

# Connecting poverty & ecosystem services

A series of seven country scoping studies

## Focus on Rwanda



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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 Rwanda 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, Mauritania, Mozambique, 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. Butare and Kibungo stand out as areas that should be the focus for development or, at minimum, further investigation. Both have all four ecosystem services stressed and four constituents of well-being threatened.
2. Expanding crop land is not a feasible solution to improve nourishment, and instead intensification of existing land, with proper management of fertilizers and inputs, could improve yields while reducing impacts on ecosystem services.
3. Continuing to reduce crops which provide good soil protection (i.e., bananas and mulched coffee) could have rapid deleterious effects on soil fertility.
4. The present supply of water will not be sufficient to meet the demands of intensified agriculture and individual water demands. More focus on watershed management will need to be put in place along with better management of wetlands.
5. The growing demand for fuel will necessitate new sources which put less pressure on ecosystems.
6. Policy-makers need to understand more fully the links between ecosystem services and well-being. Many of the links are context specific and a local-scale assessment will be useful. Integrated assessments in Kibungo and Butare provinces would serve as useful pilot studies.

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

	Mainten- ance of bio- diversity	Food prod- uction	Water supply	Energy resources	Ade- quately nour- ished	Clean water	Energy for warmth and cooking	Earn livi- hood	Incid'ce of poverty
Butare	<b>X</b>	<b>X</b>	<b>O</b>	<b>X</b>	<b>X</b>	<b>X</b>	<b>O</b>	<b>X</b>	<b>73.6%</b>
Byumba	X	X	O	O	X	O	O	X	65.8%
Cyangugu	X	X	O	X	O	O	X	X	64.3%
Gikongoro	X	X	X	O	X	O	O	X	77.0%
Gisenyi	X	X	O	X	O	O	X	X	53.5%
Gitarama	X	X	O	O	O	O	O	X	53.7%
Kibungo	<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>50.8%</b>
Kibuye	X	X	O	O	X	O	X	X	72.5%
Kigali-Ngali	O	X	X	O	X	X	X	X	70.8%
Ruhengeri	X	X	O	O	X	O	X	X	70.3%
Umutara	O	X	X	O	X	X	X	X	50.5%

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

## Ecosystem services

The literature review of Rwanda's ecosystem services revealed four critically stressed ecosystem services: maintenance of biodiversity; food and fibre provision; water supply, purification and regulation; and fuel provision.

### Maintenance of biodiversity

Rwanda is a country that is exceptional in its biodiversity. However, rapid deforestation and conversion of natural habitats to agricultural systems has caused a loss in the variability of ecosystems. Biodiversity loss in Rwanda is severe and mainly due to the progressive disappearance of national parks and large-scale habitat destruction. Specifically, natural forests have declined by 78 per cent since 1990 and the country is also experiencing a loss of its agrodiversity and wetland biodiversity.

### Food and fibre provision

In Rwanda, 90 per cent of the population is engaged in subsistence farming. Commercial or cash crops are also grown and consist of bananas, arabica coffee, tea, cattle and fish. Naturally occurring conditions such as steep slopes and mountains constrain food production in Rwanda. The demands of agriculture are causing soil fertility and moisture to decline coupled with moderate to severe soil erosion. Loss of manure, depleting water table and drought are all contributing factors. Finally, fish yields are difficult to maintain because of the poor health of the bodies of water.

### Water supply, purification and regulation

In Rwanda, there are low withdrawal rates of water, but this does not imply that the capacity of ecosystems to capture, store and release water is not being deteriorated. In low-lying areas, pressure for agricultural space has led to inappropriate marsh cultivation. In higher-elevation areas, deforestation has played a key role in decreasing the ability of watersheds to catch and restore water. Deforested areas also lead to soil erosion, when large water runoffs inundate exposed soil.

### Fuel provision

Natural forests are estimated to have covered 36 per cent of Rwanda, and this has been reduced by 78 per cent since 1990 alone, which has dire impacts on the available supply of wood. Deforestation, not only for firewood but also for logging for settlement, road

construction, over-grazing and cultivation of steep hills have all contributed to one of the highest deforestation rates in Central Africa. Dung and crop residues are also being used by households as energy sources, but these too are under threat because of the decline in agricultural and livestock productivity.

## 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 which are affected by the state of ecosystems services which 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

Ninety per cent of the population of Rwanda is engaged in subsistence farming and they are not able to grow sufficient amounts of food. This is closely linked with the ecosystem service of food production as food supply is characterized by low and mixed agricultural productivity caused by a loss of soil fertility, lack of irrigation water, and access to agricultural inputs such as fertilizer and seeds. In addition, economic entitlements are low and not enough to compensate for low agricultural productivity.

### Ability to have adequate and clean drinking water

Fifty per cent of Rwandans do not have access to clean drinking water. This is exacerbated by the conversion of watersheds, particularly wetlands, into agricultural land thereby destroying an inexpensive method of purifying water and necessitating substantially higher future investments to have clean water. Displaced migration to the capital has also brought severe urban water and sanitation problems. Institutional influences on a range of areas also affect the ability Rwandans to access clean water.

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

Currently, over 96 per cent of Rwandans depend on wood for domestic energy and 81 per cent of the country's energy consumption is from wood. As a result of this high demand, wooded savannahs in Kgali-Ngali's Bugesera region have almost disappeared and in many other regions are rapidly declin-

ing. This is clearly connected to maintenance of biodiversity and forests as they are being consumed at an unsustainable rate.

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

Fifty-one per cent of Rwandans live below the poverty line as most are subsistence farmers. Some earn a

proportion of their income from various cash crops such as bananas and coffee. This well-being constituent is most closely linked with the ecosystem service of food production and given the state of agricultural production, the future ability of Rwandans to earn a living from agriculture, with its current stressors, is poor.

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# Introduction

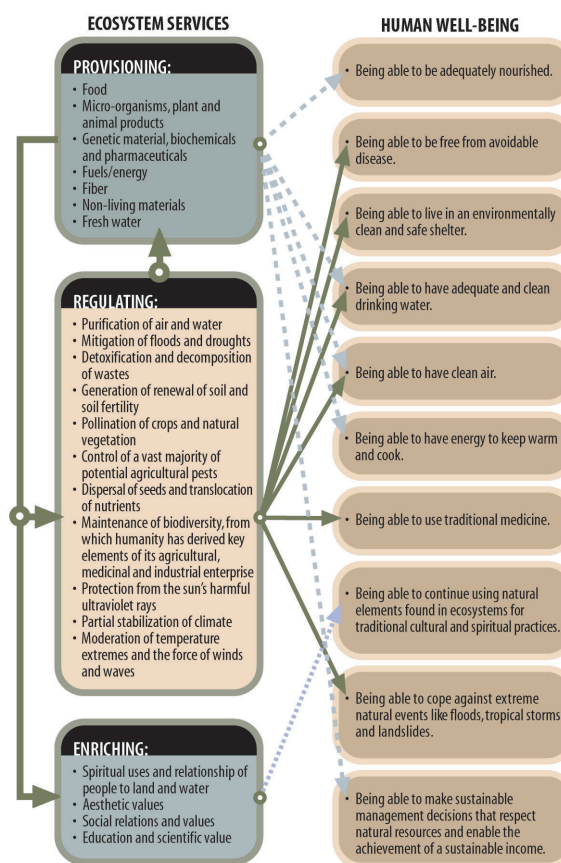
The primary objective of this report is to identify regions within Rwanda where critical ecosystem services for human well-being are stressed. These regions were identified through an extensive literature review and research which spatially connected ecosystem services and human well-being within Rwanda. 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 Rwanda 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: 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 Rwanda, 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 collocates 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**



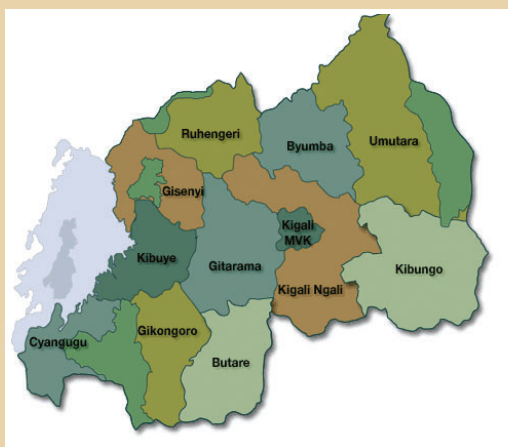
(Source: Duraiappah 2002)



# 1. Rwanda in Brief

Rwanda evokes contradictory images in the mind of the reader. This landlocked and mountainous country is where Dian Fossey studied mountain gorillas; to most observers it is a place of great natural beauty. Yet, it is where a horrific genocide occurred in 1994 forever scarring the people of Rwanda and their landscape. Since then, Rwanda has been rebuilding, but before considering the success of these efforts, shaped as they are by events of the past, we start by very briefly describing the current “state of Rwanda.”

**Map 1. Administrative Map of Rwanda**



## Rwanda: Area and provinces

**Total area:** 26,338 sq km – the smallest country in Africa

**Land area:** 24,948 sq km

**Water area:** 1,390 sq km

**Coastline:** 0 km; landlocked

**Political districts:** The Republic of Rwanda comprises 12 provinces and 116 districts and municipalities. The provinces of Rwanda are: Kigali City, Kigali-Ngali, Gitarama, Butare, Gikongoro, Cyangugu, Kibuye, Gisenyi, Ruhengeri, Byumba, Umutara and Kibungo. (Note: While Kigali City is identified as a province, it was not included in most of the analysis due to lack of consistent data as it is mainly urban.)

*(Rwanda Ministry of Local Government, Community Development and Social Affairs 2004)*

## 1.1 Physical geography and natural environment

Although Rwanda is relatively small in area, it has five distinct geographical regions. Lake Kivu, Rwanda’s largest lake, is located in western Rwanda, an area that is part of the Rift valley, while the Virunga Mountains are located in the northwest. The central part of the country is a high plateau, which was once forested but is now grasslands, and the southeast is a region of lakes and marshes. There are basically five distinct ecosystem areas in Rwanda: cropland and crop/natural vegetation mosaic form 47 per cent of total land; 32 per cent is under scrublands, savannah and grasslands; 12 per cent is under forest; eight per cent is wetlands and water bodies; and about one per cent is sparse or barren vegetation (World Resources Institute. 2003d). The southwest has one of the largest tropical montane forests in Africa and has a variety of ecosystems ranging from marshes to bamboo groves to dense forests.

**Climate:** Rwanda has an equatorial mountain climate with mild, stable temperatures and moderate rainfall averaging 1,200–1,280 mm annually (Mpyisi 2002, 3; Rwanda Ministry of Energy, Water and Natural Resources and World Bank 2000, 3). There are four seasons: a short dry season from January to February; a rainy season from March to May; a long dry season from June to September; and another rainy period from October to December. It enjoys long growing seasons, ranging from 240 to 365 days/year with the longest being in the northwest provinces of Kibuye, Gisenyi, Ruhengeri and Gitarama (FAO 2005). Despite relatively high rainfalls, Rwanda suffers from frequent droughts caused by erratic rainfall patterns (Mpyisi 2003).

**Topography:** The terrain is mountainous, declining eastward<sup>2</sup> toward the Tanzanian border (Kanyamibwa 1998, MSN Encarta 2004; FAO 2005). On the western side of the central plateau is a mountain system averaging some 2,740 m in elevation (MSN Encarta 2004). The central part of the country, comprising almost half of total land area, is covered by rounded hills and large valleys with an alti-

<sup>2</sup> Map: Relief <http://www.fao.org/countryprofiles/Maps/RWA/17/rl/index.html>

tude between 1,500 and 2,000 m. In the east, the hills give way to a large region with numerous lakes and marshes (Rwanda Ministry of Lands, Resettlement and Environment 2003, 5).

**Hydrology:** Rwanda is landlocked and situated on the eastern rim of the Albertine Rift, a western portion of the Great Rift Valley, on the watershed between Africa's two largest river systems: the Nile and the Congo (Rwanda United Nations Environment Programme). "The Nile River Basin covers 67 per cent of the national territory and drains 90 per cent of the national waters through two major water courses: the Nyabarongo, which originates in Nyungwe Forest, and the Akagera Rivers—both endowed with many tributaries" (Rwanda Ministry of Lands, Human Resettlement and Environmental Protection 2004, 2). In the east, a series of marshy lakes meander along the upper Kagera River and marshlands cover some 165,000 hectares (1,650 sq km) of the country (Rwanda. Ministry of Finance and Economic Planning 2002; MSN Encarta 2004). The largest water body is Lake Kivu, which borders Gisenyi, Kibuye and Cyangugu provinces. Numerous other lakes dot the country, notably Burera and Ruhondo in the north, and Muhazi and Mugasera in the east, which have irregular shapes following the contours of the steep mountains that enclose them (Rwanda).

**Arable land:** Approximately 1,385,000 ha of land are cultivable and of this 825,000 ha are being cultivated. "The arable area is about 825,000 ha, hillside slopes (about 660,000 ha) are not exploited in the dry season and marshlands (about 165,000 ha) are partially exploited in the rainy seasons depending on their degree of flooding" (Kanyarukiga and Ngarambe 1998).

## 1.2 Demographics

Rwanda is one of the most densely populated countries in Africa and has high fertility rates and population growth (Wise 2004; United National Development Programme 2000, 1). This situation presents enormous challenges, as the population is mainly rural and dependent on subsistence agriculture and experiencing severe shortages of arable land and high rates of poverty (United National Development Programme 2000, 1).

### Box 1. Rwanda: Demographics (2004)

<b>Population:</b>	
Total:	7,954,013
0–14 years:	42.3%
15–64 years:	55.0%
65 years and over:	2.7%
<b>Life expectancy at birth (yrs):</b>	
Average:	39.18
Male:	28.43
Female:	39.96
<b>Fertility rate:</b>	
Number of births per woman:	5.7
<b>Population growth rate:</b>	
Percentage per year:	2.9
<b>Population density (per sq km):</b>	
UNDP:	310
or Relief Web:	410
<b>Ethnic groups:</b>	
Hutu:	84%
Tutsi:	15%
Batwa (Pygmoid):	1%
<b>Languages:</b>	
Kinyarwanda (official), universal Bantu vernacular, French (official), English (official), Kiswahili (Swahili)	

*(United Nations Development Programme 2003a; United Nations Development Programme 2003c; Relief Web 2000; United States Central Intelligence Agency 2004; Unrepresented Nations and Peoples Organization)*

## 1.3 Economy: Observable constraints

Between 1995 and 2004, average real GDP growth has been eight per cent (OECD and African Development Bank 2005, 381). The economy, however, collapsed in 2003 mainly due to unfavourable weather conditions which lead to substantial reductions in agricultural productivity. Furthermore, "Rwanda's economy remains highly vulnerable to exogenous shocks" (OECD and African Development Bank 2005, 382).

Rwanda continues to receive substantial financial aid; during 2000–2004 foreign aid accounted for 50 per cent of the current budget (OECD and African Development Bank 2005, 381). The absence of functioning markets, lack of credit for small and medium-sized enterprises, high bank interest rates and price volatility have constrained commercialization of

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agriculture and the development of non-farm employment (Rwanda Ministry of Finance and Economic Planning 2002, 87). Attempts to diversify into non-traditional agriculture exports such as

flowers and vegetables have been stymied by an inadequate transportation infrastructure (United States Central Intelligence Agency 2004).

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

**GDP (2003) (in constant 1995 dollars):** \$1.637 million

**Allocation of GDP by sector (2003):**

Agriculture:	42%
Manufacturing:	9%
Services:	13%
Other (construction, mining, tourism, trade, transport and communications, government services):	36%

**Trade account:**

*Exports*—\$149 million (2000 estimates)

Notably, eco-tourism represents the second largest source of income for the country

*Imports*—\$432 million (2000 estimates)

**Main employment sector:**

Approximately 90% of the population is engaged in mainly subsistence agriculture

**Per capita income (2003):** \$220

**PPP per capita income:** \$1,290

**Income distribution:**

Gini coefficient (100 is perfect inequality): 29

Percentage of income earned by richest 20% of population: 39.1%

Percentage of income earned by poorest 20% of population: 9.7%

**National poverty rate:** 51.2%

**Adult literacy rate (per cent ages 15 and above) 2002:** 69.2

**Human Development Index value (HDI) 2002:** 0.431

**Human Development Index (HDI) rank (out of 175) 2002:** 159

*(Kanyamibwa 1998; World Resources Institute 2003c; United Nations Development Programme 2003a; United States Department of State 2005; OECD and African Development Bank 2005; Rwanda Ministry of Finance and Economic Planning 2002; World Bank 2005)*

## 2.

## State of Ecosystem Services

The literature review identified maintenance of biodiversity, food and fibre provision, water supply, purification and regulation and energy resources as the four critical ecosystem services stressed<sup>3</sup> in Rwanda. We discuss each in detail below, outline some of the main factors influencing their deterioration and, where possible, identify the provinces 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.

### State of biodiversity

Ecosystems in Rwanda, the primary source of biodiversity, genetic resources and biochemicals, are composed of forests (12 per cent of total land area), savannah (32 per cent), wetlands (eight per cent) and mixed cropland/natural vegetation (47 per cent). Rapid deforestation and conversion of natural habitats to agricultural systems, however, has caused a loss in the variability across them (World Resources Institute 2003d). Currently, Rwanda protects 7.7 per cent of its total land area and, thus, only a small proportion of its biodiversity (World Resources Institute 2003a).

Even so, Rwanda's protected areas, namely the Parc National des Volcans in the northwest (Gisenyi and Ruhengeri), Nyungwe Montane Forest Reserve in the southwest (Cyangugu), and Akagera National Park in the northeast (Umutara), hold exceptional biodiversity. Today, Akagera is considered the most complex savannah ecosystem in eastern Africa, combining wetlands and savannah habitat, and is home to 12 species of primates (Kanyamibwa 1998). Volcanoes National Park is home to approximately half (320) of the world's population of mountain gorillas, which consume vegetation from more than 70 different plant species (World Bank 2004). Nyungwe's flora alone comprises more than 250 tree and plant species, including more than 100 orchid species, and is dominated by the bamboo *Arundinaria alpine* (Kanyamibwa 1998). It is also home to the owl-faced monkey *Ceropithecus hamylini* and 275 known bird species (Kanyamibwa 1998, World Bank 2004).

### Factors influencing biodiversity loss

Biodiversity loss in Rwanda is severe and mainly due to the progressive disappearance of national parks and large-scale habitat destruction (World Bank 2004). Between 1958 and 1979, Volcanoes National Park lost 55 per cent of its natural habitat mainly for pyrethrum growing (Kalpers 2001). During the genocide, in addition to human casualties, direct fighting and bombs killed wildlife throughout

<sup>3</sup> Ecosystem services found to be deteriorating or in danger of being deteriorated in the near future.

Rwanda; large-scale fighting occurred inside Akagera National Park and soldiers killed many animals (Kanyamibwa 1998). Akagera National Park lost approximately 90 per cent of its megafauna, and approximately two-thirds of its original area (Kanyamibwa 1998). Since the genocide, Akagera National Park and Mutara Game Reserve have been taken over by 700,000 grazing cattle from Uganda, and temporary and permanent buildings are widespread while Nyungwe Montane Forest Reserve is now fragmented by agriculture (Kanyamibwa 1998). In addition, natural forests have declined by 78 per cent since 1990 (World Resources Institute 2003d). Rwanda's most recent biodiversity strategy (2003) mentions Mukura and Gishwati forests as having particularly high rates of deforestation (Rwanda Ministry of Lands, Resettlement and Environment 2003). Three plant and 13 animal species are IUCN red listed (critically endangered, endangered and vulnerable) and primates are threatened by habitat destruction and poaching (FAO Forestry Department 2003; World Bank 2004).

A loss of agrodiversity is occurring as the genetic base erodes for cattle breeds, crops, and vegetables/fruits; fewer benefits are realized from local variety qualities, which traditionally increase tolerance, productivity and resilience, and there is growing dependence on exotic seeds and imported varieties (World Bank 2004). Fish diversity is also decreasing along with a loss of wetland biodiversity and habitat, though exact data is lacking (World Bank 2004). In addition, the invasion of water hyacinth into East Africa's Lake Victoria 13 years ago has reduced water quality and threatened biodiversity, particularly along the Kagera River system, at the eastern border (Moorhouse, Agaba and McNabb 2000).

### Provinces most affected by biodiversity loss

- Butare: More than half of wetlands are cultivated
- Byumba: Akagera National Park
- Cyangugu: Nyungwe National Park; almost all wetlands are cultivated
- Gikongoro: Almost all wetlands are cultivated

- Gisenyi: Gishwati forest; almost all wetlands are cultivated
- Gitarama: Almost all wetlands are cultivated
- Kibungo: Akagera National Park
- Kibuye: Mukura forest; almost all wetlands are cultivated
- Ruhengeri: Volcanoes National Park; more than half of wetlands are cultivated

*(Kanyarukiga and Ngarambe 1998; World Bank 2004)*

## 2.2 Food and fibre provision

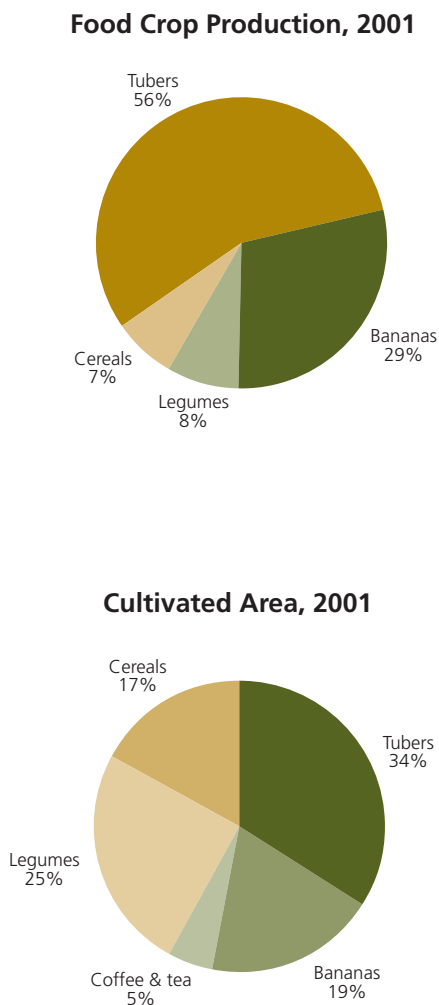
Ecosystems are the medium for growing food on which humans and domesticated animals are dependent; this includes the vast range of food products derived from plants, animals and microbes. If the cultivation of plants for food and livestock is to succeed, then natural factors like fertile soils, adequate 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.

In Rwanda, 90 per cent of the population is engaged in subsistence farming, with the main subsistence food crops produced in 2001 being tubers (56 per cent), bananas (29 per cent), legumes (eight per cent), and cereals (seven per cent). Root and tuber crops, such as sweet potatoes, cassava and Irish potatoes account for 34 per cent of the total cultivated land, while legumes, bananas and cereals took 25 per cent, 19 per cent and 17 per cent respectively of the remaining cultivated land (see Figure 2).

Commercial or cash crops are also grown and comprise 47 per cent of GDP. They consist of bananas, arabica coffee, tea, cattle (milk and meat hides and skin), and pyrethrum (United States Department of State 2005). In addition, fish production is becoming a major cash crop with financial returns—profit per unit hectare—far superior to other crops raised in Rwanda's wetland valleys called marais (Hishamunda *et al.* 1998).



**Figure 2. Food crop production and cultivated area, 2001**



(Mpyisi and Edson 2002)

There are, however, some naturally occurring conditions that constrain food production. Primary among these is the topography, as much of the country has steep slopes and mountains, which are prevalent in Gikongoro, Cyangugu, Kibuye, Gisenyi, Ruhengeri, Byumba and Kibungo provinces. In other areas, low soil suitability also reduces food production potential; this is particularly evident in Gikongoro, Butare, Kibuye and Kigali provinces (FAO 2005). Climate also plays a role, as frost and snow are possible in the mountains and there are periodic droughts (United

States Central Intelligence Agency 2004). Last, most of Rwanda's fishing occurs in the Rift Valley lakes, where the abundance of fish is poor and where most fishing in this lake is for a small fish (*Limnothrissa miodon*) introduced from Lake Tanganyika (World Bank 2004, Field Museum 2003).

### State of food and fibre provision service

"Agricultural production per capita and crop yields have been declining since the mid-1980s" (Rwanda Ministry of Lands, Human Resettlement and Environmental Protection 2004). Although there is a continual downward trend in productivity overall, recent data show national-level increases for cassava, Irish potatoes and sweet potatoes with decreases for legumes and cereals (Donovan, Mpyisi and Leveridge 2002; Mpyisi *et al.* 2000, 4). In 2004, national crop production was 3,281,395 mt (similar to the same season in 2003). This production translates into 1,832 kilo calories (kcal)/person/day for Rwanda (or 87 per cent of the recommended daily requirements of 2,100 kcal/person). Donovan, Mpyisi and Loveridge (2002) found that increases in Irish potato production are probably due to increased and better inputs including improved seed potatoes, while increased cassava production and yields can be attributed to new cassava varieties with better yields and its desirability as a drought- and flood-resistant crop.

Goats and cattle are raised in significant numbers by small-holder farmers (World Agroforestry Centre 2003). In mixed crop-livestock farming characteristic of Rwanda, 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. While empirical data on the contribution livestock makes towards daily nourishment were not found, anecdotal information based on decreases in the supply of organic fertilizers implies a corresponding drop in livestock numbers. Existing data indicate that Umutara and Gitarama provinces have the largest number of livestock, while Ruhengeri Province has the highest density with 50–100 animals per sq km throughout the district (FAO 2005).

Fish protein comprises one per cent of the total protein supply, and the supply of fish and fisheries products was a one kg/person/year (World Resources Institute 2003b). Rwanda's freshwater fish catch in 2000 was 6,726 metric tons, up from 2,350 metric tons in 1990 (World Resources Institute 2003e). Freshwater aquaculture has also increased to 270 metric tons (World Resources Institute 2003b).

## Factors influencing overall food and fibre provision deterioration

Although production and yields of tubers have increased, the decrease in legumes and beans points to an overall drop in the productivity of the natural system to support crops which are more demanding in terms of soil fertility and moisture. There is no doubt that, over time, the food production of tuber crops will subsequently fall due to deteriorating soil conditions.

Approximately half of Rwanda's farmlands show evidence of moderate to severe soil erosion (Global Environmental Facility and the International Fund for Agricultural Development 2002). It is estimated that, on average, approximately one ton of soil per hectare is swept away from Rwanda's sloping farmlands every month. One reason for this high rate of soil erosion is because much of the land farmed is on slopes of 30 degrees or more and prone to soil erosion if special precautions are not taken (Lewis and Berry 1988). For example, continuing reduction of area in crops providing good soil protection such as bananas and mulched coffee could have rapid deleterious effects on Rwanda's soil fertility, particularly if these crops are replaced with cassava (Donovan, Mpyisi and Loveridge 2002, 13).

Soil fertility is also declining, as there is a lack of fertilizer and rapid decline in fallow fields. Loss of manure due to reduced livestock inventories is another indicator that soil fertility is increasingly at risk (Donovan, Mpyisi and Loveridge 2002, 13). In general, however, rather than erosion, over cultivation appears to have been the principal factor behind falling fertility. Grosse (in Percival and Homer-Dixon 1995) notes that "the major perceived cause of decreasing soil fertility in Rwanda is depletion of soil nutrients by cultivation rather than erosion." Even in Ruhengeri Province, where erosion is the most severe, farmers mention soil exhaustion as a problem much more often than erosion (Percival and Homer-Dixon 1995). Soil fertility has also been reduced by declining water tables, particularly where marshes have been cultivated without proper land management (Rwanda Ministry of Finance and Economic Planning 2002).

Recurring droughts are particularly troublesome in a country where farmers rely on the rains and natural properties of the soil to retain rainwater in the absence of irrigation systems. Unfortunately, rain is unpredictable in Rwanda, even if the annual amount is high by comparison to the more arid regions of the continent. In addition, the Crop Soil Water Index—indi-

cating soil moisture content—is low in many provinces, indicating that soil resilience is deteriorating.

Rural households mainly eat food produced from their own production; hence, shifts in agricultural production directly impact the availability of macronutrients to them. Using the method outlined in Donovan, Mpyisi and Loveridge (2002, 10) and based on adult requirements for kilocalories, "83 per cent of minimum needs could be met from home production in 1990, yet only 63 per cent of needs could be met in 2001, with much of the decline due to reduced production of bananas" along with a decline in protein production from 71 per cent to 60 per cent for the same period. The following provinces saw a decline in both kilocalories and protein availability from 1990 to 2001: Byumba, Cyangugu, Gisenyi, Gitarama, Kibungo, Kigali-Ngali, Ruhengeri and Umutara (Donovan, Mpyisi and Loveridge 2002, 12).

Lastly, fish yields are difficult to maintain. The continuing spread of weeds, eutrophication and infestation of rivers and lakes, particularly in the Kagera River (Kibungo Province) and the Nyabarongo River (Kigali, Gitarama, Ruhengeri and Gisenyi provinces) and lakes Cyohoha and Rwero (Kigali Province) creates moderate to severe problems for navigation and fishing activities (World Bank 2004).

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

- Butare: Lower food production especially in districts which have high acidic soils and use less lime
- Byumba: Decline in kilocalories and protein production
- Cyangugu: Decline in kilocalories and protein production
- Gikongoro: High acidic soils and low lime use limits the food production potential in many districts
- Gisenyi: Decline in kilocalories and protein production; deteriorating fish yields in the Nyabarongo River
- Gitarama: Decline in kilocalories and protein production; decline in sweet potato production; deteriorating fish yields in the Nyabarongo River

- Kibungo: Decline in kilocalories and protein production; deteriorating fish yields in the Kagera River
- Kibuye: Food production is stressed only in high altitude districts where heavy rainfall and erosion occur together during a single growing season
- Kigali-Ngali: Decline in kilocalories and protein production deteriorating fish yields in the Nyabarongo River and lakes Cyohoha and Rwero
- Ruhengeri: Decline in kilocalories and protein production; soil exhaustion; deteriorating fish yields in the Nyabarongo River
- Umutara: Decline in kilocalories and protein production; province where poor condition of pastures may lower milk yields for the pastoralists

It is important to stress here that data at even the provincial level hide many pockets of areas where food production potential is being severely deteriorated. Most of the information presently available only addresses meeting the immediate food demands and not the long-run sustainability of the food production service. What is critically missing in the literature is an assessment of the food production potential of the various districts within the provinces and then analyzing what other inputs are needed to increase food production in a sustainable manner.

## 2.3 Water supply, purification and regulation

“Freshwater flows are a prerequisite for the existence of ecosystems,” and generation of ecosystem services (FAO 2000, 35). In turn, ecosystems play a key role in the provisioning of clean freshwater, water flow regulation and water purification. The ability of ecosystems to provide these services is in part determined by the quality of the country’s watersheds (see Box 3).

Rwanda’s main source of freshwater comes from its yearly average precipitation of 1,200–1,280 mm/year.

It has an Internal Renewable Water Resource (IRWR) value of five cu km per year with the internal renewable water resource per capita being 638 cu m per year. 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). Many factors determine the internal renewable water resource including inflows from other countries. The literature does not indicate if Rwanda’s watersheds are coming under increasing pressure to capture, store and safely release water. Despite an abundance of rainfall and watersheds, the provinces of Bugesara (Kigali-Ngali), South and East Kibungo, Butare, Gikongoro and Umatara suffer from occasional droughts and are rain deficit (FAO 2001).

### 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).

## State of freshwater supply, purification and regulation service

The main user of water in Rwanda is the agricultural sector (94 per cent) followed by the domestic sector (five per cent) and finally the industrial sector (two per cent). The total withdrawal rate is 0.8 cu km per year or 141 cu m per capita per year. This is approximately 22 per cent of total allowable withdrawal based on the internal renewable water resource value<sup>4</sup> (World Resources Institute 2003e).

The low withdrawal rate suggests that there is presently little pressure on Rwanda’s water systems in meeting demands. However, this does not imply that the internal capacity of ecosystems to capture, store and release water is not being deteriorated. Indeed,

<sup>4</sup> Water withdrawals as a percentage of renewable water resources is the proportion of renewable water resources withdrawn on a per capita basis, expressed in cubic meters per person per year (cu m/person/year). The value is calculated by dividing water withdrawals per capita by actual renewable water resources per capita; data are usually from different years. While this ratio can indicate that some countries are depleting their water resources, it does not accurately reflect localized over-extraction from aquifers and streams. In addition, the calculation does not distinguish between groundwater and surface water.



FAO data show a decrease in per capita IRWR from 833 cu m/year in 1994 to 638 cu m/year in 1999–2000 (FAO in Karyabwite 2000, 11), lending support to the argument that the present system cannot meet the demand for water if all individuals are given the minimum amount of 1,000 cu m as recommended by the United Nations. To do this, the estimated IRWR would have to be in the vicinity of eight cu km a year, implying a shortage of water based on present recharge rates, a projection supported in UNEP's GEO 2000 report (United Nations Environment Programme 1999, 61). Therefore, more research into the ability of the ecosystem to capture, store and release water will be needed if Rwanda is to ensure water to its citizens in the future.

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

In low-lying and wetland areas, pressure for agricultural space and inappropriate marsh cultivation has caused stream flow changes, increased water evaporation, and reduced water tables and groundwater recharge (Odada *et al.* 2004; World Bank 2004). Currently, at least 93,754 ha of the total 164,947 ha of wetland surface area have been cultivated (Kanyarukiga and Ngarambe 1998). In Kigali-Ngali (Lakes Cyohoha, Bugesera and Rweru) and in Kibungo (Lake Mugesera regions), reclamation, siltation, flood damage and water weed infestation have severely decreased and degraded wetlands. In Bugesera Region of Kigali-Ngali Province, Gashora marsh was drained for food emergency assistance in 2000 (FAO 2001).

In higher-elevation and mountainous areas, deforestation has played a key role in decreasing the ability of watersheds to catch and restore water (Rwanda Ministry of Lands, Human Resettlement and Environmental Protection 2004, 2). Furthermore, large quantities of precipitation in the rainy season cause water run-off problems when high-volume water flows, inundate exposed soil, sedimentation and point and non-point sources of pollution (Hakizimana 2002; Rwanda Ministry of Lands, Human Resettlement and Environmental Protection 2004, 2).

### Provinces most affected by deterioration in freshwater supply, purification and regulation

There was limited information available on which provinces were facing serious drops in internal renew-

able freshwater resource. Hence, we use proxy indicators to determine which provinces may be experiencing water services stress.

- Gikongoro: Suffers from occasional drought and rain deficit
- Kibungo: Suffers from occasional drought and rain deficit; Lake Mugesera regions have severely decreased and degraded wetlands
- Kigali-Ngali: Suffers from occasional drought and rain deficit; lakes Cyohoha, Bugesera and Rweru have severely decreased and degraded wetlands; Gashora marsh was drained for food emergency assistance in 2000
- Umatara: Suffers from occasional drought and rain deficit

## 2.4 Fuel provision

Ecosystems provide biomass, such as wood for fuel wood and soil and water for growing crops and livestock from which crop residues and dung can be harvested, the main biological products which provide energy in Rwanda. The supply of fuel wood is determined by the state of the natural and plantation forests in the country, while dung and crop residues depend on crop yield.

The total forest area in Rwanda, comprised of natural forests and plantations, is 307,000 ha or 3,070 sq km, approximately 12.3 per cent of total land area in Rwanda. Natural forest is estimated to be 46,000 ha or 460 sq km while the area under forest plantations is 261,000 ha or 2,610 sq km (World Resources Institute 2003d). Originally, natural forests are estimated to have covered 36 per cent of total area, but this has been reduced by 78 per cent since 1990 alone (World Resources Institute 2003d).

Dung and crop residue are increasingly being used by households as an energy source. However, the supply of these biological products in turn depends on the amount of livestock available and the availability of crop residue after harvests. There are no real estimates of the proportion of household demand is met by these resources, but the constraints listed earlier for food production will also be constraining factors for the availability of dung and crop residue as a fuel (World Energy Council and FAO 1999, 134).

### State of fuel as an ecosystem service

The rapid decline of forest area has had dire impacts on the supply of fuel wood. Moreover, the decline in agricultural and livestock productivity imply similar circumstances for the supply of dung and crop residue as fuel. Rwanda has a long tradition of agroforestry, however, planted species are now threatened by pests and fungal pathogens and the preferred species in forest plantations, the eucalyptus, consumes large amounts of water and nutrients. Drought and termites further constrain reforestation in Rwanda's eastern savannah regions (FAO Forestry Department 2003).

### Factors influencing decline in biological fuel services

Ninety-eight per cent of Rwandan households use wood or charcoal for cooking and these represent the country's main energy sources (Rwanda Ministry of Finance and Economic Planning 2002). In order to satisfy demands for fuel wood and charcoal production, Rwandans clear forests and vegetation (Odada *et al.* 2004). Other factors contributing to deforestation are uncontrolled logging for settlement and road construction, overgrazing, intensive cultivation of steep hills and lack of reforestation (World Bank Environmental Assessment and Social Management Analysis 2004).

In the 1990s, Rwanda protected 77 per cent of its tropical forest (World Resources Institute 2003d). Since 1990–1994, however, Rwanda has one of the highest deforestation rates in Central Africa, and perhaps all of Africa, currently at four per cent per year (FAO Forestry Department 2003, FAO 2001). Partly as a result of genocide, displacement and repatriation, forested areas have been reduced by almost half in less than a decade and areas customarily protected by conservation legislation have been re-designated as refugee settlement areas (Global Environmental Facility and the International Fund for Agricultural Development 2002; FAO Forestry Department 2003, World Resources Institute 2003d).

### Provinces most affected by deterioration in biological fuel services

The south has suffered the greatest loss in fuelwood.<sup>5</sup> The 1994 ethnic struggle displaced approximately one million people from the agriculturally productive north to regions surrounding the Kigali capital, and to the south where deforestation of plantation forests (and low agricultural production) have been widespread (Kanyamibwa 1998).

- Cyangugu: Nyungwe montane forest is threatened
- Byumba: Akagera National Park
- Gisenyi: Mutara Reserve; Gishwati forest
- Kibungo: Akagera National Park

(World Bank 2004)

## 2.5 Summary of ecosystem services stresses

The ecosystem services, which we have described as stressed, are essential to the well-being of Rwandans. The extreme losses in biodiversity are especially poignant and show how quickly the riches provided by ecosystems can be eroded.

Based on the limited, disparate and incomplete information found in English, we found all provinces except Kigali City were experiencing ecosystem services deterioration to some degree. Of these, all four ecosystem services were stressed in Kibungo, while three out of four were stressed in Buture, Cyangugu, Gikongoro and Gisenyi. Food and fibre provision stress was noted in 11 provinces; biodiversity loss in nine; water supply, regulation and quality in four; and fuel (energy) was also found in four provinces. Now that we have gained an understanding of which ecosystem services are stressed and where they are deteriorating the most, we next investigate how they are impacting on the well-being of the people of Rwanda.

<sup>5</sup> Map: Forest Cover, Rwanda. FAO <http://www.fao.org/forestry/foris/webview/forestry2/index.jsp?siteId=2181&sitetreeId=5966&langId=1&geoId=10>

**Table 1. Ecosystem services stressed/province**

Province	Ecosystem service stressed
Butare	Biodiversity loss Food production Fuel (energy)
Byumba	Biodiversity loss Food production
Cyangugu	Biodiversity loss Fuel (energy) Food production
Gikongoro	Biodiversity loss Food production Water supply, purification and regulation
Gisenyi	Biodiversity loss Food production Fuel (energy)

Province	Ecosystem service stressed
Gitarama	Biodiversity loss Food production
Kibungo	Biodiversity loss Food production Water supply, purification and regulation Fuel (energy)
Kibuye	Biodiversity loss Food production
Kigali-Ngali	Food production Water supply, purification and regulation
Ruhengeri	Biodiversity loss Food production
Umutara	Food production Water supply, purification and regulation

## 3.

# State of Human Well-being in Rwanda

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 need to be necessarily dependent on the state of ecosystem services. Therefore, as stressed in the beginning, only constituents and/or determinants of well-being affected by the state of ecosystem services are reported in this report. Our preliminary review identified the following critical constituents which appear to be under serious threat among many social groups within Rwanda.

### 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 as well as incidence of malnutrition among others.

#### State of ability to be adequately nourished

Since the 1980s, per capita food production in Rwanda has declined steadily and stands at less than 70 per cent of required levels (United States Agency for International Development 2001). Food insecurity affects the population at large, but is particularly acute in 12–15 per cent of rural households (“vulnerable households”). These are concentrated in the southwest of the country, i.e., in Kibuye, Gikongoro and Butare provinces, where high altitudes, poor soils and high population density are pervasive. “Protein-energy malnutrition among children under five years of age is estimated at an average of 30 per cent, with an incidence as high as 37 and 64 per cent in

Gikongoro and Butare, respectively. The national average of acute malnutrition in this age group is around 10 per cent” (FAO 1997). Statistics indicate that a significant portion of the population is presently undernourished with the percentage of people undernourished increasing between 1992 and 2000 from 34 per cent to 40 per cent (United Nations Development Programme 2003).

#### Factor influencing the ability to be adequately nourished

In Rwanda, where 90 per cent of the population is engaged in subsistence farming, the main factor contributing to inadequate nourishment for many is their inability to grow a sufficient amount of food. Food supply is characterized by low and mixed agricultural productivity caused by loss in soil fertility and lack of adequate irrigation water, access to agricultural inputs like fertilizers and seeds and the lack of economic entitlements to purchase food (Rwanda Ministry of Finance and Economic Planning 2002).

In addition, the economic entitlements of a majority of people in Rwanda are low and not sufficient to compensate for low agricultural productivity; 84.6 per cent of the population lives on less than \$2 a day, while 36 per cent of the population lives on less than \$1 a day (World Resources Institute 2003c). A price comparison of staple commodities in Butare shows that 2004 prices are significantly higher than those in 2003 or 2002 (national market prices for staple foods are monitored only in Butare). This is especially the case for sorghum, maize and cassava, and is consistent with trade information showing imports of these products into the country (FEWS 2004a).

#### Provinces most affected by inability to be adequately nourished<sup>6</sup>

- Butare: High food insecurity (75.5 per cent)
- Gikongoro: High food insecurity (80.2 per cent)

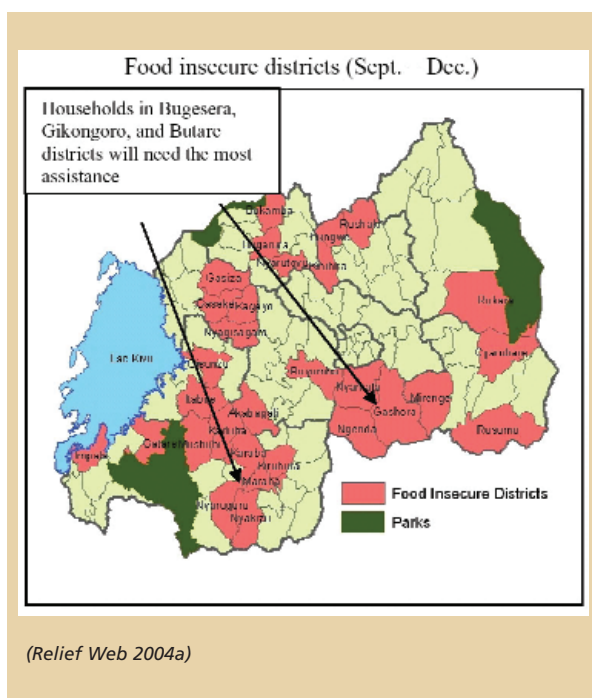
<sup>6</sup> Food Insecure Districts Map <http://www.reliefweb.int/w/map.nsf/wByCLatest/AE7B444886C1D38385256F090075F8B6?Opendocument>

- Kibungo: Food insecurity has worsened due to unseasonably dry conditions
- Kibuye: High food insecurity (79.4 per cent)
- Kigali-Ngali: High food insecurity
- Ruhengeri: High food insecurity (83.7 per cent)
- Umutara: Food insecurity has worsened due to unseasonably dry conditions

(Rwanda. Ministry of Finance and Economic Planning, 2002; FEWS NET 2003)

It is also important to note that although Gisenyi Province is considered a relatively prosperous agricultural region, it contains different sub-regions which rely on temporary or permanent migration to other regions to deal with chronic food insecurity (FEWS NET 2003). For example, Gisenyi inhabitants suffer inadequate nourishment along the Lake Kivu border, and in the volcanic high lands (Mutura and Cyanzarwe Districts) due to high population densities (FEWS NET 2003). Also, Nyagisagara/Kageyo Zone in eastern Gisenyi, and the Congo Nile mountain Ridge central Gisenyi suffer food insecurity due to excessive soil erosion (FEWS NET 2003).

**Map 2. Food Insecure Districts, September 2004**



(Relief Web 2004a)

### 3.2 Ability to have adequate and clean drinking water

The ability to have adequate and clean drinking water contributes to well-being in various ways. First and foremost, water is essential for life. The minimum standard set by the United Nations as required by an individual to satisfy human needs are 1,000 cu m per year (Biggs *et al.* 2004, 13). Clean water is also a necessary condition for a healthy life and to be protected against water-borne diseases like typhoid and cholera; for example a recent typhoid outbreak in Ruhengeri Province was attributed to unclean drinking water (AFRO/WHO 2004). Clean water can be provided in a number of ways. Filtration plants using modern technology provide clean water. 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 have adequate and clean drinking water

Year 2000 data show that 50 per cent of Rwanda's population does not have access to clean drinking water (United Nations Development Programme 2003). This situation is exacerbated by the conversion of many watersheds, particularly wetlands, in the various provinces into agricultural land and other human driven activities thereby destroying an inexpensive method for purifying water and necessitating substantially higher future investment to receive this service.

Displaced migration to the capital has also brought severe urban water and sanitary problems (Kanyamibwa 1998). Poorer groups are confined to unauthorized settlements and peri-urban areas without service from the city's Electrogaz company. The inadequate existing infrastructure provides standing pipe water only to upper-middle income household areas; consequently, the urban poor must buy water at high prices or resort to unsafe sources. (Rwanda. Ministry of Finance and Economic Planning 2002).



In contrast, Butare's Simbi and Maraba districts have access to good water in centrally-located spigots due to favourable social conditions; in both districts, a municipal employee services the water pipes, spigots and water tanks (den Biggelaar 1996).

### Factors influencing the ability to have adequate and clean drinking water

Both natural and institutional factors influence access to drinking water. The rural population has mainly settled in high areas of the approximate 1,800 hills in Rwanda, necessitating the carrying of water from low-lying springs, a job mainly done by women and children. Unfortunately, little use has been made of rain-water catchment systems (Rwanda Ministry of Energy, Water and Natural Resources and World Bank 2000, 3). Institutional influences include "a range of issues from top-down programming of investments, poor cost recovery, limited private sector participation and high per capita investment costs for system construction" (Rwanda, Ministry of Energy, Water and Natural Resources and World Bank 2000, 3).

### Provinces most affected by inability to have adequate and clean drinking water

- Butare: On average, households are more than 800 m from a water source
- Kibungo: On average, households 1,185 m from water source
- Kigali-Nali: On average, households are more than 800 m from a water source
- Umutara: On average, households are more than 800 m from a water source

*(Rwanda Ministry of Finance and Economic Planning 2002)*

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

A reliable source of energy is essential for human well-being, as it is needed for daily domestic activities like cooking, keeping warm and providing light. As previously noted, the majority of Rwandans depend on biological sources of energy for household use.

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

Currently, over 96 per cent of Rwandans depend on wood for domestic energy and, indeed, 80.4 per cent

of country's energy consumption is from wood (Rwanda and United Nations 2003, Rwanda Ministry of Finance and Economic Planning). In the 1980s, Rwanda's consumption of wood outstripped its production by 2.3 million cu m annually (Rwanda Ministry of Finance and Economic Planning 2002). Studies from 1981–1982 and 1989–1990 show that, during those periods, wood demand exceeded existing supply by 3.0 million cu m (Rwanda Ministry of Finance and Economic Planning).

#### Box. 4. Fuelwood demand

Woodfuel demand: 5,394,696 cu m (year not specified!)  
Wood energy demand per capita: 0.68 cu m/person/year

*(World Energy Council and FAO 1999)*

### Factors influencing ability to have energy to keep warm and cook

As a result of this high demand, wooded savannahs in Kgali-Ngali's Bugesera Region, and eastern regions of the country (Kibungo and Umutara) have almost disappeared (Rwanda Ministry of Finance and Economic Planning). Additionally, natural forest in the northwest on the Congo-Nile Crest (which runs through Ruhengeri, Gisenyi, Kibuye, and Cyangugu provinces), Btrunga and Gishwati, and in the northeast, Akagera (Umutara) is rapidly declining (Rwanda Ministry of Finance and Economic Planning).

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

- Cyangugu: Deforestation
- Gisenyi: Deforestation
- Kigali-Ngali: Deforestation
- Kibungo: Deforestation
- Kibuye: Deforestation
- Ruhengeri: Deforestation
- Umutara: Deforestation

## 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 as indicators. In efforts to identify those

needing government support, poverty lines are established using an estimate of the cost of food and non-food basic needs for individuals and families. In Rwanda, an extensive “household condition living survey” was conducted in 2001, which surveyed for household consumption level, income, education, health and other dimensions (Rwanda Ministry of Finance and Economic Planning 2002, 11).

### State of the ability to earn a livelihood

As previously indicated, Rwanda’s economic entitlements are low with 51 per cent of the population living below the poverty line. This translates into 84.6 per cent of the population living on less than \$2 a day, and 36 per cent of the population living on less than \$1 a day (World Resources Institute 2003c).

While most Rwandans are subsistence farmers, some earn a proportion of their income from various cash crops. Banana is the primary cash crop across Rwanda and is grown exclusively by small-scale farmers. The cash income from banana can be as high as 60–80 per cent of total income with the rest of crops providing the remaining 20–40 per cent (Institute des Sciences Agronomiques du Rwanda (ISAR). Coffee is produced by about 400,000 small-holder farmers (only 60 per cent of the number before 1994), mostly in tree stands where 20–25 per cent are over 30 years old. Coffee, however, is a low-return cash crop and its widespread planting reflects an imposed colonial policy (Rwanda, Ministry of Finance and Economic Planning 2002). Fish provide another source of income; in 2000, 5,690 Rwandans were employed in fishing and aquaculture with most of Rwanda’s annual fish catch occurs in the Rift Valley lakes (Shearer 2003).

The incidence of income poverty is highest in Gikongoro, Butare, Kibuye, Kigali-Ngali and Ruhengeri provinces (see Table 2). Pastoralists are one group whose livelihoods are particularly affected by changes in ecosystem services. The total pastoralist population in Umutara is an estimated 105,000 people 20,000 of whom are considered “very poor” and 40,000 of whom are considered “poor.” In this province, nearly 40 per cent of the population obtains most of its income from the sale of livestock products

such as animals and milk and the poor and very poor receive most of their incomes from labour, the availability of which is extremely dependent on livestock product sales (FEWS NET 2001).<sup>7</sup>

**Table 2. Incidence of income poverty, by province**

Province: Inability to earn livelihood	Incidence of income poverty	Gini coefficient
Butare	73.6%	0.429
Byumba	65.8%	0.417
Cyangugu	64.3%	0.433
Gikongoro	77.2%	0.365
Gisenyi	53.5%	0.364
Gitarama	53.7%	0.346
Kibungo	50.8%	0.356
Kibuye	72.5%	0.324
Kigali-Ngali	70.8%	0.411
Kigali City	12.3%	0.427
Ruhengeri	70.3%	0.397
Umutara	50.5%	0.392
Average	60.3%	0.451

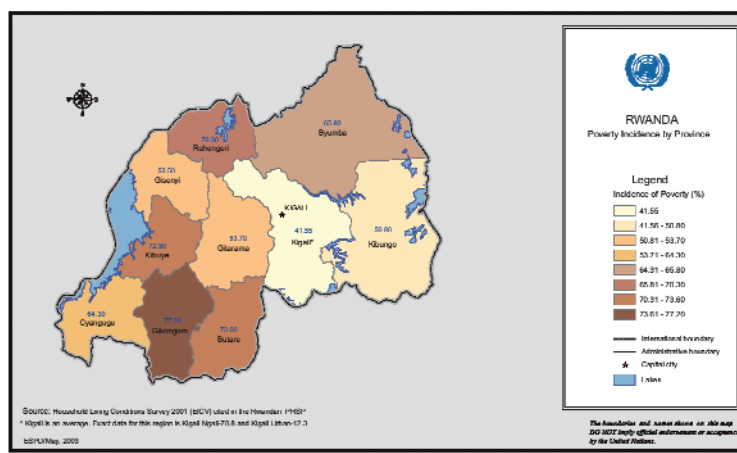
(Government of Rwanda Poverty Reduction Strategy Paper, June 2002)

### Provinces most affected by inability to earn a livelihood (income poverty)

The income poverty map (see Map 3) for Rwanda uses data from the 2001 “Household Living Condition Survey” by mapping it according to a head count index, which indicates the proportion of the population who are below the poverty line (Woldemariam, Elizabeth and Mohammed 2003). This map and the income data in Table 2 show that all provinces have high levels of income poverty, except Kigali City.

<sup>7</sup> In 2001, the spike in milk and meat prices caused by a foot and mouth disease (FMD) outbreak in Umutara Province, stripped the middle and upper income groups of their major source of income (the sale of livestock products) and badly affected food security in the Umutara region. [http://www.fews.net/centers/files/Rwanda\\_200102en.pdf](http://www.fews.net/centers/files/Rwanda_200102en.pdf)

Map 3. Human poverty incidence by province<sup>8</sup>



Note: Province of Umutara is not included on this map. (UNECA 2003)

### 3.5 Summary of constituents of well-being under threat

All four constituents discussed were found to be threatened in three provinces, namely Kibungo, Kigali-Ngali and Umutara, while Butare and Ruhengeri provinces were found to have three constituents under threat. The remainder had two with the exception of Byumba and Gitarama. The inability to earn an adequate livelihood was evident in all provinces, except Kigali City, a particularly distressed problem given the high fertility and population growth rates in Rwanda. There was also high numbers of people in seven provinces, experiencing problems in being adequately nourished with children being particularly hard hit, a situation that does not bode well for the future.

Table 3. Constituents of well-being under threat, by province

Province	Constituent of well-being under threat
Butare	Adequately nourished Adequate and clean drinking water Earn a livelihood
Byumba	Earn a livelihood
Cyangugu	Energy Earn a livelihood

Province	Constituent of well-being under threat
Gikongoro	Adequately nourished Earn a livelihood
Gisenyi	Energy Earn a livelihood
Gitarama	Earn a livelihood
Kibungo	Adequately nourished Adequate and clean drinking water Energy Earn a livelihood
Kibuye	Adequately nourished Energy Earn a livelihood
Kigali-Ngali	Adequately nourished Adequate and clean drinking water Energy Earn a livelihood
Ruhengeri	Adequately nourished Energy Earn a livelihood
Umutara	Adequately nourished Adequate and clean drinking water Energy Earn a livelihood

<sup>8</sup> [http://www.uneca.org/eca\\_resources/Publications/ESPD/PovertyProfiles.pdf](http://www.uneca.org/eca_resources/Publications/ESPD/PovertyProfiles.pdf)



## 4. Linking Ecosystem Services to Human Well-being

In Table 4, the ecosystem services stressed and constituents of well-being threatened are listed for each province. At first glance, several discrepancies appear, in that each ecosystem service listed does not have a corresponding constituent when examined at the provincial level. This problem is most likely caused by lack of data or inconsistent data and indicates where more detailed work is advisable.

However, some provinces do stand out, having several stresses and threats, suggesting that they should be the focus of development efforts or at least warrant further investigation. One province, namely Kibungo,

has all four ecosystem services stressed and all four constituents of well-being threatened. As expected, those provinces where the food and fibre provision ecosystem service is stressed are where the ability to be adequately nourished is also threatened. This holds for Butare, Gikongoro, Kibungo, Kibuye, Kigali-Ngali, Ruhengeri and Umutara unlike Byumba, Cyangugu, Gisenyi and Gitarama where only food production problems are listed. Like income poverty (ability to earn a livelihood), biodiversity loss is prevalent in a majority of provinces and urgent, as the richness that has sustained Rwanda in the past is now quickly being eroded.

**Table 4. Ecosystem services stressed and human well-being/province**

Province	Ecosystem service stressed	Constituents of well-being threatened
Butare	Biodiversity loss Food and fibre provision Fuel (energy)	Adequately nourished Adequate and clean drinking water Earn a livelihood
Byumba	Biodiversity loss Food and fibre provision	Earn a livelihood
Cyangugu	Biodiversity loss Fuel (energy) Food and fibre provision	Energy Earn a livelihood
Gikongoro	Biodiversity loss Food and fibre provision Water supply, purification and regulation	Adequately nourished Earn a livelihood
Gisenyi	Biodiversity loss Food and fibre provision Fuel (energy)	Energy Earn a livelihood
Gitarama	Biodiversity loss Food and fibre provision	Earn a livelihood
Kibungo	Biodiversity loss Food and fibre provision Water supply, purification and regulation Fuel (energy)	Adequately nourished Adequate and clean drinking water Energy Earn a livelihood
Kibuye	Biodiversity loss Food and fibre provision	Adequately nourished Energy Earn a livelihood

Province	Ecosystem service stressed	Constituents of well-being threatened
Kigali-Ngali	Food and fibre provision Water supply, purification and regulation	Adequately nourished Adequate and clean drinking water Energy Earn a livelihood
Ruhengeri	Biodiversity loss Food and fibre provision	Adequately nourished Energy Earn a livelihood
Umutara	Food and fibre provision Water supply, purification and regulation	Adequately nourished Adequate and clean drinking water Energy Earn a livelihood

### Recommendations for a local-scale integrated assessment

There is no doubt that Rwanda faces many challenges in its attempts to reduce poverty and improve the well-being of its citizens. The analysis in the preceding paragraphs highlights a number of critical linkages between ecosystem services and human well-being in Rwanda. All provinces face a multitude of problems and challenges; but with some provinces faring worse than others. Butare and Kibungo in particular have serious deteriorations in all four main ecosystem services with poverty in at least three constituents of well-being.

The first reaction will be to increase food production and reduce hunger and ensure adequate nourishment for all individuals. However, it should be kept in mind that only 52 per cent of the land is considered arable and of this 90 per cent is already under cultivation. Therefore, expanding crop land is not a feasible solution unless marginal lands are brought under cultivation. This is a sub-optimal solution as productivity will be low and, in fact, may cause further deterioration in other ecosystem services like water regulation and supply. The solution lies in intensification of existing agricultural land but with proper management of the use of fertilizers and other inputs. The objective is to improve yields while reducing the impacts on other ecosystem services.

Water is another critical issue in Rwanda. The present supply, although within the internal renewable rate, will not be sufficient to meet the demands of intensified agriculture and meet the individual demand for water as stipulated by the United Nations. More focus on watershed management will need to be put in

place. Management of wetlands for better water management and not just for agricultural production will need to be pursued more aggressively. This will also be true for meeting the growing demand for fuel. New sources which put less pressure on ecosystems will have to be pursued including exploring renewable energy sources.

It will be critical for Rwanda to get more information on the various links between ecosystem services and human well-being if it is to make sustainable progress toward achieving many of the Millennium Development Goals (MDGs). Many recent studies have highlighted the potential for trade-offs among the various MDGs if the inter-dependency among the goals are not considered in decision-making (Millennium Assessment). For example, a strategy to increase food production through increase in fertilizer use and expansion of arable land may produce desired results but also put increasing pressure on the water supply, regulation and purification ecosystem service. Furthermore, strategies to reduce extreme poverty through economic growth can have negative impacts on the regulating and supporting ecosystem services, thus making meeting goal seven (environmental sustainability) more difficult.

It should also be recognized that we were not able to distinguish the different stakeholders using and dependent on the various ecosystem services for their well-being. A subsistence farmer will have a very different relationship with the food production and water supply ecosystem services *vis-à-vis* a commercial farmer who may be able to access a multitude of substitutes for some of the ecosystem services; in the short run anyway because in the long run, deteriorating ecosystem services will affect all individuals.

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It would, therefore, be useful for policy-makers to understand more fully the nature of the links among ecosystem services and well-being in the country. Many of these links are context specific and a local-scale integrated assessment would be a useful first step

in increasing the knowledge base of these links. Integrated assessments in the Kibungo and Butare provinces would serve as useful pilot studies which can then be scaled up to include other provinces.

## References

- AFRO/WHO. *EPI/IDS Bulletin*, Vol 5, Issue 7, July 2004. <http://www.afro.who.int/csr/ids/bulletins/eastern/jul2004.pdf>
- Alcamo, Joseph *et al.* 2003. *Ecosystems and human well-being: a framework for assessment*. Washington, D.C.: Island Press, xiv, 245 p.
- American Association for the Advancement of Science. *Malaria and Development in Africa: A Cross-Sectoral Approach*. <http://www.aaas.org/international/africa/malaria91/background.html>
- Biggs, R. *et al.* 2004. *Nature supporting people: the southern African millennium ecosystems assessment: integrated report*. Harare: Southern African Sub Global Assessment, SAfMA, 68 p. <http://www.millenniumassessment.org/en/subglobal.safma.aspx>
- Brinkmann U. and A. Brinkmann. "Malaria and health in Africa: the present situation and epidemiological trends." *Trop Med Parasitol*. 1991 Sep;42(3):204-13. [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&list\\_uids=1801148&dopt=Citation](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&list_uids=1801148&dopt=Citation)
- Chemonics International Inc. 2003. *Rwanda Environmental Threats and Opportunities Assessment*. Task Order No. 818, under the Biodiversity and Sustainable Forestry (BIOFOR) IQC. USAID Contract No. LAG-I-00-99-00014-00. [http://www.google.ca/search?q=cache:8BO7qCt4bU4J:www.biofor.com/documents/BIOFOR%2520Rwanda%2520ETOA\\_Complete%2520Final%2520Report..pdf+bugesera+marsh+minaloc&hl=en&client=firefox-a](http://www.google.ca/search?q=cache:8BO7qCt4bU4J:www.biofor.com/documents/BIOFOR%2520Rwanda%2520ETOA_Complete%2520Final%2520Report..pdf+bugesera+marsh+minaloc&hl=en&client=firefox-a)
- Daily, Gretchen C. 1997. *Nature's services: societal dependence on natural ecosystems*. Washington, D.C.: Island Press, xx, 392 p.
- Daily, Gretchen C. and Katherine Ellison. 2002. *The new economy of nature: the quest to make conservation profitable*. Washington, D.C.: Island Press, 260 p.
- den Biggelaar, Christoffel, FAO 1996. *Farmer Experimentation and Innovation: A case study of knowledge generation processes in agroforestry systems in Rwanda*. [http://www.fao.org/documents/show\\_cdr.asp?url\\_file=/DOCREP/006/W2406E/W2406E02.htm](http://www.fao.org/documents/show_cdr.asp?url_file=/DOCREP/006/W2406E/W2406E02.htm)
- de Treville, D. "Notes on Dairy Goats and Artisan Cheese Production in Central Africa." *Newsletter of the Society for Dairy Technology*, Cumbria, United Kingdom. Heart of Africa: Burundi Goat Rehabilitation Project. [http://burundigoats.tripod.com/Tropical\\_Emphasis/Dairy\\_\\_\\_Cheese/dairy\\_\\_\\_cheese.html](http://burundigoats.tripod.com/Tropical_Emphasis/Dairy___Cheese/dairy___cheese.html)
- Dix, H. M. 1981. *Environmental Pollution*. Chichester: John Wiley.
- Donaldson, Susan and Sherman Swanson. 2001. "Water Quality." *Modified from Living on the Land 2001: Stewardship for Small Acreages*. University of Nevada, Cooperative Extension and University of Nevada, Reno.
- Donovan, Cynthia, Edson Mpyisi and Scott Leveridge. 2002. *Forces driving change in Rwandan smallholder agriculture, 1990–2001*. Kigali: Rwanda Ministry of Agriculture, Livestock and Forestry. 19 p. <http://www.aec.msu.edu/agecon/fs2/rwanda/ForcesDrivingChangeinRwandaSmallholderAgricultureexd0303.pdf>
- Duraiappah, A. K. 2002. *Poverty and ecosystems: a conceptual framework*. UNEP Division of Policy and Law paper. Nairobi: UNEP. 49 p.
- Duraiappah, Anantha Kumar. 2004. *Exploring the links: human well-being, poverty & ecosystem services*. Winnipeg, MB: IISD/UNEP-DPDL, 44 p.
- Duraiappah, A. K. 2005. *An economic approach for evaluating health and environment linkages*. Geneva: WHO/UNEP. 40 p.
- Economic Commission for Africa. *Poverty Mapping for Selected African Countries*. [http://www.uneca.org/eca\\_resources/Publications/ESPD/PovertyProfiles.pdf](http://www.uneca.org/eca_resources/Publications/ESPD/PovertyProfiles.pdf)
- Episcopal Relief and Development. 2004. *Rwanda*. [http://www.er-d.org/programs\\_39567\\_ENG\\_HTM.htm](http://www.er-d.org/programs_39567_ENG_HTM.htm)

- FAO. *Major Food and Agricultural Commodities and Producers*. <http://www.fao.org/es/ess/top/country.jsp?lang=EN&country=184>
- FAO. 1997. *FAO/WFP Crop and Food Supply Assessment Mission to Rwanda*. July 1, 1997. [http://www.fao.org/documents/show\\_cdr.asp?url\\_file=/docrep/004/w5836e/w5836e00.htm](http://www.fao.org/documents/show_cdr.asp?url_file=/docrep/004/w5836e/w5836e00.htm)
- FAO. 2001. *Africa Environment Outlook: Forest cover and quality in easteren Africa*. <http://www.grida.no/aeo/134.htm>.
- FAO. 2005. *Country Profiles and Mapping Information System: Rwanda*. Retrieved from the World Wide Web, February 2005. <http://www.fao.org/countryprofiles/index.asp?lang=en&ISO3=RWA>
- FAO. 2001. "FAO emergency projects in Rwanda." *ReliefWeb* latest updates (April 6, 2001). <http://www.reliefweb.int/rw/rwb.nsf/AllDocsByUNID/6635216273806bcec1256a260034265e>
- FAO. Forestry Department. 2003. *Country profiles: Rwanda*. [www.fao.org/forestry/site/23747/en/rwa](http://www.fao.org/forestry/site/23747/en/rwa)
- FAO. Land and Water Development Division. 2000. *New dimensions in water security: water, society and ecosystem services in the 21st. century*. Rome: FAO. 82 p. [ftp://ftp.fao.org/agl/aglw/docs/misc25.pdf](http://ftp.fao.org/agl/aglw/docs/misc25.pdf)
- FAO. Land and Water Development Division. 2005. *Review of Water Resource Statistics By Country, 2005*. [http://www.fao.org/ag/agl/aglw/aquastat/water\\_res/rwanda/index.stm](http://www.fao.org/ag/agl/aglw/aquastat/water_res/rwanda/index.stm)
- FAO and World Energy Council. *Wood fuels situation in Africa Table A1*. <http://www.worldenergy.org/wec-geis/global/downloads/FAOdata.pdf>
- FEWS. 2004a. *Rwanda Food Security Update*, May 14, 2004. [http://www.fews.net/centers/files/Rwanda\\_200404en.pdf](http://www.fews.net/centers/files/Rwanda_200404en.pdf)
- FEWS. 2004b. Rwanda Food Security Update: July 29, 2004 – "Recent dry spell threatens crops," *ReliefWeb* 2004, September 2004: Food Security Update. <http://www.fews.net/centers/innerSections.aspx?f=rw&m=1001386&pageID=monthliesDoc>
- FEWS NET. 2001. Rwanda: a monthly report on food security and vulnerability (March 15, 2001). Retrieved from the World Wide Web, February 2005. [http://www.fews.net/centers/files/Rwanda\\_200102en.pdf](http://www.fews.net/centers/files/Rwanda_200102en.pdf)
- FEWS NET. 2003. "Rwanda food security update, November 23, 2003." Retrieved from the World Wide Web, February 2005. <http://www.fews.net/centers/innerSections.aspx?f=rw&m=1001114&pageID=monthliesDoc>
- Field Museum. 2003. *Photo gallery: experience the wonders of the Albertine Rift: the human landscape*. Retrieved from the World Wide Web, February 2005. [http://www.fieldmuseum.org/congo/phohum\\_lackivuboa.html](http://www.fieldmuseum.org/congo/phohum_lackivuboa.html)
- GlideNumber. 2002. <http://www.glide-number.net/glide/public/search/details.jsp?glide=11114&record=2&last=8>
- Global Environmental Facility and the International Fund for Agricultural Development. 2002. *Tackling Land Degradation and Desertification, 2002*. [http://www.ifad.org/events/wssd/gef/GEF\\_eng.pdf](http://www.ifad.org/events/wssd/gef/GEF_eng.pdf)
- Goteborg University. *Water Hyacinth's Spread, Emerging Problems, Control Measures and Indicators of Weed Abundance: Experiences from Lake Victoria*. <http://www.handels.gu.se/econ/EEU/waterhyacinth.pdf>.
- Hakizimana, Prosper. 2002. "Preserving Water for a Sustainable Development: African Great Lakes Region (Central Africa)." In *Managing shared waters: towards sustainable transboundary coastal ecosystems [abstracts]*. Toronto: Pollution Probe, 2002. Managing Shared Waters: towards sustainable transboundary coastal ecosystems [conference] June 23–28, 2002, Hamilton, Ontario, Canada. <http://www.pollutionprobe.org/managing.shared.waters/MSWAbstracts.pdf>
- Hishamunda, Nathanael *et al.* 1998. *Small-Scale Fish Farming in Rwanda: Economic Characteristics*. Pond Dynamics/Aquaculture Collaborative Research Support Program Research Reports 98-124. June 1, 1998. <http://govdocs.aquacore.org/cgi/reprint/2003/804/8040010.pdf>
- Institute des Sciences Agronomiques du Rwanda (ISAR). 2000. "Importance of banana crop in Rwanda." ATDT Project-Rwanda. Retrieved from the World Wide Web, February 2005. <http://www.isar.cgiar.org/atdt/Banana/banana.htm>
- International Monetary Fund. Poverty Reduction Strategy Plan (PRSP) Interim report, November 2000. <http://www.imf.org/external/NP/prsp/2000/rwa/01/110100.pdf>



- Jackson, Dorothy. *Forest Peoples Programme WRM's bulletin* N° 62, September 2002. <http://www.wrm.org.uy/bulletin/62/Rwanda.html>
- Jose, A. M. *Sustainable Agricultural Development and Environment: Conflicts and Contradictions in the context of Rwandan Agriculture*. Organization for Social Science Research in Eastern and Southern Africa (OSSREA), 2004. <http://www.ossrea.net/announcements/jose.pdf>
- Kalpers, José. 2001. *Volcanoes under Siege: Impact of a Decade of Armed Conflict in the Virungas*. 2001. World Wildlife Fund. <http://www.worldwildlife.org/bsp/publications/africa/144/Intro.htm>
- Kanyamibwa, S. 1998. "Impact of war on conservation: Rwandan environment and wildlife in agony." *Biodiversity and Conservation*. 7, (1998): 1399-1406.
- Kanyarukiga, Sam G. and Vincent Ngarambe. 1998. *Wetland Characterization and Classification for Sustainable Agricultural Development*. FAO Document Repository. [http://www.fao.org/documents/show\\_cdr.asp?url\\_file=/DOCREP/003/X6611E/x6611e02c.htm](http://www.fao.org/documents/show_cdr.asp?url_file=/DOCREP/003/X6611E/x6611e02c.htm)
- Karyabwite, Diana Rizzolio. 2000. *Water sharing in the Nile River Valley*. Geneva: UNEP/DEWA/GRID. 85 p. <http://www.isr.umd.edu/CELS/research/nilesim/nilereport.pdf>
- Kelly, Valerie, Edson Mpyisi, Emanuel Shingiro and Jean Baptiste Nyarwaya. *Agricultural Intensification in Rwanda: An Elusive Goal Fertilizer Use and Conservation Investments. FSRP/DSA Policy Brief*. January 2001. <http://www.aec.msu.edu/agecon/fs2/Rwanda/agintensification.pdf>
- Lewis, L. A. and L. Berry. 1988. *African Environments and Resources*. Boston MA: Unwin and Hyman.
- Loevinsohn M. E. 1994. "Climatic warming and increased malaria incidence in Rwanda." *Lancet*. 1994 Mar 19;343(8899):714-8.
- Loreau, Michel, Shahid Naeem and Pablo Inchausti. 2002. *Biodiversity and ecosystem functioning : synthesis and perspectives*. Oxford: Oxford University Press. 306 p.
- Malaria Foundation International. 2005. *Executive summary for Economics of Malaria Center for Development, Harvard University and the London School of Hygiene and Tropical Medicine*. <http://www.malaria.org/jdsachseconomic.html>
- MINITRAPE/UNICEF. 1995. *UNEP Common Country Assessment: 1999–2000*. [http://www.unrwanda.org/undp/health\\_final.pdf](http://www.unrwanda.org/undp/health_final.pdf) or [http://www.google.ca/search?q=cache:1chGOKSwhewJ:www.unrwanda.org/undp/health\\_final.pdf+rwanda+water+contamination+trend&hl=en&client=firefox-a](http://www.google.ca/search?q=cache:1chGOKSwhewJ:www.unrwanda.org/undp/health_final.pdf+rwanda+water+contamination+trend&hl=en&client=firefox-a)
- Moorhouse, T. M., P. Agaba, and T. J. McNabb. 2000. *Recent Efforts in Biological Control of Water Hyacinth in the Kagera River Headwaters of Rwanda*. [http://www.cleanlake.com/rwanda\\_biological\\_control\\_program.htm](http://www.cleanlake.com/rwanda_biological_control_program.htm)
- Mpyisi, Edson. 2002. *Estimation of Area and Production of Root and Tuber Crops in Rwanda, December 2002*. Food Security Research Project (FSRP/USAID/MINAGRI). Michigan State University/Ministry of Agriculture, Rwanda. [http://www.aec.msu.edu/agecon/fs2/rwanda/mpyisi\\_paper\\_14\\_root\\_tuber\\_crops.pdf](http://www.aec.msu.edu/agecon/fs2/rwanda/mpyisi_paper_14_root_tuber_crops.pdf)
- Mpyisi, Edson *et al.* 2000. *Food security survey: phase 1: Agricultural production and land use season 2000A*. Kigali: Rwanda Ministry of Agriculture, Animal Resources, and Forestry. 19 p. [http://www.aec.msu.edu/agecon/fs2/rwanda/ag\\_prod\\_2000e.pdf](http://www.aec.msu.edu/agecon/fs2/rwanda/ag_prod_2000e.pdf)
- MSN Encarta. 2004. *Rwanda*. Retrieved from the World Wide Web, February 2005. [http://encarta.msn.com/encyclopedia\\_761560996/Rwanda.html](http://encarta.msn.com/encyclopedia_761560996/Rwanda.html)
- Nicholson, Charles F., Lucy Mwangi, Steven J. Staal and Philip K. Thornton. 2003. *Dairy Cow Ownership and Child Nutritional Status in Kenya. December 2003*. Cornell University.
- Odada, E. O. *et al.* 2004. *Global International Water Assessment, Regional Assessment 47*. East African Rift Valley Lakes. Kalmar: University of Kalmar/UNEP, 2004, [180 p.] Series title: GIWA regional assessment /No. 47. [http://www.giwa.net/areas/reports/r47/giwa\\_regional\\_assessment\\_47.pdf](http://www.giwa.net/areas/reports/r47/giwa_regional_assessment_47.pdf)
- OECD and African Development Bank. 2005. *African economic outlook*. Paris: OECD. 540 p.
- Percival, Valerie and Thomas Homer-Dixon. 1995. "Environmental Scarcity and Violent Conflict: The Case of Rwanda," University of Toronto: Occasional Paper for the Project on Environment, Population, and Security. Retrieved from the World Wide Web, February 2005. <http://www.library.utoronto.ca/pcs/eps/rwanda/rwanda1.htm>

- Ravenga and Cassar. WWF. [http://www.wwf.org.uk/filelibrary/pdf/africa\\_freshwater.pdf](http://www.wwf.org.uk/filelibrary/pdf/africa_freshwater.pdf)
- Relief Web. 2000. "Rwanda: Land Scarcity May Jeopardise Peace Process." Retrieved from the World Wide Web, February 2005. <http://www.reliefweb.int/w/rwb.nsf/0/c4cd2a690820c5c1c125698f004c64a3?OpenDocument>
- Relief Web. 2004. "Rwanda: Government implements low-cost housing for returnees." <http://www.reliefweb.int/w/rwb.nsf/0/aa774f135f18da4a49256f25001ab967?OpenDocument>
- Relief Web. 2004a. *Food insecure districts*. <http://www.reliefweb.int/w/map.nsf/wByCLatest/AE7B444886C1D38385256F090075F8B6?Opendocument>
- Rwanda, [Official Website]. <http://www.gov.rw/>
- Rwanda. *Rwanda at a glance*. Retrieved from the World Wide Web, February 2005. <http://www.ortpn.gov.rw/rwandaataglance.htm>
- Rwanda. Ministry of Energy, Water and Natural Resources and World Bank. 2000. *Project appraisal document on a proposed credit in the amount... to the Rwandese Republic for a rural water supply and sanitation project, May 10, 2000*. World Bank report no. 20419. World Bank Africa Regional Office. 56 p. [http://www-wds.worldbank.org/servlet/WDSContentServer/WDSP/IB/2000/06/10/000094946\\_00051905305043/Rendered/PDF/multi\\_page.pdf](http://www-wds.worldbank.org/servlet/WDSContentServer/WDSP/IB/2000/06/10/000094946_00051905305043/Rendered/PDF/multi_page.pdf)
- Rwanda, Ministry of Finance and Economic Planning. [n.d.] *Energy and Water*. Retrieved from the World Wide Web, February 2005. <http://www.ambarwanda.org.uk/privatisation/4-1>.
- Rwanda. Ministry of Finance and Economic Planning. 2002. *Poverty Reduction Strategy Paper*. [s.l.]: The Ministry National Poverty Reduction Programme, 2002. 160 p.
- Rwanda. Ministry of Lands, Resettlement and Environment. 2003. *National strategy and action plan for the conservation of biodiversity in Rwanda*. The Ministry. 80 p. <http://www.biodiv.org/doc/world/rw/rw-nbsap-01-en.pdf>
- Rwanda. Ministry of Lands, Human Resettlement and Environmental Protection. 2004. *Republic of Rwanda: integrated management of critical ecosystems*. Initial project information document (PID), report no. AB840. World Bank. 15 p. [http://www-wds.worldbank.org/servlet/WDSContentServer/WDSP/IB/2004/04/14/000104615\\_20040414094455/Rendered/PDF/PID0P070700.pdf](http://www-wds.worldbank.org/servlet/WDSContentServer/WDSP/IB/2004/04/14/000104615_20040414094455/Rendered/PDF/PID0P070700.pdf)
- Rwanda. Ministry of Local Government, Community Development and Social Affairs. 2004. Retrieved from the World Wide Web, February 2005. [http://www.minaloc.gov.rw/admin\\_territory/admin\\_map\\_rwanda.htm#Byumba](http://www.minaloc.gov.rw/admin_territory/admin_map_rwanda.htm#Byumba)
- Rwanda and the United Nations. 2003. *Millennium Development Goals: Status Report 2003*.
- Schulze, E.-D., and H. A. Mooney. 1993. "Ecosystem function of biodiversity: a summary." Pages 497-510 in E.-D. Schulze and H. A. Mooney, editors. *Biodiversity and ecosystem function*. Berlin, Germany: Springer-verlag.
- Sen, A. 1990. "Food entitlements and economic chains," in *Hunger in History*. Edited by L. F. Newman, pp. 374-385. Cambridge, MA and Oxford: Basil Blackwell.
- Shearer, Catherine. 2003. Pisculture (Rwanda) IDRC. July 2003. [http://web.idrc.ca/en/ev-35272-201-1-DO\\_TOPIC.html](http://web.idrc.ca/en/ev-35272-201-1-DO_TOPIC.html)
- Stevenson and Frazier. 2001. Australian Government Department of the Environment and Heritage. <http://www.deh.gov.au/ssd/publications/ssr/pubs/status-african-ssr161.pdf>
- Tallon, F. 1988. "Food self-sufficiency and the population problem in Rwanda." *Imbonezamuryango* Dec;(13):6-12 [http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&list\\_uids=12315664&dopt=Abstract](http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&list_uids=12315664&dopt=Abstract)
- United Nations Development Programme. 2000. "Population." In *UNDP Rwanda - CCA* (Common Country Assessment. [s.l.]: UNDP, various.
- Other title: Common country assessment 1999-2000.
- United Nations Development Programme. 2003a. *Human Development Report: Human Development Indicators 2003*. Retrieved from the World Wide Web, February 2005. [http://www.undp.org/hdr2003/indicator/cty\\_f\\_RWA.html](http://www.undp.org/hdr2003/indicator/cty_f_RWA.html)
- United Nations Development Programme. 2003c. *Millennium Development Goals: status report 2003*. [s.l.] : Rwanda; United Nations Development Programme. 29 p.

- United Nations Environment Programme. 1999. *Global environment outlook 2000*. Nairobi: UNEP. 398 p.
- United Nations Environment Programme. *Global Resource Information Database*. Retrieved from the World Wide Web, February 2005. <http://grid2.cr.usgs.gov/greatlakes/basins.php3>
- United States Agency for International Development. 2004. *Rwanda Integrated Strategic Plan 2004-2009* (Volume 1). January 9, 2004. <http://www.usaid-rwanda.rw/SO2/ISP2004%202009%20vol%201.pdf>
- United States Agency for International Development. 2001. *Rwanda Overview*. <http://www.usaid.gov/pubs/bj2001/afr/rw/>
- United States Central Intelligence Agency. 2004. *World factbook: Rwanda*. Retrieved from the World Wide Web, January 2005. <http://www.cia.gov/cia/publications/factbook/geos/rw.html>
- United States Department of State. Bureau of African Affairs. 2005. *Background Note: Rwanda*. January 2005. <http://www.state.gov/r/pa/ci/bgn/2861.htm>
- Universiteit Utrecht. Universiteitsbibliotheek. 2004. <http://www.library.uu.nl/wesp/populstat/Africa/rwandag.htm>
- Unrepresented Nations and Peoples Organization. *Batwa*. Retrieved from the World Wide Web, February 2005. <http://www.unpo.org/print.php?arg=10&par=32>
- van der Helm, Wim. <http://www.documentary.de/erwanda.htm>
- VERWIMP, Ph., 2001. *The Ruriganiza Famine in Southern Rwanda (1989): a Prelude to Genocide?*, Centre for Economic Studies, KU Leuven, mimeo, 70 p.
- Wangwe, Samuel M. and Dennis Rweyemamu. [WWW site] Enhancing regional integration: a case of the Great Lakes region [s.l.]: Economic and Social Research Foundation, ESRF, 2002, Conference/meeting: Symposium on the Great Lakes Region: Reinforcing the Region's Solidarity and Setting an Agenda for a Culture of Peace, Unity and People-Centered Development Kampala UG, April 8–10, 2002
- White, F. (1983). The vegetation of Africa, a descriptive memoir to accompany the UNESCO/AETFAT/UNSO Vegetation Map of Africa (3 Plates, Northwestern Africa, Northeastern Africa, and Southern Africa, 1:5,000,000). UNESCO, Paris.
- Wise, Victoria. 2004. *Nutritional situation of young children in Rwanda: an analysis of anthropometric data collected by the Household Living Conditions Survey 1999–2001*. Kigali: Rwanda Ministry of Agriculture, Livestock, and Forestry Food Security Research Project. 23 p. [http://www.aec.msu.edu/agecon/fs2/rwanda/wpr\\_anthro\\_rwanda\\_english\\_wise.pdf](http://www.aec.msu.edu/agecon/fs2/rwanda/wpr_anthro_rwanda_english_wise.pdf)
- Woldemariam, Elizabeth and Limia Mohammed. 2003. *Poverty Mapping for Selected African Countries*. Economic Commission for Africa. May 2003. [http://www.uneca.org/eca\\_resources/Publications/ESPD/PovertyProfiles.pdf](http://www.uneca.org/eca_resources/Publications/ESPD/PovertyProfiles.pdf)
- World Agroforestry Centre. 2003. "Agroforestry checks the devastating loss of land on Rwanda's thousand hills." *Agroforestry in Action*. Retrieved from the World Wide Web, February 2005. [http://www.worldagroforestry.org/ar2003/downloads/2pager\\_LP\\_Web002.pdf](http://www.worldagroforestry.org/ar2003/downloads/2pager_LP_Web002.pdf)
- World Bank. 2004. *Environmental Assessment and Social Management Analysis*. Washington, D.C.: World Bank, 2004.
- World Bank. 2005. *World development report 2005: a better investment climate for everyone*. New York: Oxford University Press. 271 p.
- World Energy Council and FAO. 1999. *The challenge of rural energy poverty in developing countries*. World Energy Council, 1999. 185 p. <http://www.worldenergy.org/wec-geis/global/downloads/rural.pdf>
- World Resources Institute. 2003a. *Earthtrends: Country Profile: Biodiversity and Protected Areas: Rwanda*. 2003. [http://earthtrends.wri.org/pdf\\_library/country\\_profiles/Bio\\_cou\\_646.pdf](http://earthtrends.wri.org/pdf_library/country_profiles/Bio_cou_646.pdf)
- World Resources Institute. 2003b. *Earthtrends: Country Profile: Coastal and Marine Ecosystems: Rwanda*. [http://earthtrends.wri.org/pdf\\_library/country\\_profiles/Coa\\_cou\\_646.pdf](http://earthtrends.wri.org/pdf_library/country_profiles/Coa_cou_646.pdf)



World Resources Institute. 2003c. *Earthtrends: Country Profiles: Economic Indicators: Rwanda 2003*. [http://earthtrends.wri.org/pdf\\_library/country\\_profiles/Eco\\_cou\\_646.pdf](http://earthtrends.wri.org/pdf_library/country_profiles/Eco_cou_646.pdf)

World Resources Institute. 2003d. *Earthtrends: Country Profile: Forests, Grasslands and Drylands: Rwanda*. 2003. [http://earthtrends.wri.org/pdf\\_library/country\\_profiles/For\\_cou\\_646.pdf](http://earthtrends.wri.org/pdf_library/country_profiles/For_cou_646.pdf)

World Resources Institute. 2003e. *Earthtrends: Country Profile – Water Resources and Freshwater Ecosystems: Rwanda*. 2003. [http://earthtrends.wri.org/pdf\\_library/country\\_profiles/wat\\_cou\\_646.pdf](http://earthtrends.wri.org/pdf_library/country_profiles/wat_cou_646.pdf)

World Resources Institute. 2003f. *Earthtrends: Country Profile – Water Resources and Freshwater Ecosystems: Tanzania*. [http://earthtrends.wri.org/pdf\\_library/country\\_profiles/wat\\_cou\\_834.pdf](http://earthtrends.wri.org/pdf_library/country_profiles/wat_cou_834.pdf)