

# Connecting poverty & ecosystem services

A series of seven country scoping studies

## Focus on Mauritania



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## Connecting poverty and ecosystem services: A series of seven country scoping studies

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# Background

Ecosystems provide more than the resources needed for material welfare and livelihoods. In addition to supporting all life and regulating natural systems, they specifically provide health and cultural benefits to people. Moreover, their loss is a significant barrier to the achievement of the Millennium Development Goals related to reduction of poverty, hunger and disease. The Millennium Ecosystem Assessment (MA),<sup>1</sup> released in 2005, reported, though, that 15 of the 23 ecosystem services assessed were being degraded or used unsustainably.

In light of these findings, this report sets out to provide a preliminary review of ecosystem services in Mauritania and the corresponding constituents and determinants of well-being related to the availability of these services. This paper is one of seven scoping studies prepared by the International Institute for Sustainable Development for the United Nations Environment Programme. Other countries examined in this series are Kenya, Mali, Mozambique, Rwanda, Tanzania and Uganda. All of the papers are available online at <http://www.iisd.org/economics/>

The objective of the series is not to provide a detailed assessment of the poverty-environment linkages, but to identify the regions within the countries where critical ecosystem services for human well-being are stressed, signalling the need for immediate attention. This information is expected to inform and guide the selection of potential areas where a more detailed local-scale integrated assessment of the links between ecosystem services and human well-being can be carried out.

These reports do not cover previous policy interventions, as the local-scale integrated assessment would gather such information and report on the impacts these policies have had in the past. Lessons learned can then be used together with new knowledge gathered on the links between ecosystem services and human well-being to design more finely-tuned intervention strategies that would seek to promote the reduction of poverty and improve well-being while protecting and enhancing vital ecosystem services.

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<sup>1</sup> The Millennium Ecosystem Assessment was a four-year study requested by the United Nations Secretary General in 2001 to provide an overview of the state of the global ecosystems and the consequences of ecosystem changes on human well-being.

## Executive Summary

1. Assaba, Gorgol and Guidimaka emerge as the highest priority areas given the well-being constituents threatened and stressed ecosystem services, coupled with dense population.
2. Local-scale integrated assessments in these regions would provide valuable information of the life-determining trade-offs that are being made as agricultural production is increasing.
3. The Diarma dam serves as an example of where an attempt was made to provide more secure electricity at the expense and deterioration of ecosystem services like flood control, water regulation and soil fertility.
4. Mauritania's relatively small population is a positive factor in terms of ecosystem stresses. This may not always be the case in the future given the country's high fertility rates.
5. Urbanization is an issue in Mauritania and 50 per cent of the population is employed in the industrial and service sectors—priorities about poverty and ecosystems will need to be made.
6. Good land management practices would not only stall the encroachment of the desert, but would increase carbon sequestration and prevent the release of more carbon.

### Ecosystem services and constituents of well-being: degrees of threat by region

	Mainten- ance of bio- diversity	Food prod- uction	Water supply	Energy resources	Carbon seques- tration	Adequ- ately nour- ished	Clean water	Energy for warmth and cooking	Earn liveli- hood
Adrar	X	X	X	X	X	X	X	X	O
Assaba	<b>X</b>	<b>X</b>	<b>X</b>	<b>X</b>	<b>X</b>	<b>X</b>	<b>X</b>	<b>X</b>	<b>X</b>
Brakna	X	X	X	X	X	X	O	X	X
Dakhet Nouadhibou	X	X	X	X	X	X	X	X	O
Gorgol	<b>X</b>	<b>X</b>	<b>X</b>	<b>X</b>	<b>X</b>	<b>X</b>	<b>X</b>	<b>X</b>	<b>X</b>
Guidimaka	<b>X</b>	<b>X</b>	<b>X</b>	<b>X</b>	<b>X</b>	<b>X</b>	<b>X</b>	<b>X</b>	<b>X</b>
Hodh ech Chargui	X	X	X	X	X	X	X	X	X
Hodh el Gharbi	X	X	X	X	X	X	X	X	X
Inchiri	X	X	X	X	X	X	X	X	O
Tagant	X	X	X	X	X	X	X	X	X
Tiris Zemmour	X	X	X	X	X	X	X	X	O
Trarza	X	X	X	X	X	X	X	X	X

- X indicates an ecosystem service or well-being constituent under threat in the particular region
- O indicates that an ecosystem services of well-being constituent in not under threat
- **Bold** highlights those areas of immediate priority

## Ecosystem Services

The literature review of Mauritania's ecosystem services revealed five critically stressed ecosystem services in Mauritania: maintenance of biodiversity; food and fibre provision; water supply, purification and regulation; fuel provision; and carbon sequestration.

### Maintenance of biodiversity

Mauritania boasts significant biodiversity, but over-hunting, habitat loss and competition with livestock are the primary reasons for the decline of many critically endangered species as well as the now extinct wild oryx population. Marine species are equally threatened with accidental fishery by-catch, over-harvesting, habitat loss, invasive species and pathogens. In addition, the country has experienced decreased vegetation covers. In the Senegal River valley, there is considerable population growth accompanied by urban and industrial development and expansion. The Diama dam project in the Senegal River floodplain has not met its targets for increasing agricultural production, and has also destroyed downstream ecosystems upon which food production and biodiversity depend.

### Food and fibre provision

Growing enough food for human and livestock consumption is dependent on fertile soils, soil moisture and adequate climatic conditions, but a number of these services are in decline. However, food production is in decline, and in 2004 Mauritania's aggregate cereal production is estimated to have fallen by 44 per cent from the previous year. Food production faces substantial natural constraints with the most significant being prolonged and periodic drought. Desertification threatens Mauritania's drylands which cover 100 per cent of the country's agriculturally productive area. In general, arable land with suitable soil is scarce covering less than one per cent of the country. In addition, 60 per cent of farms are under one ha and there is a lack of secure land tenure, thus farmers are not motivated to make investments in agriculture, which further encourages soil degradation. The availability of water is the main limitation to agricultural production with natural disasters such as floods and pests negatively impacting production.

### Water supply, purification and regulation

Mauritania's main source of water is rain and is highly dependent on water flowing from other countries. Agriculture uses 92 per cent of the water. Mauritania depends on upstream countries for over 90 per cent of its total renewable water resources and under these conditions is expected to experience water scarcity by 2025. Water contamination is also an issue as perennial surface water is frequently contaminated by pathogens which pose a serious risk for human health. The construction of the Diama dam also reduced a once productive floodplain into a dry saline desert.

### Fuel provision

Biofuels are the main source of energy in Mauritania and most are fuel wood gleaned from forests. In the Sahara, where vegetation is lacking, camel dung is an important fuel source. Fuel wood is becoming increasingly scarce due to decreasing forest area which is primarily caused by drought, fires, over-grazing and clearing for agricultural purposes.

### Carbon sequestration

Carbon dioxide induced climate change and desertification are connected through land degradation and precipitation. Stemming the loss of vegetation in drylands has significant potential for carbon sequestration and greenhouse gas storage. As well, because drylands contain the greatest proportion of the world's soil carbonate, wind and water erosion potentially have a very serious effect on the country's carbon stores and there is a huge potential for increasing soil carbon uptake through soil conservation. Expanding land degradation, deforestation and desertification are serious problems in Mauritania that are augmenting negative feedback loops, thus increasing exposure to climate change.

## Human well-being

Human well-being is multi-dimensional with many constituents and is closely linked with the state of ecosystem services. This report focuses on those well-being determinants that are affected by the state of ecosystems services and include: ability to be adequately nourished; ability to access adequate clean water; ability to have energy and to keep warm; and ability to earn a livelihood.

### **Ability to be adequately nourished**

Food insecurity affects the population at large in Mauritania with over one million people experiencing food insecurity. This well-being constituent is closely linked with the ecosystem service of food production, as illustrated by the devastation of recent crop harvests due to poor rainfall and pests leaving only two months worth of food. Rising food prices have also affected people's ability to buy food.

### **Ability access clean water**

Today, 63 per cent of Mauritania's population is without sustainable access to an improved water source. This well-being constituent is clearly linked to the ecosystem service of water purification, as much of the water available in Mauritania is of tenuous hygienic quality. In urban areas, the ability to access clean and adequate water is also a function of economic entitlements.

### **Ability to have energy to keep warm and cook**

Woodfuel to keep warm and cook is used by 85 per cent of the population. This is clearly connected to maintenance of biodiversity and forests as they are being consumed at an unsustainable rate. This has led to further stresses in urban and peri-urban areas, as more people are flocking to populated areas seeking employment because fuel wood production is dropping in rural areas.

### **Ability to earn a livelihood**

Currently in Mauritania, 57 per cent of the population lives below the poverty line. Human induced ecosystem degradation has lowered Mauritians' ability to earn a living whether that is through agriculture or fisheries. For example, dam construction in the Senegal River estuary has devastated a perennial grass that women used for weaving, which earned a substantial portion of their income.

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# Introduction

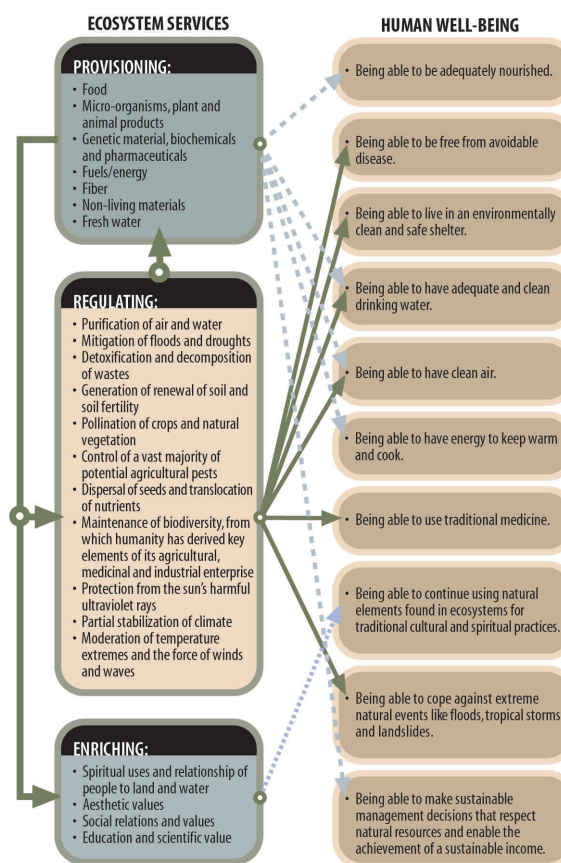
The primary objective of this report is to identify regions within Mauritania where critical ecosystem services for human well-being are stressed. These regions were identified through an extensive literature review and research which spatially connected ecosystem services and human well-being within Mauritania. The framework of ecosystem services and human well-being categories developed by the Millennium Ecosystem Assessment, illustrated in Figure 1, was used (Alcamo *et al.* 2003; Duraiappah 2002; Daily 1997). This review does not intend to be an exhaustive description of all ecosystem services. Instead, it identifies those ecosystem services in Mauritania found to be deteriorating or in danger of deteriorating in the near future—in other words, ecosystem services that are stressed. Furthermore, when considering human well-being, we broaden our attention beyond the traditional constituent of material wealth (economic growth and livelihood) to also include other constituents, including: the ability to be adequately nourished; the ability to have access to freshwater; and the ability to have access to energy to keep warm and to cook, among others (Duraiappah 2004). Like ecosystem services, we only report on human well-being constituents directly or indirectly related to ecosystem services and, hence, this report should not be viewed as a comprehensive survey of all constituents of human well-being.

While not exhaustive, this overview does point out what ecosystem services and constituents of human well-being are most in need of attention and where they are located at the regional level. By taking this unique approach and using a finer spatial lens, areas where well-being and ecosystems are stressed emerge and clarify difficult trade-offs being made at the local level.

This report is organized into four sections with the first briefly describing the people and landscape of Mauritania, thus providing a backdrop for the rest of the overview. Section 2 scopes out the main ecological services stressed and pinpoints their locations.

Section 3 then discusses the related constituents of well-being that are increasingly being threatened by these deteriorating ecosystem services, and, as with ecosystem services, locates them. The concluding section co-locates those regions where ecosystem services are stressed with those where the constituents of human well-being are threatened and then briefly outlines the more outstanding trade-offs being made.

**Figure 1. The links among ecosystem services and human well-being**



(Source: Duraiappah 2002)

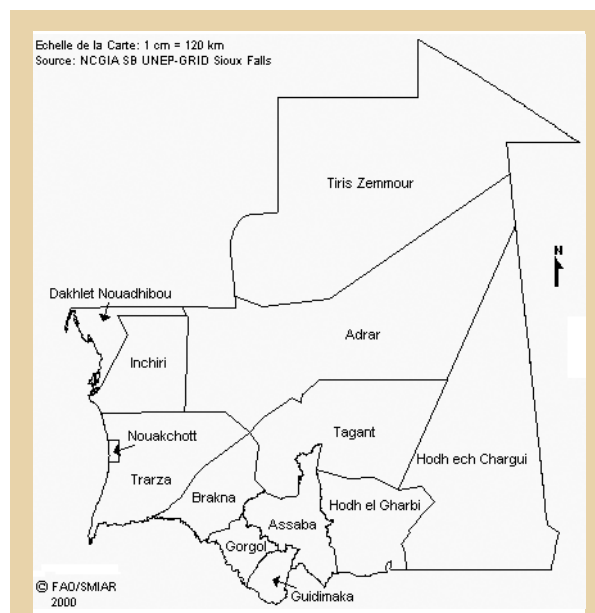


# 1.

## Mauritania in Brief

The encroaching Sahara desert dominates the landscape in this country, which is plagued by persistent droughts; even the several hundred kilometres of coastline on the Atlantic Ocean has minimal rainfall. South of the Sahara and Sahel, the country is drained by the Senegal River, creating a river valley suitable for agriculture. Sparsely populated in northern regions, the people of Mauritania are concentrated in the south near water sources; they are primarily of Arab-Berber descent, unified “through the use of various dialects of Hassaniya Arabic,” and of African descent, most being sedentary agriculturists who speak African languages (United States Library of Congress 2003).

**Map 1. Mauritania regions**



### Mauritania: Area and regions

**Total area:** 1,030,700 sq km **Land area:** 1,030,400 sq km **Water area:** 300 sq km **Length of coast:** 754 km

**Administrative divisions:** The Islamic Republic of Mauritania is divided into 12 regions and one capital district\*: Adrar, Assaba, Brakna, Dakhlet Nouadhibou, Gorgol, Guidimaka, Hodh ech Chargui, Hodh el Gharbi, Inchiri Nouakchott\*, Tagant, Tiris Zemmour and Trarza.

(FAO/SMIAR 2000)

### 1.1 Physical geography and natural environment

Mauritania is a very dry country at the western extreme of the Sahara desert, bordering the Atlantic Ocean. It consists of three distinct zones determined by precipitation, which decreases with the latitude, namely the Sahara zone, the Sahel zone, and the Sudano-Sahelian zone, bordering the Senegal River (FAO/SMIAR 2001). There are two distinct ecosystem types: tropical desert in the north covering 87 per cent of the country and tropical shrub land in the south covering 13 per cent (FAO Forestry Department 2000, 2000a; World Resources Institute 2003a).

**Climate:** On average, the country’s annual rainfall is 99 mm and the rainy season lasts only three months (FAO Land and Water Development Division 2005). Rainfall is minimal in the hyper-arid Sahara zone, which receives less than 100 mm of average annual rainfall while the arid Sahel zone to the south receives between 100–400 mm and the semi-arid Sudano-Sahelian zone receives 500 mm (FAO/SMIAR 2001). Mauritania experiences hot, dry, dust and sand-laden sirocco winds which blow primarily in March and April (Mauritania 2005). The average minimum and maximum temperatures vary between 16°C in January (Bir Mougrein) and 36°C in June (Kiffa) (FAO Land and Water Development Division 1997).

**Topography:** Mauritania has varied relief consisting of plateau, sand dunes and plains, though the terrain is mostly barren with some central hills and steep slopes of >30 per cent that cover four per cent of the land area (FAO/SMIAR 2001; United States Central Intelligence Agency 2004; FAO Land and Water Development Division 2000). The lowest point is Sebkhet Te-n-Dghamcha, at five m above sea level and the highest is Kediet Ijill, at 915 m above sea level (United States Central Intelligence Agency 2004).

**Hydrology:** The southern portion of the country is in a rather narrow basin of the Senegal River, with two major tributaries originating in Mauritania (FAO Land and Water Development Division 1997a). One tributary, the Karakoro River, flows into the Senegal River at the border between Mali, Senegal and

Mauritania. The other, namely the Gorgol River, joins the Senegal about 200 km downstream (FAO Land and Water Development Division 1997a). The Senegal River opens into a delta floodplain at the extreme southeast of the country where it flows into the Atlantic Ocean.

**Arable Land:** The available arable land is 208,000 ha, or 0.2 per cent of the nation's territory (FAO Land and Water Development Division 2000). Of that, 15.1 per cent (208,000 ha) or approximately 0.01 per cent of total land area is under cultivation, providing approximately 0.2 ha of arable land per member of the agricultural population (FAO Land and Water Development Division 2000). Permanent crops and arable land are situated in the Sahelian zone, mainly in Trarza, Brakna and Gorgol regions and throughout the Sudano-Sahelian zone (FAO/SMIAR 2001; FAO 1998b).

## 1.2 Demographics

### Box 1. Mauritania: Demographics

#### Population:

Total (July 2004 est.):	2,998,563
0–14 years:	45.9%
15–64 years:	51.9%
65 years and over:	2.2%

#### Life expectancy at birth (2002):

Average:	52.3 years
Male:	50.7 years
Female:	53.9 years

#### Fertility rate (2000–2005):

Number of births per woman:	5.8
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#### Annual population growth rate (1975–2002):

Per cent per year:	2.5
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#### Population density (inhabitants per sq km):

Average:	2
Most dense region: Gorgol Region	18.5
Least dense region: Tiris Zemrour Region	0.1
Most of the population is concentrated in Nouakchott and Nouadhibou cities along the Senegal River in the south of the country	

#### Ethnic groups:

Mixed Moor/Black:	40%
Moor:	30%
Black:	30%

#### Religion:

Muslim:	100%
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#### Languages:

Arabic Pulaar, Soninke, French, Hassaniya, Wolof

*(United States Central Intelligence Agency 2004; United Nations Development Programme 2004; FAO Land and Water Development Division 1997; FAO/SMIAR 1996).*

For centuries Arab and African cultures have influenced life in Mauritania. Formerly, in the 1960s, almost 90 per cent of the population was nomadic and rural but, due to frequent droughts and government policies, much of the population has migrated south leaving an estimated population density of only 1.8 people per square kilometre in northern regions in 1987. Many of these people headed to cities, especially Nouakchott and Nouadhibou on the Senegal River, creating many urban-based problems due to rapid urbanization (United States Library of Congress 2003).

## 1.3 Economy: Observable constraints

During the period from 1991 to 2000, Mauritania recorded an average growth of four per cent per annum, but as population was also growing, the per capita growth was only one per cent (World Resources Institute 2003ab). This growth was accompanied by a slight 1.6 per cent drop in poverty and a two per cent drop in extreme poverty (Mauritania 2000). Mauritania's economic performance has been hindered by a decline in the world demand for iron ore, leading to a balance of trade of US\$-141 million in 2000 (World Resources Institute 2003c). That same year, Mauritania qualified for debt relief under the World Bank/International Monetary Fund (IMF) Heavily Indebted Poor Country (HIPC) initiative and because of its reform efforts, received significant support from donor and lending countries at the triennial Consultative Group meeting in 2001 (United States Central Intelligence Agency 2004; United States Energy Information Administration 2004). Thus, in 2002, foreign direct investment generated a net inflow of US\$5 million and GDP grew by 3.3 per cent (World Resources Institute 2003c; Mauritania 2003). Irrespective of its improving economic situation, Mauritania remains vulnerable to several sources of instability; its economy is heavily dependent on primary products such as mining, fishing and agriculture and is exposed to exogenous factors such as extreme weather and fluctuations in international markets (United States Energy Information Administration 2004).

Despite being dominated by the world's largest desert, the Sahara, and its harsh climate, humans have flourished in Mauritania for eons. The relentless encroachment of the desert, though, is forcing

continued migration into southern areas and cities, gradually emptying northern, arid regions. As the economy flounders due to a dependency on mining, fishing and agriculture and vulnerability to extreme weather and international markets, many

Mauritanians are seeking work in other countries. Ultimately, Mauritania has few ecosystem services upon which to base human well-being when compared to many other countries in the world, making functioning ecosystems all the more critical.

### Box 2. Development and macro-economic indicators

#### Natural resources:

Iron ore, gypsum, fish, copper, phosphate (Mauritania 2005), diamonds, gold  
Iron ore accounts for almost 40% of total exports

**GDP (2003):** \$1,128 million

#### Allocation of GDP by sector:

Agriculture (7% agriculture and 15% livestock production):	22%
Industry:	31%
Services:	47%

#### Main foreign exchange by sector (2000):

*Imports:* US\$518 million:  
Machinery and equipment, petroleum products, capital goods, foodstuffs, consumer goods.  
*Exports:* US\$394 million:  
Iron ore, fish and fish products, gold

#### Main employment sector:

Agriculture:	50%
Industry:	10%
Services (2001 est.):	40%

#### GDP (constant 1995 US dollars):

2000: \$1,321 million

**Per capita income (per year):** US\$410

#### Income distribution:

Gini coefficient (100% is perfect inequity):	37
Per cent of total income earned by richest 20% of population:	44.1%
Per cent of total income earned by poorest 20% of population:	6.4%

#### Adult literacy rate (2002):

Percentage, ages 15 and above: 41.2

**Human Development Index (HDI) value, 2002:** 0.465

**Human Development Index (HDI) rank (out of 177):** 152

*(World Bank 2005; United States Central Intelligence Agency 2004; World Resources Institute 2003; African Forum and Network on Debt and Development 2003; United Nations Development Programme 2004)*

## 2.

# State of Ecosystem Services

The literature review identified maintenance of biodiversity, food and fibre provision, water supply, purification and regulation, fuel provision and partial stabilization of the climate through carbon sequestration as the five critical ecosystem services stressed<sup>2</sup> in Mauritania. We discuss each in detail below, outline some of the main factors influencing their deterioration and, where possible, identify the regions in which they are declining. In some instances, for example water, there may be deterioration in more than just one ecosystem service, which is linked to various environmental problems, while in other instances, we might see how unsustainable use of one ecosystem service may be causing a deterioration in another ecosystem service which is subsequently the underlying reason for a particular environmental problem. We start with biodiversity, which is maintained by ecosystems and underpins ecosystem functioning and hence determines the availability of ecosystem services overall.

### 2.1 Maintenance of biodiversity

Only very recently, theoretical and empirical work has identified linkages between changes in biodiversity and the way ecosystems function (Schulze and Mooney 1993; Loreau, Naeem and Inchausti 2002). The common perception of the value of biodiversity is limited to specific uses of a limited number of specific species for human use. However, there is increasing evidence, theoretical and empirical, of a much more complex relationship between biodiversity—defined as the variability among living organisms; this includes diversity within species, between species and of ecosystems. Species perform numerous services for ecosystems; for example, in many ecosystems, there are a variety of species which fix nitrogen in the soil. The importance of the composition of the species is determined by how much a loss in the ecosystem service is experienced when one or more of the species is lost. The lower the impact of a loss in species to ecosystem functions, the higher is the level of redundancy in the system.

“Functional biodiversity (the variety of different ecological functions in a community independent of its taxonomic diversity) shows patterns of association (biota typical of wetlands, forests, grasslands, estuaries and so forth) with geography and climate known as biomes with ecosystems and ecoregions being smaller divisions of biomes (Duraiappah and Naeem 2005, 21).

Based on this and according to a classification system of terrestrial ecoregions developed by the World Wildlife Fund, Mauritania has one marine and five terrestrial ecoregions<sup>3</sup> and their approximate location by region is:

1. Continental shelf and immediate marine area is part of the West African marine ecoregion (WAMER)
2. Atlantic coastal desert: Dakhlet Nouadhibou, Trarza, Inchiri regions
3. Sahelian acacia savannah: Southern Trarza, Brakna, Gorgol, Guidimaka, Assaba, Hodh el Gharbi, most of Tagant and Hodh ech Chargui and a small portion of Adrar Region
4. South Saharan steppe and woodlands: A portion of Adrar and northern Hodh ech Chargui Region
5. Sahara desert: Northern Adrar and Tiris Zemmour regions
6. North Sahara steppe and woodlands: Northwest portion of Tiris zemmour, Inchiri and small portion of Dakhlet Nouadhibou Region

### Status of biodiversity

Mauritania boasts considerable biodiversity; it is home to 1,100 known plant species, 61 known mammal species, 172 known breeding birds, 72 species of reptiles, three amphibians, and 117 species of fish (World Resources Institute 2003a). The Atlantic coastal desert is relatively rich in arid-adapted flora and is a staging area for migratory birds. While there

<sup>2</sup> Ecosystem services found to be deteriorating or in danger of being deteriorated in the near future.

<sup>3</sup> For the purposes of this discussion ecoregions and ecosystems are considered synonymous.

are almost no endemic animals here, it is the habitat of the critically endangered monk seal (Magin 2001). The much larger Sahelian acacia savannah, however, is not especially rich in species, though it was once part of the range of huge herds of ungulates, while the South Saharan steppe and woodlands has few endemic plants, but attracts grazing animals after annual rainfalls (Magin 2001a, 2001b). The Sahara, not surprisingly, has low species richness and endemism with vegetation concentrated along wadis<sup>4</sup> and dayas<sup>5</sup>, while the North Sahara steppe and woodlands has a number of plant and small animal endemics and some ungulates (Berrahmouni and Burgess 2001; Berrahmouni and Burgess 2001a).

Mauritania protects 0.2 per cent, or 250,000 ha of its land area, and 1,496,000 ha of marine and littoral areas (World Resources Institute 2003a). There are nine terrestrial reserves including: the Reserve du Moufflon Faunal Reserve; three Integral Reserves, namely Baie du Levrier (Cap Blanc), Iles Mauritanienes, and Las Cuevecillas; two National Parks, namely Banc d'Arquin and Diawling, and three Partial Faunal Reserves, namely El Agher, Elephant and Tilemsi (Mauritania 2005). Mauritania also has three Ramsar Wetlands of International Importance, covering 12,156 sq km and protects five marine or littoral areas and two World Heritage Convention Reserves on the coast (World Resources Institute 2003a; Mauritania 2005).

In 1985, UNEP and the World Conservation Union estimated that over 80 per cent of the wild habitats in Mauritania were gone already (World Energy Council 2001). Currently, there are eight critically endangered, 11 endangered and 23 vulnerable species (Mauritania 2005). Of the five critically endangered animal species, three are marine, namely the Hawsbill Sea Turtle, the Mediterranean Monk Seal and the Common Sawfish (IUCN *et al.* 2004). Another species, the Sable oryx is extinct from the wild and exists only in zoos (Mauritania 2005; IUCN *et al.* 2004). In addition, many mammal species have been extirpated from the Northern Sahara and Sahel acacia ecoregions and suffered extreme losses of numbers in all other ecoregions (Magin 2001, 2001a, 2001b; Berrahmouni and Burgess 2001, 2001a).

Agro-diversity is also rapidly being lost in the Senegal floodplain. Among threatened species are the indigenous water lily used as a cereal substitute and a floating wild rice variety, compatible with flood plain cultivation (World Commission on Dams 1999). Unfortunately, there are no details of the threatened status for 805 of Mauritania's species (Mauritania 2005).

### Factors influencing biodiversity loss

Over-hunting, habitat loss and competition with livestock are the primary reasons for the decline of many critically endangered species as well as the now extinct wild oryx population (IUCN *et al.* 2004). Marine species are affected by accidental fishery by-catch, heavy over-harvesting, habitat loss, invasive species, and pathogens (IUCN *et al.* 2004). Other factors leading to the decline of species in Mauritania are human disturbance, tourism and infrastructure development, causing habitat loss (IUCN *et al.* 2004). In addition, low rains, excessive grazing and increasing pastoralist sedentarization have decreased vegetation cover (FAO 2003). Specifically, biodiversity is threatened in coastal and marine areas and the Senegal River valley where there is considerable population growth accompanied by urban and industrial development and expansion of agriculture (Mauritania Ministry of Rural Development and Environment 1997).

The Diama dam construction in the Senegal River floodplain in Trarza Region is also causing problems. Not only has this construction project not met targets for increasing agricultural production, but it has destroyed downstream ecosystems upon which food production and biodiversity depend (World Water Forum 2001). In 1994, in the area once teeming with bird wildlife, researchers counted precisely two birds (World Water Forum 2001). However, there has been some success in restoring biodiversity to the Diawling Senegal delta, which is at the mouth of the Senegal River. It resulted in freshwater and brackish marsh fish catch increases to 113 tons/year in 1999 compared to a mere one ton/year in 1992 and biodiversity indicators to rise sharply such as the number of migrating waterfowl to rise from just 2,000 in 1992 to 38–40,000 in 1997–1999 (IUCN 2002).

4 Wadi is a valley, gully or streambed in northern Africa and southwest Asia that remains dry except during the rainy season.

5 Daya is a depression which is not salty and favourable to the development of vegetation.



## Regions most affected by biodiversity loss

- Adrar: remnant mammal fauna highly threatened by over-hunting and desiccation; tree cover in south and along wadis threatened by over-harvesting and over-grazing (no mature trees)
- Assaba: some extirpation of species, reduction of ungulate herds largely due to over-hunting and loss of vegetation and mature trees largely due to farming on marginal land
- Brakna: some extirpation of species, reduction of ungulate herds largely due to over-hunting and loss of vegetation and mature trees largely due to farming on marginal land
- Dakhlet Nouadhibou: severely degraded due to prolonged droughts, over-grazing, over-hunting, soil erosion and cutting of trees for firewood
- Gorgol: some extirpation of species, reduction of ungulate herds largely due to over-hunting and loss of vegetation and mature trees largely due to farming on marginal land
- Guidimaka: some extirpation of species, reduction of ungulate herds largely due to over-hunting and loss of vegetation and mature trees largely due to farming on marginal land
- Hodh ech Chargui: some extirpation of species, reduction of ungulate herds largely due to over-hunting and loss of vegetation and mature trees largely due to farming on marginal land (in south); remnant mammal fauna highly threatened by over-hunting and desiccation; tree cover in south and along wadis threatened by over-harvesting and over-grazing (no mature trees)
- Hodh el Gharbi: some extirpation of species, reduction of ungulate herds largely due to over-hunting and loss of vegetation and mature trees largely due to farming on marginal land
- Inchiri: severely degraded due to prolonged droughts, over-grazing, over-hunting, soil

erosion and cutting of trees for firewood; many mammals and bird species extirpated from area by over-hunting

- Tagant: some extirpation of species, reduction of ungulate herds largely due to over-hunting and loss of vegetation and mature trees largely due to farming on marginal land
- Tiris Zemmour: many mammals extirpated and remnant mammal fauna highly threatened by over-hunting and desiccation
- Trarza: some extirpation of species, reduction of ungulate herds largely due to over-hunting and loss of vegetation and mature trees largely due to farming on marginal land; severely degraded due to prolonged droughts, over-grazing, over-hunting, soil erosion and cutting of trees for firewood; Diama dam impacts on habitat and biodiversity

## 2.2 Food and fibre provision

Ecosystems provide the medium for growing the food on which humans and domesticated animals depend; this includes the vast range of food products derived from plants, animals and microbes. If the cultivation of plants for food and livestock is to succeed, then natural factors such as fertile soils, adequate soil moisture, suitable climatic conditions and a rich source of plant and animal species are necessary. Deficiencies in some of these elements or attributes can be augmented by technology through the use of fertilizers, irrigation, high-yield seeds and domesticated animals over the short term and for longer periods if managed sustainably.

### State of food and fibre provision

In Mauritania, 50 per cent of the population is primarily employed in subsistence agriculture with the main food products being cereals (63.2 per cent), meat (22.9 per cent), pulses (12.1 per cent), and roots and tubers (1.8 per cent) (Famine Early Warning System Network 2001; World Resources Institute 2003). Sorghum accounts for approximately 73 per cent of area harvested, followed by millet (12 per cent) and rice (nine per cent) (FAO 1998b). Grain production, predominately wheat, millet, sorghum and rice, is concentrated in the south, in the Sudan-

Sahelian Zone in southern Trarza, Brakna, Gorgol, Guidimaka, Assaba, Hodh el Gharbi, and Hodh ech Chargui where most of the population is located (FAO/SMIAR 1996a). In general, amounts that food products contribute to available calories are: cereals and grains 53 per cent; milk, eggs and derivatives 12 per cent; oil and fats 10 per cent; sugar 10 per cent; meat five per cent; beans three per cent; fruits and vegetables two per cent; and fish one per cent (FAO/SMIAR 2001).

Food production is on the decline. From the early 1970s to 2001, Mauritania made limited gains in agricultural productivity by expanding the area under permanent cultivation (Mauritania 2005). In 2000, rain-fed sorghum accounted for over 50 per cent, or 134,442 mt, of annual cereal production, falling to approximately one third by 2002 and by 2004 wetland cultivated rice production amounted to 77,409 mt, surpassing sorghum yields by 10,000 mt (United States Agency for International Development 2002; FAO 2000). Then in 2001, net cereal production decreased 11 per cent to 117,792 mt due to a freak storm that killed thousands of livestock and destroyed crops only to be followed by low and erratic rainfall, thus only meeting 25 per cent of annual food needs (United States Agency for International Development 2002). In the Senegal River Valley, food production dropped between 70–90 per cent and imports from neighboring Senegal also declined (United States Agency for International Development 2002). This trend has continued, in 2004 Mauritania's aggregate cereal production is estimated to have fallen by 44 per cent from the previous year (FAO 2005).

Livestock production is also a source of food and income with Gorgol Region having the most cattle at more than 100 animals per sq km in some areas (FAO 1998a). Annual meat production is about 75,427 tonnes, coming mostly from small ruminants, camels, cattle and poultry (Soule 2003). In total, the livestock sub-sector generates 15 per cent of GDP, almost 80 per cent of the agriculture sector's value, mostly through the sale of live animals (Mauritania 2000; United States Central Intelligence Agency 2004; Soule 2003). Meat production increased in the early 1990s, but is on the decline and average calories supplied from animal products per capita has dropped dramatically since 1997 (Mauritania 2005).

Milk is an important component of the Mauritanian diet generally and production is an estimated 362,866 tons with 36 per cent coming from cattle, 8.5 per

cent from small ruminants, and 55.5 per cent from camels (Soule 2003). Specifically, milk is a staple and the main source of water for survival for nomadic pastoralists occupying the southeast Hodh ech Chargui Region, areas of Tagent, Hodh el Gharbi and Adrar regions and north Tiris Zemmour Region. For all of Mauritania, consumption is 56 L per person annually, on average, but there is insufficient milk produced, necessitating the importation of milk powder and sterilized milk (Mauritania 2000; Soule 2003).

Mauritania's coastal waters are among the richest fishing grounds in the world, but less than 10,000 traditional and "artisanal" fishers make their living by marine fishing, probably due to the harsh climate and lack of drinking water and wood for energy in coastal areas (Famine Early Warning System Network [2005]). Hence, total fish and fish products comprise only four per cent of the country's animal protein supply or nine kg/person annually (World Resources Institute 2003b). Moreover, 60 per cent of food fish produced by artisanal fishermen consists of low-value, pelagic species such as cephalopods and shrimp, while most of the high-value marine species, such as tuna, are caught by licensed foreign fleets or by domestic industrial vessels for export (FAO 1992). Marine fisheries, however, dominate fish production. Inland fisheries on freshwater lagoons, rivers and lakes contribute 20 per cent of the country's total fish supply and aquaculture does not provide a substantial source of either marine or freshwater fish (FAO 1992; World Resources Institute 2003b).

Fishery production, though, is showing signs of stress. Since 1987, marine mollusk and crustacean catch, a primary source of food for the coastal population, steadily declined from 45,000 metric tons to 24,055 metric tons by 1997 (Mauritania 2005; World Resources Institute 2003b). Marine fish catch has also fluctuated and shows recent decline, from an all time high of 58,000 metric tons in 2001, to less than 57,000 within a year (Mauritania 2005). Lastly, despite its stability through the 1980s, freshwater fish catch declined between 1990 and 2000, from 6,000 to 5,000 metric tons (World Resources Institute 2003b).

### Factors influencing deterioration in food and fibre provision

Food production faces substantial natural constraints with the most significant being prolonged and periodic drought, severely affecting Brakna, Gorgol, Tagent, north Hodh el Gharbi and central Hodh ech

Chargui regions (Mauritania 2005; ReliefWeb 1997). Indeed, a high risk of desertification<sup>6</sup> threatens Mauritania's drylands which cover 100 per cent of the country's agriculturally productive area and affects 98 per cent of the population, severely limiting food production (FAO Land and Water Development Division 2000).

In general, arable land with suitable soil is scarce, covering less than one per cent of the country (Mauritania 2000; FAO Land and Water Development Division 2000). Specifically, soil is constrained by salinity over 9,000 sq km, or one per cent of total land area, and shallowness affects 226,000 sq km or 22 per cent of total area (FAO Land and Water Development Division 2000). Human-induced land degradation is also contributing to desertification and currently 26 per cent of Mauritania's territory faces severe or very severe land degradation, four per cent of which is due to agricultural activities (FAO Land and Water Development Division 2000). Over-grazing, deforestation, bush fires and soil erosion are exacerbated by episodes of drought and also contribute to desertification (Mauritania 2005; Famine Early Warning System Network 2003). In addition, 60 per cent of farms are under one ha and there is frequently a lack of secure land tenure, thus farmers are not motivated to make investments in agriculture, which further encourages soil degradation leading to desertification (Mauritania 2000).

The main limitation to agricultural production is availability of water; Mauritania is the most arid Sahelian country and there is very limited natural freshwater away from the Senegal River, the only perennial river (FAO 2003; Mauritania 2005). Farmers rely on precipitation and the natural properties of the soil to retain rain water in an environment where rain is unpredictable. The Crop Soil Water Index, which indicates soil moisture content, is low in many regions. Low soil suitability and/or erratic rainfall affect Trarza, Brakna, Gorgol, Guidimaka, Tagant, Assaba, Hodh el Gharbi and Hodh ech Chargui regions (FAO 1998). Furthermore, rain-fed crops cannot be grown in the southern portion of the country, specifically Guidimaka and the southern fringes of Hodh el Gharbi, and Hodh ech Chargui regions (Mauritania 2000). Drought has also adversely affected cattle production and caused many to leave the nomadic pastoralist system and migrate to cities (Soule 2003).

Furthermore, natural disasters including floods and pests negatively impact food production. In January 2002, torrential rains caused major damage, killing 120,000 cattle, sheep and goats, destroying 25 per cent of previously harvested crops, and ruining pastureland and property (United States Agency for International Development 2002; United States Energy Information Administration 2004). As a result of the rainstorms, 250,000 were left food insecure in Hodh ech Chargui, Hodh el Gharbi, Assaba, Gorgol, Brakna, Trarza and Tagant regions (United States Agency for International Development 2002). These floods aggravated the poor food production situation of herders in the southwest who already lacked pasture as a result of dam construction and faced deteriorating livestock health and rising animal feed costs (United States Agency for International Development 2002). Another natural disaster struck in 2004 when a locust invasion affected some 1.6 million ha causing extensive crop damage and again in 2005, locusts destroyed not only cereals, but also pulses and vegetables, creating a food deficit of 187,000 tons (U.S. Agency for International Development 2004; Mauritania 2005).

Yields are also constrained by grain-eating bird infestations and a lack of good quality seeds (United States Agency for International Development 2002). Interestingly, abnormally wet conditions indirectly limit cereal production, as grain-eating bird populations expand with the absence of dry season mortality (World Commission on Dams 1999).

Marine fishery over-harvesting by large, commercial fishers and foreign vessels threaten food security and income for many local Mauritians (United States Central Intelligence Agency 2004). Since 1996, factory-style fishing vessels of the EU, Japan and China that have been granted licences to fish off the coast of West Africa are causing "alarming reductions in fish stocks" (Labonte *et al.* 2004). Although Mauritania will receive US\$426 million from the EU for fishing rights between 2001–2006, recent over-fishing has caused serious depletions in fish stocks, and "the staple diet of coastal communities... is no longer available in some places" (Labonte *et al.* 2004).

Another factor is reduced fishing catch along the Senegal River that is attributed to development projects like dams and dikes, which have led to significant

<sup>6</sup> Desertification is "a process of soil loss and declining nutrient quality characteristic of semi-arid conditions" (FAO 1993).



decreases in salinity, the proliferation of waterweeds and eutrophication (Organization for the Development of the Senegal River 2003). As a result of Diama dam construction in the Senegal Valley, a tenacious reed (*Typha*) has replaced pasture in the former flood plain and obstructs fishing in reservoirs (World Commission on Dams 1999).

### Regions most affected by deterioration in food and fibre provision

All regions are affected by deterioration in food and fibre provision.

## 2.3 Water supply, purification and regulation

Ecosystems play a key role in the provisioning of clean freshwater, regulating the flow of water and the control of floods. The effectiveness of ecosystems to provide these services is determined largely by the quality of the country's watersheds (see Box 3).

### Box 3. What is a watershed?

A watershed is the area of land that catches rain and snow (if applicable) and drains or seeps these into a marsh, stream, river, lake or groundwater. Their primary function is to capture, store and safely release water. This function is indicated by The Internal Renewable Water Resource (IRWR). For example, as snow melts on mountain peaks in the spring, much of the water soaks into the ground, replenishing soil moisture and groundwater. This water will be a source of flow to local streams and rivers during dry seasons. Healthy soils and vegetation in the watershed are essential to proper watershed functioning (Donaldson and Swanson 2001).

Mauritania's main source of water is 94.7 cu km of annual precipitation (FAO Land and Water Development Division 2000). It has an Internal Renewable Water Resources (IRWR) of 0.4 cu km which translates to 141 cu m per capita. Tanzania by comparison has an internal renewable water resource value of 82 cu km per year and a per capita level of 2,227 cu m (World Resources Institute 2003f). On the other hand, the country has total renewable water resources per year of 11.4 cu km or 4,029 cu m/person/year with the additional 11 cu km being inflows from other countries. Tanzania by comparison has 91 cu km of total renewable water resources or 2,472 cu m per capita. Therefore, Mauritania is actually in a bet-

ter position with respect to water availability. However, it is highly dependent on the water flow from neighbouring countries and is, therefore, dependent on good water management in other countries along the Senegal River (FAO 2005; FAO Land and Water Development Division 2000; World Resources Institute 2003e).

### State of freshwater supply, purification and regulation service

Water is primarily used for agriculture, accounting for 92 per cent of water consumed, followed by domestic use at six per cent and industrial use at two per cent (FAO Land and Water Development Division 1997; World Resources Institute 2003e). Total withdrawal is roughly 1.6 cu km per year (based on 1985 data), or 923 cu m per capita, an amount that is only 22.9 per cent of the actual renewable water resources (FAO Land and Water Development Division 1997; World Resources Institute 2003e). Tanzania on the other hand has a withdrawal rate of 39 cu m per capita, an amount only 1.6 per cent of the actual total renewable resources. Even though significantly higher than Tanzania, the low withdrawal rate in Mauritania suggests that currently, there is little pressure on the country's water system in meeting demands. Although natural renewable water resources are adequate, present internal recharge rates show a shortage of water. Not surprisingly, Mauritania depends on upstream countries for over 90 per cent of its total renewable water resources and under these conditions, Mauritania is expected to experience water scarcity by 2025 (FAO 2005; UNEP 2004).

Water purification and regulation services provided by ecosystems are also under considerable strain. Even when perennial surface water is available, it is frequently contaminated by pathogens (UNEP 2004). In addition, the Senegal River's water quality and regulation have suffered as new dams and dikes, livestock run-off, and the discharge of pesticides and domestic wastewater into the river have led to organic and chemical pollution, eutrophication, the spread of water weeds, reduced oxygenation and diminished water flow velocity (Organization for the Development of the Senegal River 2003; FAO 1994). There are an estimated 5.86 natural log mm/L of suspended solids and 0.48 mg/L phosphorus in drinking water (NationMaster.com 2005). This poses serious risks for human health as water is often consumed untreated (UNEP 2004).

### Factors influencing water supply, purification and regulation services

Water resource exploitation is naturally limited by accessibility to rivers and oases, high evapo-transpiration ranging from 2,000–3,000 mm/year from south to north, and insufficient and erratic rainfall and surface flow in the seasonally dry watercourses or *wadis* (FAO Land and Water Development Division 1997; Magin 2001). In the early 1990s, the Diama dam constructed in Mauritania's portion of the Senegal delta to block the intrusion of sea water into the river valley reduced a once productive floodplain into a dry saline desert interspersed with sand dunes (IUCN 2002). Dam construction has also reduced the flow of freshwater (World Water Forum 2001). In addition, the high costs of irrigation development and groundwater extraction, insufficient investment, inadequate organization of operation schemes, and marketing problems plague water resource utilization and management (FAO Land and Water Development Division 1997).

### Region most affected by deterioration of freshwater supply, purification and regulation services

All regions lack sufficient water due to erratic rainfall, little or no groundwater for wells, drought conditions and/or pollution.

## 2.4 Fuel provision

Biofuels are the main source of energy in Mauritania and most are fuel wood gleaned from Mauritania's 317,000 ha of forest, comprised of 293,000 ha of natural forest and 25,000 ha of plantations (World Resources Institute 2003d). In 1996, total woodfuel consumption, including fuel wood, charcoal and black liquor,<sup>7</sup> was 9,000 cu m or 0.77 cu m/person/year (Amous 1999; World Resources Institute 2003d; World Energy Council 2005). In urban areas, charcoal consumption is 143 kg /capita/year, or 0.1 Tg in total (Yevich and Logan 2003). In total, woodfuel consumption for all sectors increased from 6,000 cu m in 1985 to 9,000 cu m in 1996 (Amous 1999). By 2000, woodfuel consumption was 1,865,000 cu m and is projected to increase to 2,456,000 cu m by 2010 and to 3,042,000 cu m by 2020 (FAO 2003).

Non-wood biofuels are also vital to Mauritania's fuel supply. In the Sahara desert, where vegetation is lacking, camel dung is an important fuel source (Smith

and Sanders 1997). Likewise, in the semi-arid Sub-Saharan zone where drought is frequent, there is low biomass productivity and lack of forest cover, making crop residue, particularly from millet, sorghum and maize, an important source of household fuel (Yevich and Logan 2003). Cow dung is also used (Soule 2003). The supply of both dung and crop residue fuel resources depends on the amount of livestock available and the availability of residues after harvests. There are no real estimates of the proportion of household demand that is met by these resources, however, the constraints listed earlier for food production will also be constraining factors for the availability of dung and crop residue as a fuel.

### State of fuel ecosystem service

Fuel wood is becoming increasingly scarce. From 1990–2000 natural forest area decreased by 30 per cent, and total forest area decreased by 24 per cent to approximately 4.3 per cent of total land area (Mauritania 2005; World Resources Institute 2003d). During this time period, the average annual rate of deforestation was 2.7 per cent, or -9,971 ha per year (FAO Forestry Department 2000a). Moreover, the decline in agricultural and livestock productivity imply similar circumstances for the supply of dung and crop residue as fuel. The southwestern regions Trarza and Brakna have a rate of forest loss higher than the national average. Between 1977 and 1999, in Trarza's classified forests, annual forest loss was approximately five per cent (FAO 2003). In Brakna's classified forest, annual forest loss was approximately three per cent during the same period (FAO 2003). Trarza Region also suffers heavily from livestock population declines and faces associated loss of biofuels.

### Factors influencing deterioration in biological fuel sources

The main causes for forest loss are drought, fires, over-grazing and clearing for agricultural activities (FAO Forestry Department 2000a). In west Africa generally, the leading causes of deforestation are clearing for subsistence agriculture combined with poor farming practices, livestock grazing, logging, urban development and iron-ore mining (FAO 2000; Mongabay.com). Furthermore, the banning of charcoal production and marketing in Mauritania has driven producers underground, and precluded the proper control of its production (Girard 2002).

<sup>7</sup> An indirect woodfuel recovered from paper manufacture (Amous 1999).

## Regions most affected by deterioration in energy services

- Adrar: tree cover in south and along wadis threatened by over-harvesting and over-grazing (no mature trees)
- Assaba: loss of vegetation and mature trees largely due to farming on marginal land
- Brakna: loss of vegetation and mature trees largely due to farming on marginal land; rate of forest loss higher than the national average
- Dakhlet Nouadhibou: severely degraded due to prolonged droughts, over-grazing, soil erosion and cutting of trees for firewood
- Gorgol: loss of vegetation and mature trees largely due to farming on marginal land
- Guidimaka: loss of vegetation and mature trees largely due to farming on marginal land
- Hodh ech Chargui: loss of vegetation and mature trees largely due to farming on marginal land (in south); tree cover in south and along wadis threatened by over-harvesting and over-grazing (no mature trees)
- Hodh el Gharbi: loss of vegetation and mature trees largely due to farming on marginal land
- Inchiri: severely degraded due to prolonged droughts, over-grazing, soil erosion and cutting of trees for firewood
- Tagant: loss of vegetation and mature trees largely due to farming on marginal land
- Tiris Zemmour: not known, but assume energy provision is problematic due to harsh conditions of Sahara desert
- Trarza: loss of vegetation and mature trees largely due to farming on marginal land; severely degraded due to prolonged droughts, over-grazing, soil erosion and cutting of trees for firewood; rate of forest loss higher than the national average

## 2.5 Carbon sequestration

Carbon dioxide-induced climate change and desertification are connected by feedback loops between

land degradation and precipitation (Gonzalez 2000). Carbon dioxide-induced climate change aggravates desertification by altering spatial and temporal patterns of rainfall, solar insolation and winds (Gonzalez 2000). In turn, desertification exacerbates carbon dioxide-induced climate change by releasing carbon dioxide from cleared and dead vegetation, and through the diminished carbon sequestration potential of desertified land (Gonzalez 2000).

Although considerable gaps in knowledge of these systems exist, particularly with regard to below-ground biomass, drylands may hold 10 per cent of total global carbon (Salleh, [2000]). Stemming the loss of vegetation in drylands thus has significant potential for carbon sequestration and greenhouse gas storage, despite the fact that the soils in drylands have little organic matter and an organic carbon content of only 0.1–0.5 per cent, drylands themselves contain high levels of inorganic carbon (Salleh 2000; Lee and Shaaf 2003). In fact, drylands contain the greatest proportion of the world's soil carbonate, which accounts for more carbon than the world's total vegetation. Consequently, wind and water erosion have potentially very serious effects on a country's carbon store and there is a huge potential for increasing soil carbon uptake through the restoration of degraded soil and soil conservation (Arnalds 2002).

As stated in previous sections, particularly those on biodiversity and food and fibre provision, expanding land degradation, deforestation and desertification are serious problems in Mauritania that appear to be augmenting negative feedback loops, thus increasing exposure to climate change. Good land management practices would not only help stall the encroachment of the desert, but may also increase carbon sequestration and prevent to some yet to be estimate extent, the release of carbon that would exacerbate climate change.

## 2.6 Summary of ecosystem services stressed

All ecosystem services examined are deteriorating in all regions of Mauritania. People have naturally gravitated to those regions where there is water and vegetation, but even here their impact is being felt. The Senegal River, the source of most water in the country, is now experiencing new levels of pollution and the river valley is increasingly being deforested and wetlands drained. Another particularly vexing trend is the deterioration of the marine fishery, a source of

food that is even more vital now that terrestrial mammals such as ungulates, important both as a source of

food and to ecosystem functioning, have largely been extirpated from the country.

**Table 1. Summary: Ecosystem services stressed by region**

Region	Ecosystem services stressed	Region	Ecosystem services stressed
Adrar	Biodiversity Food and fibre provision Water supply, purification and regulation Fuel (energy) Carbon sequestration	Hodh ech Chargui	Biodiversity Food and fibre provision Water supply, purification and regulation Fuel (energy) Carbon sequestration
Assaba	Biodiversity Food and fibre provision Water supply, purification and regulation Fuel (energy) Carbon sequestration	Hodh el Gharbi	Biodiversity Food and fibre provision Water supply, purification and regulation Fuel (energy) Carbon sequestration
Brakna	Biodiversity Food and fibre provision Water supply, purification and regulation Fuel (energy) Carbon sequestration	Inchiri	Biodiversity Food and fibre provision Water supply, purification and regulation Fuel (energy) Carbon sequestration
Dakhlet Nouadhibou	Biodiversity Food and fibre provision Water supply, purification and regulation Fuel (energy) Carbon sequestration	Tagant	Biodiversity Food and fibre provision Water supply, purification and regulation Fuel (energy) Carbon sequestration
Gorgol	Biodiversity Food and fibre provision Water supply, purification and regulation Fuel (energy) Carbon sequestration	Tiris Zemmour	Biodiversity Food and fibre provision Water supply, purification and regulation Fuel (energy) Carbon sequestration
Guidimaka	Biodiversity Food and fibre provision Water supply, purification and regulation Fuel (energy) Carbon sequestration	Trarza	Biodiversity Food and fibre provision Water supply, purification and regulation Fuel (energy) Carbon sequestration



## 3.

# State of Human Well-being

Human well-being is multi-dimensional with many constituents and determinants closely determined by the state of ecosystem services (Duraiappah 2004). However, not all constituents may be under serious threat in a country and not all of these constituents are directly dependent on the state of ecosystem services. Therefore, as emphasized in the beginning, only constituents and/or determinants of well-being directly affected by the state of ecosystem services are examined in this report. Our preliminary review identified the following critical constituents which appear to be under serious threat among many social groups within Mauritania.

### 3.1 Ability to be adequately nourished

The ability to be adequately nourished is dependent on two factors: the ability to grow food and the ability to buy food. While the supply of food is critical, economic entitlements that individuals are able to secure such as income from non-farm labour, are also important (Sen 1990). There are several measures of the ability to be adequately nourished including that of food (in)security and the incidence of malnutrition, among others.

#### State of ability to be adequately nourished

Approximately 50 per cent of the population is engaged in subsistence crop production, with the other 50 per cent engaged in industry and services. Thus, the ability to grow food and ability to buy food are both important in determining the ability to be adequately nourished. Food supply is characterized by declining production and loss of economic entitlements. Even though Mauritania has made substantial improvements in its food security, based on available calories, between 1990 and 1996, presently, food insecurity affects the population at large. In 2002, one million out of Mauritania's 2.7 million inhabitants were food insecure to varying degrees with many remaining highly or extremely food insecure (United States Agency for International Development 2002). For example, recent crop harvests in some areas were sufficient to meet only two months of consumption

needs, due to poor rainfall and caterpillar attacks (United States Agency for International Development 2002). Malnutrition, including protein-energy malnutrition in children and micronutrient deficiency, is a major cause of death and disease particularly among women and children; 60 per cent of pregnant women suffer from anemia, and 40 per cent of children are malnourished with eight per cent being severely malnourished (Mauritania 2000). Exhaustion, loss of weight, night blindness, scurvy, dehydration and hunger-related deaths are not uncommon (United States Agency for International Development 2002).

The ability to be nourished depends not only on food supply, but also on the economic entitlements to buy food. Food is usually scarce in rural markets and when found, expensive or extraordinarily expensive (United States Agency for International Development 2002). Since November 2001, market prices of millet, sorghum and maize have been on the rise with the prices of sorghum increasing 59 per cent between January and September 2002 (FAO 2002). The price of cowpea, a product consumed mainly in rural households also rose more than 75 per cent in one year (FAO 2002). In the Hodh el Gharbi and Hodh ech Chargui regions, poor rainfall and low availability of wild foods has made farming households extremely dependent on retailers for food staples (United States Agency for International Development 2002). Due to Mauritians' poor purchasing power, however, few imports arrive and consequently many people have left to work or gather wild foods in Mali (United States Agency for International Development 2002). In 2004, unlike its neighbouring Sahelian countries which observed decent cereal production, Mauritania was one of two countries where food prices have not declined (Famine Early Warning System Network 2004).

Among other factors, insufficient money to buy cereals has forced many agro-pastoralists to de-stock, resulting in a 40–60 per cent plunge in livestock price (FAO 2002). Increasingly, pastoralists are receiving more calories from purchased grain and grain products obtained through the sale of their animals than milk (Famine Early Warning System Network 2004).

## Regions most affected by inability to be adequately nourished

In 2002, all regions of Mauritania suffered from food shortages and rising food prices with the Aftout, a resource poor area straddling Assaba, Brakna, Gorgol and Tagant regions, the Senegal River valley situated in Trarza, Brakna, Assaba, Guidimakhs, and Gorgol regions and Haratin farmers in southern Hodh ech Chargui and Hodh el Gharbi regions being particularly hard hit (Horekens and Geleta 2002; United States. Agency for International Development 2002).

## 3.2. Ability to access adequate clean water

Access to adequate and clean drinking water is essential for life. As indicated in the freshwater provision section, the minimum standard set by the United Nations as required by an individual to satisfy human needs is 1,000 cu m per year (Biggs *et al.* 2004). In addition, clean water is a necessary condition for a healthy life and to be protected against water-borne diseases like typhoid and cholera. Clean water can be provided in a number of ways such as filtration plants using modern technology, but it is also well known that a watershed in pristine condition can offer the same quality of water. In a well known example, the city of New York was able to provide clean water to its habitants by restoring and preserving the Catskill watershed which basically captures, stores, purifies and releases water. The cost saved by preserving the watershed vis à vis building a modern water filtration plant was about US\$4 billion (Daily and Ellison 2002; Duraiappah 2005).

### State of ability to access clean water

Today, 63 per cent of Mauritania's population is without sustainable access to an improved water source, as was the case as in 1990 (United Nations Development Programme 2004). Only 35 per cent of the population is connected to a water system and in eight regions, access to potable water is less than 10 per cent and in five it less than five per cent (Mauritania 2000). In rural areas, 77 per cent of households consume water from wells and 13 per cent from the Senegal River, other rivers, lakes and rainfall, all of which have tenuous hygienic quality (Mauritania 2000).

In urban areas, the ability to access clean and adequate water is also a function of economic entitlements. In cities, 52 per cent of drinking water is pur-

chased from water re-sellers at an average price of \$1.03 per cu m of water; the remaining water is supplied by a potable water supply network and, to a lesser extent, public standpipes and wells (Mauritania 2000). In disadvantaged neighborhoods, however, water costs seven times the price paid by subscribers to the national power and water company network, severely limiting water consumption by the poor (Mauritania 2000). For example, in Nouakchott 40 L/day is being consumed by those who can afford the water, but only 13–22 L/day is being consumed for half the population living in the poorer areas of the city (Mauritania 2000).

### Regions most affected

The percentage of the population with access to potable water is most favourable in Brakna (95 per cent) and Trarza (143 per cent), but below 50 per cent in Hodh ech Chargui, Hodh el Gharbi, Assaba, Gorgol, Adrar, Tagant and Dakhlet Nouadhibou regions, and is below 10 per cent in eight regions and below five per cent in five (Mauritania 2000). While these regions are not identified, one can assume that access to potable water is an issue for all regions based on data provided in the ecosystem services section on water supply. One quarter of Nouakchott's population, 35 per cent of Kiffa and 44 per cent Aioum lives in tent, shack or hut where one third lack direct access to potable water, and less than that have adequate sanitary facilities such as sewers, septic tanks or latrines (Mauritania 2000).

## 3.3 Ability to have energy to keep warm and cook

A reliable source of energy is a necessary component of human well-being; it is required for daily activities like cooking and keeping warm. Traditional fuel consumption of fuel wood, charcoal, animal and vegetable wastes is currently meeting 30.4 per cent of total energy requirements and being used by 85 per cent of the population (United Nations Development Programme 2004; Mauritania. Ministry of Water and Energy 2004). In 1996, woodfuel consumption was 1.4 million cubic metres of wood (Mauritania Ministry of Water and Energy 2004)

### State of ability to have energy to keep warm and cook

Per capita domestic use of woodfuel is relatively high at 221 kilograms of oil equivalent (kgOE) as com-

pared to neighbouring Senegal where it is 168 kgOE (Mauritania Ministry of Water and Energy 2004). Furthermore, according to a 1993 study, total annual consumption of woodfuel exceeded by 10 times the sustainable rate of forest exploitation (Mauritania Ministry of Water and Energy 2004). As a result of woodfuel shortages, since 1990, Mauritania has turned to other forms of energy for cooking, including liquefied petroleum gas (LPG), of which per capita consumption is relatively high (4.5 kg/year) (Amous 1999). The use of LPG fuel substitutes, however, has had the negative impact of creating unemployment in forest areas where fuel wood production was discouraged. This has encouraged migration towards urban and peri-urban areas, subsequently increasing the demand for more fuel wood as this is the main source of affordable energy for the poor (Girard 2002).

### Region most affected by inability to have energy to keep warm and cook

Unfortunately, data were not available at the region level and recent national level data were also not found (these data may exist in French). Therefore, it is necessary to extrapolate from data on biodiversity and woodfuel services discussed in the previous section. Based on rates of deforestation, the use of woodfuel by 85 per cent of the population and high demand, the conclusion is that all people in all regions except the wealthier citizens living in urban centres supplied by electricity and LPG, are experiencing some level of difficulty in obtaining adequate energy for heat and cooking.

## 3.4 Ability to earn a livelihood

The ability to earn a livelihood is essential to human well-being and is measured using various indicators such as per/capita GDP, household consumption levels and so on. In efforts to identify those needing government support, poverty lines or thresholds are established using an estimate of the cost of food and non-food basic needs for individuals and families.

### State of ability to earn a livelihood

Mauritania's economic entitlements remain low even though poverty and inequities decreased during the early 1990s. Currently 57 per cent of the population lives below the poverty line (Mauritania 2000; World Resources Institute 2003c). Specifically, 28.6 per cent

of the population lives below the poverty threshold, on less than \$1 a day and 68.7 per cent lives on less than \$2 a day (World Resources Institute 2003c; Mauritania 2000).

Although the rural population has become a minority composing only 46 per cent of the population, eight out of 10 poor people live in rural areas (FAO Land and Water Development Division 1997; Mauritania 2000). Overall, 64 per cent of the labour force is employed in agriculture and livestock production and these two activities account for 78 per cent and eight per cent of rural employment respectively (Mauritania 2000). Despite the number of people employed in agriculture and livestock production, they only contribute 23 per cent to GDP with five to eight per cent being attributed to agriculture and 15 per cent to livestock (Mauritania 2000). Under-employment affects half the rural working population and salaried employment is limited and only marginally increasing (Mauritania 2000). Fishing is one of the country's few exploitable natural resources, but it does not support coastal livelihoods due to the over-exploitation of this resource by foreign fishing fleets and harsh living conditions in coastal areas (Mauritania 2000). Human-induced ecosystem degradation has also lowered Mauritians' ability to earn a living. For example, dam construction in the Diawling estuary of the Senegal River has devastated *Sporobolus*, a perennial grass that women used for weaving which earned a substantial portion of their income (World Commission on Dams 1999).

The sale of cattle, sheep and livestock products including milk, meat, butter, hides, skins and wool is the main source of income for many pastoralists (Soule 2003). Sedentary agro-pastoralists live in Mauritania's southern regions employing a mixed crop-livestock system in which there is a strong linkage between crop and livestock production, as crops provide unmarketable surpluses and by-products which livestock can convert into high-value products. Thus, wealth is largely dependent on the size of animal herds as well as fields (Famine Early Warning System Network 2005).

### Region most affected in ability to earn a livelihood

Monetary poverty is mainly a rural phenomenon where 76.4 per cent of the people live below the poverty threshold due in large part to the rural arid zone, which is inhabited by 57 per cent of the poor (Mauritania 2000). The regions most affected are the

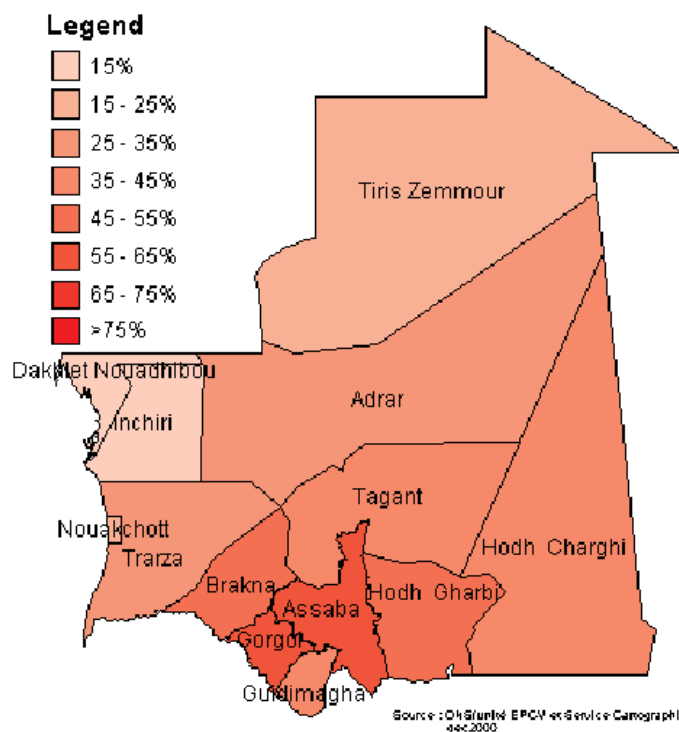
Aftout area, the rural arid zone straddling the Assaba, Brakna, Tagant and Gorgol *wilayas*, and certain parts of the Hodh ech Chargui, Hodh el Gharbi and Guidimakha regions, which have a rate of poverty of 80 per cent or higher (Mauritania 2000). The incidence of poverty in the rural arid zone is 71.1 per cent and in the “rural fleuve” (Trarza and Brakna) area is 60.2 per cent (Mauritania 2000). In general, the rural fleuve area accounts for 19 per cent of poverty, the rural arid zone accounts for 57 per cent, Nouakchott accounts for 12 per cent and other cities account for the remaining 12 per cent (Mauritania 2000). Those most affected are farmers and non-farm workers in rural areas, groups experiencing poverty rates of over 60 per cent and female-headed, single-parent households with a poverty incidence three times higher than male single-headed households (Mauritania 2000).

### 3.5 Summary of human well-being

Generally, people in all regions are finding it difficult to be adequately nourished, as is evidenced by constrained food supply, rising food prices and low economic entitlements of the majority. While conclusive data are lacking at the region level, available information suggests that energy provision is another problem shared by people in all the regions. Lack of access to adequate and clean drinking water, though, is a problem in all regions, except Brakna and Trarza, while the ability to earn a livelihood is mainly hampered in those regions with population density of more than three to 10 people per sq km, a finding that is not surprising in light of the large urban-rural migration that has occurred in Mauritania largely from the more arid areas in the north.

The regions with all four constituents of well-being threatened are Assaba, Gorgol, Guidimakha, Hodh ech Chargui, Hodh el Gharbi, Tagant and Trarza, all being in the southern portions of the country. The remaining regions each have three well-being constituents threatened.

Map 2: Mauritania: spatial differentiation of incidence of poverty (Mauritania 2000)<sup>8</sup>



<sup>8</sup> The 1990 and 1996 EPVC (“ongoing living conditions”) surveys yielded significant results for only four regions: Nouakchott, Other Cities, Rural Fleuve and Rural Other). Thus, they failed to produce totally meaningful results for all *wilayas*. The current survey which went underway in July 2000 will remedy these inadequacies, as well as incorporate a social capital component (Mauritania 2000).



**Table 2. Constituents threatened/region**

Regions	Constituents threatened
Adrar	Adequately nourished Adequate and clean drinking water Energy
Assaba	Adequately nourished Adequate and clean drinking water Energy Earn a livelihood
Brakna	Adequately nourished Energy Earn a livelihood
Dakhet Nouadhibou	Adequately nourished Adequate and clean drinking water Energy
Gorgol	Adequately nourished Adequate and clean drinking water Energy Earn a livelihood
Guidimaka	Adequately nourished Adequate and clean drinking water Energy Earn a livelihood

Regions	Constituents threatened
Hodh ech Chargui	Adequately nourished Adequate and clean drinking water Energy Earn a livelihood
Hodh el Gharbi	Adequately nourished Adequate and clean drinking water Energy Earn a livelihood
Inchiri	Adequately nourished Adequate and clean drinking water Energy
Tagant	Adequately nourished Adequate and clean drinking water Energy Earn a livelihood
Tiris Zemmour	Adequately nourished Adequate and clean drinking water Energy
Trarza	Adequately nourished Adequate and clean drinking water Energy Earn a livelihood

## 4.

# Linking Ecosystem Services to Human Well-being

When the constituents threatened and ecosystem services stressed are co-located by region, the following seven regions have all four constituents threatened and all five ecosystem services stressed: Assaba, Gorgol, Guidimaka, Hodh ech Chargui, Hodh el Gharbi, Tagant and Trarza. However, Assaba, Gorgol and Guidimaka emerge as high priority areas if we isolate the more densely populated regions. Undertaking a local scale integrated assessment in these regions would provide valuable information on the life determining trade-offs that are being made as people try to increase agricultural production and find water and energy against almost overwhelming odds, such as encroaching desertification, erratic weather and various insect infestations. The Diarma dam serves as an example of where an attempt was made to provide more secure electricity to urban centres at the expense of the other ecosystem services like flood control, water regulation and soil fertility.

A positive factor in Mauritania's favour is the relatively small size of its population. However, the high fertility rates suggest that this may not be the case in the future. The demand for food, water and material wealth by a rapidly growing population will without doubt put increasing pressure on a fragile ecosystem which is already facing some serious problems.

Mauritania, however, when compared to other countries such as Mali and Rwanda has many more people living in urban centres; almost 50 per cent of the population is employed in industry and service sectors rather than subsistence agriculture, suggesting that priorities about poverty and ecosystems will need to be made in light of this reality.

**Table 3. Ecosystem services stressed and human well-being/region**

Regions	Constituents threatened	Ecosystem services stressed
Adrar	Adequately nourished Adequate and clean drinking water Energy	Biodiversity Food and fibre provision Water supply, purification and regulation Fuel (energy) Carbon sequestration
Assaba	Adequately nourished Adequate and clean drinking water Energy Earn a livelihood	Biodiversity Food and fibre provision Water supply, purification and regulation Fuel (energy) Carbon sequestration
Brakna	Adequately nourished Energy Earn a livelihood	Biodiversity Food and fibre provision Water supply, purification and regulation Fuel (energy) Carbon sequestration
Dakhet Nouadhibou	Adequately nourished Adequate and clean drinking water Energy	Biodiversity Food and fibre provision Water supply, purification and regulation Fuel (energy) Carbon sequestration
Gorgol	Adequately nourished Adequate and clean drinking water Energy Earn a livelihood	Biodiversity Food and fibre provision Water supply, purification and regulation Fuel (energy) Carbon sequestration
Guidimaka	Adequately nourished Adequate and clean drinking water Energy Earn a livelihood	Biodiversity Food and fibre provision Water supply, purification and regulation Fuel (energy) Carbon sequestration
Hodh ech Chargui	Adequately nourished Adequate and clean drinking water Energy Earn a livelihood	Biodiversity Food and fibre provision Water supply, purification and regulation Fuel (energy) Carbon sequestration
Hodh el Gharbi	Adequately nourished Adequate and clean drinking water Energy Earn a livelihood	Biodiversity Food and fibre provision Water supply, purification and regulation Fuel (energy) Carbon sequestration
Inchiri	Adequately nourished Adequate and clean drinking water Energy	Biodiversity Food and fibre provision Water supply, purification and regulation Fuel (energy) Carbon sequestration

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Regions	Constituents threatened	Ecosystem services stressed
Tagant	Adequately nourished Adequate and clean drinking water Energy Earn a livelihood	Biodiversity Food and fibre provision Water supply, purification and regulation Fuel (energy) Carbon sequestration
Tiris Zemmour	Adequately nourished Adequate and clean drinking water Energy	Biodiversity Food and fibre provision Water supply, purification and regulation Fuel (energy) Carbon sequestration
Trarza	Adequately nourished Adequate and clean drinking water Energy Earn a livelihood	Biodiversity Food and fibre provision Water supply, purification and regulation Fuel (energy) Carbon sequestration

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