

## **MODULE 3**

# **AN OVERVIEW OF NATURAL RESOURCES AND THE ENVIRONMENT IN EASTERN AND SOUTHERN AFRICA**

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### **3.1 IMPORTANCE OF NATURAL RESOURCES AND THE ENVIRONMENT**

This module provides an overview of natural resources and the environment in the region in terms of economic and social importance, and general trends in degradation. The conventional wisdom is that eastern and southern Africa depends heavily on natural resources and the environment for economic growth and social development. Agriculture is perceived as the foundation of economic activity, particularly in rural areas. To assess this perception, this module examines regional trends in agriculture, general biodiversity, forests, freshwater, energy and mineral resource production and degradation.

First, average GDP/capita (based on purchasing power parity) is \$2,798 USD with a wide range among countries (Table 3.1). Of the 16 countries listed, 11 have GDP/capita below the regional average. Based on the share of GDP, services account for a regional average of 47.7 percent of national income. Industry and agriculture each account for about 26 percent of GDP. The share of agricultural GDP is still very high relative to industrialised nations. Countries like South Africa and Mauritius have service-sector GDP shares similar to many industrialised countries. The global trend for emerging market countries is a gradual shift from an agriculture-based economy to services as national incomes rise. However, population growth in this region is still expected to place a high demand on food production.

**Table 3.1 HDI ranking, population density, GDP and distribution of national income, eastern and southern Africa.**

Country	HDI Rank	HDI Score	Population	Land	Population	GDP/Capita	Distribution of GDP		
	1994	1994	1994	Area	Density	(PPP 1995)	1995 (%)		
			(million)	('000 ha)	(people/km <sup>2</sup> )	(\$)	Agriculture	Industry	Services
Mauritius	61	0.831	1.1	203	541.9	13,270	9	33	58
South Africa	90	0.716	40.6	122104	33.3	5,240	5	31	64
Botswana	97	0.673	1.4	56673	2.5	5,630	5	46	48
Swaziland	114	0.582	0.8	1720	46.5	2,950	x	x	x
Namibia	118	0.570	1.5	82329	1.8	4,100	14	29	56
Zimbabwe	129	0.513	10.9	38685	28.2	2,140	15	36	48
Kenya	134	0.463	30.3	56914	53.2	1,430	29	17	54
Lesotho	137	0.457	2.0	3035	65.9	1,240	11	40	49
Zambia	143	0.369	7.9	74339	10.6	990	22	40	37
Tanzania	149	0.357	29.2	88359	33.0	670	58	17	24
Madagascar	152	0.350	14.4	58154	24.8	680	34	13	53
Uganda	159	0.328	19.1	19965	95.7	1,490	50	14	36
Malawi	161	0.320	9.6	9408	102.0	770	42	27	31
Mozambique	166	0.281	16.6	78409	21.2	910	33	12	55
Eritrea	168	0.269	3.1	10000	31.0	x	11	20	69
Ethiopia	170	0.244	54.6	103366	52.8	460	57	10	33
Total			243.1	803663					
Regional Average		0.458			71.5	2,798	26.3	25.7	47.7

Source: (UNDP 1997; WRI 1999)<sup>1</sup>.

Second, countries are ranked according to the UNDP Human Development Index (HDI) for 1994 (UNDP 1997). The HDI is a composite index of income, health and education, with a score of 1.00 being the highest.<sup>2</sup> An HDI of less than 0.500 classifies a country into the low human development group according to UNDP. Only six countries scored higher than 0.500. A comparison among countries suggests that as the HDI score declines, there is a general tendency for agriculture's share of GDP to increase. Examples include Uganda, Tanzania and Ethiopia, which have a low HDI ranking and where the share of agriculture GDP is 50 percent or greater. Exceptions exist such as Eritrea, which has the second lowest HDI score but only 11 percent of GDP derived from agriculture.

Third, GDP/capita for most countries in the region is very low. As GDP/capita declines, agriculture's share tends to be higher, following the general relationship with the HDI. Also, in many countries in the region, tourism is one of the few sectors with high growth potential.

<sup>1</sup> While these data may differ slightly with various published and unpublished sources within individual countries, they provide a measure of consistency. UNDP and the World Resources Institute obtain the data mainly from official government sources in each country.

Tourism falls into the service sector national accounts. For tourists visiting a country to see wildlife, a healthy and diverse natural habitat is important. Many popular “non-wildlife” tourist destinations such as Victoria Falls, coastal beaches and deserts can only maintain high amenity values if the environment is not degraded.

Fourth, a high proportion of industrial activity (and manufacturing GDP) is based on the processing of either raw natural resources or primary products derived from the land such as in agriculture. Examples include fish processing into packaged fillets, logs into lumber and paper, tertiary manufacturing of furniture, mineral refining, and food processing (beef, dairy, bread, etc). The total GDP contribution from natural resources and the environment can be quite high. A recent study on the contribution of biodiversity to Zimbabwe’s economy, estimated that as much as one-third of total GDP was based on the direct or indirect use of natural resources (MMET 1999).

Fifth, comparisons with developed countries show that most countries in the region have an almost insurmountable distance to cover to catch up in terms of basic economic and social indicators (Table 3.2). The average regional population density of approximately 72 people/km<sup>2</sup> is not high by UK standards, but is very high by North American standards. The total land area of eastern and southern Africa is comparable to Canada’s. However, the total population in eastern and southern Africa is almost eight times high as Canada’s, and population density 23 times as great. Average GDP per capita is almost eight times lower in eastern and southern compared to Canada. The regional HDI is roughly half that of Canada’s. While the UK has a significantly higher population density, the economic and social indicators in Table 3.2 show a similar pattern. Most telling is the level of urbanisation. In eastern and southern Africa, only 28 percent of the population reside in urban areas, compared to 89 and 77 percent respectively for the UK and Canada.

Clearly, the majority of people in the eastern and southern African region are rural based. They depend on natural resources and the underlying environment for subsistence crops, water,

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<sup>2</sup> Refer to Module 4 on Causes of Natural Resource and Environmental Degradation, where the HDI is discussed in more detail in the context of poverty and environment.

materials for shelter, grazing land for livestock, and where possible, the means to generate small cash incomes (Box 3.1).

**Table 3.2: Economic, demographic and social indicators, eastern and southern Africa, UK and Canada**

Indicator	Eastern and Southern Africa	UK	Canada
Total Land Area (1,000 ha) <sup>a</sup>	803,663	24,488	997,614
Total Population (million, 1994) <sup>b</sup>	243	58	31
Average Population Density (persons/km <sup>2</sup> )	71.5	236.9	3.1
Urban Population 1994 (%)	28	89	77
Real GDP/capita (PPP\$, 1995) <sup>a</sup>	2,798	19,300	21,900
HDI (score out of possible 1.00, data for 1994) <sup>b</sup>	0.458	0.93	0.96
Notes:			
a - (WRI 1999)			
b - (UNDP 1997)			

**Box 3.1: Rural Dependency on Natural Resources, Zambezi Valley, Zimbabwe**

A detailed study was carried out in the mid-1990s in two communal areas of Zimbabwe bordering the Zambezi river. These were Sebungwe (16,000 km<sup>2</sup>) and Dande/Chiswite (8,000 km<sup>2</sup>). Human settlement from natural population growth and migration has increased, resulting in large areas of indigenous forest being cleared. From 1981 to 1993, the average rate of land conversion in Sebungwe was 9 percent per annum. In the same area, livestock numbers increased from 3,700 animals in 1983 to more than 45,000 in 1996. Household surveys revealed that residents were highly dependent on natural resources and the environment for basic needs and income generation. Based on time allocated for labour, 35 percent was used for the collection of natural resource products, 33 percent for livestock management, 24 percent to field crops, 7 percent to home affairs, and 1 percent to vegetable gardens. Natural resources were collected from areas ranging between 6 and 17 km away. As a conservative estimate, natural resources contributed to more than one-third of household value added. This result is viewed as conservative since many non-market environmental benefits were not measured.

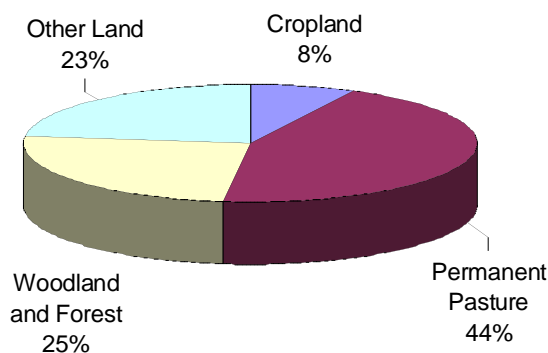
Source: Cumming and Lynam (1997).

**3.2 AGRICULTURAL PRODUCTION**

In developing countries such as in eastern and southern Africa, the pressure to grow food for domestic consumption, cash sales for income, and exports is expected to increase as populations continue to expand. Land suitable for arable production and grazing is limited and the gap between agricultural commodity supply and demand is expected to widen. For the region as a

whole, the main land classification type is permanent pasture (Figure 3.1). This is not surprising, given the importance of livestock production in the region. Surprisingly, cropland only accounts for 8 percent of the total land base. Woodland and forests (both natural and plantation) comprise of 25 percent of total land area.

**Figure 3.1: Land classification, eastern and southern Africa**



Source: WRI (1999).

With agriculture, a major environmental issue in the region is soil erosion from poor farming practices on arable land and/or overgrazing on pastures. Total cropland per capita within the region is very low, reflecting high rural populations and limited productive areas for agriculture (Table 3.3). One sign of soil erosion is declining average yields per hectare. Table 3.3 shows that on average, cereal yields increased by 7.8 percent from 1983-93. The countries with the greatest increase in average yields were Lesotho, Botswana, Ethiopia, South Africa and Uganda. Offsetting these gains were major declines in yield in Namibia, Zimbabwe and Zambia. If data were available, it would be useful to correlate soil erosion among these latter countries with declining cereal yields per hectare.

Table 3.3 also shows the change in the agriculture production index per capita from 1984-86 to 1994-96. The index represents the total value of agricultural production based on real prices (1989-91=100). Production includes both livestock and crops. Without exception, the index has fallen over the 10-year period for all countries. A main reason for this trend is that country

populations have increased. Another contributing cause of the lower index could be from reduced average output, perhaps from livestock and non-cereal arable crops.

Secondary environmental issues surround the use of agro-chemicals, including fertilisers, pesticides and herbicides. Inefficient application of these chemicals may contaminate surface and ground water. Fertilisers high in nitrogen can contribute to eutrophication of water bodies with negative impacts on aquatic resources. Chemical pesticides and herbicides pose a threat to human health through improper handling, storage and application practices. Children are more susceptible to health problems, including the impairment of brain functions.

**Table 3.3: Agricultural production, eastern and southern Africa**

HDI Rank 1994	Country	Total Cropland (1,000 ha) 1994	Cropland per Capita (ha) 1994	Agriculture Production Index/Capita 1984-86 <sup>1</sup>	Agriculture Production Index/Capita 1994-96 <sup>1</sup>	% Change Cereal Yield per ha 1983-1993	% Change in Fertiliser Use (kg/ha) (1984-94)
61	Mauritius	106	0.1	102	96	-4.40	8.7
90	South Africa	15500	0.4	99	85	23.70	-32.8
97	Botswana	420	0.3	115	83	43.60	-33.3
114	Swaziland	191	0.2	107	80	-12.00	42.9
118	Namibia	750	0.5	95	94	-43.50	0.0
129	Zimbabwe	2878	0.3	109	85	-24.60	13.5
134	Kenya	4520	0.2	94	89	11.20	72.2
137	Lesotho	320	0.2	106	99	56.20	26.7
143	Zambia	5273	0.7	91	86	-17.40	0.0
149	Tanzania	3675	0.1	106	84	3.60	-16.7
152	Madagascar	3105	0.2	111	88	12.50	100.0
159	Uganda	6800	0.4	92	98	20.70	0.0
161	Malawi	1700	0.2	116	101	4.40	-48.4
166	Mozambique	3180	0.2	98	87	18.30	100.0
168	Eritrea	519	0.2	n/a	103	n/a	x
170	Ethiopia	11012	0.2	103	n/a	24.40	600.0
	Regional Average		0.26	102.93	90.53	7.78	55.5
	Note:	<sup>1</sup> , 1989-91 = 100, includes all crop and livestock production Index is the disposable average output for the period X 1989-91 average producer price. The index represents the total value of the commodity for that period in terms of the 1989-91 price.					

Sources: UNDP (1997), WRI (1999).

As pressure increases to grow food on a limited, or at best, a land base slowly expanding into less productive areas, farming practices might be used that favour more intensive use of agrochemicals. From the preceding table, average regional fertiliser use per hectare increased by approximately 56 percent from 1984-94. Only four countries showed a decline in fertiliser use. To some extent, increasing the intensity of fertiliser use can offset declining soil productivity from erosion. However, the sustainability of this approach, both from a farm income and environmental perspective is questionable. No comparable data were available for other agrochemicals.

### **3.3 TERRESTRIAL AND AQUATIC BIODIVERSITY**

#### **3.3.1 The Convention on Biological Diversity**

The 1992 UN Conference on Environment and Development in Rio de Janeiro, Brazil, focused on the implications of the world's environmental problems for development and economic growth. The participants in the conference, drawn from governments and NGOs from throughout the world, decided that action must be taken, at both global and national levels, to address the world's environmental problems. Among other things, this resulted in a number of international conventions being established, under which countries agreed to take actions to safeguard environmental resources and processes.

One of the key topics at the Rio conference, and one of the international conventions arising from it, concerned the world's biodiversity. The Convention on Biological Diversity (CBD), which came into force in 1993, has been signed and ratified by most of the countries in eastern and southern Africa (Table 3.4). Biodiversity is a critical resource in the region (Box 3.2)

**Table 3.4: Signatories to the CBD in eastern and southern Africa**

<b>Country</b>	<b>Signed</b>	<b>Ratified</b>
Angola	1992	1998
Botswana	1992	1995
Comoros	1992	1994
Djibouti	1992	1994
Eritrea		1996
Ethiopia	1992	1994
Kenya	1992	1994
Lesotho	1992	1995
Madagascar	1992	1996
Malawi	1992	1994
Mauritius	1992	1992
Mozambique	1992	1995
Namibia	1992	1997
Seychelles	1992	1992
South Africa	1992	1995
Sudan	1992	1995
Tanzania	1992	1996
Uganda	1992	1993
Zambia	1992	1993
Zimbabwe	1992	1994

**Box 3.2: Terrestrial and Aquatic Biodiversity in eastern and southern Africa**

A huge number of living organisms are found in eastern and southern Africa. For example the *Flora Zambeziaca* phytogeographic region of south-central Africa contains about 8,500 species of trees. More than 300 species of mammals and 900 bird species are found in southern Africa, and over 200 freshwater fish species are found in Uganda alone and over 10 percent of the world's bird species are found in Kenya. Some of these sets of living organisms have evolved in relative isolation from those on other continents. Thousands of the species found in eastern and southern Africa are found nowhere else on the planet (for example, over half of the tree species found in the *Flora Zambeziaca* phytogeographic region, more than 100 bird species in southern Africa and over 800 plants in East Africa). This unique nature applies also to (some of) the genes that these species contain and the ways in which species combine to form complex communities and ecosystems.

Perhaps the most impressive example of a unique ecosystem in Africa is the Serengeti ecosystem in Kenya and Tanzania, where millions of large herbivores still undertake a seasonal migration of the kind now extinct on all other continents. This threatened phenomenon is rivalled by complex ecological relationships which exist between the highly diverse communities of Cichlid fish which have evolved in the African Great Lakes (Victoria, Tanganyika and Malawi) and the evolution from a single lineage of over 10,000 plant species in the Fynbos in South Africa's Cape.

The many sunbird species (Family *Nectariniidae*) which pollinate flowers throughout Africa are not found anywhere else in the world, but, in America, a separate lineage of birds, the hummingbirds (Family *Trochilidae*) has evolved to play the same ecological role. In a similar manner, the species of dung-beetle found in Africa are uniquely adapted to the dung of African large mammals like the elephant, while those in Australia are adapted to the dung of different marsupial mammals such as kangaroos and wallabies.

Even at the genetic level, Africa contains a wealth of diversity, much of it still almost completely unknown and unexplored. Many of the world's important food and cash crops originate from wild plant species found in Ethiopia and Eritrea, for example coffee, sesame, chickpea, sorghum and millet. A variety of wild coffee species is found through East Africa: each contains different sets of genes controlling how the plants are adapted to different climate and soils, resist disease, and so on. One species even produces fully decaffeinated beans.

The CBD's major objectives are the conservation of biodiversity, the sustainable use of its components and the equitable sharing of the benefits arising from the utilisation of genetic resources. It sets out a series of strategies and actions by which to achieve these objectives and to deal with different aspects of biodiversity. Throughout the CBD there is reference to the use of economics and the CBD provides a useful framework for carrying out economic analysis and for addressing economic issues relating to terrestrial and aquatic biodiversity.

### 3.3.2 What is Biodiversity?

According to the CBD, biodiversity is *the variability between living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems*. From the outset, it is important to distinguish between *biodiversity* and *biological resources*. Biological resources can be defined (again by the CBD) as *genetic resources, organisms or parts thereof, populations, or any other biotic component of ecosystems with actual or potential use or value for humanity*. This includes individuals and collections of living organisms such as trees, fish or microbes. Biodiversity on the other hand, is an attribute of life and a measure of the difference between biological resources, or their variability. Examples are species-rich forest complexes, the different types of micro-organisms, which provide soil fertility, or the mixture of plankton, fish and marine mammals found around coral reefs). The economics of biodiversity is therefore concerned with the variability within and between genes (such as those which determine the ability of plants to cope with drought); species (such as fish, trees, plants or animals); and ecosystems (such as forests, river basins, wetlands, savannahs or marine and coastal environments).

Incorporating biodiversity concerns into economics involves introducing concepts of sustainability into the basic economic problem of unlimited wants and scarce resources. The economics of biodiversity attempts to find ways to meet people's current needs in a way, which is both equitable and efficient and does not diminish the amount and diversity of scarce biological resources available for future generations. A key concern in biodiversity economics is to assess how biodiversity contributes to economic activity. It is also important to highlight how economic forces in turn impact on biodiversity and to identify economic tools and measures which can be used to conserve biodiversity and to manage it better (this issue is dealt with in module 7).

### 3.3.3 The Economic Importance of Biodiversity

One of the first steps in the economics of biodiversity is to understand its economic importance, as reflected in the call in the CBD for the identification of ecosystems, habitats, genomes and genes of *economic importance* and species and communities of *economic value*.

Basically, biodiversity is economically important because biological resources, ecosystems and their diversity form the basis of most human production and consumption systems. This is especially true for predominantly rural, natural resource-based economies in eastern and southern Africa, where there is a high reliance on biological resources and their variability – from the household, subsistence level through to the national economic level. The concept of total economic value<sup>3</sup> provides a particularly useful framework for identifying and defining the different values associated with biodiversity, which include (Figure 3.2):

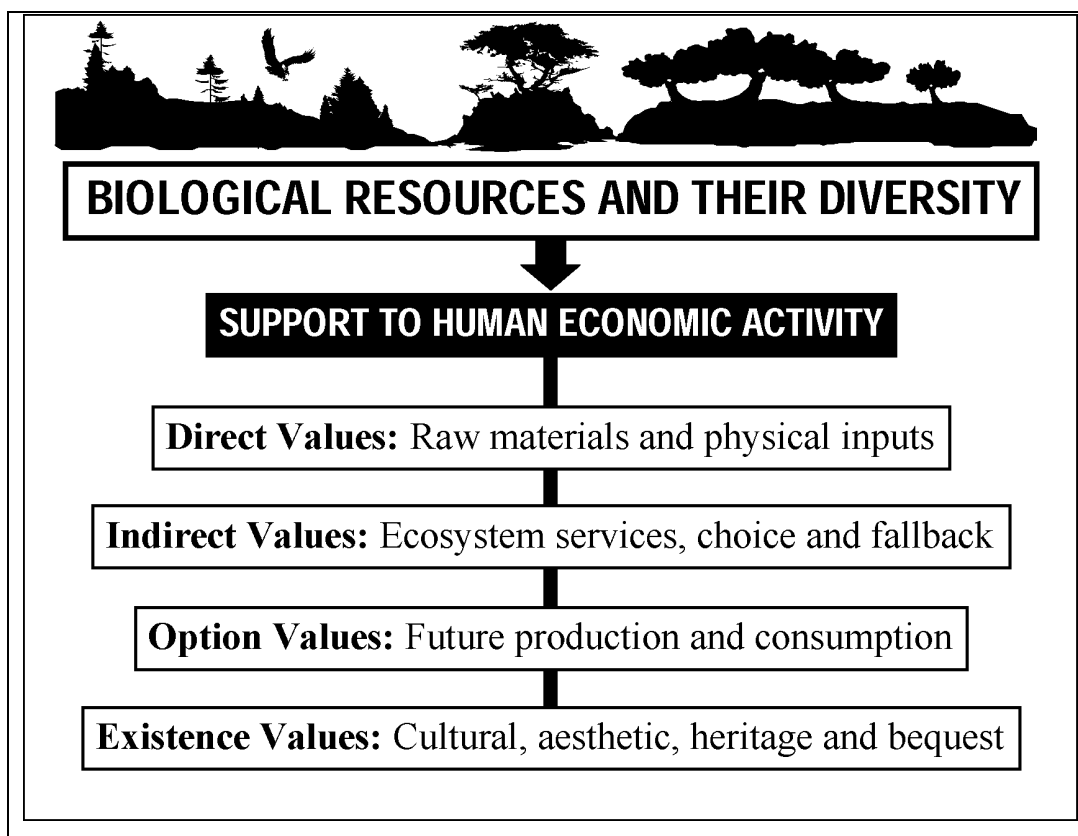
- **Direct values:** Biological resources provide the raw materials and physical inputs (such as timber, pasture, fish, thatch, gums and resins, firewood or wild medicines) for economic production and consumption. As well as forming the basis of rural livelihoods throughout eastern and southern Africa, these raw materials and physical inputs often make an important contribution to industrial production and exports.
- **Indirect values:** Ecosystems provide services such as the water quality regulation functions of forests, the climate control functions of coral reefs or the land and water protection functions of mangroves and grasslands). These enable economic activity because they protect human and natural resources through providing a sink for wastes and residues and maintaining essential life support functions. The variability within and between biological resources and ecosystems also contributes to the resilience of natural and human systems by ensuring that people have continued economic choice and security in their consumption and production, especially in situations of stress, change or uncertainty. In many of the countries of eastern and southern Africa which are subject to severe and recurrent drought and economic uncertainty, and where both national economies and rural livelihoods rely on a

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<sup>3</sup> Refer to module 9 for a more detailed discussion of total economic value.

limited and insecure production base, the contribution of biodiversity to choice, resilience and security has particular economic importance.

**Figure 3.2: The economic value of biodiversity**



- **Option values:** Maintaining a pool of biological variability allows for the option of carrying out economic activities in the future, some of which may not even be known now (for example through developing new leisure, pharmaceutical or industrial applications of wild genes, species and ecosystems). Biodiversity, already significant in economic terms, may play an important role in the future economic growth and economic diversification of many eastern and southern African countries.
- **Existence values:** Regardless of actual use, the biodiversity and its components yield aesthetic pleasure, holds cultural significance, and is considered an item of bequest or heritage for future generations, for many people and in many places. Many eastern and

southern African countries contain species and ecosystems of great global, national and local interest and importance.

Once the different components of the economic value of biodiversity have been identified, it is often possible to express, or at least partially estimate their economic importance in monetary terms. Valuing biodiversity helps to underline its economic importance. It can also provide an important and much needed justification for taking action to conserve biodiversity, as an integral part of economic growth and development strategies. Biodiversity typically has economic significance for many people, at most levels, and its loss or degradation can impose untenable costs throughout the economy.

Many examples can be found of the economic importance of biodiversity in eastern and southern Africa, at global, regional, national and local levels. As an example, Djibouti's forests and coral reefs together provide carbon sequestration services, which in turn help to mitigate the effects of global warming, to a value of nearly US\$ 1 million a year). Another example is Kenya's wildlife: the attractiveness of its component species to people in other countries is reflected in a global tourist surplus of over US\$ 450 million a year from with the mixture of savannah wildlife species in Kenya's protected areas<sup>4</sup>. Also the global value-added of Eritrea's exports of marine resources is about US\$ 63 million a year (Emerton 1999).

The economic value of countries' biodiversity is typically high in overall terms. For example biodiversity has been estimated to yield annual values in excess of US\$ 310 million in the Seychelles, US\$ 750 million in Uganda and some US\$ 350 million in Eritrea. However, biodiversity plays an extremely important part in national economies and in the outputs of their component sectors. In the Seychelles, for example, biodiversity-related goods and services contribute nearly a fifth of GDP, a quarter of national employment, more than a third of government revenues, three quarters of foreign exchange earnings and in excess of 95 percent of export earnings. Over half of Uganda's GDP is biological resource-based, and Eritrea's biodiversity contributes over US\$ 40 million a year to the commercial output of the energy, forestry and fisheries sectors.

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<sup>4</sup> Refer to module 9 for examples on how to value natural resources and the environment.

Biodiversity is also extremely important at the local level in many eastern and southern African countries, and plays an especially significant role in rural livelihoods. For example up to half of the per capita income of rural households in Eritrea is contributed by biodiversity, and forest biodiversity generates over a third of the cash income of households living around Chibwe National Forest in Zambia. Many of the pastoralist livestock herds in eastern Africa would find it impossible to survive through dry seasons without the plant diversity found in forests and wetlands. Throughout eastern and southern Africa a range of different wild food sources provide ultimate fallback when households are faced with drought or crop failure.

### **3.3.4 Biodiversity Loss as an Economic Problem**

Throughout the region, pressure from rapidly expanding human populations and economic activities are reducing biodiversity at rates greater than that even of major extinctions, including the demise of the dinosaurs. This loss of biodiversity threatens to undermine both the natural ecology and the sustainability of the human economies of the regions.

The 25,000 km<sup>2</sup> Serengeti ecosystem contains 30 species of ungulate, 13 species of carnivores, and 500 bird species, but is unique for the sheer number of individual animals which undertake long-distance migrations in search of seasonally growing vegetation. Around 1.3 million wildebeest and more than 0.5 million zebras and other ungulates move over hundreds of kilometres, accompanied by the lions, cheetah and hyenas which prey upon them. This unique wildlife phenomenon is increasingly threatened by changing land use, as previously pastoral communities convert to crop agriculture, and animal migration routes are blocked by fields and fences. There are many other examples of the human modification of natural ecosystems, which is widespread throughout eastern and southern Africa. For example, forest cover in Uganda has declined from nearly half of the country in 1890 to less than one fifth today, and more than 7 percent of wetlands have been drained and put under agriculture.

Ecosystems such as the Serengeti or Uganda's forests and wetlands may be under threat, but Lake Victoria, spanning Kenya, Tanzania and Uganda, has passed beyond the threat stage.

Already over 200 species of fish, not found anywhere else in the world are extinct – gone forever. The ecology of the lake has collapsed as the result of pollution, invading plants and introduced predatory fish and another 300 species are still declining in number. Similar threats are now developing in Lakes Tanganyika and Malawi.

Invading plants (such as pines and acacias) are also the root cause of the threats to the unique plant species of the fynbos habitat in South Africa. In addition to the loss of species, this invasion is disrupting important ecosystem services provided by the fynbos-covered hills, which form the water catchment area for Cape Town. As the trees spread on the hills, they retain water and evaporate it to the atmosphere instead of allowing it to run-off and form the supply for Cape Town.

These scenarios can be repeated for other species throughout the region, from the fynbos to the eastern Arc Mountains of Tanzania and the Ethiopian highlands, where each species extinction removes another unique evolutionary lineage, which is impossible to replace.

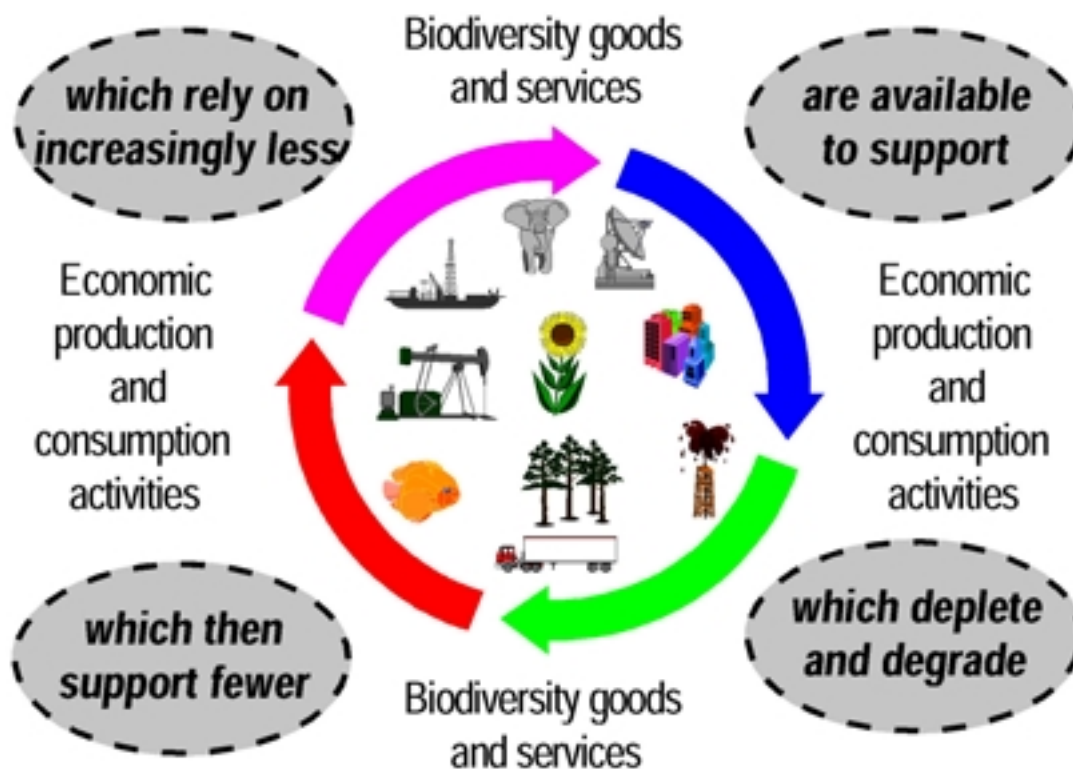
The biodiversity degradation and loss described above is an economic, not just a biological or ecological problem – in its causes as well as its effects. Isolating the direct causes of biodiversity degradation and loss forms an important step in the economics of biodiversity, and is given great emphasis in the CBD. Most biodiversity loss can be attributed to human sources, and occurs as a direct result of economic production and consumption activities, including:

- **Over-exploitation of biological resources:** Economic activities degrade biodiversity when they use up particular biological resources at a rate faster than that at which they can regenerate naturally – for example through indiscriminate logging of indigenous hardwoods, overfishing of commercially-valuable species or agricultural land exhaustion.
- **Conversion or modification of natural habitats:** Economic activities degrade biodiversity when they convert natural habitats to other land uses or fragment them – for example through diversion of rivers for dams, clearfelling of natural forests for settlement or draining of wetlands for agriculture.

- **Interference with environmental quality:** Economic activities degrade biodiversity when they add pollutants, wastes and effluents to the air, land and water – for example through acid rain impacts on forests, untreated agrochemical disposal into water courses or dumping of oil and shipping wastes into the sea.

The economic costs of biodiversity degradation are typically huge, resulting in the loss of some or all of the values described above in section 3.3.3. They are also progressive: as economic activities degrade biological resources and their diversity, they increasingly undermine their own production base and preclude the possibility of production and consumption in the future. This results in a downward spiral of decreasing economic opportunities, declining economic growth and increasing economic insecurity as biodiversity becomes more and more degraded (Figure 3.3). Imagine the implications of biodiversity degradation for economic growth in countries such as the Seychelles where three quarters of foreign exchange is generated by biodiversity-related goods, or Uganda, where over half of GDP is contributed by biodiversity.

This downward spiral has implications for economic efficiency. It can also impact negatively on the ability of different groups and individuals to secure livelihoods and economic opportunities. The groups who bear the costs associated with biodiversity loss are not necessarily those who are causing degradation, either spatially or temporally. For example many of the indirect effects of biodiversity degradation such as poor health, loss of earnings or ecological disaster are felt by poorer people who lack the resources to cope with these costs, or will be felt by future generations as a result of activities carried out today. It is questionable whether biodiversity degradation-related losses are tolerable in economic terms for groups such as the rural households in Eritrea for whom more than half of livelihood value depends on biodiversity. A similar case can be made for the pastoralist communities across eastern Africa who each year depend on wild plant diversity for the survival of their livestock herds. Identifying, and where possible quantifying, the economic overall impacts of biodiversity degradation and for different economic sectors and groups, forms an important step in understanding the economics of biodiversity.

**Figure 3.3: Downward spiral of biodiversity degradation and economic loss**

### 3.4 FOREST RESOURCES

Forests are valuable resources in the region, providing a range of marketed and non-marketed benefits. Market benefits include commercial wood production and secondary processing. Lumber, pulp, paper and panel products, commercial fuelwood and charcoal are good examples. Other forest products that might be marketed include poles for fencing and building materials, fodder, fruits and other foods, medicines, bark for weaving, and honey. Many of these products are also directly consumed instead of being traded. Non-market benefits include ecological services such as providing shelter from wind and sun, creating a habitat for fauna, and helping maintain water quality downstream by stabilising soil.

These benefits are derived from both natural, indigenous forests and commercial plantations, the latter usually of exotic species such as pine and eucalyptus. Zambia and Tanzania have the largest forest areas (Table 3.5). Kenya, Tanzania and South Africa have the highest total roundwood production, which includes commercial roundwood (export logs or logs for domestic lumber, pulp, paper, and veneer processing) and energy roundwood (fuelwood and charcoal production). For the region, approximately 81 percent of all roundwood is consumed for energy. Kenya and Tanzania have extremely high domestic production of fuelwood and charcoal.

**Table 3.5: Forest area and production, eastern and southern Africa**

HDI Ranking	Country	Total Forest 1995 (000' ha)	Average Annual % Change Since 1980	Average Annual Roundwood Production, 1993-95 (000' m <sup>3</sup> )					Balance of Trade for Roundwood Average, 1993-95 (million US\$)
				Total Production	Fuel and Charcoal	(%) of Total	Industrial Roundwood	(%) of Total	
61	Mauritius	12	0.83	18	8	44.4	10	55.6	-2148
90	South Africa	8499	-0.14	23978	7162	29.9	16816	70.1	161545
97	Botswana	13917	-0.50	1538	1443	93.8	95	6.2	x
114	Swaziland	146	0.00	1469	560	38.1	909	61.9	x
118	Namibia	12374	-0.30	x	x	x	x	x	x
129	Zimbabwe	8710	-0.71	8075	6269	77.6	1806	22.4	1511
134	Kenya	1292	-0.39	40353	38462	95.3	1891	4.7	35
137	Lesotho	6	10.04	690	690	100.0	x	x	x
143	Zambia	31398	-0.92	14422	13341	92.5	1081	7.5	1286
149	Tanzania	32510	-1.13	35680	33533	94.0	2147	6.0	1718
152	Madagascar	15106	-0.92	10456	9950	95.2	506	4.8	121
159	Uganda	6104	-0.90	16684	14466	86.7	2218	13.3	x
161	Malawi	3339	-1.43	10196	9669	94.8	527	5.2	21
166	Mozambique	16862	-0.70	17852	16844	94.4	1008	5.6	1232
168	Eritrea	282	0.00	x	x	x	x	x	x
170	Ethiopia	13579	-0.50	46003	44279	96.3	1724	3.7	122
Regional Average			0.15			80.9		20.5	

Source: WRI (1999).

South Africa is the region's largest commercial roundwood producer with an average output of almost 17 million m<sup>3</sup> during 1993-95. The balance of trade for roundwood, measured in product values for 1993-95, is generally positive for countries where data exist. The exception is Mauritius.

A major regional environmental issue is deforestation, which is linked to soil erosion. The data indicate that from 1980, the average annual change in forest cover was 0.15 percent. This value is surprising, however the figures are masked by the major positive value for Lesotho. If this anomaly is removed, the regional average drops to -0.51 percent per annum. Extrapolating this

value from 1980 to 1999 means an aggregate loss of forest cover of almost 10 percent. In most countries, the predominant cause of forest decline is land conversion to agriculture. The above figure does not include forest degradation from unsustainable forestry practices. Therefore, the regional average (net of Lesotho) is an underestimate of forest loss. The bulk of forest decline occurs in natural, indigenous stands. Commercial plantations tend to be reforested to various standards following harvesting, however a major debate exists about the environmental impacts of exotic trees, especially on the water table. Short-term economic returns might be higher with exotics but if environmental costs are measured, the viability might be less attractive.

The loss of indigenous forests is serious because these ecosystems represent islands of natural biodiversity that have taken centuries to develop. These forests support the basic needs of a high proportion of rural inhabitants. Loss of indigenous forest cover reduces potential market and non-market benefits at the community level. Another consequence of indigenous forest loss is the additional time required by rural people (usually women) to collect fuelwood. This in turn means less time for agricultural production, lower family income from farming, and possibly even reduced family nutrition.

### **3.5 FRESHWATER RESOURCES**

While the world's oceans contain a virtually unlimited supply of water, the supply of freshwater for human consumption is a finite resource. The demand for freshwater continues to grow with the human population to satisfy commercial and domestic needs. Within the eastern and southern African region, countries in the south, such as Zimbabwe, Namibia, Botswana and South Africa face ongoing challenges to supply enough surface water to meet growing demands. Periodic droughts put enormous pressure on water supplies. As surface water supplies become uncertain, for example during a drought, groundwater sources are increasingly tapped. In Namibia, there are more than 100,000 registered boreholes. Since 1970, the number of boreholes where the date and location were specified increased from about 8,000 to 16,000 (Lange *et al.* 1997). The principle concern with this strategy is that little information exists on the capacity and

natural recharging rate for major groundwater sources in the region. There is a very real danger that some aquifers are being depleted faster than they can recharge.

Within the region, data are available for surface water showing per capita consumption versus water flow, and estimated withdrawals by sector (Table 3.6). Annual internal renewable water flow ranges from 789 m<sup>3</sup> per capita in Eritrea to more than 20,000 m<sup>3</sup> per capita in Madagascar. Comparing annual internal withdrawals of freshwater allows a ratio of withdrawals to water flow.

The ratio ranges from 0.7 percent in Mozambique to approximately 42 percent in Swaziland. South Africa and Mauritius are next highest at 36 and 21 percent respectively. These figures do not look alarming. However, within a country, local water constraints could be a problem.

More important is the quality of delivered water, especially for human consumption. Unsafe water can lead to serious health problems and subsequent increased medical costs, lower labour productivity, etc.

For the region, more than three-quarter of all freshwater withdrawals from surface flows is consumed by the agricultural sector. This raises questions over water pricing relative to economic rent and delivered marginal costs. Inappropriate pricing through subsidies can lead to excess consumption. Domestic withdrawal accounted for 16 percent and reflects the low level of urbanisation in the region. Urban-rural migration will no doubt increase the proportion of people living in cities and hence, demand for domestic water. Industrial withdrawals accounted for less than 7 percent of the total, and mirror the low level of industrial activity in most countries. Exceptions are Botswana and Lesotho, where industrial consumption was more than 20 percent of total withdrawals.

**Table 3.6. Annual surface water balance, eastern and southern Africa**

HDI Rank 1994	Country	Annual Internal	Annual Internal	Ratio of	Sectoral Withdrawals (%)		
		Renewable Water Flow M <sup>3</sup> /Capita	Withdrawals of Freshwater M <sup>3</sup> /Capita	Withdrawals to Annual Flows (%)	Domestic	Industrial	Agriculture
61	Mauritius	1915	410	21.4	16	7	77
90	South Africa	1011	359	35.5	17	11	72
97	Botswana	1870	84	4.5	32	20	48
114	Swaziland	2836	1171	41.3	2	2	96
118	Namibia	3751	179	4.8	29	3	68
129	Zimbabwe	1182	136	11.5	14	7	79
134	Kenya	696	87	12.5	20	4	76
137	Lesotho	2395	30	1.3	22	22	56
143	Zambia	9229	216	2.3	16	7	77
149	Tanzania	2485	40	1.6	9	2	89
152	Madagascar	20164	1579	7.8	1	0	99
159	Uganda	1829	20	1.1	32	8	60
161	Malawi	1690	98	5.8	10	3	86
166	Mozambique	5350	40	0.7	9	2	89
168	Eritrea	789	x	x	x	x	x
170	Ethiopia	1771	51	2.9	11	3	86
	Regional Average			10.3	16.0	6.7	77.2

Source: WRI (1999).

### 3.6 ENERGY RESOURCES

Energy is a fundamental requirement for industrial development and improving human welfare. Heating, cooking, industry, transportation, lighting and modern telecommunications all rely on energy. Shortages of energy could be a serious impediment to economic growth that is required in the region to increase national incomes and address poverty. Developing countries use one-sixth the energy per capita as northern, industrialised nations. Yet, developing countries face a paradox. Cheap energy is needed to fuel economic and social transformation but at the same time, widespread subsidies do little to encourage energy conservation. Inefficient energy consumption can result in serious environmental impacts, particularly in urban areas.

Within the eastern and southern African region, the majority (69 percent) of fuel consumed is from commercial sources such as coal-fired thermal and hydro-generated electricity (Table 3.7). Traditional fuels such as wood and charcoal comprise the remainder. South Africa heavily weights this regional picture. Removing South African data results in a significantly different

portrait of energy consumption, with 79 percent from traditional sources and only 21 percent from commercial sources. This result emphasises the importance of wood and charcoal energy in the region. It also reflects the high rural population and loss of forest cover.

**Table 3.7: Energy consumption, percentage changes since 1985 and lead concentration in petrol, eastern and southern Africa**

HDI Rank 1994	Country	Total Energy Consumption		Percentage Change		Maximum Concentration of Lead in Petrol 1992-96 (gm/ltr)
		1995 (petajoules)		Since 1985		
		Commercial Fuels	Traditional Fuels	Commercial Fuels	Traditional Fuels	
61	Mauritius	21	13	134	-26	0.40
90	South Africa	3659	151	-16	13	0.40
97	Botswana	x	x	x	x	0.44
114	Swaziland	x	x	x	x	x
118	Namibia	x	x	x	x	0.40
129	Zimbabwe	128	74	-7	7	0.84
134	Kenya	111	388	82	17	0.40
137	Lesotho	x	x	x	x	x
143	Zambia	50	135	-10	29	x
149	Tanzania	34	134	24	29	x
152	Madagascar	17	105	13	66	0.80
159	Uganda	16	149	65	38	0.84
161	Malawi	12	103	38	-22	0.53
166	Mozambique	16	170	8	21	0.65
168	Eritrea	x	x	x	x	x
170	Ethiopia	43	449	64	29	0.76
	Total	4107	1871			
	Regional Average			35.9	18.3	0.59

Source: WRI (1999).

The consumption of commercial fuels has increased by approximately 36 percent since 1985 while traditional fuel consumption has increased by 18 percent. These values reflect growing rural-urban migration within the region, and to a lesser extent, rural electrification in some countries. As country incomes gradually increase, a growing urban middle-class can afford to purchase a private motor vehicle. One environmental concern is the impact of vehicle emissions on human health in large urban centres. There are two main concerns. First, cheaper second-hand cars are finding their way into the regional market. These vehicles do not meet tougher

emission standards in developed country markets. They are “dumped” in the region, in part because of high demand for cheaper cars, and from a lack of clear and measurable air quality standards in many countries. Second, these vehicles use leaded petrol (ignoring diesel engines). Table 3.7 provides data on lead concentrations in petrol, averaged over 1992-96. The average for eastern and southern Africa is 0.58 grams per litre with a range from 0.40 to 0.86. By contrast, western European countries have a range from 0.00 to 0.40 grams per litre. New vehicles in North America were required to use lead-free petrol from 1975. Consequently, lead is no longer a health issue. In Western Europe, similar legislation was passed in 1993 and as a result the market share of unleaded petrol is expanding rapidly.

With the exception of South Africa, the market share of unleaded petrol in the region is either zero or very negligible. The market share of unleaded petrol in South Africa is approximately 12 percent. A number of serious health impacts result from lead absorption into the bloodstream, including retarded brain development in young children. As urban air pollution from the consumption of fossil fuels increases in the region, long-term health impacts will become a growing concern. More broadly, emissions from fossil fuels contributes to global warming and acid rain, although the share of emissions from developing countries is insignificant compared to industrialised countries in the north.

### **3.7 MINERAL RESOURCES**

For several countries in the region, primary production of minerals is an important component of GDP, exports and employment. South Africa, Botswana, Namibia, Zimbabwe and Zambia are major mineral producers (Table 3.8). Copper has the highest production tonnage from the minerals listed in Table 3.8. The region is a significant producer of precious metals such as gold and silver. Diamonds are not listed, but are highly valuable mineral exports from South Africa, Namibia and Botswana. As an example, diamond production accounts for more than five percent of total GDP in Namibia (Lange and Motinga 1997).

**Table 3.8: Selected mineral production, eastern and southern Africa**

HDI Rank 1994	Country	Production of Selected Minerals, 1995 (metric tonnes)							
		Iron	Copper	Silver	Gold	Sulfur	Salt	Nitrogen	Cement
61	Mauritius	x	x	x	x	x	x	x	x
90	South Africa	19806	199600	174	524	509	313	600	9071
97	Botswana	x	21029	x	0.09	x	208	x	x
114	Swaziland	x	x	x	x	x	x	x	x
118	Namibia	x	22530	66	2.1	x	300	x	x
129	Zimbabwe	160	9500	10	24.3	x	x	70	1000
134	Kenya	x	x	x	0.2	x	x	x	1500
137	Lesotho	x	x	x	x	x	x	x	x
143	Zambia		329200	14	0.1	x	x	10	300
149	Tanzania	x	x	x	0.1	x	x	x	800
152	Madagascar	x	x	x	0.5	x	30	x	60
159	Uganda	x	x	x	x	x	5	x	130
161	Malawi	x	x	x	x	x	x	x	139
166	Mozambique	x	x	x	0.9	x	40	x	20
168	Eritrea	x	x	x	0.1	x	255	x	350
170	Ethiopia	x	x	x	4.5	x	5	x	611

Source: WRI (1999).

Minerals are a non-renewable natural resource. As reserves are gradually depleted, the economic benefits from mining activity also decline. Countries like South Africa that are heavily dependent on mining for economic growth must develop strategies to diversify into renewable-resource based industries and services such as finance and tourism. Environmental concerns from mining are related to loss of biodiversity and productive soil (from strip mining), leaching of toxic materials from mine tailings and contamination of surface and ground water, excess dust and noise. As countries in the region implement sound environmental assessment policies, many of the impacts from new mining projects will be reduced. However, the problem of what to do with old mine sites remains.

There is also evidence (Auty and Mikesell 1998) of the so-called “resource curse” phenomenon. This implies a lower rate of economic diversification among developing countries that has a rich mineral base and hence lower level of development.

### **3.8 INDUSTRY AND THE ENVIRONMENT**

Natural resources are only measured by conventional national income statistics such as Gross Domestic Product, when they are extracted and marketed. For many natural resources, contribution to GDP occurs at least twice, first during the initial extraction, and second, during subsequent processing. Mining and petroleum industries often see the raw material used as an input into downstream processing, for example silver used to manufacture film, and crude oil into chemicals or petrol. Forestry is a good example of additional processing where raw timber is manufactured into lumber and pulp, and then tertiary manufacturing into furniture and various grades of paper.

As illustrated in Module 2, economic activity uses natural resources as production inputs towards final outputs and at the same time generating waste into the environment. Table 3.9 shows that in 1995, industrial activity contributed just over one-quarter to total regional GDP. The range among countries is 10 percent for Ethiopia and 46 percent for Namibia. With a few exceptions, countries with the higher GDP per capital tended to have larger industrial sectors. As countries try to implement policies to increase economic growth, industrial development is often a central feature. Under the sustainable development models shown in Module 2, industrial growth (usually in urban centres), can increase air and water pollution, and improper disposal of hazardous substances.

**Table 3.9: Industrial activity and GDP, eastern and southern Africa**

Country	HDI Rank	HDI Score	GDP/Capita (PPP 1995) (\$)	Distribution of GDP		
	1994	1994		1995 (%)		
				Agriculture	Industry	Services
Mauritius	61	0.831	13,270	9	33	58
South Africa	90	0.716	5,240	5	31	64
Botswana	97	0.673	5,630	5	46	48
Swaziland	114	0.582	2,950	x	x	x
Namibia	118	0.570	4,100	14	29	56
Zimbabwe	129	0.513	2,140	15	36	48
Kenya	134	0.463	1,430	29	17	54
Lesotho	137	0.457	1,240	11	40	49
Zambia	143	0.369	990	22	40	37
Tanzania	149	0.357	670	58	17	24
Madagascar	152	0.350	680	34	13	53
Uganda	159	0.328	1,490	50	14	36
Malawi	161	0.320	770	42	27	31
Mozambique	166	0.281	910	33	12	55
Eritrea	168	0.269	x	11	20	69
Ethiopia	170	0.244	460	57	10	33
Total						
Regional Average		0.458	2,798	26.3	25.7	47.7

Source: WRI (1999).

### 3.9 MONITORING ENVIRONMENTAL CHANGE

#### 3.9.1 Background

The preceding sections imply that serious natural resource loss and environmental degradation is occurring within the region. Environmental issues such as deforestation, soil erosion, urban and industrial pollution, and loss of biodiversity are generally acknowledged. A major constraint to addressing these issues however, is inadequate information to aid in our understanding of ecological processes, and lack of an efficient system for monitoring and reporting on changes in natural resource and environmental quality. The preceding sections have portrayed a rough picture of natural resource and environmental change at a broad national and regional level. However, decision-makers within countries require environmental information at local as well as national levels. Without high-quality information on environmental changes, including natural resource use, inappropriate policy decisions might be made or alternatively, no decisions

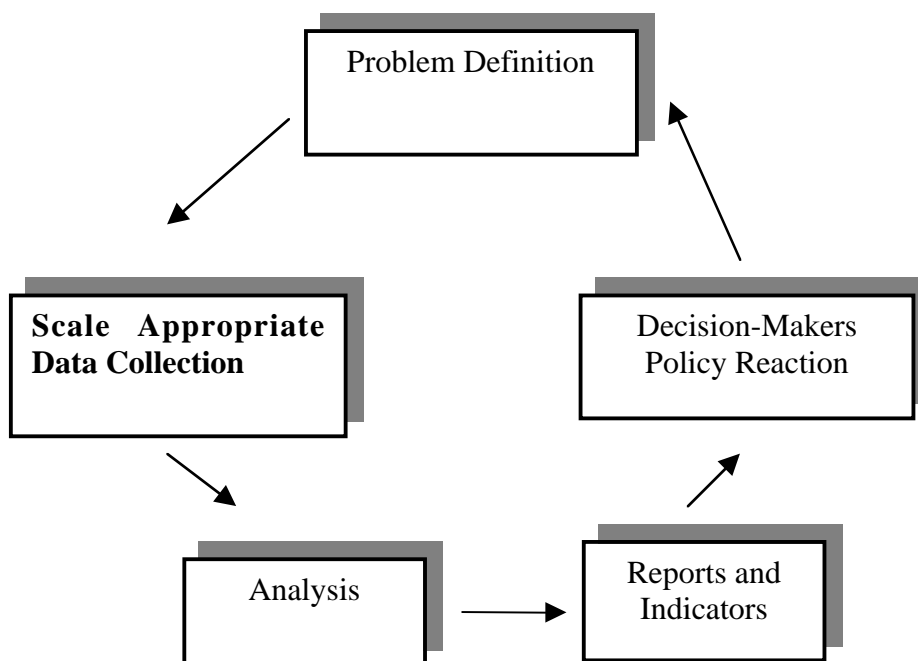
developed to correct a degrading environment. Good information is an essential but insufficient prerequisite for good policy.

### 3.9.2 Environmental Monitoring

Monitoring is the *institutionalised and ongoing observation of conditions and trends in a target sector to answer the specific information needs of a policy-maker, decision-maker, or resource manager* (Rodenburg 1995). Monitoring for environmental sustainability requires an information system with the following characteristics:

- Identified users who help define the system;
- A problem focus based on user's information needs;
- The collection of spatial and temporal data, and indicators;
- A framework for analysis appropriate to the problem;
- Data availability;
- Reporting requirements; and
- Responsibilities identified for follow-up actions based on reports.

A model for a typical environmental monitoring system has five key steps, which encompass the previous characteristics (Figure 3.4). The **problem definition** must define the audience or users. Some systems are designed for resource managers, others for Parliamentarians or an Environment Council. When an environment agency is developing a monitoring system, the principal users should be involved in the design. Having a system designed to meet the needs of an amorphous group called “decision-makers” can lead to failure. The system might be developed but no follow-up actions or response will occur. A specific user group must be identified, preferably one that can formulate and implement decisions or policy regarding natural resources and the environment.

**Figure 3.4: Environmental monitoring system**

Source: Rodenburg (1995).

**Scale-appropriate data collection** is critical. Key questions relate to the time horizon for data and the spatial scale. The time horizon must be long enough to establish consistent trends in natural resource use and environmental degradation. Data can either be coarse or intense depending upon needs and budgets. Data collection that is too coarse, for example at a national level, can miss specific local changes. The costs of collecting data are important. More site-specific data tend to cost more to collect and maintain. The technology towards data collection is evolving. While many data sets must be measured on the ground, aerial photography and satellite imagery offer effective means of gathering data over large geographical areas. A Geographic Information System (GIS) provides efficient computer storage and mapping. Overlays of various natural resource and environmental attributes such as topography, roads, population, forests, water systems, etc. can be managed with a GIS. On the other hand, GIS technology is expensive to procure and maintain. In many instances, large-scale maps and mylar overlays can work just as well (although more cumbersome) at a fraction of the cost.

Determining the appropriate level of technology is an important issue. In developing countries, it is often clouded by donors offering the latest in technology on short-term programmes that cannot be sustained by the host agencies. There are countries in the region where GIS's have been acquired by different resource management agencies from various donors. Each system can have different architecture, software and geographic referencing points, making collaboration among agencies impossible. This kind of "aid" represents a significant waste of resources. To address this potential problem, it is imperative that countries develop common architecture, definitions and referencing points.

Establishing a conceptual framework for natural resource and environmental **analysis** is difficult. The analysis depends on the data collected and **indicators**, which are part of the reporting process. Indicators are special data sets or transformed data that provide information to the principal users, who then can implement remedial actions and policies. This reporting function is the heart of any environmental information system. Indicators generally fall into two categories: biophysical and socio-economic. Biophysical indicators deal with changes in the natural environment, such as soil erosion or loss of forest cover. Socio-economic indicators on the other hand deal with people and economic impacts of environmental change. Examples might include changing crop yields per hectare over time, or the change in government costs per unit to treat polluted water. Indicators must be measurable and comparable over time. They require clear definitions. As an example, what constitutes a forest when classifying an area as "reforested"? What is the crown closure or tree spacing? At what age or size is a tree counted in the inventory?

An effective environmental information system will allow a country to produce periodic State of the Environment (SOER) reports for public review. Some countries in the region such as Zimbabwe legally require an SOER to be presented to Parliament and debated, much like a new budget by the Minister of Finance. This high-level user group is in a strong position to influence policy and actions that can address environmental problems.

### **3.9.3 Institutional Considerations**

Building a solid environmental information system, complete with an array of biophysical and socio-economic indicators is not simple. It requires time, financial resources and commitment from government. One key question is which agency should lead the development of an environmental information system? Some would argue that a central planning agency is best positioned since they are a powerful organisation in the national programme planning and budgeting process. Another option is a country's national statistics agency, which has expertise in collecting and managing data. Others would argue that a Ministry of Environment is best placed because of specific expertise surrounding natural resources and the environment. A guiding force is current legislation. Does it provide for a Ministry of Environment or Environment Agency to lead the development of an environmental information system? If so, does the organisation have the necessary technical capacity and financial resources to successfully undertake this task and sustain the effort over time?

It is unlikely that one Ministry would have access to all required data. This implies that formal co-operation with other agencies such as a national statistics department, Forestry Commission, National Parks, Ministries dealing with water, agriculture, industrial development, population, etc. will be required. One approach for dealing with multi-agency co-operation is to establish a national environmental statistics task force or committee to guide the process. It could be chaired by the agency with the legal mandate to design and manage the environmental information system.

## **3.10 SUMMARY**

Based on GDP per capita and the Human Development Index, the majority of countries in the region are classified under low human development. Various economic and social statistics lag far behind developed countries in the north. Although the share of GDP in regional countries is gradually shifting away from agriculture to services, the dependency on natural resources and the environment for economic and social development is still very high. This dependency is

particularly high in rural areas where the majority of people live. While rural-urban migration is increasing, the level of urban population is still quite low compared to northern, developed countries.

With **agriculture**, average crop yield for cereals has increased slightly over time, although for several countries, the trend is negative. One reason for the overall positive gain in yield per hectare is likely the expanded use of fertiliser per hectare in addition to better farm extension services. Application of fertiliser can offset declining soil productivity from erosion, however the sustainability of the practice remains questionable. In real terms, the average index of value of agriculture production per capita has declined. The main reason would be the increased population in the region over time compared with little change in real agriculture commodity prices.

**Forests** are a valuable natural resource, generating a wide range of market and non-market products, and ecological services such as soil stability and water filtration. South Africa is the region's largest producer of commercial roundwood. For the region as a whole, 81 percent of all roundwood production is for energy either as fuelwood or charcoal. A major regional environmental issue is deforestation, which is linked to soil erosion. If data for Lesotho are removed (which had a major increase in forest cover), the region experienced an estimated 10 percent loss of forest cover from 1980 to 1999. In most countries, the predominant cause of forest decline is land conversion to agriculture. These losses occur primarily in indigenous forests where biodiversity is greater and a wider range of benefits can be generated. The impact is greatest at the community level. One serious consequence of deforestation is the extra time required for women to collect fuelwood.

Annual internal **renewable water flow** ranges from 789 m<sup>3</sup> per capita in Eritrea to more than 20,000 m<sup>3</sup> per capita in Madagascar. The ratio of annual internal withdrawals of freshwater to withdrawals ranges from 0.7 percent in Mozambique to approximately 42 percent in Swaziland. South Africa and Mauritius are next highest at 36 and 21 percent respectively. For the region, more than three-quarter of all freshwater withdrawals from surface flows is consumed by the agricultural sector. This raises questions over water pricing relative to economic rent and

delivered marginal costs. Inappropriate pricing through subsidies can lead to excess consumption.

**Energy** is a fundamental requirement for industrial development and improving human welfare. Heating, cooking, industry, transportation, lighting and modern telecommunications all rely on energy. Shortages of energy could be a serious impediment to economic growth that is required in the region to increase national incomes and address poverty. Cheap energy is needed to fuel economic and social transformation but at the same time, widespread subsidies do little to encourage energy conservation. Within the eastern and southern African region, the majority (69 percent) of fuel consumed is from commercial sources such as coal-fired thermal and hydro-generated electricity. Traditional fuels such as wood and charcoal comprise the remainder. This result emphasises the importance of wood and charcoal energy in the region. It also reflects the high rural population and loss of forest cover. The consumption of commercial fuels has increased by approximately 36 percent since 1985 while traditional fuel consumption has increased by 18 percent. One environmental concern is the impact of vehicle emissions on human health in large urban centres. Lead is one emission of concern. Lead concentration in petrol in eastern and southern Africa is 0.58 grams per litre with a range from 0.40 to 0.86. By contrast, western European countries have a range from 0.00 to 0.40 grams per litre.

For several countries in the region, primary production of **minerals** is an important component of GDP, exports and employment. South Africa, Botswana, Namibia, Zimbabwe and Zambia are major mineral producers. The region is a significant producer of precious metals such as gold and silver. Diamonds are highly valuable mineral exports from South Africa, Namibia and Botswana. Environmental concerns from mining are related to loss of biodiversity and productive soil (from strip mining), leaching of toxic materials from mine tailings and contamination of surface and ground water, excess dust and noise.

**Industry** is a major cause of environmental degradation, especially in urban areas. Natural resources are a major production input resulting in intermediate or final products as well as waste products generated into the environment.

A major constraint to addressing environmental issues in the region is inadequate information to aid in our understanding of ecological processes, and an efficient system for **monitoring and reporting** on changes in natural resource and environmental quality. Without high-quality information on environmental changes, including natural resource use, inappropriate policy decisions might be made or alternatively, no decisions developed to correct a degrading environment. A model for a typical environmental monitoring system must define the audience or users. A specific user group must be identified, preferably one that can formulate and implement decisions or policy regarding natural resources and the environment. Key questions relate to the time horizon for data, spatial scale and intensity. The technology towards data collection is also evolving. Determining the appropriate level of technology is an important issue. The analysis and reporting process depends on the data collected and indicators, which are part of the reporting process. Indicators are special data sets or transformed data that provide information to the principal users, who then can implement remedial actions and policies. An effective environmental information system will allow a country to produce periodic State of the Environment (SOER) reports for public review.

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