in order to stem the threats to food security, human health and the other socio-economic benefits that flow from sound environmental management. The Sustainable World Scenario reveals the optimizing strategies needed to bridge this gap. Table 9.4 summarizes the gaps in each theme. The two scenarios reflect the well-known business as usual and transformative scenarios that have been reported in many environmental future studies and policy analyses.

The transformational concept that sets the ideals for the promising actions and policies focuses on ultimate mindset change and adjustment of institutional rules and feedbacks for efficient improvement in the environment and health spheres. Countries are encouraged to use existing technologies and promote innovation for emergent technologies that would, through capacity building, education and behavioural change, improve environmental governance. Relevant measures should also aim to protect biodiversity, promote climate change resilience and safeguard the health provisioning services of ecosystems. Shifting mindsets remains at the core of the envisaged transformation towards 2050. The interlinkages approach advanced in AEO-2 (UNEP 2006) continues to hold the key to sustainable development. With health implications coming to bear, the interlinkages approach will harness the synergies and minimize negative trade-offs, especially on health outcomes.

Table 9.4: Manifestations of CWS and SWS, and strategies for moving towards SWS

Theme	Conventional World Scenario	Sustainable World Scenario	Some important strategies for addressing gaps
Air quality	• Rising use of solid fuels especially in the rural areas and informal settlements • Outdoor air pollution in Africa's megacities rises sharply • Harmattan phenomenon is more recurrent in West Africa • Rising incidences of respiratory diseases associated with both indoor and outdoor air pollution	• Dramatic reduction of use of solid fuels especially in the rural areas and informal settlements • Outdoor air pollution in Africa's megacities reduces sharply • Falling incidences of respiratory diseases associated with both indoor and outdoor air pollution	• Promote uptake of improved cooking devices and of better kitchen ventilation • Carry out sensitization campaigns to reduce user exposure to smoke through behavioural change • Promote uptake of renewable sources of energy through a combination of command and control and fiscal incentives • Make electricity an affordable cooking energy alternative by constructing off-grid power generation systems • Institute and implement outdoor air quality standards and regulations.
Biodiversity	• Accelerating biodiversity loss and extinctions leading to a loss of attendant medicinal value • Dramatic habitat loss especially through deforestation, wetland conversion and aquatic ecosystem degradation leading to a rising number of biodiversity hotspots • Rising incidences of zoonotic diseases due to rising human-wildlife contact • Increasing pathways of invasive alien species	• Extinction of species halted and declines reversed • Sustainable use of biodiversity in health provisioning • Conservation and protection of terrestrial, wetland and aquatic habitats • Incidences of zoonotic diseases are declining • Threats posed by invasive alien species contained through coordinated national, regional and sub-regional initiatives	• Scale up the capacity of lead agencies to rein in poaching, deforestation, wetland conversion and coastal and marine degradation • Foster participatory management approaches e.g. CBNRM, PES and ensure equitable benefit sharing • Strengthening monitoring and early warning systems for zoonotic diseases • Utilize TBNRM to address regional and sub-regional threats e.g. invasive alien species
Chemicals and waste	• Rising cases of human chemical contamination • Stockpiling of POPs, inorganic fertilizers and agro-chemicals continues unabated • Increasing accumulation of e-waste and municipal waste • Dumping and regional generation of toxic waste rising • Non-fuel sources of lead are still a challenge • Region unable to adequately manage waste from increased oil and gas production	• Declining cases of human chemical contamination • Mechanisms for safely disposing of chemical stockpiles instituted • Amount of e-waste and municipal waste generated reduces owing to adoption of the 4Rs: reduction, reuse, recycling and recovery • Illegal dumping of toxic waste is contained • Command and control measures reduce the generation of non-fuel sources of lead • Oil and gas producing countries develop the financial, technical and human resource capacity to dispose of petroleum waste	• Adapt Strategic Approach to International Chemicals Management (SAICM) framework to African context • Accelerate domestication and implementation of Basel, Stockholm and Bamako Conventions • Sensitize public on the benefits of the 4Rs: reducing, reusing, recycling and recovery • Strengthen national and institutional capacity for chemicals management including recycling and disposal technologies • Strengthen implementation of the polluter pays principle
Climate change and variability	• Floods, drought, crop failure and other EWEs become more frequent and severe • Incidence of weather-sensitive illnesses e.g. malaria, meningitis, cholera and Rift Valley Fever increase as these expand into hitherto disease-free zones • Adaptation costs amount to over 5 per cent of GDP by 2030	• Adverse effects of EWEs are headed off • Robust adaptation plans have reduced incidences of weather- sensitive diseases • Warming is accompanied by energy savings due to the increased use of renewable energy (notably solar) • Climate change and variability benefits the region as it is able to tap lucrative funding mechanisms e.g. CDM, REDD+ and FCPF	• Encourage vulnerable populations e.g. women to engage in alternative livelihoods • Step up climate resilient national development planning through NAPAs and NAMAs • Climate proof investments in climate sensitive areas such as agriculture and infrastructure through more robust planning, construction and the use of weather-indexed insurance
Coastal and marine resources	• Coastal erosion rises to more than 30m per year by 2050 • Increased marine pollution from land-based sources and maritime accidents • Increased IUU fishing leads to a rapid decline in landed fish quantities • Increased morbidity and mortality from siltation, sea level rise, and coastal erosion	• Coastal erosion and marine biodiversity losses are significantly reduced • Increased monitoring and surveillance reduce pollution of coastal and marine waters and IUU fishing • Adaptation to climate change promotes resilience to sea level and temperature rises • Wider establishment of MMAs is witnessed.	• Enforcement of the concept of integrated coastal zone management (ICZM) • Rigorous application of the polluter pays principle • Coordinated sub-regional ocean surveillance reduces IUU fishing and deliberate dumping of waste at sea • Consolidate MPAs into the more effective MMAs
Freshwater and sanitation	• Water availability remains below the globally accepted minimum threshold of 1 000 m3 per capita • Rising percentage of inhabitants experience water scarcity by 2030 • Only 26 countries meet the MDG target of halving the proportion of people without access to safe drinking water • Over 35 per cent of the population does not have access to adequate sanitation by 2050 • Organic water scarcity is manifested through falling aquifer levels, persistent water shortages and exorbitant pricing • Total sanitation proves elusive • Child mortality due to waterborne diseases e.g. cholera and typhoid rise sharply	• MDGs on water and sanitation and other global targets are achieved • Only a negligible proportion of people live with severe water scarcity • Considerable reduction in water withdrawal is achieved through behavioural change and technological innovation that promotes use efficiency • Substantial gains are made in increasing access to safe drinking water and sanitation by 2050 • Remarkable reduction in incidence of waterborne diseases	• Protect watersheds including water towers • Promote education and awareness in water saving, waste water recycling and Total Sanitation • Promote conservation of water in households, industry and agriculture through economic incentives which encourage water harvesting and recycling • Encourage research and technological innovation that promotes water use efficiency • Implement the concept of IWRM
Land	• Land degradation, coupled with climate change lowers crop and livestock yields by over 34 per cent after 2030 • Perennial hunger and famine in some sub-regions coexist with abundant food in other sub-regions • Increased leasing of large scale tracts of land to foreign companies and for biofuels production pushes vulnerable communities to degraded, marginal land and precipitate food and nutrition insecurity and ill health	• Coordinated holistic shift to sustainable land management • Improved food production is not achieved at the expense of biodiversity • Policies to improve the productivity of the arid and semi arid lands lead to strong gains in food and nutrition security, with positive health outcomes leading to increased life expectancy and reduced child mortality due to malnutrition • Leasing of land to foreign companies and for production of biofuels is well-thought through to ensure that it does not foment land dispossession.	• Regulate large-scale land acquisition and use to ensure that they do not threaten food and livelihood security • Institute land reforms that ensure food security and sustainable land management • Improve irrigation coverage and efficiency in order to increase the proportion of land under agriculture.

Source: Compiled by the authors from various sources

Conclusion

This chapter has given a dual pathway approach to exploring future health and environment interlinkages. The future interaction between various drivers, pressures, exposure factors, health effects, state of both the environment and related human condition will be determined by whether or not we act on the many goals tracked in this chapter. The exploration of both CWS and SWS exposes the pathways and transitional strategies towards the targets. By 2050, the vision is to have a sustainable environment that supports various human socio-economic aspirations including health and the quality of life. Obviously, continuing on the current trajectory will not lead to such a future and major policy interventions to bend the curve and close the wedge need to be urgently instituted. The SWS narrates a future pathway that attempts to correct past miss-steps in order to achieve these targets and reduce the risk of adverse health effects.

Achieving the different goals addressed in this chapter through the interlinkages approach would enable harnessing of the inherent co-benefits between the different environmental themes and strategies. Indeed, failure to recognize and consider such cross-sector links may end up eroding the gains already secured towards ensuring sustainability in Africa. Governance and adaptive management will also be important to the desired transformation through participatory management of natural resources, consensus building and effective coordination between scales and across borders. Adaptive management will strengthen the management of uncertainties and risks associated with this future.

It will remain pivotal to adopt systems thinking that is grounded on the principle that small catalytic events can cause very large changes in complex fields such as the environment and human health. Great change can occur from small calculated actions, if action is directed at the right leverage point. The creation of long-term profound change is an important and challenging goal but begins with the individual through mindset and behavioural changes. Policies that promote environmental management with positive human health benefits need to be advanced in a manner that promotes action at strategic leverage points at several system levels.

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10

Enhancing Implementation of Environmental and Health Policies

Background

A good number of relatively good policy and legislative instruments in pursuit of ecosystem integrity and human health exist in Africa. However, the implementation of these policies and laws has not been very effective. While a variety of reasons account for this, it is recognized that lack of careful conceptualization as well as assessment and analysis of poverty-environment-health linkages have largely contributed to their ineffectiveness. Insufficient understanding and managing of the barriers to policy implementation are also part of the problem.

The Brundtland Commission's Report, *Our Common Future*, identified the role that human beings play in changing the environment and established the impact that environmental changes, in turn, have on human health and well-being (Brundtland 1987). Agenda 21 adopted at the United Nations Conference on Environment and Development in 1992 emphasized the need to pay attention to the linkages between health and improvement of the physical and socio-

Table Mountains
South Africa

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economic environment (Forget and Lebel 2001). It also emphasized the need to ensure intra- and inter-generational equity. The World Summit on Sustainable Development (WSSD) in 2002 specifically dealt with the poverty-environment-health linkages, especially the linkages between water, energy, health, agriculture and biodiversity (WEHAB) (WEHAB Working Group 2002).

In the last two decades, efforts have been targeted at more rigorous articulation of the poverty-environment-health linkages. Notable among these are efforts by the Stockholm Environment Institute (SEI) (for example, McGranahan and others 1999) the World Bank (e.g. Kishore 2006), WHO (e.g. Prüss-Üstün and Corvalán 2006), and inter-agency efforts represented by Poverty and Environment Initiative (PEI) (UNDP and UNEP undated)and the Poverty-Environment Partnership (PEP 2008). Members of PEP include AfDB, DFID, the German Federal Ministry of Economic Cooperation and Development, London School of Hygiene and Tropical Medicine, Water Aid, Austrian Development Agency, European Union, IIED, the Norwegian Agency for Development Cooperation (Norad), UNDP, the World Bank, World Health Organization (WHO), Ministry of Foreign Affairs of Denmark, Ministry of Foreign Affairs of Finland, Irish Aid, Swedish International Development Cooperation Agency (Sida), UNEP and the World Resources Institute (WRI).

In recognition of the importance of hard evidence on environment-health linkages to guide policy decisions and implementation, the African Ministers of Environment and of Health in 2008 requested for up-to-date information on health and environment linkages. The request informed the partners' decision to dedicate this issue of the African Environment Outlook (AEO-3)

Table 10.1: Selected policies, related health interventions and attendant benefits

AEO-3 Theme	Policy framework	Policy goals to promote health	Benefits of successful attainment of policy goals
Air quality	• Dakar Declaration (2001) • FEMA Maputo Declaration (2007) • Johannesburg Plan of Implementation (JPOI) [2002] • Algiers Declaration (2008) and Launch of African Commission on Energy (AFREC)	• Phase out leaded gasoline in all sub-Saharan Africa countries. Complete this latest by 2005. • Increase access to modern energy services to reduce indoor air pollution and adverse health effects mostly on women and children. • Reduce respiratory diseases and other health impacts resulting from indoor air pollution, with particular attention to women and children (Chapter 5, Section 56). • Safeguard environment and health when developing the energy sector and accelerating industrial development of the continent.	• Adverse effects of lead on neurodevelopment and intelligence quotient reduced. • Health risks associated with upper respiratory tract infection, especially in children and women as a result of indoor air pollution are minimized. • Health risks associated with indoor air pollution reduced. • Industrial pollution and attendant health and environmental hazards reduced. • Morbidity and deaths associated with indoor air pollution reduced as use of clean energy sources is scaled up.
Biodiversity	• Convention on Biological Diversity (1992), Article 19 (4)	• Provide information about the use, safety regulations and potential adverse impact of GMOs.	• Health and environmental risks associated with application of biotechnology better managed, especially as countries design and implement biosafety regulations and invoke and adhere to the Precautionary Principle.
Chemicals and wastes	• The Bamako Convention (1991), Article 4.1 • The Declaration of United Nations Conference on Human Environment (1972) • Johannesburg Plan of Implementation (2002)	• Ban the importation of hazardous wastes and ban dumping of hazardous wastes at seas, international waters and waterways. • Halt the discharge of toxic substances or of other substances and the release of heat, in such quantities or concentrations as to exceed the capacity of the environment (Principle 6). • Chemicals be used and produced in ways that lead to the minimization of significant adverse effects on human health and the environment (Chapter 3). • Promote programmes for the environmentally sound, effective and efficient use of soil fertility improvement practices and agricultural pest control (Chapter 4, Section 40 (0)). • Phase out lead in lead-based paints and in other sources of human exposure, work to prevent, in particular, children's exposure to lead and strengthen monitoring and surveillance efforts and the treatment of lead poisoning (Chapter 5, section 57).	• Threats that these wastes pose to human health and the environment eliminated as countries strengthen the capacity to enforce the convention. • Threats that toxic wastes pose to human health and the environment are halted as countries adopt appropriate detecting and monitoring tools and enhance capacity for enforcement. • Increased availability of safe chemicals reduces morbidity and mortality in humans and the degradation of ecosystems by chemical pollution. • Reduced pollution of water sources and of morbidity and mortality associated with exposure to polluted water and soil. • Reductions in exposures to lead and incidences of lead poisoning and attendant morbidity and mortality. • Monitoring and surveillance strengthen safeguards and help to reduce incidences of human exposure to and poisoning by lead.

Table 10.1: Selected policies, related health interventions and attendant benefits (cont.)

Climate change and variability	• UN Framework Convention on Climate Change, Article 3(3) • Seychelles Declaration (2006), Item 10 • Algiers Declaration (2008)	• Take precautionary measures to anticipate, prevent or minimize the causes of climate change and mitigate its adverse effects. • Strengthen emergency preparedness and response to the health aspects of natural disasters and epidemics. • Consider the magnitude of health problems associated with poverty and climate change, including prevalent infectious diseases such as malaria, tuberculosis, HIV/AIDS, emerging diseases, neglected tropical diseases, the resurgence of epidemic-prone diseases and other complex emergency situations	• Africa's current vulnerability to a number of climate sensitive diseases including malaria, tuberculosis and diarrhoea reduced with enhanced capacity for vulnerability assessment and appropriate adaptation responses. • The inoculum effect associated with cholera outbreaks, of which global warming and anthropogenic alterations of marine ecosystems are major driving forces reduced as countries strengthen capacities for remote sensing for the management and monitoring of environmental conditions linked to cholera. • Morbidity and mortality associated with disease burdens from natural disasters and epidemics, especially those due to diseases linked to poverty and climate change better reduced.
Coastal and marine resources	• The Bamako Convention (1991), Article 4.2 • The Declaration of UN Convention of Environment and Human Settlement (1972)	• Ban dumping of hazardous wastes at sea, internal waters and waterways. • Prevent pollution of the seas by substances that are liable to create hazards to human health, to harm living resources and marine life (Principle 7).	• The adverse effects of the hazardous wastes on human health and aquatic biodiversity reduced as countries strengthen national capacities and acquire requisite tools in ensuring effective enforcement of measures.
Freshwater and sanitation	• Plan of Implementation of the World Summit on Sustainable Development (2002); • UN Millennium Declaration (2000) • eThekwini Declaration and Action Plan (2008)	• Intensify water pollution prevention to reduce health hazards and protect ecosystems through introducing technologies for affordable sanitation and industrial and domestic wastewater treatment (25d). • Halve the proportion of people who are unable to reach or to afford safe drinking water. • Review, update and adopt national sanitation and hygiene policies within 12 months of AfricaSan 2008; establish one national plan for accelerating progress to meet national sanitation goals and the MDGs by 2015; take necessary steps to ensure that national sanitation programmes are on track to meet these goals; and establish specific public sector budget allocations for sanitation and hygiene programmes, including via an 'aspirational' allocation of at least 0.5per cent of Gross Domestic Product for sanitation and hygiene.	• The provision of clean drinking water and adequate sanitation contributes to protecting human health and environment and reducing costs incurred in treating waterborne diseases • Disproportionate time spent by girls and women in fetching drinking water reduced and more time allocated to schooling and other productive activities, respectively. • The estimated one million annual deaths from sanitation, hygiene and drinking water-related diseases reduced as countries invest more in ensuring access to clean water and sanitation. • Household and national economic development enhanced as morbidity and mortality due to waterborne diseases are reduced and productivity of labour force enhanced.
Land	• Johannesburg Plan of Implementation (2002)	• Develop and implement integrated land management and water-use plans that are based on sustainable use of renewable resources and on integrated assessments of socio-economic and environmental potentials.	• Threats of flash floods and related waterborne diseases contained when surveillance and management of waterborne diseases are strengthened. • Soil and water contamination by industrial and agricultural activities and attendant pollution-related diseases reduced as appropriate tools and management techniques to that effect are widely applied.

Source: Compiled from the cited MEAs and Declarations

to health and environment. The results of the assessment are expected to inform policy actions for transformative changes, especially within the environment and health sectors in order to accelerate the attainment of policy goals that promote ecosystem integrity, and improvements in human health.

This chapter defines the priority environmental policy goals linked to human health, assesses their performance across Africa, highlights good practices and lessons learnt from policy implementation and combines these with policy-related results of the assessments in Part II of this report to propose options to enable Africa to speed up the attainment of the priority goals, including the Millennium Development Goals (MDGs). The assessment is aimed at determining the bottlenecks that are impairing policy implementation. Arguably, unless those bottlenecks are resolved, African countries will continue to face serious difficulties in attaining agreed upon environmental and health policy goals, including the MDGs and several multilateral agreements.

Providing information for mothers is important

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Selection of policy goals

The African Ministers of Environment and of Health jointly defined some environmental policy goals that are linked to human health. It is prudent to give those goals special attention when selecting the policies to focus on in this report. These priority policy goals appear in the Ministers' declarations and commitments at their joint meetings in Libreville, Gabon in August 2008, and Luanda, Angola in November 2010, respectively. Relevant policy goals in other agreements and decisions made by the African Ministers in other forums are also considered. Cases in point are the policy goals agreed upon by the African Ministers of Energy in Maputo (2007). So are the MDGs. The basic criteria used to arrive at a final list of policy goals (Table 10.1) include prioritization by the African Ministers, explicit focus on environmental and health linkages, prominence in the Report on Situation Analysis and Needs Assessment (SANA) for Implementation of the Libreville Declaration, and relevance to the thematic areas of AEO-3.

Good practice cases presented here depict positive experiences with implementing policies and programmes in Africa that focus on the links between environment and health. Although attempts were made to ensure that the cases are representative of the sub-regions, scarcity of empirical materials from secondary sources available to the authors made it difficult.

Selected policy goals

The policy goals considered for inclusion are those identified by the Ministers of Environment and of Health at their joint meetings in Libreville and Luanda. In the Libreville Declaration (2008), the Ministers committed themselves to enhancing the implementation of conventions and agreements related to health and environment. They prioritized the following:

- The Declaration of the United Nations Conference on Human Environment (1972)
- The Alma-Atta Declaration of Primary Health Care (1978)
- The Bamako Convention on the Ban of the Import into Africa and Control of Transboundary Movement and Management of Hazardous Wastes within Africa (1991)
- The Rio Declaration on Environment and Development (1992)
- The United Nations Millennium Declaration and the subsequent MDGs (2000)
- The Plan of Implementation of the World Summit on Sustainable Development (2002)
- The 2007 African Health Strategy of African Union 2007-2015
- The Algiers Declaration on Research for Health in Africa (2008)
- The eThekwini Declaration on Hygiene and Sanitation (2008).

Others relevant policy goals are expressed in the following:

- The Bali Declaration on Waste Management for Human Health and Livelihood (2008).
- The recommendation of the Joint International Conference on 'Desertification and the International Policy Imperative' (2006).

At the ministers' meeting in Luanda in 2010, they committed themselves to pursuing the following environment and health priorities:

i) provision of safe drinking water
ii) provision of sanitation and hygiene services
iii) management of environmental and health risks related to climate change and variability including rises in sea levels particularly affecting Small Island Developing States (SIDS)
iv) sustainable management of forests and wetlands;
v) management of water, soil and air pollution, and biodiversity conservation;
vi) vector control and management of chemicals (particularly pesticides) and wastes (including biomedical, electronic and electrical wastes);
vii) food safety and food security including the management of genetically modified organisms (GMOs) in food production;
viii) environmental health of children and women;
ix) health in the workplace; and
x) management of natural and human-induced disasters.

The Ministers advised on accelerated implementation of the Libreville Declaration (2008) for purposes of enhancing the attainment of the MDGs, particularly Goals 4, 5, 6, and 7 relating to child health, communicable diseases and ecosystem integrity respectively (2008). The manner in which reductions in risk factors for the environment-related disease burden can enhance achievement of MDGs is illustrated in Table 10.2.

The results of the Situation Analysis and Needs Assessment (SANA) for Implementation of the Libreville Declaration on Health and Environment in Africa confirmed the priorities identified by the Ministers. The results revealed that, in addition to environmental hazards occurring naturally, human activities lead to water pollution, air pollution, soil degradation and pollution, food contamination, biodiversity loss and the proliferation of disease vectors. Water quality, sanitation, chemical and waste management, and air pollution were defined as the most important environmental risk factors associated with these determinants (UNEP and WHO 2010).

The majority of the environmental policy actions in Table 10.1 respond to the traditional environmental risks to human health. Such risks are the most prevalent in Africa. Few of the actions in Table 10.1 pertain to Modern Environmental Health Hazards (MEHHs), which include, but are not limited to, water pollution from populated areas and industry, pollution from mines and oil wells, urban air pollution from automobiles, radiation hazards, land degradation, climate change, and emerging infectious diseases. As African countries brace for enhanced economic growth, industrialization, amidst rapid urbanization, the MEHHs are likely to increase in prominence and perhaps supersede traditional health hazards as critical contributors to the environment-related disease burden in the continent in the near future (Corvalàn and others 1999).

Already, artisanal gold miners in Burkina Faso, Senegal, Tanzania, and Zimbabwe who lack personal protective equipment were reported to be exposed to high levels of mercury during mining and processing of gold (van Straaten 2000; Savornin and others 2007; Hentschel and others 2003). Besides direct occupational

Table 10.2: Reducing the disease burden of environmental risk factors enhances achievement of MDGs

MDGs	Benefits accruing from reducing disease burden of environmental risk factors
Goal 1: Eradicate extreme poverty and hunger	Minimizing exposures to environmental risk factors indirectly contributes to poverty reduction, because many environmentally mediated diseases result in lost earnings. Also, disability or death of one productive household member can affect an entire household. With respect to hunger, healthy life years lost to childhood malnutrition is 12-times higher per capita in developing regions, compared with developed regions. There was a 60-fold difference in WHO sub-regions with the highest and lowest malnutrition rates.
Goal 2: Achieve universal primary education	Providing safe drinking-water and latrines at school (particularly latrines for girls) will encourage primary school attendance. Interventions that provide households with access to improved sources of drinking-water and cleaner household energy sources also improve student attendance, saving time that children would otherwise spend collecting water and fuel. The same interventions can save children from missing school as a result of illness or injury.
Goal 3: Promote gender equality and empower women	Access to improved drinking-water sources, cleaner household energy sources, and more generally, reduction of environmentally-attributable burden of childhood diseases, can save time women now spend in collection of fuel, water, and care for children who become sick. Time thus saved also can be invested by women in income-generating activities and education, thus contributing to the MDG goal of empowering women and promoting gender equality.
Goal 4: Reduce child mortality	The mortality rate in children under five years of age from environmentally-mediated diseases is 180 times higher in the poorest performing region, as compared with the rate in the best performing region. In terms of just diarrhoea and lower respiratory infections, two of the most significant childhood killers, environmental interventions could prevent the deaths of over 2 million children, and thus help achieve a key target of this MDG – a two-thirds reduction in the rate of mortality among children in that age category.
Goal 5: Improve maternal health	Environmental interventions can contribute to this MDG by providing a safe home environment, which is of great importance to the health of children and pregnant mothers. Conversely, a contaminated home environment is a threat to the mother and her unborn child. Childbirth, for example, requires safe water and sanitary conditions.
Goal 6: Combat HIV/AIDS, malaria and other diseases	Over half a million people die every year from malaria, and over a quarter of a million people die from HIV/AIDS, as a result of environmental and occupational causes. A large proportion of malaria, in particular, may be attributable to readily modifiable environmental factors, such as land use, irrigation and agricultural practices.
Goal 7: Ensure environmental sustainability	Diarrhoeal diseases associated with a lack of access to safe drinking-water and inadequate sanitation result in nearly 1.7 million deaths annually. Use of biomass fuels and coal by over one-half of the world's population, results in 1.5 million deaths a year from pollution-related respiratory diseases. Enhancing access to improved sources of drinking water, sanitation, and clean energy are therefore key environmental interventions that can reduce pressures on ecosystems from water and airborne contamination, and also improve health. Residents in fast-growing cities of the developing world may be exposed to the combined health hazards of unsafe drinking-water, inadequate sanitation, and indoor and outdoor air pollution. Reductions in such environmental exposures will improve both the health and the lives of urban slum dwellers, which is one of the key targets of MDG 7.
Goal 8: Develop a global partnership for development	Both the health sector and non-health sector actors can, and need, to take joint action to effectively address environmentally-mediated causes of disease. To do this, global partnerships are essential. Many such alliances already exist in the field of children's environmental health; occupational health; in joint health sector and environment sector linkages; and in actions in the water, chemical and air pollution sectors. Such global partnerships need to be strengthened and reinforced, harnessing the full range of policy tools, strategies and technologies that are already available – to achieve the interrelated goals of health, environmental sustainability, and development.

Source: Extracted from Prüss-Ustün and Corvalán 2006

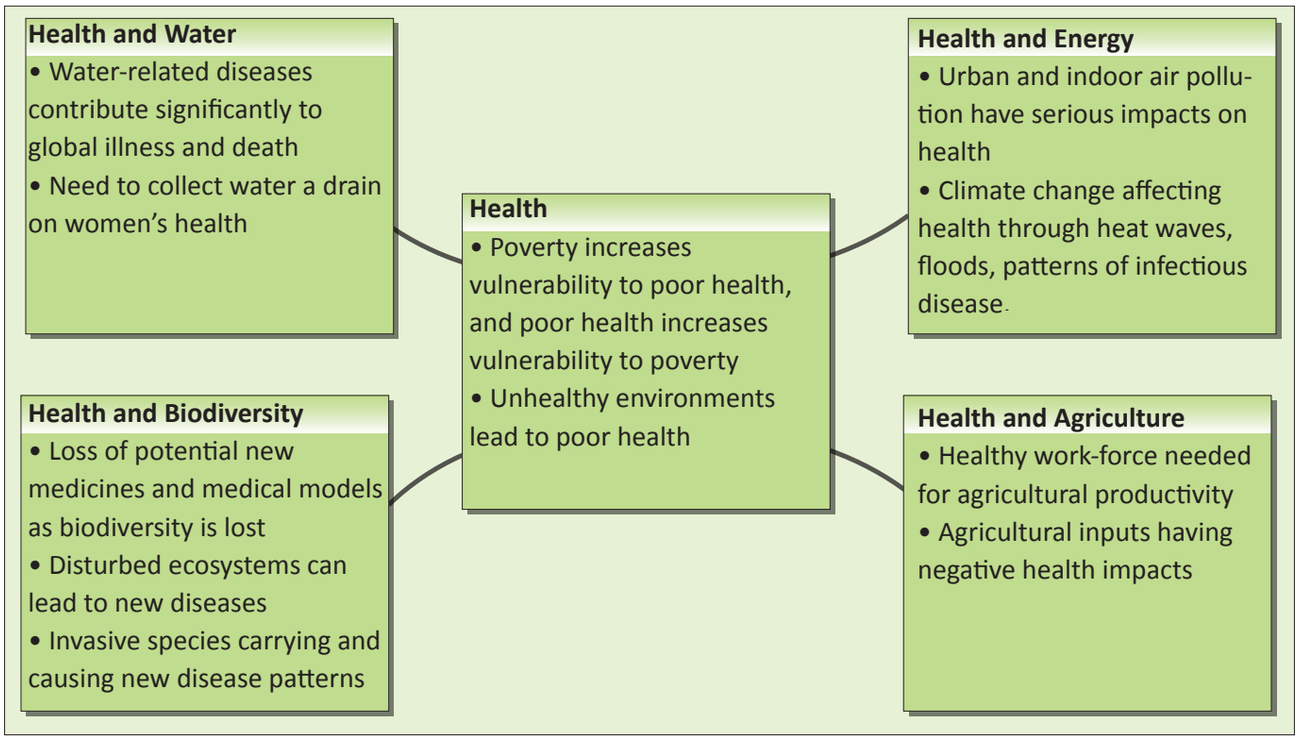
exposure to metallic mercury, residents in gold-mining communities were exposed to metallic mercury in their diet via ingestion of fish caught from local water bodies contaminated by mining activities (Nweke and Sanders II 2009). Indeed, exceedances of the WHO mercury limit were reported in fishes caught in the immediate vicinity of gold-mining activities at Rwamagasa, Tanzania (Appleton and others 2004 in Nweke and Sanders III 2009) and Kadoma-Chakari region of Zimbabwe (Billaud and others 2004 in Nweke and Sanders III 2009). In Ogoniland, Nigeria, the Ogoni community is exposed to petroleum hydrocarbons in outdoor air and drinking water, sometimes at elevated concentrations. Furthermore, community members at Nisisioken Ogale are drinking water from wells that are contaminated with benzene, a known carcinogen, at levels over 900 times above the World Health Organization (WHO) guideline (UNEP 2011a). Details of these modern environmental health hazards are discussed in Chapter 4 on Chemicals and wastes.

In Table 10.1, the selected environmental policies are cross classified against the thematic areas for AEO-3; highlighting strategic actions expected of African governments and the attendant benefits. Although the MDGs are among the priority policy goals, they are not included in Table 10.1; but treated separately in order to highlight how reducing the disease burden of environmental risk factors enhances achievement of MDGs and contributes to improved human health. These appear in Table 10.2 above.

Policy and institutional linkages during implementation

Policy and institutional linkages are implied in Principle 1 of the Rio Declaration on Environment and Development. The complexities of ecosystem dynamics, the cross-linkages among health and environment institutions and their interface with human livelihoods affect the success of policy implementation. Water related issues, for example, often fall between

Figure 10.1: Linkages between the environment and health



Source: WEHAB Working Group 2002

the responsibilities of the ministries for water, agriculture, urban development, energy and environment (Dobbs and others 2012). Harmonization and rationalization of policy actions and programmes among these ministries can contribute to better management of the water resource which in turn benefits human health and ecosystem integrity.

Policy linkages can translate into either synergy or conflict during policy implementation. Pursuit of targets under particular policy goals could compromise or enhance the attainment of targets under other goals. Pursuit of energy efficiency through improved cook stoves, for instance, generates positive effects in terms of reductions of indoor air pollution and in the pressures on communal woodlots or forests as sources of wood fuel, which is good for both forest and biodiversity conservation. On the other hand, excessive use of irrigated water in pursuit of food security could compromise other water end uses such as human consumption, energy and maintenance of ecosystems. These examples point to the need to take account of possible synergies and antagonisms that could occur during policy implementation.

Similar thematic linkages were highlighted by the working group on the Water, Health, Agriculture, and Biodiversity (WEHAB) in the run-up to the 2002 WSSD Summit in Johannesburg. Figure 10.1 illustrates the environment-health linkages in the water, biodiversity, agriculture and energy areas. Clearly, waterborne diseases, new diseases, indoor air pollution, heat waves, floods, changing patterns of infectious diseases and pollution from agro-chemicals are the health problems arising from the altered state of the environmental and natural resources. As already indicated in Table 10.2, reducing the disease burden of environmental risk factors enhances the achievement of MDGs. Policy actions that could promote such reductions are implied under each of the MDGs.

The context of policy implementation

In its widest sense, policy is used to denote any form of established societal intervention or response to existing and emerging challenges. Most commonly, policy is understood as decisions taken by those with the legal mandate to do so and these decisions are expressed in formal or official documents and executed by the relevant arms of government (Keeley and Scoones 2003). Such public policies are often supported by strategies or other implementation tools such as laws. Policies, however, are not always formally enunciated and can also be inferred from established or longstanding practices.

Situations within which governments in Africa and their development partners are implementing environmental policy goals in pursuit of ecosystem integrity and human health are changing and often rapidly. These changes include global economic crises, rapid urbanization, public sector reform, emerging technologies, the push for green economy and transformative mindsets. These changes represent both challenges and opportunities that Africa has to contend with in seeking transformative changes to enhance promotion of ecosystem integrity and improved human health.

Global economic dynamics

The sharp global economic contraction has affected both advanced and developing countries (World Bank 2009). Sub-Saharan Africa 'has been strongly affected by the global recession, despite initial optimisms that the global financial systems would have few spillover effects on the continent.' The crisis has affected Africa through contraction in global trade and a related collapse in primary commodity exports on which many countries are dependent. Foreign investment and migrant worker remittances are also expected to

decrease significantly, and some analysts predict cuts in foreign aid in the medium term if the crisis persists (Arieff and others 2010). There are, of course, sub-regional variations in the impacts of the crisis among middle-income, low income and fragile, post conflict countries. The impact on the middle-income countries, for instance, is reflected by South Africa, where GDP was projected to decline by 2.25 per cent in 2009, due largely to South Africa's close integration into global financial markets and tight trade links with the rest of the world.

Although the fallout from the crisis on public support for aid to poor countries remains inconsequential in most OECD countries (Zimmerman 2008), and aggregate aid figures appear to remain stable, it is feared that much of the new aid resources might bypass the poorer and most vulnerable countries (Mold and others 2008). Private direct investment 'is falling, particularly in the natural resources sectors, as financing becomes scarcer and as declining commodity prices lead to delays or cancelation of major projects' (World Bank 2009). If this trend persists, funding within the natural resource sectors may decline over the years.

Declining remittances, which represent a major source of foreign exchange earnings for many low income countries, will have similar effects. Overall, the fallout would mean shrinkage in the resource envelop available to sub-Saharan African countries for implementing policies and programmes that improve both ecosystem integrity and human health. Coupled with the difficulties in attracting aid, these fallouts are likely to compel African governments and their development partners to seek improvements in aid effectiveness (Mold and others 2008). The emergence of Brazil, Russia, India, China and South Africa (BRICS), which together represent about 45 per cent of the world population, portends both opportunities and challenges for African countries. In addition to receiving financial support from the BRICS, Africa could draw upon and share with them some of the good practices and technologies for resolving some of the environmental challenges that undermine human health.

Rapid urbanization

The UN-Habitat (2010) reported that Africa will experience the strongest urban growth among all regions of the world until 2050. Between 2000 and 2030, it is expected that Africa's urban population will increase from 294 million to 742 million (a 152 per cent increase). Cairo, Lagos and Kinshasha are the three largest cities. Of these, Cairo and Lagos are the megacities (with populations of over 10 million). Generally, rural-urban migration and high fertility rates in general fuel urbanization in Africa. Additionally, rural-urban migration in countries with very high population densities such as Rwanda and Burundi, is primarily driven by the inability of the local resource base to sustainably ensure food and income security for the populations.

Overall, a number of problems and outstanding opportunities ensue. The challenges include infrastructure gaps and missing capacities for power, water, and food supply, to loss of agricultural land and chaotic traffic gridlocks as well as health problems arising from air pollution, lack of sanitation and huge piles of garbage. Adequate responses by African governments to these problems would overstretch national budgets. The opportunities that businesses in Africa can seize in response to these challenges include sophisticated city planning methods, innovative waste management practices, cost efficient treatment technologies and independent power plants (Sieper 2011). Well-managed Public-Private Partnerships (PPPs) would be a useful modality in seizing these opportunities. If successful, these types of responses would improve the prospects of attaining sustainable development pathways.

Public sector reform

Public sector reform is a policy initiative that has influenced the management of resources and delivery of services, including those in the environment and health sectors. The basic premise of this reform is that inefficiency and ineffectiveness of public sector performance in Africa, that has been averse to cost containment and quality improvement, can be reversed if the public sector can emulate, as much as possible, the private sector in the way in which it is organized and managed (UNECA 2003).

Adoption of these reforms therefore introduced modifications in the context within which environmental and health policy goals were hitherto pursued. Public management reform, as outlined here, henceforth presented African countries with both opportunities and challenges in improving the management of resources and the delivery of basic environmental and health services. Initiatives such as Community Based Natural Resources Management (CBNRM), Co-management of forests, and decentralized health delivery systems have been anchored on the opportunities presented by the reform. Similarly, the adoption of Public-Private Partnerships (PPPs) by some African countries was aimed at seizing the benefits that this mild form of privatization would contribute to improved resource management and better delivery of environmental and health services.

However, while decentralization augurs well for enhanced local ownership, leadership and control of resource management and health service delivery, a variety of factors have influenced its impact. These have included: scope of transfer of responsibilities, extent of transfer of financial resources needed to fulfill the devolved functions, scope and depth of decentralized decision making powers, types of personnel management arrangements between the national and decentralized jurisdictions in pursuit of agreed upon goals, variety of accountability mechanisms in force, nature of involvement of other institutional actors, and the degree of local political competition (Olowu 2001).

In the case of PPPs, additional factors such as nature of contracts, abilities of communities to understand the contract and hold the private partner accountable, and the extent of capacity building support provided to the community are also important. With regard to decentralized delivery of health services, major factors influencing performance include governance, environment and financing arrangements (Das Gupta and others 2004). The manner in which all these and other related factors play out in a given country context determines the extent to which decentralization and privatization policies interact with environment and health policies to influence the management of natural resources and the delivery of the basic health and environmental services.

The abilities of decentralized jurisdictions to develop and apply regulations and guidelines for actualizing national environment and health policies also come into play. All these interactions account for the mixed results that Africa has reported in implementing decentralized natural resources management (Ribot 2002 and 2004; Oyono 2004; Roe and others 2001; Rutten 2004) and decentralized delivery of health services (Das Gupta and others 2004).

Staff retrenchment, euphemistically referred to as down-sizing or right-sizing, of the public service, is a feature of public sector reform that has profoundly influenced the capacities of African countries to implement policies and development programmes. As a result of staff retrenchment across sectors and countries, the continent became the least governed part of the world, with the lowest number of civil servants per 100 people. Exceptions have been Botswana (5.8) and Mauritius (5.5), which in the era of retrenchments had more than three times the sub-Saharan ratio of 1.5 civil servants per 100 people (Mkandawire

2003). This partly explains the relatively exceptional and salutary performance of these two countries in respect of growth and service delivery. Overall, the difficulties experienced by many African countries in development management in general and policy implementation in particular are partly attributable to institutional capacity deficits attendant to staff retrenchment. This situation has been exacerbated by unattractive staff incentive systems in the public service, which continues to fuel brain drain and further erode the limited institutional capacity.

Emerging technologies

Genetically modified organisms (GMOs), including Genetically Modified Crops (GMCs), represent recent biotechnological interventions that present both opportunities and challenges for human health and ecosystem integrity. The health benefits of the GMCs are exemplified by food and nutrition security, arising from enhanced crop productivity and nutrition security. The ecosystem integrity benefits accrue from sustainable agriculture, through more efficient use of external inputs and attendant minimization of pollution effects of agro-chemicals on agro-biodiversity and human health (James 2003). However, GMC applications portend challenges for human health and ecosystem integrity if the yet unknown risks become manifest in the medium to long term.

Among the emerging technologies to watch in Africa in respect of ecosystem integrity and human health are the developments in clean coal, biofuels and electro-fuels, biochar and modern Information, Communication and Technology (ICT). Innovative industrial processes now under development could help coal-fired generators to capture more than 90 per cent of their carbon dioxide, at a cost of less than $2,000 per kilowatt (kW), down from the current US$ 8,000-$10,000 per kW. On the current course, it is expected that 'coal with carbon sequestration could become cheaper, more reliable, and more widely deployable than many renewable technologies' (Rogers 2012). If this technology is viable by 2020, amidst supportive carbon regulations, it would enable African countries with huge reserves of coal and capabilities to invest in the clean coal technology to exploit those reserves for generating electricity without unduly compromising environmental sustainability and human health (Rogers 2012).

Notwithstanding some of the genuine concerns associated with biofuel production in Africa (for example, risks of food insecurity) work on 'innovative start-ups focused on cellulosic and algae-based biofuels are starting to create high-margin specialty chemicals and blend stocks, generating cash now and suggesting a pathway to deliver biofuels at $2 a gallon by 2020' (Rogers 2012). Additionally, 'bio-pharmaceutical researchers are developing electro-fuel pathways that feed carbon dioxide, water, and energy to enzymes to create long-chain carbon molecules that function like fossil fuels at one-tenth the cost of current biofuels' (Rogers 2012). It is worthwhile monitoring the economic, health, and environmental benefits of these technological developments as African countries seek cost-effective sustainability pathways.

Biochar is another emerging technology, although its merits regarding human health and the environment remain contentious. It is a carbon-rich product that results when biomass – from wood, leaves, manure or crop residue – is burned under oxygen-deprived conditions. The proponents of biochar suggest that it 'offers pathways to meet pressing challenges across agriculture, climate change and energy – and moreover to address all three domains in an unprecedented triple win' (Leach and others 2010). NGOs promoting biochar through pyrolitic cooking stoves in Burkina Faso, Republic of Congo, Democratic Republic of Congo, Kenya, Malawi, Niger and Uganda argue that what they offer 'is not just a triple win (climate change mitigation, appropriate energy, as well as agricultural benefits and income), but a fourth: improved health from reduced cooking smoke and indoor air pollution' (Leach and others 2010).

Critics of biochar, on the other hand, assert that the acclaimed benefits of biochar are exaggerated. This ongoing debate notwithstanding, the governments of The Gambia, Ghana, Lesotho, Mozambique, Niger, Senegal, Swaziland, United Republic of Tanzania, Uganda, Zambia and Zimbabwe that saw value in the biochar technology, made a joint submission urging the 15th Conference of Parties of the UNFCCC in Copenhagen in 2009 to include the potential of soils in drylands in sequestering carbon and hence the inclusion of biochar in the Clean Development Mechanism (CDM) (Leach and others 2010). Although that submission was unsuccessful, Africa needs to monitor developments in biochar, especially in regard to the continent's search for development pathways that ensure sustaining ecosystem integrity and improving human health.

Modern ICTs are another set of technologies to watch in Africa. They provide a number of opportunities in environmental management and monitoring some of the human diseases associated with changes in the state of the environment. While ICTs have been applied in the water, agriculture and rural development sectors as resource management tools (Maumbe and Okello 2010), they offer possibilities as tools for managing climate change adaptation. In this regard, Ochola and Ochola (2012) illustrate the application of ICTs for analysis and planning, implementation and management, training and capacity building, collaboration and networking, and monitoring and evaluation. In terms of disease monitoring, Colwell and Huq (2001) mention the application of remote sensing technologies to identify triggering factors for cholera epidemics associated with global warming. An example here is the satellite imaging of sea surface temperature, sea surface height and plankton that was applied in Peru and Bangladesh. This opportunity is worthy of closer scrutiny by African countries with coastal and marine ecosystems.

Briggs (1997) also indicated the usefulness of Geographic Information System (GIS) in generating maps of environmental risks and health outcomes, map analysis, and map overlay and comparison. At the most mundane level, mobile phones offer stakeholders in the environment and health sectors huge opportunities for becoming more engaged in the enforcement of environmental and public health laws. In countries where state advocates have enhanced capacities for environmental litigation, this opportunity, if seized, could yield huge dividends; particularly in terms of enforcing laws intended to curb environmental degradation and the Polluter Pays Principle.

Green economy pathways to sustainable development and poverty reduction

Underpinning the push for a green economy is the concern that 'economic growth of recent decades has been accomplished mainly through drawing down natural resources, without allowing stocks to regenerate, and through allowing widespread ecosystem degradation and loss' (UNEP 2011b). Given the comparative advantage of Africa as a continent rich in natural resources, transition to a green economy pathway provides opportunities for reaping economic benefits while at the same time sustaining ecosystem integrity and promoting human health. A good example here is reducing deforestation and increasing reforestation.

New or enhanced revenue streams could accrue from certified timber, certified rainforest products, payment for ecosystem services (PES), benefit sharing schemes for partnerships with the private sector in managing forest parks. Similar revenue streams and health benefits would also accrue from certified organic products from sustainable agricultural practices and new human medicines derived from Africa's rich plant biodiversity. Portions of these revenues could be reinvested

in conserving forest ecosystems and promoting human health.

Transformative mindset

USA President Barack Obama's 2008 campaign slogan, 'Yes We Can' and that of Dr. Nawal Al Saadawi of Egypt that 'We can change the world if we can think creatively,' both typify mindsets that inspire behaviors that spur transformative change. The general public in Africa and state functionaries would benefit from such mindsets if they are to achieve transformative change. Accelerated implementation of the policies and programmes for improving ecosystem integrity and human health that the African Ministers of Environment and of Health so desire is up against a number of technical, economic, political and cultural challenges. These challenges can be resolved if leaders and the populations at local, national and regional levels develop appropriate mindsets, especially sustainability mindsets in pursuit of economic growth for poverty reduction. Transformational change depends on the type of leadership whereby 'individuals and groups are connecting, organizing, thinking systemically, bridging, and learning as part of a dynamic leadership process that mobilizes action on the scale needed' (LLC and others 2010). The leaders spur transformative change through nurturing flexibility, creativity and imagination. This is possible when they accommodate diverse viewpoints and recognize different voices in society (Ernst and Young 2010).

The United Republic of Tanzania's pursuit of its Development Vision 2025 is exemplary in this regard. A fundamental change in mindsets is treated as a driving force for achieving the country's transformation. Confidence, commitment and empowering cultural values are the mindsets expected to drive the United Republic of Tanzania's transformation 'from a least developed country to a middle income country' (URT undated). The finer elements of these mindsets are:

a) development oriented culture of hard work and creativity
b) culture of saving and investment
c) developmental community spirit
d) broad human development strategy
e) a learning society
f) incentive system to reward excellence, creativity and innovation, and
g) education as a strategic change agent.

Assessment of implementation of priority policy goals

Most African countries exhibit weak implementation of existing policies and laws that promote sustainable development. Without resolving the implementation bottlenecks, it would be difficult to speed-up the attainment of the agreed upon priority environmental and health policy goals. Innovative policy and law making that ensure better embedding of ecosystem integrity and human health issues in national development strategies alone are insufficient. The objective of this section, therefore, is to highlight progress made in pursuit of some of the policy targets on which data is available and to draw upon experiences, especially from within Africa, to highlight implementation bottlenecks and use the lessons learned and good practices in proposing strategic actions to assist policy managers in:

a) knowing and navigating the complexities associated with policy implementation

b) taking actions to resolve implementation bottlenecks; and

c) replicating and scaling up good practices so as to speed up the implementation of priority environmental policy goals, including the MDGs that impact human health.

Policy implementation – a performance record

Progress towards policy goals

Figure 10.2 provides highlights on progress that sub-Saharan Africa has made in pursuit of some of the policy targets for which data was available to track progress. General lack of reliable time series data and the absence of specified targets for some of the selected policies made it difficult to portray progress achieved in implementing them.

Figure 10.2 illustrates progress achieved and is cross-referenced in the section below that examines the challenges of policy implementation. Africa's progress towards the poverty target remains slow, although recent economic growth performance and forecasted trends indicate that extreme poverty in Africa is expected to fall below 36 per cent (United Nations 2011). Given the intricate links between poverty, environment and health, prevalence of extreme poverty will continue to complicate the attainment of the environment and health policy goals. Reliable data is unavailable to enable determination of the extent to which Africa's slow pace towards achieving positive net change in forested areas has occurred beyond what obtained in the 1990-2000 period (Figure 10.2). High rates of deforestation and heavy dependence of the population on biomass fuel for energy contribute to both loss of vital forest ecosystem services and to health problems associated with indoor air pollution attendant to use of biomass fuel. Data was not readily available to gauge the extent to which initiatives such as Payment for Ecosystem Services (PES) and Reducing Emissions from Deforestation and Forest Degradation (REDD) and its derivative programmes – such as Reducing Emissions from Deforestation and Forest Degradation, Forest Conservation, Sustainable Management of Forests and Carbon Stock Enhancement (REDD+) – are contributing to achieving progress towards positive net change in forested areas in Africa.

Africa's progress towards halving the proportion of the population without sustainable access to safe drinking water has been commendable (Figure 10.2). Sub-Saharan Africa nearly doubled the number of people using an improved drinking water source from 252 million in 1990 to 492 million in 2008. Coverage also increased from 49 per cent in 1990 to 60 per cent in 2008 (United Nations 2011). Progress towards the target for access to improved sanitation is less impressive. Unlike North Africa where access increased from 72 per cent in in 1990 to 89 per cent in 2008, surpassing MDG target, that in sub-Saharan Africa only progressed from 28 per cent in 1990 to 31 per cent in 2008, way below the MDG target of 64 per cent.

Figure 10.2: Progress made in attaining selected policy targets

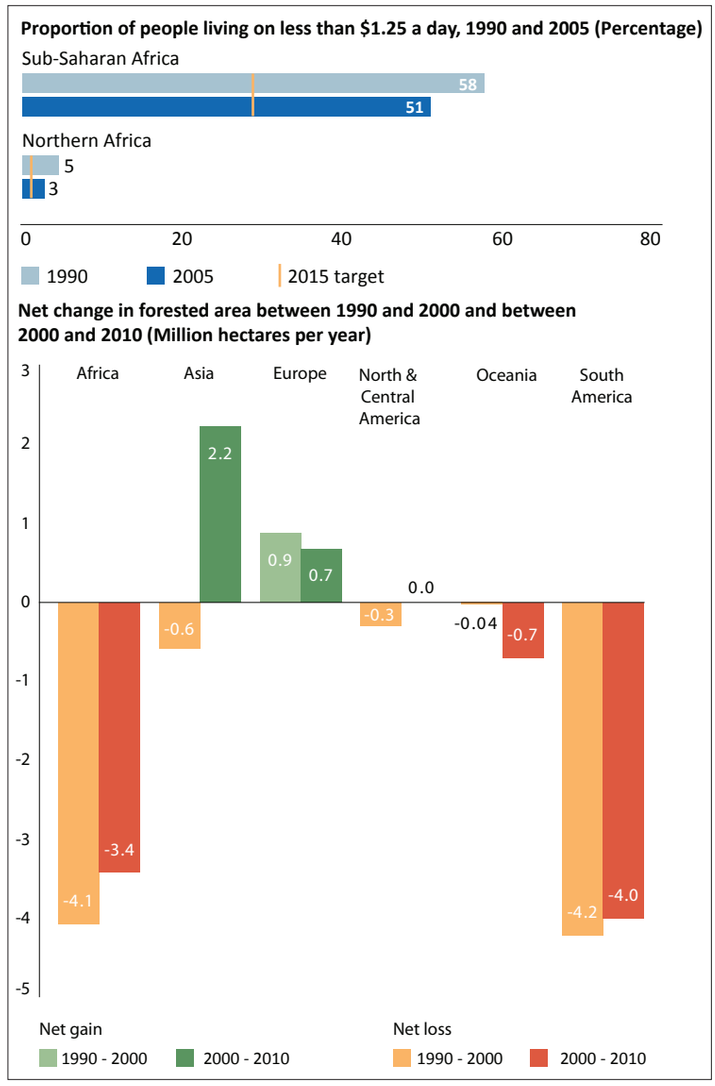
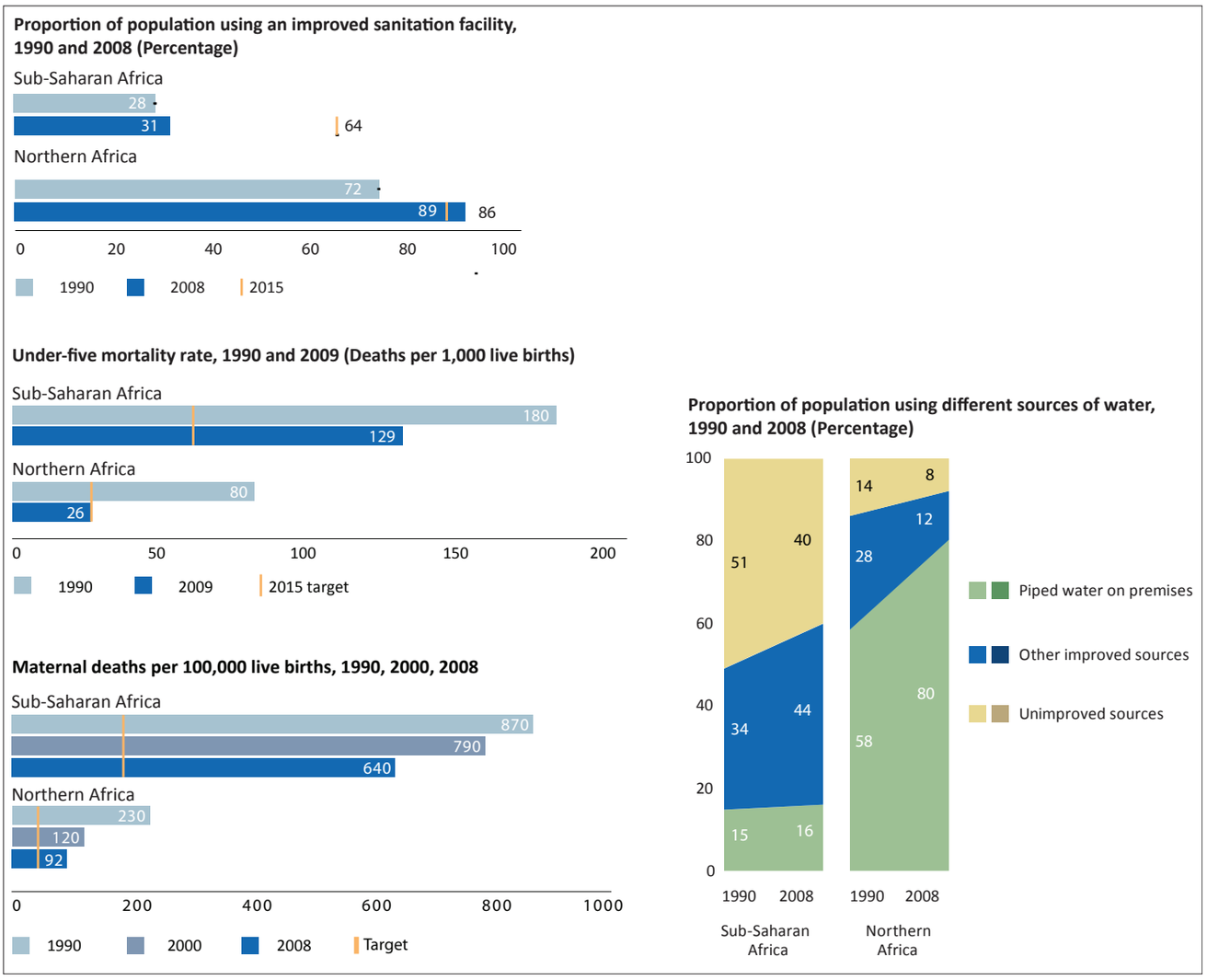


Figure 10.2: Progress made in attaining selected policy targets (continued)



Source: United Nations 2011

Slow progress in reducing poverty, reducing heavy dependence on biomass fuel, and improving access to both safe drinking water and improved sanitation partly contribute to Africa's slow progress towards reducing the rates of mortality of children under the age of five and maternal death as depicted in Figure 10.2. In the section below, examples are given of some good practices that African countries have adopted to accelerate progress towards forest, water and sanitation policy targets. Basic implementation challenges that seem to contribute to the slow progress towards achieving the policy targets in Africa are also examined.

Challenges in policy implementation

Distinguishing policy formulation from policy implementation

This is essential in order to avoid the common, but tenuous, assumption that putting good policies in place will guarantee their automatic flow into successful ground-level implementation (Spratt 2009). Table 10.3 provides an illustrative example of the differences in policy formulation and implementation. Although the illustration is based on USAID's field experiences in implementing health policies in China, Indonesia and Vietnam, it is considered to be relevant to Africa.

Table 10.3: Difference in policy formulation and policy implementation

	Policy formulation	Policy implementation
1	Primary responsibility of national government and their departments/ ministries.	Primary responsibility of provincial governments and their departments.
2	Focus of policy is all encompassing, all inclusive and broad.	Focus on specificity, mechanisms of operationalization, decentralized planning.
3	Concentrated within a small-group of high-level ministries and departments with inputs from different stakeholders.	Going to scale – often nationally – requires coordination with many stakeholders, government departments at many levels, NGOs and CBOs.
4	Maximum efforts on drafting, role of editing committee very important.	No role for either drafting or editing committees; effective programme planners and managers needed.
5	Action is at the highest levels of power and decision making.	Actions are at the decentralized levels such as provinces, districts. Municipalities and communities.
6	Does not require phasing or pilot testing.	Needs phasing, pilot models.
7	Does not need to focus on management mechanisms and processes.	Important roles of capacity building coordination, public opinion, supervision, monitoring and review mechanisms.
8	Major roles for the justice department and law professionals.	Does not require major participation of the justice department.
9	Clear guidelines in existence in terms of steps required to develop a new policy.	No guidelines or steps on how to translate policies into practice.
10	Is on paper.	Touches the lives of millions of people.

Source: Spratt 2009

The experiences from China, Indonesia and Vietnam indicate the need to pay special attention to four core circumstances related to the actors, which jointly contribute to policy implementation. These are: actors' levels of motivation; actors' access to and use of information on the policy; power dynamics among actors involved in policy implementation; and the different forms of interactions among the actors, which include cooperation, opposition and joint learning (Spratt 2009).

Managing stakeholder influences

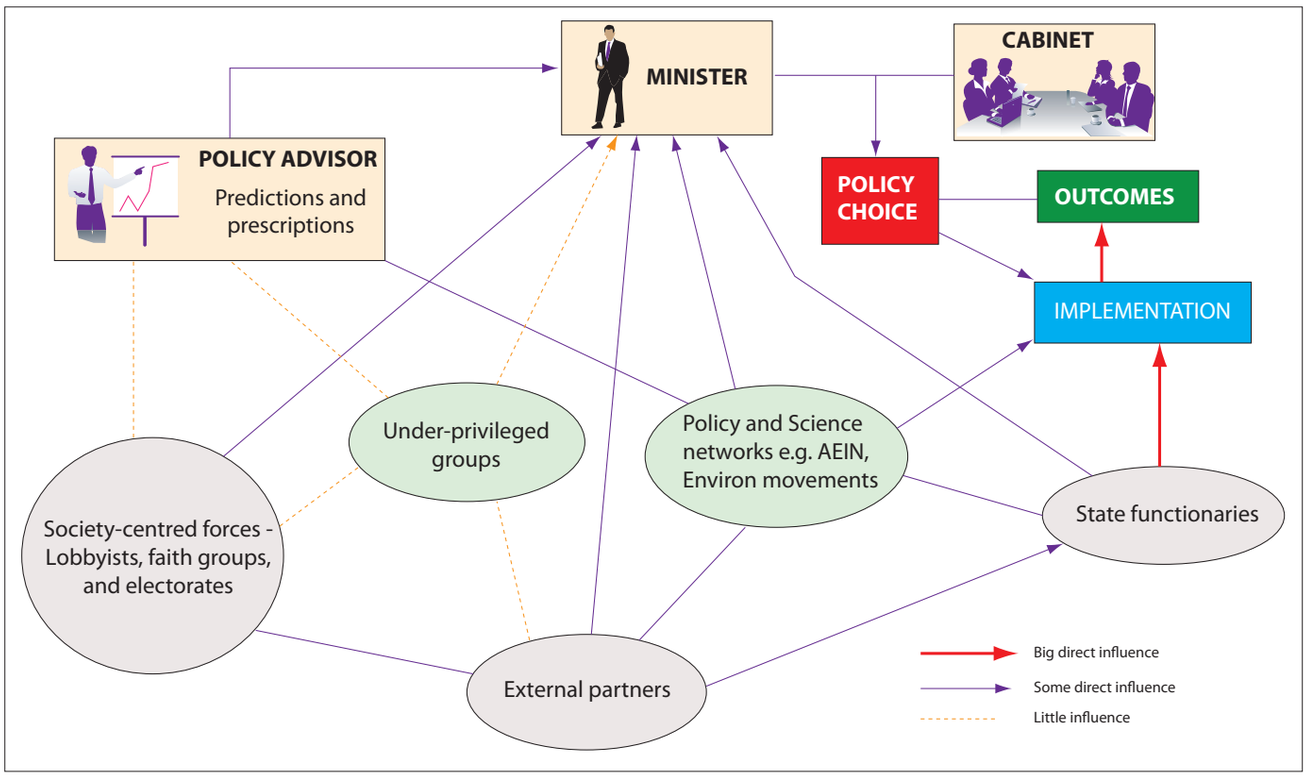
Elements of policy implementation mentioned in rows 3, 5 and 7 of Table 10.3 highlight issues of coordination, public opinion and review mechanisms. These issues are about keeping watch on stakeholder influences, many of which are usually carried over from policy formulation. While some stakeholder influences generate benefits for policy implementation, others yield barriers, which if left unchecked can derail policy implementation.

Often, efforts at policy implementation are pursued without taking due account of some of the policy formulation features that remain relevant in the implementation stage. Although the main responsibility for policy implementation

Ghana Asantahene: An influential stakeholder

Retlaw Snellac / Foter / CC BY

Figure 10.3: Policy implementation: Interface between policy making and policy outcome



Source: Developed by Joseph Opio-Odongo for this publication

rests with government agencies, the attainment of policy goals partly depends on how the other relevant stakeholders, especially those at the decentralized level, perceive and respond to policy implementation.

Figure 10.3 depicts implementation as an interface between policy formulation and policy outcome. It also shows the various stakeholders whose interests may influence decision making at both national and decentralized levels during policy implementation. Actions by these stakeholders could represent either benefits or barriers to the implementation process. Barriers analysis can help in early detection of barriers and the pertinent actions that need to be taken in order to keep implementation on course (Spratt 2009).

Figure 10.3 is inspired by the Contextual Interaction Theory (CIT). Its basic assumption is that the course and outcome of the policy process depends not only on inputs (namely; the characteristics of policy instruments), but more crucially on the characteristics of the actors involved, particularly their motivation, information and power. It considers the strategic interactions between implementers and target groups over time to be crucial in determining policy outcomes (Bressers 2004; O'Toole 2004).

Until very recently, environment and health agencies of governments in Africa tended to insufficiently engage other relevant stakeholders in policy implementation. Yet, without sufficient awareness among stakeholders on the policy agenda and the nurturing of requisite changes in their attitudes, perceptions and behaviours, ownership of the policy, which drives implementation, can be unduly compromised. Convincing the other relevant stakeholders that the policy is important, desirable and worthy of pursuit usually spurs them into actively engaging in implementation (Jones 2011). Active engagement of national and sub-national policy champions in managing the implementation tasks is particularly good for success. Champions include influential individuals and agencies capable of spurring actions, building alliances and promoting

Table 10.4: Budgets for water supply, sanitation and hygiene (WASH): Progress towards meeting the eThekwini Commitments

Country	WASH as per centage of government budget	Annual children diarrhoea deaths (UNICEF)	Population (million) [World Bank]	Child Mortality Rate (CMR) [UNICEF]
Central Africa				
Angola	1.65 (2010)	36 900	18	220/1 000
Central African Republic	0.996 (2010)	3 400	4.3	173/1 000
Eastern Africa				
Kenya	3.37 (2010)	28 900	38.8	128/1 000
Rwanda	2 (2010)	9 000	9.7	112/1 000
United Republic of Tanzania	2.46 (2010)	22 500	42.5	104/1 000
Southern Africa				
Lesotho	5.15 (2010)	100	2	79/1 000
Malawi	1.01 (2010)	10 300	14.8	100/1 000
Zambia	2.59 (2010)	11 700	12.6	148/1 000
Western Africa				
Burkina Faso	8.92 (2010)	22 600	15.2	169/1 000
Ghana	1.76 (2010)	5 700	23.4	76/1 000
Liberia	0.502 (2010	2 900	3.8	145/1 000
Mali	1.71 (2010)	18 000	12.7	194/1 000
Niger	4.23 (2010)	25 800	14.7	167/1 000
Nigeria	2.06 (2010)	145 000	151	186/1 000
Sierra Leone	3.4 (2010)	8 900	5.6	194/1 000

Source: Compiled by authors from information available at WASHwatch.org

alignment in the implementation process. Rwanda provides a good practice example of stakeholder engagement and use of policy champions in the development and implementation of policies.

Funds for implementation

Insufficient budgetary allocations for implementing environmental or health policies and programmes (which average about 2 per cent of national budgets) remain a perennial problem in Africa. Over dependency on external support is ubiquitous and tends to compromise ownership and leadership of policy implementation. Accordingly, the African Ministers of Environment and of Health declared their intention to achieve a balance in the allocation of national budgetary resources for intersectoral health-and-environment programmes in the 2008 Libreville Declaration. Through the eThekwini Declaration and Action Plan (2008), they also proposed an 'aspirational' allocation of at least 0.5 per cent of Gross Domestic Product (GDP) for sanitation and hygiene (WSP 2008).

Table 10.4 illustrates progress made by African countries towards meeting the eThekwini Commitments as of 2010. Of the 15 countries for which data was available, it is clear that overall progress has been slow, yet annual child infant mortality rates due to diarrhoea remain high with

Box 10.1: From intention to action (from PRSP to PRSC) - Ghana

With regard to water supply and sanitation, the Poverty Reduction Support Credit (PRSC) policy objective is to increase access for rural and small-town populations. For PRSC III (the third Credit in support of the PRSP) the following main objectives are identified:

- Begin implementation of a cabinet-approved comprehensive sector policy
- Carry out hydro-geological database mapping for better targeting of investments
- Support deprived districts in preparing water and sanitation plans to guide investors.

The outcome of these efforts was expected to increase access to safe water to 55 per cent and access to proper sanitation to 28 per cent by 2006. The PRSC emphasizes the importance of increasing sector investments in water supply and sanitation, along with improved sectoral planning and coordination in the water sector.

Source: Kishore 2006

Ghana and Lesotho being the notable exceptions. Because factors other than unsafe water and poor sanitation contribute to child mortality, it is not surprising that even countries that have increased budgetary allocation to water supply, sanitation and hygiene (WASH) also experience high child mortality rates.

In African countries where the Poverty Reduction Strategies (PRSs) define priorities and targets, mainstreaming environment and health issues in them or in national development plans is done to secure budgetary allocations (Kishore 2006). In the majority of African countries, reasonably good attention is given to sanitation in the PRSs (WSP 2011a). The Eastern African countries, for instance, Ethiopia, Kenya, Rwanda, Uganda and Tanzania had by 2010 mainstreamed sanitation into their Poverty Reduction Strategy Papers (PRSPs) (WSP 2011b). However, in situations where mainstreaming is achieved, failure to lobby and negotiate during the budget process for purposes of ensuring that the allocations duly reflect commitment, makes mainstreaming a theoretical exercise. Ghana provides a good practice case on necessary follow-through actions. Its Poverty Reduction Support Credit enabled the PRS to provide requisite resources for practical mainstreaming of environmental health issues that had safeguards for ensuring equitable delivery of services. This case is illustrated in Box 10.1. Specifying time-bound budgeted investments to facilitate resource mobilization is also a good practice case. Table 10.5 indicates African countries that mainstreamed environmental health in the PRSs and also specified time-bound budgeted investments.

Public-Private Partnerships (PPPs) have been used as an alternative window for securing additional funds for implementing programmes that improve ecosystem integrity and human health. Use of the PPP modality is intended to avoid the potential pitfalls of full privatization of environmental and health services; while utilizing new technology and expertise, sharing risks and gaining access to increased capital to improve operating efficiency, all of which ultimately make the sector more responsive to consumer demands. Essentially, PPPs are a combination of public need with private

Boy pumping water in Ghana

Energy for All 2030 / Flickr / CC BY NC SA 2.0

Table 10.5: Countries that mainstreamed environmental health in PRSs and those that specified time-bound budgeted investments

Responses and their links	Environmental management capacity	Countries with time-bound costed investments
Water supply programmes are tied to waterborne diseases (all are direct responses)		
Construct water infrastructure (piped water, boreholes, wells, tube wells, rainwater harvesting, water storage and dykes)	Djibouti, Ghana, Malawi, Zambia	Chad, Djibouti, Ghana, Malawi, Senegal and Zambia
Rehabilitate water facilities (piped water, boreholes, wells, tube wells, rainwater harvesting, water storage and dykes)	Djibouti, Ghana, Malawi, Zambia	Chad, Djibouti, Ghana, Malawi, Senegal and Zambia
Extend water supply	Chad, Djibouti, Ghana, Malawi, Senegal and Zambia	Chad, Djibouti, Ghana, Malawi, Senegal and Zambia
Promote management (community based or through local municipal authorities) of water facilities	Djibouti, Ghana, Malawi, Zambia	Ghana
Improve water conservation and management	Djibouti, Malawi and Zambia	Djibouti, Ghana and Zambia
Expand wastewater management	Djibouti, Ghana and Zambia	Chad, Djibouti, Ghana and Zambia
Sanitation programmes are tied to waterborne diseases (all are direct responses)		
Introduction of latrines	Ghana, Malawi	Ghana
Introduction of other rural water sanitation technologies (sanitary drainage services such as closed pit latrine)	Djibouti, Ghana, Malawi	Ghana
Outreach programmes for awareness raising	Ghana, Malawi	Ghana
Sewage and waste management	Djibouti, Ghana and Zambia	Djibouti, Ghana and Zambia
Responses to vector-borne diseases, especially malaria are identified (all are direct responses)		
Outreach, preventive interventions and programs (focusing on drainage of water, covering vessels with water)	Djibouti, Ghana, Malawi and Zambia	Chad, Djibouti and Ghana
Distribution of mosquito nets	Djibouti, Ghana and Malawi	Chad and Ghana

Source: Extracted from Kishore 2006

capability and resources to create a market opportunity through which the public need is met and a profit is made (Heilman and Johnston 1992; UNECA 2005).

The PPP collaborations can be with small-scale independent providers, non-governmental organizations (NGOs) or the private sector. And in most instances, the PPP arrangements are service or sector specific (UNECA 2005). A review under the auspices of the South African Institute for International Affairs revealed that PPP success depended on (Farlam 2005):

a) thorough planning
b) good communication
c) strong commitments from both parties and effective monitoring
d) regulation; and
e) enforcement by government.

Ghana, Lesotho and Senegal have successfully applied the PPPs to accelerate delivery of water and sanitation services. A good practice case from Ghana is depicted in Box 10.2.

Box 10.2: PPP good practice in expanding rural water supply – Ghana

In the mid-1980s, the government of the Republic of Ghana realized that the water situation was unsustainable and increased the water tariff tenfold. A stakeholder group was established to adopt best practices associated with the International Drinking Water Supply Decade (1981-1990). The result was a draft sector strategy, which was discussed and refined with line ministries, local governments and the private sector. Once the national policy for rural water supply, sanitation and hygiene education was finalized, it was implemented as a pilot project in the Volta region. It was then scaled up as the First Community Water and Sanitation Project (CWAP-1), a $20 million World Bank supported programme. The Community Water and Sanitation Agency (CWSA) was created in stages. The functions related to rural community water supply was placed in a separate division, facilitating better monitoring of donor grants. Later in 1998, the division was made into an independent agency, whose main tasks were coordination and facilitation (not implementation) of community managed water supply.

At the same time CWSA was created, the government devolved certain responsibilities to districts and communities. The district assemblies became responsible for processing and prioritizing community applications for water supply, awarding contracts for hand-dug wells and latrine construction, and running a latrine subsidy programme. The final element of the strategy was an unprecedented private sector provision of goods and services covering borehole drilling, operations and maintenance, latrine construction and community mobilization.

By 2000, the reform was complete and CWSA had settled into the role of helping the district assemblies implement a national community water and sanitation programme. CWSA formulates strategies, standards and guidelines for the sector, coordinates the work of NGOs and donors and encourages private sector participation in water and sanitation activities. The communities have primary responsibilities for managing their water and sanitation services while small-scale private sector firms take care of repairs and spare parts.

The national government played a crucial role in developing policy but is not involved in implementation. The Ministry of Works and Housing (the parent ministry of CWSA) sets the overall policy for the sector, while the Ministry of Local Government and Rural Development supports the district assemblies and line ministries.

Main outcomes

- Coverage in rural water and sanitation was extended at a rate of 200,000 people (over 1 per cent of the population) per year and accelerating
- CWSA is fully established and functioning with the active support of several bilateral and multilateral agencies
- Attaining the MDG target of 68 per cent rural water supply coverage by 2015 looks feasible as the percentage coverage of rural water was 30 per cent in 1980, 35 per cent in 1990 and increased to 41 per cent in 2000.

Key factors for success

- Strong political leadership
- Clear legislation
- CWSA's commitment and leadership in supporting devolution of decision making to local governments to implement their mandate.

Lessons learnt

- Demand-driven approaches work since communities are capable of making decisions, maintaining services and making their contributions to capital costs, operations and maintenance
- A strong and well-structured information campaign is necessary to empower communities to make an informed choice
- Support to communities is needed, particularly in the form of financial management training in order for the elected boards to continue overseeing facilities on behalf of communities
- The CWSA and the districts should provide guidance on such things as tariff setting, service upgrading to house connection, additional point source facilities – tasks in which private sector involvement is fundamental.

Sources: UNEP 2009; UNEP 2006b

Institutional and technical innovations

Successful implementation may require innovative approaches. Institutional innovations such as modification of existing organizational designs, structures, operational procedures or creation of new ones may become necessary in order to take sufficient account of prevailing or changed circumstances. However, some government functionaries may decide to resist the desired institutional innovation for a variety of reasons. Unless the policy champions and management address such fears, those individuals may resist new policy or proposed institutional reform to frustrate the innovation. Yet, without that institutional change, policy implementation may become cumbersome or compromised. Indeed, the establishment of semi-autonomous agencies to oversee environmental services and to manage water and sewerages utilities in Africa exemplifies such innovations. The establishment of the Community Water and Sanitation Agency (CWSA) in Ghana under the PPP modality (Box 10.2) is a good practice example. Additionally, Box 10.3 provides a good practice case from Mali aimed at enhancing implementation of the revised forestry law.

The Mali experience demonstrates that successful conservation certainly augurs well for the integrity of the forest ecosystem and the provision of forest ecosystem services that benefit human health.

According to Edoho and Dibie (2000), decisions on whether or not to establish new institutional mechanisms or modify existing ones can be informed by answers to the following questions:

- Should existing ministerial departments or bureaus implement the policy?
- Should the policy programmes be distributed among various departments?
- Should a new institutional mechanism be established specifically to implement the policy?

Box 10.3: Good practice: Adjusting organizational operations for policy success – Mali

Mali's Forestry Department, with USAID's analytical assistance, examined the fit between its existing structures and procedures and the implementation requirements of a revised forestry law that mandated resource management in cooperation with local communities. The analysis led to changes in the department's operations; forestry agents moved from policing towards assisting communities to achieve a sustained balance between tree cutting and conservation.

Source: USAID 2001

- Under what institutional mechanisms would the policy achieve its stated goals?

Answers to these questions are important because of the cross-sectoral nature of environment and health, which necessitates the participation of other relevant ministries if policy implementation is to be effective. That, of course, is influenced by the quality of inter-sectoral coordination, which is a main feature of policy implementation. Indeed, inter-sectoral coordination is underscored by the Ouagadougou Declaration on Primary Health Care (2008). In practice, however, existing coordination has tended to occur only in the context of sectoral specialization, with distinct responsible ministries working in 'silos' with little communication between agencies (PEP 2008). This is usually replicated at the decentralized levels. Lack of staff commitment to coordination and inter-sectoral collaboration is exacerbated by absence of directives within relevant institutions that compel staff to seriously take account of the cross-sectoral dimensions of their work (Lvovsky 2001).

Box 10.4 offers another illustrative example of how a combination of institutional and technical innovations was applied by the Government of Kenya to enhance the conservation and sustainable use of forests on the Aberdares Mountain Range.

Box 10.4: Good practice in co-management as an effective tool in forest conservation – Kenya

Introduction

The Aberdares are a volcanic mountain range and forms the easternmost wall of the Great Rift Valley in Central Kenya. The mountain range is an impressive landscape, with unusual vegetation, rugged terrain, streams and waterfalls, all constituting great scenic beauty. It is a vital water catchment area from where four out of Kenya's seven largest rivers originate. However, the Aberdares ecosystem suffered widespread exploitation and environmental degradation particularly during the period 1990-2000 through illegal logging, charcoal burning, agricultural encroachment, illegal production of cannabis sativa, forest fires, livestock grazing, quarries and landslides. There were also intense human-wildlife conflicts around the area. Between 1987 and 2000, there was a 30 per cent decrease in the forest cover of the Aberdares.

Reversing the situation

Without the forest cover, topography and climate of this conservation area, the region and indeed Kenya as a whole would not be endowed with the wildlife, industry (including agriculture) and water it currently enjoys. It is in this context that major activities had to be undertaken to conserve the forests on the mountain range and to promote sustainable development. In order to curb degradation of the Aberdares ecosystem, the government adopted a co-management approach with clear incentives for the communities. This was enabled by Kenya's decentralization policy and the Forests Act of 2005 that permits participatory forest management. The co-management approach was also underpinned by the provisions of the new Kenya Constitution focusing on environment and natural resources, the Forest Policy; and the Environmental Management and Coordination Act of 1999. The establishment of the Kenya Forest Service (KFS) that replaced the Forest Department strengthened the institutional basis for stewardship over the mountain forest ecosystem. For purposes of minimizing human-wildlife conflicts and illegal activities in protected areas, a fence (management tool) was erected between local communities and the protected areas.

Impacts

The combination of the barrier that was erected and appropriate policy and institutional measures contributed to the following impacts:

- Increase in mountain forest cover from about 62 000 ha in 2005 to 74 800 ha in 2010
- A decrease of open areas by about 54 per cent from 9 259 ha to 4 223 ha
- An overall increase of the area under plantation forests by 47per cent between 2000 and 2010
- Continuing ecological succession in areas that were disturbed by human activities that will lead to increasing diversity and productivity as natural climax communities are restored
- Enhanced carbon sequestration due to improved vegetation cover thereby enhancing Kenya's contribution to mitigation of global warming
- Wildlife populations appear to have increased due to reduced poaching as a result of the fence
- Social benefits manifested in reduced human-wildlife conflicts, improved food security and incomes.

Sources: Lambrechts and others 2003; BCS 2011; and UNEP 2006a

Improved integrity of the Aberdare forest ecosystem and regenerated capacity of the watershed to supply water to meet human and other end uses were the main outcomes of this good practice case.

The lessons learnt from the successful approach to co-management of the forest on Aberdares Mountain range include:

- Active involvement and engagement of the community as a form of

government-community partnership in co-management.

- Innovative policy and institutional arrangements that facilitated implementation of the co-management approach – the decentralization policy, the Forests Act 2005 and the establishment of both the Kenya Forest Service and the Kenya Forest Board were instrumental in this regard.
- Erection of a physical barrier was an effective tool for preventing human-wildlife conflicts and reaping both conservation and livelihood benefits.
- Adequate integration of science, economics and policy in ensuring that the co-management approach contributed to effective ecosystems management.

Coordination

The tradition of sector based planning and budgeting has tended to contribute little to coordinated actions among government agencies. Yet given the cross-sectoral nature of both environment and health, coordination is key to successful policy implementation. As a means of improving coordination, some African countries have introduced Health and Environment Sector-Wide Programes (SWAps). Although the implementation of the SWAps is gradually improving interactions between governments and donors, available evidence indicates that interventions in the health sector, for instance, have not been sufficiently coordinated with those in other relevant sectors. However, there are indications of progress towards wider stakeholder participation in health sector processes in some of the countries. Malawi, Mozambique and Tanzania provide good practice examples of where the SWAps are involving civil society in technical working groups, inviting civil society to annual reviews, and involving civil society in the sector coordination process, respectively (Walford 2007).

Strategic management

This is a dimension of policy implementation that is receiving insufficient attention in Africa. Notable exceptions are the ministries that practice strategic management in forms of management for results or results-based management. Essentially, strategic management entails three vital actions that benefit implementation:

a) looking inward on the suitability of internal structures and resources for achieving policy goals
b) looking outwards at the implications of the external environment (context of implementation) in terms of opportunities and challenges for staying the course with, or accelerating, policy implementation; and
c) looking forward in terms of deliberate combination of strategy, structure and resources and suitable coordination modalities in order to achieve policy goals.

By looking outwards, national policy implementers build capacities by extending their implementation horizons beyond the boundaries of the Ministry of Health or the Ministry of Environment. They come to know key stakeholders in other relevant ministries and agencies; create opportunities for their participation in implementation; forge partnerships with them; set feasible objectives; build constituencies for managing change; and institute conflict resolution mechanisms to ensure smooth policy implementation. By looking inwards, policy implementers judge the extent to which internal structures, systems and procedures remain relevant and supportive of policy goals. In looking forward, policy implementers bring together strategy, structure and resources in order to accomplish policy outcomes in an anticipatory and proactive manner. To that end, horizontal and vertical partnerships across and between local and state levels as well as with NGOs and the private sector are nurtured (USAID 2001). Rwanda's Environment Sub-sector Strategic Plan (2010-2015) illustrates such strategic positioning

Box 10.5: Good practice case for strategic positioning – Rwanda

The strategy has been elaborated at a time when Rwanda, like many other countries in sub-Saharan Africa, is at a crossroads – of transiting from poor to middle income countries, through the challenges of globalization, in particular, competitiveness and climate change. As a country whose population largely depends on the provisioning of natural ecosystems, restoring the ecosystems damaged by many decades of misrule and the increasing population pressure is an important prerequisite for poverty reduction. It also needs to be appreciated that as a custodian of sensitive transboundary environmental resources, such as the Nile and Lake Victoria basin, the mountain gorilla and other endangered species in the Albertine rift eco-region, Rwanda's pursuit of an environmentally sustainable development agenda will have a major impact on regional and international development.

Source: Republic of Rwanda 2010

and is a good practice case (Box 10.5).

If the agenda outlined in Box 10.5 is achieved, there are likely to be environment and health benefits for the population that is dependent on water from the Nile and Lake Victoria basins. Knowledge of changing domestic and external environment, as outlined before is crucial for appropriate repositioning to enable the attainment of expected policy outcomes.

Factors that tend to obviate inter-sectoral and inter-disciplinary actions include: neglecting or overlooking changing domestic and external situations that are relevant to policy implementation, working in departmental silos, engaging in turf battles, hiding essential information from stakeholders with similar goals and shunning stakeholders in the private and voluntary sectors, ostensibly to achieve governmental wholesomeness in policy delivery.

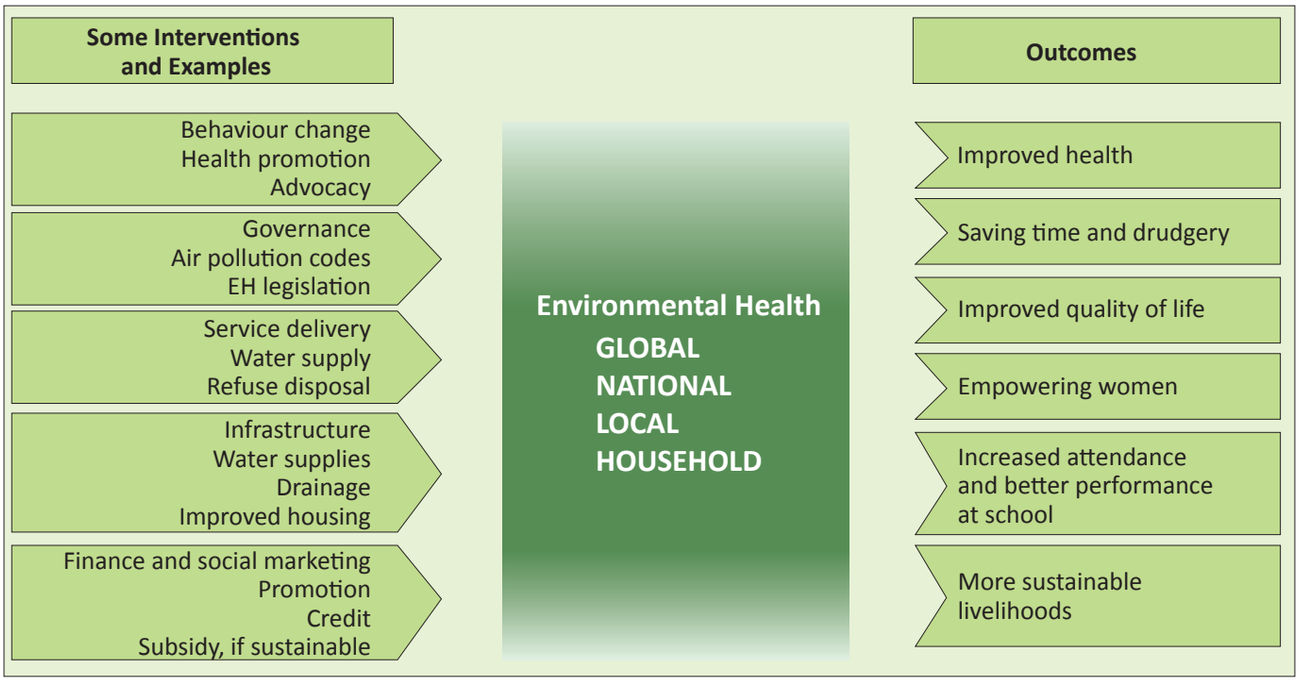
Defining and pursuing health outcomes

Various human health outcomes may be sought in implementing environmental policies (inputs). Good policies would explicitly define the expected outcomes. Keeping outcomes ambiguous complicates implementation. Among the intermediary outcomes usually pursued are changes in the attitudes and behaviours of those exposed to environmental health hazards and of those with local and national jurisdiction to plan for and allocate requisite resources in responding to the hazards. Ultimate outcomes may include improved human health, improved quality of life and more sustainable livelihoods. These inputs and outcomes are depicted in Figure 10.4.

Attainment of these ultimate outcomes could be compromised by a tendency to become complacent when some output targets are accomplished. Knowing the extent to which such outputs contribute to the attainment of ultimate outcomes (as defined by policy) is a good policy management practice. Monitoring impact or setting up and using systems to monitor progress in implementation, is a key policy implementation task. Monitoring systems alert decision makers to implementation snags and inform them on the intended and unintended impacts of the implementation efforts (USAID 2001). It is, however, important that views of primary stakeholders, particularly those vulnerable to environmental health hazards, are sought in developing and applying the monitoring mechanisms.

In measuring progress in implementing environmental policies and programmes for improving human health, systematic efforts should be made to monitor both exposures to environmental health risk, as well as health improvements. However, in most African countries, environmental and health monitoring mechanisms are weak. So are the health surveillance systems that need further enhancement and inclusion of exposure monitoring data. Furthermore, measurable and appropriate indicators are often not tracked. Although national household surveys are a key source of needed data, they often ask few questions on environment-related issues (PEP

Figure 10.4: Multiple inputs and outcomes in environmental health



Source: Cairncross and others 2003

2008). A number of African countries, however, do monitor and report on progress towards attaining the MDG targets in their fulfillment of the obligations made at the UN Millennium Summit.

Recently the African Ministers of Environment and of Health declared the need for setting national monitoring and evaluation mechanisms for assessing performance on policy implementation. However, according to Shyamsundar (2002), in any given country context, the measurement system to monitor environmental and health outcomes is dependent upon:

a) data availability
b) cost and ease of measurement and monitoring
c) stakeholder perception of what is important to monitor and acceptance of indicators, and
d) the final purpose for which the information is used.

Application of collective actions

Some of the policy goals detailed in Table 10.1 require collective actions by affected countries if implementation is to succeed. A case in point is the management of transboundary natural resources. In the case of access to water, the entire African territory lies within international river basins, with each of the 50 international river basins in Africa being shared by two or more countries. Unless riparian countries cooperate, inadequate demand management could result in compromising some of the water end uses such as those for agricultural production, human consumption, energy production and ecosystem integrity. International evidence indicates that while technical know-how and innovations of the managers of international river systems are important, success appears to hinge primarily on political processes in which institutional arrangements are designed and implemented (Bernauer 2002). The Southern African Development Community (SADC), through implementing the protocol on shared watercourses, provides a good practice case of evolving collective actions among riparian countries by applying the integrated water resources management (IWRM) concept (UNECA 2004).

A number of intra-Africa legislative instruments for ensuring ecosystem integrity and human

Box 10.6: The Montreal Protocol: Exemplary success in MEA implementation

A. Introduction

The Montreal Protocol on Substances that Deplete the Ozone Layer, adopted in 1987, is an exemplary success of a Multilateral Environmental Agreement (MEA) implemented in response to a major global environmental threat. While success is couched in terms of attained phase-out targets for the various categories of ozone depleting substances (ODS), that success benefitted from the suitability of the Vienna Convention for the Protection of the Ozone Layer that provided the essential framework for negotiating those targets.

B. Global achievements

Seven global achievements are noteworthy:

a) An unprecedented universal MEA ratification (2009) in the history of the United Nations

b) 98 per cent of all chemicals controlled by the Protocol were phased out by 2009

c) healing the ozone layer, with anticipated return to pre-1980 levels is expected by the middle of this century

d) supporting developing countries through the Multilateral Fund to phase out ozone depleting substances

e) 98 per cent compliance by most developing and developed countries, enabling achievement of phase-out targets well ahead of schedule

f) health benefits accruing from the controls under the Protocol contributed to avoiding millions of cases of fatal skin cancer, and other millions of cases of non-fatal skin cancer and cataracts, and

g) substantial climate change benefits accrued to society from reductions in the consumption of ozone depleting substances which contribute to global warming.

C. Africa case

Over 80 per cent of African countries have signed the Protocol. Almost all these African country signatories have met the first crucial target of freezing the national consumption of CFCs and two-thirds are well beyond compliance. Various factors account for these achievements.

- African countries have been able to utilize the Multilateral Fund for capacity-building
- Transfers of technologies and use of technical assistance have been well planned and adequately executed Efficient replacements and alternatives for ODS and ODS-using equipment are now available
- Industries have sufficiently engaged and cooperated in the efforts to reduce the use of ODS through the transfer of technologies, particularly in the aerosol, foam, fire extinguishing, refrigeration and metal cleansing sectors
- Cooperation, dialogue and alignment by stakeholders, both locally and abroad, have facilitated compliance with the Protocol
- The sharing of experiences through regional networks, training and partnerships within Africa and with other continents has been invaluable in empowering stakeholders in their pursuit of the agreed upon phase out targets
- Fundamentally, the creation of completely new set of national laws, policies and plans, as well as new institutions has enhanced the implementation of the Protocol. Special mention is made of the National Ozone Unit (NOU) in each country, which has championed the implementation process. The NOU technical personnel have raised awareness of ozone depleting substances, made the case for the Protocol's provisions in terms of expected benefits and the necessary and immediate legislative actions that governments are to take if anticipated positive impacts are to be achieved.

Sources: Lambrechts and others 2003; BCS 2011; and UNEP 2006a

health also depend on collective actions for their enforcement. A case in point is the Bamako Convention (1991) that bans the import of hazardous wastes into Africa and controls Transboundary Movement and Management of Hazardous Wastes within Africa. Lack of effective collective actions, however, seems responsible for its weak implementation and this is of concern to African Ministers of Environment and of Health. Its first Conference of Parties (COP) has not yet been held so many years after it came into force.

Domestication of regional and global policy and legislative instruments

Some policy instruments require domestication and appropriate institutional mechanisms for national implementation. Unlike the relatively dismal performance of African countries in implementing the various conventions and protocols, their performance on the Montreal Protocol has been relatively impressive and provides a good practice case and is highlighted in Box 10.6.

Diverse experiences are available across Africa on this issue. The diversity is due to variations in the:

- pace of national legislative processes for domestication
- scope of subsidiary policies and legislation
- strategies for resource mobilization
- establishment of institutional mechanisms for implementation, and
- availability of relevant guidelines and regulations at the decentralized levels.

The observed relative performances of Morocco, Nigeria, South Africa and Tanzania in the implementation of sound chemicals management (UNECA undated) reflect the initial state of preparedness and the institutional capacity for implementation in these countries.

Reasons for relative success of the implementation of the Montreal Protocol

1. Scientific and technical underpinning championed by scientific, environmental, technical and economic assessment panels that produced comprehensive policy relevant reports every four years to enable parties to review, adjust and amend control measures on the basis of strong evidence. The 'adjustment' provision within the Protocol enabled Parties to respond to new and emerging scientific discoveries without engaging in lengthy formal processes of national ratification.
2. Control of chemicals, whereby all Parties agreed to extend control to all countries due to the global nature of the problem of ozone depletion. They further agreed to control both production and consumption thus capping both the level of production and the quantity of the substances that actually remained in the country each year (whether such substances were used or not).
3. Flexibility of implementation, whereby countries agreed to meet specific numerical reduction targets within agreed timeframes, but, crucially, without the encumbrances of laid down rules on how those reductions were to be achieved.
4. Trade controls were a major feature of the Protocol, which obligated Parties to avoid trading in ozone depleting substances even with non-parties.
5. Participation of developing countries along the principle of common but differentiated responsibility. As a result, developing countries enjoyed special provisions, including those on financial and technical assistance as well as a 10-15 year grace period in complying with the

control provisions applicable to developed countries.

6. Compliance regime that is robust, supportive and with a clear reporting framework. Each Party is required to report annually on its production, import and export of the substances it has committed to address. The Protocol also included a mechanism for dealing with non-compliance (Article 8).
7. Promotion of consensus such that all decisions under the Protocol have been adopted on the basis of a consensus.

Lessons learned from the implementation of the Montreal Protocol that can ensure the success of other MEAs

- A strong science-base and legal framework provide sound bases for control actions. The strong evidence base also promotes the sharing of common purpose and the application of collective actions by governments, industry and environmental groups in pursuit of agreed upon targets
- Innovative, dynamic and flexible implementation mechanisms, with built-in provisions for adaptive management, facilitate implementation
- Measurable targets enable effective tracking of progress and evaluating success
- Strategic management make it possible to push the boundaries of engagement to involve even the competitive forces thereby spurring competition, entrepreneurship, innovation, collective action and even motivation for self-compliance with agreed upon actions
- Information and technology exchange foster adoption and application of alternative technologies
- A system of incentives for compliance, including funding for less developed countries is important for improving compliance.

Transformative changes necessary for enhancing policy implementation

This section focuses on transformative changes that would enable African countries to accelerate the attainment of agreed upon environment and health policy goals. In defining the options, the section builds upon thematic assessments, the scenario analysis and assessment of the policy implementation record. The focus is on challenges, which if adequately addressed, would yield high-impact human health benefits. In addition, options for transformative change that cut across themes are also proposed. For each of the challenges, an attempt is made to define the spread effects of the proposed option for transformative change, expected benefits and the factors that could either accelerate or impair uptake. All these are outlined in Table 10.6.

Cross-cutting options for transformative changes

- **Sustaining investments in assessing and monitoring the links between environment and health, so that the results and pertinent recommendations inform policy-making, planning, budgeting and investments for improved environmental quality and human health.** Sector, national and sub-national assessments would be worthwhile undertakings. The assessments could also reveal essential links such as that between epidemics, livelihoods and the policy process. Leach and others (2007), for instance, indicate that 'changing patterns in land use, interactions between humans, livestock and wildlife and new patterns of social behaviour have seen the emergence of a series of new infectious diseases that now threaten to reverse post-war progress

Table 10.6: Thematic options for transformative change

Themes	Challenges	Opportunities	Options for transformative change
Air quality	Reducing the heavy reliance by households on biomass energy in order to curb forest degradation, indoor air pollution and the attendant health risks	Continent-wide interest in promoting rural electrification and availability of alternative clean energy sources and services	Linking rural electrifications with rural transformation programmes, while providing smart subsidies to promote the uptake of modern energy services such as improved cook stoves, LPG and solar. This option, if effectively implemented, would have wider population coverage. Additional benefit would be curbing deforestation and land degradation. However, uptake requires adequate technical support services, enhanced rural incomes and favourable macro-economic environments.
Biodiversity	Altering management and governance systems for protected area management in order to curb biodiversity degradation and promote benefit sharing for populations whose livelihoods depend on protected areas.	CBNRM and Co-management models that can be strengthened to ensure sustainable management and better sharing of the accruing benefits.	Drawing upon good practices on CBNRM and similar models and ensuring that the policy and legislative environment is conducive to benefit sharing and scaling up of these models. Potential for widespread adoption is high and success would buttress self-enforcement of resource conservation policies and laws. However, the option may be less effective in situations where devolution policies and implementation arrangements are weak and contractual arrangements disadvantage the poor resource owners. Empowerment of local resource owners is therefore a basic prerequisite for success.
	Curbing bio-piracy and strengthening capacity to produce and benefit from pharmaceutical products derived from local biodiversity	Interest in relevant laws to curb bio-piracy and providing protection for indigenous bio-medicinal knowledge and technologies.	Accelerating ratification and domestication of relevant conventions and instituting national legal instruments that guard against bio-piracy. Empowering women and men who are the repository of indigenous bio-medical knowledge through, among for example, mechanisms for their systematic engagement with bio-medical scientists. Scale effectiveness of these options may be limited by the speed and domestication of relevant legislation, extent of national profiling of indigenous bio-medical knowledge and country-specific institutional mechanisms for coupling indigenous bio-medical knowledge with its modern scientific counterpart.
Chemicals and wastes	Strengthening the evidence base to inform the general public, industrialists and producers in the private sector and decision makers on the health risks of hazardous chemicals and wastes.	Recognition of the primacy of a sound evidence base in influencing attitudes, and behaviour and instituting litigation against offenders.	Strengthening the knowledge and evidence base on health risks of hazardous chemicals and wastes. This option has great potential for impact if investments in research and assessments are made to strengthen the evidence base. It has to be reinforced with appropriate information and communication techniques in order to reach the various target groups. Further, the interface between science and policy-making has to be strong. Inability to convince decision makers on why the investments in strengthening the evidence base matter and possible resistance and obfuscation by vested interests groups that benefit from clandestine trade in chemicals and wastes may be limiting factors .
	Empowering the population and other key stakeholders in understanding the health risks of chemicals and wastes	Available evidence on the health risks of hazardous chemicals and wastes and demand for such evidence by stakeholders.	Drawing upon available evidence on the health risks of hazardous chemicals and wastes, using appropriate media of communication to empower communities, local governments, ministries, civil society and the private sector. This option has great potential for rapid spread effects. However, multilingual situations in some countries may have cost implications that could slow down uptake. Countervailing propaganda by some interests groups, if strong, and lacklustre enforcement of pertinent legislations, could undermine uptake.
	Alignment of states efforts in ensuring concerted actions in curbing the transportation and dumping of hazardous wastes across Africa	General interest among member states in promoting regional cooperation and fostering regional self-reliance.	Accelerating the ratification and domestication of the Bamako Convention as well as development of pertinent action plans. This option is of potential moderate impact if the political impediments that have hitherto slowed down ratification and domestication of relevant conventions can be unlocked. Drawing upon lessons from the implementation of the Montreal protocol could benefit uptake.
		Africa Peer Review Mechanisms (APRM) that enhances learning and fostering the culture of accountability among member states	Using the APRM for learning and fostering collective actions and alignment of state efforts in curbing the transportation and dumping of hazardous wastes across Africa. The success of this option is dependent on the prospects of including environment and health as joint themes in the APRM. Notwithstanding the voluntary nature of the APRM, its present tempo could be seized to spur governments into enhanced implementation of the Bamako Convention. However, lacklustre handling of possible corrupt practices of law enforcers would undermine uptake.
Climate change and variability	Strengthening the information and knowledge base on nature of, vulnerability to, impact of, and mechanisms of adapting to climate change and variability.	Interests by both member countries and development partners in climate change related knowledge and information for crafting adaptive strategies and action plans.	Investing more in rigorous assessment and careful communication of the gravity of climate change and variability, highlighting health, economic and political costs of inaction and the expected returns on the investments. Through this option, well-communicated evidence is likely to impact greatly on planning and budgeting decisions at national levels given the climate-sensitive nature of many African economies. However, in-country capacities for economic and financial analysis may constrain spread and uptake of this option. Collation and wider-sharing of information and knowledge already in the public domain, possibly under the auspices of Climate for Development in Africa programme (ClimDev), could help in facilitating country-level uptake.
		Adaptive mechanisms such as climate proofing and Weather Indexed Insurance (WII).	Sharing experiences on the successes and challenges in: a) climate proofing of investments in climate-sensitive sectors such as agriculture and water; and b) Weather Indexed Insurance in agriculture. Potential spread effects of this option could be limited by available documented cases of weather-indexed insurance (Ethiopia and Malawi) and climate proofing of investments (Mozambique). Additional support from development partners, especially for capacity building for climate proofing of investments and operating weather-indexed insurance, would be beneficial.

Table 10.6: Thematic options for transformative change (cont.)

	Adequate preparedness and management of disasters due to extreme weather events (EWEs) and related health risks.	New technologies for enhancing surveillance and monitoring of weather events and health risks.	Strengthening preparedness and management capacities, especially of the SIDS, in responding to disasters due to EWEs. Developing the capacity for ICT application in monitoring the triggering of epidemics associated with climate change. This option has huge potential for impacts given interest among vulnerable countries in enhancing adaptive capacities and the demonstrated impetus for collective action. Strategic coupling of sub-regional (e.g. Indian Ocean Commission) and global (UN) mechanisms for disaster risk reductions would facilitate uptake.
	Selecting and applying appropriate mitigation mechanisms that offer substantial environmental and health benefits.	Available mitigation mechanisms and funding modalities.	Monitoring performance of REDD+ initiatives and the FCPF funding modality, widely share experiences, and provide support to potential beneficiaries in enabling appropriate scaling up in order to curb environmental and health problems of deforestation and land degradation. Little to moderate spread effects and impacts of this option given that common approaches and guidelines for REDD+ that can be easily adapted for use by eligible countries are yet to be developed. Uncertainties over national mechanisms for sharing benefits accruing from the carbon fund may impair uptake.
Coastal and marine resources	Curbing coastal erosion and controlling coastal pollution.	Interest in collective action as demonstrated through Integrated Coastal Zone Management (ICZM).	Scaling up ICZM. Potential impacts of this option are dependent on rationalization and harmonization of policies and management plans as well as application of the ecosystem management approach. Sharing of lessons and good practices and capacity building support from development partners would enhance uptake.
		Regional legal instrument – the Bamako Convention.	Accelerating the ratification and domestication of the Bamako Convention as well as development and implementation of pertinent action plans. Strengthening legislative instruments for effective application of the polluter pays principle. Of moderate potential impact, unless the political impediments that have hitherto slowed down ratification and domestication can be unlocked. Drawing upon lessons from the implementation of the Montreal Protocol could help in determining how best to unlock the barriers to implementation.
	Curbing degradation of biodiversity and marine resources.	Environmental and health alert on the risks of offshore drilling of oil.	Using the EIA instruments effectively in managing oil prospecting and oil drilling. Monitoring, in concert with people in the area of operation, adherence by the oil companies to their environmental and health management plans. Great potential impact in reducing adverse ecosystem and human health effects of prospecting and off-shore drilling of oil. The change would benefit both ecosystem and human health. However, its efficacy depends on the commitments of stakeholders to adequate enforcement of relevant policy and legislative instruments, including the implementation of environment and health management plans.
		Interest in collective action as demonstrated by the Western Indian Ocean Marine Eco-region (WIOMER) project.	Building upon the experiences of projects such as WIOMER to replicate and scale up transboundary and ecosystem-wide approach to curbing degradation of biodiversity and marine resources. Have potentials for huge impacts particularly on the biodiversity resources of participating countries (Comoros, France-Reunion, Madagascar, Mauritius and Seychelles). Success would also impact other African countries working on curbing degradation of biodiversity and marine resources. However, rationalization of policies and strategies for biodiversity and marine resources management, sharing of experiences and lessons on approaches to protected areas management and ensuring effective stakeholder engagement through appropriate information and communication strategy would enhance spread effects and impacts.
Freshwater and sanitation	Strengthening evidence base on ground water availability and quality.	Technologies for determining availability and quality.	Mapping out ground water availability and quality to determine overall national availability in light of growing population. Huge impacts in areas where access to safe water is constrained by lack of reliable sources. Ascertaining qualities of existing sources, especially boreholes, would reduce vulnerability to health risks associated with polluted water sources. Complementing this with public health education would contribute to reductions in health risks attributed to consumption of polluted water.
	Managing competing water demands	Techniques for demand management and ensuring safe use of waste water	Instituting water-use policies and tariffs that treat water as an economic good and ensure equitable availability of water to meet competing needs; without unduly compromising the rights of the poor to safe water. The introduction, spread effects and impacts of this change may be impaired by the politics of providing free water services in the short run. Harmonization, rationalization and enforcement of relevant sector policies and laws would contribute to positive changes. In the medium term, the demonstrable benefits such as water-use efficiency and improved availability of and access to water for various end-uses, attendant to good demand management, would enable more stakeholders to embrace this option for change.
		Techniques to assess and monitor the negative health and ecosystem effects of using waste water	Scaling up good practices in the use of waste water for agricultural production. Spread of urban agriculture and increasing demand for vegetables in urban markets would enhance the spread effect of good practices. Adherence to recommended waste water treatment methods and quality assurance of agricultural products would ensure consumer safety/confidence and facilitate uptake of the practice. However, in countries where waste water and untreated effluents are discharge directly to surface waters, these may be diverted directly for irrigation by unscrupulous producers thereby undermining quality assurance and consumer safety. The negative backlash of these on consumer confidence may become a fetter to uptake of good practices in using waste water for irrigation.

Table 10.6: Thematic options for transformative change (cont.)

	Controlling waterborne diseases.	Evidence base of the health risks associated with exposure to polluted water.	Enforcing environment and health impact assessments for development projects that expose people to waterborne diseases. Promoting country-wide Total Sanitation campaigns, involving a combination of information, education and communication (IEC) targeting households, schools and communities and aimed at changing attitudes and behavior in respect of safe sanitation. Although the spread effects and impacts of this option for change are potentially huge, realizing them would require improved collaboration between the agencies of government responsible for water, health and education services. Partnerships with civil society, the private sector and traditional leaders would facilitate enforcement of desired change.
		Technologies for production of safe water and for water purification are available and can improve access to safe water by the poor.	Expanding networks of safe water supplies in rural areas, while ensuring that sources such as boreholes and protected wells and springs are located in places that are not vulnerable to pollution from pit latrines and other relevant land-based sources. Promoting widespread adoption by low-resourced households of technologies for water purification that do not depend on chemicals. The potential huge impacts of these changes may be impaired by lack of funds for expanding the networks of safe water sources and the supply of water purification technologies that don't depend on chemicals. Smart partnerships between government, industrial entrepreneurs in the private sector, and civil society organizations may enhance the production, spread and uptake of affordable water purification technologies.
Land	Managing land-use changes and their effects on land productivity and human health.	Knowledge of environment and health risks associated with inappropriate land-use changes.	Assessing the suitability of proposed land-use changes and ensuring that they do not contribute to environmental and health risks. In a number of African countries, environment and land policies and laws may provide for this. However, the uptake and spread effects of the assessment depends on a country's land management regime and the culture of consultation and decision making between the ministries responsible for land, environment and health. Where land tenure regimes don't protect the usufruct rights and interests of local communities, their power to contribute to enforcement of proposed assessments can be severally impaired; making them vulnerable to possible adverse environmental and health consequences of unregulated land-use change.
	Protecting vulnerable populations from negative effects of the new rush for land such as for production of biofuel.	Knowledge of environment and health risks associated with new rush for land for biofuels.	Regulating land acquisition for biofuels in order to guard against contracting arrangements that undermine food and livelihood security. Ensuring that production plans do not compromise water security, safe application of agro-chemicals and do not expose workers to occupational health hazards. Spread and impact of this change depends on the nature of stewardship exercised by a country's local and national leaders. The change demands dominance of sustainability-driven – rather than just profitability-driven – mindsets among leaders and decision makers. Its success also depends on the existence of adequate capacities for negotiations and contracting with external parties so that the environmental, economic and health costs don't outweigh the benefits of proposed acquisitions and land-use changes. Drawing upon best practices from other countries would facilitate a successful implementation of the proposed change.
	Productivity-enhancing agronomic practices that can contribute to water pollution.	Knowledge of proper agronomic practices and promotion of organic farming.	Regulating relevant agro-chemical standards for products produced locally or imported. Strengthening agricultural extension services to farmers in order to promote proper application of agro-chemicals and disposal of containers. Huge potential spread and impacts given that many of the African economies are agrarian. Success depends on capacities of agencies responsible for agro-chemical standards and for curbing importation of counterfeit products. Without effective national agricultural extension services, inappropriate use of good quality agro-chemicals would still contribute to water pollution, degradation of soils and ecosystems as well as cause the ill health of agricultural producers and workers.

Source: Compiled by the authors

towards improved global public health.' *The spread and impact of this would be determined by the abilities of implementing agencies to demonstrate the economic, financial and other benefits of this option for change. Technical capacities in the sector ministries in conducting integrated environment and health assessments would also influence the depth and speed of uptake of the proposed change.*

- **Mainstreaming environmental interventions that promote human health in sectoral, national and sub-national strategic plans, taking adequate account of both the traditional and modern environmental risk factors.** This would enhance the prominence of environmental issues that affect human health in development strategies at the various levels of governance and the prospects of improved budgetary allocations for them. *Country-level efforts at poverty-environment mainstreaming provide a solid basis for promoting poverty-environment-health mainstreaming. Abilities of responsible*

agencies to demonstrate the tangible benefits of this approach to the economy and society would enhance uptake and growth in levels of investments. Abilities of the agencies to ensure that mainstreamed activities feature in plans and budgets would help to realize the desired impacts of the proposed change.

- **Building the capacities for strategic management and inter-sectoral collaboration between functionaries in the Ministries of Environment and of Health.** The Health and Environment Strategic Alliance (HESA) established by the African Ministers of Environment and of Health at the Second Inter-Ministerial Conference on Health and Environment provides an appropriate institutional basis for this. It is worthwhile extending this alliance to the decentralized levels of governance and engaging both the private sector and civil society in ensuring collaborative actions that promote both the quality of the environment and human health. *The traditional approach and associated mindsets that drive sector planning and budgeting are likely to affect uptake, spread and impact of the proposed option for change. Ability of HESA to support trail blazers (social entrepreneurs) at both the national and decentralized levels in developing and sharing of best practices would promote uptake and attract support from development partners to support the proposed option for change.*

- **Instituting mechanisms, preferably through the HESA or AMCEN Secretariats or the Regional Economic Communities, for learning and sharing of experiences on policy implementation.** Lessons and good practices, such as those from the application of collective actions in managing shared resources, is a case in point. SADC's experiences with implementing its protocol on shared water courses and the experiences gained in implementing the Cross-Border Biodiversity Programme in East Africa are instructive. Such experiences, if appropriately applied, could enhance the scaling up of good practices within countries and their adaptive applications across Africa, with clear demonstration of the human health benefits. Additionally, modest investments could be made in well-designed sub-regional case studies that analyze barriers to policy implementation. The results from the case studies would feed into the learning platform at HESA, AMCEN or both, which would be readily accessed by member states. *Carefully developed good practice cases on policy implementation, including effective handling of barriers to policy implementation, would enhance the spread and impact of this option for change. Inability of HESA and AMCEN to mobilize the resources required to provide technical support to the change process could impair its uptake. Cost-sharing arrangements between countries and/or sub-regions and AMCEN/HESA, is an option worth considering in ameliorating financing constraints.*

- **Investing more in innovative empowerment of the population so that sufficient information is available to raise awareness, trigger attitudinal changes and spur desired changes in mindsets and behavior.** The empowerment effort could also be targeted at dealing with negative mindsets that do not only encourage behaviours that undermine public hygiene but also those that discourage investments in environmental management and actions against degraders of the environment. Engaging educational institutions, faith-based organizations, environmental and public health networks and the media in this effort can yield multiplier effects. Translation of the results of the assessments

of the environment and health linkages in this report into appropriate information and communication materials for use by these agencies would contribute to the desired empowerment of the general public and other stakeholders. *The spread and impacts of this change would be influenced by the abilities of decentralized health and environment agencies to engage with civil society organizations, the private sector and traditional leaders in drawing upon available evidence and applying appropriate information and communication techniques and tools to foster changes in mindsets and behavior, especially of those vulnerable to health risks associated with environmental hazards. Inadequately managed partnerships among these agencies, however, could foreclose the reaping of anticipated benefits from collective approaches to empowering the population.*

- **Correcting for the capacity deficits incurred during public sector reform and ensuring that the skill mix of staff and organizational design ensure effective delivery of environment and health services.** The issues of incentive systems and availability of equipment and tools for effective service delivery have to be dealt with as well. Unattended to, these could contribute to further erosion in staff strength through brain drain or loss of staff to the private sector and civil society or other departments of government. *Success and impact of this change depends on a country's development vision, especially its definition of the sustainability pathway; thereby enabling the country to define its capacity development strategy and undertake an appropriate civil service reform. That reform would, among other things, determine appropriate staff strength and skills mix and prioritize the capacity deficits to remedy. However, without appropriate systems for staff performance appraisal, staff development and staff incentives including staff development and training, correcting for the deficits alone, merely in terms of numbers on the payroll, may not yield the expected dividends in terms of effective delivery of basic services that adequately respond to the country's environment and health challenges. Reform fatigue in some of the African countries could dampen interest in implementing this option for change.*

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ACRONYMS

AAPT	African Association of Public Transport
ACCNNR	African Convention on the Conservation of Nature and Natural Resources
AEO-1	First Africa Environment Outlook report
AEO-2	Second Africa Environment Outlook report
AEO-3	Third Africa Environment Outlook report
AfDB	African Development Bank
AIDS	Acquired Immune Deficiency Syndrome
AMCEN	African Ministerial Conference on the Environment
AMCOW	African Ministers' Council on Water
ARC	Applied Research Center
ARIs	Acute Respiratory Infections
ASP	Africa Stockpiles Programme
ASSA	Academy of Science of South Africa
ATSDR	Agency for Toxic Substances and Disease Registry
AU	African Union
AUC	African Union Commission
AVCASA	Association of Veterinary and Crop Associations of South Africa
AWC	Arab Water Council
AWF	Africa Water Facility
AWV	African Water Vision
AZP	Azaspiracid Shellfish Poisoning
BAN	Basel Action Network
BCLME	Benguela Current Large Marine Ecosystem
BCS	Biostope Consultancy Services
BRICS	Brazil, Russia, India, China and South Africa
CAADP	Comprehensive Africa Agriculture Development Programme
CAPD	Center for Assessment and Policy Development
CBD	Convention on Biological Diversity
CBFM	Community Based Forest Management
CBM	Cubic Metre
CBNRM	Community-Based Natural Resources Management
CDC	Center for Disease Control and Prevention (USA)
CDM	Clean Development Mechanism
CEDARE	Centre for Environment and Development for the Arab Region and Europe
CFCs	Chlorofluorocarbons
CFSPH	Centre for Food Security and Public Health
CHWG	Climate Change and Health Working Group (Ethiopia)
CIAT	Centro Internacional de Agricultura Tropical (International Center for Tropical Agriculture)
CIESIN	Center for International Earth Science Information Network
CIT	Contextual Interaction Theory
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
CLRTAP	Convention on Long-Range Transboundary Air Pollution
CMS	Convention on the Conservation of Migratory Species of Wild Animals (or Bonn Convention)
COP	Conference of Parties
CRT	Cathode Ray Tubes
CWAP-1	First Community Water and Sanitation Project
CWS	Conventional World Scenario
CWSA	Community Water and Sanitation Agency
DALYs	Disability Adjusted Life Years
DDT	Dichlorodiphenyltrichloroethane
DEA	Department of Environmental Affairs (South Africa)
DEAT	Department of Environmental Affairs and Tourism (South Africa)
DFID	Department for International Development (United Kingdom)
DHF	Dengue Haemorrhagic Fever
DSP	Diarrheic Shellfish Poisoning
EC	European Commission
ED	Endocrine Disruption
EEAA	Egyptian Environmental Affairs Agency
EMPA	Swiss Federal Laboratories for Materials Science and Technology
ENSO	El Nino-Southern Oscillation
EWEs	Extreme Weather Events
FAO	Food and Agriculture Organization of the United Nations
FARA	Forum for Agricultural Research in Africa

FCPF	Forest Carbon Partnership Facility
FLOW	Field Level Operations Watch
GCLME	Guinea Current Large Marine Ecosystem
GDP	Gross Domestic Product
GEF	Global Environment Facility
GEO-4	Fourth Global Environment Outlook
GEO-5	Fifth Global Environment Outlook
GIS	Geographic Information System
GMCs	Genetically Modified Crops
GMOs	Genetically Modified Organisms
GMP	Global Mercury Project
GoK	Government of Kenya
GWD	Guinea Worm Disease
HABs	Harmful Algal Blooms
HESA	Health and Environment Strategic Alliance
HIV	Human Immunodeficiency Virus
HRC	Human Rights Council of the United Nations
IAEA	International Atomic Energy Agency
IAPT	International Association of Public Transport
ICM	Integrated Coastal Management
ICRAF	World Agroforestry Centre
ICRW	International Convention for the Regulation of Whaling
ICT	Information and Communication Technology
ICZM	Integrated Coastal Zone Management
IEC	Information, Education and Communication
IFAD	International Fund for Agricultural Development
IICAB	Institute for International Cooperation in Animal Biologics
IICD	International Institute for Communication and Development
IIED	International Institute for Environment and Development
INEP	Integrated National Electrification Programme (South Africa)
INGC	National Institute for Disaster Management (Mozambique)
IOC	Indian Ocean Commission
IPCC	Intergovernmental Panel on Climate Change
IPCS	International Programme on Chemical Safety
IPEN	International POPs Elimination Network
IPM	Integrated Pest Management
ISD	Information System on Desertification
ISSG	Invasive Species Specialist Group
ITCZ	Inter Tropical Convergence Zone
ITNs	Insecticide Treated Nets
IUU	Illegal, Unreported and Unregulated fishing
IVM	Integrated Vector Management
IWRM	Integrated Water Resources Management
JPOI	Johannesburg Plan of Implementation
kcal	Kilocalorie
KFS	Kenya Forest Service
kg	Kilogramme
kW	Kilowatt
LCBC	Lake Chad Basin Commission
LLC	Leadership Learning Community
MA	Millennium Ecosystem Assessment
MARPOL 73/78	International Convention for the Prevention of Pollution from Ships, 1973 as modified by the Protocol of 1978
MDG	Millennium Development Goal
MEAs	Multilateral Environmental Agreements
MEHHs	Modern Environmental Health Hazards
MERIT	Meningitis Environmental Risk Information Technologies
mg	Milligram
MMAs	Marine Managed Areas
MPAs	Marine Protected Areas
MW	Megawatt
NAMAs	Nationally Appropriate Mitigation Actions
NAPAs	National Adaptation Programmes of Action on Climate Change
NCPCs	National Cleaner Production Centres
NEAA	Netherlands Environmental Assessment Agency
NEPAD	New Partnership for Africa's Development
NGOs	Non Governmental Organizations
NIOSH	National Institute of Occupational Safety and Health (United States)
Norad	Norwegian Agency for Development Cooperation
NOU	National Ozone Unit
Nox	Nitrogen Oxides
NSP	Neurotoxic Shellfish Poisoning
OctaBDE	Octabromodiphenyl ether

ODS	Ozone Depleting Substances
PAHs	Polynuclear Aromatic Hydrocarbons
PAN	Pesticide Action Network (UK)
PASICOM	Pan African Conference on Sustainable Integrated Coastal Management
PCBs	Polychlorinated biphenyls
PCFV	Partnership for Clean Fuels and Vehicles
PEI	Poverty-Environment Initiative
Penta BDE	Pentabromodiphenyl ether
PEP	Poverty-Environment Partnership
PES	Payment for Ecosystem Services
PFOS	Perfluorooctane sulfonate
POPRC	Persistent Organic Pollutants Review Committee
PoPs	Persistent Organic Pollutants
PPPs	Public-Private Partnerships
PRSC	Poverty Reduction Support Credit
PRSPs	Poverty Reduction Strategy Papers
PRSs	Poverty Reduction Strategies
PSP	Paralytic Shellfish Poisoning
PVC	Polyvinyl Chloride
R&D	Research and Development
REACH	Registration, Evaluation, Authorisation and Restriction of Chemicals
REDD	Reducing Emissions from Deforestation and Forest Degradation
REDD+	Reducing Emissions from Deforestation and Forest Degradation, Forest Conservation, Sustainable Management of Forests and Carbon Stock Enhancement
REMPEC	Regional Marine Pollution Emergency Response Centre for the Mediterranean Sea
RVF	Rift Valley Fever
SADC	Southern African Development Community
SAICM	Strategic Approach to International Chemicals Management
SANA	Situation Analysis and Needs Assessment
SEI	Stockholm Environment Institute
Sida	Swedish International Development Cooperation Agency
SIDS	Small Island Developing States
SMC	Sound Management of Chemicals
SMFEs	Small and Medium Forest Enterprises
SPR	Social Policy Research Associates
SSA	Sub-Saharan Africa
SSEE	The Smith School of Enterprise and the Environment
SWAps	Health and Environment Sector-Wide Programmes
SWS	Sustainable World Scenario
TBNRM	Transboundary Natural Resources Management
TDA	Transboundary Diagnostic Analysis
TS	Total Sanitation
UNCLOS	United Nations Convention on the Law of the Sea
UNCSD	United Nations Conference on Sustainable Development
UNDESA	United Nations Department of Economic and Social Affairs
UNECA	United Nations Economic Commission for Africa
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific and Cultural Organisation
UNFCCC	United Nations Framework Convention on Climate Change
UNIDO	United Nations Industrial Development Organization
UNSCN	United Nations Standing Committee on Nutrition
UNU	United Nations University
URT	United Republic of Tanzania
USAID	United States Aid for International Development
WASH	Water Supply, Sanitation and Hygiene
WHC	Convention Concerning the Protection of the World Cultural and Natural Heritage
WHO	World Health Organization
WIOMER	Western Indian Ocean Marine Eco-region
WRI	World Resources Institute
WSP	Water and Sanitation Programme (World Bank)
WSSD	World Summit on Sustainable Development
WWAP	World Water Assessment Programme
WWF	World Wildlife Fund

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Health is 'a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity.'
(WHO 1946)

Environment risks are blamed for about 28 per cent of Africa's disease burden, and this includes diarrhoea, respiratory infections and malaria, which collectively account for 60 per cent of known environmental health impacts in the region.
(WHO and UNEP 2010)

The Third Africa Environment Outlook (AEO-3), analyses the importance of, and interlinkages between, health and environment and the opportunities and synergies that might be derived from intensified collaboration between the two sectors. It uses the Drivers, Pressures, State, Exposure, Effects and Actions (DPSEEA) analytical framework to undertake an integrated analysis of the state and trends covering the themes of *air quality, biodiversity, chemicals and waste, climate change and variability, coastal and marine resources, freshwater and sanitation* as well as *land*. It also illustrates how socio-economic driving forces can generate environmental pressures, leading to altered ecosystem states, personal exposure to risks and adverse health effects.

AEO-3 also proffers a range of strategies for deflecting untenable business as usual behaviours and mindsets towards sustainable ones.