



Rwanda

From Post-Conflict to Environmentally Sustainable Development

United Nations Environment Programme

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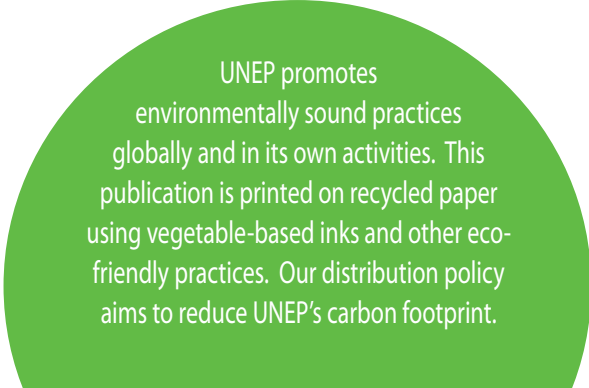
United Nations Environment Programme
P.O. Box 30552
Nairobi, KENYA
Tel: +254 (0)20 762 1234
Fax: +254 (0)20 762 3927
E-mail: unepub@unep.org
Web: <http://www.unep.org>

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Rwanda

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Sustainable Development

Table of contents

Foreword	6
Chapter 1: Introduction	10
1.1 Background.....	12
1.2 Goal and objectives	14
1.3 Linkages to UN and national planning processes.....	14
1.4 Report structure	14
Chapter 2: Country Context	16
2.1 Introduction.....	18
2.2 Geography	20
2.3 Climate	24
2.4 Biodiversity	27
2.5 Key ecological regions	28
2.6 Society	34
2.7 Governance	43
2.8 Economy.....	45
2.9 Development vision	45
Chapter 3: Assessment Process	46
3.1 Introduction.....	48
3.2 Target audience	48
3.3 Assessment approach	48
3.4 Equipment used	56
3.5 Laboratory analysis.....	57
3.6 Limitations and constraints	57
Chapter 4: Conflict, Peacebuilding and the Environment	60
4.1 Introduction.....	62
4.2 Assessment activities.....	62
4.3 Governance	63
4.4 Overview of key issues.....	64
4.5 Conclusions	71
4.6 Recommendations.....	71
Chapter 5: Population Displacement, Resettlement and the Environment	72
5.1 Introduction.....	74
5.2 Assessment activities.....	75
5.3 Overview of population displacement in Rwanda.....	75
5.4 Overview of resettlement.....	78
5.5 Governance	80
5.6 Overview of environmental issues related to population displacement and resettlement	81
5.7 Conclusions	96
5.8 Recommendations.....	96
Chapter 6: Disasters and Climate Change	98
6.1 Introduction.....	100
6.2 Assessment activities.....	100
6.3 Overview of disasters and climate change in Rwanda	101
6.4 Governance	109

6.5	Overview of key issues.....	109
6.6	Conclusions	114
6.7	Recommendations.....	114
Chapter 7: Agriculture and Land Degradation		118
7.1	Introduction.....	120
7.2	Assessment activities.....	120
7.3	Overview of the agriculture sector	122
7.4	Governance.....	129
7.5	Overview of key issues.....	132
7.6	Conclusions	146
7.7	Recommendations.....	146
Chapter 8: Forest Resources		148
8.1	Introduction.....	150
8.2	Assessment activities.....	150
8.3	Overview of the forestry sector	151
8.4	Governance.....	163
8.5	Overview of key issues.....	163
8.6	Conclusions	170
8.7	Recommendations.....	170
Chapter 9: Water Resources		172
9.1	Introduction.....	174
9.2	Assessment activities.....	174
9.3	Overview of freshwater resources in Rwanda	175
9.4	Overview of water consumption.....	179
9.5	Governance.....	183
9.6	Overview of key issues.....	184
9.7	Expanding regional cooperation	196
9.8	Conclusions	198
9.9	Recommendations.....	199
Chapter 10: Wildlife and Protected Area Management		200
10.1	Introduction.....	202
10.2	Assessment activities.....	202
10.3	Overview of wildlife and protected areas	203
10.4	Governance.....	212
10.5	Overview of key issues.....	213
10.6	Conclusions	222
10.7	Recommendations.....	222
Chapter 11: Energy and the Environment		224
11.1	Introduction.....	226
11.2	Assessment activities.....	226
11.3	Overview of the energy sector.....	227
11.4	Energy sources.....	229
11.5	Energy consumption	234
11.6	Governance.....	235
11.7	Overview of key issues.....	237
11.8	Conclusions	247
11.9	Recommendations.....	248

Chapter 12: Urban Environment and Health Issues	250
12.1 Introduction.....	252
12.2 Assessment activities.....	252
12.3 Overview of demographics and major urban centres.....	253
12.4 Governance.....	256
12.5 Overview of key issues.....	259
12.6 Conclusions.....	273
12.7 Recommendations.....	273
Chapter 13: Industry and Mining	276
13.1 Introduction.....	278
13.2 Assessment activities.....	278
13.3 Overview of the industrial and mining sectors.....	279
13.4 Key industries.....	280
13.5 Mining.....	284
13.6 Governance.....	287
13.7 Overview of key issues.....	288
13.8 Environmental issues specific to industry.....	289
13.9 Environmental issues specific to mining.....	291
13.10 Conclusions.....	295
13.11 Recommendations.....	295
Chapter 14: Environmental Governance	300
14.1 Introduction.....	302
14.2 Assessment activities.....	302
14.3 Overview of environmental governance.....	302
14.4 Overview of key issues in environmental governance.....	306
14.5 Conclusions.....	310
14.6 Recommendations.....	312
Chapter 15: Conclusions and Recommendations	316
15.1 Introduction.....	318
15.2 Main findings.....	318
15.3 Recommendations.....	321
15.4 Implementation and financing of the recommendations.....	322
15.5 The way forward.....	322
Appendices	
Appendix 1: List of Acronyms and Abbreviations.....	330
Appendix 2: List of References.....	335
Appendix 3: Endnotes.....	354
Appendix 4: GIS Soil Erosion Model.....	367
Appendix 5: Sampling Results.....	369
Appendix 6: Soil Erosion Rates by Districts.....	372
Appendix 7: List of Contributors.....	373

Foreword

Rwanda's rebirth from the tragic events of 1994 is an exceptional post-conflict success story. The country has made impressive strides on many fronts, from securing internal stability to enjoying strong economic growth. Looking forward, Rwanda has enthusiastically embarked on a profoundly transformative path that has the potential to spearhead a new economic development model for Africa.

The government's development blueprint, Vision 2020, aspires to propel Rwanda into a middle-income country within a single generation. High goals have been set to increase the GDP seven-fold, quadruple annual per capita income, create alternative jobs for half of Rwanda's subsistence farmers, boost private investment, market competitive export products and turn the country into a high-tech service hub for East Africa – all by 2020. Significant progress has been made so far in delivering on this strategy, which is closely aligned with the Millennium Development Goals to lift people out of poverty, increase literacy and promote access to potable water.

In parallel, a solid framework for environmental governance has been established, reflecting high-level awareness of the linkages between improved management of environmental assets, development and prosperity. It is in recognition of this environmental leadership that Rwanda was chosen as the host country for World Environment Day 2010.

Fast-paced development, however, also carries a number of risks in terms of social and environmental impacts. The recommendations of this multi-disciplinary assessment aim to provide the scientific advice that will help Rwanda steer an environmentally sustainable course towards the goals articulated in Vision 2020.

This report presents a package of practical interventions to assist the ongoing metamorphosis of Rwanda's economy. It calls for mobilizing and focusing investments in key areas, including ecosystem rehabilitation, renewable energy, conservation agriculture and innovative water and sanitation technologies, holds the best promise for economic growth, job creation and adaptation to climate change.



The report also highlights the strategic importance of regional environmental cooperation to mobilize such major investments. This will not only help deliver the targets of Vision 2020, but importantly showcase how a sustainable and prosperous economy can be achieved.

This assessment was made possible through the cooperation of the Rwanda Environmental Management Authority, under the overall leadership of the Ministry of Natural Resources. It was implemented within the framework of the Rwanda One UN pilot, in collaboration with the UN Country Team and United Nations Development Programme, in particular, which provided administrative support. Finally, I wish to sincerely thank the Government of Sweden for its generous financial assistance and for its long-standing commitment to UNEP's post-conflict work.

UNEP looks forward to a continued partnership with the Government of Rwanda as it lays the foundations for an environmentally sustainable future aimed at improving the well-being of its people.

A handwritten signature in blue ink that reads "Achim Steiner". The signature is fluid and cursive, written on a white background.

Achim Steiner
United Nations Under-Secretary-General
Executive Director
of the United Nations Environment Programme

Foreword

I am delighted to introduce this flagship Post-Conflict Environmental Assessment (PCEA) report on Rwanda, by the United Nations Environment Programme. Rwanda attaches a special significance to this report within the larger context of post-genocide recovery and reconstruction of our country. Indeed, the publication of this report marks an important step in the evolution of Rwanda's environmental management.

This multi-thematic assessment sheds light on the long-lasting environmental consequences caused by conflict, particularly the damage inflicted by massive population displacement and resettlement on the country's critical ecosystems, particularly forests and wetlands, both within and outside of protected areas. At the same time, the main focus of this report is on providing strategic options and practical recommendations for the future. We are deeply grateful for the analysis and suggestions provided by our UNEP colleagues and partners, who have worked in close collaboration with our national institutions and experts, throughout the preparation of this study.

One of the unique features of Rwanda's PCEA has been the intensive national consultations that have characterized this process. This has proved to be both an enriching and challenging experience, and I am pleased that we have been able to deliver an excellent product. I would therefore like to affirm that the Government of Rwanda welcomes as valuable UNEP's recommendations on the way forward.



Across the board, starting from the highest levels of our Government, there is strong understanding that the environment is the 'lifeblood' of sustainable development and prosperity, and is to play a critical role in realizing our country's Vision 2020.

I am confident that this forward-looking report is a timely and useful contribution that will add significant value to the ongoing process within Rwanda, as we embrace the concept of a low carbon growth path.

We look forward to our continued partnership with UNEP in our journey towards environmental sustainability.

A handwritten signature in blue ink, consisting of a series of fluid, connected strokes that form a stylized representation of the name Stanislas Kamanzi.

Stanislas Kamanzi
Minister of Environment and Lands
Republic of Rwanda

I. Overview

Introduction

The most densely populated country in mainland Africa, Rwanda's population is expected to double within the next 28 years. In an agrarian society, demographic pressures are a major driver of environmental stress visible in Rwanda's highly anthropogenic landscapes

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Introduction

1.1 Background

More than a decade after the war and genocide of 1990-1994, Rwanda today is a resurgent nation that is stable, engaged in pursuing innovative reconciliation activities and radiating with ambitious determination. This remarkable turnaround from a devastated war-torn country into a promising showcase of African development is an exceptional story.

Large-scale humanitarian assistance in Rwanda lasted until late 1994. From 1995 onwards, the country's focus shifted to post-conflict recovery and reconstruction. Rwanda marked a symbolic turning point in 2005 with its completion of the Highly Indebted Poor Countries (HIPC) Initiative, paving the way to a solid development track.¹ The country enjoys a high level of international goodwill and receives more international aid than most African countries.

The key institutional and legal instruments are now well placed to support long-term development. A new constitution was adopted in 2003, which guarantees fundamental human rights and political freedom. Rwanda held its first parliamentary and presidential elections the same year. A second parliamentary election was held in 2008, resulting in the world's first legislature with a female majority. In addition, a major decentralisation programme is under way that should help improve local governance of natural resources. On the economic front, the country has for successive years posted one of the highest growth rates in the region and is also actively promoting privatisation and direct investment.

Vision 2020 is Rwanda's long-term policy framework for national development. It emphasises economic development and poverty alleviation that is broadly aligned to international development targets, including the Millennium Development Goals (MDGs). Its primary aim is to transform Rwanda from a least developed into a middle-income country by 2020. Sustainable environmental and natural resource management

are also recognised as playing an important cross-cutting role in achieving the Vision's overall goals. Implementing the country's ambitious Vision 2020 strategy, however, will require radical changes and bring on major social transformation. As it transitions from recovery to long-term human and economic development, the country faces a number of key challenges.

The National Human Development Report 2007 identifies the vortex of "poverty, population growth and environmental degradation" as one of the three major bottlenecks that could undermine Rwanda's drive to achieve the objectives of Vision 2020.² Furthermore, the transformation from recovery-based growth to broad-based development coupled with Rwanda's high vulnerability to climate change and disasters will create a new set of environmental stressors, including exacerbating competition and tensions over scarce natural resources.

In pursuing its development course, Rwanda needs to continue strengthening environmental governance and the conservation and rehabilitation of critical ecosystems that underpin its food security and economic growth. In the long term, sustainably managing Rwanda's resource demands will require reinforcing regional integration by expanding and consolidating environmental cooperation with neighbouring countries.

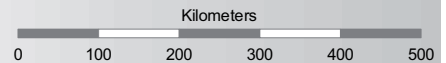
It is within this context of defining an environmentally sustainable path to its national development vision that the Government of Rwanda (GoR) requested UNEP to conduct a countrywide post-conflict environmental assessment (PCEA). Although 16 years have elapsed since the end of the 1990-1994 conflict, significant indirect and secondary environmental impacts remain. Nevertheless, this is not a typical UNEP post-conflict assessment focusing on the conflict's direct environmental impacts. Nor is it a retrospective audit of its consequences, which is not practically feasible today. Rather, the aim is to evaluate Rwanda's current state of the environment from a post-conflict perspective and provide a forward-looking analysis with practical recommendations to help chart an environmentally sustainable development course.

Map 1. Great Lakes and Eastern Africa



REGIONAL MAP

- ★ National capital
- Cities with more than 250,000 inhabitants
- Cities with less than 250,000 inhabitants
- Railway
- International boundary



Datum: WGS84
Geographic projection.

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1.2 Goal and objectives

The goal of the Rwanda PCEA is to suggest priority environmental interventions over the short term (1-5 years) that are in line with the strategic objectives laid out in national development plans, namely the Economic Development and Poverty Reduction Strategy (EDPRS 2008-2012) and Vision 2020. This goal is broken down into five specific objectives:

1. provide a holistic and scientific overview of the key environmental challenges facing the country;
2. raise awareness on the strategic priorities for sustainable management of the environment and natural resources;
3. deliver technical advice through targeted recommendations;
4. catalyse political and financial support for environmental action by development partners, UN actors, and government and non-governmental organisations (NGOs); and
5. introduce national partners to UNEP's environmental assessment methodology in order to build ownership and strengthen technical capacities.

This report was designed and implemented by UNEP in close collaboration with national authorities over the period March 2008-April 2009. It is also the product of a consultative stakeholder process involving the GoR, academic and research institutes, UN and international organisations, donors, civil society organisations and private sector representatives. While a substantial part of the opinions expressed in these consultations are reflected in the final text, this report remains an independent and neutral UNEP study aimed at policy and decision makers in government and at international development partners.

1.3 Linkages to UN and national planning processes

In November 2006, the UN Secretary-General's High-level Panel on System-Wide Coherence called for UN system reform by "Delivering as One" to overcome fragmentation and enhance

effectiveness at the country level. Upon the government's request, Rwanda was selected as one of eight pilot countries for the implementation of the "One UN" model in January 2007 ("One Programme", "One Budgetary Framework", "One Leader" and "One Office"). The United Nations Development Assistance Framework (UNDAF) was drafted in consultation with national and international development partners and is based on the national priorities articulated in the EDPRS.

UNDAF provides a common strategic framework for the UN system in Rwanda for the period 2008-2012. Specifically, UNDAF commits the UN to support the GoR in the "management of environment, natural resources, and land in a sustainable way".³ This report contributes to this UNDAF outcome by providing recommendations that integrate environmental considerations into development planning. In addition, as UNDAF is aligned with the EDPRS, this report in effect also responds to national development priorities.

1.4 Report structure

While this report is a science-based assessment, it is presented in a manner that is accessible to the non-environmental expert. Visual presentation combining photographs, satellite images, maps and graphics is used to communicate key findings. It is comprised of three main sections:

1. an introductory section providing the context for this PCEA, background information on Rwanda and a description of the assessment process.
2. eleven thematic chapters, each presented in a common format:
 - introduction;
 - assessment activities;
 - overview of the status and trends for the sector or theme;
 - description of the governance framework related to the sector;
 - assessment of the most critical environmental findings and issues, with detailed analysis presented in case studies; and
 - conclusions and detailed recommendations specific to the sector or theme.

3. overall conclusions and recommendations delineating the general way forward.

The eleven thematic chapters are grouped based on the following categories, although the sequencing does not reflect any order of importance as all areas are priority development issues for Rwanda:

Cross-cutting issues

- Chapter 4 Conflict, Peacebuilding and the Environment
- Chapter 5 Population Displacement, Resettlement and the Environment
- Chapter 6 Disasters and Climate Change

Sectoral issues

- Chapter 7 Agriculture and Land Degradation
- Chapter 8 Forest Resources
- Chapter 9 Water Resources
- Chapter 10 Wildlife and Protected Area Management
- Chapter 11 Energy and the Environment
- Chapter 12 Urban Environment and Health Issues

- Chapter 13 Industry and Mining

Policy and institutional responses

- Chapter 14 Environmental Governance

Gender and regional environmental cooperation were addressed as cross-cutting issues under the relevant themes.

Recommendations

Based on an analysis of the report's main findings, three broad policy recommendations have been deduced. These macro-level solutions in turn provide a framework for categorising the detailed thematic recommendations in each chapter and thereby help define the way forward. Each recommendation includes a brief technical description and suggests lead agencies, an approximate cost and duration period for implementation. A preliminary prioritisation of the recommendations has been undertaken in consultation with government stakeholders. However, further validation of priority setting will need to be carried out under the recently established Environment Sector Working Group (SWG). Next steps to guide the implementation of the recommendations are also provided.



Land scarcity in a subsistence agrarian economy presents a major challenge

Country Context

*Underlying Rwanda's verdant
landscapes and abundant
water supplies are serious
environmental pressures*

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Country Context

2.1 Introduction

National context

Rwanda is a small, land-locked country. Mountainous and lush, its picturesque landscape is famous as the 'land of a thousand hills'. Despite its equatorial location in the Great Lakes region in central-east Africa, the country enjoys a tropical temperate climate with diverse ecosystems. These favourable environmental conditions have allowed Rwanda to host the highest population density in mainland Africa, engaged mostly in subsistence agriculture.

As it tackles the legacies of one of the worst genocides in modern times and the challenges of a new development phase, Rwanda is faced with some underlying structural constraints. Chief

amongst these are: (i) the devastating social, economic and environmental consequences of the war and genocide; (ii) the land-locked handicap increasing transit costs and restricting access to the global economy; (iii) a limited natural resource base; and (iv) a high population density and growth rate with most people dependent on subsistence agriculture. In addition, massive conflict-induced population movement has had far-reaching consequences, including on the environment. Climate change and vulnerability to natural disasters are also emerging issues.

On the other hand, Rwanda's compact size is advantageous to manage. It enjoys a high level of internal security and public safety with a sound governance foundation, affording the country one of the highest economic growth rates and lowest corruption levels in the region. With a history as a nation-state, its society is distinguished from other countries in the region by its common culture and language.



The border crossing at Rusumo Falls between land-locked Rwanda and Tanzania



The Great Lakes region has experienced one of the largest refugee flows across international borders. Shown here is the Kiziba refugee camp in western Rwanda

Rwanda's long-term policy framework for national development and poverty reduction is embodied in Vision 2020 and the Economic Development and Poverty Reduction Strategy (EDPRS). The EDPRS emphasises economic development and poverty reduction that is broadly aligned to international development targets, including the Millennium Development Goals (MDGs). Sustainable environmental and natural resource management are recognised as playing an important role in achieving overall national goals and objectives. At the same time, implementation of the country's Vision 2020 strategy will necessitate radical changes that will bring about major social transformation and put new pressures on the country's natural assets. Addressing rapid social and environmental change will require strengthening governance structures and human capital development to sustainably manage this accelerated development process, particularly for the poorest and most vulnerable sections of society.

Regional and international context

Over the last decade, Rwanda has achieved major strides in regional integration. It has taken positive steps towards normalising relations with neighbouring countries within the Great Lakes region through peace agreements and the revival of the Economic Community of the Great Lakes Countries (CEPGL). However, tensions remain as a result of the presence of Rwandese rebel militias in the eastern Democratic Republic of the Congo (DR Congo).

Rwanda has increasingly been drawing towards anglophone East Africa. It joined the East African Community (EAC) in 2007 and is also a member of the Nile Basin Initiative and the Common Market for Eastern and Southern Africa (COMESA), joining its free trade area in 2004.

At the international level, Rwanda is an active member of the United Nations (UN) and contributes troops

to peacekeeping missions. It is also a signatory to many environmental conventions and international agreements.

2.2 Geography

Rwanda straddles Central and East Africa, situated between 1°04' and 2°51' latitude south and between 28°53' and 30°53' longitude east. It is a small, mountainous country of 26,338 km² and is surrounded by four countries: (i) the northern border with Uganda rises to the volcanic Virunga massif; (ii) the eastern frontier with the United Republic of Tanzania (Tanzania) is delineated by the Akagera River; (iii) the western boundary with the DR Congo is formed by Lake Kivu and the Rusizi River Valley; and (iv) the southern border with Burundi is separated by the Akanyaru and Ruvubu Rivers. The distance to the Indian Ocean is 1,270 km.

Lying on the east African plateau at elevations of mostly over 1,000 m, Rwanda's landscape has been shaped by intense tectonic action as well as rain and river erosion. Its dominating physical

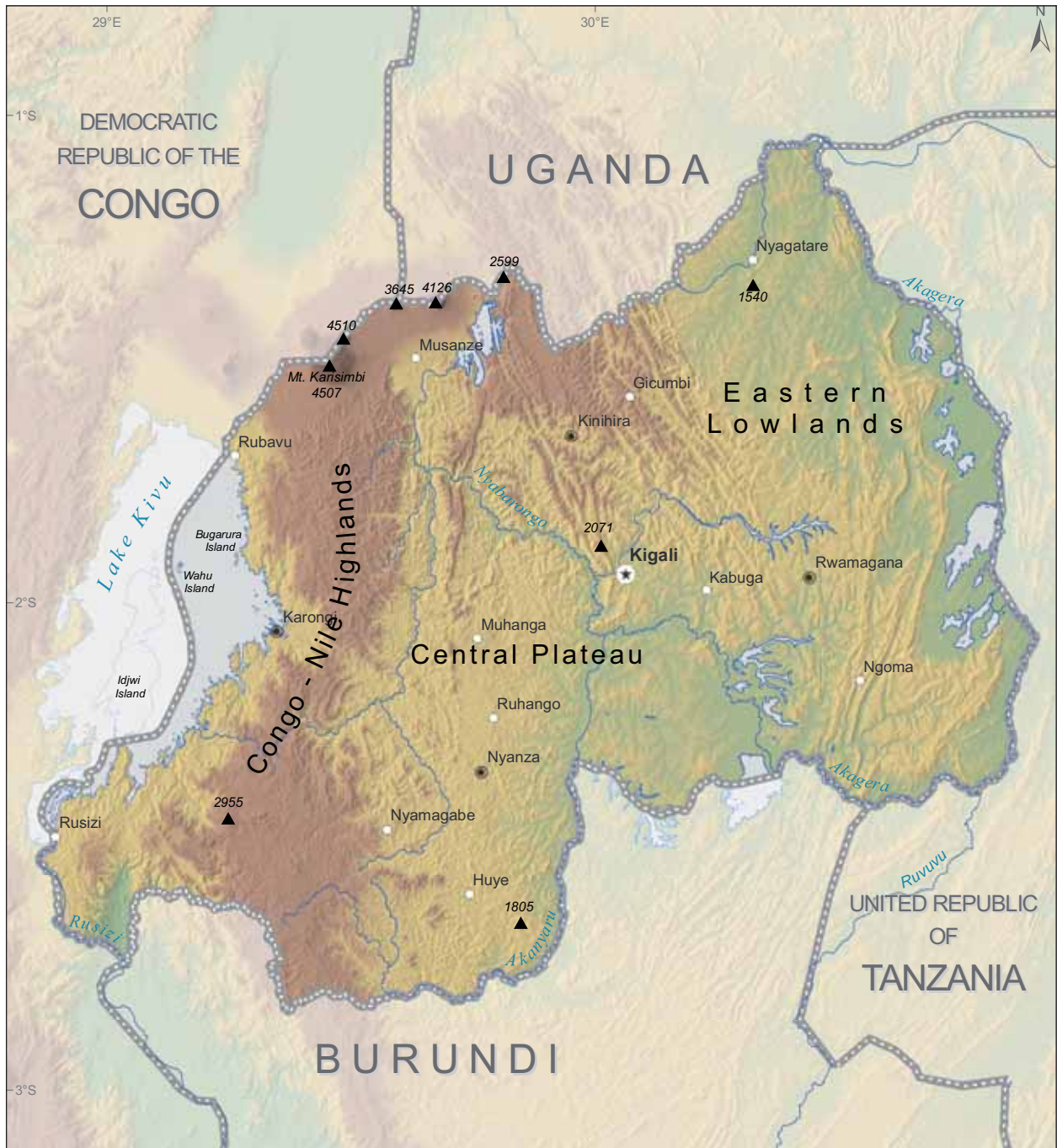
feature is the Albertine Rift Valley, which is part of the Great Rift Valley system, the largest fracture in the Earth's crust. The typical Rwandan vista is one of hilly terrain carved by a dense network of valleys, springs and marshes. Its natural vegetation cover ranges from savanna in the east to tropical mountain forest and Afro-alpine moorland in the west.

Sloping downward from west to east, the country is topographically divided into three main zones: (i) the Congo-Nile highlands that run in a north-south axis between 2,000 and 3,000 m high overlooking Lake Kivu and separating two watersheds; (ii) the rounded hills of the central uplands, covering nearly half of the country, between 1,500 and 2,000 m; and (iii) the eastern lowlands between Kigali and the Tanzanian border, made up of plateaus and plains ranging from 1,000 to 1,500 m and interspersed with many hilly ridges, lakes and swamps. The highest point is Karisimbi (4,519 m), part of the volcanic mountain chain in the northwest, while the lowest point is the Rusizi River (950 m), which connects Lake Kivu with Lake Tanganyika in Burundi.



The Virunga Mountains mark the intersection of the Rwanda, DR Congo and Uganda border

Map 2. Rwanda topographic relief



Soils

Rwanda's soils are naturally fragile, derived from the physical and chemical alteration of schistose, quartzite, gneiss, granite and volcanic rocks that form the surface geology of the country. Soils are generally acidic (typically with a pH of less than 5), have low levels of plant nutrients, and high levels of aluminium and iron oxides that may create toxicity problems and are highly erodible. According to the soil map of Rwanda (1992), there are six types of soils (Table 1).

The organic matter in these soils is rapidly depleted by deforestation and tillage, which makes

them problematic for cultivation.¹ The map of soil capability identifying soil suitability for various uses shows that more than half of Rwanda's soils have major limitations, thus reducing the choice of crops that may be cultivated.²

The most fertile soils are those of volcanic origin in the northwest and the alluvium and colluvium that have accumulated in the larger river valleys and extensive marshlands. Exploitable mineral resources are limited to deposits of cassiterite (tin), coltan (columbium and tantalum), wolframite (tungsten) and gold.

Water resources

Rwanda is divided between Africa's two largest river systems: the Nile and the Congo. One of the Nile's two main sources, the White Nile, has its headstream, the Akagera, partly in Rwanda. The Akagera River, the main contributor of water to Lake Victoria, drains 76 percent of its territory. The remaining 24 percent falls within the Congo basin. Lake Kivu, part of the Congo catchment, is Rwanda's largest water body, which it shares with the DR Congo.

In addition to numerous lakes, the country has a diverse array of wetland systems covering one-tenth of the land area. Wetlands constitute a crucial cornerstone of Rwanda's natural capital, regulating water supply and supporting its rich biodiversity.

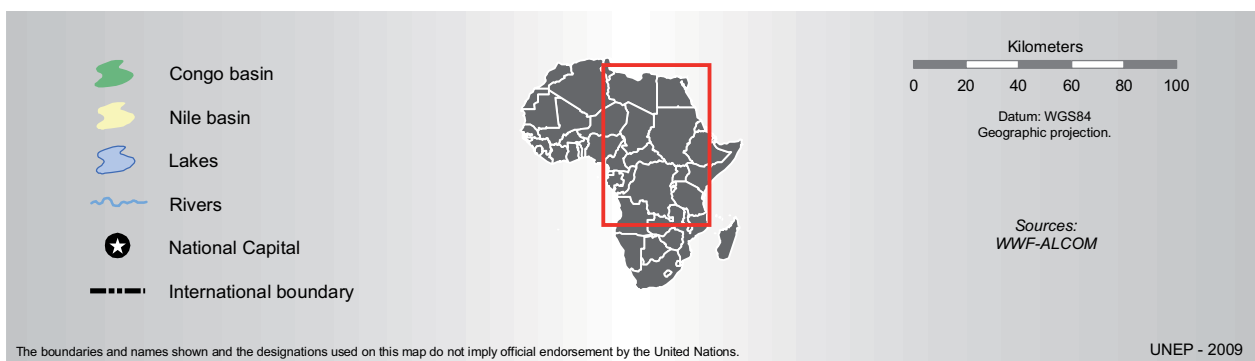
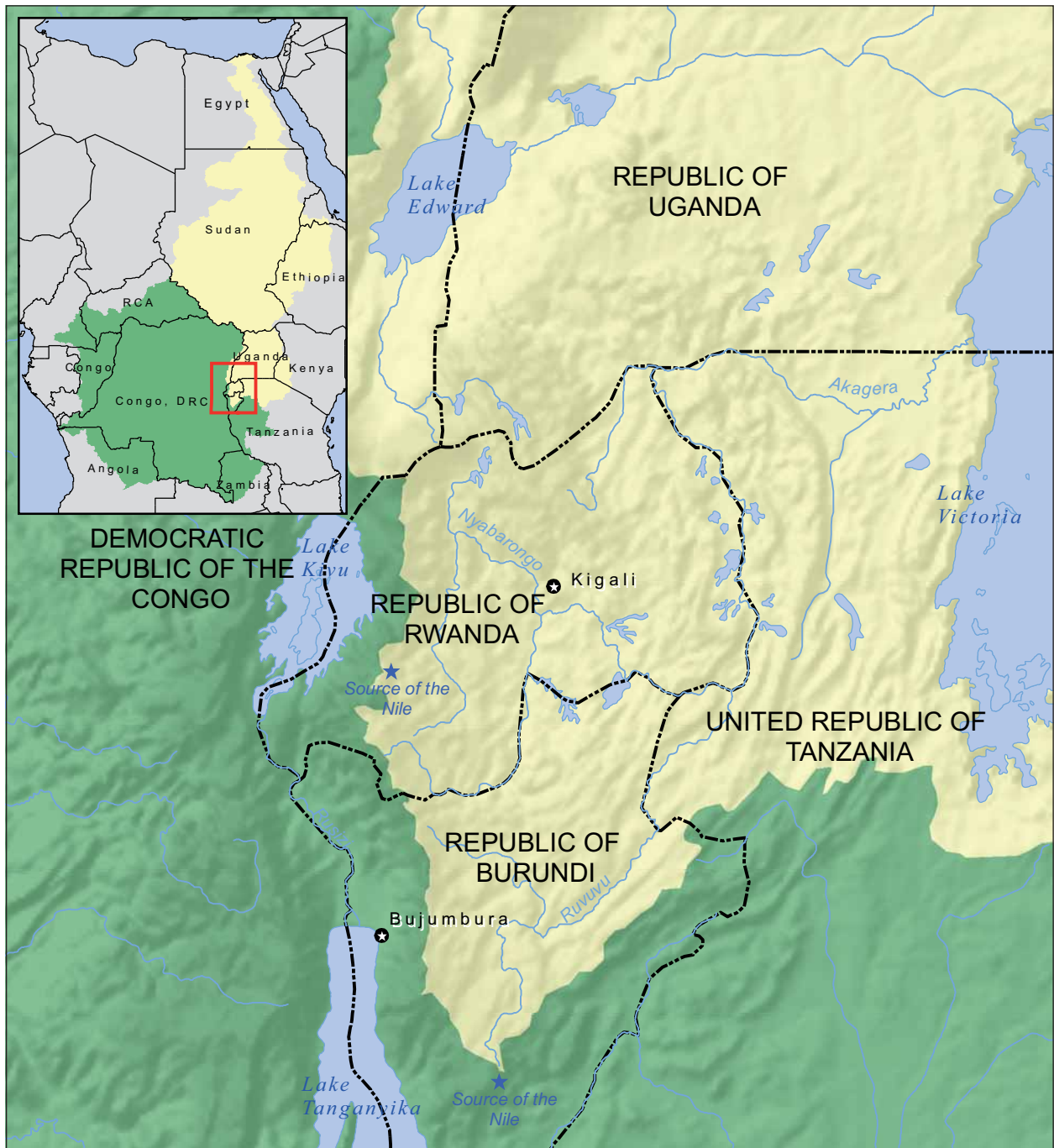
Table 1. Six types of soils in Rwanda

Soil origin	Approximate percentage of national territory
Schistose, sandstone and quartzite	50
Granite and gneiss	20
Intrusive basic rocks	10
Recent volcanic materials	10
Ancient volcanic materials	4
Alluvial and colluvial soils typically found in swamps	6



Fisherman heading for night fishing at Lake Kivu near Kibuye

Map 3. Rwanda watershed basins



2.3 Climate

Despite its tropical location, Rwanda's climate is tempered by its high altitude that averages around 2,000 m. With the exception of the highland areas, temperature deviations are small with average monthly temperatures ranging between 16 °C and 24 °C. In the higher mountains, night temperatures dip to 10 °C and frosts occur during the dry season. The hottest areas are in the east and southeast lowland areas, where temperatures can reach more than 35 °C in February and July-August.³

While temperature variations are limited, rainfall is more variable. Rainfall averages 1,200 mm annually and ranges from 2,000 mm in the western and north-western highlands to 600 mm in the eastern savanna, where rainfall events are more erratic with frequent droughts.⁴

Rainfall defines Rwanda's seasons. The climate is divided into two rainy and two dry seasons almost throughout the country:

- long rainy season (February to May with 48 percent of annual rainfall);
- long dry season (June to mid-September);
- short rainy season (mid-September to December with 30 percent of annual rainfall); and
- short dry season from (January to February with 22 percent of annual rainfall).

Seasonal rainfall distribution in Rwanda is influenced by three key factors: (i) its equatorial and continental location; (ii) the southwest monsoon, which brings most of the rain and global phenomena, particularly the El Niño Southern Oscillation; and (iii) the moderating role of the Great Lakes (Victoria, Tanganyika and Kivu). The issue of climate change and its potential impacts on environmental problems and economic sectors is addressed in Chapter 6.

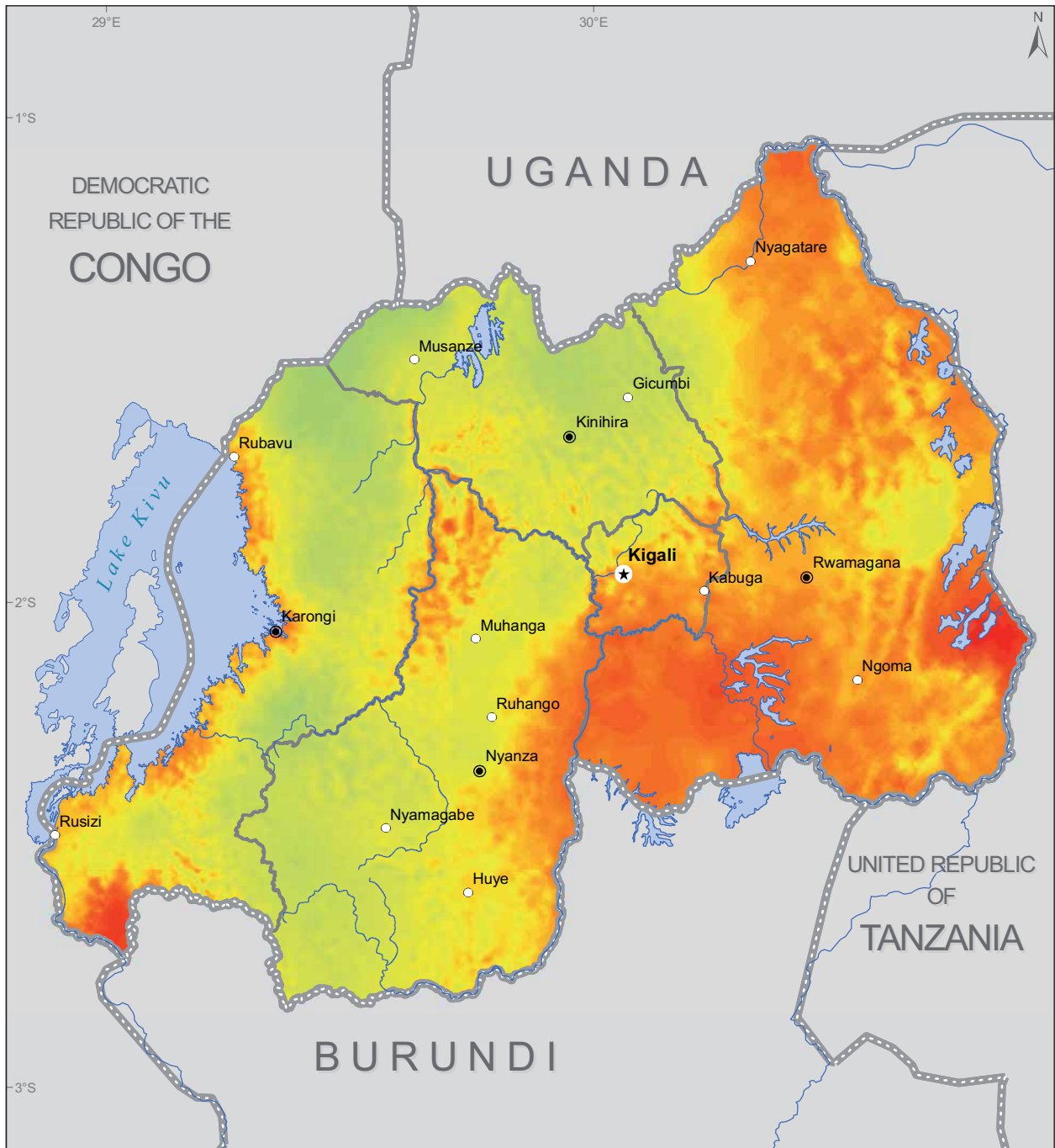
Table 2. Summary of climatic conditions in the three regions of Rwanda⁵

Parameters	High altitude (1,800-3,000 m)	Central plateau (1,500-1,800 m)	Eastern plateau (1,250-1,500 m)
Rainfall (mm)	1,300-2,000	1,200-1,400	600-1,400
Temperature (°C)	16-17	18-21	20-24
Evapotranspiration (mm)	1,000-1,300	1,300-1,400	1,400-1,700
Relative humidity (%)	80-95	70-80	50-70
Insolation (hrs/day)	5-6	5-6	6-6.5
Wind (km/hr)	7-8	6-7	4-6



The summit of Mount Karisimbi, Rwanda's highest peak at 4,507 metres, is occasionally covered in snow

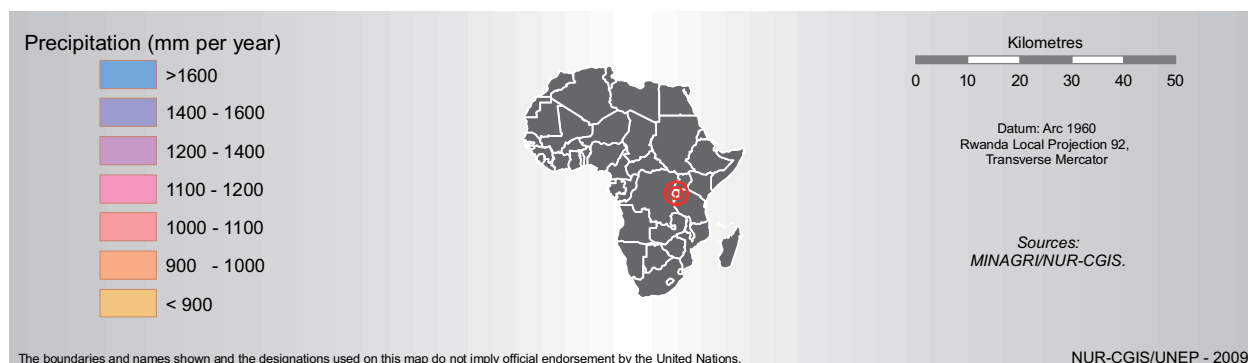
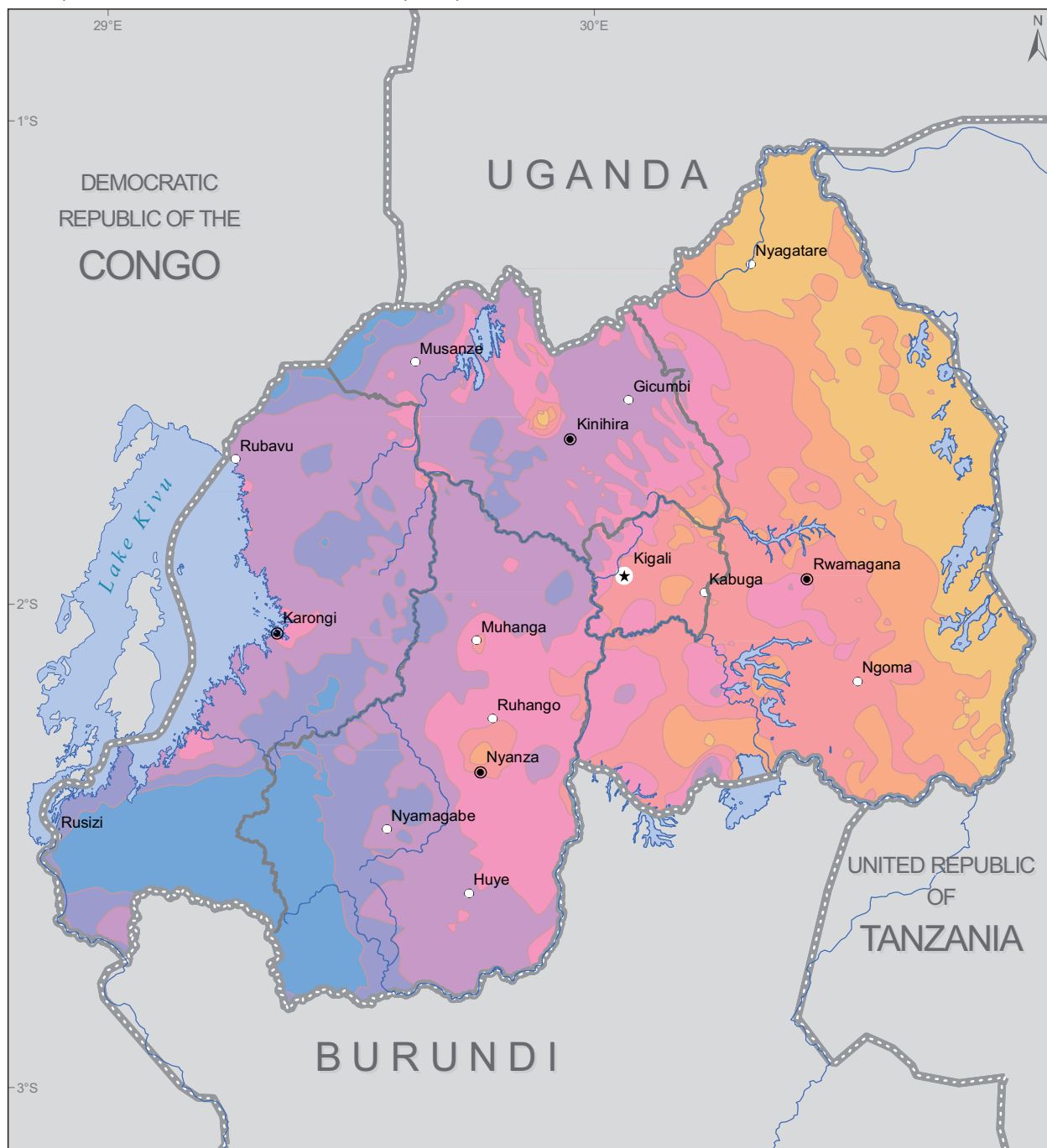
Map 4. Rwanda mean annual temperature



The boundaries and names shown and the designations used on this map do not imply official endorsement by the United Nations.

NUR-CGIS/UNEP - 2009

Map 5. Rwanda mean annual precipitation



2.4 Biodiversity

Rwanda falls within the Albertine Rift montane forest and East African forest-savanna ecoregions. The former is widely recognised as a ‘biodiversity hotspot’ of global significance.⁶ The country’s varied topography and wide elevation range has allowed a remarkable variety of flora and fauna to flourish, with many species inhabiting distinct altitudinal niches.



Afro-alpine vegetation on Mount Karisimbi

As human activity has disturbed to various degrees almost the whole of Rwanda’s landscape, threats to its biodiversity are numerous and serious. At the same time, there are promising opportunities to promote biodiversity conservation and sustainable natural resource management.

Flora

Rwanda’s flora is a complex regional mosaic comprising Guineo-Congolian, Sudanian, Zambezian, Somalia-Masai and Afro-montane vegetation types.⁷ These include savanna with grasses, bushes and trees; mountain forests and meadows; forest galleries; swamps and aquatic vegetation. It harbours 2,150 species of plants, with eight species of trees listed by the UNEP World Conservation Monitoring Centre as either threatened or of conservation concern. Despite its rich biodiversity, floral endemism is not considered to be exceptionally high.⁸

This floral diversity has been significantly impacted, particularly by agricultural conversion, deforestation, reforestation with exotic species such as eucalyptus and pines, and the spread of invasive species such as the water hyacinth.



Large turacos in Nyungwe montane forest

Fauna

Despite extensive habitat depletion, fragmentation and poaching, Rwanda still has a varied wildlife. The country is famous for its wealth of primates (14-16 species), the most prominent of which is the mountain gorilla, one of the world's most endangered apes found in the Virunga massif. In addition, several species of duiker are found in Nyungwe and Volcanoes National Parks, including the yellow-backed duiker, threatened with extinction in the early 1990s by intensive hunting. Other wildlife includes buffaloes, zebras, antelopes, warthogs, baboons, elephants, hippopotamuses, crocodiles, tortoises and rare species such as the giant pangolin.⁹

Rwanda has one of the most outstanding avifauna on the continent. An impressive 670 different species of birds have been recorded, including storks, egrets, ibises, plovers, sandpipers, kingfishers and herons commonly seen in the Akagera floodplain. In addition, Rwanda is thought to have 19 known species of fish, particularly in its lake and river systems. Further description of wildlife and endangered species in Rwanda is covered in Chapter 10.

2.5 Key ecological regions

Despite Rwanda's small land area, variations in topography and climate have given rise to a diverse range of ecological regions. There are various classification systems in use, which are largely based on agro-bioclimatic zones.

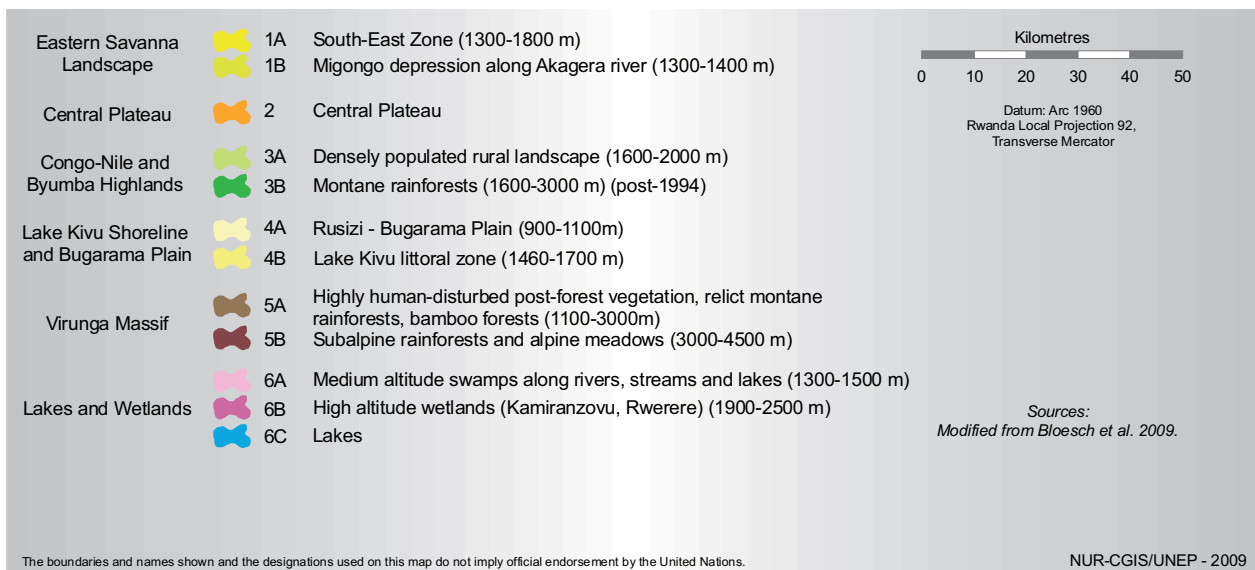
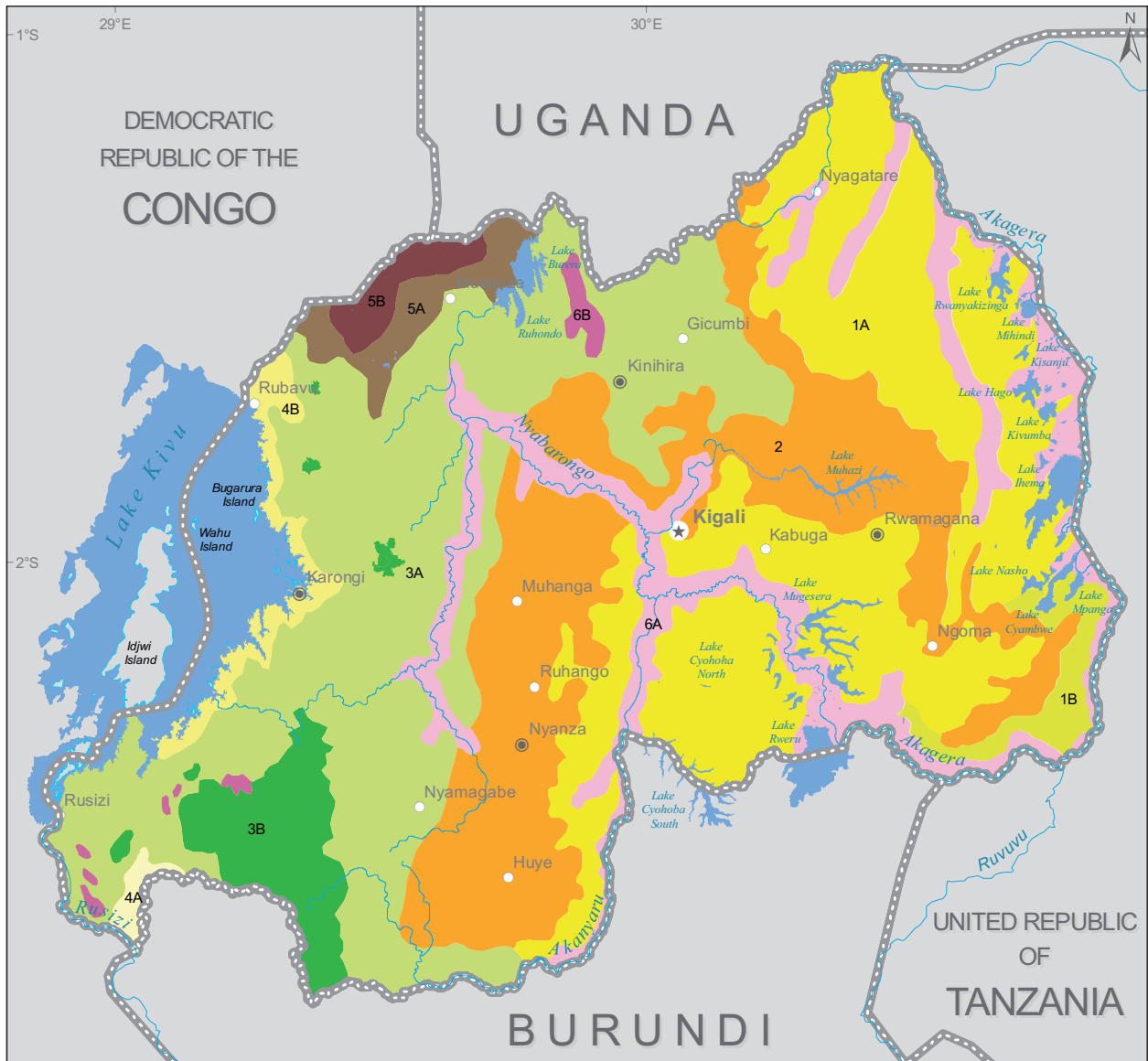
For the purposes of this study, the country is divided into six major ecological zones. This categorisation is based on merging existing classification systems, with a focus on highlighting their respective distinguishing environmental features. The key ecological regions, as indicated in Map 6, are:

- eastern savanna landscape;
- central plateau;
- Congo-Nile and Byumba highlands;
- Lake Kivu shoreline and Bugarama plain;
- Virunga massif; and
- lakes and wetlands.



Endangered mountain gorilla

Map 6. Rwanda ecological regions



It should be noted that due primarily to cultivation, the human impact on the environment has been so significant that Rwanda today is an overwhelmingly (>90%) anthropogenic landscape.

Eastern savanna landscape

Savanna landscape previously covered nearly one-third of the country, extending through almost half of the eastern part of the country from Nyagatare in the north to east of Kigali in the centre and to Bugesera and Huye in the southeast. It comprises different savanna types, classified as grass, shrub, tree and woodland savannas.

Savanna landscapes are typically interspersed with small forest formations of variable size, which include thicket clumps, dry forests, gully forests, gallery forests and riparian forests. The composition and density of savanna vegetation is determined by climate, altitude, soil conditions and fire events. Outside of the Akagera National Park on the Tanzanian border and parts of Bugesera, woody vegetation has been eliminated or considerably thinned out by intensive cultivation, grazing pressure from livestock overstocking and demands for firewood.¹⁰

Central plateau

The central plateau, with an average altitude of 1,700 m, forms the interior core of the country and is covered by rolling hills and deep valleys. It is this landscape that made Rwanda popularly known as the 'land of a thousand hills'. Historically, the central plateau was covered by dry tropical forest, transitioning from west to east into heavily wooded savanna. Densely inhabited for centuries, this region has been almost entirely converted by farming.



Typical rural landscape of the central plateau



Eastern savanna landscape



Intensive cultivation on steep, angular hills of the Congo-Nile highlands

Congo-Nile and Byumba highlands

With an average elevation of 2,750 m and a width of 40 km, the Congo-Nile and Byumba highlands run in a north to south axis. Its steep ridge acts as a water divide, separating the rapid streams, dotted with waterfalls and cataracts that feed the Congo and Nile basins. This region of angular hills was almost entirely covered with Afro-montane rainforest of the Albertine Rift; however, it has been severely degraded by human activity and only relict and secondary forests remain today.

The most significant remaining forest in this ecoregion and the country as a whole is in the Nyungwe National Park in the southwest, along the border with Burundi. The smaller Gishwati and Mukura Forest Reserves have almost disappeared due to resettlement of refugees and displaced persons following the 1994 conflict.¹¹



Nyungwe National Park is the largest block of intact tropical montane forest in Africa



Secondary forest in Gishwati with signs of heavy encroachment

Lake Kivu shoreline and Bugarama plain

On the western slopes of the Congo-Nile divide, the land slopes abruptly to the Lake Kivu shoreline at an altitude of 1,460-1,600 m. Under the influence of the humid tropical climate, the narrow 300 km lake coastline and its numerous small islands are dominated by dry Guinea-Congolese savanna vegetation. This vegetation type is also prevalent in the Rusizi-Bugarama plain along the Burundi border in the extreme southwest. Natural vegetation cover, however, has been heavily disturbed by the high population density and intensive cultivation in this region.



Evergreen Afro-montane forest



Lake Kivu's densely cultivated shoreline

Virunga massif

The Virunga massif covers a total area of 447 km² and comprises eight volcanoes, six of which are shared by Rwanda with the DR Congo and/or Uganda. Well watered with a cool humid climate, this region is naturally covered by evergreen Afro-montane forest of the Albertine Rift.

A layered vegetation succession predominates, primarily influenced by altitude and temperature gradients. The lower areas between 2,000 and 2,900 m have been degraded into secondary rainforest dominated by the pioneer species *Neoboutonia macrocalyx*. It also includes patches of giant *Arundinaria* bamboo forest often occurring in pure stands. In the next tier, stunted *Hagenia* and *Hypericum* trees grow, covered by moss and epiphytic orchids. Above the treeline between 3,200 and 3,500 m, there is a sub-alpine vegetation of heath formations and giant *Lobelias* and *Senecons*. Finally, above 3,500 m Afro-alpine moorland emerges characterised by ecologically fragile communities of grasses, mosses and lichens.

The Virunga massif provides one of the last two residual habitats for the endangered mountain gorilla, as well as many other endemic and threatened species. The remaining vestige of natural Afro-montane forest is almost entirely within the borders of the Volcanoes National Park, as the lower plains have been taken over by farming and livestock-keeping.¹²

Lakes and wetlands

Lakes and wetlands sustain Rwanda's dense and extensive hydrological network and play a critical role in supporting the country's socio-economic development. Wetlands supply and buffer inflows into lakes, which in the case of Bulera and Ruhondo act as natural reservoirs for hydropower production. A recent inventory recorded 860 wetlands and 101 lakes covering a total surface area of 2,785 km² and 1,495 km², respectively.¹³ This is equivalent to 16 percent of the country's land area.

Lake Kivu, which shares waters with the DR Congo, accounts for approximately 70 percent of Rwanda's lake area. A deep lake with a maximum depth of 485 m, its bed lies on the bottom of the Rift Valley and is influenced by associated volcanic activity. Lake Kivu is the most completely stratified in Africa, at the bottom of which lies a massive pool of dissolved methane and carbon dioxide gas.¹⁴ Another 28 lakes of significant size are found in Rwanda, but others such as Cyohoha and Rweru are shared with Burundi.

Most of Rwanda's wildlife outside protected areas, particularly birds, is found in wetlands and lakes.

Of the wetlands inventoried, 41 percent are in natural conditions and 59 percent are farmed, mainly using traditional methods. There are two main types of wetlands in Rwanda, which are largely defined by altitude. Low-lying wetlands (typically referred to as marshes or swamps) are often seasonal and occupy the flat valley bottoms at an altitude between 1,300 and 1,500 m. The vegetation is characterised by grasses, mainly *Cyperus papyrus* and *Cyperus latifolius*. The largest of these are the Akagera marshes in the east along the Rwandan-Tanzanian border and the swamp complex along the broad valleys of the Akanyaru and Nyabarongo Rivers.

Permanent high altitude wetlands (1,900-2,500 m) are the other major type. Found in the Congo-Nile highlands and the high central plateau, these wetlands are generally dominated by *Cyperus* species but have a richer flora compared to the low altitude swamps. The two main highland wetlands are Rugezi located below the Virunga volcanoes and Kamiranzovu, which is inside the Nyungwe forest near the source of the Nile River. This category also includes peatlands, with reportedly significant deposits and existing largely in their natural state.¹⁵



Low lying wetlands in the eastern Savanna

2.6 Society

Population

According to the 2002 census, Rwanda's population was 8.12 million people. With an annual growth rate of 2.6 percent per year, the population in 2008 was estimated to be around ten million. In 2005, the Demographic and Health Survey (DHS) reported the number of children per woman at 6.3 in rural and 4.9 in urban areas, respectively. Based on these high fertility rates, it is projected that the population will reach over 13 million by 2020 and 16 million by 2030. Rwanda's population structure is shaped like a pyramid, with the bottom 60 percent under 20 years old.¹⁶

Rwanda is predominantly an agrarian society, with 83 percent of the population residing in rural areas. The urban population has more than tripled since 1991 to almost 17 percent in 2002. Kigali

City alone accounts for 45 percent of the urban population, followed by Muhanga and Huye¹⁷.

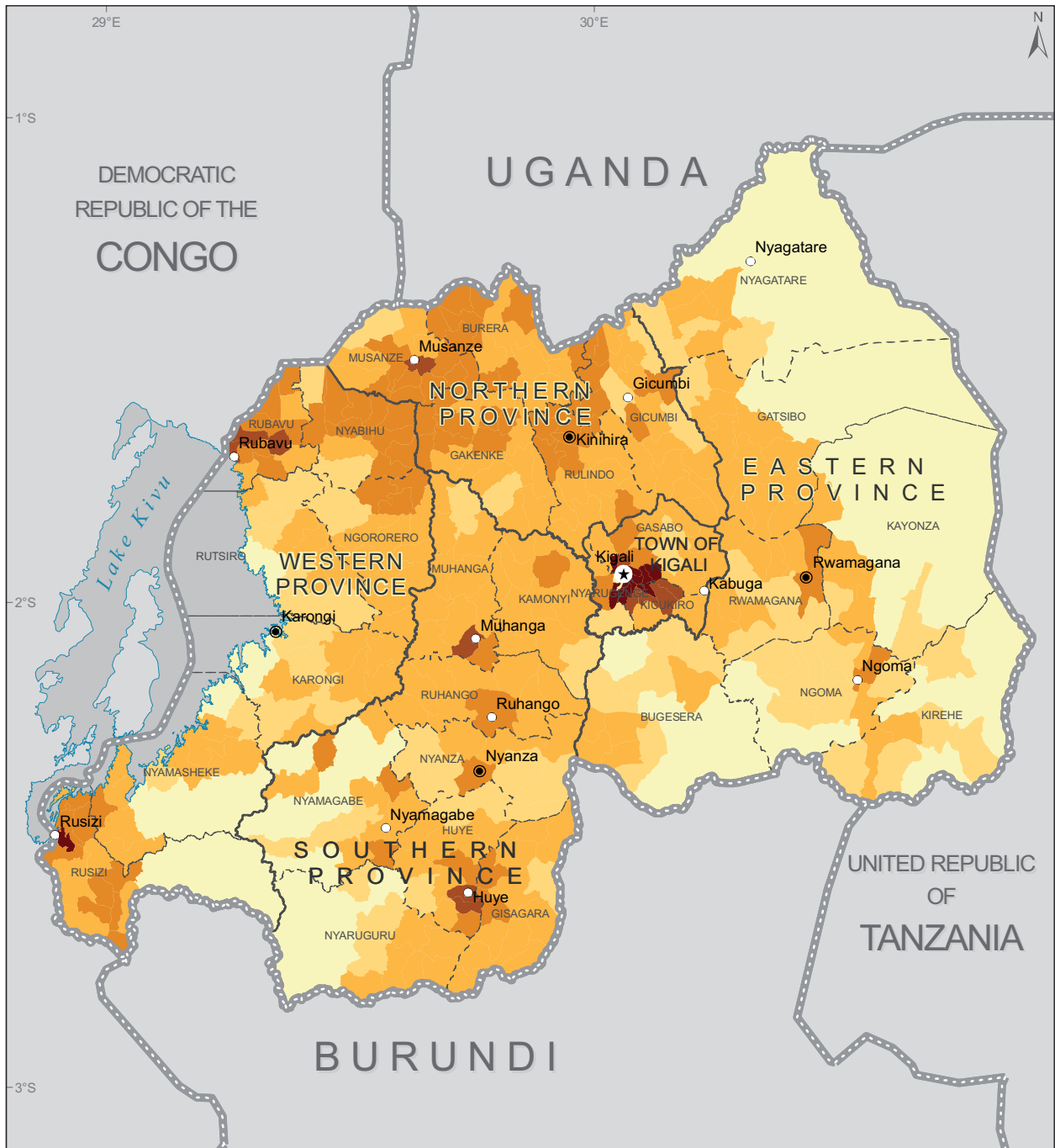
With a population density of over 350 inhabitants per square kilometre, Rwanda is the most densely populated country in Africa.¹⁸ Population density is highest on the fertile volcanic soils of the northwestern parts of the country, reaching 541 and 424 persons per square kilometre, respectively, in the former provinces of Ruhengeri and Byumba located both in the Northern Province. It is lowest in the semi-arid Umutara savanna areas of the northeast at 100 persons per square kilometre, but this region has had a large population influx in recent years.¹⁹

High population pressure has resulted in the downward cycle of land fragmentation. Average land size in Rwanda is 0.6 ha,²⁰ falling below the Food and Agriculture (FAO) minimum land size of 0.9 ha required to feed a household. Moreover, almost 30 percent of households cultivate less than 0.2 ha of land.²¹



The size of average land holdings in Rwanda is below the FAO minimum of 0.9 ha required to feed a household

Map 7. Rwanda population density





In 2005, the average number of children borne by women was 6.1

Case study 2.1 Population, poverty and the environment

Demographic and poverty dynamics have far-reaching impacts on the nature and scale of environmental degradation in Rwanda. The complex linkages in this process, however, are often misunderstood. The risk arises when population, poverty and environment interact to reach dangerous thresholds creating a crisis. Specifically, rapid population growth, declining agricultural productivity and the lack of alternative livelihoods in Rwanda combine to exert considerable pressures on resources, especially arable land, forests and water.

In the Rwandan context, it is essential that joint policies and programmes be devised to unlock the downward spiral of high population growth, poverty and natural resource mismanagement. This case study attempts to provide a framework to better understand the intricate interrelationships between population-poverty-environment in Rwanda.

Population status and trends

Population figures

From 1978 to 2002, the population increased by 41 percent to 8,128,553. Of this total, 47.7 and 52.3 percent were comprised of men and women, respectively. With an estimated annual population growth rate of 2.6 percent, Rwanda is one of the fastest growing populations in Africa. Assuming a similar growth rate, the population in 2008 is expected to be close to ten million and will double in the next 28 years.

A number of factors have influenced Rwanda's population dynamics since the 1990s. First, the 1990-1994 conflict and genocide led to significant loss of lives, estimated at around one million. Second, there was a massive exodus of refugees who fled the country in the aftermath of the genocide, which left entire villages and towns deserted. In the late 1990s, however, the majority of these refugees returned to Rwanda. Third, shortly after the end of the conflict between 1994 and 1996, 'old caseload' refugees and their descendants, who had fled Rwanda since the 1950s but before 1990, returned to Rwanda in large numbers.

Table 3. Population numbers from 1978 to 2002²²

Census	Population	Males	%	Females	%
1978	4,831,527	2,363,177	48,9	2,468,350	51,1
1991	7,157,551	3,488,612	48,7	3,668,939	51,3
2002	8,128,553	3,879,448	47,7	4,249,105	52,3

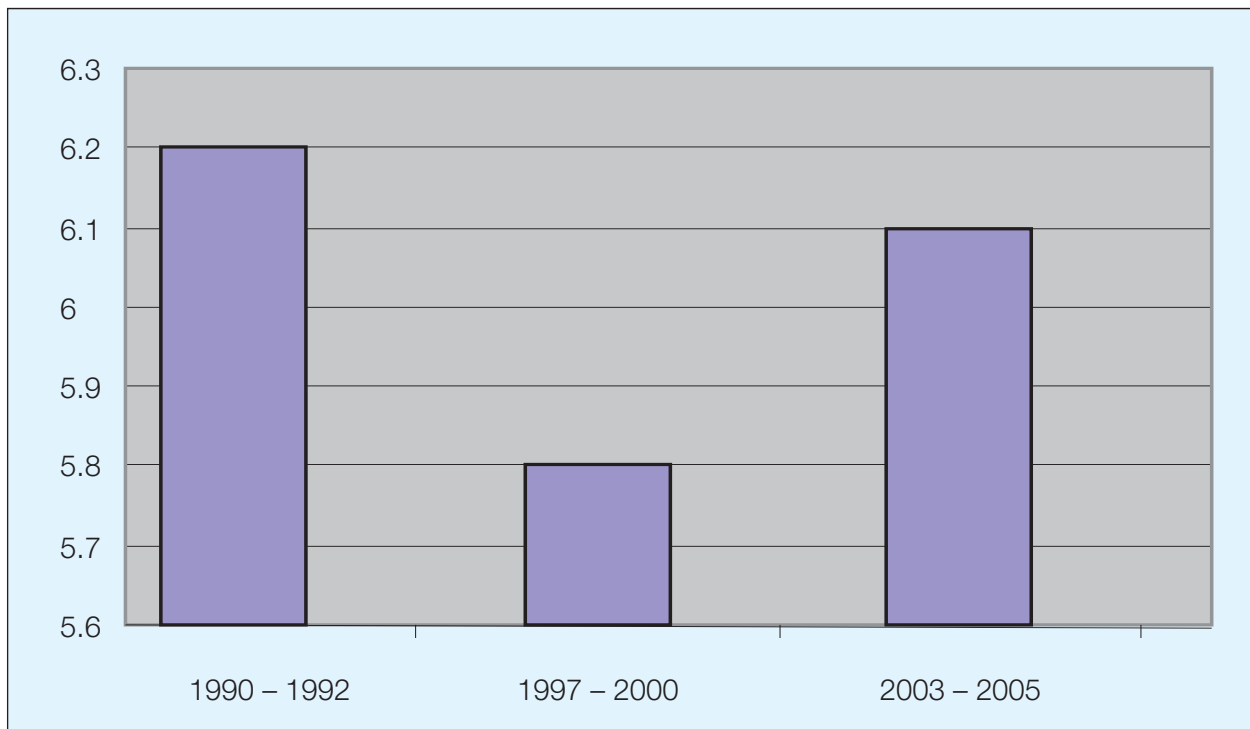


Figure 1. Total fertility rate in Rwanda from 1990 to 2005 ²³

Case study 2.1 Population, poverty and the environment (continued)

Fertility rates

The total fertility rate in Rwanda has remained fairly high, although it is slowly declining. In 1970, it was estimated at 7.54 children per woman. Based on the DHS in 2005, the total fertility rate was about 6.1. This protracted decline has been brought about by the increased school enrolment of girls and improved access to birth control. Nonetheless, DHS findings indicate that measures taken to reduce fertility rates have not worked as successfully as anticipated.

Other key demographic indicators

From the early 1990s to 2000s, the infant mortality rate dropped by 30 percent to 86 deaths per 1,000 infants.²⁴ With progressive improvements in healthcare, particularly through increased immunisation and malaria treatments, a further decline is anticipated in the medium and long term. The under-five mortality rate stands at 152 deaths per 1,000 children, while the maternal mortality ratio is 750 deaths per 100,000 live births.

In the early 2000s, life expectancy in Rwanda declined to 39 years, down from about 50 years in the early 1990s. This decline was largely attributed to the impacts of the HIV/AIDS pandemic and the collapse of the health and other related infrastructure as a result of the conflict and genocide. However, a strong campaign against the HIV/AIDS health crisis has significantly decreased the prevalence rate from 13 to 3 percent of the population from the 1990s to the 2000s, respectively, raising life expectancy to the current 49 years. Despite improved healthcare services, only 37.9 percent of the population had access to health facilities in 2005.²⁵ Since then, the government has introduced a medical insurance scheme known as *mutuelle de santé* that should significantly improve access to healthcare.

Household size and composition

According to DHS (2005) figures, the average size of households is 4.6 persons. In terms of household composition, 66 percent of Rwandan households are headed by men, while 34 percent are headed by women, which have implications on the available human resources to maximise agricultural productivity as well as other socio-economic pursuits (discussed further in Chapters 7 and 11).

Key features of poverty in Rwanda²⁶

Poverty incidence

According to the Household Living Conditions Survey (EICV-2) conducted in 2005/2006, the proportion of Rwandans described as poor decreased from 60.4 percent in 2001/2002 to 56.9 percent in 2005/2006, signifying a 3.5 percent reduction in overall poverty.



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Food distribution in Masaka, Kigali. Strengthening the safety net for the poorest is essential to stem environmental degradation

Case study 2.1 Population, poverty and the environment (continued)

The survey further indicates that the poverty headcount decreased across all categories of households, both in rural and urban areas. While there have been reductions in the proportion of the population living in poverty, similar results were not achieved with regards to the actual number of people regarded as poor, mainly due to population growth.

Poverty incidence varies across the country. The poverty headcount remains lowest in Kigali City, where income is much higher than in both rural and other urban centres. The Southern Province fared worst in the EICV surveys, whereas Kigali City, the Northern and Eastern Provinces registered lower incidences of poverty. The poorest of the poor live in rural areas, making these locations more deserving of poverty reduction interventions in the country.

Poverty depth and severity

Based on EICV II results, extreme poverty declined from 41.3 to 36.9 percent from 2000 to 2005, respectively, with the highest reductions occurring in rural areas. However, even with this modest proportional decline, a significant number of people did not show improvement in their poverty status during the same period. The Southern Province is the worst affected, with the districts of Gisagara, Nyanza, Huye, Nyamagabe and Nyaruguru representing the bulk of those in extreme poverty.

Income distribution

The EICV results indicated a positive growth in all strata, with higher rates registered in rural areas. However, there are wide income disparities across society, which is evidenced by the Gini coefficient ratio that increased from around 0.47 in 2000/2001 to 0.50 in 2005/2006.

While the Gini coefficient fell in urban areas as well as in rural-urban differentials, three of the five provinces registered increases in their Gini coefficients. Inequality is most acute in the Southern Province, with only the Kigali and Northern Provinces demonstrating a decrease in inequality.

Widening income disparities highlight important challenges in the country's strong push for increased economic growth. While economic development has reduced poverty incidence, it has not been accompanied by significant reductions in income inequalities.²⁷ Although a substantial proportion of the poor actually participates in and derives benefits from the country's economic development process beyond meeting their subsistence needs, a widening income gap still remains.

The population, poverty and environment nexus

As discussed previously, the vast majority of Rwanda's population is based in rural areas, relying on rain-fed agriculture.



Rwanda has one of the highest urbanisation rates in Africa

Case study 2.1 Population, poverty and the environment (continued)

Resource utilisation remains largely extractive, with very limited use of improved technology and other agricultural inputs to enhance production. This is largely due to poverty and the lack of alternative livelihoods, leaving the rural poor with few options to improve resource management. Therefore, a fast growing – yet poor – rural population could signal rapid depletion and degradation of natural resources.

Land degradation is already evidenced by low agricultural yields. Due to high population pressures, soils such as in Bugesera, Nyaruguru and Nyamagabe are over-cultivated, resulting in declining soil fertility and increased erosion. Severe land degradation has significantly reduced agricultural productivity, thereby contributing to internal migrations (discussed further in Chapters 5 and 7).

Also, since 1960, there has been a 41 percent reduction of Afro-montane forests and a 75 percent reduction of forests in the savanna, largely due to population demand for additional arable land as well as wood for fuel and building materials (see Chapter 8). Finally, population pressures could potentially result in water resource over-extraction and degradation as witnessed by the drying up of Lake Cyohoha North, which is partly attributed to encroachment on its surrounding wetlands (see Chapter 9).

Acute land scarcity poses a further challenge to employing and sustaining a growing rural population. Population pressures have led to increased land fragmentation, with many rural households subsisting on less than one hectare. Especially in the more densely populated areas of the northeast, land has become extremely scarce. Land scarcity reinforces unsustainable farming practices, such as short or non-existent fallow periods, which become necessary to intensify production but also exacerbate an already deteriorating resource base.

Poverty, population growth and resource degradation, therefore, pose a real threat to food security as rural households become more vulnerable to food shortages. Internal migrations may not provide a long-term sustainable solution to deteriorating environmental conditions.

Challenges of poverty reduction

Rwanda's accelerated economic development model can potentially result in increased marginalisation of the poorest of the poor. Indeed, the most recent surveys have indicated that the bottom quintile (20%) has fallen behind the rest of the population, signifying that the poor are possibly getting poorer and are not deriving benefits from the economic growth registered by the country. As a result the Government has been in the process of re-examining and reinforcing the current economic development strategy with a view to integrating more specific pro-poor interventions (e.g. One Cow per Household Programme, national insurance scheme, collective community work (Ubudehe) and universal primary education programmes).



Competition over scarce land, fuelwood and water place accentuating pressures on these resources

Case study 2.1 Population, poverty and the environment (continued)

The growing urban poor population

As a result of land scarcity and deteriorating livelihoods in rural areas, it is expected that more people will relocate to urban areas in search of non-agriculture-based forms of employment. The country needs to prepare for the challenges of a growing urban poor population, which is already visible in the spread of slums in Kigali. This would include provision of low-cost housing as well as other critical services (health, water, energy, etc.) in order to enable the poor to participate meaningfully in the country's development (e.g. *imidugudu* programme, see chapter 5).

Keeping Vision 2020 on track

Although Rwanda's population growth rate has declined from 3.2 to 2.6% between the two most recent demographic surveys, the population growth rates remains high. Should this trend continue, there is a risk of suppressing the gains achieved thus far in combating poverty. This will likely undercut targets set by Vision 2020, as these may have been based on a lower population growth rate. Continuous review and necessary adjustments of development plans will therefore need to be made.

Moving beyond strategy to action

Important progress has been made in mainstreaming environmental considerations in national development strategies, such as Vision 2020 and the EDPRS. Rwanda is also currently implementing a Poverty and Environment Initiative (PEI) in collaboration with international partners.

Next steps should focus not only on the implementation of poverty and environment plans, but also on strengthening the engagement of communities in undertaking local, environmentally sustainable pro-poor interventions. Development programmes that specifically target the poor will likely yield enduring benefits at household and community levels. One approach would be to pilot pro-poor interventions in selected communities, as is being done under the Poverty and Environment Initiative (PEI) and Support Project for the Strategic Transformation of Agriculture (PAPSTA), which would allow for lessons to be readily processed and for best practices to be replicated in other areas.

The people

Unlike most African countries, Rwanda is relatively homogenous. Its people speak the same language, Kinyarwanda, and share a common culture. It is also different from many other pre-colonial African societies in that its social system was highly organised under a centralised state administration led by a *Mwami* (king).

Present-day Rwanda

Rwanda today is working to rebuild its social cohesion, which was seriously undermined by the 1994 genocide. To promote national unity, the new Constitution has entrenched political power-

sharing as the basic principle of governance, and implemented a wide range of reconciliation and peacebuilding initiatives, including reintroducing the traditional *Gacaca* court system (a type of community court to administer justice based on a restorative process), demobilisation and reintegration of ex-combatants, and the establishment of the National Unity and Reconciliation Commission. Future peacebuilding and national reconciliation efforts will need to take into account the rapid and profound social changes generated by the drive towards Vision 2020.²⁸ Strengthening governance capacity, including in environmental management, will be critical to ensure the country's successful development transition.



Community-based courts, known as Gacaca, have been used to promote reconciliation following the 1994 genocide

Table 4. Rwanda socio-economic indicators²⁹

Indicators	2006/2007	Target 2010	Target 2020
Economy			
GDP per capita (USD)	272	400	900
GNI per capita, PPP (current international)	860	–	–
GNI, PPP (current international) (USD billions)	8.40	–	–
Average real GDP growth rate (%)	6.5	8.0	8.0
Nominal GDP (current USD billions)	3.32	2.90	13.25
Non-agriculture jobs (thousands)	419	1,000	2,500
Poverty (% below national poverty line - 1 USD/day)	56.9	40	30
Population living in extreme poverty (%)	36.9	24.0	–
Average real growth rate of agriculture sector (%)	4.4	8	6
Agriculture population (% of active population)	80	75	50
Agriculture land protected against soil erosion (%)	20	80	100
Modernised agricultural land (%)	^a 3	20	50
Access to electric energy (% of population)	4.3	25	35
Annual electricity consumption (kw/inhabitants)	^a 30	60	100
Road network (km/km ²)	^a 0.54	0.56	0.60
Aid per capita (current USD)	62	–	–
Population			
Rwandan population (USD millions)	9.74	10.0	13.07
Population growth rate (%)	2.8	2.3	2.2
Urban population (% of total population)	17	20	30
Education			
Literacy level (%)	74	80	100
Net primary school enrolment (%)	90	100	100
Health			
Life expectancy (years)	51	50	55
Total fertility rate	6.1	5.5	3.9
HIV/AIDS prevalence rate (% of population aged 15-49)	2.8	11	5
Mortality rate, infant (per 1,000 live births)	98	80	50
Maternal mortality rate (100,000 births)	750	600	200
Malnutrition prevalence, weight for age (% of children under five)	18	20	10
Prevalence of undernourishment (% of population)	[*] 37	–	–
Access to clean drinking water (% households)	64	80	100
Improved sanitation facilities (% of population with access)	23	60	85

Notes:

^a Indicates data for 2000.

^{*} Indicates data for 2002.

– Indicates data not available.

2.7 Governance

Rwanda is widely acknowledged to have succeeded in establishing a sound governance framework.³⁰ Various international ratings of governance performance have consistently ranked Rwanda in the solid middle range for sub-Saharan African countries, in league with Tanzania, a major achievement given the country's turbulent past. Amongst the key areas requiring additional support is strengthening governance capacities, including in environmental management. Improvements in this area have recently been noted.

Decentralising government

In 2000, the government adopted a new National Decentralisation Policy (NDP). Since then, a range of administrative and political reforms have been undertaken to foster participatory governance. Emphasis is on local community inclusion in the design and implementation of the development process, including management of natural resources and the environment.

A significant decentralisation milestone was reached in 2006. Local government structures were reorganised by amalgamating the 106 districts into 30, with a view to creating strong, viable local governance structures that are functionally effective in planning and delivering services to the population. This move aims to reduce government costs, make

a clear break with the past and promote power sharing and reconciliation. Rwanda is subdivided into four levels of local administration comprising five provinces, 30 districts, 416 sectors and 2,150 cells. Under an ongoing resettlement programme, villages (*imidugudu*) with 50-150 households have been developed as a new administrative tier. All political positions in the local government system are elected, and the provincial administration has only a coordinating role. Key constraints in the devolution process include the creation of a viable revenue base and building capacities of local authorities, which are being tackled in the NDP's ongoing second phase.

Decentralisation and new governance policies have significant implications for the future management of natural resources. It has often been said that, in everyday life, everything important in Rwanda happens on a hill. To actively engage local communities, it is critical that this landscape feature forms the basic spatial unit of development and environment projects at the grassroots level. There is also a new land policy and law in place that will address land reform and tenure security.³¹ This will have far-reaching implications for the conservation and management of land resources. Chapter 14 elaborates further on these issues.

It should also be noted that the constitution of 2003 contains specific provisions for environmental protection.



Demarcation of land holdings with the aid of aerial photos and satellite imagery is meant to expedite mass land registration

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Map 8. Rwanda administrative divisions



2.8 Economy

Rwanda is one of the poorest countries in the world. The UN classifies it as a Least Developed Country (LDC), ranking 161 of 177 in the United Nations Development Programme (UNDP) Human Development Index for 2007/2008. The 1994 genocide devastated Rwanda's fragile economic base, which shrunk by 40 percent, plunging its population, particularly women, into severe poverty and discouraging private and foreign investment. GDP per capita stands at less than USD 250 per year, with the typical Rwandan living on USD 0.70 per day.³²

The country is heavily dependent on foreign aid, receiving USD 497 million in 2007. This accounts for 40 percent of the government's budget and represents an Official Development Assistance (ODA) of USD 55 per capita per year, one of the highest in Africa.³³ In 2006, Rwanda significantly lowered its foreign debt load with the completion of the Heavily Indebted Poor Countries (HIPC) and the Multilateral Debt Relief Initiatives.

Recovery

Rwanda's economy has experienced an impressive recovery to its pre-1994 levels, with GDP growth rates averaging 7.4 per year during the period 1995-2005. In 2007, its USD 3.3 billion economy grew at a slightly lower rate of 5.5 percent.³⁴ However, in 2008, the National Bank of Rwanda reported a growth rate of 11.2 percent, which is the highest in the past five years. This boost in economic growth has been largely due to a major improvement in agricultural productivity, which until now had been sluggish.

The Government of Rwanda (GoR) is credited for improving the investment climate and opening it to global markets. This includes establishment of independent regulatory agencies, implementing public sector reforms, privatisation of government-owned assets and a strong performance in anti-corruption.³⁵

A predominantly agrarian economy

Agriculture remains the base of Rwanda's economy: 80 percent of the population is engaged in rain-fed, small-scale subsistence farming, with limited participation in the market economy.³⁶ Despite its high share in employment, agriculture only contributes 39 percent of GDP. Growth in this sector has until recently been almost flat, recording a slight decline in 2007. In 2008, however, there was a massive increase in

agricultural productivity registering a growth rate of 16.4 percent. Agriculture is heavily dependent on food crop production, dominated by beans and bananas, followed by sorghum, Irish potatoes, sweet potatoes, cassava and maize.³⁷ Traditional export crops (coffee, tea, pyrethrum) account for around 40 percent of foreign exchange earnings.

Key drivers of current economic growth are an increase in export earnings (minerals, tourism, cash crops), a construction boom and the industrial and service sectors. The industrial sector is very small but is growing rapidly, reaching 13.4 percent in 2007.³⁸ Rwanda is working to address its precarious energy situation and increase electricity access through hydropower and methane gas development. Currently, only 5 percent of the population has access to electricity.

2.9 Development vision

Rwanda's people are poised to undergo profound changes in their way of life. In 2000, the government adopted Vision 2020, which outlines the country's long-term national development strategy. Inspired to a large extent by the South-East Asian experience, Vision 2020 focuses on achieving economic development and poverty alleviation by modernising Rwanda from an agrarian economy into a regional service- and knowledge-based hub.

The goal is to graduate Rwanda from a least developed to a middle-income country within a generation. This would require raising per capita income from its current base of USD 250 to USD 900. In order to achieve this ambitious transformation, the focus is on securing an economic growth rate of over 7 percent. This will be a major challenge given Rwanda's limited export base and vulnerability to fluctuations in world prices of primary commodities.

Under this overall development vision, a mid-term EDPRS is currently under way covering the period 2008-2012. While the first poverty reduction strategy cycle (2002-2007) was mainly based on post-conflict recovery and reconstruction, the EDPRS draws a roadmap for longer-term economic development. Its priorities are: (i) poverty reduction; (ii) infrastructure development; (iii) privatisation of government-owned assets; (iv) modernisation of the agricultural sector; and (v) public sector reform. Environmental considerations are integrated in the EDPRS, both as a crosscutting issue and as an independent sector, largely due to improved understanding of the role of environmental management in development, with significant support provided by the UNDP-UNEP PEI.

Assessment Process

UNEP expert drives a soil core sampler in a lake bed to estimate rates of soil loss. The UNEP team travelled throughout the country and was accompanied by government experts who acted as resource guides

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Assessment Process

3.1 Introduction

This report was conceived as a forward-looking integrated environmental assessment. Its central theme is to build environmental considerations into decision making and suggest priority areas for action within the overall context of Rwanda's development targets as outlined in Vision 2020. At the same time, a post-conflict lens has been extended to analyse the conflict's indirect environmental legacies and the specific challenges that these may continue to pose to the country's long-term development prospects.

3.2 Target audience

The target audience for this report is primarily policy and decision makers in government as well as Rwanda's development partners. The former includes high- and mid-level leaders and planners

in public agencies working at national, provincial, district and municipal levels.

The media, schools and others may also use the report findings for public awareness-raising purposes. In addition, the report is of relevance to civil society and non-governmental organisations (NGOs) as an advocacy tool, as well as to academia and the private sector whose active engagement will be critical in successfully implementing several of the report's recommendations.

3.3 Assessment approach

The concept and rationale for a post-conflict environmental assessment (PCEA) emerged from discussions with the Government of Rwanda (GoR) in 2006-2007. UNEP's key counterpart in this project was the Rwanda Environmental Management Authority (REMA), working under the overall leadership of the Ministry of Natural Resources (MINIRENA).



UNEP expert with MINIRENA and Forestry Management Support Project (PAFOR) officials inspecting rehabilitation of the Gishwati Forest with indigenous species



UNEP experts interviewing community leaders from the Kiziba refugee camp

While national partners were fully engaged throughout the process, the final report is, however, an independent UNEP assessment, based on scientific expert evaluation. The full list of contributors and stakeholders consulted during the assessment process is provided in Appendix 7.

This assessment was carried out between March 2008 and April 2009. It comprised the following major activities, which are described in more detail below. The sequencing of these activities was not necessarily linear and often overlapped:

- scoping
- desk study
- fieldwork
- environmental sampling
- mapping and remote sensing
- Geographic Information System (GIS) modelling
- analysis and reporting
- national consultations.

Scoping

As a future-oriented assessment, the report outlook has been aligned to the country's long-term development plan, which defines major goals to be achieved by 2020. The 1990-1994 conflict served as a benchmark for evaluating the environmental consequences of conflict. In order to situate the assessment within a larger historical context, the report also examines environmental status and trends and the evolution of natural resources and key sectors since the second half of the twentieth century.

The assessment's geographical scope encompassed the entire national territory of Rwanda. It also addressed transboundary issues with neighbouring countries.

The thematic scope of the assessment was determined to ensure broad and integrated analysis of the most critical environmental issues facing the country. In consultation with national partners, ten priority topics were identified and are now reflected as individual chapters in the report.

Desk study

In consultation with REMA, UNEP commissioned 12 national experts to prepare a desk study of the selected priority themes. The purpose of the desk study was to provide an overview of the status of the environment and identify key environmental problems and threats, as well as highlight data gaps for each priority theme.

National experts were selected based on their knowledge and experience of the thematic subject. UNEP provided specific guidelines for each topic and a reporting format to be followed by national experts in preparing the desk study. The desk study was based on a review of information available in the public domain and did not involve fieldwork. It proposed key sites to be investigated during the fieldwork phase of the UNEP assessment.

The desk study was completed in June 2008. It was subsequently used by REMA as the basis for preparing the government's national state of environment report.

Fieldwork

Fieldwork was conducted on 13–23 August 2008. It involved a multi-disciplinary UNEP team of ten experts, with each expert focusing on one or more of the 11 selected themes. In addition, the UNEP gender specialist participated in the fieldwork to help mainstream gender issues in the assessment process and findings. In total, fieldwork comprised over 120 person days inclusive of other field missions.



UNEP energy team in discussion with technical personnel of the Aggreko power station in Ruhengeri



National expert presenting the desk study during the first consultation workshop in August 2008

For logistical reasons, the UNEP team was divided into five groups:

1. natural resources covering the areas of agriculture, forestry, displacement and resettlement and gender;
2. water resources, climate change and disasters;
3. energy;
4. urban environment, industry and mining; and
5. wildlife and protected areas management, and environmental governance.

It should be noted that these five groups merged on various occasions and sometimes separated into subgroups. Group membership was fluid with individual experts joining different teams depending on assessment requirements.

The UNEP team was based in Kigali and travelled from the capital to sites throughout the country. This arrangement enabled the UNEP team to convene regularly as a group and to discuss findings and interlinkages between the different thematic areas. It also allowed for the collected water and soil samples to be kept cool and preserved for follow-up laboratory analysis. Nevertheless, on several occasions the UNEP subteams stayed overnight outside of Kigali to reduce travel time as well as follow the most effective route for subsequent site visits.

Selection of assessment sites drew upon information from the desk study, literature review (national and international), archive satellite images and feedback from national stakeholders during the first consultation workshop. Deliberate effort was made to cover the range of environmental regions in the country and, to the extent possible, included the following categories: (i) degraded areas; (ii) pristine or areas in good environmental condition; and (iii) areas of successful practice. Details on the sites visited and stakeholders consulted are provided in the thematic chapters.

The field itineraries were finalised in consultation with REMA and other national partners. Staff from REMA and MINIRENA, the Ministry of Agriculture and Animal Resources (MINAGRI), Ministry of Infrastructure (MININFRA) and Ministry of Local Government, Community Development and Social Affairs (MINALOC) accompanied the relevant UNEP subteams during the fieldwork. They acted as resource guides and facilitated contact with local authorities and communities. Individual national experts, including several who authored the desk study reports, also participated in the field visits. In

addition, officials from the provincial and district authorities frequently joined the UNEP team on selected site tours.

Although the approach varied by expert and theme, the standard sequence of activities included:

- Site visits: Reconnaissance walkovers to acquire first-hand field observations and to validate information from the desk study, literature review and stakeholder consultations. Site tours were guided by local experts or persons familiar with site history and operations.
- Stakeholder consultations: Interviews and focus group discussions with government officials, local experts, academia, NGOs, international organisations, the private sector and households. These sought to obtain additional local knowledge and updated information as well as solicit stakeholder views on priority challenges and potential remedial measures.
- Field documentation: Geographically referenced photographs and field notes of the key issues and problems encountered.



UNEP in discussion with household members

Environmental sampling

Soil and water samples were collected to support empirical analysis for the following thematic areas: (i) agriculture and land degradation; (ii) water resources; (iii) industry and mining; and (iv) urban environment. For certain sites (e.g. Gikondo industrial area, Kigali) an in-field water/soil monitoring plan was developed to systematically assess the situation. In other locations, random samples were taken to control for ambient environmental conditions.

It should be emphasised that in all cases the collected samples only provide a single site-specific snapshot. Rigorous long-term monitoring programmes are required to provide a reliable representation of environmental parameters and trends over time.

Surface and groundwater quality

On-site measurement of temperature, electric conductivity, pH, nitrate, total dissolved solids (TDS), dissolved oxygen (DO) and oxygen reduction potential (ORP) was carried out in the field. Analysis of microbial and pathogenic contamination was conducted at the UNEP base in Kigali.



UNEP and REMA experts taking water quality readings at Rugezi wetland



UNEP expert collecting a soil sample in Gikondo

More detailed laboratory analysis was also conducted for certain samples. The parameters tested included nitrate, Kjeldahl-N, total suspended solids (TSS), total organic content (TOC), nutrients, heavy metals, volatile organic compounds (VOCs), extractable petroleum hydrocarbons (EPH) and polycyclic aromatic hydrocarbons (PAH).

The internationally accepted World Health Organization (WHO) Guidelines for Drinking Water Quality were used as a reference standard for measuring the safety of drinking water. In total, 87 water samples from 56 sites were collected for both field and laboratory water quality analysis.

Soil/land contamination

Surface stream sediments from locations exposed to potential contamination sources were collected for laboratory analysis and were tested for heavy metals and the full range of hydrocarbons. As there are no applicable soil contamination standards in Rwanda, the widely used Dutch Values for environmental pollutant reference levels were used by UNEP. In total, ten sediment samples were collected.



UNEP expert examining annual layering in a soil core

Soil sedimentation rates

To help provide a quantitative indication of the soil erosion problem in Rwanda, direct measurement of soil sedimentation rates was done within selected catchment sinks. Sediment cores were taken from the bottom of four lakes/reservoirs from different environmental regions in Rwanda using a hand-driven piston sediment core sampler. As the field mission was carried out during the dry season when lakes and reservoirs were at an annual low point, it was possible to take samples well away from the shore where sediment is not likely to be highly disturbed.

Sediments were dated by measuring their ^{210}Pb isotope content.¹ An unstable radioactive element, ^{210}Pb has a half-life of 22.3 years that is produced naturally as part of the decay series of uranium-238 in soil; therefore, the amount of radioactive ^{210}Pb remaining in a sediment is a useful indicator of the length of time that has passed since the sediment was deposited.

Sediment cores were sectioned at 5.0 cm intervals, and a 1.0 cm section was then homogenised, dried and subsampled. Chemical separation of ^{210}Po from each sample was carried out in order to minimise interferences between multiple alpha emitting nuclides. ^{210}Po decay was measured by α -spectroscopy over a period of 50,000 seconds. The excess amount of ^{210}Po found in each sediment sample, over the amount that would naturally be produced by the decay of 'background' radium-226, is a measure of the amount deposited in precipitation or washed in via drainage water.

The log of this excess was regressed against the cumulative dry mass of sediment, assuming a constant rate of sediment supply. The regression coefficient is a direct estimate of the sedimentation rate. The results obtained from this method may also be used to provide some independent verification of the magnitude of sediment loss attained using the GIS soil erosion model described below.

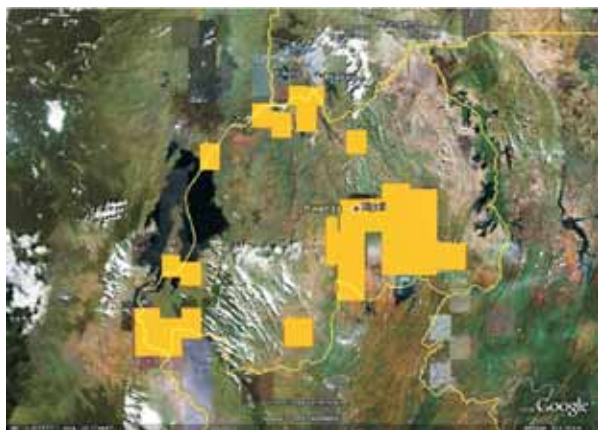
Mapping and remote sensing analysis

Satellite imaging and mapping outputs formed an integral part of this assessment and were extensively used to document baseline conditions and visualise key environmental issues. Cartographic and remote sensing work was carried out in close collaboration with the Centre for Geographic Information Systems and Remote Sensing (CGIS) of the National University of Rwanda (NUR).

As part of this mutual undertaking, UNEP provided a standard template for map design. The CGIS team compiled existing national data sets, completing and updating them as necessary and also extracted information directly from satellite imagery. An iterative work method ensued with CGIS creating intermediate mapping outputs that were subsequently reviewed and amended by UNEP until satisfactorily finalised. Although this was largely carried out on remote basis, a one-week joint work session involving UNEP and CGIS/NUR experts was organised in Butare to help facilitate the process.

Mapping outputs include:

- baseline country scale maps illustrating key socio-economic and physical features;
- change detection maps focused on specific areas of interest to illustrate significant land-cover/land use transformations – environmental change was visually observed by applying a “before and after” approach using multi-temporal images and partially aided with local expert knowledge and field verification;



Rwanda is well covered with very high-resolution images, shown here in orange zones, that are available in the public domain via Google Earth

- photo-interpretation maps of single, very high-resolution images to highlight specific patterns or features of interest; and
- classified maps derived from satellite image analysis to quantify the scale of changes that have occurred, particularly over large areas – for this purpose, information was extracted from the Rwanda Forest Mapping Project conducted by CGIS for MINIRENA in 2007.

An archive of more than 40 satellite images acquired by various sensors between 1972 and 2008 was compiled by UNEP and provided to CGIS/NUR. This included the first satellite images of Rwanda acquired by Landsat MSS in 1972 with an 80-metre resolution to very high one-metre resolution images collected by Ikonos. The latter are freely accessible on the Internet using Google Earth software.

GIS-based soil erosion modelling

UNEP opted to use GIS modelling to obtain a quantitative estimation of soil erosion rates, given fieldwork time constraints and the lack of long-term monitoring data. Direct measurements of sedimentation rates in a small number of selected sink areas were made to help validate the model.

The modelling approach used the Universal Soil Loss Equation (USLE), a widely used method for estimating large-area soil erosion risk resulting from rainfall. Although the model has its limitations, if due caution is exercised, it can be a valuable decision-making tool for land managers. The model is advantageous because the input data are relatively easy to obtain. This is an important criterion, given the paucity of long-term environmental data in Rwanda.

It is important to emphasise that any estimate of soil loss expressed, for example, as tonnes/ha/year can only be used as an illustration of the magnitude of an erosion problem. There is

Table 5. Satellite sensors used in the Rwanda assessment

Satellite	Provider	Resolution	Acquisition date
Landsat	NASA	80-14 m	1972-2008
Aster	NASA	15 m	2005-2007
DMC	Surrey Satellite	32 m	2006
Ikonos	Geoeye	1 m	2000-2007



In collaboration with REMA, UNEP organised two major consultation workshops to discuss the assessment process and review the findings and recommendations of the draft report

a danger that this type of average figure will be interpreted as if it had a sound statistical basis. Soil loss is extremely variable in both space and time. It is typically dominated by a small number of extreme events that are very rarely measured simply because they occur so infrequently, or because when they do occur they overwhelm monitoring equipment. Average rates measured over periods that do not encompass such extreme events can be grossly misleading.

UNEP developed a modelling protocol based on the USLE and provided it to CGIS/NUR for implementation. The final output of this model represents a “worst case scenario” that should provide a better basis for future planning decisions. Once the model is fully operational it will be possible to use it to examine the costs and benefits of soil conservation measures in different parts of the country. The modelling protocol is provided in Appendix 4 of the report and the results are discussed in Chapter 7 on Agriculture and Land Degradation.

Analysis and reporting

UNEP experts reviewed and analysed fieldwork data, laboratory results, satellite imagery, GIS modelling products, the PCEA desk study and

national and international literature. Individual experts used the information gleaned to draft ten thematic reports based on a standard format and guidelines provided by UNEP.

The draft reports were then submitted for an internal peer review by technical divisions within UNEP for quality control and revised as required. The draft text was then reviewed in a holistic manner to distil underlying conclusions and formulate recommendations cutting across multiple themes. These key findings and recommendations were subsequently streamlined in thematic chapters to reinforce overarching messages and provide greater coherence. Finally, a language edit of the text was made to ensure a consistent structure and style throughout the report.

National consultations

UNEP engaged in a consultative and participatory process throughout the assessment. This approach was adopted to promote to the extent possible national buy-in and ownership of report findings and recommendations. The process also sought to leverage knowledge and maximise input from national partners and ascertain the report’s relevance and accuracy.



A wide range of stakeholders participated in the consultations

Consultations were an integral and continuous aspect of the UNEP assessment process. Two major workshops were jointly organised with REMA in Kigali to formally obtain feedback and ideas from stakeholders. Both workshops were attended by over 80 representatives from government ministries and agencies, research institutes, academia, United Nations (UN) organisations, development partners, civil society organisations, the media and the private sector.

The first workshop, which took place on 11-12 August 2008, discussed the findings of the PCEA desk study and the proposed assessment methodology, including identifying potential fieldwork sites. A second workshop on 28-29 April 2009 reviewed and discussed the draft document with a focus on the proposed recommendations. While the objective was to maximise agreement on the text and recommendations, the final report is ultimately an independent UNEP assessment and does not necessarily reflect the views of government.

3.4 Equipment used

UNEP provided a range of equipment for use by its experts during the fieldwork, which are described below.

Hand augurs kit (soil sampler kit)

An Eijkelkamp hand augur kit was used to collect wetland and lake/reservoir bottom sediments. These manually operated and extendable augers can collect soil samples at various depths.



Portable equipment was used to measure environmental conditions on-site

Multi-parameter field analyser

A Multi-Parameter Troll 9000 was used to carry out on-site analysis of water quality. The instrument is equipped with five standard probes measuring temperature, pressure, electrical conductivity, pH, DO and ORP. In addition, an optional sensor to test for nitrate was fitted on the Troll. Win-Situ software installed on a laptop computer was used to interface with the Troll and record the measurements collected.

Colilert kit

A Colilert kit was used to detect the presence of total coliforms and *Escherichia coli* in water. Drinking water was collected in specially inoculated reagent tubes and placed in an incubator at $35^{\circ} \pm 0.5^{\circ}\text{C}$. After 24 hours, the tubes were controlled for the presence of total coliforms and *E. coli* using a fluorescence comparator.



UNEP expert testing for the presence of coliforms in drinking water samples

Sample containers and kits

Alcontrol Laboratories provided sterilised bottles and accompanying information sheets for collection of water and soil samples. Portable mini-kits containing various accessories were used to assist in sample collection.

GIS and remote sensing software

ESRI ArcGis 9.3 software, enhanced with the 3D Analyst and Spatial Analyst extensions, was employed to produce all maps in the report. For remote sensing analysis, ERDAS Imagine was used to pre-process satellite imagery, while image mosaicking and compression was done with ER Mapper. Google Earth was extensively used throughout the project, including for reconnaissance site visualisation, mapping of field itineraries travelled by experts and selecting satellite images for acquisition.

Geographic Positioning System (GPS) and photographic documentation

All of the experts used handheld GPS devices (Garmin 60 and Etrex, accuracy up to 3 m) to collect the coordinates of sites visited and sampling points. The devices also enabled field verification to support satellite image interpretation. The GPSs were set to record a continuous track-log and time synchronised with cameras thereby automating geographic referencing of photographs taken. A GPS camera (Ricoh 500 SE) with a built-in GPS was also used. In total, over 2,500 high-resolution photographs were acquired during the fieldwork.

3.5 Laboratory analysis

The soil and water samples collected by UNEP were submitted to Alcontrol Laboratories in the United Kingdom for analysis. Alcontrol has ISO 170253 standard accreditation and participates in the MCERTS4 programme of certification, as well as the AQUACHECK and CONTEST proficiency testing programmes. UNEP has used the laboratory services of Alcontrol in previous environmental assessments for several years.

Soil core samples were analysed by the Oxford University laboratory to measure sedimentation rates.

3.6 Limitations and constraints

Although the entire country was covered during the fieldwork, the short time period limited possibilities to design rigorous site investigations and collect empirical data. Nevertheless, given the issue-based and sector-wide approach of this assessment and the focus on strategic and policy relevant issues, it was possible to identify the priority environmental challenges with a satisfactory level of confidence. Moreover, a relatively large multi-disciplinary UNEP team allowed experts to concentrate on specific environmental themes.

One of the main constraints encountered was the absence of quantitative baseline data, a substantial part of which was destroyed or lost during the conflict. Even when data existed, restrictions on accessibility were sometimes an issue. Data sets were also often dispersed, poorly documented and contradictory, further undermining their reliability. This data problem constrained UNEP's ability to assess prevailing environmental conditions and the effectiveness of policy interventions, and therefore expert judgement and comparisons with similar situations in other countries was exercised.

As with other field-based investigations, this assessment is vulnerable to the problem of observer bias and the risk of interviewer or respondent influence. Therefore, a concerted effort was made to triangulate information by cross-checking findings with other sources in order to obtain an accurate understanding of key issues.



Water samples revealing high content of suspended sediments

II. Cross-Cutting Issues

Conflict, Peacebuilding and the Environment

*Conflict-induced population displacement
in 1994 created massive environmental
damage as more than three million
people moved in and out of the country.
Repercussions of ensuing deforestation and
encroachment on national parks and wetlands
will continue for many years in the future*

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Conflict, Peacebuilding and the Environment

4.1 Introduction

Fifteen years after the tragic events of 1994, Rwanda has made remarkable progress in re-establishing peace and security, and today is considered one of the most stable countries in the region. This chapter considers the overall environmental impacts of the 1990-1994 conflict and genocide, and looks at opportunities for the environment in the now well advanced peacebuilding process. The possible role of environmental factors in exacerbating tensions was beyond the scope of this assessment.

4.2 Assessment activities

The UNEP team conducted fieldwork in four provinces to observe the direct and indirect environmental impacts of the 1990-1994 conflict and genocide. The team visited protected areas, forest reserves, three out of four camps for refugees from neighbouring countries, the two transit camps and *imidugudu*.

Areas experiencing heightened environmental stress and high vulnerability to natural disasters

and climate change, such as Gishwati, Bugesera and Bigogwe, were also visited.

Consultations took place with a number of government stakeholders including Rwanda Environment Management Authority (REMA), Ministry of Agriculture and Animal Resources (MINAGRI), Ministry of Natural Resources (MINIRENA), Ministry of Infrastructure (MININFRA) and NUR, as well as district authorities.

Other consultations held with United Nations (UN) agencies based in Rwanda included the Food and Agriculture Organization (FAO), United Nations Development Programme (UNDP) and United Nations High Commissioner for Refugees (UNHCR).

Data and critical analysis of the 1990-1994 conflict drew on the UNEP-commissioned desk study, a literature review, as well as discussions with Rwandan national experts during the stakeholder consultation workshop held in Kigali in August 2008. Extensive field interviews with local authorities and residents during the fieldwork provided further insights into key issues related to the impact of conflict on the environment, and environmental opportunities for peacebuilding.

Table 6. Field sites visited by province

Province	Sites visited
Northern	<ul style="list-style-type: none"> • Gihembe refugee camp in Gicumbi District
Southern	<ul style="list-style-type: none"> • Kigeme refugee camp in Nyamagabe District • Huye: National University of Rwanda (NUR) and National Museum • Muhanga • Nyamagabe • Kiyumba in Muhanga District
Western	<ul style="list-style-type: none"> • Kiziba refugee camp in Karongi District • Gishwati Forest in Rutsiro District • Rubavu • Karongi • Nyamasheke • Arusha resettlement area in Nyabihu District • Nyungwe National Park • Bigogwe in Nyabihu District • <i>imidugudu</i> areas: Mirama,
Eastern	<ul style="list-style-type: none"> • Akagera National Park • Nyagatare transit camp in Nyagatare District • Nkamira transit camp • <i>imidugudu</i> areas: Gahama and Mwidagaduro • Bugesera • Ngoma • Ngarama Plateau



IDP camp at Buhoro in 1994

4.3 Governance

The National Unity and Reconciliation Commission (NURC) and the National Human Rights Commission (NHRC) are the key government institutions responsible for implementing a wide-range of reconciliation and peacebuilding initiatives. However, as newly established bodies, the NURC and NHRC require substantial support to successfully manage their complex and highly challenging mandates.

One of the common dangers of modern conflicts is mines and unexploded ordinance (UXO). To this end, the government established a National Demining Office under the Ministry of Defence in 1995. Its objectives include: (i) develop a national de-mining capacity; (ii) clear all mines and UXO from the 1990-1994 conflict; (iii) carry out mine awareness and mine risk education campaigns; and (iv) coordinate activities with government agencies, non-governmental organisations (NGOs) and international partners on issues pertaining to landmines and UXO.

Decentralisation promises to expand opportunities for community-level reconciliation by providing mechanisms for local decision making in the management and use of natural resources. For instance, Environment Committees at the district level should help facilitate community participation in natural resource management, but will require substantial capacity-building support (see also Chapter 14).

At the regional level, Rwanda is participating in a number of transboundary environmental initiatives (e.g. Nile Basin Initiative, Lake Victoria Environment Management Project (LVEMP II), Congo Basin Forest Partnership) with neighbouring countries, including Burundi, the Democratic Republic of the Congo (DR Congo), Uganda, and the United Republic of Tanzania (Tanzania). These initiatives aim to promote the sustainable development and management of shared natural resources. Rwanda's major strides at regional integration, including through the East African Community (EAC) and the Economic Community of the Great Lakes Countries (CEPGL), should also help bolster opportunities for environmental cooperation.



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Legacy of the 1990-1994 conflict, the Kanombe minefield outside Kigali required mechanical demining due to thick vegetation and difficult terrain

4.4 Overview of key issues

The key issues related to conflict and the environment in Rwanda relate to:

- direct and indirect environmental impacts of the 1990-1994 conflict; and
- opportunities to enhance peacebuilding and reconciliation through environmental management.

Direct and indirect environmental impacts of the 1990-1994 conflict

Direct impacts on the environment are defined as those arising clearly and solely from military action during the conflict or its immediate aftermath (typically within six months). These include landmines and explosive remnants of war, destroyed target-related impacts, defensive works and deliberate natural resource destruction. Indirect and secondary impacts are all consequences that can be credibly sourced in whole or part to the conflict, excluding direct impacts. This category refers to the environmental impacts of population displacement, natural resource looting, collapse of environmental governance and information vacuum, funding crisis and squandered time and investment opportunities.

Direct impacts

The direct military impacts on the environment of the 1990-1994 conflict were relatively small and appear to have been largely remedied. Fifteen years following the conflict, direct impacts related to defensive works as well as unintended and targeted destruction of natural resources were not found to have left an enduring footprint.

The most important legacy is that of landmines and UXO. Rwanda signed the Mine Ban Treaty in 1997 (the Ottawa Treaty) and ratified it in 2000. Under the treaty, countries pledge to destroy all antipersonnel mines in mined areas under their jurisdiction within one decade of ratification. Hence, Rwanda is expected to be landmine free by 1 December 2010. In May 2006, the National Demining Office (NDO) under the Ministry of Defence reported that almost 900,000 m² or 3.5 percent of the country, remained to be cleared of mines and UXO in 16 minefields in four provinces.¹ Land mine clearance has been highly efficient and Rwanda has been declared a landmine-free country.² UXO remain an issue, and the NDO reported that it destroyed 102 and 106 tonnes of ordnance in 2007 and 2008, respectively.³

4 CONFLICT, PEACEBUILDING AND THE ENVIRONMENT

The environmental impacts of landmines and UXO are relatively small and include chemical and physical consequences relating to highly toxic and persistent explosives and vegetation clearance to facilitate de-mining operations. However, the main impact of mines and UXO has been their role in further diminishing, for a given period of time, Rwanda's already limited land base. According to the NDO, the tea industry was on the verge of collapse if it were not for de-mining activities as all firewood sources in Pfunda, Mulindi, Nyabihu and Rubaya tea factories were mine contaminated.⁴ Mine clearance has, therefore, played an important role in removing obstacles for accessing fertile land and revitalising the agricultural sector. Furthermore, following land clearance, the NDO reports that it jointly develops land use strategies with government agricultural experts and has also been releasing newly cleared land to landless families. It is, therefore, important that the last remnant of mine impacted land is cleared to make it safe and accessible to local communities to lessen land pressures as well as to reduce human safety risks.

Indirect impacts

While, overall, the direct military impacts on the environment have been low, the indirect environmental consequences of the conflict have been of a much greater magnitude. Indeed, most of the adverse environmental impacts experienced in Rwanda as well as in bordering regions occurred after June 1994, as more than three million people moved in and out of the country. The most significant indirect and secondary environmental consequences of the various episodes of conflict that culminated in the 1990-1994 war and genocide include: (i) extensive deforestation and encroachment on national parks and wetlands; and (ii) the loss of human and institutional capacities for natural resource management.

Extensive deforestation and encroachment on national parks and wetlands

The displacement of more than two million and resettlement of about one million people have had major environmental impacts on land cover



Wetland conversion, for both cultivation and resettlement, has increased since 1994

and land use throughout Rwanda. The most affected areas are the savanna landscapes in the Eastern Province and the Afro-montane forests in the Congo-Nile highlands. Major physical impacts include: (i) extensive deforestation, particularly of Gishwati and Mukura Forests as well as tree plantations throughout the country; (ii) considerable encroachment on the Akagera National Park and elimination of the Mutura Game Reserve; and (iii) widespread wetland reclamation. Ensuing reduction in vegetation cover and cultivation on steep slopes and marginal lands by returnees, as well as the destruction of soil conservation measures (e.g. trenches, hedges), further amplified Rwanda's chronic problem of land degradation and soil erosion (see Chapter 5).

At the regional level, population displacement caused extensive deforestation in and around refugee camps, especially in the five camps located in the DR Congo where they had uncontrolled access to the natural resources of the Virunga National Park. As many as 80,000 refugees entered the park daily to collect firewood.⁵ According to one source, the deforestation rate caused by those five camps in 1994 was equivalent to ten hectares per day.⁶ The illegal charcoal industry as well as illegal poaching of wildlife became deeply entrenched following the 1994 events.

In addition, rapid and unplanned post-1994 urbanisation, particularly in Kigali, due largely to the influx of returnees has resulted in sprawling slums further aggravating poor sanitation and public health problems (see Chapter 12).

Loss of human and institutional capacities for NRM and disruption of monitoring programmes

Across all natural resource sectors, the conflict and genocide has had a devastating impact on both Rwanda's human and institutional capital. These include losses in professional and skilled labour and destruction of long-term environmental data sets, scientific research facilities and environmental monitoring stations.

The resulting shortfall in human resources and an information vacuum has seriously strained the country's capacity for environmental governance. Although Rwanda has made rapid and impressive

progress in rebuilding its human and institutional capacity for environmental governance, major gaps in scientific knowledge generation, strategic policy formulation and implementation, and systematic environmental monitoring remain (see especially Chapters 6, 7, 9, 11 and 14).

Opportunities to enhance peacebuilding and reconciliation through environmental management

As detailed by UNEP in the policy report *From Conflict to Peacebuilding: the Role of Natural Resources and the Environment*, an emerging area of work looks at the role of the environment in peacebuilding processes, both as a pathway for confidence-building, as well as a form of capital readily available to support sustainable livelihoods. The emphasis of environmental management through a participatory approach and engagement of all stakeholders can substantially contribute to conflict resolution and peacebuilding.⁷

National reconciliation and peacebuilding

Since 1994, Rwanda has succeeded in re-establishing public security and made remarkable progress in dismantling the negative forces and ideologies that led to the genocide. Ex-combatants are being demobilised and reintegrated. Furthermore, foreign aid and grants have provided some insulation from sudden commodity price changes on the world market. Post-conflict recovery efforts remain ongoing and include infrastructure repair, community-level reconciliation initiatives, resettlement of the remaining Rwandan refugees and displaced populations, as well as environmental rehabilitation.

In 2000, the government unveiled Vision 2020, an ambitious long-term plan for social and economic transformation. Along with the Poverty Reduction Strategy Paper (PRSP) and the decentralization process, the Vision signalled the transition from post-conflict recovery to long-term development. The involvement of civil society in the design and formulation of these strategies is a positive step that should further promote national unity and reconciliation.

Regional integration represents one of the key strategies of Vision 2020 and is a critical factor in promoting peace and security not only in



Rwanda enjoys a high level of public security

Rwanda, but also for the wider region. In this respect, the environment provides a promising opportunity to strengthen peacebuilding and development through transboundary cooperation in the sustainable trade and development of natural resources.

Supporting national reconciliation through environmental recovery plans

In recognition of the country's environmental challenges, the government has endeavoured to integrate them in its attempt to create a suitable platform for sustainable development. At the same time, Rwanda's environmental recovery plans can substantively reinforce ongoing national reconciliation efforts. These recovery plans seek to support and enhance peacebuilding and prevent the emergence of future possible tensions arising from environmental change. Doing so will also require building the necessary expertise and diffusing innovative policies and best practices.

Four key areas in which the environment can contribute to peacebuilding and reconciliation are:

1. Ecosystem rehabilitation to improve livelihoods

Rwanda's population is projected to grow from approximately 10 million in 2008 to 16 million by 2030. Both rapid population growth and poverty

have increased pressures on scarce resources – most notably land, water and fuelwood in rural and urban areas. In rural areas, high population pressures and acute land scarcity have resulted in land fragmentation, which in turn have led to overcultivation and overgrazing, exacerbating Rwanda's chronic soil erosion problem.

Accentuating environmental degradation may undercut human development options and progress towards the goals of Vision 2020. Government efforts to create safety nets for the poorest segment of society should therefore include the promotion of environmentally sustainable livelihood options.

In Rwanda, unique approaches to ecosystem rehabilitation have helped to further consolidate national unity, reconciliation and peacebuilding. The Work for Public Interest (TIG) programme of community service as an alternative to imprisonment provides an interesting model for promoting reconciliation through environment and development projects. This programme, which is coordinated by the Ministry of Justice (MINIJUST) was conceived for a category of genocide-related prisoners, who continue to serve their sentences by engaging in public interest work, such as maintaining roads and community infrastructure, building terraces, and carrying out other environment-related work, such as tree planting. The rationale was to decongest prisons



The imidugudu resettlement programme aims to consolidate land for agriculture and facilitate access to services but represents a departure from traditional scattered settlements

while at the same time promoting reconciliatory and productive rehabilitation of genocide convicts. The convicts usually work on projects within their own communities or their areas.

The *imidugudu* resettlement programme seeks to provide grouped housing in villages to free up land for intensive agriculture. This villagisation programme is premised on the willingness of farmers to allow their land to be consolidated and collectively managed under intensive agricultural programmes, which seek to increase yields by grouping cropping into regionally specific types and includes the promotion of irrigation, fertilisers, cash crops, mechanized farming, as well as adoption of capital-intensive, anti-soil erosion measures (e.g. radical terracing). The scheme envisages apportioning the general harvest to individual farmers, which is expected to be more than what farmers could produce on their own. In addition, farmers and their families in grouped settlements have greater access to improved basic services, including schools, healthcare, water supply and sanitation. In order to ensure that gains are attained, it is important to reinforce community participation in the resettlement process and that livelihoods are supported through adequate access to drinking water supplies, fuelwood, food and infrastructure⁸.

Ubudehe is an old Kinyarwanda tradition by which residents come together and collectively identify their development challenges, plan, prioritise and mobilise resources, implement, and monitor the identified activities. The *ubudehe* concept was instrumental in rejuvenating community mobilisation and participatory planning in the 1999-2000 poverty assessment and community-driven development since the first PRSP, and has since been used in implementing local community development programmes.

Capitalising on these approaches, as well as on the existing high-level government support for sustainable development by embarking on large-scale ecosystem rehabilitation should also considerably assist in alleviating environmental stressors and help strengthen reconciliation efforts.

2. Land tenure reform

In 2004, the Government of Rwanda adopted the first-ever National Land Policy (2004) and Land Law (2005). To operationalise this law, a land tenure reform programme is being implemented, which will legalise land ownership by providing individuals with land titles. This programme primarily focuses on two issues:

4 CONFLICT, PEACEBUILDING AND THE ENVIRONMENT

(i) land use management, which seeks to promote rational and productive use of land; and (ii) land administration, which facilitates equitable access to land and guarantees security of tenure for all Rwandans and particularly women, who were historically disadvantaged. Under this programme, security of tenure will be guaranteed through registration and issuance of land titles, as well as the establishment of land committees and tribunals at the local level to resolve any arising conflicts. One expected benefit of land ownership is to encourage farmers to adopt soil conservation measures. Another rationale of land tenure reform is to establish a land market, enabling the possibility of consolidating land parcels and promoting intensive agriculture.

3. Climate change adaptation and disaster risk reduction

Rwanda's high vulnerability to climate change is likely to intensify prevailing environmental degradation, amplify disaster risk (floods, droughts, fire outbreaks) and modify historical



Difficult living conditions in refugee camps could potentially strain relations with neighbouring communities over limited resources

weather patterns. Climate change in Rwanda is predicted to raise temperatures and bring about extreme rainfall patterns in different parts of the country. More frequent, severe rainfall events are expected, particularly in the northwest of the country, which will increase vulnerability to flash floods and landslides, especially in heavily deforested areas. On the other hand, extended dry seasons and prolonged droughts are projected in the east and southeast, which can exacerbate already degraded pasture areas and water supply shortages (discussed in Chapter 6).

Climate change will introduce considerable uncertainties into the agricultural, forestry and energy sectors and pose challenges to long-term planning. Complex synergies between existing environmental stress, disasters and climate change may increase the risk of surpassing environmental thresholds that have the potential to threaten livelihoods⁹. Therefore, developing capacities to reduce disaster risks and adapt to climate change, including investing in climate change research and technology transfer, need to be recognized as priority areas from both an environmental and national sustainable development perspective.

4. Improving living conditions in refugee camps

Due to acute land scarcities in Rwanda, refugee camps in Rwanda for those displaced by conflicts in the DR Congo and Burundi are sited on marginal lands offering little prospects for cultivation, income generation and water and firewood collection. While the overall environmental impact of refugee camps is low (see Chapter 5), deteriorating living conditions could potentially result in frictions with neighbouring Rwandan communities. For instance, severe fuel and water shortages are forcing refugees, mainly women, to forage illegally outside of their camps over large distances. Resource shortages in refugee camps, therefore, need to be addressed as a priority issue.

Enhancing regional environmental cooperation initiatives

Rwanda is strategically located between the anglophone Eastern Africa and the pre-dominantly francophone Central Africa. Its bilingual status, geographic positioning and recent post-conflict management experiences, have enabled it to play

an active role in various regional peacebuilding and reconciliation initiatives, including the active participation of the Rwanda Defence Forces (RDF) in peacekeeping missions in Darfur, the Great Lakes Disarmament Programme, and the AMANI Peace Programme initiated by the Great Lakes Parliamentary Forum.

Prevailing insecurity and violence in the Great Lakes region is at odds with its latent human and natural resources base. From a broad perspective, this enormous under-realised potential for prosperity through regulated and sustainable trade in natural resources could significantly improve the living standards of its people. For this promise to materialise requires peace, which in turn needs international support to promote transparent good governance and the facilitated transboundary flow of people, technology, financial capital, natural resources, and goods and services.

Regional environmental cooperation can help resolve some of the prevailing tensions. It could provide the framework for the sustainable development of the region's major resource endowments, through a concerted manner that effectively balances supply and demand. Environmental cooperation would enable

countries to take advantage of the region's natural capital and, thereby, assist in meeting the demographic and climate challenges of the future. It would also significantly add to ongoing regional peacebuilding and integration efforts. For this to come about, Rwanda, which has actively engaged in transboundary environmental initiatives and as one of the more stable countries in this volatile region, may have a very important role to play.

Some of the key transboundary environmental cooperation interventions may include the following initiatives:

- large-scale sustainable trade in raw and added-value natural resources (Chapters 8 and 10);
- harnessing the energy potential from shared rivers and the vast methane gas deposits in Lake Kivu (Chapter 11);
- management of transboundary parks for the protection of biodiversity and development of ecotourism (Chapter 10);
- joint research programmes on regional climate change, including climate change monitoring and adaptation (Chapter 6); and



Rwanda-DR Congo border crossing at Rubavu – sustainable trade in natural resources could offer a win-win situation for the two countries

4.5 Conclusions

Past conflicts in Rwanda have caused serious environmental impacts, particularly extensive deforestation and land degradation. Since 1994, Rwanda has made substantial progress towards peacebuilding and public security and is now on a solid development track. Opportunities to support reconciliation efforts and progress towards the goals of Vision 2020 have been identified. These include: (i) ecosystem rehabilitation and poverty reduction; (ii) land tenure reform; (iii) climate change and disaster risk reduction; and (iv) improving living conditions in refugee camps. Another promising area is Rwanda's engagement in regional cooperation initiatives, which has considerable potential for promoting region-wide economic development and peacebuilding.

Practical environmental interventions that can contribute to national development and peacebuilding are identified in the relevant sectors of this assessment, which – when incrementally applied – should help strengthen social cohesion and peace. It is, therefore, critical that policy makers are also aware of the potential peace dividends that may accrue from improved environmental management. Some key intervention measures include:

- encouraging community participation in the use and management of local resources through the ongoing decentralisation process (see especially Chapters 8, 10, and 13);
- creating environment friendly off-farm sources of income generation for *imidugudu* residents (Chapter 7);
- rehabilitating montane forests (Chapter 8);
- promoting conservation agriculture and agroforestry (Chapters 7 and 8);
- developing alternative and affordable energy sources to reduce dependency on fuelwood, especially in rural areas (Chapter 11);

- strengthening environmental governance that is adaptive to emerging issues and threats (discussed in all chapters); and
- promoting integrated water resource management (IWRM) in order to develop mechanisms for stakeholder collaboration and collective decision making regarding the allocation of water resources, especially at the local level (Chapter 9).

4.6 Recommendations

R4.1 Improve public awareness of land tenure reform arrangements, including processes of distributing and demarcating land. It is important to ensure that people perceive the land reform process to be both transparent and participatory. Improving public awareness would help relieve potential concerns regarding distribution and access to land.

Lead agencies: National Land Centre, MINIRENA. Cost estimate: USD 1 million. Duration: 5 years.

R4.2 Implement an environmental and technical assistance project in the four refugee camps. This entails assignment of an environmental coordinator to provide training and technical advice to refugees as well as develop environmental guidelines for camp planners and management staff. Off-farm activities should be promoted to provide employment, address resource shortages as well as undertake specific environmental initiatives. For instance, paid working groups could be established to carry out soil conservation, establishment of tree nurseries, tree planting in and around the camp. Environmental initiatives would target vulnerable sectors, such as women-headed households. Joint environmental activities should also be initiated with decentralised institutions and the local population to manage environmental challenges around refugee camps.

Lead agencies: MINALOC, MINAFET, MINAGRI/RAB/RADA, district authorities. IP: UNHCR. Cost estimate: USD 0.5 million. Duration: 2 years.

Population Displacement, Resettlement and the Environment

*Gihembe is Rwanda's largest refugee camp
in Rwanda and hosts nationals from the
eastern DR Congo. The Great Lakes region
has witnessed massive refugee flows across
borders in the past decades*

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Population Displacement, Resettlement and the Environment

5.1 Introduction

Population distribution and settlement patterns in Rwanda have historically been influenced by geographical and cultural factors respectively, primarily to maintain social cohesion with the family unit as the centre of settlement clusters. Colonial and post-colonial governments, however, changed these patterns through involuntary migration and forced resettlement. Since 1959, when large-scale displacement first took place, involuntary resettlement and out-migration have characterised population movement and settlement in Rwanda.

Population displacement and resettlement caused by the 1990-1994 conflict and genocide have had a major impact on the environment, substantially altering land cover and land use in many parts of the country. Refugee flows into Rwanda arising from conflicts in neighbouring countries, particularly the Democratic Republic of the Congo (DR Congo) and Burundi, have also left an environmental footprint at the local level, where refugee camps were established.

Unplanned resettlement in the immediate aftermath of the genocide (1994-1998) was characterised by poor site selection and inappropriate, hastily constructed settlements or *imidugudu* with limited infrastructure and services. This was mainly due to the urgent need to resettle the large numbers of returning refugees, as well as the absence of appropriate government structures and systems. While this enabled the resettlement of many people in a relatively short time, it created a number of environmental problems with important implications on the livelihoods of *imidugudu* residents. Major environmental issues include: (i) land degradation and severe soil erosion; (ii) fuelwood supply shortages; (iii) inadequate access to agricultural land and unsustainable agricultural practices; (iv) water shortages and poor sanitation; and (v) managing future population expansion in the *imidugudu*.

In the context of rapid population growth, poverty and land scarcity, the future challenge will be to sustain livelihoods by improving environmental conditions in existing *imidugudu* and applying better environmental standards in planning new settlements. Developing alternative, off-farm rural employment needs to be an integral component of the resettlement package. In addition, proactive interventions tackling emerging causes of displacement, due to heightened vulnerability to natural hazards and environmental degradation, are necessary to stem environmentally induced migration.



Building houses in Bukora resettlement site for Rwandan returnees from Tanzania

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5.2 Assessment activities

Fieldwork covered the entire country and included principal types of displacement and resettlement. The UNEP team visited refugee camps in Rwanda (three out of four) and rural and urban *imidugudu* (16 in total). The field visits covered 18 districts in four provinces (see Table 7). Former camps in Rwanda previously occupied by internally displaced persons (IDP) were not visited by UNEP, mainly because none of these camps exists today.

Assessing the environmental impacts of displacement and resettlement proved difficult due to limited information and the length of time elapsed since the end of the conflict, including government remedial actions. Nonetheless, stakeholder consultations and interviews, in addition to the desk study and literature review, made it possible to develop a sound understanding of the key environmental issues related to displacement and resettlement.

Interviews and focus group discussions were undertaken with refugees and villagers in all sites visited. Consultations were held with a number of government institutions, namely: Ministry of Infrastructure (MININFRA), Ministry of Agriculture and Animal Resources (MINAGRI), Rwanda Environment Management Authority (REMA) and Ministry of Natural Resources (MINIRENA).

Various United Nations (UN) agencies were also consulted, including: United Nations High Commissioner for Refugees (UNHCR), Food and Agriculture Organization (FAO), United Nations Development Programme (UNDP) and United Nations Human Settlements Programme (UN-HABITAT).

5.3 Overview of population displacement in Rwanda

Since the mid-twentieth century, conflict has been the main driver of large-scale population displacement in Rwanda. Started by the colonial administration, waves of conflicts were perpetuated by successive post-colonial governments, culminating in the 1990-1994 conflict. The other causes of displacement are disasters and persistent environmental degradation, discussed in more detail in Section 6.5.

There are three types of conflict-related displaced persons in Rwanda, namely: (i) those who fled the country since 1959, referred to as 'old caseload' returnees; (ii) those displaced as a direct result of the 1990-1994 conflict and genocide, referred to as 'new caseload' returnees; and (iii) refugees from the DR Congo and Burundi.

Population displacement from conflict starting in the 1950s

Large-scale, conflict-induced population displacement began in 1959, shortly before independence. The abrupt transfer of political power resulted in massacres prompting several hundred thousand from the Tutsi community to flee to neighbouring countries, namely Uganda, Burundi, DR Congo and the United Republic of Tanzania (Tanzania). In the following decades, successive episodes of violence caused thousands of casualties and led to mass out-migration. By the end of the 1980s, an estimated 700,000-800,000 Rwandans, mostly from the Tutsi ethnic group, were involuntarily living outside Rwanda.

Table 7. Field sites visited by province

Province	Field sites
Kigali	– Imidugudu sites: Batsinda, Bwiza, Kinyinya
Northern	– Musanze imidugudu – Gihembe refugee camp
Western	– Kiziba refugee camp – Gishwati Forest Reserve – Imidugudu sites: Nyabihu, Arusha, Bigogwe
Eastern	– Nyabiheke refugee camp – Imidugudu sites: Kirehe, Kayonza, Gatsibo, Nyagatare, Rugero, Karangazi, Mirama, Rutete, Nemba, Bukora, Rwimikoni – Bugesera – Akagera National Park



DR Congo refugees at Kiziba camp in western Rwanda

© POLLONAS

Table 8. Refugees in Rwanda, as of June 2008¹

Camp	Nationality	Refugees
Kigeme	Burundi	1,994
Gihembe	DR Congo	18,319
Nyabiheke	DR Congo	8,734
Kiziba	DR Congo	18,301
Kigali (urban refugees)		2,383
Nkamira	DR Congo	2,191
Nyagatare	DR Congo	2,832
Total refugees		54,754

Population displacement from the 1990-1994 conflict and genocide

The 1990-1994 conflict and genocide sparked unprecedented population displacement in the country. During this period, about 1.5 million civilians fled their homes and lived in camps. By the end of the conflict, after the Rwanda Patriotic Front (RPF) took over the country, an estimated two to three million people fled from Rwanda, mainly towards the North Kivu Province of the DR Congo. This massive out-migration created a major refugee problem in the Great Lakes region.

Even after the conflict officially ended in 1994, fighting continued and created significant internal population displacement, especially in

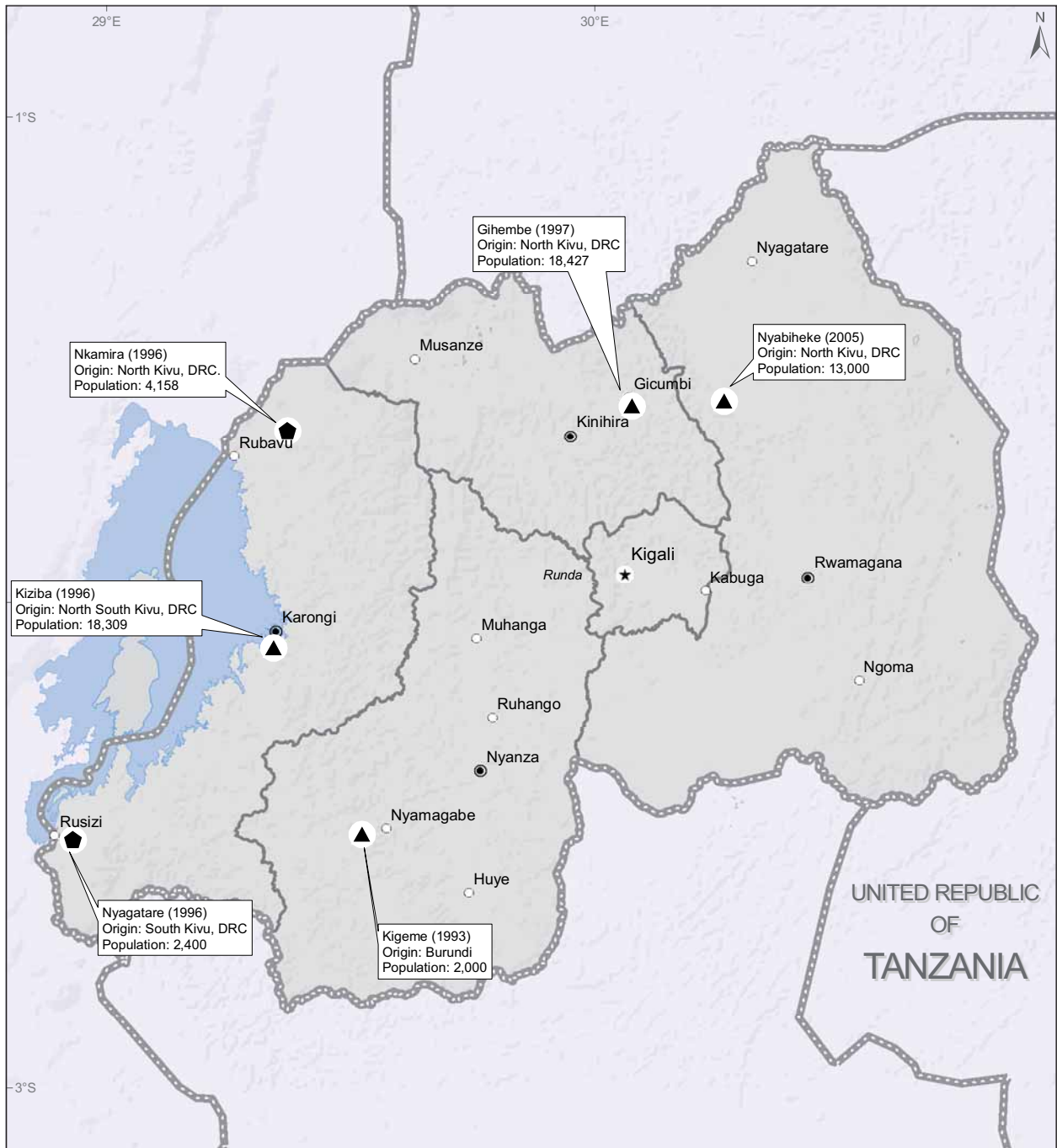
northwestern Rwanda. Total numbers of IDPs peaked in 1997 and 1998 (Table 9, page 79).

Refugees from neighbouring countries

Persistent regional conflicts have also resulted in massive population displacement, with some refugees seeking sanctuary in Rwanda. There are currently 54,754 refugees registered in Rwanda, mainly from the DR Congo and Burundi (see Table 8). The majority of refugees live in four camps managed by UNHCR. The largest camps are Gihembe and Kiziba, each of them housing more than 18,000 refugees. A smaller number of about 2,000 refugees live in and around Kigali City. Nkamira and Nyagatare are transit camps for refugees as well as returnees.

5 POPULATION DISPLACEMENT AND THE ENVIRONMENT

Map 9. Refugee camps in Rwanda



5.4 Overview of resettlement

The Arusha Accords, which constituted the basis for establishing a power-sharing arrangement between the RPF and the former Government of Rwanda (GoR), included provisions for the return and resettlement of old caseload refugees, degazetting part of the Umutara game reserve and eventually a portion of the Akagera National Park and Gishwati natural forest to resettle the returning population. The Arusha Accords also envisaged that returnees would be grouped in village settlements called *imidugudu*. Between 1994 and 1997, due to the urgency of the resettlement process, appropriate site identification and resettlement planning proved difficult. As a result, *imidugudu* were established in small, often environmentally inappropriate areas with limited infrastructure. This presented particular difficulties in the Eastern Province, as the area was newly opened up, with no roads or infrastructure such as water sources. Due to the relative success of the concept in resettling large numbers of people the Transitional Government of National Unity decided to adopt this model in 1997 and expand it into a full villagisation programme across the country.

Post-1994: Grappling with the large numbers of returnees

Soon after the RPF took over the country in July 1994, the first major wave of old caseload returnees arrived in Rwanda in large numbers and in a spontaneous manner. Old caseload returnees continued to arrive in Rwanda until 2000, though the majority had already returned as early as 1995. As of June 2008, approximately 800,000 old caseload returnees had been registered.

Also in 1994, new caseload refugees began to return to Rwanda in large numbers. However, the majority of the two to three million displaced persons, who fled Rwanda following the end of the 1994 conflict, returned between 1996 and 1997. As of June 2008, approximately two million new caseload returnees had been registered.

While the influx of returnees has diminished over the last few years, the repatriation of Rwandan refugees is still ongoing. In the DR Congo, there are still about 40,000 Rwandan refugees, while in Uganda they number approximately 20,000. The total number of Rwandan refugees in Tanzania is unclear, following the forceful eviction of 15,000 Rwandans from the country in 2006 and 2007.³



The sheer scale of the Great Lakes refugee crisis in the mid-1990s underscored the importance of incorporating environmental considerations in relief operations. Shown here is the Nyarushishi IDP camp in 1994

5 POPULATION DISPLACEMENT AND THE ENVIRONMENT

Table 9. Numbers of returnees and IDPs in Rwanda since 1994²

Year	Old caseload	New caseload	Unspecified	Total returnees	Refugees	IDPs
1994	608,000	600,000	–	1,208,000	–	–
1995	146,476	79,302	–	225,778	–	–
1996	28,646	1,271,936	–	1,300,582	25,257	–
1997	19,680	199,314	–	218,994	34,227	21,877
1998	7,723	3,167	–	10,890	33,403	625,000
1999	890	19,337	18,001	38,228	34,365	–
2000	1,012	23,460	–	23,460	28,398	–
2001	–	–	21,656	21,656	34,786	–
2002	–	–	38,643	38,643	30,863	–
2003	–	–	23,290	23,290	36,608	–
2004	–	–	14,136	14,136	50,221	–
2005	–	–	9,854	9,854	45,206	–
2006	–	–	–	37,432	49,192	–
2007	–	–	–	13,965	53,201	–
June 2008	–	–	–	7,655	54,754	–

Note:

– Indicates data not available.

Resettlement of old caseload returnees and IDPs

In order to deal with the enormous task of providing housing and livelihoods to the hundreds of thousands of returnees and IDPs, the government actively promoted the *imidugudu* resettlement strategy. It sought to transform the traditional scattered settlement pattern in favour of grouped settlements or *imidugudu*. The *imidugudu* scheme provided each household with a plot for housing construction and, when possible, another plot for agricultural activities located outside *imidugudu*.

As envisaged in the Arusha Accords, old caseload returnees resettled on public or state-owned land, which included protected areas and forest reserves as well as fragile lands and steep slopes. For new caseload returnees, the majority returned to their former homes; those who could not were resettled in *imidugudu*.

Scaling up of the imidugudu resettlement programme

The *imidugudu* approach was endorsed and subsequently upscaled in 1997 into a grouped settlement programme as prescribed under the National Human Settlement Policy. Under this policy, *imidugudu* schemes were adopted as a national strategy to rationalise land use and facilitate cost-effective service delivery to the population.



After 1996, thousands of returning old caseload Rwandan refugees mainly from Tanzania were resettled in the Eastern Province, as shown here in Bukora village

This concept has since been incorporated into the Integrated Development Programme that is being piloted through the “Vision 2020 *Umurenge*”.

Government rationale in favour of the *imidugudu* approach was essentially two-pronged. First, grouped settlements would free up agricultural land and allow for intensive agriculture, thus enhancing agricultural productivity. Second, *imidugudu* would facilitate the delivery of basic services, such as water, healthcare, education, communications and security, and evolve into hubs of development. It was anticipated that clustered settlements would also promote reconciliation and consolidate the unity of the Rwandan population. The government remains convinced that the village-type settlement pattern is the most viable alternative to effectively tackle the issue of land scarcity and high population density in Rwanda.

Rural *imidugudu*

As of 2007, an estimated two million people, amounting to 20 percent of the rural population, were living in 5,486 *imidugudu*.⁴ *Imidugudu* are located mainly in the east, but are also scattered in other parts of the country. The government’s objective is that 45 percent and 70 percent of the population by 2011 and 2020, respectively, would reside in *imidugudu*.

Urban and peri-urban *imidugudu*

During the post-conflict period, many returnees settled in Kigali City, contributing to the proliferation of informal settlements and slums without adequate access to basic services, such as water, sanitation and solid waste disposal. To address these problems, the government is developing planned urban and peri-urban settlements for low-income households in order to provide shelter for all Rwandans and facilitate the cost-effective delivery of basic services.

5.5 Governance

Resettlement and *imidugudu* development

The National Human Settlement Policy is the main policy instrument to guide human settlement in the country in general and the resettlement of displaced populations in particular. Since December 2008, at the national level, the Ministry of Local Government, Community Development and Social Affairs (MINALOC) is responsible for human

settlement policy implementation and coordination of the National Human Settlement Re-organisation Programme, under the Integrated Development Programme. It oversees *imidugudu* planning and development, which will be enhanced through the programme known as “Vision 2020 *Umurenge*”. District councils and district land commissions are responsible for the supervision and monitoring of resettlement activities carried out in the districts.

At the district level, site selection for *imidugudu* is undertaken in cooperation with local communities. Local authorities work out procedures for organising available land, including compensation and land exchange issues. District authorities are also responsible for *imidugudu* development and the provision of services. Housing construction is the responsibility of beneficiaries.⁵

With respect to urban and peri-urban *imidugudu*, district and town commissions coordinate the development and management of resettlement areas. Local authorities assist in identifying sites and supervising the implementation of resettlement plans. Private land and real estate development companies, local firms producing building materials, human settlement groupings and residential area associations are responsible for the construction and maintenance of planned settlements.⁶ REMA has drafted guidelines for environmental impact assessment of housing and other infrastructure projects, which future medium- to large-scale settlements plans will be required to follow.

Refugee camps

With the support of UNHCR, MINALOC and MININTER are responsible for the management of refugee camps in Rwanda. They work together with other government agencies and a range of international humanitarian agencies and non-governmental organisations (NGOs). The National Refugee Council, coordinated by MINALOC, is the focal point for refugee camps in Rwanda.

Usually, environmental impact assessments are not carried out before setting up a refugee camp, especially under emergency pressures. While the experiences in the region during the period 1994-1996 were a key factor in prompting the UNHCR to develop environmental guidelines to mitigate impacts of refugee camps, they appear to have been partially applied in Rwanda.



DR Congo refugees in Nkamira transit camp near Gisenyi, Rwanda

5.6 Overview of environmental issues related to population displacement and resettlement

Conflict-induced population displacement has had major environmental repercussions in Rwanda. Furthermore, potential displacement from natural hazard-induced disasters and persistent environmental degradation will exert new environmental pressures as people cope by migrating to other provinces, unless appropriate risk reduction measures are undertaken.

Poorly planned resettlement activities have also contributed to a range of environmental problems, particularly with respect to inappropriate site selection and planning. Rapid population growth, poverty and land scarcity, in turn, have exacerbated environmental degradation in resettled areas. The government has recently developed rigorous environmental standards to guide new resettlement programmes.

The discussion of environmental issues related to displacement and resettlement is addressed under five main areas:

- informal resettlement of displaced populations and their environmental impacts;
- refugee camps and their environmental impacts;
- planned *imidugudu* and their environmental impacts;
- improvements in environmental planning of new resettlements; and
- emerging causes of displacement.

Informal resettlement of displaced populations and their environmental impacts

Given the severe land scarcity problem in Rwanda, the resettlement of displaced populations has had the most enduring environmental impacts. During the first wave of old caseload returnees from 1994 to 1996, unprecedented numbers of returnees were resettled on the little free public land available and areas previously gazetted for conservation uses. As a result, key ecosystems in the eastern savanna landscape and the Afro-montane forests in the Congo-Nile highlands experienced serious impacts.

Old caseload returnees, mostly from neighbouring Uganda and Tanzania, arrived with large herds of cattle and settled mainly in the eastern part of the country. This region is drier than the rest of the country and characterised by savanna vegetation, which made it ideal for raising livestock. Returnees were resettled in an area covering the entire Mutura Game Reserve, and their resettlement eventually led to the de-gazettement of two-thirds of the Akagera National Park. Land was subdivided into ranches and converted into pastureland.

In the northwestern part, it is estimated that Gishwati and Mukura high altitude natural forests, which had suffered encroachment since 1990, suffered losses of 93 and 43 percent respectively. Deforestation during this period is to a large measure attributable to the resettlement of old caseload returnees mainly from the DR Congo. Within a short time span, returnees transformed the area into pastureland and cultivated plots.

Gishwati Forest, in particular, was most affected. Initially covering an area of 23,000 ha in 1980, Gishwati shrunk to a mere 600 ha by 2002.⁷



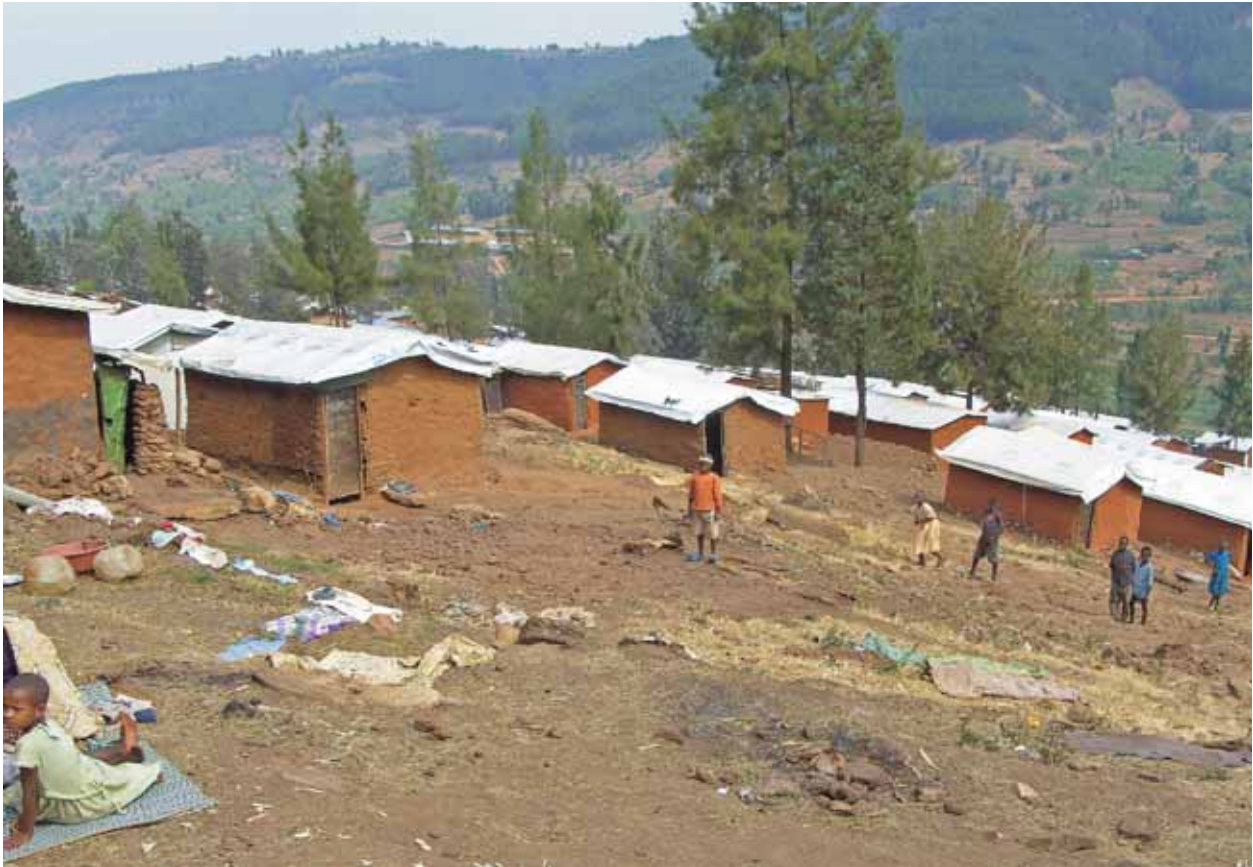
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Inappropriate campsite selection such as on steep slopes can significantly accentuate land degradation



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Cooking and shelter needs of displaced populations were a major driver of deforestation, as shown here in Mururu IDP camp in 1994



Nyabiheke refugee camp is situated on a rocky hill partly covered by a pine forest plantation

For the over two million people displaced following the 1994 conflict, it is difficult to gauge their environmental footprint as they mostly scattered beyond Rwanda's borders. Most of them eventually returned in 1996 and 1997. Based on the UNEP assessment, the environmental consequences of displaced Rwandans who remained *inside* the country during the immediate post-conflict period may be characterised as one of short duration, high local impact and requiring a medium- to long-term recovery period.

The most visible environmental impact is localised deforestation around temporary camps. For example, IDPs that temporarily settled near Volcanoes and Nyungwe National Parks reportedly caused significant forest degradation and loss of biodiversity. They exploited the forests inside the parks for firewood. To earn some income, they converted firewood into charcoal and sold it along roadsides, thereby increasing pressure on forest resources. Poaching and the illegal hunting of wildlife were also a problem, which are now considerably reduced. Deforestation and loss

of wildlife in protected areas are addressed in Chapters 8 and 10, respectively.

Similarly, large Rwandan IDP camps in the north near the border with Uganda were marked by intensive localised deforestation. Vegetation clearance was also partly driven by military operations to flush militia hideouts. After the conflict, these former camps were transformed into agricultural land for *imidugudu*.

Refugee camps and their environmental impacts

The overall environmental impact of the refugee camps in Rwanda is low, but remains locally significant. The principal problem is deforestation around the camps from uncontrolled fuelwood collection. Firewood, the main source of cooking energy in Rwanda, is rarely provided by UNHCR and other relief organisations working in these camps; therefore, refugees collect timber and firewood in the camp's vicinity, rapidly exhausting firewood supplies within a short walking distance.



Prior to 1994, dense mountain forest covered the Arusha village site as shown above; locating such settlements on nearby pasturelands would have been a wiser land use choice

Case study 5.1 Arusha: Returnee resettlement in Gishwati Forest Reserve

Even before deforestation had taken hold due to resettlement, about two-thirds of Gishwati's natural forest had already been converted into pastures and pine plantations by a World Bank-funded project in the 1980s. Gishwati subsequently became one of the choice destinations for resettlement of old caseload returnees from the DR Congo. One major resettlement site was Arusha, where local authorities provided returnees with land inside the remaining intact forest, whereas available pastureland nearby would in retrospect have been a better option.

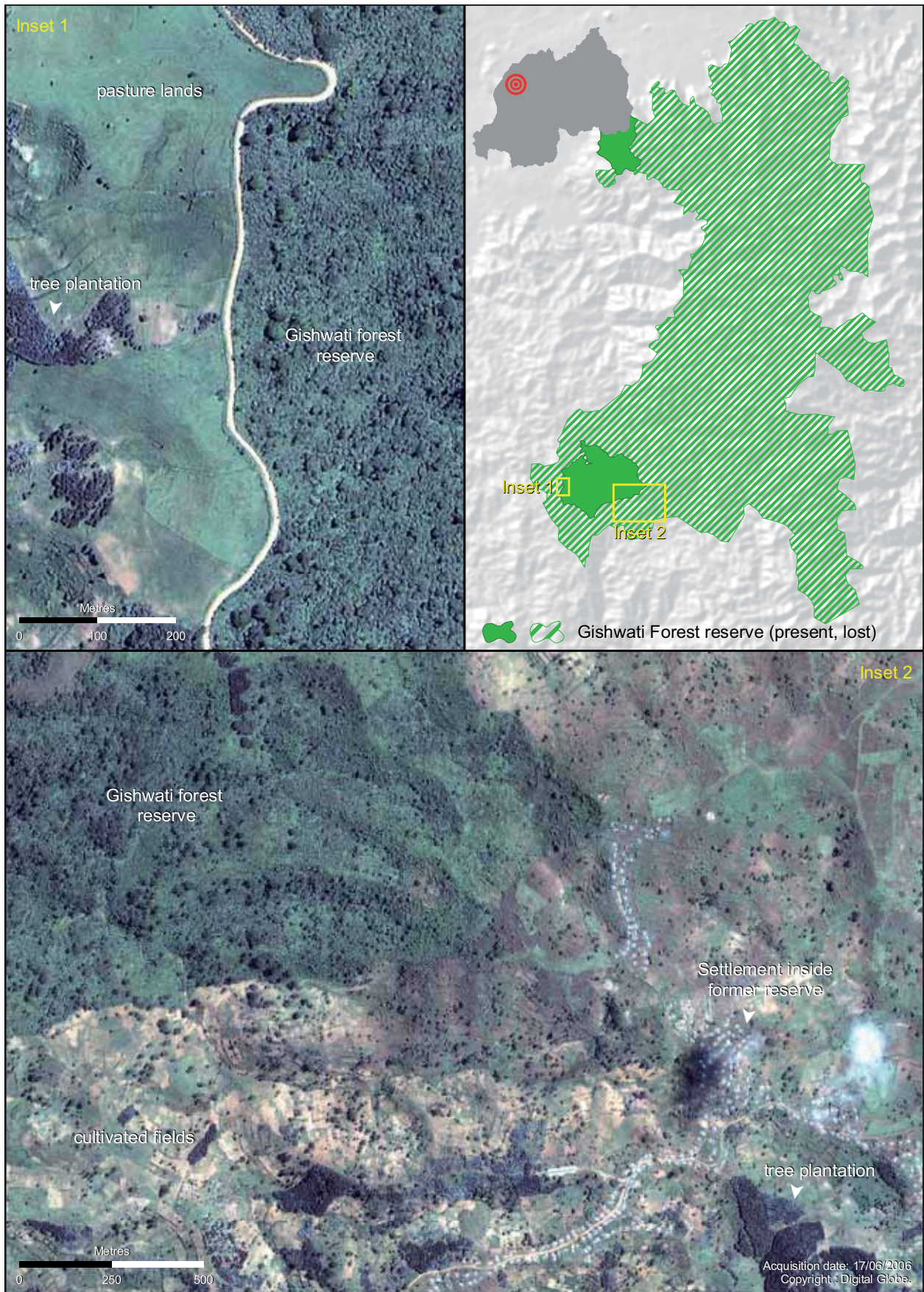
When returnees first arrived in Arusha in 1995, they were temporarily sheltered under plastic sheeting. As settlement became permanent, more trees were cut down for construction purposes and the undergrowth cleared for cultivation. The first 500 families received about one ha of land each, which thereafter was reduced to 0.6 ha. In 1999, the resettlement area in Gishwati was restricted to 3,070 ha and the Council of Ministers decided to remove people from Gishwati forest and resettle them in nearby sites. Today, about 818 families live in Arusha, which has a primary school and a health centre.

Local authorities are presently considering relocating the entire population of Gishwati (about 20,000 people) and resettling them along the main road from Musanze District to Rubavu. Plans for relocation were spurred by devastating floods in 2007, linked to extensive deforestation in Gishwati. However, such a large-scale relocation programme needs to be carefully planned and accompanied with appropriate livelihood and income-generation opportunities.

Another option is to improve land use practices, for instance, by establishing forest plantations using indigenous tree species, promoting agroforestry and the cultivation of perennial crops and fodder grasses along contour lines to improve soil cover and reduce flood risk. One promising initiative that UNEP observed in the area is the installation of 60 solar panels by a UNDP project to promote renewable energy and reduce fuelwood pressures.

5 POPULATION DISPLACEMENT AND THE ENVIRONMENT

Figure 2. Land use pressures in Gishwati forest reserve





A major problem in refugee camps as shown above in Kiziba is the lack of adequate fuelwood

During the immediate post-conflict period, massive deforestation occurred around refugee camps, as there were no regulations in place. Apart from being used as a source of energy, wood was also used for shelter construction and brick production. In some cases, refugees converted fuelwood into charcoal for sale to earn income. However, there are now strict government regulations, which prohibit the felling of trees for firewood and construction.

As there are no alternative energy sources in refugee camps, UNHCR has proposed a number of measures to reduce fuelwood demand as well as increase the camp's own wood supplies. For instance, fuel-saving stoves and tree planting (e.g. bamboo plantations) have been promoted. Nonetheless, there is a serious lack of funding to implement these measures (Case study 5.2).

Due to limited fuelwood supplies, refugees have to buy or even steal wood outside camp areas. This poses a potential source of conflict with the local population. Moreover, women and children spend several hours everyday in search of wood outside

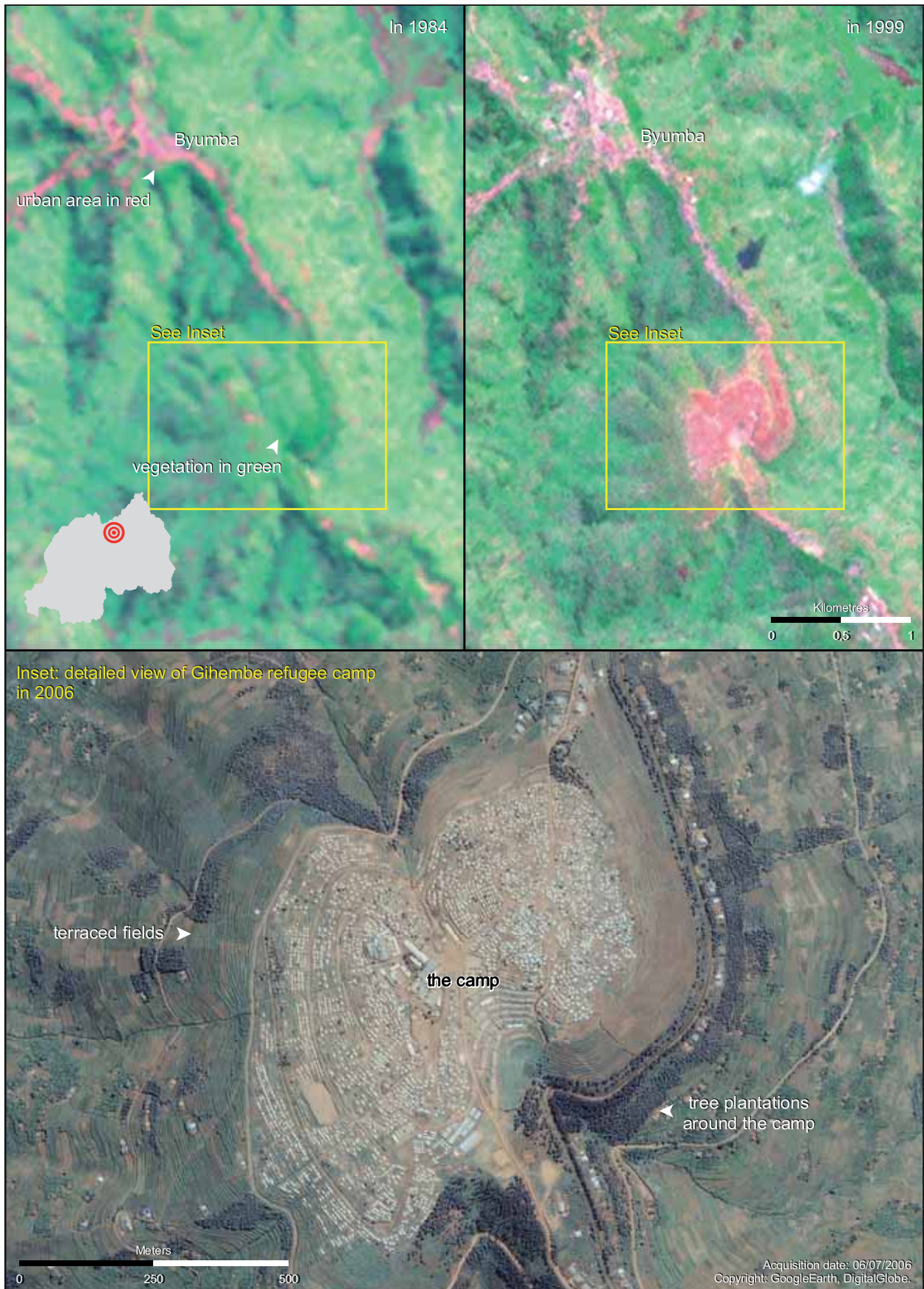
camp, exposing themselves to risks of abuse and harassment.

Future efforts to address fuelwood shortages in refugee camps should focus on reducing wood energy demand and developing alternative energy sources for refugees, such as the installation of biogas plants. In addition, adopting soil conservation measures in and around camps is critical to control land degradation arising from deforestation. Already, in some camps that are situated on steep slopes, refugees have built terraces to control erosion under a food-for-work programme. One advantage of this initiative is that even after the camp is eventually shut down, these erosion-control measures would benefit future cultivators in the area.

Although UNHCR and other relief agencies provide food, water, basic shelter, cooking equipment and other relief supplies, these supplies generally prove inadequate. Refugees usually experience insufficient water and sanitation and poor waste management.

5 POPULATION DISPLACEMENT AND THE ENVIRONMENT

Figure 3. Environmental footprint of Gihembe refugee camp





View of the Kiziba refugee camp near Karongi in western Rwanda (top)

Income-generating activities of women's groups play an important role in sustaining refugee families (bottom left)

Planting vegetables in plastic bags to supplement household nutrition (bottom right)

Case study 5.2

Difficult living conditions in Kiziba refugee camp

Kiziba refugee camp is located about 15 km southwest of Karongi District, Western Province. It is one of four refugee camps in Rwanda, hosting mainly people fleeing the war that has been raging in North Kivu in the DR Congo since March 1996.

Presently, Kiziba accommodates about 18,300 refugees. Livelihood opportunities are very limited for camp refugees, who previously practised either farming or pastoralism. Raising livestock is prohibited due to scarce fodder sources. Formal employment is restricted to about 600 people, employed by NGOs to provide health and education services for camp residents. About 30 small women's cooperatives also offer limited entrepreneurial opportunities.

Housing and access to basic services are also inadequate. Each family lives in a standardised mud house of 20 m³. Water is pumped from a spring (about three km away), with eight water points serving approximately 350 families. Because of limited firewood supplies, UNHCR initially provided refugees with firewood for cooking. Due to funding constraints, UNHCR substantially reduced its firewood provisions and now only satisfies about 25 percent of household fuelwood needs.⁶ Refugees, therefore, opt to collect wood as far as eight km outside the camp, raising potential tensions with the local population.

To reduce the camp's demand for fuelwood, UNHCR promoted several measures, but so far with limited success. Families were encouraged to share communal kitchens, but camp residents preferred to cook separately in their own kitchens. In 2006, energy-saving cooking stoves were introduced in Kiziba and other camps, which reduced fuelwood consumption considerably. Tree nurseries and tree planting were also promoted in and around the camp, but have since been curtailed due to lack of funding. UNHCR is currently attempting to secure additional funding for livelihood-oriented projects aimed at sustainable resource use, including training on soil conservation and micro-gardening activities (i.e. planting vegetables in plastic bags).



Through its One Cow per Household Programme, the government promotes zero-grazing, which tackles the land scarcity problem and supplies manure to support crop production (left)

In Rutete resettlement, standard housing units include a separate kitchen, pit latrine and washroom (right)

Case study 5.3

Challenges of resettling old caseload returnees on degraded land in Bugesera

In 2006, the Government of Tanzania expelled thousands of Rwandans who had lived there since 1959. After one week in a transit camp, 300 families were sent to Rutete in Bugesera's savanna landscape, close to the Burundi border. The resettlement site in Rutete, selected by the then Ministry of Lands, Human Resettlement and Environmental Protection (now the Ministry of Lands, Environment, Forestry, Water and Mines) (MINITERE), was largely degraded land.

Each of the 300 families received one hectare of land, on which they cultivated sorghum, maize, beans and cassava for subsistence. Although in Tanzania they lived by agriculture and raising cattle, their farming skills were not transferable or entirely adaptable to the new area. As a result, they had a precarious livelihood and until March 2008 received food aid from the World Food Programme (WFP).

The Bugesera region was once famous as Rwanda's breadbasket prior to the conflict. Since 1998, however, the district has been experiencing prolonged and repeated droughts, resulting in food insecurity and significant population movements. One potential solution for both new and old inhabitants in the area is to adapt land use practices to changing climatic conditions, for instance, by using drought-resistant crop varieties. The promotion of conservation agriculture, combined with erosion control and agro-sylvopastoral activities, could increase land productivity and improve food security, as well as reduce environmental degradation.

As livestock remains an essential part of local livelihoods, the government is implementing the One Cow per Household Programme, which distributes cows to vulnerable families and women-headed households to support local livelihoods and reduce overall grazing pressures. Combined with the planting of fodder crops and grasses along contour lines, this programme could augment household incomes as well as promote soil conservation.

Planned *imidugudu* and their environmental impacts

In the initial emergency phase, environmental considerations were not adequately addressed in resettlement planning and site selection. Most resettlement sites were on available state land, which was mostly covered by forests. In some cases, allocated

land was already degraded (Case study 5.3). In other cases, *imidugudu* were built on flat fertile land to facilitate construction, while less fertile land on steeper slopes was set aside for cultivation. Poor site selection – combined with high population densities, acute land scarcity, poverty and unsustainable agricultural practices – has created significant pressures on scarce resources and fragile ecosystems.

Environmental problems in *imidugudu* include: (i) land degradation and soil erosion; (ii) fuelwood supply shortages; (iii) water shortages and contamination; and (iv) poor sanitation.

Land degradation and soil erosion

Deforestation and vegetation clearance to construct *imidugudu* have resulted in significant localised land degradation and soil erosion. In severely deforested areas, such as Gishwati, heavy rains compounded with the area's steep topography have washed great amounts of productive topsoil and caused serious flooding. The disastrous floods in 2007 can be linked directly to the deforestation of Gishwati (Case study 5.1; also discussed in Chapters 6 and 7).

In the savanna region where additional land was cleared for pasture, severe erosion and land

degradation have occurred due to overgrazing and trampling by animals, particularly in Nyagatare and other parts of the former Mutara Game Reserve. In some *imidugudu*, designated grazing areas, palatable plants and grasses appeared to have disappeared. Moreover, this region has been experiencing recurrent droughts, which will likely worsen soil conditions.

A limiting factor for many rural *imidugudu* is the insufficient availability of agricultural land. In many cases, the population in the settlements does not have sustainable sources of income, which has important implications on their ability and willingness to invest in soil conservation measures. Given the limitations of the agricultural sector to absorb the growing population, greater emphasis should be placed on the provision of environment-friendly alternative income opportunities.



Some resettlement sites were built on degraded land with a limited carrying capacity, particularly for free grazing cattle such as above in Rutete



Improved cooking stoves could help reduce firewood consumption by up to one-third, but widespread adoption has so far been limited

Fuelwood supply shortages

In settlements, wood and other biomass constitute the main source of cooking energy. However, due to deforestation and uncontrolled cutting, fuelwood supplies are very limited in settlements. Access to electricity in rural *imidugudu* is very rare, while other alternative energy sources, such as kerosene, are too costly for the majority of residents. Therefore, local residents remain highly dependent on biomass energy.

In some *imidugudu*, inhabitants have insufficient land to plant trees and shrubs to produce their own firewood. They either have to buy wood or walk long distances in search of fuelwood. As in refugee camps, women and girls spend considerable time and energy in firewood collection and are at risk of gender-based violence.

In settlements located in the drier regions of the Eastern and Southern Provinces, the fuelwood crisis is more acute than in other parts of the country. For example, in Bugesera, deforestation has had a much greater impact, since the ecosystem in this area is more fragile, with less rainfall and slower tree growth.

Water shortages and contamination

To provide humans as well as animals in the settlements with sufficient amounts of water, small valley dams and bore holes have been constructed, but are usually insufficient to meet water needs. In the eastern savanna region and in the south (e.g. Nyagatare and Bugesera) where many old caseload returnees have settled, recurrent droughts combined with the increased demand for water have led to water supply shortages. Women and children usually have to walk longer distances to fetch water. In some villages, water can be purchased, though often at high prices. Relatively well-off people tend to cope by using bicycles.

The water supply problem is linked to the problem of land degradation, which has impaired the water absorptive capacity of soils and its ability to replenish groundwater supplies. As groundwater statistics in Rwanda are scanty at best, it is difficult to reliably assess the impacts on groundwater resources. However, there is reportedly an increase in the incidence of dry wells, and the potential impacts of climate change may further exacerbate water shortages in the future. To protect water supplies, soil conservation as well as water conservation measures, such as rainwater harvesting, are needed in *imidugudu*.



Rainwater harvesting helps alleviate water shortages in drought prone areas such as in Rwimikoni village, Bugesera District



Queuing for water in Bukora imidugudu

With respect to water quality in settlements, a government study found that the main problem is bacterial contamination from human and animal waste. The study is based on the analysis of 948 groundwater samples from springs and bore holes in the eastern part of the country.⁹ However, this study provides only a snapshot of water quality in settlements. Systematic water quality monitoring is needed to provide an accurate assessment. Over the next few years, as the planned development of agriculture and industry takes off, there is greater potential for water contamination in both rural and urban *imidugudu*.

Poor sanitation

Sanitation and waste disposal facilities remain inadequate in both rural and urban *imidugudu* throughout the country. In rural areas, organic waste is composted and mixed in fields; other types of waste are reused or buried. In urban areas, the local administration usually manages solid waste collection and disposes waste in open dumpsites (discussed in Chapter 12).

As cited in Chapter 9, the majority of the population (80%) relies on pit latrines, which tend

to be shallow and inappropriately constructed, increasing the risk of ground and surface water contamination. Water contamination due to poor sanitation is likely to be a growing problem in urban *imidugudu* and informal settlements because of increased population densities and lack of planning at the outset.

Improvements in environmental planning of new resettlements

Although the *imidugudu* process has slowed down considerably since the immediate post-conflict emergency period, it remains a key government strategy under Vision 2020. While there have been problems related to inappropriate site selection and planning, the *imidugudu* concept has helped improve living conditions in some areas by facilitating the provision of services and infrastructure and becoming growth poles for local development. Moreover, MINALOC has developed environmental standards for new resettlement design, though technical assistance and capacity-building are needed to ensure their effective implementation, particularly at the district level.

5 POPULATION DISPLACEMENT AND THE ENVIRONMENT



Recommended disposal of household waste into two separate pits – one for organic and the other for non-degradable rubbish (left). Open dumping of waste in Batsinda imidugudu on the outskirts of Kigali (right)

The government has also taken measures to improve conditions in existing *imidugudu*. In grouped villages, housing construction must now only use sun-dried adobe bricks, which are not fired in traditional kilns, thereby reducing fuelwood consumption. New settlements are now usually provided with small plots for households to grow their own trees and shrubs for firewood. One big challenge in the immediate future will be to develop affordable alternatives to fuelwood (discussed in Chapter 11).

In urban areas, the government is attempting to upgrade informal and slum settlements. Proposed housing projects aim to provide low-cost, affordable housing to the urban poor and address livelihood needs, such as the pilot project currently being implemented in Batsinda *imidugudu* on the outskirts of Kigali. Another proposed initiative is the use of constructed wetlands in urban areas for treating sewage.

Finally, in order to stop deforestation, the government has restricted the cutting of trees for fuelwood and charcoal production with noticeable success. In settlements where pastureland is provided, the government has implemented an agricultural livestock policy, which aims to reduce the number of cattle by using more productive, improved breeds.



A new housing resettlement project in Kageyo for returnees from Tanzania



Solar battery charging at Arusha imidugudu in Gishwati

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Generating off-farm rural employment

To reduce human pressures on the environment and given the land shortage problem, it is crucial that alternative, environmentally friendly, off-farm sources of income generation are developed as an integral part of the programme to promote resettlement in *imidugudu*. For instance, some villages can be developed to serve as rural development ‘hubs’ or entrepreneurial centres, which would provide key services, such as vocational training, health services and skilled labour. Other villages can establish cooperatives or micro-credit enterprises, while those near protected areas may benefit from eco-tourism or community management of public tree plantations (discussed in Chapters 8 and 10).

While such initiatives have the potential for generating off-farm rural employment, they may still be insufficient to employ the majority of young rural people. In the context of rapid population growth and land shortages, the government must tackle the continuing challenge to find solutions for environmentally sustainable and economically productive settlements.

Emerging causes of population displacement: Disasters and environmental degradation

Rwanda has made remarkable progress in establishing peace and security in the country, thereby greatly diminishing the potential for conflict-induced population displacement. Nevertheless, there are emerging causes of internal population displacement. Loss of livelihoods – due to environmental degradation and natural hazard-induced disasters accentuated by climate change – has forced people to migrate to other regions in search of employment and more productive land. In this context, displacement is linked to the decline in environmental services, particularly clean water and fertile soil that threatens agricultural potential. As a result, environmental migration continues to exist.

For instance, drought, especially in the east and south of Rwanda, has occurred more frequently and for longer periods since the 1980s, leading to significant population movements. Prolonged droughts are attributed in part to increasing climatic

variations and more extreme weather events (i.e. higher mean temperatures and reduced rainfall), leading to significant population movements. Moreover, landslides and flooding, due partly to extensive deforestation and exceptionally heavy precipitation in the north and west, have also led to localised displacement, as experienced in and around Gishwati in 2007.

Complex linkages between disasters, environmental degradation and climate change set in motion a downward cycle of resource over-exploitation and unsustainable environmental practices that ultimately forces people to migrate to other regions (e.g. Nyagatare, Bugesera). Increased human pressures in newly-settled areas could, in turn, result in further environmental degradation and perpetuate the cycle of displacement. Displacement could also be a driver of increased urban migration, contributing to urban sprawl and slum growth. Unfortunately, there are no studies linking internal migrations to environmental factors, which make it difficult to accurately assess the trends and patterns in environmentally induced population movements.



Residents in Nyabihu District produced sun-dried adobe bricks to reconstruct their homes destroyed by flood



© NYABIHU DISTRICT AUTHORITY

Increased and more severe flooding and landslides aggravated by climate change may lead to increased population movements

Case study 5.4 Displacement induced by flash floods

In September 2007, heavy rains caused disastrous floods and landslides that destroyed houses and agricultural fields of approximately 1,000 families in Nyabihu and Rubavu Districts in the Western Province. A total of 342 houses were completely damaged, while 678 houses were partially damaged with walls cracked, roofs blown away and windows shattered.

Floods and landslides affected formerly productive areas, where potatoes and vegetables were cultivated for local consumption. In the disaster's aftermath, the affected families were settled in two temporary camps in Bigogwe and Kanzenze. Meanwhile, the government sought to identify sites for resettlement.

Out of a total of 664 families, 203 of the most affected in the sector of Bigogwe eventually received new plots of land, located only a few hundred metres from their former village. This short distance should enable them to continue cultivating their agricultural plots on the foothills of the former Gishwati Forest Reserve.

It was evident that the community's coping capacity is limited. About 40 families were constructing their houses with adobe bricks using volcanic soil transported to the new site from the Virunga region. Residents also produced bricks in the destroyed settlement, where clay is dug from open pits by hand. In the rainy season, these pits are likely to fill with stagnant water and may pose a health hazard by providing habitat for vector diseases such as malaria. It was also noted that people consumed charcoal imported from the nearby DR Congo, which is only 20 km away. The difficult circumstances of the people illustrate their need for more sustainable livelihood strategies.

5.7 Conclusions

Large-scale population displacement and re-settlement have a salient environmental legacy in Rwanda that continues to unfold to this day. The most lasting environmental impacts are associated with the resettlement of old caseload returnees, causing extensive deforestation and extensive clearance of savanna landscapes. In response to the environmental problems of *imidugudu*, the government developed rigorous environmental standards for planning new resettlements. These efforts should be reinforced through technical assistance and capacity-building to ensure their effective implementation, particularly at the district level. The main challenge in both rural and urban *imidugudu* is to develop effective strategies for sustaining livelihoods and minimising environmental degradation. In this regard, developing alternative off-farm rural employment opportunities should become an integral component of resettlement plans.

Complex linkages between natural hazards, environmental degradation and climate change risks are likely to generate a growing number of environmental migrants. To reduce the potential for future displacements linked to environmental causes, efforts should focus on gaining a better understanding of the issue. Reducing disaster vulnerabilities through improved environmental management and climate change adaptation should also be a priority, building on current policy initiatives.

5.8 Recommendations

R5.1 Promote biogas plants and other renewable energy options in *imidugudu*. Establishing biogas plants would reduce people's dependency on fuelwood and other biomass as well as improve the sanitation problem in the villages by utilising human and animal waste. Biogas plants should be established in different environmental regions of the country to assess their effectiveness and social acceptability. Other renewable energy options for *imidugudu* should be assessed in terms of their feasibility and affordability.

Lead agencies: MININFRA; MINIRENA; REMA; MINALOC, district authorities. International Partner: UNDP. Cost estimate: USD 5.0 million. Duration: 3 years.

R5.2 Implement 'cash-for-environment' projects. This initiative would provide project beneficiaries a cash payment in exchange for undertaking environmental conservation activities, which could be implemented on a community or individual household basis. Environmental projects might include: establishing tree nurseries, tree planting, soil conservation initiatives, planting of fodder crops along contour lines and improved sanitation measures. The projects would support local livelihoods by providing alternative income opportunities, while promoting improved environmental management. The very poor and most vulnerable sectors, including women-headed households, should receive priority.

Lead agencies: MINAGRI, district authorities, RADA, NAFA. International Partners: FAO, WFP. Cost estimate: USD 3 million. Duration: 3 years.

R5.3 Provide alternative, environment-friendly income-generation opportunities for *imidugudu* residents. Alternative non-agricultural income opportunities, such as micro-credit provision, that target the most vulnerable groups should be promoted. Other initiatives could encourage employment generation in the food processing sector (e.g. small cheese dairies) as well as the formation of cooperatives to facilitate food processing and marketing. Establishment of vocational training centres in new settlement areas should also be considered.

Lead agencies: MINALOC, MINICOM, RADA/RARDA, district authorities. International Partner: UNDP. Cost estimate: USD 5 million. Duration: 3 years.

R5.4 Develop pilot projects for rainwater harvesting in *imidugudu*. This aims to mitigate water supply problems experienced in many *imidugudu* sites, especially in the Eastern Province and the Volcanoes region, by promoting rainwater harvesting. The project would install rainwater collection systems as well as provide training on water management in selected pilot villages. The most vulnerable families would be prioritised. Rainwater harvesting also has the potential to address erosion and other problems resulting from rainfall run-off.

5 POPULATION DISPLACEMENT AND THE ENVIRONMENT

Lead agencies: MININFRA, MINALOC, MINIRENA, REMA, district authorities. International Partner: UNEP. Cost estimate: USD 2 million. Duration: 2 years.

R5.5 Develop an environmental management master plan for *imidugudu*. The master plan would be a multi-agency effort to ensure appropriate site design and that environmentally sustainable agriculture and livestock production are integrated in *imidugudu* planning.

Lead agencies: MININFRA, MINALOC, NLC, REMA, RADA, RARDA. International Partner: UN-HABITAT. Cost estimate: USD 0.5 million. Duration: 1 year.

R5.6 Strengthen environmental planning capacities of designated authorities for resettlement schemes. Environmental planning and implementation capacities at ministerial and district levels need to be strengthened in order to effectively incorporate environmental standards in resettlement design. This would entail training, awareness raising and direct technical support.

Lead agencies: MININFRA, MINALOC, REMA, NLC, district authorities. International Partner: UN-HABITAT. Cost estimate: USD 2 million. Duration: 2 years.

R5.7 Promote biogas technology and other renewable energy options in refugee camps.

Installation of biogas plants utilising human and animal waste would reduce dependency on firewood as well as improve sanitation conditions in refugee camps. At the same time, this proposal requires careful study to address refugee reservations on using biogas-operated communal kitchens in camps. Other alternative energy options include setting up solar plants to provide electricity to communal infrastructures, such as health centres and schools.

Lead agencies: MINALOC, district authorities. International Partner: UNHCR. Cost estimate: USD 0.5 million. Duration: 1 year.

R5.8 Pilot the use of constructed wetlands for wastewater treatment in urban *imidugudu*.

The use of constructed wetlands could be a cost-effective solution for wastewater treatment, particularly in urban areas. Constructed wetlands rely on natural processes in the treatment of wastewater and sewage and typically require low investments and running costs. Pilot projects would help determine the feasibility of this innovative approach and establish design requirements within the local Rwandan context. Constructed wetlands could also provide valuable wildlife habitats.

Lead agencies: MINALOC, KCC, REMA. International Partners: UN-HABITAT, UNEP. Cost estimate: USD 3 million. Duration: 2 years.

Disasters and Climate Change

*Climate change projections indicate
that most parts of the country
will experience increased but
irregular rainfall, raising the risk
of flooding events*

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Disasters and Climate Change

6.1 Introduction

Rwanda is highly vulnerable to a range of natural hazards. Over the last decade, the frequency and intensity of natural hazard-induced disasters, particularly floods and droughts, have significantly increased, raising the toll of human casualties as well as economic and environmental losses. Potential consequences of climate change are likely to further exacerbate Rwanda's vulnerability to disasters and the magnitude of their impacts. Projections suggest that most parts of the country will experience increased but irregular and unpredictable rainfall patterns, raising the risk of flooding events. At the same time, savanna landscapes are likely to endure prolonged droughts. Priority development areas that are most at risk include food security, water and energy supply, and critical infrastructure.

Rwanda's vulnerability to disasters and climate change is rooted in the reliance of the majority of its population on rain-fed subsistence agriculture practised on steep topography. Given this intimate livelihood dependence on weather conditions, it is

critical that robust climate change studies are carried out to help guide interventions aimed at reducing vulnerability to potentially adverse impacts. This calls for a cross-sectoral, coordinated approach to disaster risk reduction and climate change adaptation that is fully integrated in national development plans and poverty reduction strategies.

6.2 Assessment activities

Fieldwork covered the areas most vulnerable to disasters as well as those potentially impacted by climate change, including hydropower and water supply sources.

Consultations were carried out with the following government stakeholders: Rwanda Environment Management Authority (REMA), Ministry of Agriculture and Animal Resources (MINAGRI), Ministry of Natural Resources (MINIRENA), Rwanda Meteorological Service/Ministry of Infrastructure (RMS/MININFRA), the Disaster Management Unit/Ministry of Internal Security (DMU/MININTER) and Electrogaz, the public utility responsible for water, gas and electricity distribution. Consultations also took place with HELPAGE Rwanda (HAR), a local non-governmental organisation (NGO).



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Flooding and landslides pose a major disaster risk in the northern and western regions of the country

Table 10. Field sites visited by province

Province	Field sites
Northern	<ul style="list-style-type: none"> - In Musanze and Bulera Districts: Mutobo water treatment plant Ntaruka and Mukungwa hydropower dams Gifurwe mining sites Ruhengeri lava region - In Gicumbi District: Byumba highlands
Western	<ul style="list-style-type: none"> - In Nyabihu and Rubavu Districts: Arusha resettlement sites Mizingo and Gihira water treatment plants Gihira hydropower dam Bigogwe flood-affected areas Gisenyi lava region - In Ngororero District: Gatumba mining sites
Eastern	<ul style="list-style-type: none"> - Akagera National Park and the Akagera flood plain - Bugesera, Nyagatare, and Mayaga (drought-affected areas) - Water supply sources and lakes in Ihema, Hago, Mugesera and Rumira (affected by eutrophication)

Table 11. Summary of disasters in Rwanda from 1974 to 2008²

Disaster	Category	Number of events	People killed		People affected	
			Total	Average per event	Total	Average per event
Drought	Drought	6	237	40	4,156,545	692,758
Earthquake	Earthquake	2	81	41	2,286	1,143
Flood	Unspecified	6	111	19	34,516	5,753
	Flood	2	48	24	1,921,678	960,839
Landslides		1	24	24	2,000	2,000
Total		17	501	29	6,117,025	359,825

6.3 Overview of disasters and climate change in Rwanda

Overview of natural hazards

Natural hazards in Rwanda are in two main categories: (i) hydro meteorological, namely floods, including those combined with landslides and droughts; and (ii) geological, that is earthquakes and volcanic eruptions. Of these, floods and droughts have caused the most serious disasters in terms of the number of people affected (Table 11).¹ Disasters have had significant environmental and socio-economic impacts, posing a serious threat to livelihoods, food security and economic growth.

Table 12. Top ten disasters from 1974 to 2003, by number of people affected³

Type of disaster	Date	Total number of people affected
Flood	June 1974	1,900,000
Drought	1976	1,700,000
Drought	March 1903	1,000,000
Drought	November 1999	894,545
Drought	October 1984	420,000
Drought	December 1996	82,000
Drought	December 1989	60,000
Flood	May 1988	21,678
Flood	April 2002	20,000
Flood	October 2003	7,016

Map 10. Natural hazards in Rwanda



- ▲ Volcanoe (active, dormant)
- Flood and landslide risk zone
- Drought risk zone
- Distance to the Epicenter of the 3/02/2008 Earthquake
- ✳ Gas exploitation

Kilometres

0 10 20 30 40 50

Datum: Arc 1960
Rwanda Local Projection 92,
Transverse Mercator

Sources:
Smithsonian Institution, Global Volcanism Program.
Drought and Landslides: Mutabazi Alphonse, May 2008.
Earthquake data: UNOSAT.

The boundaries and names shown and the designations used on this map do not imply official endorsement by the United Nations.

Hydro-meteorological induced disasters: Floods, landslides and riverbank erosion, and droughts

Floods are common in Rwanda but have increased in frequency over the past decade. Floods usually originate from heavy rainfall, which causes rapid and unpredictable surges in the flow of rivers downstream. The two predominant types of floods are: (i) localised floods caused by exceptionally heavy rains and run-off; and (ii) widespread floods caused by overflow of the Nyabarongo, Akanyaru and Sebeya Rivers and their tributaries. Recorded flood events of the Nyabarongo and Akanyaru and its tributaries – 1963, 1979, 1998, 2001, 2002, 2006 and 2007 – suggest that their frequency has significantly increased over the last ten years.

Heavy rains and run-off can generate flash floods. The northwestern part of the Congo-Nile highlands, especially deforested areas such as Gishwati, are particularly vulnerable to catastrophic floods.⁴ While flash floods generally have a short duration, they can cause major damage to downstream human settlements and agricultural lands, as witnessed by UNEP in the Bigogwe sector of Nyabihu District.

Steep topography in the country's northwestern region has meant that flash floods there are frequently

associated with landslides. These two hazards often combine to constitute a single event, posing a serious disaster risk downstream. In other instances, landslides may conversely give rise to flood events by temporarily blocking the flow of a small river. Mounting water pressure upstream could subsequently cause this natural 'dam' to collapse, releasing huge volumes of water and presenting an immediate threat to people and settlements in the valleys.



Flash floods triggered this landslide, which damaged agricultural land near Cyambara, Western Province



Torrential rains in 2007 caused extensive flooding, destroying crops in Gishwati

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The frequency of flash floods often accompanied with landslides has significantly increased in the past ten years since 1998⁶

Riverbank erosion is a natural phenomenon in Rwanda, which in extreme cases may become a local disaster due to its socio-economic and environmental impacts. This problem occurs in many rivers where peak wet season flows intensify soil erosion processes. While adjustments in river morphology are a natural phenomenon, human action in altering stream discharge and sediment loads has played a significant role in accelerating this process. Principal causes include watershed degradation due to deforestation, overgrazing, overcultivation and poor farming practices without adequate soil conservation measures, and inappropriate mining practices. The deliberate removal of natural riparian vegetation to expand agricultural land further aggravates the problem, as it weakens the ability of riverbanks to withstand the erosive power of flood peaks. To deal with this problem, government authorities have imposed a blanket ban on cultivation within 10 m of riversides and 50 m of lakeshores, and are initiating projects to rehabilitate riparian vegetation. Such measures, however, require time to take effect and need to be accelerated.

While flooding and landslides pose a major disaster risk in the northern and western parts of the country, droughts are a serious threat in the east

and southeast. Droughts in Rwanda are mainly triggered by a prolonged dry season or a delay in the onset of the rainy season. Recurrent drought incidence over the past decade, between 1998 and 2000 and annually from 2002 to 2005, has caused a serious deterioration in food security. Recurrent droughts have caused crop failures and severe food deficits, threatening the most vulnerable with malnutrition and famine. These events prompted government and humanitarian agencies to provide food aid in heavily affected areas such as Bugesera in the southeast, and Nyagatare, Kirehe and Ngoma in the east.

Drought adversely impacts on other key sectors. Livestock production has suffered due to water shortages and the decline in both the quality and quantity of pasture. Moreover, when water levels in northern lakes ebbed due partly to prolonged drought, the reduced hydropower supply caused the first major electricity crisis in the country in 2004, which had serious implications on the national economy (discussed further in Chapters 9 and 11). Rwanda's forests have become particularly susceptible to fire hazards due to drought, as witnessed by the major fire outbreaks in Nyungwe National Park in 2005 (see Chapter 10).

Recurrent droughts are likely to have an important impact on the environment both in terms of vegetation cover profile and soil conditions. Combined with the potential impacts of climate change predicting reduced rainfall in the east and southeast, there is growing concern that desertification is gaining a foothold over the savanna landscapes. Repeated droughts, especially in Bugesera, has been a driving cause of internal population displacement, as families abandon drought-prone lands in search of alternative livelihoods elsewhere.

Geological induced disasters: Earthquakes and volcanic activity

Western Rwanda lies on the eastern rim of the Albertine Rift Valley, part of the Great Rift Valley, a seismically active fault system that makes the area prone to earthquake and volcanic activity. The most recent disaster was a series of earthquakes that hit the border area between the Democratic Republic of the Congo (DR Congo) and Rwanda in February 2008. The earthquakes measuring between 5 and 6.1 on the Richter scale killed 37

people in Nyamasheke and Rusizi Districts in the Western Province as well as damaged infrastructure and displaced local communities.⁶

Volcanic eruptions represent a potentially significant hazard in the northwestern Virunga region straddling the borders of Rwanda, DR Congo and Uganda. This region is part of a volcanic chain, including the highly active Nyiragongo and Nyamulagira Volcanoes in the DR Congo, which experience frequent eruptions. The last serious eruption occurred in 2002 and devastated the city of Goma and caused an estimated 400,000 people to flee across the border from the DR Congo into Rwanda near Rubavu District. According to volcanologists, both Rubavu, Nyabihu and Goma face long-term risks of volcanic eruptions that could also potentially produce massive emissions of methane or carbon dioxide gas from Lake Kivu. Emissions would have potentially devastating consequences for the population at lower altitudes.⁷ This is a situation for which both countries are ill-prepared to undertake a safe evacuation of the local population.

Table 13. Estimated total population affected by the Nyiragongo volcanic eruption in 2002⁸

Affected ⁹	Deaths ¹⁰	Displaced populations ¹¹	Displaced populations moving towards Sake (DR Congo) ¹²	Displaced populations moving into Rubavu and Nyabihu (Rwanda) ¹³
350,000	147	up to 74,000	1/3 or approximately 25,000	2/3 or approximately 50,000



Over 400,000 people were evacuated from the DR Congo to Rwanda following the eruption of the Nyiragongo Volcano in 2002

Key trends of climate change

A description of Rwanda's climate is provided in Chapter 2 and highlights the role of rainfall rather than temperature in defining the country's seasons. Mountain ecosystems, such as Rwanda's, are recognised by the United Nations Framework Convention on Climate Change (UNFCCC) and the Intergovernmental Panel on Climate Change (IPCC) to be highly vulnerable to climate change.¹⁴

Some climatological observations indicate that climate change is very likely happening in Rwanda, which would have major implications on agricultural production. Nevertheless, reliable evidence on climate change remains limited. Indeed, the data gap due to the destruction of most of the meteorological stations during the conflict period (only one station at Kigali International Airport remained in service in 1994) renders modelling difficult. Ongoing efforts to study and monitor climate change at the national scale are warranted (discussed under "Key issues").

Increase in average annual temperatures

During the past 36 years, the average annual temperature in Kigali has increased gradually by 0.9 °C, from 19.8 °C in 1971 to 20.7 °C in 2007.¹⁵ A similar trend can be observed for Kamembe and Rubavu, based on data from the very few functioning meteorological stations in the country. Furthermore, variations of standardised absolute maximum

temperatures in Kigali point to an alarming temperature increase of 2.7 °C, from 32.7 °C to 35.4 °C between 1983 and 2005, respectively.¹⁶

Irregular and unpredictable rainfall

Available data indicate that Rwanda is experiencing irregular and unpredictable rainfall patterns, with less weather predictability for farmers as a result. At the same time, the lack of crop yield projections due to climate change risks makes it difficult to provide sound advice for agricultural planning. One predicted effect of climate change is an increase in more extreme rainfall events that will likely cause an increase in floods and associated landslides. Of the recorded seven major floods since 1963, five occurred in the past decade (1998-2008).

Erratic rainfall patterns are demonstrated by data analysis from Kigali, one of the few locations for which continuous records are available. From 2000 to 2006, the total average annual rainfall dropped by 10 percent compared with the mean of 1,029.3 mm from 1961 to 1990.¹⁸ From 2000 to 2006, during the rainiest month of April, rainfall averages were below normal except for 2004 and 2006, which registered higher rainfall levels (114% and 124%, respectively). It is noteworthy that these excessive rainfall events are not well distributed throughout the month; rain typically falls in less than three days, or in a single day in some cases, and often results in floods and landslide events.

Figure 4. Change in annual mean temperature from 1971 to 2007, recorded at the meteorological station at Kigali airport¹⁷





Rwanda's steep slopes are prone to landslides, which are predicted to increase due to flooding associated with climate change

Table 14. Monthly rainfall (mm) at Kigali Airport from 2001 to 2006, further expressed as a percentage of the 1961-1990 rainfall average¹⁹

	Mean 1961-1990	2000		2001		2002		2003		2004		2005		2006	
	mm	mm	%	mm	%	mm	%	mm	%	mm	%	mm	%	mm	%
January	72.8	22.1	30	80.3	110	155.0	213	60.3	83	67	92	64.6	89	22.7	31
February	108.9	58.2	53	64.8	60	65.7	60	29.8	27	71.8	66	41.8	38	90.6	83
March	113.6	100.7	89	257.0	226	98.9	87	74.6	66	114.3	101	134.3	118	112.2	99
April	176.4	48.1	27	84.3	48	156	88	124.0	70	201.4	114	91.6	52	218	124
May	101.6	51.3	50	61.4	60	145.6	143	49.9	49	23.1	23	88.0	87	117.8	116
June	21.2	0	0	0.2	1	0	0	0	0	4.0	19	10.3	49	5.3	25
July	8.4	0	0	120.8	1441	0	0	0	0	0	0	0	0	14.5	173
August	29.2	5.4	18	21.8	75	0.2	1	65.1	223	15.1	52	41.6	142	25.1	86
September	78.2	32.6	42	86.1	110	34.6	44	147.5	189	74.6	95	112.4	144	35.4	45
October	99.9	129.2	129	225.9	226	99.7	100	106.7	107	70.7	71	128.2	128	57.4	57
November	127.0	144.2	114	185.0	146	116.5	92	101.1	80	75.8	60	55.3	44	210.2	165
December	92.1	76.3	83	98.9	107	131.7	143	48.5	53	82.8	90	68.8	75	141.4	153
Annual total	1029.3	668.1	65	1286.5	125	1003.9	98	807.5	78	800.6	78	836.9	81	1050.6	102

Other expected outcomes of climate change are prolonged periods without rain and an extension of the dry season. The longest and most severe rainfall shortages on record since 1961 occurred in the period between 1991 and 2000. This decennial drought was followed by two years of unusually excessive rains. The flooding, which occurred soon after the drought, had significant socio-economic impacts, including human and livestock casualties as well as damage or destruction of crops, houses and infrastructure.²⁰

Analysis of rainfall data recorded by the RMS between 1971 and 2007 further show a tendency towards progressively shorter rainy seasons, as shown in Figure 5. Average dates for the beginning and end of the rainy season in 1971 were 20 March and 1 June, respectively, as compared with 13 March and 18 May in 2007. This reflects a shortening of about one week of the rainy season. Nonetheless, rainfall data from the RMS provide serious ground for concern and requires further investigation. This is particularly significant, as changes in the onset of the growing season could have enormous repercussions on crop failure and food shortages.

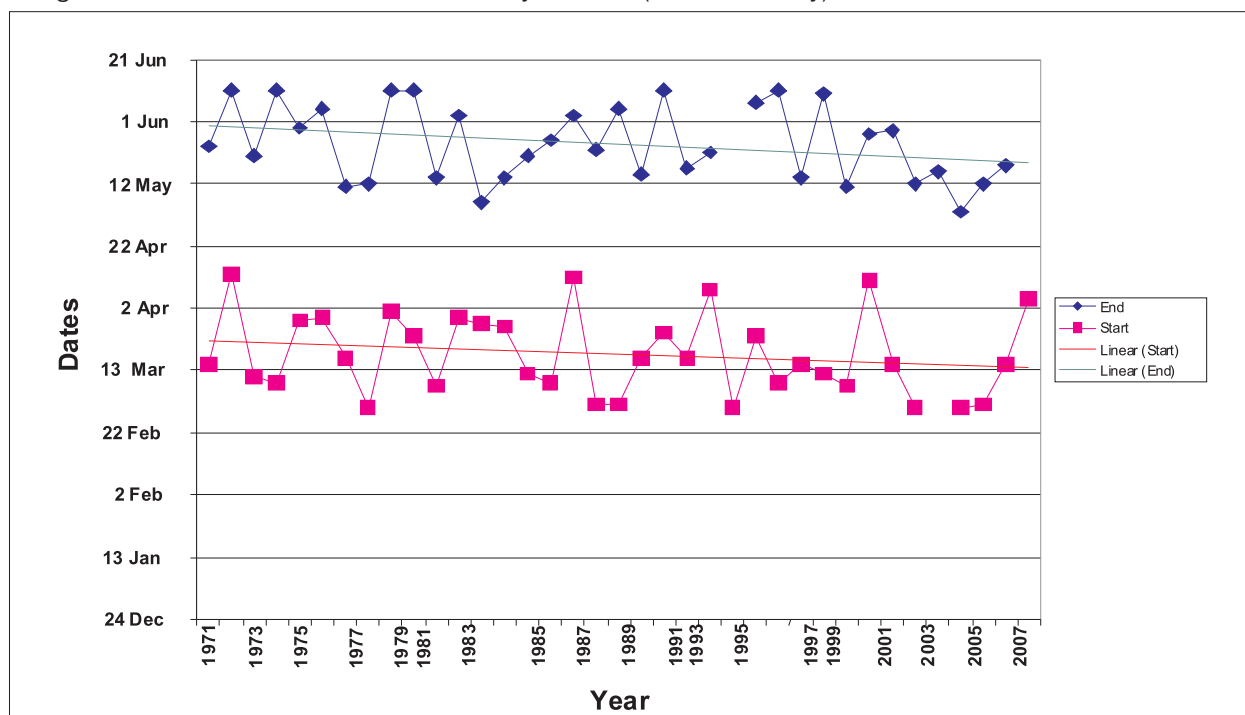
Rainfall shortages as a potential result of climate change will particularly affect the savanna landscapes in the east and southeast, which are already more

prone to drought. Nevertheless, given total annual rainfall in these regions of over 500 mm, it should be feasible to adapt to such drought events, especially as they are relatively less severe compared to similar prevailing situations in sub-Saharan Africa.



Although the eastern savanna landscapes are more prone to drought, it is feasible to adapt to such conditions given annual rainfall levels

Figure 5. Onset and cessation of rainy season (March to May) from 1971 to 2007²¹



6.4 Governance

The National Adaptation Programme of Action (NAPA) is the key document that provides an action-oriented strategy to reduce vulnerability to climate change in Rwanda. NAPA provides a solid technical basis for decision makers to prioritise action areas and enhance adaptive capacity to climate change.

The Cabinet has recently approved the creation of a department dedicated to climate change issues within REMA. The department, which is currently under development, will require strengthening and support. The Rwanda Meteorological Service, which falls under MININFRA, is responsible for national collection of climatological data and for providing forecasting services. However, it remains seriously hampered from fulfilling its mandate due to the destruction of its installations during the conflict period.

A Disaster Management Unit (DMU) composed of different ministries and government institutions under the coordination of the Prime Minister's Office was established in the early 2000s. In 2008, it was transferred to the Ministry of Internal Security (under the Rwanda Police), which is better equipped to handle disaster response. At the same time, as a fledgling institution, the DMU has very limited capacity in disaster prevention and preparedness and requires substantial technical support and strengthening. For example, the DMU has no archive of historical disasters that have struck Rwanda or of the lessons learnt from the response measures carried out. Nevertheless, tentative performance targets have been drawn up by the DMU to expand disaster risk reduction initiatives and integrate these in development planning.

6.5 Overview of key issues

The key challenges related to disasters and climate change in Rwanda stem from the country's high physical vulnerability, combined with its limited capacity to reduce and respond effectively to disasters and climate change impacts. Rwanda's significant vulnerability to disasters and climate change is closely linked to a number of factors, including having one of the highest population densities in the world, mountainous terrain, elevated poverty levels, the dependence of the majority of its population

on rain-fed agriculture practised on erosion-prone steep hillsides, deforestation and land degradation as a result of resettlement, and other forms of unsustainable land use pressures. In addition, the planned drive to reclaim wetlands for agriculture could undermine their role in regulating both floods and droughts and increase disaster risks.

Reducing disaster vulnerability requires a significant upgrading of institutional capacities, including development of a robust knowledge base and technical skills, improving institutional coordination and raising awareness.

Three key issues are examined, namely:

- heightened vulnerability to disasters and climate change;
- limited knowledge base on climate change; and
- strengthening institutional capacities and cross-sectoral coordination on disaster risk reduction and climate change adaptation.

Heightened vulnerability to disasters and climate change

Disaster vulnerability refers to underlying social, economic and environmental conditions that increase the susceptibility of a community to hazard impacts (e.g. flooding and drought). High vulnerability interacting with natural and human-induced hazards, combined with the limited capacity to reduce and respond to disaster risks, plays a major role in the scale of disaster losses in Rwanda.²²

To illustrate this point in Rwanda, post-conflict resettlement, high population pressures, acute land scarcity and poverty have resulted in unsustainable land use practices, such as deforestation and overcultivation of steep slopes. Unsustainable land use practices, in turn, have contributed to watershed degradation and severe erosion, thus heightening people's vulnerabilities to catastrophic flash floods, as exemplified in Gishwati. It is important to recognise that unsustainable human activities are a significant factor amplifying people's vulnerabilities to disasters. Climate change as an emerging threat can exacerbate already existing environmental degradation and thus contribute to increased disaster vulnerability.



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Flooding in Gishwati in 2007. Women-headed households are amongst the most vulnerable as they have limited resources to recover from disasters

The country's vulnerability to disasters is complicated by two other key factors. First, the majority of people is dependent on rain-fed agriculture for subsistence and have very limited livelihood options to reduce pressure on land resources (for a detailed discussion on agriculture and land degradation, see Chapter 7). Moreover, there is limited water storage capacity (i.e. dams, water-harvesting projects) in Rwanda, which limits the capacity of farmers to cope with reduced rainfall. Climate variability and extreme events will thus have a major impact on agricultural production and food security.

Second, almost half of Rwanda's electricity supply is from hydropower, which potentially may be compromised by reduced rainfall. For example, a series of wetlands and lakes in the Northern Province (Rugezi, Bulera and Ruhondo) that feed the country's two largest hydropower plants, Ntaruka and Mukungwa, are highly sensitive to climate variations. During the prolonged drought period from 2002 to 2005, reduced run-off and water availability compromised hydropower production from the two power plants by three-quarters and resulted in major power outages (for further discussion, see Chapter 9).

Vulnerable groups

The rural poor, especially women, in Rwanda are most affected by disasters and climate change because of their heavy dependence on natural resources and



Almost half of Rwanda's electricity supply is derived from hydropower, which potentially may be compromised by erratic rainfall. Shown here is the Ntaruka hydropower plant in the Northern Province

climate-sensitive livelihoods. In addition, they have limited capacity (i.e. available resources and abilities) to cope with or respond to disasters and extreme climate events. Disaster risk reduction in Rwanda, therefore, needs to focus on building local resilience to mitigate and cope with the adverse impacts of hazards and climate change.

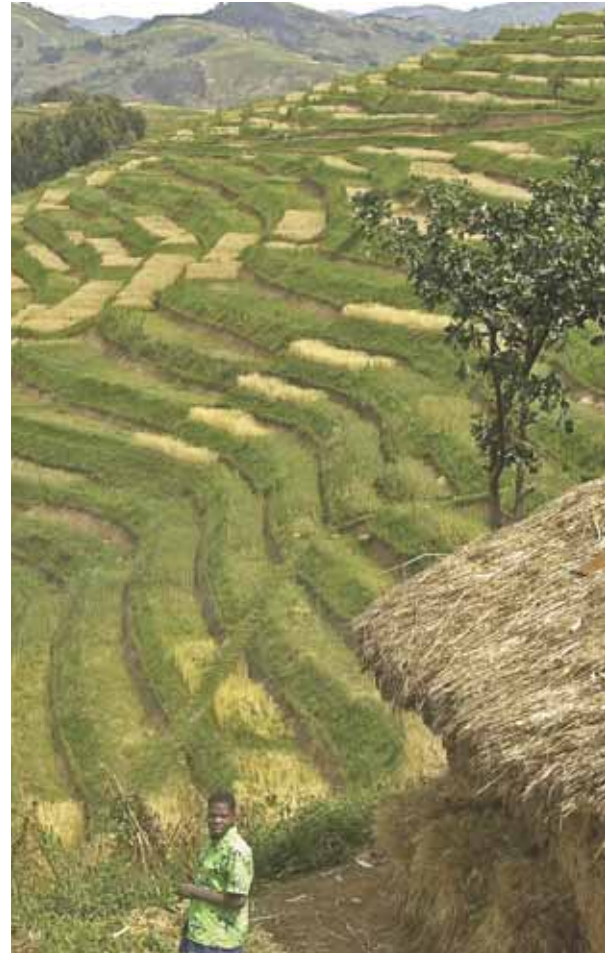
As disaster vulnerabilities are tied to socio-economic and environmental factors, disaster risk reduction needs to adopt a cross-sectoral and integrated approach. One example of an integrated approach is through better ecosystem management, which reduces disaster risks as well as promotes sustainable land use and improved livelihoods.

Applying ecosystem management and disaster risk reduction measures

To avert and reduce the scale of future disaster and climate change impacts, it is critical to expand and build on practical environmental management measures. Such measures are already being gradually implemented to reduce disaster risks, but need to be supported with substantial follow-up actions. Positive ecosystem management interventions include: (i) better integrated watershed management to mitigate flood risk; (ii) lake and riverbank protection and rehabilitation; and (iii) sustainable management of wetlands and lakes in order to enhance drought coping capacity.

It is clear that many of the actions taken in other sectors (i.e. forestry, agriculture, water, energy) will ultimately contribute to disaster risk reduction and climate change adaptation, as they enhance peoples' options to respond to environmental change. These interventions also illustrate the importance of cross-sectoral coordination to ensure the cost effectiveness of the investments made.

In addition, there is a need to develop better guidelines for the construction of critical infrastructure, particularly buildings and roads, to strengthen their resistance to disasters and climate change impacts (e.g. increased flooding).



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Terracing hillsides helps reduce vulnerability to flash floods



Practical measures, such as creation of buffer zones and afforestation around lakes, help mitigate disaster and climate change impacts. Shown here is Lake Karago, Western Province

Limited knowledge base on climate change

Regional climate change projections

The most recent and comprehensive assessment of climate change projections in the East Africa region was undertaken in 2007 by the IPCC.²³ This report uses a moderate scenario for greenhouse gas emissions (the so-called A1B scenario). It predicts that East Africa, including Rwanda, will experience a 3 °C rise in average temperature and a 7 percent increase in annual mean rainfall with more intense high-rainfall events by the end of this century. Furthermore, the IPCC's crop yield projections for the African continent are alarming, with crop production declining by up to 50 percent in some countries by 2020. This will have critical implications on food security and malnutrition. However, the extent to which current regional precipitation models can be reliably downscaled to the national level is unclear, as the limitations of such modelling methods are not fully understood.

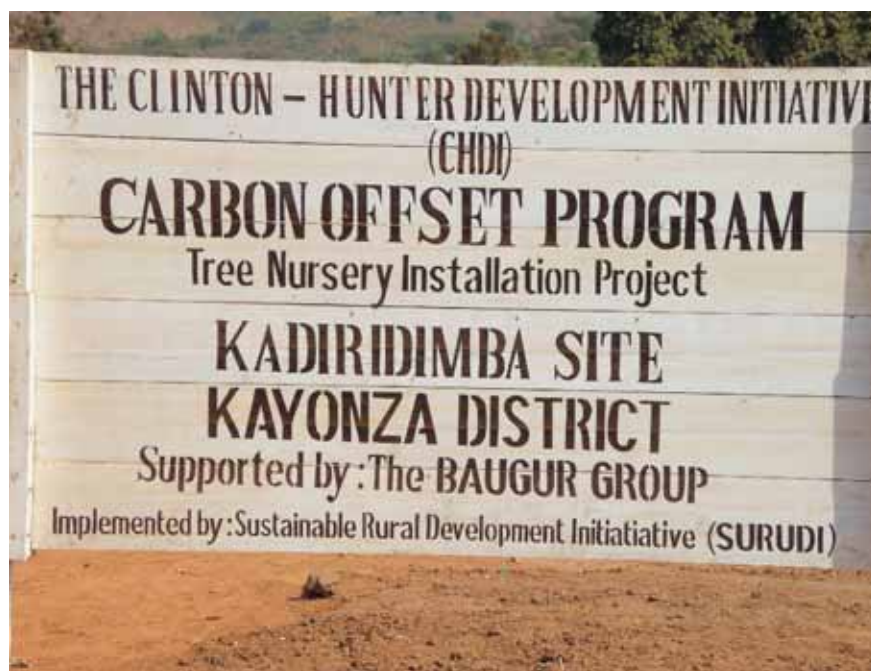
A subregional study covering the Nile Equatorial Lakes region was carried out to assess the potential impacts of climate change on hydropower generation in the region and provides climate modelling results based on data from the IPCC's

best-performing scenarios.²⁴ It makes similar projections, forecasting that temperatures in northern Lake Tanganyika, which lies along the Congo-Nile watershed in close proximity to Rwanda, are likely to increase by 3 °C, precipitation by 19 percent and run-off by 37 percent.

National climate change projections

To date, there is no specific national-scale climate change assessment for Rwanda. The limitations of coarse continental and regional climate projections for policymaking, however, should be acknowledged. This further underscores the importance of carrying out Rwanda-specific climate analysis and disaster prediction. Specifically, the importance of developing projections on agricultural production at an adequate resolution cannot be overemphasised for an agrarian country such as Rwanda. Modelling work is reportedly under way to provide simulations of potential crop yields as part of Rwanda's Second National Communication to the UNFCCC.

The lack of meteorological data during the conflict period constitutes a major handicap for national projections, as most models require uninterrupted data for at least 20 years.



Carbon offset schemes can provide funding for tree planting and environmental projects in Rwanda

Rwanda's meteorological services are presently operating at a bare minimum and require substantial capacity-building. The monitoring network which was devastated during the 1990-1994 conflict needs to be fully rehabilitated.²⁵ This is essential to create the requisite knowledge base for developing robust climate change projections, early warning systems as well as potential mitigation measures. While there are current plans to rehabilitate the monitoring network, financing remains insecure as it is solely dependent on domestic resources.



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Relief agencies provide emergency shelter to flood victims

Strengthening institutional capacities and cross-sectoral coordination on disaster risk reduction and climate change adaptation

Strengthening technical capacities

Technical capacity-building is needed to support the DMU on disaster risk reduction and REMA and the RMS on climate change adaptation. Developing technical expertise within the DMU should focus on conducting disaster risk assessments (i.e. hazard analysis) and vulnerability/capacity assessments, establishment of early warning systems (including forecasting, dissemination of warnings, preparedness measures and reaction capacities) and knowledge development (including education, training, advisory, research and information management). The DMU has initiated a vulnerability and risk assessment survey that identifies and ranks susceptible areas and groups, but so far only one district has been completed.

Within REMA, developing technical capacities should focus on undertaking Rwanda-specific climate change monitoring and modelling work as well as providing technical advice on

climate change. This needs to be implemented in close collaboration with the RMS, which requires proper equipment and staff trained in the collection of meteorological data to support climate simulation models.

Improving cross-sectoral coordination

There appears to be limited cross-sectoral communication and coordination on disasters and climate change. Efforts to strengthen disaster risk reduction capacities need to catalyse more active engagement of line ministries and agencies and integrate disaster issues in core development sectors. A positive step in this direction is the establishment of a cross-sectoral Disaster Management Task Force under the DMU that includes representatives from key ministries and agencies, as well as international partners. There is equally a need to develop disaster risk reduction and preparedness plans at different levels of administration from the national to the local level, and ensure that these are mainstreamed in national and district development plans.

With respect to climate change, there is a need to improve collaboration between REMA and the RMS in order to strengthen national capacity

on climate change modelling and monitoring. Implementation of NAPA will also require improved cross-sectoral coordination to ensure that climate change adaptation measures are incorporated in national, sectoral and local development plans and aligned with disaster risk reduction strategies.

As a follow-up to NAPA, a GEF project on early warning and disaster preparedness systems is currently under development. If it is approved, this project will be piloted in Gishwati to address the root causes of environmental degradation and climate change vulnerability in a comprehensive and integrated manner. It would provide practical lessons on adaptation measures within the Rwandan context and serve as a model for other regions to follow.

Improving public awareness

Despite the critical challenges posed by climate change and gradually increasing awareness among policy makers, there is still a lack of clear understanding of climate change issues. This was apparent in UNEP consultations with government officials who openly confirmed that they had limited access to climate change studies. Government should be at the forefront of raising public awareness about disasters and climate change, as increased public awareness enhances people's capacities to adopt risk reduction and climate change adaptation measures. One affirmative step in this direction is the range of awareness raising activities undertaken by REMA (e.g. national environmental weeks since 2006 have focused on climate change issues; organisation of national and international climate change conferences).

6.6 Conclusions

Observations indicate that both climate change and an increased incidence of weather-related disasters are very likely occurring in Rwanda. This represents a substantial threat to the impressive achievements made by Rwanda during the recovery phase and may undermine its ongoing development drive towards Vision 2020 targets and the Millennium Development Goals (MDGs). Several factors underlie Rwanda's heightened vulnerability to disasters and climate

change, not least of which is its high dependency on rain-fed agriculture practised on steep slopes and persistent environmental degradation.

Changes in climate conditions are an added stress on an already struggling agricultural sector. The rural poor, particularly women, are especially vulnerable as they have the least resources to mitigate and cope with disaster and climate change impacts. Flooding and droughts have already caused internal population displacements and could potentially fuel rural to urban migration. Changes in temperature and rainfall also increase risks of altering the geographic range of vector-borne diseases, for example, by potentially extending malaria prevalence to the cooler highland areas.

The magnitude of disaster impacts in Rwanda underlines the urgent need for disaster risk reduction and climate change adaptation measures, at both national and local levels. This requires high-level government commitment to tackle the challenges of disasters and climate change through coordinated and cross-sectoral programmes. Furthermore, disaster risk reduction and climate change adaptation need to be integrated in poverty reduction and ecosystems management plans. Strengthening technical capacities at the national level will also be critical in establishing a robust knowledge base to design effective risk reduction and adaptation strategies.

6.7 Recommendations

R6.1 Strengthen governance capacities and establish institutional mechanisms for cross-sectoral coordination on climate change and disaster reduction. This would focus on strengthening institutional and technical capacities of both the Climate Change Unit under REMA and the DMU and their capacity to coordinate and integrate climate change and disaster reduction measures in on-going programmes, projects and plans at national and subnational levels. With respect to climate change adaptation interventions, priority areas identified in NAPA would be targeted to enhance adaptive capacities of local communities. The proposed GEF project on integrated watershed management to be implemented in Gishwati provides a useful model. With respect to disaster

reduction measures, assistance to the DMU will be provided to undertake risk assessments, develop disaster preparedness and risk reduction plans, and establish a public awareness-raising programme.

Lead agencies: REMA, MINECOFIN, MINAGRI, DMU, RMS. International Partners: UNEP, UNDP. Cost estimate: USD 5 million. Duration: 3 years.

R6.2 Strengthen the institutional and technical capacities of the RMS. There is a need to further rehabilitate meteorological stations around the country in order to monitor, predict and report on climate variability and long-term change. The national meteorological monitoring network should be reinforced through the installation of modern equipment, establishment of new stations and provision of training on climatological data collection and weather, flood and drought forecasting. It would also support development of projections on the critical issue of climate change impacts on crop yields.

Lead agency: RMS, MININFRA, MINAGRI (agrometeorology) and Rwanda Civil Aviation Agency. International Partner: UNDP. Cost estimate: USD 1.5 million. Duration: 2 years.

R6.3 Strengthen national and regional volcanological and seismic monitoring in the countries of the Albertine Rift Valley. This aims to strengthen national capacities in seismic monitoring as well as enhance regional coordination and preparedness on volcanic eruptions and earthquakes by establishing a regional monitoring system. By improving early warning services, timely alerts would facilitate the evacuation of local communities in the event of seismic and volcanic activity.

Lead agency: DMU, MINAFET, OGMR. International Partners: UNDP, ISDR. Cost estimate: USD 1.5 million. Duration: 3 years.

R6.4 Pilot micro-finance projects targeting disaster affected areas. The International Strategy for Disaster Reduction (ISDR) advocates that people affected by disasters are able to recover and rebuild more quickly if they have quick and preferential access to emergency funds. This initiative would undertake a feasibility study and pilot test projects that deliver micro-credit and micro-insurance to disaster affected communities and also contribute to improved watershed management. Such a programme should be implemented in collaboration with NGOs specialising in micro-finance for disaster victims.

Lead agency: REMA. International Partner: UNDP. Cost estimate: USD 1.5 million. Duration: 5 years.

R6.5 Establish Clean Development Mechanism (CDM) projects based on run-of-the-river hydropower plants in rural areas. This aims to mobilise resources for greenhouse gas emissions reduction through the construction of hydropower plants, each with a total installed capacity of up to 15 mw. This initiative would produce renewable energy to be delivered to the national grid, which could replace electricity currently generated from fossil fuel sources. As this replacement will reduce carbon dioxide emissions, it would be eligible for funding through the CDM, a global facility aimed at reducing global carbon emissions by providing financing for emissions reduction projects in developing countries.

Lead agencies: MININFRA, REMA, MINIRENA. International Partner: UNDP. Cost estimate: USD 10 million. Duration: 5 years.

III. Sectoral Issues

Agriculture and Land Degradation

The main challenge for the agricultural sector is to ensure food security for a heavily populated country without degrading a highly vulnerable tropical mountain environment

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Agriculture and Land Degradation

7.1 Introduction

Agriculture is the basis of Rwanda's economy and the primary means of subsistence and employment for the vast majority of its population. Moreover, it is one of the country's main sources of foreign currency exchange. The Economic Development and Poverty Reduction Strategy (EDPRS) identifies agriculture as one of the four priority economic sectors for stimulating economic expansion and having the greatest contribution on poverty reduction and national development as a whole.

At present, the agricultural sector is failing to meet the demands of a rapidly growing population. It is also at the heart of one of the country's most serious environmental problems: land degradation. Land degradation in Rwanda is characterised by soil erosion and declining soil fertility and is driven by unsustainable land use practices, namely deforestation, overcultivation including on steep slopes without appropriate soil conservation measures, and overgrazing. Massive

population displacement and resettlement due to past conflicts in Rwanda have served as an underlying cause of unsustainable land use practices.

The Government plans to increase agricultural productivity through intensification and commercialisation, which will likely create environmental risks if it is not well managed. Major investment is therefore needed to improve land management and promote sustainable agriculture, in order to ensure household food security and support effective poverty reduction, and thereby contribute to national sustainable development.

7.2 Assessment activities

The fieldwork consisted of two main activities: (i) field visits, including consultations, interviews and measurement of sedimentation rates; and (ii) a Geographic Information System (GIS) modelling component to estimate soil erosion rates on a national scale that was carried out in collaboration with the Centre for Geographic Information Systems (CGIS) of the National University of Rwanda (NUR). A detailed description of the GIS methodology is elaborated in Appendix 4.



Agriculture is the mainstay of Rwanda's economy, contributing around a third of economic output and employing the majority of its population. After years of sluggish performance, the sector registered a major boost in growth in 2008

Table 15. Field sites visited by province

Province	Field sites
Northern	<ul style="list-style-type: none"> - Tea plantations in Musanze District - Bulera Lake - Tea plantations in Mushubi and Kiruri - Rugezi wetland
Western	<ul style="list-style-type: none"> - Gishwati Forest Reserve - Hillside cultivation and terracing in Arusha resettlement areas - Bigogwe in Nyabihu District - Karago Lake - Rubavu and Kinamba
Eastern	<ul style="list-style-type: none"> - Cattle ranches in the former Mutara Game Reserve and Akagera National Park - Bugesera savanna areas in Rweru District - Nagashanga and Kanyonyomba dams - Gatebe and Muhazi Lakes - Rurenge, Marimba, Rugende, Rwinkwavu, Kibaya, Bukora, Rusumo, Rutete, and Gahama
Southern	<ul style="list-style-type: none"> - Huye

Table 16. Location of the sediment cores taken during the UNEP field mission, August 2008

Place name	Location	Sediment core length
Nagashanga dam	S01°25.0615' E030°27.9307'	42 cm
Kanyonyomba dam	S01°45.1992' E030°21.8727'	36 cm
Bulera Lake	S01°23.2203' E029°47.8552'	58 cm
Karago Lake	S01°37.8033' E029°30.1988'	54 cm

Field visits

A preliminary visit to Rwanda was made in April 2008, which helped determine the most appropriate method to carry out a rapid estimation of soil erosion rates in the country for the purposes of this assessment.

Fieldwork recommenced in August 2008 to undertake a broader study of the agricultural sector. UNEP examined farming schemes, land use practices, resettlement areas, amongst other areas. A number of locations were visited across the country, covering lowland and highland regions.

Consultations were undertaken with the following government stakeholders: Ministry of Agriculture and Animal Resources (MINAGRI), Rwanda Environment Management Authority (REMA), Akagera National Park management, NUR and the CGIS, Rwanda Agricultural Research Institute (ISAR), Rwanda Agricultural Development Authority (RADA), Rwanda Animal Resources Development Authority (RARDA), Institute of Scientific and Technological Research (IRST), Institute of Agriculture and Animal Husbandry (ISAE), the Forestry Management Support Project

(PAFOR), Rwanda Meteorological Service (RMS) and district government authorities.

Other consultations were carried out with: United Nations Development Programme (UNDP), World Bank, Food and Agriculture Organization (FAO) and the Centre for Environment, Entrepreneurship, and Sustainable Development. Additional interviews included local experts from civil society organisations and farmers.

GIS modelling of soil erosion

Due to time constraints and the lack of long-term monitoring data, the UNEP team concluded that the optimum approach for assessing the magnitude of soil erosion was to use GIS modelling. The modelling approach applied the Universal Soil Loss Equation (USLE), a widely used method for estimating annual soil erosion rates (tonnes/ha/year) over a large area caused by rainfall (sheet or rill erosion).

To obtain a direct measurement of sedimentation rates, four sediment cores were taken from the bottom of four lakes and reservoirs across Rwanda (Table 16). For details, see Chapter 3 on the Assessment Process.

7.3 Overview of the agriculture sector

Key agricultural trends in Rwanda

Rwanda has historically been an agrarian society, with peasantry occupying a majority of the population. This continues to be the case despite the upheaval in the sector created by the 1994 conflict. Agriculture is the mainstay of Rwanda's economy, contributing on average 32.6 percent of gross domestic product (GDP) during the period 2004-2008 (Table 17). Its importance to national development is highlighted by the fact that it employs 80 percent of the working population and generates around 30 percent of economic growth.¹ Almost all rural households depend on agriculture for subsistence.

Despite the importance of agriculture, growth in this sector in the post-conflict period has until recently been sluggish, resulting in low growth of per capita income levels. Principal constraints on growth are severe land scarcity, land degradation and very low productivity. Nevertheless, according to the Agriculture Joint Sector Review Report,³ a very strong growth rate of 15 percent was registered in 2008, up from 0.7 percent in 2007. This in turn has generated a major boost in national economic growth reaching 11.2 percent in 2008 and raised the per capita income of the rural population.⁴ The improved performance is attributed to early results from the government's agricultural intensification programme.

During the 1980s, Rwanda was able to avoid chronic food shortages by expanding the area of land that was cultivated. By the 1990s, however, there was little new land available for agricultural expansion, as shown in Figure 6. The size of farms became smaller, and cultivation pushed increasingly into marginal

and more fragile lands. Acute land scarcity has also created a growing population of landless peasants, making it equally imperative to develop off-farm rural employment to reduce land pressure.

Over the last decade, growth in agricultural productivity has been possible largely through the expansion of the cultivated area and increased human effort, rather than through increased investment in infrastructure or agricultural inputs. Thanks to the Strategic Plan for the Transformation of Agriculture (PSTA), a new impetus has been given to the sector. Based on overall trends, however, agriculture in Rwanda faces major challenges to meet the food needs of its growing population. A national health survey conducted in 2005 showed that over 45 percent of children under five years old suffered moderate to severe chronic malnutrition.⁶ The agricultural intensification programme and reported increases in crop food production, however, may be able to reverse this downward trend. The recent increase in crop yields boosted food availability per person from 1,857 kcal in 2007 to 2,100 kcal in 2008.⁷ A key issue is how to sustain these gains over the long term.



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Farming is mainly of a low-input, low-yield subsistence type, almost entirely rain-fed and practised on very small landholdings

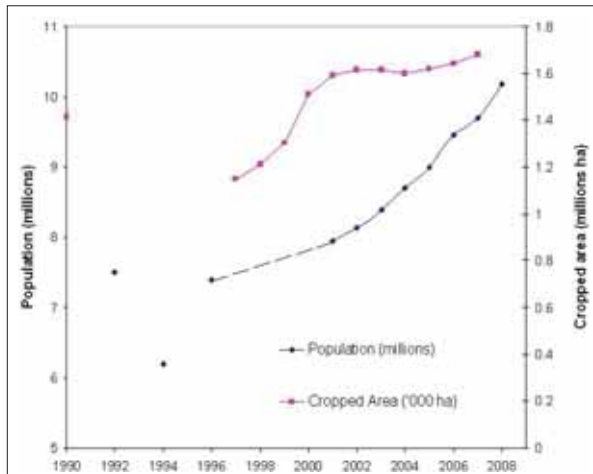
Table 17. Trends in agriculture sector performance and GDP growth estimates (2004-2008)²

GDP	2004	2005	2006	2007	2008*	5-year average
Agriculture	0.1%	4.8%	1.1%	0.7%	15.0%	4.3%
Food crops	-1.8%	6.4%	0.02%	1.8%	16.4%	4.6%
Export crops	58.2%	-24.3%	29.8%	-33.1%	20.3%	8.8%
Livestock	2.7%	2.7%	2.7%	2.7%	2.7%	2.7%
Fisheries	2.6%	2.6%	2.6%	2.6%	2.6%	2.6%
Forestry	2.6%	2.6%	2.6%	2.6%	2.6%	2.6%
Agriculture as % of GDP	34.9%	34.2%	32.2%	30.0%	31.0%	32.6%

Note:

* Data for 2008 are projected as agreed with the International Monetary Fund

Figure 6. Total population and total cropped area in Rwanda from 1996 to 2008⁵



Agricultural land use systems in Rwanda

Agriculture in Rwanda is comprised of two main subsectors: crop cultivation and livestock production.

Crop cultivation

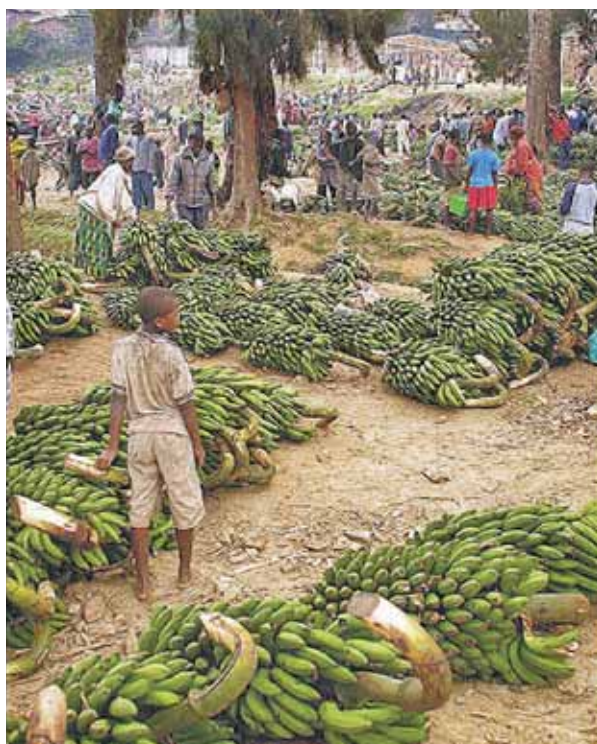
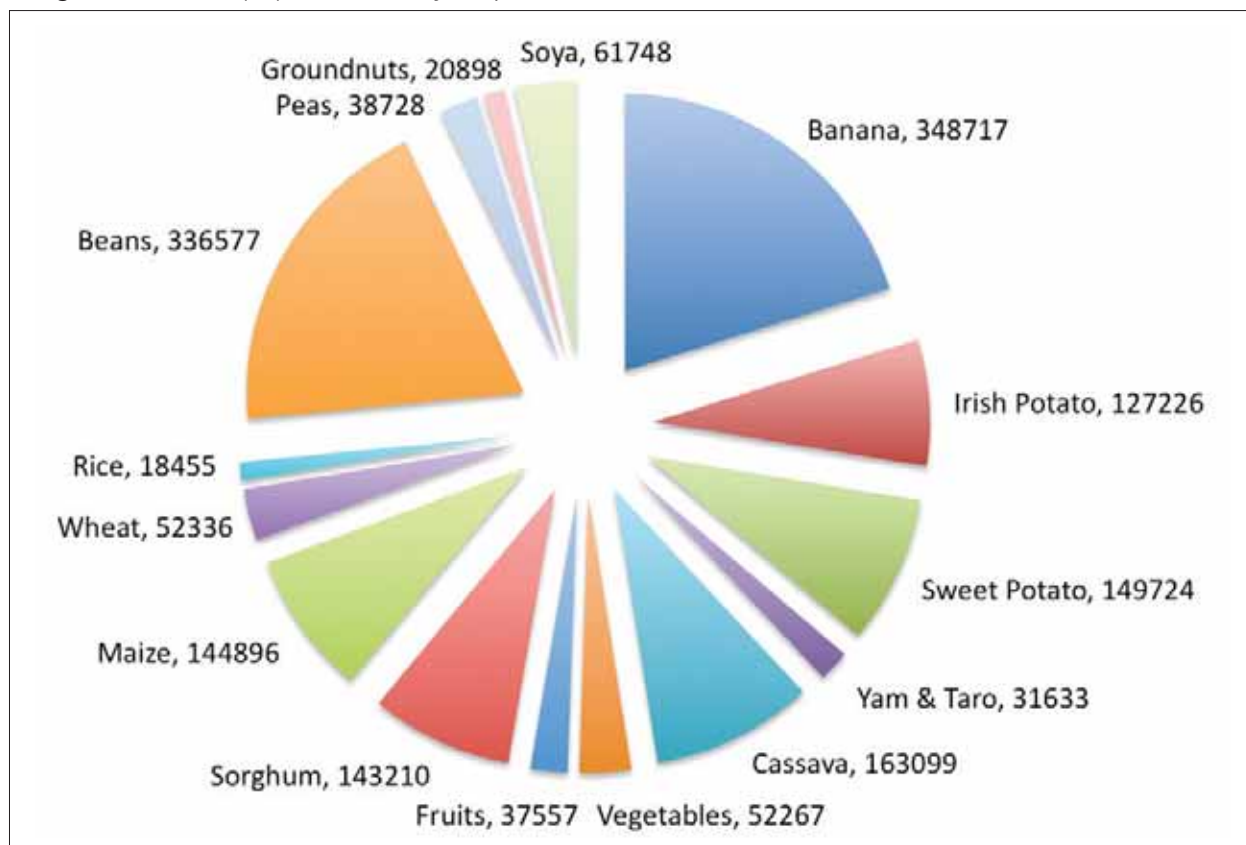
Most land in Rwanda is farmed as very small landholdings, primarily for household subsistence. More than 60 percent of households cultivate less than 0.7 ha, 50 percent cultivate less than 0.5 ha and about 30 percent cultivate less than 0.2 ha.⁸ Small plot sizes are aggravated by the fact that most farms consist of multiple, scattered plots.⁹

Subsistence agriculture in Rwanda is generally characterised by the high diversity of crops grown throughout the country. The main types of cultivated crops are food staples, namely: bananas (plantain), beans, sorghum, potatoes (including sweet potatoes), cassava and maize. Of these, the most important staple crop in Rwanda is bananas, providing a major component of daily calorific intake as well as a key income source. On the other hand, cash crops occupy less than 3 percent of the harvested land area and consist mainly of coffee and tea (Figure 7, next page).



As there are virtually no additional land reserves, more than 60 percent of households cultivate less than 0.7 ha of land, which is below the minimum 0.9 ha required to feed a household according to the FAO

Figure 7. Area (ha) cultivated by crop in 2008¹⁰



Bananas are Rwanda's most important staple crop, supplying a major part of household nutritional needs

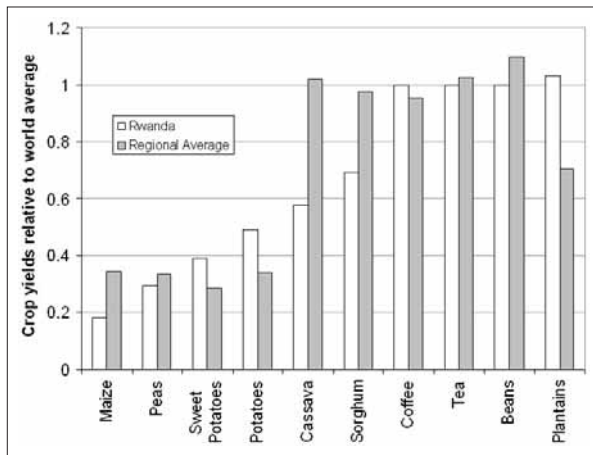
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It is important to note that most food crops are inter-cropped and are not cultivated as monocultures, as is the case with some cash crops (e.g. tea). Inter-cropping is a common land use strategy applied by poor farmers to help them minimise the risk of crop failures.

Crop cultivation practices are generally characterised by very low levels of inputs (e.g. fertilisers and pesticides) and limited mechanisation throughout the production process. As a consequence, crop yields remain low, even in comparison with generally poor levels of productivity in the region, as shown in Figure 8. Moreover, the yields of several food crops remain low despite increases in the cropped area (Figure 9).

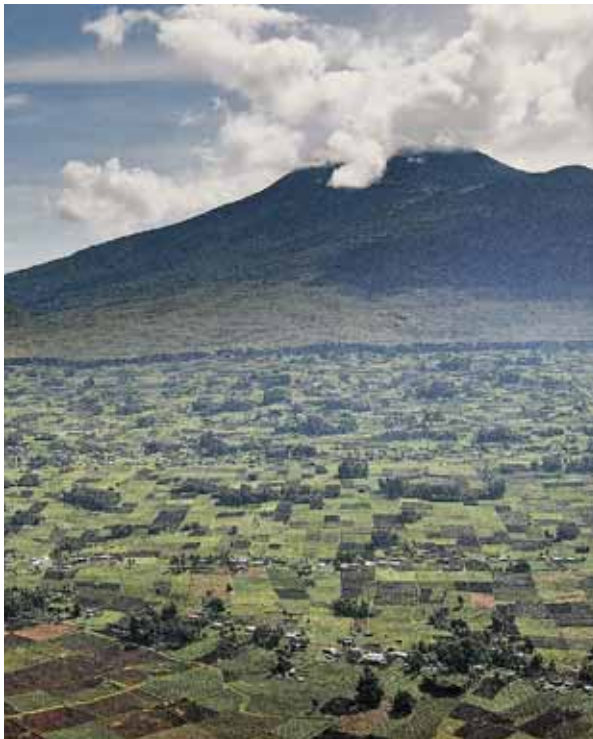
Productivity varies in different parts of the country. The most fertile areas are the volcanic soils of the northwest as well as the larger river valleys and extensive marshlands. In lowland areas in the east, soils are relatively fertile, but there is a long dry season during which irrigation is required to sustain crops. Traditionally, the

Figure 8. Rwandan and regional average crop yields compared to world average yields from 1999 to 2003¹¹



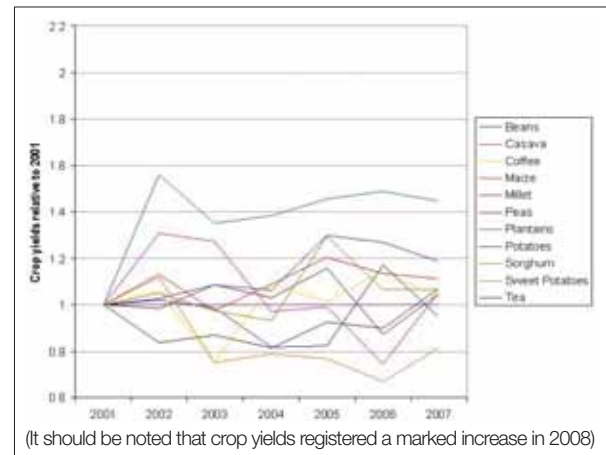
lowland savanna landscapes in Rwanda have been used to raise large herds of Ankole cattle. As a result of the growing population, much of this land, especially the wetter and more fertile areas, have been converted to arable farming.

Highland areas to the west are characterised by steep slopes and high rainfall. Soil erosion by



The most fertile areas of the country are the volcanic zone in the northwest as well as river valley bottoms

Figure 9. Yields of major crops from 2001 to 2007, expressed relative to the yield in 2001¹²



surface run-off and landslides are common. In highland areas, soils are deep but often heavily leached of nutrient and mineral content. As a consequence, soils in these parts are typically acidic (with a pH of less than 5.0). At low pH levels, aluminium in soil becomes increasingly soluble, which is toxic to plants and could lead to high soil phosphorus fixation. In addition, the organic matter in highland soils is rapidly depleted by deforestation and tillage, which make these areas problematic for long-term cultivation.

Livestock production

Livestock are an integral part of subsistence farming in Rwanda. Livestock production is mostly located in the east and in some southern parts of the country. Three major types of livestock are raised, namely: cattle, sheep and goats. Patterns of livestock ownership, particularly of cattle, mirror levels of household prosperity. Larger farms in the east and central regions have greater numbers of cattle, in contrast to in the north, west and southwest regions that rely more on agriculture.

In the most impoverished regions, farm sizes are generally less than 0.5 ha per household and few farms own cattle. Consequently, there is a shortage of animal products, including milk, meat and manure. In these areas, the government is promoting a One Cow per Household Programme, which aims to increase agricultural production by supplying manure and to reduce child malnutrition through milk production.

Figure 10. Fenced ranches in eastern savanna region

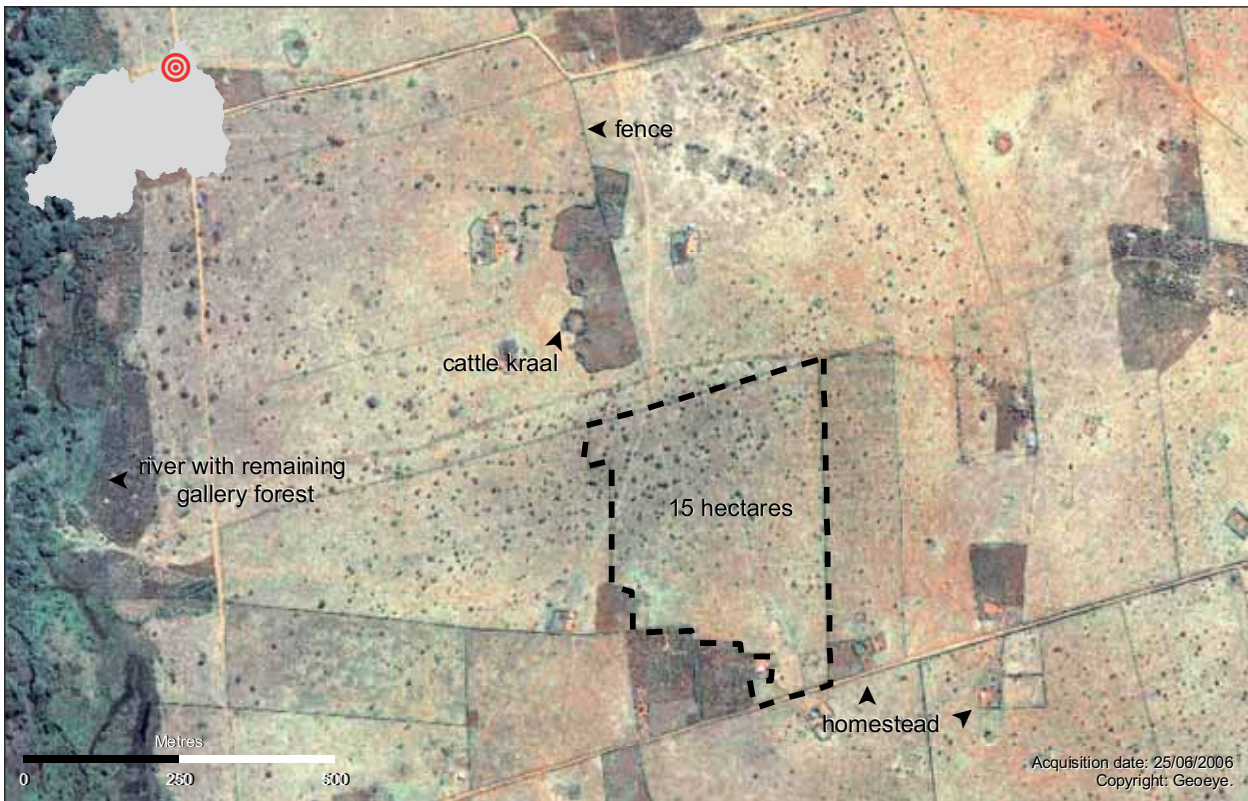
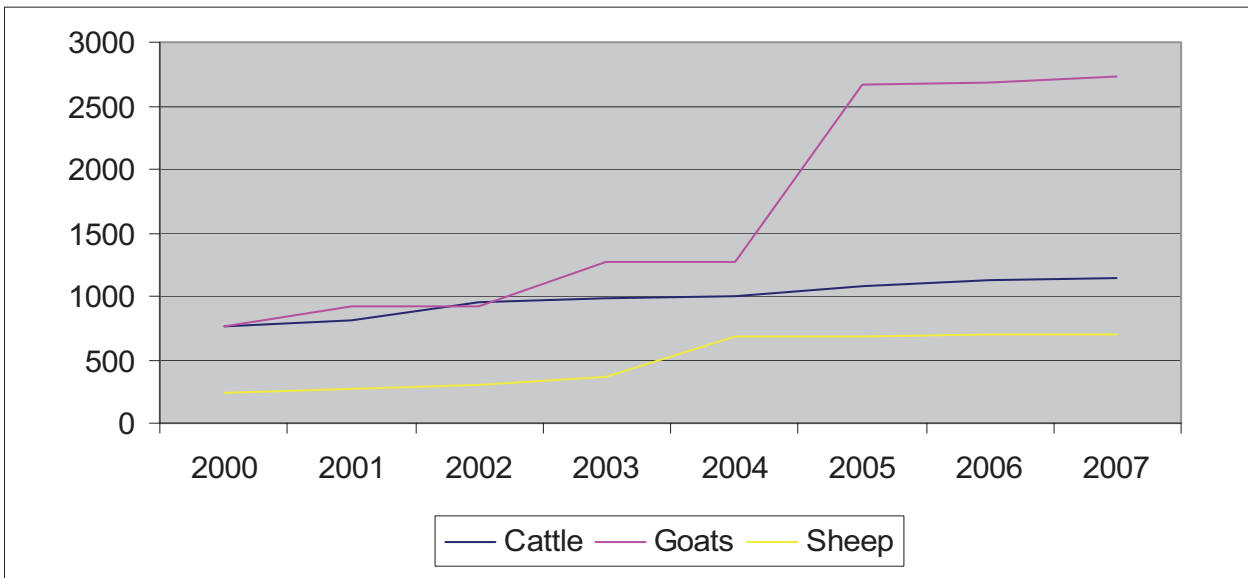


Figure 11. Trends in livestock numbers (thousand head), 2000-2007¹³



As part of the land reform and redistribution programme, limits have been set on farm sizes in the Eastern Province where a large part of public lands had been allocated for resettlement. Consequently, cattle keepers with large herds have limited pasture areas, resulting in the potential for

overgrazing that exacerbates land degradation. Government has embarked on promoting a zero grazing programme, through which farmers are actively encouraged to reduce the size of their herds in exchange for improved livestock breeds that are more productive.



Large cattle herds are concentrated in the eastern savanna region and Congo-Nile highlands

Impact of the 1990-1994 conflict and genocide

The agricultural sector was devastated by the 1994 genocide. Immediate impacts included: (i) loss and displacement of skilled farmers and agricultural professionals; (ii) a high level of female and children headed-households with minimum production means (crops, animals and equipment); (iii) loss and damage to long-term data sets, as well as monitoring tools and research facilities; and (iv) agricultural expansion into fragile and marginal lands, including concentration of cattle in the semi-arid eastern region, due to the influx of returnees, as well as internal migrations from mostly northern and western densely populated areas to relatively less populated eastern parts of the country.

As there are traditional gender-differentiated functions in crop cultivation and livestock production, the loss and displacement of household members placed significant constraints on role substitution. Women-headed households, in particular, are amongst the most affected, because they carry the double burden of agricultural production and important household tasks including



In the east, cattle herds are now confined in fenced pastures. The government is promoting a destocking programme to reduce overgrazing and land degradation

water and fuelwood collection (see Case study 7.1). Loss of household members has also inhibited the transfer of agricultural skills between generations. (Chapter 5 provides a more detailed discussion on population displacement and resettlement).



Due to resource constraints, women-and children-headed households have a limited capacity to effectively participate in agricultural intensification plans

Case study 7.1

Agricultural challenges of women-headed households

After the 1990-1994 conflict, the number of women-headed households in Rwanda sharply increased. They currently comprise 35.2 percent of the total population of whom 56 percent are widows. The challenges faced by these women seriously limit their effective participation in the agricultural sector, including capitalising on potential gains from the government's drive for agricultural intensification.

Focus group discussions were held with female-headed households in various *imidugudu* in the Kigali, Eastern and Western Provinces. These consultations provided important insights on the particular vulnerabilities of women farmers.

While male- and female-headed households may have been allocated equal land parcels under resettlement schemes, women are obliged to recruit extra labour during peak agricultural seasons. Women pay for the additional labour usually in kind, such as part of the harvest, or from sales revenue. In addition, female-headed households, especially in water scarce regions or during drought, face significant challenges in securing sufficient water supplies for their fields and home consumption. Women as household heads, therefore, have a double burden of securing water and undertaking agricultural work.

These underlying constraints seriously compromise the capacity of female-headed households to maximise agricultural production. It is, therefore, perhaps not surprising that female-headed households have a higher and deeper incidence of poverty. According to Household Living Conditions Survey (EICV-2), 62.15 percent of women-headed households were poor, which is 7.3 percentage points higher than for male-headed households. An estimated 37 percent of women-headed households are also food insecure compared with 25 percent for male-headed households. Although, women rarely own cattle, a valuable livelihood asset and an important status symbol, many of those interviewed expressed a strong desire to own a cow.

Given their resource limitations, women-headed households will find it difficult to effectively participate and benefit from agricultural intensification plans that are based on labour and capital intensive investments. Therefore, it is essential that special programmes be developed for women and other vulnerable groups as part of intensification. Moreover, children of vulnerable women-headed households are likely to be disadvantaged in terms of educational prospects, given their required involvement in household and agricultural work. This will make it all the more difficult for future generations to overcome chronic poverty.

7.4 Governance

Policy and legal framework

Vision 2020: Transforming agriculture

Due to the constraints of the immediate post-conflict period, it was only with the development of Vision 2020, in 2000, that the government was able to formulate a strategy for agriculture in Rwanda. Vision 2020 sets out key targets to be achieved by the sector, including:

- increase the proportion of the country farmed under modern agricultural methods from 3 to 50 percent;
- increase in fertiliser use from an average of 0.5 to 15 kg ha⁻¹ yr⁻¹;
- expansion of soil protection from 20 to 90 percent of the country;
- increase in agricultural production from 1,612 to 2,200 kcal day⁻¹ person⁻¹ (minimum daily needs are typically 2,100 kcal); and
- major increases in export earnings from traditional (i.e. tea and coffee) and new cash crops (i.e. horticulture).

The EDPRS and the Millennium Development Goals (MDGs), using 2006 as a baseline, set out the following medium-term targets shown in Table 18.¹⁴

In order to achieve the agricultural targets of the EDPRS and the 2008 Strategic Plan for the Transformation of Agriculture (PSTA), a number of key policy and legal instruments have been put in place to bring about the transformation of the agricultural sector. These include: (i) National Agricultural Policy (NAP) (2004); (ii) PSTA (2004 and 2008); and (iii) National Land Policy (2004) and Land Law (2005) and (iv) the Environment Policy and Law (2003, 2005) (see Chapter 14).



Promotion of new cash crops such as maracuja (passion fruit) is a key target of the planned agricultural transformation

Table 18. Medium-term targets in the EDPRS and MDGs

Indicator	2006	2012
EDPRS		
Agricultural land protected against erosion (%)	40	100
Area under irrigation (ha)	15,000 ¹⁵	24,000
Area under hillside irrigation (ha)	130	1,100
Reclaimed marshland (ha)	11,105	31,105
Fertiliser application (kg/ha)	4	12
Inorganic fertiliser use (% households)	11	17
Improved seed use (% households)	24	37
Rural households with livestock (% total)	71	85
MDGs		
Child 0-5 years stunted (%)	45	27.2
Child 0-5 years wasted (%)	4	2.5
Child 0-5 years underweight (%)	23	16.3
Protein needs available/head (%)	–	–
Proportion of land area with titles (%)	1	–

Note:

– Indicates data not available.



Members of a tea cooperative in Burera District discuss the challenges they face with UNEP. Cooperatives play an important role in helping organise rural communities in the fight against extreme poverty

It is important to note that the Ministry of Natural Resources (MINIRENA) is currently preparing a National Land Use Master Plan, which is scheduled for completion by the end of 2009. This Master Plan will provide the basis for preparing all subnational land use plans and will define land suitability for all major crops in Rwanda. It will be used to guide implementation of the PSTA, specifically to maximise regionalisation of crop production.

National Agricultural Policy

The key thrust of NAP is to promote the transition of the agricultural sector from a subsistence-based to a market-oriented production through intensive cash crop farming.¹⁶ As successful change depends on good access to markets, NAP promotes investment in rural infrastructure and the development of rural financing schemes and markets. Development of a strong agro-based manufacturing industry would add value to agricultural produce and provide salaried employment for those displaced by commercial agriculture. The use of modernised farming methods is also an integral part of this transformation process.

Furthermore, agricultural development will be based on applied research and extension services but with a more decentralised and locally responsive approach.

NAP is promoting greater participation of farmers in agricultural research and extension through training for cooperatives and farmers' associations.

Strategic Plan for the Transformation of Agriculture

The PSTA is being implemented in two phases: the first phase began in 2004 (PSTA-I) and the second phase in 2008 (PSTA-II). It is intended to operationalise the strategic objectives and guidelines set by NAP.¹⁷

The National Land Policy and Land Law

The National Land Policy of 2004 and the Land Law enacted in 2005 provide guidance to improve land management and promote agricultural productivity by guaranteeing land tenure through long-term lease hold titles (20-99 years renewable) and allowing for land market transactions.¹⁸ By giving farmers the right to buy, sell, mortgage and inherit land, the government aims to provide incentives favouring land consolidation and the expansion of commercial agriculture. The Land Law creates mechanisms for confiscating poorly or unexploited land and has provisions for managing land belonging to vulnerable people such as widows and orphans.

7 AGRICULTURE AND LAND DEGRADATION

Following criticisms of the effectiveness of policy implementation, MINAGRI has been at the forefront of adopting the 2000 Decentralization Policy and involving local authorities more directly in the development process. The implementation of agricultural policies and programmes has been devolved at provincial and district levels. Consequently, programmes defined by the MINAGRI are implemented under the aegis of the Ministry of Local Government, Community Development and Social Affairs (MINALOC) through local authorities and non-governmental organisations (NGOs). However, there are concerns about whether there is adequate local capacity to ensure effective implementation of devolved functions (discussed further under “Key issues”).¹⁹

Key institutions

MINAGRI is the key institution responsible for agricultural policy formulation and implementation. The National Land Centre

(NLC), under the supervision of MINIRENA, was created by the Land Law to implement the land reform programme, including land use planning, land tenure regularisation and systematic land registration.

Other important government actors in the agricultural sector include three autonomous agencies operating under the supervision of MINAGRI, namely: RADA, RARDA and the Rwanda Horticulture Development Authority (RHODA). The role of these three agencies is mainly to implement policies and provide improved technology and extension services, including training. ISAR plays a key role in implementing the agricultural research component of the agricultural transformation strategy. A tea (OCIR Thé) and coffee (OCIR Café) agency, respectively, supervise and coordinate the production of these key cash crops. In addition, it should be noted that a Rwanda Agricultural Board (RAB) has recently been established under which the various agencies will be reorganised.



While Rwanda's verdant landscapes do not generally exhibit the gullies and bare lands associated with severe land degradation, soil fertility has been seriously depleted and almost all available land is cultivated, including this extinct volcano

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7.5 Overview of key issues

The agricultural sector in Rwanda is strained by rapid population growth, severe land shortages and low agricultural productivity and the legacy of conflicts in the country. As a result of the transformation process, the sector is expected to undergo significant changes. Government and farmers will have to develop strategies to respond to longstanding problems as well as future environmental risks. Environmental sustainability and food security should be important considerations in determining planned agricultural growth.

The key issues in the agricultural sector include:

- persistent and severe land degradation;
- sustainable agriculture and improving farmer livelihoods;
- barriers to adopting soil conservation;
- environmental risks of agricultural intensification;
- changing land use patterns on steep and fragile slopes; and
- strengthening agricultural governance.

Persistent and severe land degradation

Land degradation, as defined by the United Nations Convention to Combat Desertification, is the reduction or loss of the land's biological or economic productivity caused by human-induced land use processes.²⁰ Land degradation in Rwanda is characterised by soil erosion (i.e. loss of topsoil) and declining soil fertility. Although a widespread problem in east and central Africa, soil erosion reaches an extreme in Rwanda due to its steep topography, natural soil susceptibility to erosion and leaching and climatic conditions. While soil erosion is a longstanding problem dating from the colonial period, it has become more severe since 1994.

Soil erosion results in a significant decline in soil fertility, which is the primary cause of low agricultural productivity in Rwanda. Heavily degraded soils are incapable of supporting a large plant biomass because of low or depleted soil

nutrients and soil organic matter (SOM). Organic matter is important for maintaining soil structure and maximising nutrient retention. It is the glue that holds soil nutrients, namely nitrogen and phosphorus, in place until they are accessed by cultivated crops. Frequent, continuous cultivation has accelerated the rate of SOM depletion in the country.

Moreover, soil erosion has important downstream impacts. High sediment loads reduce the size of river channels and water-holding capacities of lakes, choke water harvesting and storage systems, and exacerbate flooding. In addition, erosion is a major cause of progressive eutrophication in many of the country's lakes, promoting the proliferation of algal blooms and water hyacinth (*Eichhornia crassipes*), which reduce the amount of dissolved oxygen in water.

Land scarcity and fragmentation

The high pressure on agricultural land is illustrated in the following farming typology: (i) 17 percent of farms are less than 0.25 ha; (ii) 26 percent are between 0.25 ha and 0.5 ha; (iii) 29 percent are between 0.5 ha and 1 ha; and (iv) 28 percent are more than 1 ha.²¹ Given the land scarcity and excessive fragmentation, promotion and diversification of off-farm activities as a source of income generation are critical in the planned *imidugudu* and land consolidation programmes. It is also important to complement agriculture production by promoting small- and medium-scale agro-industry units to add value to agriculture products and encourage a market-oriented environment.

Extent of soil erosion

Although soil losses are generally acknowledged to be quite high, there are few long-term studies in Rwanda with reliable data on soil erosion rates. GIS modelling to estimate soil erosion rates was constrained by data gaps and the short time scale available to carry out field measurements. A national-scale soil erosion map was produced as part of the assessment by the CGIS in collaboration with UNEP (Map 11). It is based on the USLE (Weischmer equation) modelling results and provides a preliminary estimation of soil erosion rates at the national scale (Table 19, page 134). Appendix 6 tabulates rates of soil erosion loss by district.

7 AGRICULTURE AND LAND DEGRADATION

Map 11. GIS modelling of soil erosion rates in Rwanda

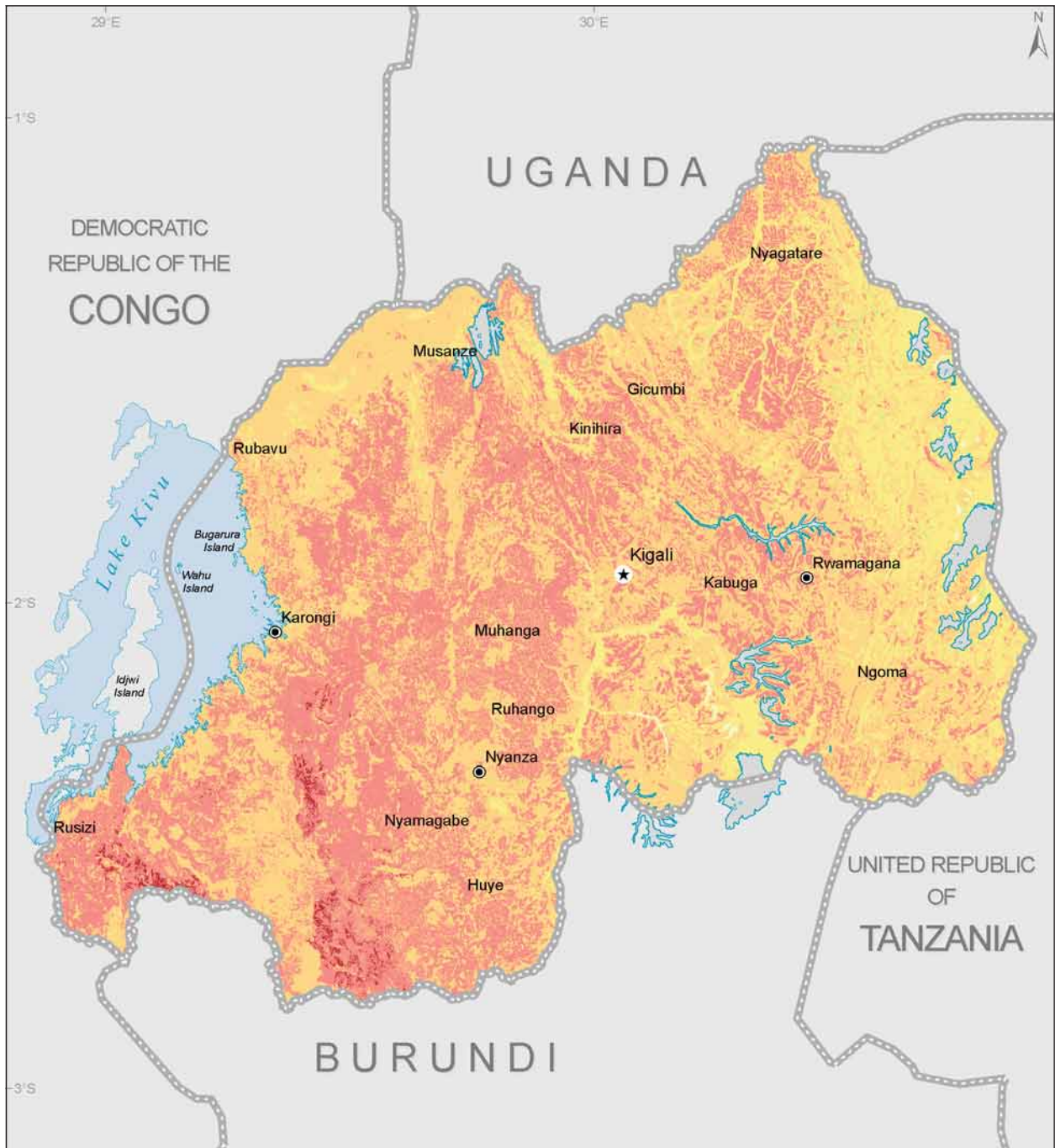


Table 19. Preliminary soil erosion rate estimates in Rwanda based on GIS modelling

Erosion rate (tonnes/ha/year)	Surface area		Percentage of total surface area
	Square km	Hectares	
0-30	113	11,290	0.45
30-50	2,967	296,655	11.77
50-100	11,953	1,195,262	47.41
100-150	8,524	852,399	33.81
150-300	142	14,181	0.56
Water bodies	1,511	151,130	6.0
Total	25,210	2,520,917	100

The modelling results clearly illustrate the extreme gravity of the soil erosion problem facing Rwanda, with 47 percent and 34 percent of the country experiencing soil erosion rates of between 50 and 100 tonnes per hectare per annum, respectively. GIS modelling estimates are considered to be relatively conservative and provide a reliable indication of the extent of soil erosion in the country. Nevertheless, it should be emphasised that these estimates are only preliminary and need to be validated based on field measurements. It should also be stressed that given the multiple variables influencing soil erosion rates (soil type, drainage, vegetation cover, slope of land, land use practices), the danger of unscientifically estimating a national mean for soil loss expressed in tonnes per hectare per year should be avoided as it is of limited use.

Soil erosion modelling work highlights the importance of better data collection for a more accurate modelling process. The paucity of information in the country presently makes it difficult to develop objective assessments of soil erosion and design anti-erosion strategies. However, a simple, inexpensive and widely used method is to take point measurements of soil loss using erosion pins, which could significantly increase the accuracy and confidence levels in GIS modelling results.

The magnitude of the soil erosion problem is further illustrated by UNEP’s measurements of sedimentation rates in selected lake/reservoir sinks across the country, which revealed high rates of soil loss (Table 20). For example, radioactive dating showed that in excess of 54 cm of sediment had been deposited in Lake Karago at the sample

point in less than one year. This figure is the absolute minimum value since only a small proportion of the sediment from the catchment area will be deposited in the sink and most would have been lost with the drainage water. It is, therefore, important to emphasise that these figures are site specific and it is very difficult to use them to estimate rates of soil loss within the catchment areas. Nevertheless, the sedimentation measurements taken provide some independent verification of the extent of soil erosion that was estimated using the GIS model.



The formation of this sediment delta in Lake Karago illustrates the high levels of soil loss in its watershed. The reduction in water quality due to high turbidity has reportedly almost eliminated the fish catch from the lake

Table 20. Results of sedimentation sampling by the UNEP assessment team

Sampling point	Sediment core length	Sedimentation rate
Nagashanga Dam	42 cm	8.2 cm yr ⁻¹
Kanyonyomba Dam	36 cm	6.7 cm yr ⁻¹
Bulera Lake	58 cm	15.1 cm yr ⁻¹
Karago Lake	54 cm	>54 cm yr ⁻¹

The loss of lake and reservoir volume indicated by UNEP's measurements has major environmental implications in terms of reducing water storage capacity and compromising productive functions. High sediment loads in the country's rivers are another visible sign of the soil erosion problem (see Chapter 9).

Inadequate soil erosion control

Despite the government's strong commitment to address soil erosion as a national priority, practical measures are insufficiently implemented on the ground. The focus has been on capital-intensive

erosion control projects, particularly radical terracing. There is a need to complement this approach by developing and adopting integrated soil conservation techniques (see section on Sustainable agriculture) that correspond to the topography and physical characteristics of the soils to ensure sustainable results.

Because soil erosion itself is a symptom of poor land management, erosion control measures alone will remain insufficient to improve long-term agricultural productivity. There should be a switch of emphasis to focus on the promotion of a high-quality integrated soil management system rather than stand-alone erosion control measures. High-quality soil management could be achieved through an integrated conservation agriculture approach that provides profitable agricultural yields, while minimising environmental damage.

Unsustainable land use practices

Unsustainable land use, in combination with Rwanda's steep topography, fragile soils and climate, is the driving cause of soil erosion. Unsustainable land use practices include: (i) deforestation and expansion into fragile ecosystems; (ii) overcultivation; (iii) overgrazing; and (iv) poor road construction.



Erosion control structures such as radical terracing require more upkeep and space and are not enough on their own to control soil erosion. They need to be combined with biological systems such as grassed banks, hedges, mulching and green manure

Deforestation and expansion into fragile ecosystems

Normally, forests are situated on fragile lands that are unsuitable for agriculture, mainly on hilltops, very steep slopes and mountains and on poor and stony soils. For example, in the former Gishwati Forest Reserve, UNEP observed slopes greater than 60° being regularly and deeply tilled with limited signs of soil conservation measures. As a result, huge sediment inputs carried by the Nyamukongoru River that drains this area have reduced the surface area of downstream Lake Karago by an estimated 25 percent based on UNEP satellite observations. Lake Karago was originally an important source of fish for local communities, but sedimentation has killed off the fish population.

Overcultivation

Acute land scarcity has led to the overcultivation of land. Fallow periods have grown much shorter or have become non-existent. In many cases, cultivation periods have been extended, up to two to three times per year, with very limited soil inputs



In the former Gishwati Forest Reserve resettled by returnees, UNEP observed slopes greater than 60° being cultivated with limited soil conservation measures

or soil conservation measures. Overcultivation has had a major impact on reducing soil fertility and productive capacity.

Farmer response to offset low production yields by overcultivation creates negative feedback loops that only worsen land degradation. A practical way to break out of this cycle is to increase both soil nutrient capital and SOM through the simultaneous application of organic inputs (e.g. animal manure) and chemical fertilisers (discussed further under section on Sustainable agriculture and improving farmer livelihoods).

Overgrazing

Despite government efforts to reduce the size of cattle herds, overgrazing remains an issue. Overgrazing is characterised by a significant reduction in plant cover, SOM content and soil biological activity. As a consequence, there is increased exposure to erosion by rainfall, which degrades the soil physical structure and reduces soil nutrients. Pastures in the Eastern Province are amongst the most heavily degraded grazing areas.



Due to land scarcity, farmers are cultivating almost throughout the year with major impacts on soil fertility and productive capacity

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The impacts of overgrazing in Umutara are visible in the bare landscapes

Erosion is compounded by the physical impact of animal trampling, leading to surface compaction, which is particularly problematic around watering points where large numbers of animals congregate. Compaction causes the water infiltration capacity of soils to decline, causing significant surface run-off. Not only does this run-off lead to accelerated loss of topsoil, but it also reduces soil moisture and groundwater recharge.²²

Soil erosion due to overgrazing causes a decline in pasture productivity. Nutritious, deep-rooted forage species are typically replaced by slow growing, non-palatable plants of low nutritional value. Continuous grazing favours the growth of these less nutritious plants and makes pasture restoration difficult. Government needs to reinforce its efforts to control herd sizes, promote zero-graze pastoral systems and improve the cattle breeding system.

Poor road construction

Most major roads used by the UNEP team were well designed to cope with run-off and avoid erosion. However, the network of secondary unsurfaced roads generally lacked adequate roadside drainage and was observed to be important hotspots of land degradation. Many of these roads have inadequate roadside drainage and so collect surface overland flow that generates significant run-off.²³ Moreover, cultivation immediately along the roadside could

also accentuate soil erosion and landslides and undermine road construction.

Poor road conditions could also represent a major obstacle to efficient transportation. Based on UNEP's interviews with local farmers, improved transport links was cited as one of their major priorities for increased market access. In a recent government survey, however, less than 10 percent of the country's roads were judged to be in good condition.²⁴



Secondary unsurfaced roads were observed to be important hotspots of soil erosion



Conservation agriculture combines stabilising the ground with hedges and agroforestry as shown above, with mulching and a mineral fertiliser supplement to keep soil erosion at an acceptable level while ensuring good yields

Sustainable agriculture and improving farmer livelihoods

Conservation agriculture could prove to be an effective strategy in overcoming poor land management and soil erosion. It aims to achieve sustainable and productive agriculture based on three main principles: minimal soil disturbance, permanent soil cover and crop rotations.²⁵ The focus here is on improving land management practices through the synergistic application of conservation techniques by smallholder farmers.

Ensuring minimal soil disturbance is important because tillage disrupts soil physical structure and accelerates the decomposition of SOM as well as removes and buries vegetation cover. In addition, maintaining a permanent organic cover protects the soil from direct rainfall impact and daily temperature extremes. It also provides a source for replenishing the SOM. Finally, crop rotations need to be an integral part of the cropping system, which preferably should include nitrogen-fixing legumes as well as improved fallow periods.

Promoting agro-sylvopastoral systems

One integrated system that has good potential in Rwanda is agro-sylvopastoralism, which aims to integrate on-farm tree cultivation and animal husbandry. While this practice is still comparatively new in Rwanda, there are many valuable examples of integrated agro-sylvopastoral systems in the region (e.g. Uganda and Kenya). The idea is to combine the application of legume leafy biomass and animal manure in crop cultivation. This was found to increase the soil pH levels as well as potassium (K), calcium (Ca) and magnesium (Mg) and exchange capacity in an upland soil in Rwanda.²⁶

As mentioned above, the government has promoted a One Cow per Household Programme, which provides a good opportunity for promoting an integrated agro-sylvopastoral package. This programme enables farmers to raise cows to improve their nutritional status (milk and meat) and produce manure to increase farm productivity. Many small farms lack good pasture; therefore, government is encouraging the adoption of zero-graze systems.

7 AGRICULTURE AND LAND DEGRADATION

Promoting the cultivation of fodder shrubs can provide plentiful, easily accessible and inexpensive fodder supplies for livestock, a measure that government has been promoting as part of its policy on hillside intensification. In particular, planting nitrogen-fixing legume species as a fodder crop could also help improve soil fertility and does not compete with other crop species for nutrients. Other fodder crops such as alfalfa can be manually harvested and fed to livestock in zero-graze systems.

Cultivation of forage crops to support zero-graze systems will require skilful government promotion and support by extension services. The provision of animals and chemical fertilisers could be used as incentives for farmers to establish fodder crop hedges on erosion-prone land.

Improving agroforestry systems

Agroforestry, which promotes mixed cultivation of trees and food crops, has been widely promoted in Rwanda (e.g. through the Crop Intensification Programme) as a very effective way of reducing soil erosion. Short-term trials indicate that agroforestry can reduce erosion by up to 90 percent.²⁷ In addition, agroforestry trees and

hedges can provide firewood and high-quality fodder, which would reduce deforestation and overgrazing pressures.

On its own, however, agroforestry and green manure cover crops are not likely to increase agricultural productivity.²⁸ This is because phosphorus is the major limiting nutrient in most Rwandan soils and plant compost is deficient in this element.²⁹ Therefore, additional inputs of animal manure or chemical fertiliser are required in order to increase soil productivity.

Appropriate use of chemical fertilisers

The importance of appropriate fertiliser application to increase agricultural productivity and sustain livelihoods cannot be overemphasised. At the same time, it is critical that fertilisers are applied based on scientific knowledge of soil status and crop requirements. MINAGRI's updated soil database needs to be linked to crop requirements in order to develop an appropriate fertiliser application scheme. The risk of fertiliser misuse by farmers due to lack of soil and crop specific information is real and needs to be addressed through scientific research and disseminated through the extension services.



The One Cow per Household Programme provides a good opportunity for promoting an integrated agro-sylvopastoral package

Of specific importance in conservation agriculture is raising soil fertility through the simultaneous application of animal manure and chemical fertilisers. It is generally recognised that organic fertilisers, such as animal manure and plant compost, are insufficient to sustain soil nutrients. As in plant compost, animal manure is typically low in available phosphorus (P). Therefore, the application of chemical fertilisers in combination with organic inputs is considered the most effective treatment in boosting soil fertility and production.³⁰ Without artificial amendments, arable soils have been found to be unable to sustain continual losses to intensive cropping and erosion.³¹

Barriers to adopting soil conservation measures

Although soil erosion control is considered a national priority, the adoption of soil conservation measures by farmers is greatly limited. While UNEP observed a number of farms with soil protection measures along contours, the team also noted many farms across the country without even basic erosion control.³² A government survey in 2005 found that 35.7 percent of farmlands did not practise any type of soil erosion control.³³

The lack of tangible progress in establishing effective soil erosion control is an indication that there remain significant barriers to farmer adoption of soil conservation measures. Understanding these constraints on farmers is critical in order to develop more effective policies and programmes that substantially alleviate the soil erosion problem in the country.

There is a risk of attributing the failure of farmers to invest in soil conservation solely to a lack of technical knowledge. One study, for example, found that Rwandan farmers who had been exposed to extension services promoting soil conservation were no more likely to make investments than farmers without this information.³⁴ Other important factors inhibit farmers from investing in soil conservation, namely: (i) lack of resources; (ii) land tenure insecurity; and (iii) lack of perceived benefits.

Lack of resources

Many farmers, especially those who have less than one ha, lack resources to invest in soil conservation measures to improve agricultural productivity. Only a few households have sufficient or extra resources to spare (i.e. time, labour and financial capital), even though they may be willing to do so.



Lack of resources has been identified as a major constraint on farmers to invest in soil conservation measures

Capital intensive strategies to arrest land degradation and increase farm productivity, such as radical terracing and fertilisers, are often the most costly to implement even though they may be necessary on the steep slopes and marginal lands extensively cultivated in Rwanda. Unfortunately, households farming the steepest slopes and least productive lands are also often those who lack capital resources. In particular, female-headed households and households impacted by HIV/AIDS face considerable obstacles to undertake soil conservation measures that are resource demanding (see Case study 7.1).

Land tenure security

In Rwanda, land tenure insecurity is a major disincentive for many farmers to invest in farm improvements.³⁵ Although the National Land Policy and the Land Law promote land tenure security as a tool to increase agricultural investment and productivity, land tenure reform remains in its initial stages. As a result, farmers still face difficulties in contracting loans for soil conservation investments and farm improvement. Nevertheless, the government's ongoing land tenure reform programme through regularisation and systematic land registration should play an important role in motivating farmers to invest in land improvements.

Lack of perceived benefits

Many investments in soil conservation have a comparative long pay-back period. If farmers perceive little immediate return on their investment, they may not be prepared to outlay time and effort. In other cases, farmers interviewed by UNEP expressed concerns that erosion control measures may take up extra land and reduce their already limited area for crop cultivation. One way to encourage farmers to adopt erosion control measures may be to provide resource incentives that would compensate for a reduced cropping area.

It will be important to tailor soil conservation strategies according to local conditions and capacities in order to maximise potential benefits. For instance, the effectiveness of traditional soil conservation measures to control soil loss varies with slope.³⁶ Farmers have been found to make their greatest investments in soil conservation

on intermediate slopes (9° to 26°), where these measures are most likely to result in improved yields.³⁷ The lack of appropriate soil conservation measures on steeper land may simply reflect farmers' experience that traditional strategies are ineffective and costly in such areas.

Environmental risks of agricultural intensification

Given the rapid pace of population growth and urbanisation, it is critical that Rwanda increases agricultural productivity through intensification. Agricultural intensification is necessary in order to prevent food shortages and avoid falling into an inflationary trap of rising food prices. However, care should be taken that the transformation to intensification does not compromise environmental sustainability.

There are three main environmental risks associated with agricultural intensification, namely: (i) increase in fertiliser use; (ii) improved seeds and protection of crop diversity; and (iii) wetland reclamation.

Increase in fertiliser use

A considerable increase in fertiliser use is expected with the current drive to increase agricultural productivity. In May 2008, the World Bank announced that it would lift its moratorium on subsidies for fertiliser imports as part of a larger global initiative to support food production.³⁸ This decision enables the Rwandan government to subsidise fertiliser imports, thus making fertilisers affordable and readily accessible to farmers. The development of a government policy on fertiliser usage is reportedly under way.

Few Rwandan farmers, however, have experience using chemical fertilisers. Hence, there is a real danger of fertiliser over-application. Increased fertiliser usage could result in heavy run-off, polluting streams and groundwater that requires rigorous environmental assessment and monitoring.

Clear guidance from MINAGRI is needed on crop-specific use of fertilisers. Extension services should prioritise training to farmers, emphasising fertiliser use as part of integrated conservation agriculture.

Improved seeds and protection of crop diversity

The government is promoting the use of improved seeds not only to maximise yields, but also to tackle soil erosion by augmenting the vegetation cover and biomass production. ISAR is leading national research efforts in this field, while RADA will disseminate the results to farmers.

As agriculture shifts towards commercial crop production, the government plans to consolidate the cultivation of specific crops on a regional basis. This regionalisation of agriculture aims to

maximise crop productivity based on the country's climatic and soil zones. At the same time, one of the risks of consolidated monocultures and introduction of hybrid seeds is the potential loss of on-farm biodiversity.³⁹

Subsistence agriculture in Rwanda is based on the diversity of cultivated crops. Farmers typically grow a range of crop species and varieties in order to match production to ecological conditions and their own family needs.⁴⁰ Crop diversity enables farmers to spread or reduce their risks (i.e. of crop failures), especially during periods of climate variability and extreme events as well as disease outbreaks.⁴¹



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Rwanda's huge variety of beans can play an important role in adapting to unpredictable climate variability



Wetlands are targeted for agricultural reclamation, especially for rice cultivation with potentially significant environmental consequences

Experience during the 1994 genocide emphasises this point.⁴² Rwanda is well known for its extraordinary diversity of beans; it is estimated that there may be some 1,300 varieties. Following the civil war, bean production recovered rapidly as farmers established crops from their own seed stocks or traded in local markets. In contrast, potato production depended on a very small number of improved varieties. Farmers required commercial supplies of seed potatoes, fungicide and fertiliser. When these supply chains were disrupted, potato production collapsed. It is, therefore, important to conserve local crop varieties to maintain agricultural resilience against unanticipated shocks. In addition, local cultivars may provide the critical genetic material to produce high-yielding improved seeds that are resistant to drought and disease and also assist farmers in adapting to the potential impacts of climate change.

Wetland reclamation and use

Wetlands, including swamps and marshlands, are an important target for agricultural expansion,

particularly for rice cultivation. MINAGRI has developed a master plan for marshlands that identifies those areas that can be converted to agriculture with relatively limited environmental consequences⁴³. REMA has also conducted a national wetland inventory that identifies three categories of use. Nonetheless, uncontrolled wetland reclamation continues to occur, resulting in loss of important wildlife habitats and damage to key environmental functions. At present, wetland protection measures remain inadequate and are weakly enforced. Wetlands encroachment by agricultural activities was intensified in the aftermath of 1994 due to lack of institutional framework for protection of fragile ecosystems (see Chapter 9).

Changing land use patterns on steep and fragile slopes

While cultivation on steep and fragile slopes is not recommended, it is unavoidable. Nevertheless, cultivation on slopes greater than 40° should be restricted to perennial crops (e.g. coffee, tea, jatropha) that provide permanent vegetation cover



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Cultivation on steep slopes should be restricted to perennial crops that maintain permanent vegetation cover

without requiring tillage. This recommendation draws on studies in northern Thailand that revealed accelerated soil erosion on tilled slopes greater than 40° .⁴⁴ However, given potential socio-economic difficulties of applying this threshold for no cultivation, first priority should be given to slopes greater than 55° . Appendix 4 provides a GIS-based computation of the surface area having a slope greater than 55° per district and identifies the extent that is not under forest cover.

Government will need to provide farmers with incentives to change cultivation patterns and adopt soil conservation on these marginal and fragile lands. The obvious long-term strategy would be to generate off-farm rural employment to supplement incomes of the poorest farmers and reduce tillage on steep slopes. In the short term, cultivating perennial crops could potentially support a paid workforce and provide paid employment to farmers for planting and maintaining these crops. Some perennial crops such as *Jatropha curcas* also have the potential for generating biofuel energy that could replace local demand for fuelwood (see Chapter 11).

Strengthening agricultural governance

Post-conflict institutional memory loss has significantly hampered planning in the agricultural sector. There is a major lack of reliable baseline data to assess trends in agricultural production as well as effectiveness of agricultural interventions, particularly anti-erosion control strategies.⁴⁵ This problem is compounded by the loss of highly qualified agricultural professionals and extension service staff. Major investments in agriculture research and data collection as well as in capacity-building will hence be necessary for effective planning.

Development of national and local land use master plans

The development of national and local land use master plans with the engagement of all stakeholders are key tools in ensuring agricultural production sustainability and the ecological equilibrium of fragile ecosystems. A national land use master plan is currently being developed under the auspices of MINIRENA, which should be completed by June 2010. This will in turn allow for the preparation of

detailed land use plans at the local level. An important aspect in this planning process is determining soil suitability for Rwanda's major crops, which is a critical element in agricultural regionalisation and provision of guidance on fertiliser application.

Inadequate investment in research and data collection

Rwanda lacks applied research programmes of the size and scope needed to meet the country's planning requirements as well as to provide locally specific information for extension work and early warning on emerging threats, including food security issues, climate change and disease outbreaks. Agricultural research to improve crop and livestock production should be a priority area for investment.

Establishing national-scale monitoring of soil erosion

There is great value in establishing soil erosion monitoring stations across the country, which should be maintained for at least five years in order to obtain reliable benchmark data. The use of simple erosion pins (pegs, spikes or rods) provide a cheap and easy-to-use method for national-scale monitoring of soil erosion. The widespread use of erosion pins in local communities would also serve to raise farmers' awareness regarding the importance of soil conservation. Furthermore, the results of these field measurements would also help validate and enhance the USLE GIS model carried out as part of this assessment and provide a more accurate indicator of soil erosion rates.

Eliminating disease outbreaks

Disease outbreaks have also been an added obstacle to improved crop and livestock production. For instance, in 2005 an outbreak of banana disease (banana xanthomonas wilt) was reported in the northwest of Rwanda. This disease spreads rapidly and results ultimately in the death of the banana plant and total yield loss. At present, there are no effective control measures for this disease, which is a major threat to banana production in the whole of East Africa. The development of disease resistant cultivars must be given a high priority in Rwanda, given its implications on food security. In this regard, Rwanda would benefit from participating in regional research and development activities to address this problem.

Another important area for research and monitoring are livestock diseases. For example, epizootic disease is having a significant impact on livestock productivity in Rwanda. In addition, tsetse and trypanosomiasis remain widespread.

Wastewater biosolids as a fertiliser alternative

As discussed earlier, natural fertilisers such as animal manure and plant compost typically have low levels of phosphate; therefore, they do not significantly increase soil productivity when applied on their own. In contrast, biosolids from human wastewater contain phosphate as well as large quantities of organic matter. Further research is needed to assess the potential for converting biosolids into plant fertiliser, which could also improve sewage waste treatment in communities.

Building capacities at national and local levels

There are major technical capacity shortfalls at both national and local levels that need to be addressed. At the national level, MINAGRI has faced considerable challenges in taking up the full responsibility for developing and implementing agricultural policies, strategies and operational programmes. Although the staff are highly dedicated, there are capacity constraints and many key officers are comparatively inexperienced. For example, there is often difficulty in translating government strategic plans into research priorities and then matching them with local research expertise and funding. Furthermore, there is also a need to strengthen access to international agricultural literature including research carried out in Rwanda prior to the 1994 genocide.

With respect to the provision of extension services, implementing agencies such as RADA are playing an important role especially in promoting more sustainable agricultural techniques. However, RADA remains under-resourced and needs further capacity-building. In addition, both the NUR and ISAR have the potential to support the development of locally appropriate soil restoration strategies, but currently lack the resources to do so. Given the high variability of soils in Rwanda, it is important that technical assistance is provided based on local needs rather than general prescriptions.

At the local level, there is an urgent need to build the capacities of local authorities to enable effective implementation of decentralised functions. Many district staff have neither the training nor experience to provide credible extension services. To address this gap, RADA and RARDA need to expand their training role.

7.6 Conclusions

The transformation of agriculture in Rwanda has been set in motion and will likely accelerate with greater access to cheap fertiliser imports and the transition to commercial agriculture. The sense of urgency driving this transformation is well founded. Low agricultural productivity, combined with rapid population growth and urbanisation, will most likely result in food shortages and increased dependency on food imports in a period of rising global food prices.

At the same time, it is critical that the transformation towards market-oriented production does not compromise environmental sustainability. Urgent action is needed to address more effectively declining soil fertility, a root cause of low agricultural productivity. Major investment in agricultural research is also essential for future planning, especially in anticipation of increased climate variability. In addition, building technical capacities, at both national and local levels, will help deliver more responsive and locally appropriate solutions to soil degradation and declining yields.

The agricultural intensification package – comprising agrochemical inputs, hybrid seeds, radical terracing, cash crops and irrigation – should go a long way in revitalising the sector and meeting Rwanda's growing food demands. At the same time, to ensure environmental sustainability and take full advantage of the intensification programme, particularly expensive mineral fertilisers, a supplementary conservation agriculture option should also be embraced as an integral part of the package. This would emphasise integrated soil fertility management through a web of activities, including biological measures (hedges, progressive terracing), increasing SOM (mulching, manure), crop rotation, agroforestry including fertiliser trees, food crops and conservation of on-farm biodiversity. Conservation agriculture

should also help the poorest subsistence farmers, who may lack the resources to immediately embark on capital-intensive agriculture, feed themselves and improve their capacity to adapt to climate variability and extreme events.

7.7 Recommendations

R7.1 Promote integrated conservation agriculture. Agricultural policies and extension services should emphasise the importance of an integrated conservation agriculture approach, especially as part of the Crop Intensification Programme and other relevant government initiatives. Conservation agriculture would incorporate soil and water conservation techniques with land management practices that minimise tillage on steep slopes, maintain permanent organic cover, promote agroforestry and agrosylvopastoral systems to increase SOM and improve soil structure. At the same time, it would include application of appropriate levels of chemical fertiliser according to crop type and to restore depleted nutrients and soil fertility.

Lead agencies: MINAGRI, MINALOC, MINIRENA. International Partners: FAO, World Bank. Cost estimate: USD 5 million. Duration: 5 years.

R7.2 Improve agricultural research and data collection systems and capacity. The current absence of accurate benchmark data makes it difficult to assess the effectiveness of agricultural policy interventions as well as to provide early warning on food security issues. The objective is to build applied research programmes on subjects such as disease outbreaks, potential impacts of climate change on crop yields, integrated pest management, rangeland conservation, rural land use planning and improving soil fertility.

Lead agencies: MINAGRI, NUR, ISAR, NISR. International Partners: FAO, World Bank. Cost estimate: USD 3 million. Duration: 3 years.

R7.3 Establish national-scale monitoring of soil erosion. This would promote simple, cost-effective measurement methods, such as the extensive use of soil erosion pins (>1,000) across the country, as opposed to elaborate and expensive soil run-off plots. The large sample size would provide a solid

basis for soil erosion assessment as well as serve as a practical demonstration to farmers on the rapid rates of soil loss. Furthermore, the results of these field measurements would also help validate and enhance the USLE GIS model carried out as part of this assessment and provide a more accurate indicator of soil erosion rates.

Lead agencies: ISAR, CGIS/NUR, REMA. International Partner: FAO. Cost estimate: USD 1.5 million. Duration: 5 years.

R7.4 Increase investment in agricultural extension services. Decentralisation provides opportunities for wider involvement of local farmers and communities in designing appropriate solutions to agricultural problems. However, in order to maximise the opportunities of devolved services, substantial investment in agricultural extension services and training would be required at the local level. In this regard, expanding the training roles of RADA, RARDA and ISAR in support of local authorities and extension officers would also be needed.

Lead agencies: RADA, RARDA, RHODA. International Partners: IFAD, World Bank. Cost estimate: USD 3 million. Duration: 3 years.

R7.5 Phase out tillage cultivation on steep slopes. In principle, tillage systems on slopes greater than 40° should be replaced by the cultivation of perennial crops (e.g. jatropha, tea, and coffee). However, application of the 40° threshold for tillage cultivation should be carefully planned and address the needs of very poor farmers who cultivate these fragile and marginal lands. Therefore, priority should be on halting cultivation on slopes greater than 55°. Alternative employment should be provided, for instance, paid work for planting and maintaining perennial crops, many of which have the potential for commercialisation and, therefore, may support a paid workforce.

Lead agencies: MINAGRI, MINALOC, ISAR. International Partners: World Bank, IFAD. Cost estimate: USD 1.25 million. Duration: 5 years.

R7.6 Monitor the environmental impact of accelerating fertiliser use. A survey should be undertaken to measure the rates of nitrogen

(N) and phosphorus (P) being discharged from agricultural fields into drainage water and to assess their environmental impacts.

Lead agencies: RADA, REMA, ISAR. International Partner: World Bank. Cost estimate: USD 0.15 million. Duration: continuous.

R7.7 Promote the conservation of agricultural biodiversity. In view of the severe stress that climate change may exert on agriculture and the resilience of many traditional crop and livestock varieties, policies for their long-term conservation should be developed. Landraces (i.e. local crop varieties) are a vital genetic resource for future breeding work. Seed banks and collections of local breeds may be appropriate methods for the conservation of some varieties.

Lead agencies: MINAGRI, REMA, ISAR. International Partner: FAO. Cost estimate: USD 0.5 million. Duration: 2 years.

R7.8 Reduce the prevalence of livestock disease and improve pasture quality. The objective is to improve livestock productivity and reduce herd size to alleviate overgrazing pressures. Reductions in livestock disease would require investment in veterinary services as well as countrywide programmes of animal vaccination and vector control. Pasture improvement and the conversion of pastureland to no-till forage cropping land would further help reduce land degradation and enhance productivity.

Lead agencies: RARDA. International Partner: FAO. Cost estimate: USD 2.5 million. Duration: 5 years.

R7.9 Engage in regional and international agricultural research. As government investment in agricultural research is limited, there is a need to enhance collaboration and benefit from outside expertise including accessing external funding sources for agricultural research. Because agricultural research and development (R&D) can be slow and costly, regional and international cooperation in agricultural research would help address current capacity and resource shortfalls.

Lead agencies: MINAGRI, ISAR. International Partner: FAO. Cost estimate: USD 1 million. Duration: 3 years.

Forest Resources

*Harvesting of mature plantations
can significantly contribute
to the national economy*

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Forest Resources

8.1 Introduction

Despite reforestation efforts, there has been a drastic reduction in total forest cover in Rwanda since independence. Indeed, forest resources have been under increasingly severe stress, due to high population growth and resettlement of displaced persons, and related demands for agricultural land, firewood and other forest-based products.

The forestry sector was heavily impacted by the 1990-1994 conflict, as well as earlier conflicts in the country. Bush fires were started to remove vegetation cover from being used by military forces for concealment, tree plantations were cut down to install IDP and refugee camps, and trees were felled to provide fuelwood for camp populations. In addition, many forestry professionals and technicians were killed and others left the country, as donors withdrew and development projects shut down. The post-conflict period (1994-2000) also witnessed accentuated deforestation and forest degradation, due to the resettlement of returnees and survivors of the genocide.

Today, the country faces the challenge of re-organising, decentralising and strengthening forest management, including development of institutional capacity and human resources. In this context, there are three main areas of work critical for sustaining forest resources: (i) rehabilitating the remaining natural forests; (ii) developing the livelihood potential of forest resources; and (iii) strengthening governance in forest management, including regional cooperation on transboundary resources.

This chapter focuses on forest management issues. The issue of forest biodiversity is not covered in this post-conflict assessment and may be found elsewhere in the literature.

8.2 Assessment activities

The assessment of the forestry sector covered the entire country. Fieldwork included site visits to montane forests, forest patches in the savanna, tree plantations and nurseries, logging areas, agroforestry areas, local markets selling wood-based products, and rural communities.



Gishwati Forest was heavily impacted by resettlement during the post-conflict period, converted mainly for pasture and farming; an estimated 2 percent of the original forest remains today

Table 21. Field sites visited by province

Province	Field sites
Kigali	– Gakinjira wood market
Northern	– Buhanga relict montane forest in Musanze District – Yanze agroforestry and watershed management project in Rulindo District
Southern	– Busaga relict montane forest and logging area in the Ndiza mountains, in Muhanga District – Kitabi - Mudasomwa buffer zone tree plantations of Nyungwe National Park, in Nyamagabe District
Western	– Gishwati tree rehabilitation sites and remnants of forest reserve in Rutsiro District – Rubavu tree nursery ¹ – Karongi: Sakinyaga tree plantations – Gakeri (Rutsiro District) logging area
Eastern	– Akagera National Park – Nyagatare District: grouped settlement (imidugudu) in Mirama – Bugesera District : plantations on the shores of Lake Rumira – Muvumba River Gallery Forest – Makera swamp forest – Tree plantations in Ngoma and Kirehe Districts

The forestry sector assessment received substantial support from the Ministry of Natural Resources (MINIRENA), including organising consultations and site visits and imparting detailed information. Consultations with other key government stakeholders included: Ministry of Agriculture and Animal Resources (MINAGRI), Rwanda Environment Management Authority (REMA), Rwanda Office of Tourism and National Parks (ORTPN), Rwanda National Forestry Authority (NAFA), Forestry Management Support Project (PAFOR), National University of Rwanda (NUR) and district authorities.

Other stakeholders involved in consultative meetings and focus group discussions included development agencies such as the Belgian Technical Cooperation (BTC) and the Swiss Agency for Development and Cooperation (SDC); international and local NGOs, such as Care International and the Rwanda Ecological Association (ARECO), and local communities.

8.3 Overview of the forestry sector

Historically, about 70 percent of the national territory was covered with natural forests, but a drastic 60 percent reduction in the natural forest area has occurred since independence. Today, natural forests,

which are located almost entirely in protected areas, account for only 5.3 percent of the land area.²

To provide a broad understanding of forest resources in Rwanda, this chapter expands on four main areas:

- types of forests, woodlands and trees outside forests;
- extent of forest cover;
- major causes of deforestation; and
- forest services and utilisation.

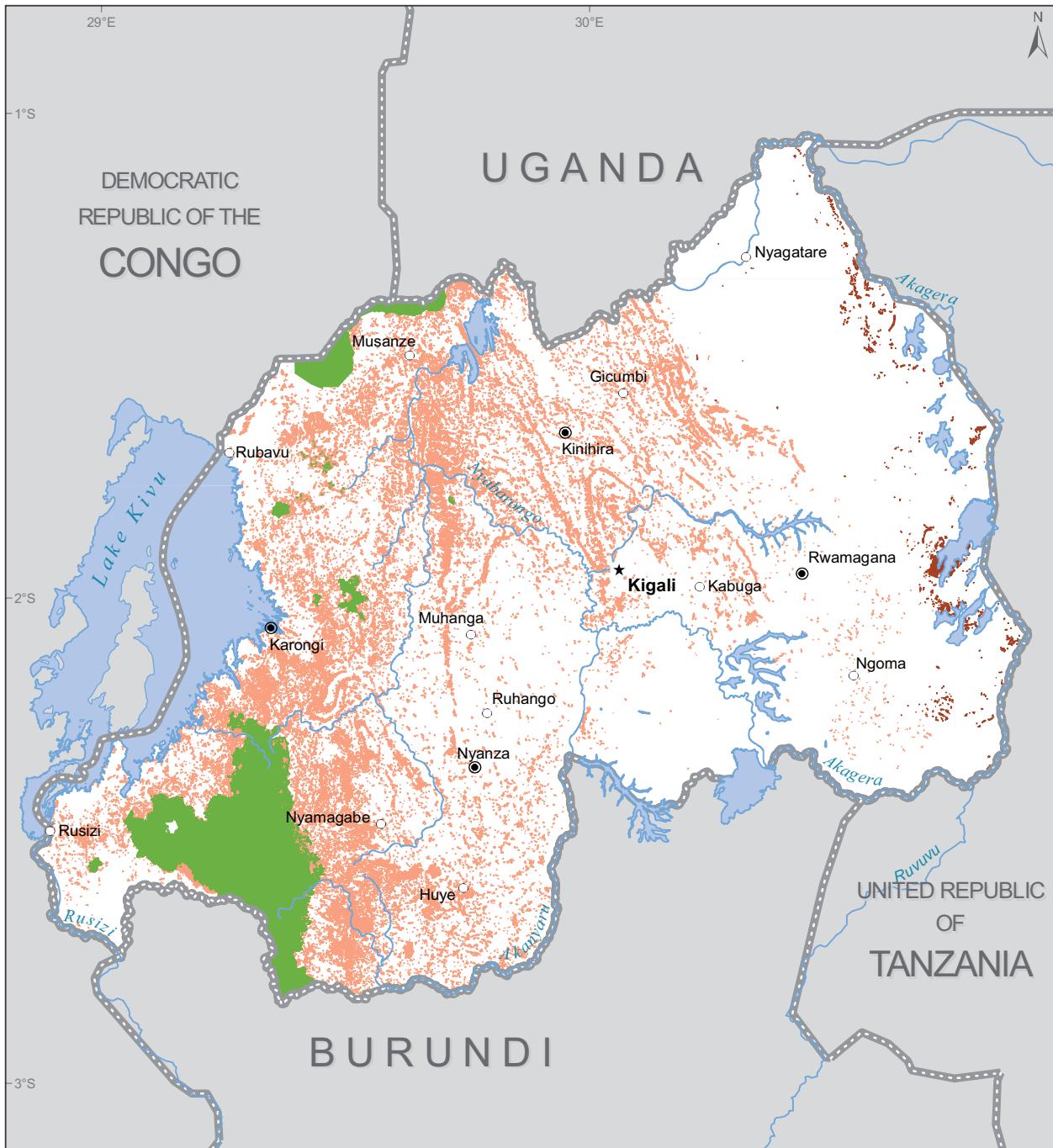
Forests, woodlands and trees outside forests

The wide variety of forest and woodland ecosystems found in Rwanda is due to the highly variable relief and latitude, soil types and rainfall. There are four major types of forest and woodlands in Rwanda:

- Afro-montane rainforests;
- forest patches in savanna landscapes;
- tree plantations; and
- other trees and shrubs outside natural forests and tree plantations, including tree stands in agricultural lands as well as agroforestry systems.

Natural forests consist of Afro-montane rainforests and forest patches found in savanna landscapes. Almost the entire area of the remaining montane rainforests lies in protected areas, i.e. either in national parks, forest reserves or culturally protected areas.³

Map 12. Rwanda forest cover



Afro-montane rainforests

Afro-montane rainforests are those located along the Congo-Nile watershed and include those in Volcanoes National Park, Gishwati and Mukura Forest Reserves, and Nyungwe National Park. There is great floral variation and diversity, mainly because of the wide altitudinal range in this area. However, most of the remaining montane forests are highly degraded to secondary forests, which are dominated by low timber value trees, shrubs and invading plants. Only a few patches of primary forests are found in remote areas of Nyungwe National Park.

The forests found in Nyungwe National Park, including the rainforest patch in Cyamudongo, comprise the largest block of remaining montane rainforest in East Africa. This rainforest block rises from 1,600 to 2,950 m above sea level. The western section, on schist, supports fine *Chrysophyllum-Entandrophragma-Newtonia* forest that descends to about 1,600 m above sea level. The eastern section, on granite, lies higher (2,200-2,500 m above sea level) and is covered with *Macaranga*-dominated secondary forest, which is interrupted by very large clearings. Open clearings are mostly covered with rapidly invading bracken (*Pteridium aquilinum*)

and *Sericostachys scandens*. The shallow soils support heath and bamboo (*Arundinaria alpina*). Extensive peat bogs occupy many stream depressions. The varied topography and soils, along with the broad altitudinal range found in Nyungwe, provide a wide span of micro-habitats, creating a high level of terrestrial biodiversity.⁴ A buffer zone planted mainly with pine surrounds the forest and serves as a production area to generate income for local communities.

Located up to 3,300 m above sea level in Volcanoes National Park, montane and sub-alpine rainforests are largely dominated by monospecific stands of bamboo (*Arundinaria alpina*) or *Hagenia-Hypericum* forests. Alpine grasslands occur 4,000 m above sea level. At a lower altitude between 2,400 and 2,500 m above sea level, secondary montane rainforests are dominated by the pioneer species *Neoboutonia macrocalyx* and Giant *Lobelia* spp. *Senecio* spp. covers the meadows above the treeline.

There are remaining forest patches that were part of the formerly continuous rainforest covering the Congo-Nile highlands. These include Gishwati and Mukura Forest Reserves and consist primarily of secondary forests due to high human disturbance.⁵



Giant Lobelia in disturbed part of Nyungwe Forest



Relict Afro-montane rainforest of Busaga

Box 8.1 Remnant rainforest patches

Few relict or remnant rainforest patches still exist, mainly due to historical and cultural reasons. These include:

Buhanga forest is located about 7 km south of Ruhengeri City in Musanze District. Gazetted as a nature reserve in 2006, this forest is located at 1,650 m above sea level and covers an area of about 15 ha on volcanic soil. Buhanga forest is also known as Gihondohondo, which is the vernacular name for *Dracaena steudneri*, the dominant species at this site. The canopy is very open and characterised by solitary *Ficus thonningii*. The understory is highly encroached and dominated by secondary species.⁶ It is believed that the first king of Rwanda ruled from Gihondohondo, a belief that afforded this site some protection. There are plans to promote tourism in Gihondohondo as a natural heritage site for its historic and cultural value.

Sanza forest is located in Ngororero District and covers an area of about 20 ha along the Satinskyi River, between 1,600 and 1,650 m above sea level. It is highly degraded and dominated by secondary species.⁷

Busaga forest is located on the Ndiza mountain chain in Muhanga District. It covers an area of about 150 ha, between 1,900 and 2,200 m above sea level, and borders the Sumo River at its northern end. This partly closed canopy forest still contains primary species.⁸ The adjacent local communities believe that the kings used certain plants and animals as fetish to enhance their powers and to amass fortune. This myth contributed to the protection of this forest patch over the centuries. Before 1994, to protect the area, a narrow strip of *Eucalyptus* was planted along the forest boundary and forest guards assigned. Despite these measures, UNEP was informed that illegal logging and hunting persist.

Forest patches in savanna landscapes

Gallery forests are a characteristic feature of the savanna landscape, consisting of narrow belts along stream channels. Previously, they were widespread along rivers and streams of southeastern and eastern Rwanda. These forests have their own floristic composition and provide critical protection for riverbanks.⁹

Other types of forest patches include: thicket clumps, dry forests, gully forests and riverine forests. These semi-evergreen forests are irregularly distributed within the savanna grass landscape.¹⁰ Outside the Akagera National Park, small forest

formations have been largely decimated due to local collection of firewood, including for charcoal production. Of note is an old specimen of the wild olive tree (*Olea europaea* subsp. *africana*), a characteristic species of thicket clumps, that has almost completely disappeared due to the prized high-quality charcoal produced from its wood.¹¹

Noteworthy is a discovery by the UNEP team of *Ximения americana* var. *americana*, a new species for Rwanda, in the vicinity of Lake Hago in the Akagera National Park. This thorny shrub of the *Olacaceae* family is found in the adjacent dry savannas of the United Republic of Tanzania.



Thicket clumps and dry forest patches are a characteristic feature of Akagera savanna landscape



Makera swamp forest along the Akagera River at Ibanda (left)

The saline Makera stream is highly valued as a watering point for livestock (right)

Case study 8.1

Makera swamp forest: Individual action triggers conservation success

The swamp forest of Makera is a unique forest in the savanna landscape, along the Tanzanian border. This forest was heavily damaged in the late 1970s and 1980s by the Bugesera-Gisaka-Migongo agricultural project and by immigrants from northwestern Rwanda searching for farmland. The remaining area of about 150 ha is surprisingly intact¹² and is the only remaining forest swamp of this size on the Rwandan side of the Akagera River.

The swamp forest's closed-canopy has a distinctly wetter micro-climate than the surrounding savanna, accounting for its high biodiversity. Makera is distinguished by palm trees (*Phoenix reclinata*) in its wetter parts. Its wood is termite-resistant and is highly valued by locals as building material. *Ficus* trees are abundant in the canopy, while the understorey is dominated by *Dracaena afromontana*, which outside of Makera is naturally found only in montane rainforests.¹³

It is remarkable that this unique swamp forest endured the conflict period without serious human disturbance, despite the absence of local authorities even long after the conflict ended. This positive outcome is largely attributable to the initiative of a former forest guard of the Rwanda Institute of Science in Agriculture (ISAR), who was able to mobilize assistance from the army commander in the area to prevent illegal activities.

Tree plantations

Tree plantations are spread all over the country, but are mainly concentrated in the more humid parts. There are three types of tree plantations: (i) state; (ii) district; and (iii) private.

About two-thirds of tree plantations are governed under public law. These include both state and district plantations, which are managed, respectively, by central government and district authorities.

State plantations mainly include buffer zone plantations around the natural forests of the Congo-Nile highlands and hilltop afforestation all over the country implemented under various development projects. They also include some old plantations established before independence.

District plantations comprise afforestation activities carried out during the colonial period by (i) religious



Many people rely on trees and shrubs found on marginal lands and along roads to help meet their fuelwood needs

organisations; (ii) non-governmental organisations (NGOs); and (iii) community work (*umuganda*), especially as part of the National Tree Day launched in 1976. Most private plantations consist of small woodlots (<0.5 ha) on individual farms.

Two-thirds of the total tree plantation area and most private plantations consist of *Eucalyptus* trees. Pines (mainly *Pinus patula*) have been planted extensively as buffer zones around natural forests in the Congo-Nile highlands.¹⁴ Small-scale activities to propagate indigenous trees using enrichment planting techniques are under way to rehabilitate degraded montane rainforests.¹⁵

Other trees and shrubs outside forests

Other trees and shrubs outside natural forests and tree plantations make up the rest of general tree cover in Rwanda. This significant category includes agroforestry areas (mainly on farmlands), as well as trees and shrubs found in marginal lands and other open spaces.

Rwanda has an established tradition of agroforestry, promoted in large measure since the 1980s by various international agencies.¹⁷ Nowadays, trees and shrubs are an integral part of most agricultural fields in Rwanda, including trees such as the widely used *Grevillea robusta*, *Maesopsis eminii* or *Markhamia lutea*, and shrubs such as *Calliandra calothyrsus*, *Cajanus cajan*, *Leucaena* spp. or *Sesbania sesban* var. *nubica*. As many agroforestry species are leguminous with nitrogen fixation capacity, these trees contribute to soil conservation and help sustain and restore soil fertility. Agroforestry is also an important provider of wood and non-timber products for domestic use and for the market.¹⁸

Table 22. Ownership of tree plantations in 1989¹⁶

Tree species	State plantations		District plantations		Private plantations		Total	
	ha	%	ha	%	ha	%	ha	%
Eucalyptus	30,600	12.4	69,370	28.1	61,040	24.6	161,010	65.1
Pinus	18,360	7.4	9,910	4.0	4,360	1.8	32,630	13.2
Cupressus	4,900	2.0	7,930	3.2	8,720	3.5	21,550	8.7
Acacias	4,280	1.7	6,940	2.8	–	–	11,220	4.5
Grevillea	1,230	0.5	1,980	0.8	4,360	1.8	7,570	3.1
Callitris	1,830	0.7	2,970	1.2	–	–	4,800	1.9
Others	–	–	–	–	8,720	3.5	8,720	3.5
Total	61,200	24.7	99,100	40.1	87,200	35.2	247,500	100

Note:

– Indicates data not available.

Extent of forest cover

There are considerable discrepancies in the estimates and data on forest coverage, depending largely on how forests are classified. According to Food and Agriculture Organization (FAO) estimates, about 19.5 percent of the land area is covered with forests, including tree plantations.¹⁹ However, according to a forest inventory carried out by the NUR Centre for Geographic Information Systems and Remote Sensing (NUR-CGIS) in collaboration with the Ministry of Lands, Environment, Forestry, Water and Mines (MINITERE) - now Ministry of Natural Resources (MINIRENA) - in 2007, Rwanda's forest cover is only 9.7% of the land area.

The CGIS study, which is based on satellite remote sensing, shows that natural forests currently cover about 127,000 ha, while the total area of tree plantations is 114,000 ha.²⁰ This figure obtained for tree plantations represents only 37 percent of the tree plantation area in 2002.²¹ The data revealed that the total forest cover, including plantations, decreased from about 265,000 ha in 1988 to 241,000 ha in 2007.

Even though the CGIS inventory does not include the large number of small plantations (<0.5 ha), the discrepancy between these two inventories remains very significant. Such a large difference in forest cover data undermines future planning. It is therefore imperative that additional field

verification of the CGIS forest inventory and mapping are carried out in order to obtain one single accurate baseline (discussed further under "Key issues").

Major loss of natural forests

As shown above, a reduction of at least 60 percent of the natural forest area has occurred since independence, with 41 percent reduction of the montane rainforests. The post-conflict period has witnessed major forest reduction, resulting in a 25 percent reduction in montane rainforests and gallery forests and the loss of two-thirds of the protected savanna landscape between 1990 and 2002.

The loss of natural forests has been partially offset by the considerable increase in the area under tree plantations, mainly of eucalyptus and pines. Major efforts to establish tree plantations were made throughout the country both before and after the conflict. In 1970, there were less than 30,000 ha of tree plantations, which has expanded by 10 to 14 times to 307,000 ha in 2002 according to the Ministry of Lands, Human Resettlement and Environmental Protection (MINITERE, 2005) and 419,000 ha in 2005 according to FAO statistics (2005). This translates to an increase from 1 percent of the land area covered by tree plantations in 1960 to 12.4 percent in 2002 (or 17 percent in 2005 according to FAO).

Table 23. Change of forest area in Rwanda between 1960 and 2002²²

Vegetation type	Area in ha							Percentage change in forest cover
	1960	1970	1980	1990	1996	1999	2002	1960-2002
Natural montane forests								
Volcanoes National Park	34,000	16,000	15,000	12,760	12,760	12,000	12,000	-65%
Gishwati	28,000	28,000	23,000	8,800	3,800	600	600	-98%
Mukura	3,000	3,000	2,100	2,100	1,600	1,200	1,200	-60%
Nyungwe National Park	114,000	108,800	97,500	97,500	94,500	92,400	92,400	-19%
Subtotal	179,000	155,000	137,600	121,160	112,660	106,200	106,200	-41%
Forest patches in the savanna								
Akagera National Park [*]	241,000	241,000	241,000	241,000	241,000	90,000	90,000	n.a.
Mutara Game Reserve [*]	64,000	45,000	45,000	34,000	0	0	0	n.a.
Gallery forests	150,000	150,000	90,000	55,000	30,000	25,000	25,000	-83%
Subtotal	455,000	436,000	376,000	330,000	271,000	115,000	115,000	n.a.
Forest plantations	24,500	27,160	80,000	247,500	232,000	252,000	306,663	n.a.

Notes:

^{*} Only a minor part consists of small dry forest formations of variable size (thicket clumps, dry forests, gully forests, gallery forests, riverine forests along lakeshores), n.a. = Indicates not applicable.



Tree plantations, mainly of eucalyptus and pines, account for the major part of Rwanda's forest cover

Despite their major share in total forest cover, tree plantations have a considerably lower biodiversity value compared with natural forests and consume large quantities of water (especially in the case of eucalyptus trees). Moreover, only 0.1 ha of forest area per capita remains in Rwanda today, compared with an average of 0.7 ha per capita in Africa.²³

Major causes of deforestation

Forest resources are increasingly under severe stress due to high population growth. The high human pressure on forest resources is driven primarily by: (i) increased demand for agricultural lands; (ii) resettlement of internally displaced persons (IDPs) and returnees as well as to a limited extent the settlement of foreign refugees; and (iii) demand for firewood and other forest-based products.

Deforestation and forest degradation of the highly vulnerable montane forest ecosystems have resulted in more frequent and serious flooding and landslides. Since 2006, floods and landslides have occurred with increasing frequency and severity in the Western and Northern Provinces, resulting in casualties and major damage to infrastructure and food crops.

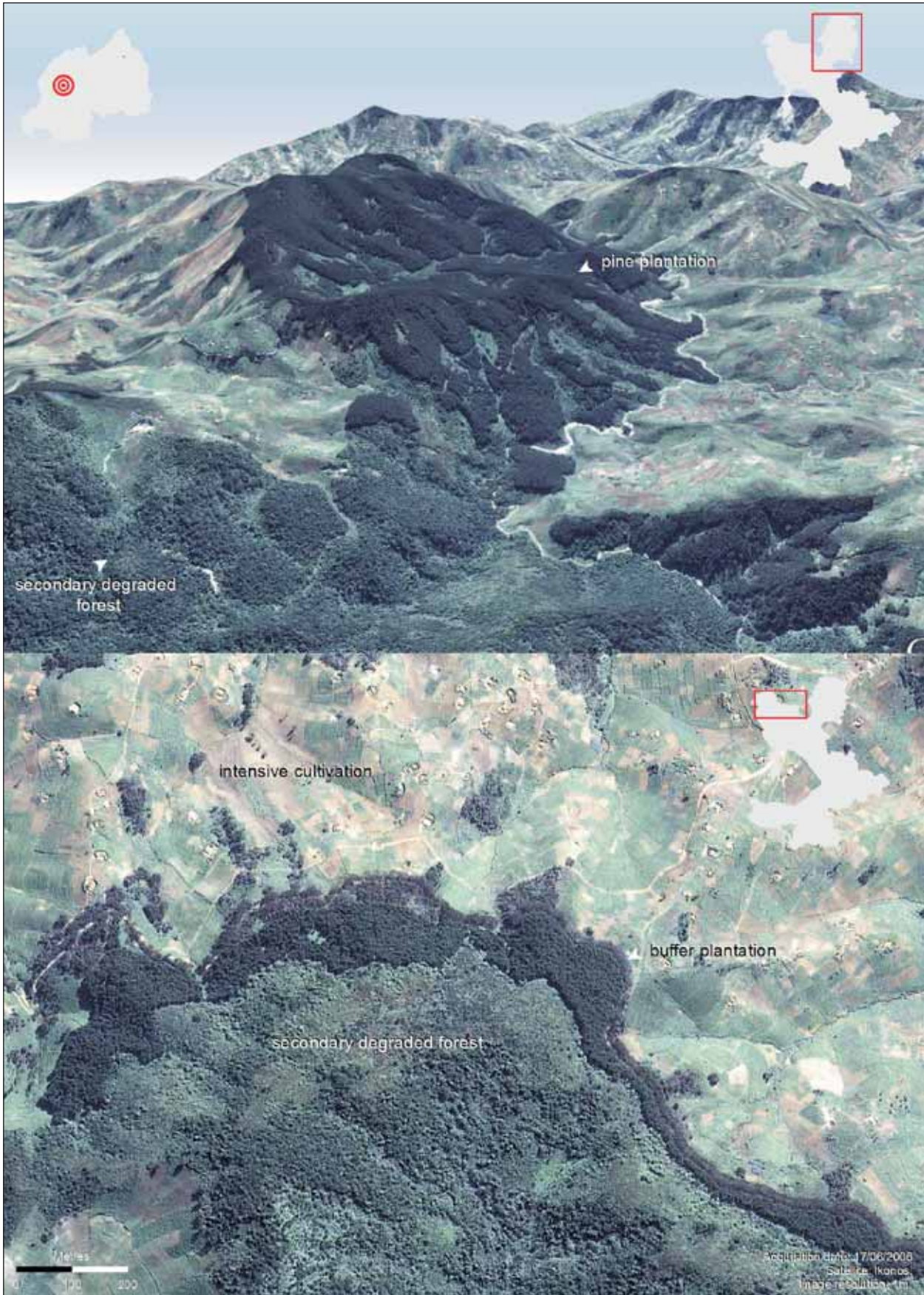


Demand for agricultural land remains the main pressure on forests; shown here are tea plantations surrounding Nyungwe Forest

Direct conflict impacts

Gishwati and Mukura rainforests were almost completely cleared during the post-conflict period, mainly to fulfil returnees' needs for farmland, pastures, building materials and firewood. In addition, numerous tree plantations greatly suffered during and following the conflict with the installation of regrouped settlements (*imidugudu*) within or nearby plantations. Estimates cited about 15,000 ha of tree plantations destroyed and about 35,000 ha seriously degraded.²⁴

Figure 12. Land use pressures surrounding Mukura rainforest





Complete burning of the vegetation by dry season fires in the northern part of the Akagera National Park

Other stress factors

Other factors exacerbate deforestation. Mining of gold, colombo-tantalite and cassiterite have led to large mining camps inside forests, which result in significant encroachment and forest degradation in localised areas. The growth of invasive liana plants and spread of fires are also becoming more widespread, seriously degrading the remaining montane forests. These threats mainly affect natural forests in protected areas, as discussed in Chapter 10.

Development projects also put pressure on Rwanda's forests. Most of the gallery forests have been cleared to produce cash crops, by subsistence farmers as well as pastoralists.²⁵ Deforestation, however, has been significantly reduced in natural forests due to firm political commitment and better enforcement.

Efforts have been made to rehabilitate tree plantations and reforest some areas, by PAFOR as well as by local governments and their various partners. The Rwanda Reforestation Programme (PAREF), supported by the Belgian Government,

is currently undertaking preparations for a major intervention. Nonetheless, illegal cutting continues in tree plantations, although at reduced levels.

Forest services and utilisation

A range of ecosystem services

Woodland ecosystems – including forests, tree plantations and other trees and shrubs – provide a wide range of services crucial for the livelihoods of rural as well as urban communities in Rwanda. They have ecological, economical, recreational and cultural values, known collectively as ecosystem services.

Forests and tree plantations are essential for regulating the hydrological cycle and the regional climate and for protecting watersheds that service adjacent communities and those further downstream. They play a critical role in climate change mitigation by storing large quantities of carbon and harbour biodiversity of global importance. In addition, the remaining natural forests not only provide a potential source for ecotourism, but are also an important part of local heritage and culture.

Trees and shrubs provide building materials, and wood is by far the main household energy source in both rural and urban areas. Other benefits derived from afforested areas (i.e. tree plantations, agroforestry, etc.) include provision of fodder and non-timber products such as wild fruits and vegetables, medicinal plants, mushrooms and honey.²⁶

Contribution to the national economy

Despite providing a wide range of goods and services, the contribution of the forestry sector to the gross domestic product (GDP) is not fully recognised. According to an estimate by MINAGRI (1998), the forestry sector contributed only 0.6 percent to GDP in 1997. This low figure may be explained by the fact that not all forest products have been considered and that the full range of forest ecosystem services was not valued. For instance, according to one estimate, the value of firewood and charcoal alone in 2007 was about USD 122 million, amounting to 5 percent of GDP in 2007.²⁷

In addition, no reliable data exists on household use and selling of wood products (e.g. round wood, sawn

wood, charcoal, firewood, etc.) and the import or export of wood products. As the wood processing industry is poorly developed, Rwanda imports wood-based materials (e.g. fibreboards, particleboards, plywood) as well as high-value timber, such as mahogany and teak, from neighbouring countries.



Children collect honey from a tree plantation near Ruhango. Smoking out the bee nest, however, has accidentally caused a bush fire



The central wood market at Gakinjoro in Kigali

8.4 Governance

Governance of the forestry sector is currently undergoing major restructuring. Institutional mandates and policies are therefore still under development.

At present, forest management is regulated by Law No. 47/1988 on the Organization of the Forestry Regime in Rwanda, which was the first forestry law to be enacted after the colonial period. This law, which is currently under review, recognises only three forest domains in the country: state forests, district forests and private forests. Only trees from plantations are exploitable and extraction from natural forests is prohibited. Logging any area greater than 2 ha is subject to a felling permit, regardless of whether the plantation is on public or private land. The sale certificate and transport permit are supplied free of charge. A ministerial order of 2004 sets the rules for joint forest management of public tree plantations with the private sector.

NAFA, the national authority for forest management was established in 2007 and should considerably facilitate the coordination of forestry activities and contribute to improved governance in the forestry sector. Under the ongoing restructuring of public agencies, NAFA will be incorporated into the new Rwanda Natural Resources Board (RNRB), which will oversee the management of natural resources including forestry and agroforestry resources. At the district level, the official in charge of natural resources and environment deals with forest issues. Duties



Abundant natural regeneration of pines (Pinus patula) in windfall gap

include collecting baseline data, which are forwarded to central government institutions for compilation.

Decentralisation is also expected to improve forestry governance, in particular through the involvement of local communities in forest management.

8.5 Overview of key issues

Forests provide a wide and critical range of ecosystem services, and major opportunities exist to maximise the development potential of forests in a sustainable manner. The forestry sector needs to be strengthened in three key areas:

- rehabilitating natural forests;
- developing the livelihood potential of forests, through agroforestry, tree plantations and participatory forest management; and
- strengthening governance, specifically capacity-building and information management.

Rehabilitating natural forests

Given the extent of loss and exploitation of natural forests especially during the post-conflict period, there is a need to conserve and rehabilitate degraded sites. Restoration measures are usually very costly; therefore, priority should be given to rehabilitating montane rainforests because of their high conservation value. Rehabilitation of gallery forests is also important for protecting riverbanks and biodiversity.

The rehabilitation of degraded montane forest ecosystems in the Congo-Nile highland area needs to be reinforced to ensure the conservation of their unique biodiversity. Initiatives are already underway for Gishwati and Mukura Forests. Rehabilitation efforts in Gishwati Forest aim to support the survival of endangered populations of chimpanzees, and improve the livelihoods of the local communities. In Mukura Forest, a project is being conducted by the local NGO ARECO to develop a forest management plan, focused on securing the livelihoods of adjacent local communities.

Rehabilitation of montane forests and the afforestation of degraded sites constitute also important measures for disaster risk reduction, especially in the context of climate change and increasing frequency and severity of natural hazards.



*Gallery forest restoration along the Muvumba River near Nyagatare with *Acacia kirkii* subsp. *mildbraedii* wildlings planted in December 2005 (top)*

Illegal felling and charcoal making in Muvumba Gallery Forest at Nyagatare (bottom)

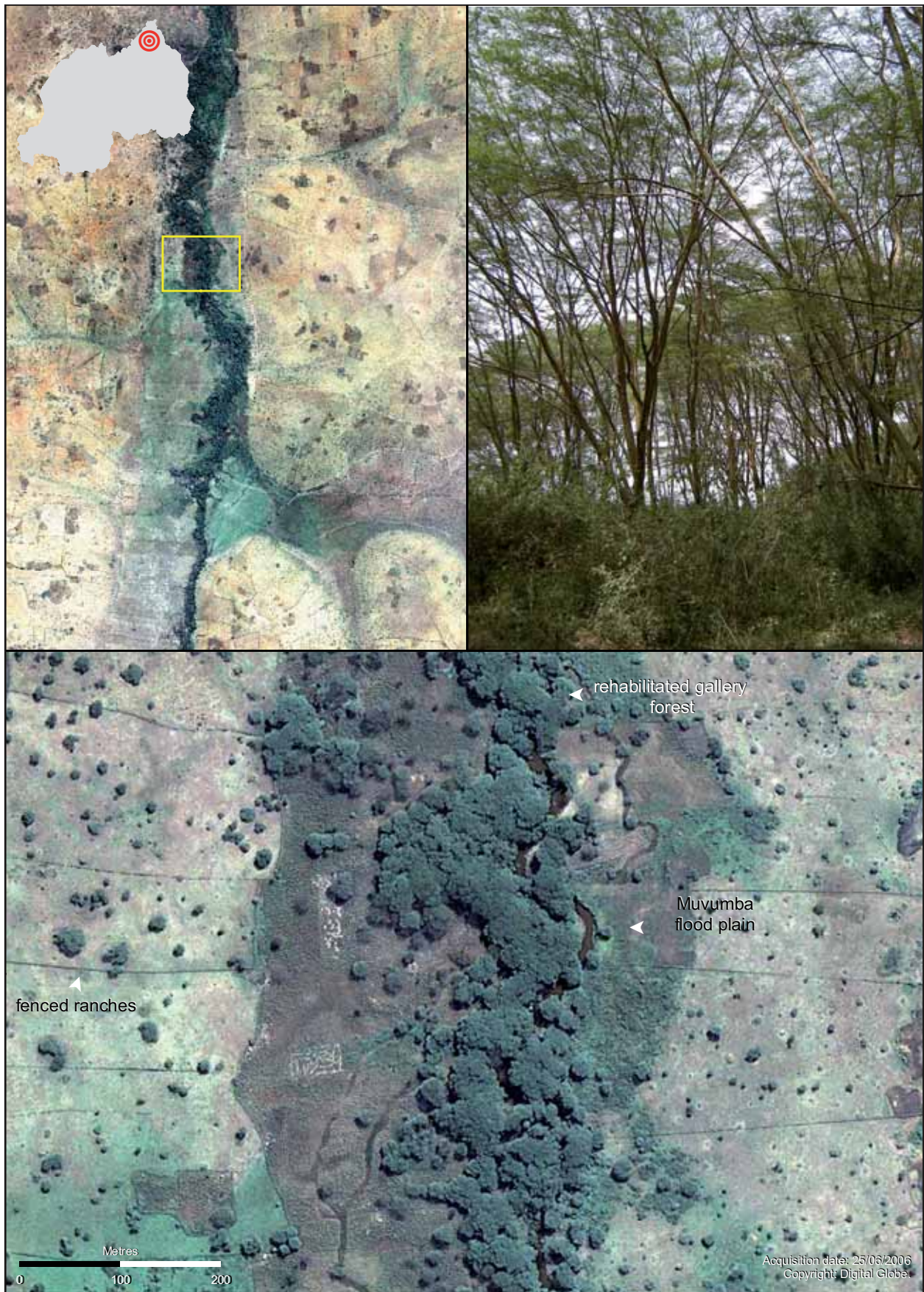
Case study 8.2 Restoration of gallery forests along the Muvumba River

Most gallery forests in savanna landscapes were decimated during the last decades. *Acacia kirkii* subsp. *mildbraedii*, a gallery forest flagship species is now rare and threatened with extinction. Consequently, erosion has greatly increased due to bare, unprotected riverbanks.

Through the African Development Bank project PAFOR, efforts have been made to restore gallery forests along Muvumba River in the Eastern Province. Although first attempts to protect the river banks in Nyagatare District by planting exotic species failed, planting indigenous *A. kirkii* subsp. *mildbraedii* wildlings proved successful.

In order to ensure natural regeneration, *Acacia* seedlings under mother trees were artificially watered within the remaining gallery forests in the area. Seedlings of adequate height and quality were then placed in pods and transferred to the rehabilitation site. This innovative approach allowed gallery forests to be restored in an ecologically sound way, within a short time and at low cost.

Figure 13. Rehabilitation of degraded Muvumba gallery forest



Developing the livelihood potential of forests

Alternative livelihoods based on forests could provide much needed new income sources for rural communities and reduce their dependency on agricultural activities. In this regard, there is a need to empirically quantify the importance of the forestry sector to national development and poverty reduction. This should include economic valuation of the wide range of forestry products that are both used domestically and traded on the market.

Three ways of harnessing the livelihood potential of forests are highlighted in this section:

- maximising the potential for agroforestry;
- harvesting mature tree plantations; and
- involving local communities in the management of public tree plantations.

Maximising the potential for agroforestry

Trees and shrubs outside protected areas and tree plantations are a major source of wood and non-timber products for the majority of the

rural population. Yet the extent and benefits of agroforestry resources are not fully known and, therefore, remain underutilised.

The role of agroforestry in firewood supply has not been quantified, but is considered to be substantial. About 99 percent of household energy needs, mainly for cooking, are met by biomass,²⁸ which not only come from forests and plantations, but also to an important extent from trees and shrubs growing on agricultural fields and small private woodlots. Greater recognition of this source of fuelwood is needed, as it has significant implications on planning for the forestry and energy needs of a growing population. Further discussion on household energy sources is found in Chapter 11.

Agroforestry also supplies a range of non-timber products (e.g. medicinal plants, fruits, honey, etc.), which can be an important source of additional income and household nutrition. In addition, agroforestry systems can play an important role in watershed management, as demonstrated by a World Food Programme (WFP) pilot project visited by UNEP in Yanze, Rulindo District (Northern Province).



Typical agroforestry system in the Congo-Nile highlands



An example of an agroforestry project in Umutara

Vision 2020 aims to extend agroforestry systems to 85 percent of all cultivated area, but progress to date has been slow and should be reinforced in the upcoming revision of the National Forestry Plan. There is still considerable potential to increase tree and shrub cover on farmlands, rangelands, marginal lands and other bare or open spaces.

Growing multipurpose trees and shrubs, in particular, has considerable merit and could complement agricultural and livestock activities. Even at higher altitudes, multipurpose bamboos (*Arundinaria alpina* and *Bambusa vulgaris*) are highly productive and a good alternative to trees.²⁹

Harvesting mature tree plantations

A major economic potential exists from the harvesting of at least 20,000 ha of mature pine plantations estimated to be worth USD 36 million.³⁰ The value of these pine plantations could significantly contribute to GDP.

The mature pine plantations are located along the buffer zones of Nyungwe National Park, which are now ripe for a final cutting. The remaining younger plantations are ready for thinning. Generally neglected over the years, most pine stands are now very dense, and some are even overmature. This major asset, however, is currently at risk of being damaged from natural hazards. Due to high stem density, the stands have become increasingly vulnerable to windstorms; many uprooted pine trees were found during the field visit. They are also vulnerable to fire and disease outbreaks.

A management plan should be developed for the sustainable management and exploitation of buffer zone plantations, taking into account their economic potential and ecological value. It will be important to span the harvest operation over several years in order to avoid oversupply and decline in wood product prices. This should also enable the development of downstream economic activities, thus increasing the added value of wood products. In addition, careful management practices must be put in place based on consultations with various stakeholders. Specifically, both rapid thinning and final cutting are very much needed, not only for ecological reasons but also to avoid economic loss. The harvesting of these pine plantations also represents an ideal opportunity to involve local communities.

Involving local communities in the management of public tree plantations

Participatory forest management is a new approach in Rwanda and is particularly relevant within the ongoing context of decentralisation. Public tree plantations offer a good opportunity to introduce participatory forest management. Involving local communities in managing public tree plantations could provide a significant source of off-farm employment.



Community involvement is essential to stem the illegal cutting of cypresses (*Cupressus lusitanica*) as shown here at Sakinnyaga, near Karongi



Women are typically involved in tree nursery activities as shown here at the COJEPE cooperative in Rubavu District

Community involvement could also extend to harvesting operations based on formal contracting between local communities and districts or MINIRENA. For instance, communities could play a greater role in monitoring the issuance of logging and transport permits and thereby reduce illegal logging activities.

Other possibilities for community participation include the reconversion of old eucalyptus plantations. Due to the age and poor cutting techniques, the productivity of most of these stands is currently very low.³¹ Old stands, therefore, need to be replaced by new plantations. Species selection has to be done carefully depending on the purpose of the plantation and site properties.

Major obstacles to participatory management include: (i) lack of trained associations; (ii) poor monitoring by the forest service; and (iii) the absence of an appropriate revenue-sharing arrangement between districts, local communities and the National Forestry Fund to help ensure equitable distribution of forest revenue. Larger plantations offer the possibility of developing forest management contracts between districts and private investors.

Strengthening governance in forest management

Achieving sustainable forest management will largely depend on strengthening governance in the sector. Improving governance has three aspects: (i) developing capacity, both at national and local levels; (ii) updating and harmonising baseline data and information management for long-term planning; and (iii) promoting regional forest cooperation.

Developing capacity

Governance in the forestry sector remains inadequate due to lack of sound institutions and competent personnel.³² Additional capacity-building for the various institutions, including local government institutions, involved in forestry management is required at all levels to ensure the protection of the remaining natural forests and better management of tree plantations. Increased patrolling and more effective control of felling and transport permits in tree plantations are also necessary. A capacity development strategy should be developed and implemented in line with the national skills audit undertaken by MIFOTRA / HIDA in 2008.

Each district should have at least one professional forester, for instance through NAFA, who can also oversee participatory forest management efforts.³³ Ongoing initiatives aimed at human resources development in the sector also need to be strengthened and supported, including a post-graduate programme (MSc) in agroforestry offered by NUR, training of agroforestry technicians at the secondary school at Kibisabo, and training programmes in natural resource management at Kitabi College of Conservation and Environmental Management (KCCEM).

Filling the information gap

In order to improve planning in the forestry sector, there is a need to quantify the full extent of its contributions to social and economic development, including those from firewood, non-timber forest products and environmental services.³⁴

A future challenge will be to mobilise resources for basic information and knowledge management. Baseline information is particularly needed on:

- current growing stock (total wood volume) of public and private tree plantations and their priority for thinning or final cutting;
- use of wood and non-timber forest products at the household level; and

- extent of tree and shrub cover outside of natural forests and tree plantations, including cultivated lands and rangelands.

There is a need to facilitate direct access to forestry data through centralised information management. A databank for this purpose could be established under NAFA. To ensure the reliability of the data, training of field persons in charge of data collection is necessary.

Promoting regional forest cooperation

The Conference of Ministers in Charge of Forests in Central Africa (COMIFAC), in which Rwanda participates, provides a high-level political forum for interstate dialogue. COMIFAC addresses both the conservation and sustainable management of forests and savannas.

While there are a number of transboundary forest cooperation initiatives, one major endeavour is the Congo Basin Forest Partnership (CBFP), of which Rwanda is a member. Established in 2002, the CBFP includes donors, government agencies, international NGOs and research institutes. Under this initiative, 12 ecologically sensitive and biologically diverse areas and wildlife corridors have been identified within the Congo Basin including the Virunga landscape in the Democratic Republic of the Congo (DR Congo) and Rwanda.



High-value timber from DR Congo on sale in Kigali central wood market. There are good opportunities for large-scale sustainable trade in forest products between the two countries

Another initiative is the Congo Basin Forest Fund (CBFF), which was launched in 2008 as a global initiative to help countries in the Congo Basin better manage their forests. The Fund aims to slow the rate of deforestation by building the capacities of the people and institutions in the Congo basin countries to manage their forests.

A significant opportunity exists for specific transboundary cooperation between Rwanda and the DR Congo to develop large-scale regulated and sustainable trade in forest products, particularly for charcoal and high-value timber. Currently, there is high demand in Rwanda for hardwood (e.g. African mahogany and teak) that is imported from the DR Congo. However, there are serious concerns about the current unsustainable and illegal logging in eastern DR Congo. In addition, a significant portion of the charcoal consumed in Rwanda is imported from the DR Congo through Gisenyi, most of which has been illegally extracted from the Virunga National Park. The CBFF can provide the forum for regulating and managing this trade. In the addition, the Action Plan for Forest Law Enforcement, Governance and Trade (FLEGT) adopted by the European Union also aims to facilitate trade in legal timber and for which Central Africa is one of the target regions.

8.6 Conclusions

Sustaining the integrity of forest ecosystems is fundamental for national development. Continuous deforestation and forest degradation, especially of the highly vulnerable montane forests, have increased the frequency and magnitude of flooding and landslides. Therefore, enhancing the watershed protective functions of natural forests and tree plantations along the Congo-Nile watershed will become even more important in the future, as changes in rainfall patterns related to climate change result in more extreme weather events.

Yet, the future outlook for the forestry sector appears positive. There is firm political commitment to stop deforestation and intensify reforestation efforts and a strong willingness to reach across borders and establish partnerships to protect forests. Nonetheless, much work needs to be done, especially in recognising and maximising the full economic potential of forest services. This work will have to be undertaken in the context of decentralisation

and involve local communities in the sustainable management of forests. In addition, agroforestry in both rural and urban areas could be made an integral part of local development planning. As part of efforts to increase tree cover, opportunities for urban forestry should also be explored.

8.7 Recommendations

R8.1 Promote participatory forest management.

A national workshop should be organised in order to define an overall vision, technical approach and the rules for introducing participatory management of tree plantations including revenue sharing arrangements. This workshop needs to be preceded by an inventory of the growing stock in public tree plantations and their priority for silvicultural interventions. The agreed approach for participatory forest management should be pilot tested in several plantations with different community-based organisations (CBOs).

Lead agencies: MINIRENA, MINAGRI, MINALOC, NAFA, district authorities. International Partner: UNESCO. Cost Estimate: USD 1 million. Duration: 2 years.

R8.2 Increase the extent of agroforestry, including small private woodlots.

A survey of existing initiatives in the field of agroforestry should be carried out to assess their constraints and propose follow-up programmes. Such programmes would assist community stakeholders (e.g. individual farmers, local associations) in establishing small woodlots and multipurpose trees and shrubs on farmlands, rangelands and marginal lands as well as in urban and peri-urban centres. These programmes should be based on the CGIS inventory (in consultation with other forest inventories) and follow a site-specific approach. Stakeholders will also need support in identifying and promoting markets for non-timber forest products as well as for small-scale timber-processing enterprises. This recommendation should be undertaken in conjunction with efforts to increase biomass energy supplies (see R11.1 in Chapter 11: Energy and the Environment).

Lead agencies: MINIRENA, MINAGRI, MINALOC, NAFA. International Partners: UNDP, ICRAF. Cost Estimate: USD 3 million. Duration: 3 years.

R8.3 Assessment of the extent of trees and shrubs outside forest areas. The CGIS should complement its forestry inventory by assessing small woodlots (<0.5 ha) and the degree of tree and shrub cover outside forests and tree plantations. This would provide the basis for evaluating the total available woody biomass and species composition outside of forests and by region. This assessment should be linked with R9.1 in Chapter 9: Water Resources.

Lead agencies: MINIRENA, MINAGRI, CGIS, NAFA. International Partner: ICRAF. Cost estimate: USD 0.5 million. Duration: 1 year.

R8.4 Rehabilitation of the Mukura montane rainforest. Natural regeneration of many high value timber species is still taking place in this highly degraded forest. Rehabilitation will involve silvicultural tending operations, which will favour the growth of these primary forest seedlings and remove invading plants, such as forbs and lianas. This innovative project could be carried out as a pilot under CBFF.

Lead agencies: MINIRENA, NAFA, REMA, Rutsiro District, ARECO. International Partner: UNEP. Cost Estimate: USD 0.5 million. Duration: 3 years.

R8.5 Restoration of gallery forests. Based on the pilot project of PAFOR in Nyagatare, this initiative would re-establish gallery forests by planting indigenous tree species on bare riverbanks in southeastern and eastern Rwanda.

Lead agencies: MINIRENA, REMA, PAFOR, NAFA, NUR, district authorities. International Partner: UNEP. Cost estimate: USD 1.0 million. Duration: 2 years.

R8.6 Assessment of the wood market. A baseline study should be carried out to assess the current use of wood products from timber (i.e. according to tree species, prices, harvesting localities, transport distances, etc.) and their potential added value. This should include a feasibility study for processing the raw materials in the country and be accompanied by a business plan.

Lead agencies: MINECOFIN, MINALOC, NAFA. International Partner: UNDP. Cost estimate: USD 0.2 million. Duration: 1 year.

R8.7 Strengthen the capacity of the forest police to protect relict forests and control logging operations in tree plantations. This would involve training and technical support of the forest guards. Close collaboration with environment committees at the sector level in the delivery of felling and transport permits could efficiently reduce the abuse in logging activities.

Lead agencies: MINIRENA, NAFA, Forest Protection Service, district authorities. International Partner: FAO. Cost estimate: USD 1.0 million. Duration: 2 years.

R8.8 Establish a central forestry databank under NAFA. This would include training on data collection for officials in charge of forestry at the district level, as well as training on data analysis and reporting for databank managers at the central level. The database should be accessible to all actors in the forestry sector.

Lead agencies: MINIRENA, NAFA, ISAR, NISR. International Partners: UNEP, AfDB/EIS. Cost Estimate: USD 1 million. Duration: 2 years.

R8.9 Establish a biodiversity inventory of the Sanza relict forest and possibly other unknown relict forests. A scientific exploration of the relict montane rainforest at Sanza should be undertaken to assess the current state of the forest, including its biodiversity, conservation values and current threats. A management plan should subsequently be developed in collaboration with local stakeholders. Other unknown relict forests should also be surveyed such as the Gihondogo Forest in the Southern Province.

Lead agencies: MINIRENA, REMA, ISAR, NUR, NAFA, district authorities. International Partner: UNEP. Cost estimate: USD 1.0 million. Duration: 2 years.

R8.10 Initiation of sustainable and regulated trade in forest products with neighboring countries. Large-scale sustainable and regulated trade in forest products, particularly of charcoal and high-value timber, could be established through the CBFP.

Lead agencies: MINIRENA, MINICOM, NAFA, NUR. International Partner: CBFP. Cost estimate: USD 1.0 million. Duration: 2 years.

Water Resources

*The main challenge facing Rwanda's
water sector is a shortage
of investment in human capacity
and infrastructure*

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Water Resources

9.1 Introduction

As a headwater country, Rwanda enjoys both ample and good quality water resources. It has abundant renewable water supplies that are sufficient to meet the country's growing water needs. While Rwanda has made substantial progress in increasing safe drinking water coverage, many Rwandans continue to experience water shortages arising from inefficient supply and limited access. Cyclical droughts are a serious challenge in the east and southeast, but this periodic water deficit can be resolved through basic investments. In this context, the primary challenge facing the water sector in Rwanda is essentially one of infrastructure and governance.

The growing water demands of Rwanda's development drive, particularly for agricultural intensification, are likely to accentuate water stress and exacerbate sectoral competition over available water supplies. A viable approach for mediating between multiple water users

is through the adoption of Integrated Water Resources Management (IWRM), which at a conceptual level is now well embedded in national water governance.

The main challenge now is to move forward and implement IWRM, which will require substantial capacity-building both at central and local levels. Rwanda is also well engaged in various transboundary water initiatives, which should further widen opportunities for meeting its water needs through coordinated basin plans and joint investments.

9.2 Assessment activities

The UNEP team carried out fieldwork in all provinces and tested water quality in 21 sites across the country (including one well, two springs, four streams, seven lakes and seven rivers). Water samples were analysed by portable field equipment on-site and collected for further laboratory analysis. Complete results of water sample analysis are provided in Appendix 5. In this chapter, the main water sampling results are examined within the context of the key issues identified.



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A headwater country of both the Nile and Congo basins, Rwanda enjoys abundant and good quality water resources

Table 24. Field sites visited by province

Province	Field sites visited
Kigali	<ul style="list-style-type: none"> - Nyanza dumpsite - Selected sites within the Nyabarongo river system
Northern	<ul style="list-style-type: none"> - Ruhengeri lava region - Musanze and Bulera Districts - Mutobo water treatment plant - Ntaruka and Mukungwa hydropower dams - Gifurwe mining sites - Ruhondo and Bulera Lakes - Rugezi wetland - Byumba highlands
Southern	<ul style="list-style-type: none"> - Muhanga: "Mine de Cyubi"
Western	<ul style="list-style-type: none"> - Arusha resettlement sites - Gihira hydropower dam - Mizingo and Gihira water treatment plant - Rubavu, Nyabihu, Ngororero Districts - Gisenyi lava region - Gatumba mining sites - Cyambara (flood prone areas)
Eastern	<ul style="list-style-type: none"> - Akagera National Park and the Akagera flood plain - Kagera river basin - Bugesera (drought affected areas) - Ihema, Hago, Mugesera and Rumira Lakes - Rwinkwavu mining site

Consultations were held with a number of government stakeholders, including: Rwanda Environment Management Authority (REMA), Ministry of Agriculture and Animal Resources (MINAGRI), Ministry of Natural Resources (MINIRENA), as well as the secretariat for the National Water Resources Management Project (PGNRE).

Other consultations were undertaken with the following: Nile Equatorial Lakes Subsidiary Action Program (NELSAP) Secretariat (part of the Nile Basin Initiative); Electrogaz, the government-owned public utility that provides water, gas and electricity; and HELPAGE Rwanda (HAR), a local non-governmental organisation (NGO).

9.3 Overview of freshwater resources in Rwanda

The main basins

There are two main drainage basins in Rwanda, the Nile and the Congo. The Nile basin occupies 76 percent of the country's surface area and drains 90 percent of its waters through the Nyabarongo and Akagera Rivers. The Akagera is the main tributary

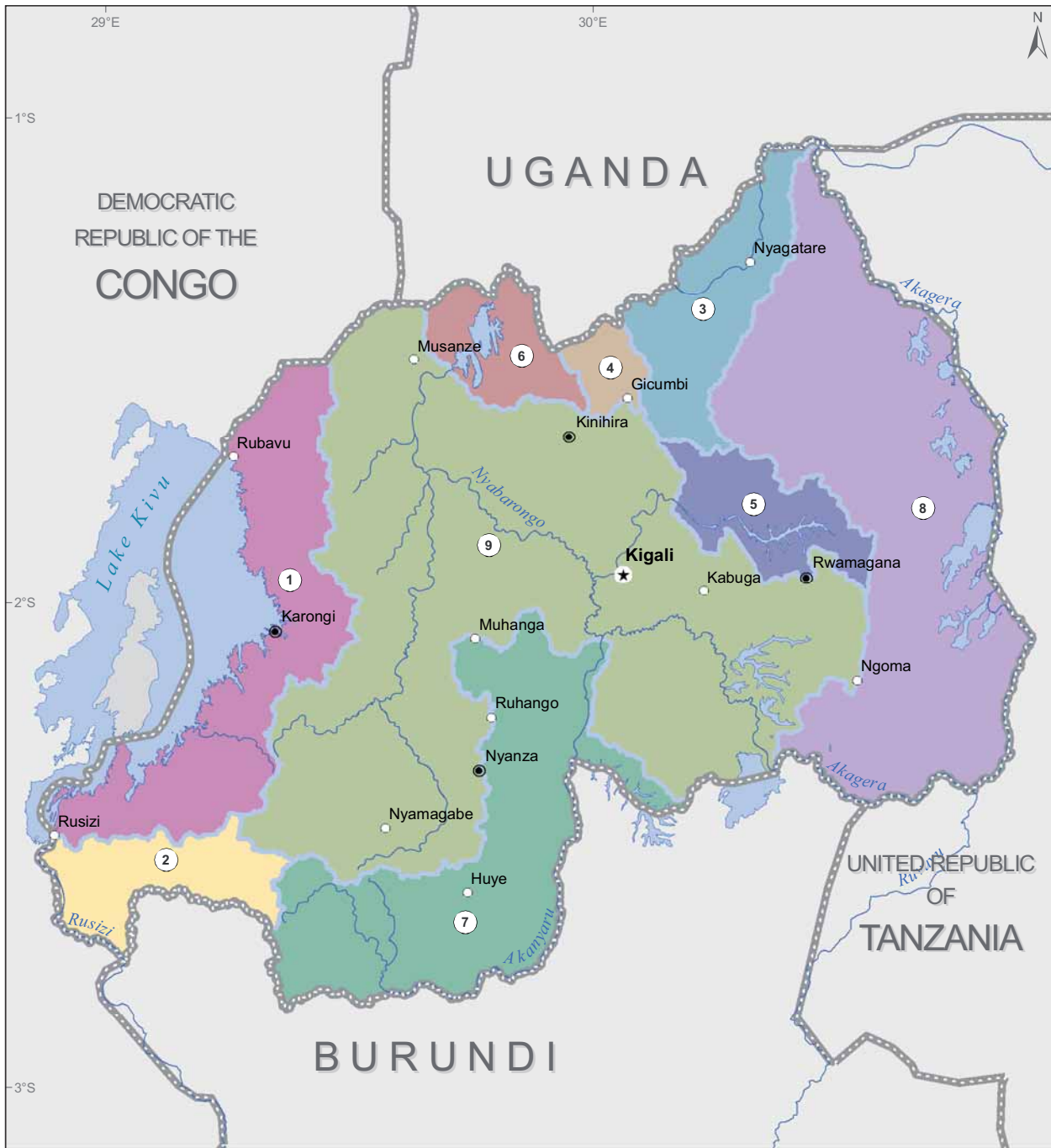
feeding Lake Victoria, which alone provides an estimated 10 percent of the Nile's waters.¹ The Congo basin occupies 24 percent of the country's surface area draining 10 percent of its waters, flowing from Lake Kivu to Lake Tanganyika via the Rusizi River.² For background information on the country's climate, see Chapter 2.

Surface waters: Rivers, lakes and wetlands

Surface waters include river systems, lakes and wetlands (including marshlands and swamps). Lakes and wetlands sustain Rwanda's extensive hydrological network. A recent inventory recorded 101 lakes and 860 wetlands, covering a total surface area of 1,495 km² and 2,785 km², respectively.³ This is equivalent to 16 percent of the country's land area. Lake Kivu, whose waters are shared with the Democratic Republic of the Congo (DR Congo), is the largest lake in Rwanda and is economically strategic for its methane gas reserves, which are currently under exploration.

As a signatory to the Ramsar Convention on Wetlands, Rwanda has endorsed the international definition of wetlands, which includes lakes, rivers, streams, marshlands, swamps and peat bogs.⁴ However, as

Map 13. Rwanda drainage sub-basins



<p>Congo Basin</p> <ul style="list-style-type: none"> 1 Kivu 2 Rusizi <p>Nile Basin</p> <ul style="list-style-type: none"> 3 Umuvumba 4 Mulindi 5 Muhazi 6 Rugezi 7 Akanyaru 8 Akagera 9 Nyabarongo 		<p>Kilometres</p> <p>0 10 20 30 40 50</p> <p>Datum: Arc 1960 Rwanda Local Projection 92, Transverse Mercator</p> <p>Sources: NUR-CGIS.</p>
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The boundaries and names shown and the designations used on this map do not imply official endorsement by the United Nations.

NUR-CGIS/UNEP - 2009

Map 14. Rwanda wetlands inventory





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Kamiranzovu wetland in Nyungwe Forest is an important headwater source of the White Nile

in many other countries, there is ambiguity in the practical day-to-day usage of the term wetlands, depending partly on their perceived value.

While the terms wetlands and marshlands are often used interchangeably in Rwanda, the term wetland appears to signify an ecologically valuable resource worthy of conservation. It was also noted that the term wetlands is often applied for high altitude areas with permanent water cover, which typically host a higher number of flora species compared to other wetland types. Marshlands, on the other hand, appear to denote lands that are potentially suitable for reclamation. The term marshlands is used to refer to low altitude areas that are seasonally flooded and are dominated by *Cyperus* grass species. This uncertainty over the definition of wetlands seems to have created some loopholes in their use and management.

In this chapter, the term wetlands is used to refer to both high and low altitude wetlands, which have permanent or temporary water cover and may contain peat and other minerals (see also Chapter 2). In Rwanda, all wetlands are designated as state lands managed by government. Most lakes and rivers are fed by wetlands. Wetlands are amongst the most productive ecosystems in Rwanda in terms of plant matter, fisheries and supporting freshwater biodiversity. They provide critical services: they feed lakes and rivers, trap and filter sediments and

nutrients, absorb floodwaters, buffer croplands and settlements from strong run-off, and replenish rivers and streams during the dry season.

Of the wetlands inventoried, 41 percent are in natural condition and 59 percent are farmed.⁵ While there has been growing awareness and protection of wetlands particularly following the 2002-2005 drought, uncontrolled farming, mostly for subsistence, is widespread. All valley bottom wetlands are public lands managed by government.

Rwanda also has a dense river network, as shown in Map 17, page 197.⁶ The hydrological network has been impacted by ecosystem degradation and the intensification of farming activities in the post-conflict period. Critical watershed and catchment areas have been compromised by agricultural conversion and settlements, which has in turn affected water quality and supply, including transboundary waters.

Groundwater and springs

Limited information is available on the extent and quality of groundwater sources in Rwanda. Except for alluvial valleys and major volcanic deposits, there are no continuous aquifers in Rwanda. Aquifers are often comprised of layers of weathered quarts or fractures in Precambrian formations.⁷



Springs are an important source of water supply for rural communities

Groundwater is an important source of potable water in Rwanda, which is obtained primarily through pumps, wells and bore holes by local communities. Until recently, groundwater exploration by drilling has been limited, mainly due to relatively easy access to surface waters and springs. However, the government is currently supporting projects to increase water supply by drilling bore holes with reportedly good results.⁸

Surface outlets of localised aquifers give rise to Rwanda's numerous springs. There are approximately 22,300 identified springs, mainly located in the northwestern part of the country.⁹ Springs are especially important for maintaining the minimum flow of rivers mainly in the north and west of the country, and are important sources of drinking water for local communities.

Groundwater as well as springs in the northwestern volcanic areas and along the eastern rim of the Albertine Rift Valley is potentially at risk of having elevated mineral content. Due to interactions between groundwater and surface waters, the latter may also be naturally contaminated. This issue requires further detailed investigation to ensure that water in these areas is suitable for human consumption.

9.4 Overview of water consumption

Per capita consumption

Domestic consumption accounted for approximately 5 percent of total water withdrawals in 2000. In terms of available water supplies, the estimated volume of drinking water in 2005 was 85 million m³ per year.

Despite its abundant water resources, Rwanda experiences water scarcities due to inadequate and inefficient supply networks, which limit access to water (discussed further under "Key issues"). Currently, only 71 percent of the Rwandan population has access to safe drinking water supplies.¹⁰ Per capita water availability at 610 m³ per year in 2005 is well below the international limit of water scarcity at 1,000 m³ per year.¹¹ It should be noted that while there are significantly different estimates for annual per capita water availability in Rwanda, they are all less than the water stress limit of 1,700 m³ and closer to the aforementioned water scarcity threshold.¹²



Despite abundant water resources, per capita water availability is below the water scarcity threshold

The principal sources of clean water supply in Rwanda include national piped water supply (operated by Electrogaz), protected springs and public standpipes, and shallow wells. Whereas urban areas have greater access to improved water sources, in rural areas a significant proportion of the population (32%) remains dependent on unprotected water sources, such as unprotected springs, open wells and surface water (rivers, streams, lakes, etc.).¹³

Water demands by sector

The agricultural sector is by far the leading water consumer accounting for 93 percent of available water consumption.¹⁴ While the bulk of agricultural production is rain-fed, a relatively small area is under irrigation, which amounts to approximately 12,000 ha or 1.3 percent of total arable land.¹⁵ Cultivated area under irrigation, however, is expected to expand significantly with the current programme for agricultural intensification. In addition, a number of irrigation projects are already underway in various parts of the country, notably the eastern and southern provinces.

The industrial sector accounts for only a small portion of total water withdrawals (2%), as it remains a small activity. Nevertheless, water use by industry will likely increase with the government's push to develop

Rwanda's industrial park. Water consumption by industries is mainly concentrated in Kigali City. The scale-up of washed coffee production has also increased use of water in industrial activities, and interventions are needed to improve efficient water use in this field of activity.

Although water used for generating hydroelectric power is typically not classified as part of total water consumption, water demand by this sector must also be taken into consideration in the overall allocation and management of water resources. Hydropower is the main source of energy in Rwanda, generating almost half of the country's electricity supply. Hydropower is sourced mainly from four national hydroelectric stations (Ntaruka, Mukungwa, Gihira and Gisenyi), with a portion coming from shared hydroelectric dams with neighbouring countries (Rusizi I and Rusizi II).

Hydropower stations in Rwanda are currently operating below their potential capacity, resulting in a major electricity deficit and causing the government to rely more on fossil fuel for electricity production (see Chapter 11). This problem is partly attributed to low water levels in reservoirs, especially those that supply Mukungwa and Ntaruka stations, as well stream turbidity and reservoir sedimentation (see Case study 9.2).¹⁶



Agriculture accounts for an overwhelming share of national water consumption

Table 25. Electricity production in Rwanda drawn from hydropower and conventional fuel sources¹⁷

Existing stations	Type	Actual capacity kW		Actual production MW/ year
		Actual	Design	Actual
1. Production				
Inside Rwanda				
Mukungwa	Hydropower	5,000	12,200	43,800
Ntaruka	Hydropower	2,000	11,250	17,600
Gihira	Hydropower	1,800	1,800	6,000
Gisenyi	Hydropower	600	1,200	4,300
Gasata	Diesel	4,800	4,800	36,000
Jabana	Diesel	7,800	7,800	54,400
Imported				
Rusizi I	Hydropower	3,500	3,500	20,000
Rusizi II	Hydropower	12,000	12,000	67,000
Total		37,500	54,550	249,100
2. Demand		60,000		289,100
3. Deficit		-22,500		-40,000

Some of the hydropower plants impacted by the conflict have been rehabilitated but are still below the required capacity. New hydropower developments have been commissioned or are currently underway. These include the Rusumo hydropower project that is shared with Tanzania and Burundi, and a medium-size dam along the Nyabarongo River. There are also ongoing efforts to develop small and micro-hydropower stations in various parts of the country, which are anticipated to enhance electric power generation.

Water deficits due to rainfall variability

On a national scale, available water resources in Rwanda are sufficient to cover its water needs, as shown in Table 26, next page. Indeed, the estimated water demand in 2020 would still account for less than 5 percent of internal renewable water resources. However, as discussed in Chapter 2, there are great variations in rainfall over time and space, with the east and southeast savanna landscapes being particularly vulnerable to droughts and water shortages.

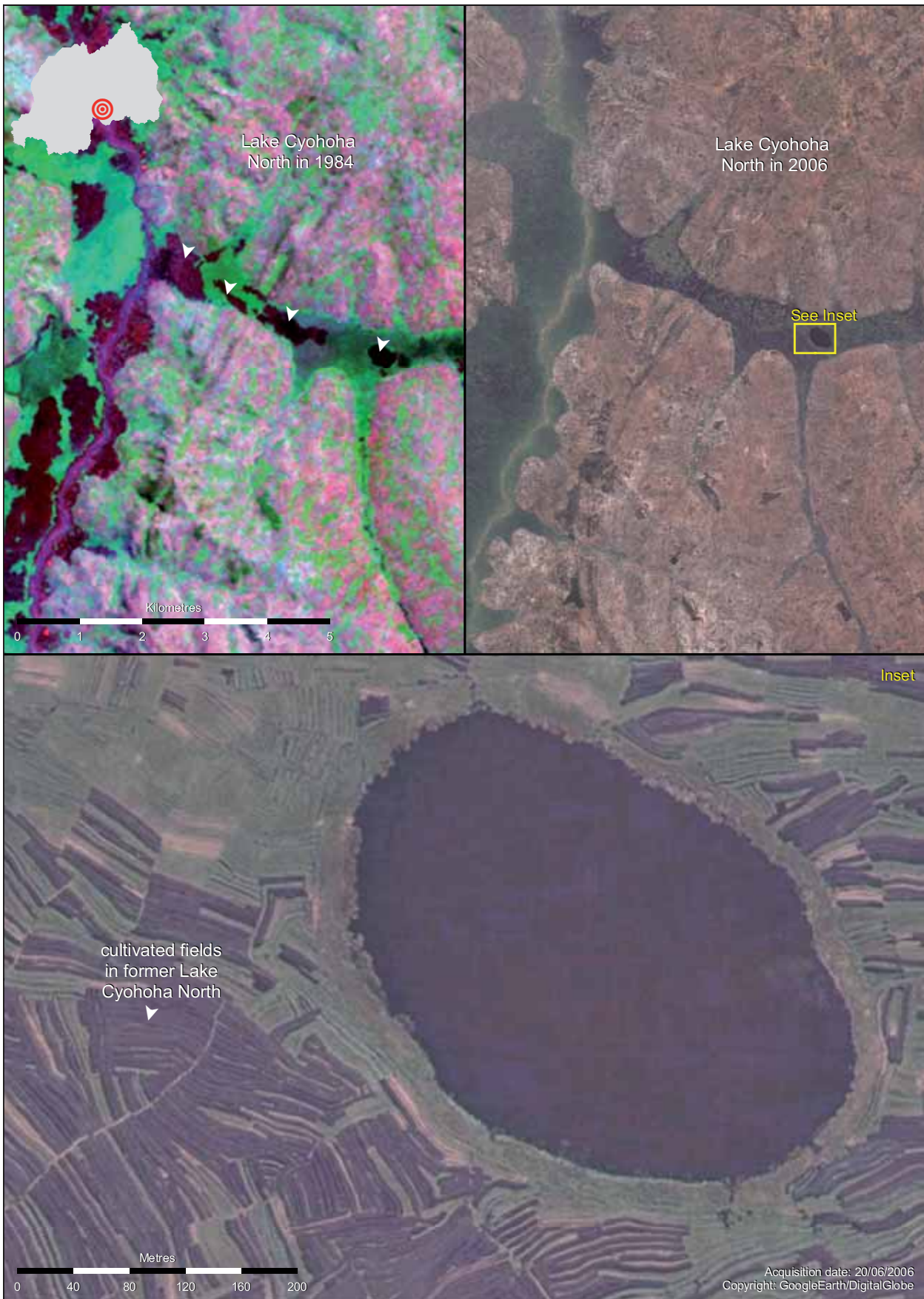
Wide fluctuations in rainfall accentuate the underlying challenge of matching water demand to accessible supply (see Chapter 6). Additional investments in infrastructure are required, such as water storage structures and rainwater harvesting, to better cope with erratic rainfall in the east and southeast regions. Investments in water infrastructure will be critical particularly within the evolving context of climate change.

One of the areas most impacted by rainfall fluctuations and drought spells is Bugesera in the southeast, which has experienced a substantial decline in lake and wetland resources. A case in point is the near drying of Lake Cyohoha North, partly induced by conversion of surrounding feeder wetlands to farming. Water quality subsequently deteriorated due to eutrophication and the fish catch dropped, negatively affecting the nutrition and livelihoods of local communities. Recent remedial measures, including restoration of vegetated shoreline buffers, such as around Lake Rumira, have reportedly been accompanied by an increase in water levels and an improvement in water quality. In the northern and western parts of the country, where high precipitation is a major factor in soil erodibility, a number of innovative activities are being implemented to capture, store and use rainwater runoff in agriculture and other activities.



Vulnerability to rainfall fluctuations and drought in the east and southeast can be addressed through investments in water supply infrastructure

Figure 14. Agricultural reclamation of Lake Cyohoha North and surrounding wetlands





Fishing is managed by cooperatives that educate farmers on proper fishing practices such as not to use mosquito nets, as shown here in Lake Rumira, Bugesera

Table 26. Projected water demand and available water resources in 2020¹⁸

Total demand/available resources	Yearly volume
Demand in 2020	MCM / year
Agriculture	840
Domestic	170
Industries	6
Total demand in 2020	1,016
Estimated available resources	27,920

9.5 Governance

Policy and legal instruments

Rwanda has developed a policy and legal framework to guide water governance. The Water Policy (2004) sets the key principles and guidelines for the sustainable management and utilisation of water resources. It focuses on access to drinking water and sanitation services, water conservation and sustainable resource management, and increased stakeholder participation in water resource management. The Water Policy adopts IWRM as a main tenet to secure the equitable and sustainable utilisation of water (see Box 9.1). The new Water Law adopted in July 2008 establishes provisions for carrying out IWRM in Rwanda.

The Water and Sanitation Sector Policy (2004) reinforces the importance of IWRM. Specifically, it promotes increased access to safe drinking water through improved sanitation services.

Box 9.1 IWRM

IWRM is defined by the Global Water Partnership as a process that promotes the coordinated development and management of water, land and related resources in order to maximise social and economic benefits in an equitable manner without compromising the sustainability of vital ecosystems. IWRM recognises that the sustainable development of water resources requires coordination between different sectors and various stakeholders with multiple water needs and priorities.

The water drainage basin is the basic planning and management unit in the IWRM approach. Decision making over water allocations between different users is undertaken within this spatial framework of analysis. The main steps in the IWRM process includes articulating common goals and objectives with respect to water resources, developing a plan of action, establishing legal and institutional frameworks and mobilising funding to implement IWRM activities. Even where IWRM has been applied, ecosystem concerns have often been overlooked when reconciling water demands by economic sectors (agriculture, energy) and continues to be a major challenge.



The government has committed to provide clean water to all its citizens by 2020

While Rwanda has made good progress in establishing the policy and legal support necessary to improve water resources management, significant reforms in the water sector need to be pursued. The Water Policy underscores the need for establishing a cross-sectoral, institutional framework to coordinate effective decision making in resource management. In addition, continuous monitoring and assessment of water resources are recognised as critical long-term activities for improving sustainable resource utilisation and management.

Key institutions

MINIRENA is responsible for overall governance and management of the water sector in Rwanda. Responsibilities include water policy development and oversight, inventorying and monitoring of water resources and coordination of resource mobilisation and allocation. A Water Resources Management Agency is to be established under MINIRENA to coordinate the implementation of an IWRM programme.

Water supply and sanitation as a subsector is under the responsibility of the Ministry of Infrastructure's (MININFRA) Energy and Water Board, which is responsible for the implementation of the water and sanitation policy. Electrogaz is the public utility responsible for treatment and distribution of potable water in the capital Kigali and major urban centres of the country. Rural water supply systems are supported through MININFRA and NGO projects. Within the context of ongoing decentralisation, contracting of the local private sector to provide water services in the form of private-public partnerships is being promoted by the government, as is a participatory model where water users form associations with rules to manage water supply facilities.

The management of wetlands falls under MINIRENA, except those located inside protected areas, which are within the jurisdiction of the Rwanda Office of Tourism and National Parks (ORTPN). REMA plays a regulatory role to ensure environmental compliance with respect to their management.

Decentralisation

As part of the decentralisation process, districts now have authority over the development of water infrastructure within their jurisdiction and can

encourage private sector investment. Furthermore, community development committees (CDCs) provide a mechanism for increased community participation in local water governance. CDCs are responsible for the coordination of water-related activities, including implementation of community water projects. CDCs must include women and youth as members, thus enhancing their potential role in improving water resources management and conservation. Decentralisation offers a good opportunity to make water resource management more responsive and adaptive to local needs and priorities, as well as facilitate a more coordinated approach across different sectors. To this end, all potable water facilities in rural areas are managed by user committees, which are elected by the user communities, and are responsible for regular maintenance of the facilities.

9.6 Overview of key issues

As noted earlier, UNEP tested for water quality in 21 sites across the country. Although UNEP's snapshot field analysis needs to be supplemented by long-term water resource monitoring, it confirmed that the quality of Rwanda's waters are overall within pristine range conditions. This conclusion is based on a comparison of sampling results with conditions found in pristine natural streams and rivers as well as with similar studies of river water quality in Uganda.¹⁹ Full details of sampling results are provided in Appendix 5.

Despite having abundant and good quality water supplies, Rwanda faces a number of challenges in the water sector. The key issues identified in water sector include:

- projected massive increases in water demand;
- drinking water scarcity;
- suspended sediment pollution;
- emerging threats to freshwater supplies; and
- strengthening water governance.

Projected massive increases in water demand

Water use is projected to expand by 5.5 fold by 2020. As planned industrial development progresses, the estimated water demand by

industries is expected to experience an over four-fold growth. This is likely to accentuate water stress across all sectors. In the overall picture, however, industrial water consumption by 2020 will remain modest (6.1 MCM per year). Domestic and agricultural water consumption, however, is forecast to reach 170 MCM and 840 MCM per year, respectively, by 2020. The most significant increase in water demand is clearly from the agricultural sector (discussed further under “Emerging threats to freshwater supplies”, see page 190).

With the marked increase in water use across all sectors, there will likely be a decline in per capita water availability.²¹ This is mainly due to the challenge of building the necessary infrastructure to deliver water supply and provide sanitation facilities to Rwanda’s growing population in such short-time scales. It is important to emphasise, however, that growing water scarcity is not absolute, given the country’s substantial water resource base. Rwanda’s water predicament can be readily tackled with an appropriate combination of governance, technological, ecosystem restoration and market-based responses.

Table 27. Projected water demand by different sectors²⁰

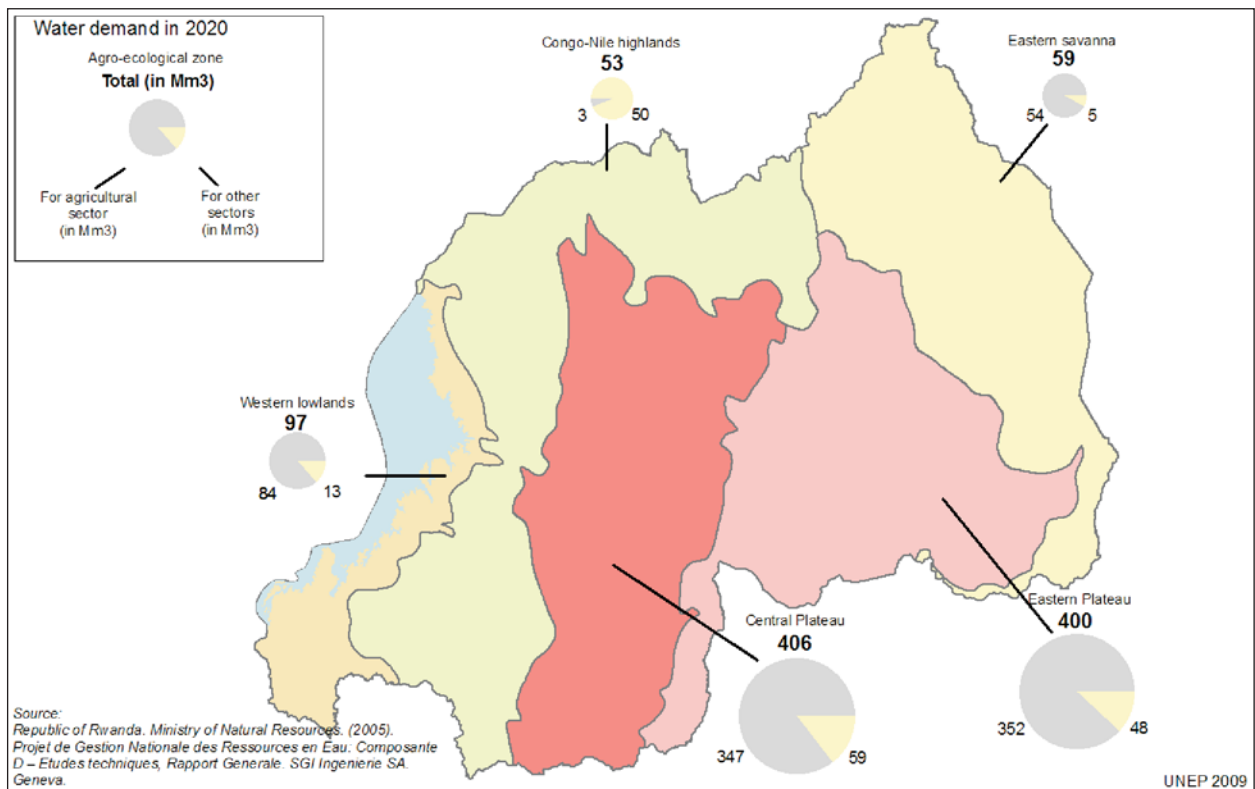
Sector	2005	2020
	Water demand m ³ per year	Water demand m ³ per year
Industry	1,300,000	6,100,000
Agriculture	100,000,000	840,000,000
Domestic	85,000,000	170,000,000
Total demand	186,300,000	1,016,100,000



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Water demand in the agricultural sector is projected to increase by over seven fold by 2020

Map 15. Projected water demand in 2020



Drinking water scarcity

Limited access to drinking water supply

Rwanda's drinking water problem is essentially one of improving access. Extending supply infrastructure and investing in operation and maintenance are critical. It can be achieved to a large extent through low-cost, small-scale water supply technology that is provided in particular to the poorest segments of society.

While 71 percent of the Rwandan population currently has access to safe drinking water, this figure drops slightly in rural areas. As of 2008, approximately 68 percent of the rural population had access to potable water supplies, which is an important increase from 2005 (at 54 %). In contrast, 76 percent of the urban population is served by an improved water source.²² However, in 2005 only 1 percent of the rural population had piped connections to their houses, as compared with 14 percent of the urban population.²³ A government report further indicates that actual per capita water consumption in rural areas is only ten liters per day, which is half the national recommendation of 20 liters per person per day.²⁴ Based on current investments, however, water coverage in rural areas is expected to improve significantly over the period 2008-2012.²⁵

Access to water is highest in Kigali City (about 98%), but only about half of nationally recommended per capita water demand is provided.²⁶ The urban and

semi-urban centres generally have water supply systems, but distribution systems often do not have adequate capacities to meet water demands.²⁷ Actual per capita water consumption in Kigali and semi-urban centres is 48 and 35 liters per day, respectively, which is far below the recommended national standard of 90 liters per day.²⁸

Access issues are linked to the limited water distribution infrastructure as well as to the high costs of paying for safe drinking water. This is particularly the case in rural areas, where approximately 70 percent of the population still rely on unprotected water sources (e.g. unprotected springs, rivers, streams).³⁰ This situation considerably raises the risk of exposure to waterborne diseases (discussed below). The limited water distribution network and hilly terrain further increases the difficulties of accessing water in rural areas. Approximately 30 percent of the rural population, usually women and children, have to walk for more than 30 minutes a day to access improved water sources (see Case study 9.1).³¹

Table 28. Per capita water consumption per day (in litres)²⁹

Area	Current water consumption per day	Recommended water consumption
Kigali City	48	90
Semi-urban	35	90
Rural	10	20



Approximately 68 percent of the rural population has access to safe drinking water compared to 76 percent in urban areas



Despite a number of innovative pilot activities as shown here in Batsinda imidugudu, rainwater harvesting remains a major underutilised opportunity to improve water supply access at the household level

Given limited water supply access at the household level especially in rural areas, rainwater harvesting represents a major underutilised opportunity in Rwanda. It is a simple and low-cost technology where rain or run-off is collected locally and which can be stored in a variety of ways. Limited trials on rainwater harvesting have been made, for example, by the Food and Agriculture Organization (FAO) at Batsinda imidugudu near Kigali, as well as for irrigation of school gardens. The results of these pilot initiatives need to be showcased and disseminated to raise awareness on rainwater harvesting potential. Other countries have been able to make extensive use of rainwater harvesting techniques to meet domestic water consumption needs, including for irrigation of small household plots. Moreover, this technology has alleviated the water collection workload for women in several developing countries.

Drinking water contamination

Access issues are accentuated by problems of drinking water contamination. The main problem is biological contamination of drinking water sources found in 90 percent of random samples collected by the UNEP team, of which at least 47 percent were pathogenic (see Chapter 12). This result is not surprising considering that only 10 percent of household sanitation facilities are within required norms.³²

Case study 9.1 Women and water scarcity

Water scarcity is a particular challenge for women as they are largely responsible for providing their families with a water supply. This problem is compounded in the dryland savanna environment of Bugesera District in the Eastern Province, which has been experiencing repeated droughts. According to Teddie Uwamariya, head of Nemla *imidugudu*, the village well that provided residents with clean groundwater has reportedly dried up as a result. Consequently, women and girls have to walk to the nearest lake some two kilometres away, from where they collect their water.

Refugee women in the transit camp of Nyabihu District face similar water shortages. Without access to drinking water inside the camp, refugees either have to buy water from private vendors, who deliver it at a cost of FRW 50, equivalent to USD .09 per 25 liter-container. Yet even this amount is unaffordable for the women, who have to trek 2.5 kilometres to the nearest river to collect water.

These two cases are not unique but reflect a daily challenge for women across Rwanda. Limited access to safe water sources makes women and girls' journey longer distances in search for water that is often neither protected nor treated. This problem increases the time expended by women on water collection, at the expense of more productive work. It also increases health and safety risks. Consumption of unprotected drinking water heightens the risk of waterborne diseases, one of the leading causes of mortality and illness in Rwanda, especially amongst children under the age of five. In addition, walking long distances increases exposure and vulnerability to gender-based violence.

To address the problem of water shortages, the government is aiming to provide safe drinking water to all of the population by 2020. For urban residents this means having access to an improved water source within 200 metres of their homes, while in rural areas the target distance is 500 metres.



Collecting surface water from a small lake. Biological contamination of drinking water is a major public health threat

The majority of the population, both in rural and urban areas, uses pit latrines that are not always well constructed or adequately maintained. According to government estimates, 80 percent of the entire population relies on pit latrines, with only 8 percent having access to improved pit latrines.³³ As a result, there is high risk of biological contamination of groundwater, especially in Kigali as well as in semi-urban centres, due to the high concentration of human waste. The problem of poor sanitation is exacerbated by limited solid and liquid waste management facilities for domestic, urban and industrial waste, resulting in increased contamination risk of both surface and groundwater sources (see Chapter 12 for a more detailed discussion on Rwanda's urban environment).

In addition, sampling results showed relatively elevated levels of nitrates, ranging from less than 0.3 to 7.7 mg per liter. Elevated levels of nitrates provide additional evidence of potential sewage contamination. However, because of time differences between dates of sampling and analysis, nitrate concentrations may be overestimated due to oxidation processes. Furthermore, high pH levels above 8.2 were recorded in several samples (14 out of 21), which is an indicator of organic contamination. Long-term water quality monitoring is required to assess the extent of this problem with a good level of accuracy.

Drinking water contamination has significant implications on public health. Waterborne diseases due to microbial contamination are one of the leading causes of human death and illness in Rwanda, especially amongst children under the age of five. Thus, infrastructure investments in common sewage treatment plants are needed, particularly in Kigali and other major urban areas, such as Musanze, Huye, Rubavu and Muhanga. Equally important are low-cost measures to protect springs and wells that are the main source of water supply for the majority of Rwandans, which should significantly improve human health and economic productivity. While water supply and improved sanitation coverage has been modestly improving, investments need to be significantly boosted to attain stated goals of 100 percent population coverage by 2020.

Suspended sediment pollution

Since 1994, Rwanda has experienced extensive land cover and land use changes, particularly extensive deforestation in the Congo-Nile highlands and cultivation on steep slopes. Post-conflict resettlement, rapid population growth and acute land scarcities have pushed farming activities into already erosion-prone, fragile and marginal lands. Land conversion and agricultural expansion, as a result, have profoundly impacted the water regime, water quality and ecosystem integrity.



Suspended sediment, visible in Rwanda's highly turbid streams, is the most important form of surface water pollution

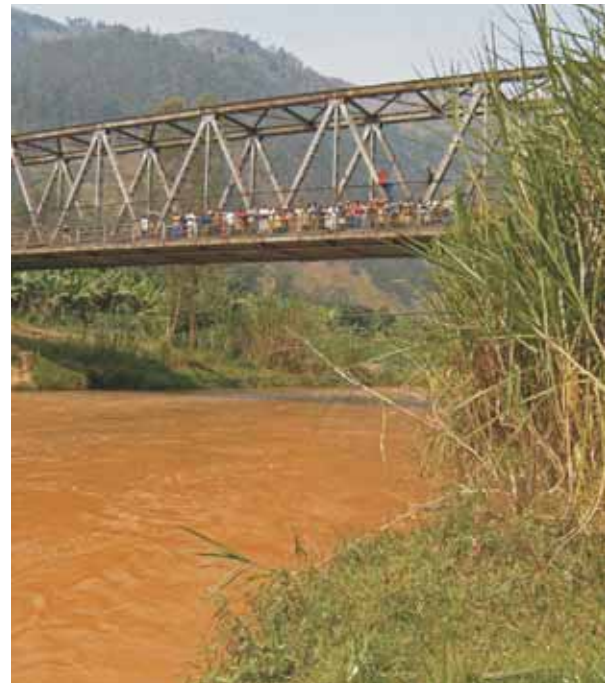
The most significant impact of intensive land use on water quality has been its contribution to increased levels of suspended sediments in surface waters. High sediment loads are readily visible in Rwanda's highly turbid and muddy streams and rivers, particularly during the rainy season. The problem of high sediment loads, validated by UNEP laboratory measurements, is intimately tied with excessive soil erosion from human activity (see Chapter 7). Total suspended solids (TSS) were especially elevated in water samples taken from the Sebeya and Nyabarongo Rivers, which registered from 500 to 660 mg/L and 320 to 350 mg/L, respectively. However, as sediment concentrations vary considerably with run-off patterns, long-term monitoring of soil erosion and suspended sediments is required to assess the magnitude of the problem.

High levels of suspended sediment degrade water quality by acting as carriers of pathogens and other pollutants, increase the cost of drinking water treatment and adversely impact aquatic life. They have also led to considerable economic losses due to siltation of rivers, lakes and reservoirs that generate almost half of Rwanda's electricity. For example, deforestation in Gishwati contributed to severe soil erosion and flooding, causing severe siltation in the Sebeya River, which UNEP sampling results validated. The resulting increase in the river's turbidity has adversely affected the

Gisenyi hydropower plant, which has been forced to limit its operations. It has also caused disruptions to the operations of two major local industries downstream.

One problem facing water supply in Kigali is the high sediment load in river water, which is costly to remove. According to Electrogaz's Kimisagara water plant, annual suspended sediment levels averaged 250 mg/L and 134 mg/L for 2006 and 2007, respectively. To address this problem, installation of a water sheet to filter sediments is planned to improve water quality.

Managing non-point pollution sources of sedimentation requires an integrated water catchment approach. High sediment loads can be alleviated by soil conservation measures, restricting cultivation on the steepest slopes (above 40°) to perennial crops, and rehabilitating the Congo-Nile highland forests and wetland ecosystems that are source areas for Rwanda's renewable freshwater supply. Government policy restricting cultivation within 15 m of riverbanks and 50 m of lakeshores is a positive measure to protect water resources. (For detailed discussion on improving land use management and the rehabilitation of natural forests, see Chapters 7 and 8).



The muddy waters of the Nyabarongo River are a clear indication of sediment pollution; sediment load at this point measured 370 mg/l

Emerging threats to freshwater supplies

Agricultural intensification

Rwanda plans to boost the presently low levels of agricultural production through intensification, including increased irrigation and use of mechanised farming methods, cash crops and chemical inputs (fertilisers and pesticides). While agriculture's share in total water withdrawals is expected to drop from 93 to 80 percent, water demand in this sector is estimated to increase by a substantial 740 percent to 840 MCM per year by 2020. Of this amount, 14 MCM is the projected use for livestock, which is a greater share than that anticipated for the industrial sector.³⁴

Substantial increases in water demand

This massive increase in agricultural water demand is attributed to the planned expansion of irrigation schemes. Agriculture is, therefore, a logical target for water savings and demand management, including improving yields of subsistence rain-fed agriculture, use of more efficient techniques such as drip irrigation and treadle pumps, and cultivation of less water-demanding and drought resistant crops.

Increase in fertiliser use

In addition, the promotion of cash crops will likely result in a marked increase in fertiliser use in

Rwanda, particularly with the World Bank's lifting of its moratorium on importation subsidies. Increased fertiliser use will increase chemical pollution and nutrient loadings in agricultural run-off (mainly nitrogen), with potentially serious impacts on both surface and groundwater quality. As mentioned earlier, UNEP's random sampling showed relatively elevated levels of nitrates, which are a cause of concern. Environmental assessment and long-term monitoring of fertiliser use are, therefore, needed to alert decision makers on potential problems. Moreover, farmers should be trained on fertiliser application methods to ensure compliance with technical guidelines.

Wetland reclamation

Agricultural intensification also aims to expand cultivation into wetlands, especially in the central plateau and eastern regions. As discussed earlier, 59 percent of Rwanda's wetlands is already farmed, while a substantial segment of the remaining wetlands is considered prime areas for agricultural conversion. Additional development of wetlands will considerably compromise critical wetland ecosystem services, including water replenishment and purification, flood and drought mitigation, as well as their role in food production and as wildlife habitat. It is therefore essential that all such wetland conversion initiatives be subject to prior environmental impact assessments.



Almost 60 percent of Rwanda's wetlands has been reclaimed for agriculture and additional development plans are in the pipeline, mainly for agriculture and peat mining



While most of the planned hydropower projects are relatively small, their environmental impacts need to be carefully examined and mitigated

In addition, government may consider developing a market mechanism for Payment for Ecosystem Services (PES) to promote wetland conservation and restoration. This approach, based on a financial evaluation of wetland services, has been successfully applied in several developing countries (e.g. Colombia, Indonesia, South Africa) from which Rwanda can draw relevant lessons.

Small and micro-hydropower projects

In order to meet growing energy demands, Rwanda is pursuing hydropower generation as its key source of electricity. In addition to several large dam projects, such as Rusumo Falls and Kakono, undertaken in consortium with neighbouring countries, Rwanda presently has 20 small and micro-hydropower plants in the pipeline and around 300 potential sites are under study.

Although the environmental impacts of small and micro-hydropower plants individually are generally low and do not generate the same controversy associated with large hydro, their impacts may be cumulatively significant. Hydropower development has a critical role to play in assisting Rwanda to meet its growing energy needs, particularly for providing off-

grid electrification in isolated rural areas. At the same time, the projected increase in hydropower projects and associated engineering projects should not compromise the sustainability of inland water systems through fragmentation, habitat destruction and loss of biodiversity.

Other issues

Invasive plant species, particularly the water hyacinth (*Eichhornia Crassipes*), are a growing concern. The water hyacinth was first observed in 1987 in Mukungwa wetlands from where it spread through the Akagera River up to the Nyabarongo River. This aquatic weed grows rapidly to form thick mats on water surfaces, reducing dissolved oxygen levels, which consequently impair water quality as well as affect fish stocks. UNEP observed the presence of water hyacinth in relatively limited quantities of two to three metre bands along lakeshores and wetlands inside the Akagera National Park, such as in Lake Hago. Water hyacinth, however, was not detected during inspections of water bodies in other parts of the country. A programme to remove hycanith infestation has recently been implemented; however, it remains to be seen if this will translate into long-term control.

Map 16. Rwanda dams and hydropower plants



The potential impacts of climate change and extreme weather events constitute an overarching challenge for sustainable water management in Rwanda and render sectoral coordination and application of IWRM more complex. The unpredictability of rainfall could further accentuate localised water shortages, especially in Bugesera District, which is already prone to droughts (see Chapter 6).

Other emerging threats include the growing sources of urban pollution. Planned industrial development and rapid urbanisation, especially in Kigali, can increase the risk of surface and groundwater pollution. Water contamination will likely be an increasing concern in urban and peri-urban areas, given the absence of adequate wastewater treatment facilities and engineered sanitary landfills (elaborated further in Chapter 12).

Strengthening water resource governance

At present, water management in Rwanda is characterised by weak sectoral coordination. Strengthening water governance is central to tackling the prevailing situation of water scarcity and meeting growing water demands across all sectors. This will require the application of an IWRM approach that would include developing human resource capacities, institutional arrangements, water monitoring programmes, increased transparency and participation in decision making as well as mobilising financial resources.

Promoting and strengthening IWRM

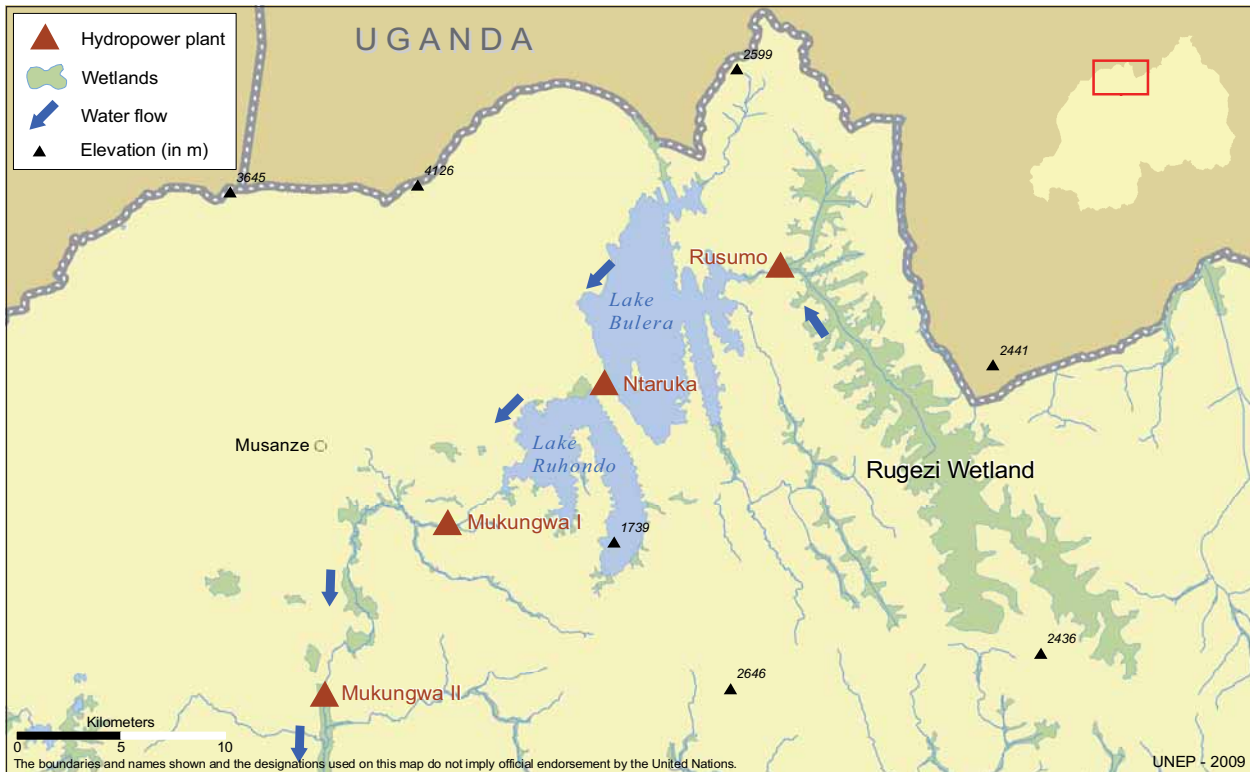
Rwanda has embarked on major governance and water policy reforms incorporating a progressive ecosystem approach based on IWRM. Widening the scope of the water agenda through IWRM should help improve coordination and balance the diverse demands of drinking water, agriculture, energy and environment stakeholders. The institutional arrangements, legislative instruments and technical capacity to support cross-sectoral consultations within an IWRM framework are in their initial stages and need to be expanded. The development of a national IWRM plan would help guide this process as well as showcase potential investment opportunities to financial partners.

Pilot projects at water catchment level should be undertaken to help develop a Rwanda-specific IWRM approach. Piloting would help build technical and institutional capacity through applied learning based on concrete cases. Cross-sectoral collaboration in watershed management has already been successfully attempted in the case of the Rugezi wetlands and needs to be reinforced and replicated in other areas (see Case study 9.2, next page).

Decentralisation offers a valuable opportunity to apply IWRM at the watershed or catchment level and promote participation and ownership by local communities, particularly women, in water resources management and conservation. Developing human resource capacity at the local level to coordinate and manage the interests of all water stakeholders, maintain infrastructure and collect data for decision making is critical for the benefits of IWRM to materialise on the ground.



The silt laden Sebaya River flowing into Lake Kivu reflects an underlying watershed problem that needs to be addressed by improving land management and conservation practices



Rugezi wetlands map

Case study 9.2 Applying IWRM: The case of the Rugezi wetlands

A headwater of the Nile River, Rugezi wetlands is one of Rwanda's strategic water resources. Located in the northern Buberuka highlands at 2,050 m, Rugezi is the largest highland wetland in the country covering an area of 67.35 km². It plays a critical role in regulating and filtering water flows into Lakes Bulera and Ruhondo downstream, which are the main reservoirs feeding Rwanda's largest hydropower stations, Ntaruka and Mukungwa.

Between 2004 and 2006, significantly reduced water levels in Lakes Bulera and Ruhondo resulted in severe hydropower shortfalls and a tripling of utility prices. There were daily power outages and rationing of electric supply, which mainly affected Kigali. The unprecedented energy crisis galvanized national attention, prompting the government to undertake quick action to tackle the underlying causes of the problem.

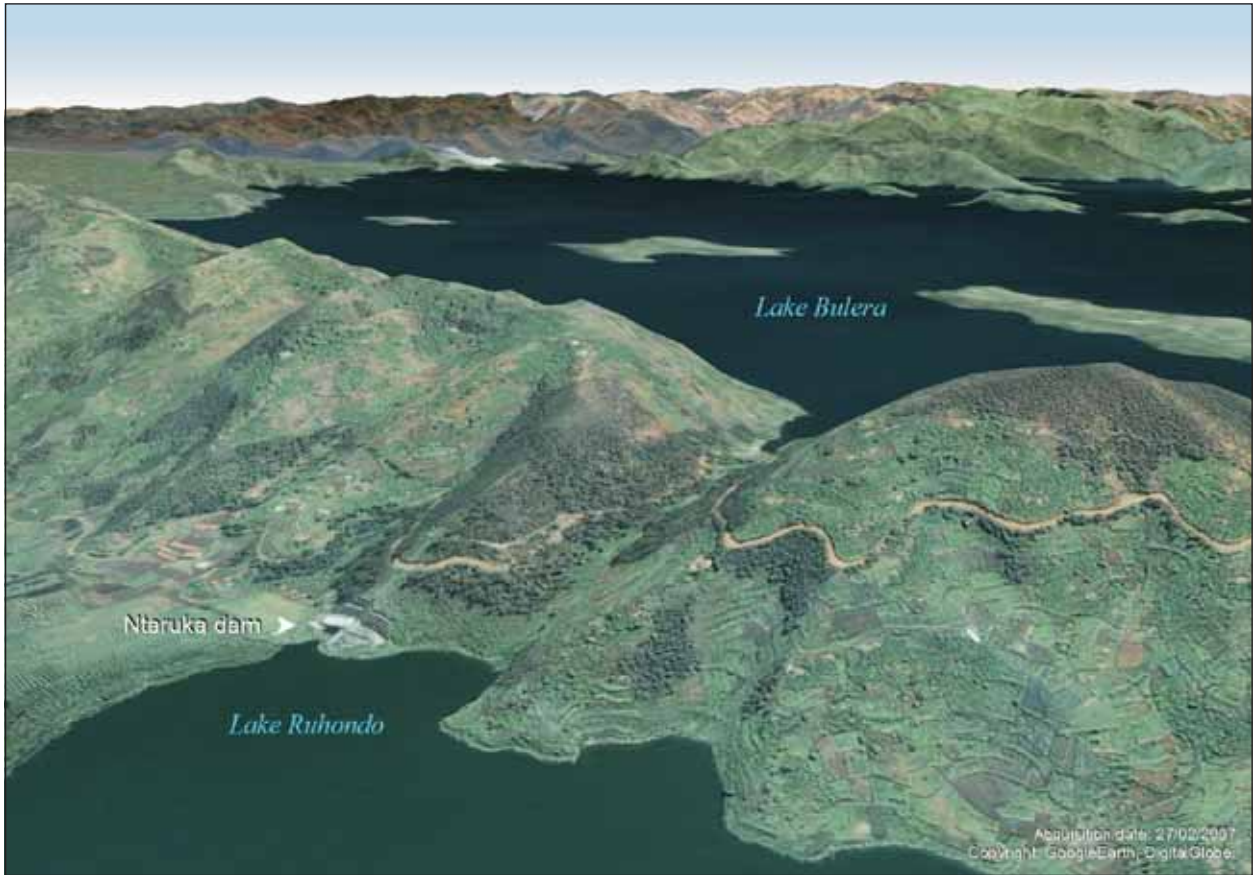
Reduced lake levels were attributed to rainfall changes, agricultural encroachment on the Rugezi wetland and increased sedimentation due to land degradation in the catchment as a whole. The government responded by prohibiting settlement and agricultural activity in the wetlands, which was confirmed during the UNEP visit. It also designated the Rugezi-Bulera-Ruhondo complex as the country's first site under the Ramsar Convention on Wetlands, which increased its conservation status.

Since these actions were taken, water levels have stabilised in Lakes Bulera and Ruhondo. At the same time, UNEP discussions with the hydropower plant operator revealed that water overabstraction to generate electricity was also an important factor in the lakes' declining water levels. This situation was further complicated by the fact that hydropower plant installations were not operating efficiently and required rehabilitation. Subsequent adjustment of hydropower plants' operations is, therefore, an important factor in the lakes' restored water levels.

The environmental and energy crisis in the Rugezi wetlands clearly illustrates the importance for different sectors and institutions to come together, discuss their water needs and jointly agree on water allocations. Key institutions that were involved in resolving the problem included MINAGRI for the agricultural sector, MININFRA for the energy sector and MINIRENA to ensure adequate water flows for ecosystem services and biodiversity.

Nevertheless, consultations need to be expanded to include local authorities and communities, in order to ensure that their needs are also addressed. Establishing a formal mechanism for consultations and information exchange is also crucial so that key stakeholders are kept abreast of latest developments and reach decisions based on mutual understanding. The Rugezi wetlands also provide an interesting case for exploring the feasibility of applying a PES scheme to reduce community vulnerability and uphold energy supplies.

Figure 15. Ntaruka dam



The role of the Rugezi wetlands in improving water quality through filtration is demonstrated by the clear water (right) flowing from it and the murky stream originating from an agricultural area



Water resource monitoring collapsed following the 1990-1994 conflict and is only now gradually being rebuilt

Establishing a comprehensive water monitoring programme

Water resource management continues to be impeded by the destruction of the hydrological monitoring network and loss of long-term data sets during the 1990-1994 conflict. Although a new national surface network has been designed and is partially under construction with the installation of the first 17 out of a planned 71 stations, the state of Rwanda's water resources remains inadequately monitored. Inadequate availability of information on the quantity and quality of surface and groundwater resources makes it difficult to undertake long-term planning in the sector.

A comprehensive water monitoring programme needs to be developed covering surface and groundwater, standard water quality surveillance and freshwater biological indicators. Human resource issues as well as financing shortfalls appear to be hindering factors in re-establishing the water monitoring system. It is estimated that 60 percent of water professionals fled the country or died due to the war,³⁵ and efforts to train a skilled cadre of water resources technicians have been slow.

Mobilising international partner support

Rwanda should endeavour to mobilise international partner support for its water sector, which is presently minimal. Similar to other countries implementing IWRM in the region, Rwanda should collaborate with international partners to support capacity-building activities, develop a national IWRM plan, establish a monitoring programme and implement pilot projects. Operational costs should be covered by government to promote sustainability.

9.7 Expanding regional cooperation

Rwanda is positively engaged in regional dialogue and cooperation on transboundary waters, particularly through the Nile Basin Initiative (NBI) and the Nile Equatorial Lakes Subsidiary Action Program (NELSAP), whose secretariat is based in Kigali. Through NELSAP, NBI has been able to mobilise substantial economic investments that have benefited Rwanda, including joint hydropower projects, small

Map 17. Rwanda proposed hydrological monitoring network



water supply projects within the basin, and exploring the navigation potential on the Akagera River. Other activities include reforestation of the Akagera Basin as well as removal of the water hyacinth.

Similarly, Rwanda should also participate in initiatives promoting shared management and development of the Congo Basin's water resources. The Commission of the Congo-Oubangui-Sangha Basin offers one potential entry point for developing joint initiatives. Also, a new initiative to protect the watershed of Lake Tanganyika sub-basin is currently under way. In addition, Rwanda's national water policies and laws can be further strengthened through harmonisation with those of the East African Community (EAC) and the application of IWRM principles on a shared basis.

9.8 Conclusions

Water is central to Rwanda's efforts for poverty alleviation. At least 25 percent of the population and a little over 30 percent of the rural population still do not have access to improved water supply. While Rwanda has made significant strides in increasing safe water supply coverage, the fact remains that most households, including those in urban areas, are not connected to

water infrastructure, including piped water and sanitation. This situation has in turn created an ideal environment for waterborne disease transmission, as evidenced by UNEP's snapshot sampling results. The increasing demands of a rapidly growing population will enlarge the challenge of improving access to safe water.

As Rwanda embarks on an accelerated development path, managing the multiple water demands of the competing sectors will be its greatest challenge. In particular, balancing the water demands of agricultural intensification, which is necessary to feed its growing population, with those of the other sectors, including for environmental services, will be a critical test.

Given Rwanda's abundant water resources, the problem is not one of water shortage. Rather, it is due to an investment shortage in both human capacity and physical infrastructure. Strengthening water governance is, therefore, critical. The government's adoption of an IWRM approach represents a positive step to bring stakeholders together and manage their water needs in an integrated and flexible manner. The challenge now is to tailor IWRM to the Rwandan context. Building water management capacities and generating reliable hydrological data are essential



Many people, like this young boy, rely on jerry cans to secure their daily water needs

elements for the successful implementation of IWRM, which will also require international support. This will become all the more important with the projected uncertainties in rainfall that are likely to result from climate change.

9.9 Recommendations

R9.1 Develop a national IWRM plan. The aim is to create a tailored national IWRM plan for Rwanda that would articulate a long-term vision, quantify sectoral water needs, establish operational objectives and develop a plan of action. This process would identify and engage key stakeholders and establish mechanisms for cross-sectoral consultations and the implementation of IWRM activities. An evaluation of the current legislative framework on water resources in relation to its integration of IWRM principles would also be undertaken.

Lead agencies: MINIRENA, Water Resources Management Agency. IP: GWP, UNEP. Cost estimate: USD 1 million. Duration: 2 years.

R9.2 Pilot IWRM projects at catchment level. The purpose of piloting IWRM at catchment level is to both develop a Rwanda-specific IWRM approach and build national capacity in IWRM application through hands-on experience. The case of the Rugezi wetlands provides an ideal pilot study, especially given its strategic national importance as well as ongoing efforts to improve watershed management through cross-sectoral collaboration. Pilot initiatives would also support the development of a national IWRM institutional framework based on hydrological boundaries.

Lead agency: MINIRENA, Water Resources Management Agency. IP: UNEP. Cost estimate: USD 1 million. Duration: 2 years.

R9.3 Develop a national wetlands programme. This programme would focus on building national and local government capacity for wetlands management including at the community level. It should include training in establishing a wetland inventory, monitoring and information management. Economic valuation studies would also be carried out for all wetlands to determine the feasibility of developing local PES schemes.

Lead agency: REMA, Water Resources Management Agency. IP: UNDP. Cost estimate: USD 2 million. Duration: 2 years.

R9.4 Support the re-establishment of a national water monitoring programme. The aim is to rebuild the hydrological monitoring network that was destroyed during the conflict. This national programme would cover surface and groundwater and monitor both water quantity and quality. Funding for setting up this programme would need to be mobilised from international partners.

Lead agency: MINIRENA, Water Resources Management Agency. IP: WHO. Cost estimate: USD 3.5 million. Duration: 3 years.

R9.5 Scale-up rainwater harvesting projects at household and community levels to improve water supply. This programme would initially evaluate the performance and potential of existing rainwater harvesting initiatives at the household level, as well as by region. Part of the scale-up is expected to identify effective rainwater collection strategies drawing on lessons learned from current interventions, in both rural and urban areas, in order to augment water supply accessibility in local communities. This programme would also seek to integrate rainwater harvesting into watershed management plans.

Lead agency: MININFRA, MINIRENA, Water Resources Management Agency. IP: UNEP. Cost estimate: USD 2 million. Duration: 3 years.

R9.6 Develop a strategy to promote water management cooperation in the Congo Basin. This proposal seeks to develop entry points to engage with Congo Basin countries on the sustainable development of its shared water resources, including potential joint investments in the energy sector. Due consideration should be given to existing cooperation frameworks, including the Commission of the Congo-Oubangui-Sangha Basin.

Lead agencies: MINIRENA, REMA, Water Resources Management Agency (as appropriate). IP: UNEP. Cost estimate: USD 0.05 million. Duration: 1 year.

Wildlife and Protected Area Management

*The emergence of mountain gorilla tourism
in the aftermath of the 1994 conflict
into a key contributor to Rwanda's
national economy has been a major
conservation success story*

© Gilles Tordjeman



Wildlife and Protected Area Management

10.1 Introduction

Rwanda boasts a remarkable variety of wildlife. A flagship achievement is its successful efforts in protecting one of the last remaining populations of mountain gorillas in the wild, even through conflict and the competing demands of post-conflict recovery. Most of the country's wildlife in Rwanda is found in protected areas, though they also inhabit ecosystems outside protected areas.

Protected areas and wildlife populations were significantly impacted by the 1990-1994 conflict and the resettlement of returnees during the post-conflict period. Today, strong political commitment exists in Rwanda to protect wildlife and their habitats. However, high population growth and rural poverty resulting in acute land scarcity have rendered protected areas to resemble

'fortresses under siege'. The country now faces an interlinked, dual challenge of protecting the remaining wildlife population while earning the support of local communities to participate in conservation.

This chapter examines wildlife and protected areas as a specific sector. The larger topic of biodiversity, despite its importance, was deemed beyond the scope of this assessment. With respect to wildlife, this chapter focuses on large fauna in greater detail; more comprehensive discussions on the country's flora and fauna are found elsewhere in the literature.¹ The aim of this study is to highlight key issues, including those arising from the 1990-1994 conflict, and to propose short-term solutions that can feed into long-term conservation of wildlife and protected areas.

10.2 Assessment activities

The field assessment focused mainly on national parks and important biodiversity hotspots. The assessment did not involve in-depth investigations of



Wildlife populations, particularly in the Akagera National Park, have significantly declined in the post-conflict period, mainly due to habitat loss



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Nyungwe’s designation as a national park in 2005 almost doubled the country’s total park area

Table 29. Field sites visited by province

Province	Field sites
Northern	– Volcanoes National Park – Rugezi wetlands
Southern	– Nyungwe National Park
Eastern	– Akagera National Park

wildlife resources or the integrity of protected areas. However, an extensive review of existing literature and stakeholder consultations provided a sound basis for obtaining a comprehensive view of the sector.

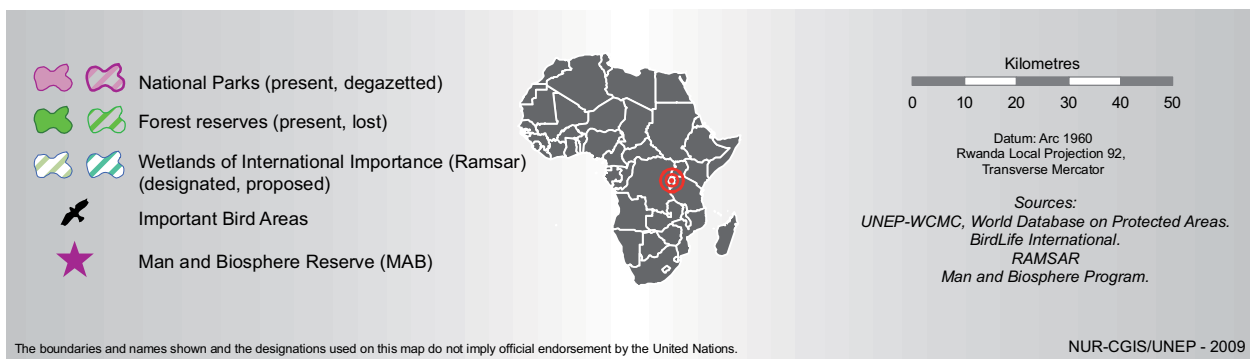
Stakeholder consultations included: managers of national parks, heads of local administrative units (e.g. mayors, district officers), Rwanda Office of Tourism and National Parks (ORTPN), Rwanda Environment Management Authority (REMA) and the Ministry of Natural Resources (MINIRENA).

10.3 Overview of wildlife and protected areas

There is a long history of protected area management in Rwanda. Despite their official protection status, however, national parks and their boundaries have remained fluid over the past 50 years. Rwanda’s protected area network currently consists of three national parks and other significant wildlife habitats with protected status such as forest reserves and protected wetlands.

The national parks are: (i) Akagera National Park in the east bordering the United Republic of Tanzania (Tanzania); (ii) Nyungwe National Park in the southern Congo-Nile highlands bordering the Kibira National Park in Burundi; and (iii) Volcanoes National Park in the northwest, which forms part of the Virunga Volcanoes landscape that is shared together with the Democratic Republic of the Congo (DR Congo) and Uganda.

Map 18. Protected areas of Rwanda



The formally designated national park area has more than doubled in the post-conflict period from 3.9 percent of the country in 1990 to 8.4 percent in 2008. This expansion is mainly due to the upgrading of Nyungwe's status from a forest reserve to a national park in 2005. However, this increase masks the fact that Akagera National Park has lost two-thirds of its surface area since 1994, mainly to accommodate returnees during the post-conflict period. Moreover, other areas with protected status, including wetlands, have decreased in size and number due to deforestation for energy needs, human settlement and agriculture expansion. Conversely, while the national park area has increased, the area of national territory under protection has actually declined. Chapter 8 provides further details on the extent of forest cover in protected areas.

Extent of protected area coverage

National park boundaries and area coverage

The Akagera and Volcanoes National Parks were established during the colonial period, while Nyungwe National Park only achieved legal status as a national park in 2005. These national parks

span a wide altitudinal range and cover all key habitats found in Rwanda, including: savanna, woodlands, low and high altitude wetlands, lakes and Afro-montane rainforests.

Volcanoes National Park originally covered a surface of 19,000 ha in 1925, but its forest area coverage had increased to 34,000 ha by 1960. Between 1958 and 1973, relatively large areas were set aside for human settlement and pyrethrum production, reducing the size to its current 16,000 ha. The park was used as a base by the Rwandan Patriotic Army during the 1990-1994 conflict and was a theatre of military operations, experiencing significant human impact as a result.

Akagera, including the adjoining Mutara Game Reserve, spanned a surface area of 335,000 ha in 1954. By 1994, the park's boundaries were reduced to 241,000 ha. The most dramatic reduction in the park's area, however, occurred from 1994 to 1998 during the massive return of repatriated refugees after the conflict. The Mutara Game Reserve has since completely disappeared. With the redrawing of Akagera's park boundaries in 2003, current area coverage stands at 108,500 ha.



Lacking a buffer or transitional zone, the Volcanoes National Park lies in striking contrast with the densely populated surrounding farmland

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A large swath of Akagera National Park and the entire Mutara Game Reserve were ceded to resettlement of returnees following 1994

Between 1958 and 1979, Nyungwe was reduced in size from 114,100 to 101,300 ha, primarily due to encroachment by local farmers.² Today, following its gazettement as a national park, Nyungwe covers an area of 92,400 ha. It is the largest conservation block in the country with one of the highest biodiversity levels in Africa.

It should be noted that substantial encroachment and degazetting of protected areas has now stopped, reflecting the current political commitment to keep these areas intact. The downsizing of national parks and other protected natural reserves, however, has had a major impact on wildlife populations and their diversity (discussed further below). It also has had wider implications for the country in terms of provision of ecosystem services, including regulation of regional climate and rainfall.

Nyungwe National Park is an important water catchment area in Rwanda, contributing 70 percent of the country's rainfall.³ It supplies nearly 75 percent of the dry season river flow in the country's principal river system.⁴ Moreover, rivers and streams originating from Nyungwe flow both east and west into the Nile and Congo basins and provide most parts of the country with stable sources of water. Furthermore, Kamiranzovu and Uwasenkonko swamps located in the park are known to be important water reservoirs for the country and contain one of the largest peat bodies in Africa.⁵

Volcanoes National Park is also an important water catchment. While it covers 0.5 percent of total land area in the country, it is estimated to provide 10 percent of existing watershed

protection in Rwanda. The volcanic soils in and around Volcanoes are some of the richest and most productive in the country.

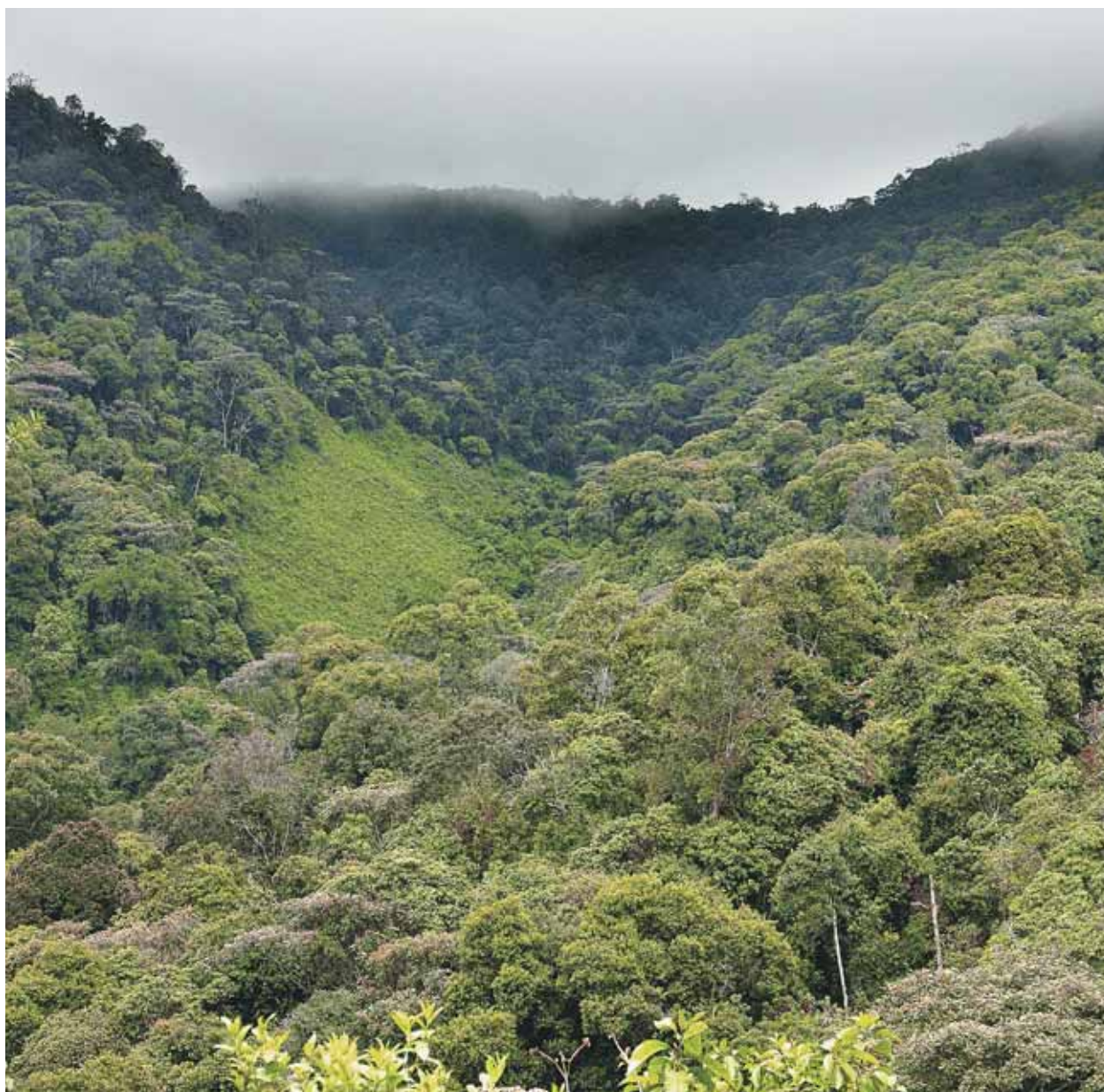
Other protected areas outside of national parks

Apart from the three main national parks, there are several important wildlife habitats, which have varying legal protection status. The remaining forests in Gishwati and Mukura are classified as forest reserves. Gishwati, in particular, experienced significant reductions in total area, when large tracts were degazetted for resettlement after the conflict.

The Rugezi wetland, which is an important bird area, was designated as a Ramsar site under the International Convention on Wetlands in 2005.⁶

Overview of wildlife

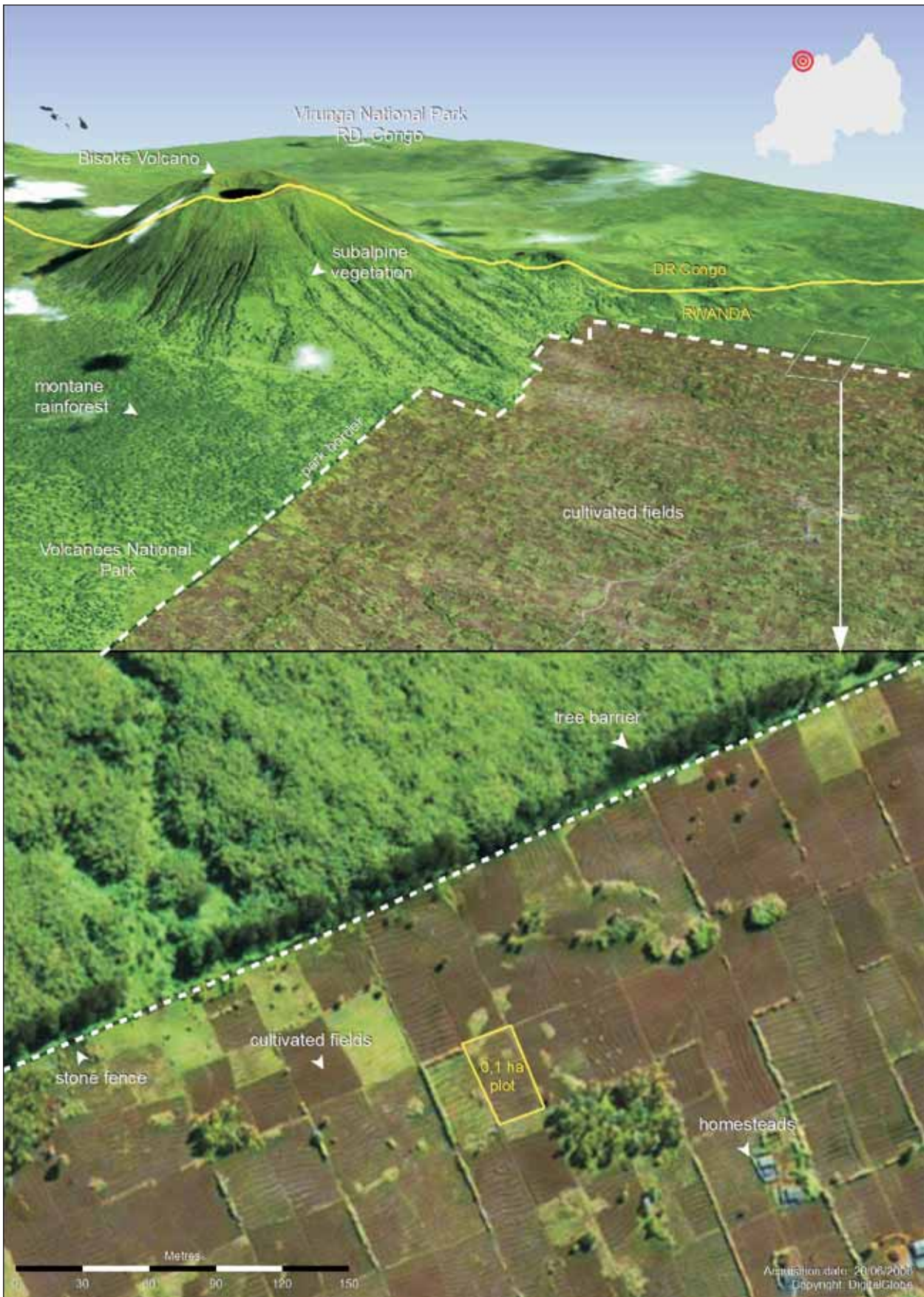
The country has witnessed a significant decline in wildlife populations in recent decades due mainly to habitat loss and to a lesser extent to poaching and wildlife trade⁷. Rwanda harbours at least 16 globally endangered vertebrate species (Table 30, page 209). A list of endangered plant species in the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) is presented in Table 31 (page 210).



Nynugwe is a strategic water catchment area generating an estimated 70 percent of the country's rainfall

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Figure 16. Land use pressures surrounding Volcanoes National Park



10 WILDLIFE AND PROTECTED AREA MANAGEMENT

Table 30. Globally endangered and vulnerable vertebrate species in Rwanda⁸

Common name	Scientific name	IUCN Red List category*	Location
Mammals			
Mountain gorilla	<i>Gorilla beringei</i>	EN	Volcanoes
Mountain monkey	<i>Cercopithecus l'hoesti</i>	VU	Nyungwe
Eastern chimpanzee	<i>Pan troglodytes ssp. Schweinfurthii</i>	EN	Nyungwe, Gishwati
Owl-faced monkey	<i>Cercopithecus hamlyni</i>	VU	Nyungwe
L'hoest's monkey	<i>Cercopithecus lhoesti</i>	VU	Nyungwe, Gisenyi
Golden monkey	<i>Cercopithecus mitis ssp. Kandti</i>	EN	Volcanoes, Nyungwe
Black-fronted duiker	<i>Cephalophus nigrifrons ssp. Rubidus</i>	EN	Akagera, Nyungwe
Yellow-backed duiker	<i>Cephalophus silvicultor</i>	CR	Akagera, Nyungwe
Black rhinoceros	<i>Diceros bicornis</i>	CR	Akagera
Lion	<i>Panthera leo</i>	VU	Akagera
African elephant	<i>Loxodonta Africana</i>	NT	Akagera
African buffalo	<i>Syncerus caffer</i>	EN	Akagera
Hill's horseshoe bat	<i>Rhinolophus hilli</i>	CR	Nyungwe
Kivu long-haired shrew	<i>Crocidura lanosa</i>	EN	Uinka
Rahm's brush-furred rat	<i>Lophuromys rahmi</i>	EN	Volcanoes
Medium-tailed brush-furred rat	<i>Lophuromys medicaudatus</i>	VU	Volcanoes
African wild dog**	<i>Lycaon pictus</i>	EN	Akagera
Congo bay-owl	<i>Phodilus prigoginei</i>	EN	Nyungwe
Cheetah***	<i>Acinonyx jubatus</i>		
Delany's swamp mouse	<i>Delanymys brooksi</i>	VU	Volcanoes, Nyungwe
Common hippopotamus	<i>Hippopotamus amphibious</i>	VU	Akagera, Mutara
De Graaff's Praomys	<i>Praomys degraaffi</i>	VU	Nyungwe, Kayove, Volcanoes
Ruwenzori shrew	<i>Ruwenzorisorex suncoides</i>	VU	Volcanoes
Moon forest shrew	<i>Sylvisorex lunaris</i>	VU	Volcanoes
Kemp's thicket rat	<i>Thamnomys kempii</i>	VU	Volcanoes, Nyungwe
Charming thicket rat ^o	<i>Thamnomys venustus</i>	VU	Volcanoes
Ruwenzori horseshoe bat	<i>Rhinolophus Ruwenzorii</i>	VU	Mutara
Birds			
Shoebill	<i>Balaeniceps rex</i>	VU	Akagera
Grauer's rush-warbler	<i>Bradypterus graueri</i>	EN	Volcanoes, Nyungwe, Rugezi
Kungwe apalis	<i>Apalis argentea</i>	EN	Nyungwe
Congo bay owl	<i>Phodilus prigoginei</i>	EN	Lake Kivu area
Shelley's crimson wing	<i>Cryptospiza shelleyi</i>	VU	Nyungwe
Madagascar pond-heron	<i>Ardeola idea</i>	EN	Akanyaru
Red-collared mountain babbler	<i>Kupeornis rufocinctus</i>	NT	Nyungwe
Kivu Ground-thrush	<i>Zoothera tanganjicae</i>	NT	Nyungwe
Papyrus yellow warbler	<i>Chloropeta gracilirostis</i>	VU	Rugezi
Chapin's flycatcher ^o	<i>Muscicapa lendu</i>	VU	Nyungwe
Lesser kestrel	<i>Falco naumanni</i>	VU	Volcanoes
Albertine owlet	<i>Glaucidium albertinum</i>	VU	Nyungwe
Rockefeller's sunbird ^o	<i>Nectarinia rockefelleri</i>	VU	Nyungwe
Lappet-faced vulture	<i>Torgos tracheliotos</i>	VU	n.a.
White-headed vulture	<i>Trigonoceps occipitalis</i>	VU	Volcanoes

Notes:

* CR = critically endangered; EN = endangered; VU = vulnerable; NT = near threatened.

** An IUCN report published in 1997 states that these dogs are extinct in Rwanda.

*** The IUCN Red List 2008 listed this as extinct in Rwanda.

^o The IUCN Red List 2008 listed its presence in Rwanda as uncertain, requiring verification.

n.a. Indicates data not available.

Table 31. Plant species listed by CITES⁹

Family	Scientific name	Status
CYATHEACEAE	<i>Cyathea dregei</i>	Potentially threatened species
LILIACEAE	<i>Aloe bukobana</i> <i>Aloe dawei</i> <i>Aloe lateritia</i> <i>Aloe macrosiphon</i> <i>Aloe myriacantha</i> <i>Aloe secundiflora</i> <i>Aloe secundiflora</i> <i>Aloe volkensii</i>	Potentially threatened species
ROSACEAE	<i>Prunus africana</i>	Potentially threatened species
ZAMIACEAE	<i>Encephalartos septentrionalis</i>	Species threatened with extinction



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Rwanda's exceptional bird diversity is highly dependent on the country's many wetlands and lakes

Rwanda is known to have 151 different types of mammal species, at least 12 of which are currently endangered. It is famous for its wealth of primates, the most prominent of which is the mountain gorilla, one of the world's most endangered apes, found in Volcanoes National Park. Nyungwe and Volcanoes are inhabited by several species of duiker, including the yellow-backed duiker threatened with extinction. A total number of 97 reptiles and 25 amphibian species have been recorded,¹⁰ of which one reptile – the tortoise – is listed with concern under the IUCN Red List.¹¹

An impressive 670 different species of birds have been documented in the country, including the red, yellow, and black papyrus gonolek, the blue-headed coucal and the much sought after shoebill stork, which are mostly found in wetlands.¹² A significant threat to birdlife in the country is the current push towards wetland reclamation.

Rwanda shelters 2,150 species of plants, eight of which are listed by the UNEP World Conservation Monitoring Centre (WCMC) as either threatened or otherwise of conservation concern.¹³

Akagera National Park

Wildlife decline has been especially marked in Akagera National Park. From 1990 to 1994, the park was the scene of significant military activity. Nonetheless, it was only after the conflict – between 1994 and 2002 – that wildlife declined from a remarkable 50 to 80 percent. This decline was mainly due to habitat conversion by agricultural activities (including cattle grazing) and resettlement of displaced populations. Poaching by locals as well as hunters from Tanzania has added further pressure.¹⁴

Today, Akagera remains an exceptional conservation area and is classified as an Important Bird Area.¹⁶ Its extensive wetland complex shelters a wide variety of birds, including the rare shoebill stork. Akagera has 525 species of birds, as well as 90 species of mammals and 35 species of fish.



The zebra population in Akagera National Park declined by almost 80 percent between 1997 and 2002

Fauna is essentially East African, including species of baboon, vervet monkey, silver monkey, roan antelope, eland, hippopotamus, impala, oribi, warthog, bush pig, waterbuck, reedbuck, sitatunga, buffalo, topi, zebra, duiker, klipspringer, lion, leopard, spotted hyena and side-striped jackal. There are also populations of crocodile, monitor lizard, aardvark, snakes, mongoose, scrub hare, serval cat, golden cat, and bush hyrax. Elephants were reintroduced in 1975 and giraffes in 1985. However, the African wild dog, giant forest hog and red river hog are locally extinct and no longer exist in the park.

The most threatened species are the rhino and large carnivores, particularly lions. The Black rhinoceros introduced in 1956 was thought to be extinct, but tracks have recently been sighted. However, discussions during the fieldwork cast serious doubts on the current existence of the rhino. A number of species are protected under the CITES convention,¹⁷ including the African elephant, buffalo, leopard and sitatunga.¹⁸

Nyungwe National Park

Because of its high biological diversity, Nyungwe is recognised as a priority conservation site in Africa.¹⁹ It is home to 85 mammal, 32 amphibian and 38 reptile species. In addition, there are 1,068 plant species recorded in the park, of which approximately 250 are endemic to the Albertine Rift.

Nyungwe hosts a diverse number of primate communities, some of which are amongst the most threatened primate species.²⁰ Threatened primates include the eastern chimpanzee, owl-faced monkey and golden monkey.²¹ Primate species that are not threatened include L'Hoest's monkey (*C. lhoesti*),

Table 32. Changes in wildlife population in Akagera National Park (1990-2002)¹⁵

Species	1990	1997-1998	% change	2002	% change
Buffalo	10,000	2,260	-77	791	-78
Eland	325	103	-68	114	+11
Impala	30,000	5,660	-81	1,890	-67
Reedbuck	1,890	–	–	74	-96
Topi	7,500	2,020	-73	713	-65
Warthog	1,500	380	-75	383	+1
Waterbuck	1,600	350	-78	191	-54
Zebra	3,800	3,050	-20	652	-79

Note:

– Indicates data not available.



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Nyungwe National Park hosts one of the richest primate communities in Africa. Shown here are colobus monkeys that can be found in very large troupes of several hundred

vervet monkey (*Cercopithecus aethiops*), olive baboon (*Papio anubis*), grey-cheeked mangabey (*Lophocebus albigena*) and red-tail monkey (*Cercopithecus ascanius*). The black and white colobus groups (*Colobus angolensis*) in Nyungwe are unusually large, ranging up to 450 individuals – larger than any other group recorded for this species.²² Nyungwe also supports other mammal species such as the black-fronted duiker, bush pig, serval cat and numerous species of bats and rodents.

Nyungwe is also home to 278 bird species, including 26 Albertine Rift endemics, including the Ruwenzori turaco, the red-chested alethe, sunbirds, giant hornbills and the great blue turaco.²³ Three bird species are listed as threatened: the Kungwe Apalis, Grauer's swamp warbler and Shelly's Crimson wing. Two species listed as near threatened are the red-collared mountain babbler and the Kivu ground-thrush.²⁴

Volcanoes National Park

Volcanoes National Park has 245 plant species of which 17 are threatened, at least 187 bird species, and 115 mammal species.²⁵ Volcanoes is highly acclaimed as the home of the largest wild

population of mountain gorillas. A 2003 census puts the total population of mountain gorillas in the Virunga range at 380; of these, Rwanda hosts 250 individuals including 14 habituated groups. Rwanda's mountain gorilla population is believed to constitute 30 percent of the global population of the species. The park also shelters 27 species of reptiles and amphibians, 51 species of rodents and 33 arthropod species.²⁶

10.4 Governance

National parks are protected by a series of laws, which restrict local access to them. An overall policy governing the management of protected areas and a legal framework for the management of wildlife are still in the process of development. It should also be noted that a master plan for protected areas is under preparation.

Currently, only the Environment Policy and Law provide a general framework for the protection of wildlife, national parks and other natural reserves. However, there are no specific regulations or standards with respect to wildlife and protected areas to implement the law.

The management of wildlife and protected areas is divided between a number of institutions. The Rwanda Office of Tourism and National Parks (ORTPN) has recently been integrated into the Rwanda Development Board (RDB), under the President's Office in order to enhance investment in the growing tourism industry. ORTPN is charged with the conservation, protection and promotion of tourism sites, which include the three national parks. It also undertakes law enforcement, research and wildlife monitoring in protected areas.

MINIRENA is responsible for the forest reserves, such as Gishwati and Mukura, and the buffer zone pine plantations established along the borders of national parks, as well as wetlands outside national park boundaries. REMA is charged with Environment Law enforcement and the regulation and monitoring of natural resource use and management, including public areas not having legally sanctioned protected status.

Presently, the management of national parks and other areas with protected status is centralised at the national level. Local governments (i.e. provincial or district levels) do not play a role in wildlife and protected area management.

10.5 Overview of key issues

There are major threats to wildlife but also great opportunities for conservation, poverty reduction and transboundary cooperation. The key issues highlighted in this section are:

- community participation in wildlife conservation and protected area management;
- wildlife tourism as a growing source of national income;
- emerging threats in protected areas;
- strengthening wildlife and protected area governance; and
- promoting regional wildlife cooperation.

Community participation in wildlife conservation and protected area management

Community participation in wildlife conservation and protected area management is a novel approach in Rwanda that needs to be further promoted. Community participation is critical to the long-term survival of wildlife and the integrity of the protected area system. This relates especially to communities living around protected areas and wetlands.



Strengthening the protected area network through training and recruitment of new staff is an important priority

Increasing community awareness

While the local population is aware that encroachment on park boundaries and wildlife poaching are illegal, these two activities continue to occur in protected areas based on UNEP discussions with park authorities. Poaching is prevalent in all three national parks and is discussed further below under section “Promoting regional wildlife cooperation”.

With respect to encroachment, park management authorities perceived a strong tendency by communities to expand their activities into protected areas. Particularly in Akagera National Park, heavy grazing pressure – together with wood harvesting for fuel and construction and deliberately set fires – has resulted in considerable vegetation change in and around the park. It is estimated that there are 270,000 cattle grazing in the region surrounding Akagera. Park management also cited a problem in Nyungwe, where the density of the population surrounding the park has resulted in localised habitat clearance for agricultural activities.

Raising community awareness about the value of protecting wildlife and their habitats is, therefore,

necessary to minimise future encroachments on park boundaries. Otherwise, communities will continue to look at protected areas as potential lands for expansion. Increased awareness must be undertaken in conjunction with development of alternative and economically viable income-generation options for communities living around protected areas.

Developing viable income-generation options

Although there are a number of community development initiatives around protected areas, their impact on reducing the threat to wildlife appears to be minimal. In addition, communities reported a general lack of incentive to engage in conservation activities.

In some cases, local livelihood activities are even in conflict with wildlife and habitat conservation. For instance, there have been uncontrolled fires in Volcanoes due to the local harvesting of honey from wild hives located near park boundaries. Also, extensive bamboo harvesting in Nyungwe by local communities for arts and crafts could undermine conservation efforts, as bamboo is a preferred habitat by rare wildlife such as the owl-faced monkey.



A portion of the revenue generated by gorilla tracking tourism is invested in community projects to help encourage their participation in conservation efforts



The Volcanoes National Park is delineated by a simple rock wall that serves to curtail raiding of crops by wildlife, particularly buffalos, as well as inhibit encroachment by farmers

In developing alternative livelihood options, there is a need for a clear linkage between the proposed income-generating activities and the continued health and integrity of wildlife and protected areas. Proposed community-based enterprises need to be mindful of their economic value chain; that is, of the need for participating communities to earn meaningful returns from conservation activities.

A promising entry point for developing alternative livelihoods is community-based management of the buffer zone pine plantations around national parks. In Nyungwe, buffer zones serve as boundary markers and have been planted with a variety of exotic tree species, including pine (*Pinus patula*), cypress (*Cupressus lusitanica*) and acacia (*Acacia melanoxylon*). Residents usually harvest firewood and building poles from tree plantations.

Communities could play a greater role in managing buffer zone tree plantations, including control over harvesting and transport, which would be a

major source of alternative income (also discussed in Chapter 8). Long-term conservation of the remaining montane rainforests, including Volcanoes and Nyungwe National Parks, will depend on the success of community-based management of buffer zones and sustainable harvesting of forest products by local communities in designated sectors within protected areas.

Wildlife tourism: A growing source of national income

Government policies have recognised the significant contribution of wildlife tourism to national economic development and poverty reduction, as tourism is the third fastest growing source of foreign exchange in the country. Consequently, the government has taken positive steps to promote ecologically friendly tourism (ecotourism) and re-channel tourism revenues to local communities and protected area management.

Volcanoes and Nyungwe, in particular, are being promoted as a core national tourist destination, especially targeting ecotravellers and explorer tourists.²⁷ Volcanoes has a prime position in Rwanda's tourism package, as mountain gorilla tracking has become an international attraction. In 2007, gorilla tracking drew in more than 16,000 tourists, each paying an equivalent of USD 500 to join an organised trek. This represents a substantial growth from a negligible base of USD 5 million in 2002 to USD 33 million in 2006 and USD 42 million in 2007.²⁸



A luxury hotel in Akagera National Park; foreign investors have shown interest in developing Rwanda's tourism facilities

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Table 33. Number of visitors in Rwanda's National Parks, 2004-2007³⁰

Visitor category	2004	2005	2006	2007
Volcanoes National Park				
Rwanda resident	561	577	776	735
Foreign resident	562	693	512	510
Foreign visitors	7,417	9,225	12,720	16,764
Subtotal	8,540	10,495	14,008	18,760
Akagera National Park				
Rwanda resident	11,866	7,196	8,018	9,400
Foreign resident	2,185	1,258	1,737	2,066
Foreign visitors	2,425	2,785	3,965	4,978
Subtotal	16,476	11,239	13,720	16,323
Nyungwe National Park				
Rwanda resident	172	250	392	252
Foreign resident	469	419	492	453
Foreign visitors	1,339	1,717	2,204	3,276
Subtotal	1,980	2,386	3,088	3,981
Total	26,996	24,120	30,808	39,064

Tourism in Nyungwe generates a small but growing amount of direct revenue to the national park system. Nyungwe has an important role in developing the tourism industry, as a key component of a larger tourist circuit.²⁹ The park has unique potential to be a highly profitable tourist attraction, since its diverse range of ecosystems offers a number of possible tourism activities. Akagera National Park, on the other hand, is increasingly becoming a favoured destination for domestic tourism. As the country's middle class grows, the importance of Akagera is also likely to expand.

Overall, there is a need to review current revenue-sharing arrangements to redistribute the benefits generated by wildlife tourism. This applies in particular to ecotourism in Volcanoes National Park. Currently, local communities receive 5 percent of the total income from mountain gorilla tracking. More resources from gorilla tourism should be channelled to the communities in order to strengthen local support for wildlife conservation. The local share of ecotourism revenue is used to implement community projects, such as provision of safe water, health and education.

However, a comprehensive economic valuation of the full range of ecosystem goods and services provided by protected areas is, therefore, needed to better guide policy planning. This should include valuing the indirect, positive influence these resources have

Table 34. Total economic value of Nyungwe watershed³²

Ecosystem services	Economic value (USD/year)
Watershed protection	117,757,583
Biodiversity protection	2,000,000
Carbon sequestration and storage	162,080,000
Recreation and tourism	3,372,313
Total	285,209,896

on other sectors of the economy and human well-being in the country.³¹ For instance, one study by Masozera (2008) calculated the total economic value of the multiple services provided by the Nyungwe watershed, which can be used as a basis to mobilise resources for forest conservation (Table 34).

Emerging threats in protected areas

While the significant decline in wildlife populations has been mainly due to habitat loss (i.e. deforestation) as well as poaching, there are emerging problems in protected areas that threaten (indirectly) wildlife conservation.

Three emerging threats are highlighted in this section:

- spread of the invasive indigenous liana vine;
- forest fire hazards; and
- introduction of exotic species.

Spread of *Sericostachys scandens*, an invasive liana vine

The spread of an invasive indigenous liana (*Sericostachys scandens*) is an emerging problem in



The risk of forest fires in the Afro-montane zone is likely to increase due to climate change. Shown above is a fire scar in Nyungwe National Park

Nyungwe National Park. Widespread openings in the forest canopy due mainly to deforestation, but substantially worsened by major fire outbreaks, have encouraged the spread of this vine, which inhibits natural tree regeneration.

It is thought that this vine was previously browsed by large ungulates or hoofed mammals, such as elephants and buffalo, which have since disappeared from the park. Some experts concur that the reintroduction of liana-feeding elephants and buffalo should be carefully studied as a practical option to reduce the spread of this highly invasive plant, though this solution remains debated.³³

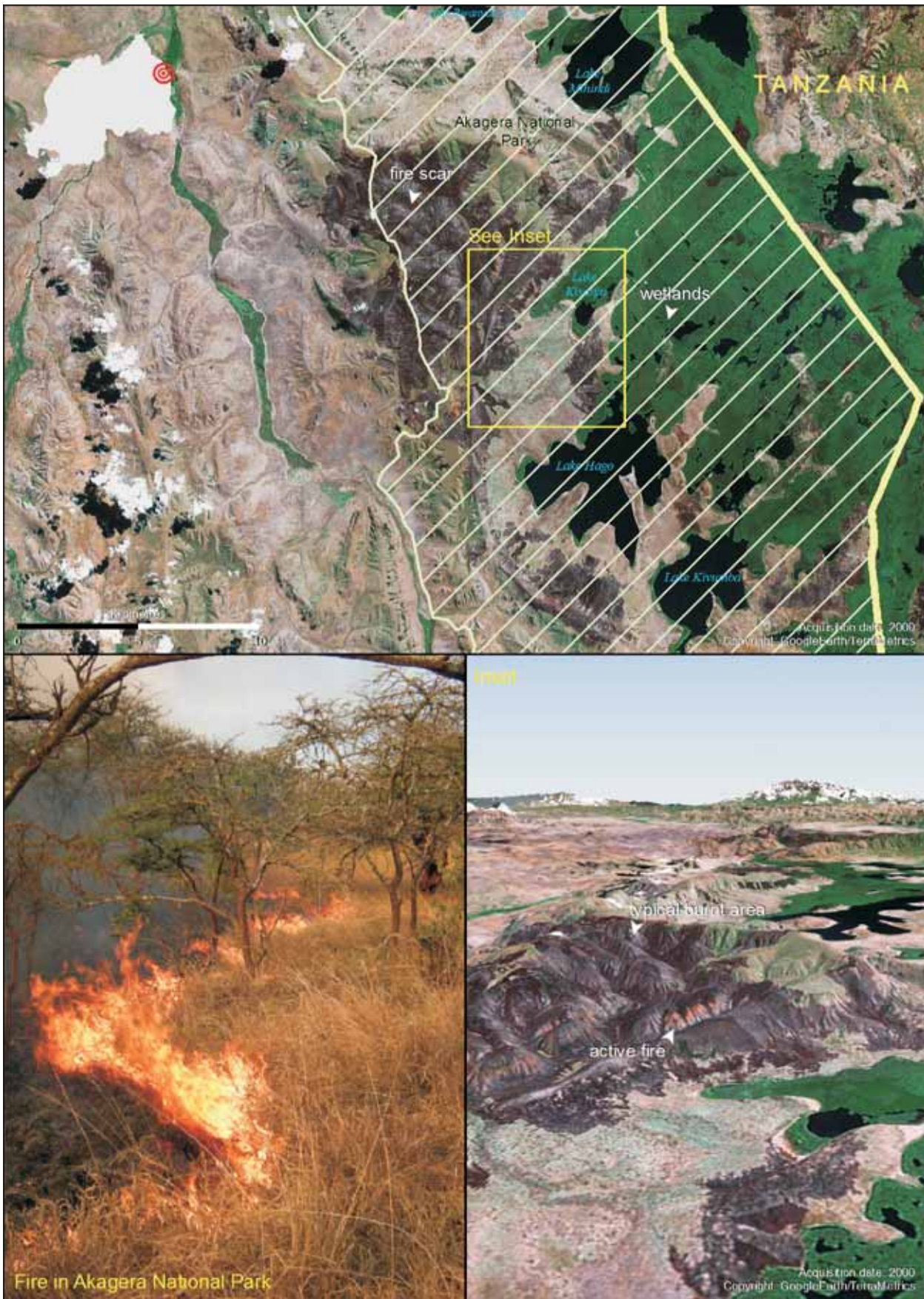
Forest fire hazards

Forest fires constitute a threat to national parks and protected areas. Forest degradation has greatly increased fire hazards, since degraded forests are much more prone to fire. Grasses and vines (i.e. liana) growing in opened spaces dry faster and are more flammable than woody plants.



Widespread opening of the forest canopy in the Nyungwe Forest has encouraged the spread of invasive indigenous liana, which inhibits tree regeneration

Figure 17. Fire scars in Akagera National Park





Security forces attempt to control a fire outbreak in Akagera National Park. There is a need to strengthen fire preparedness and response capacity

Uncontrolled fires in 1997 and 2005 devastated large parts of Nyungwe.³⁴ The fires have worsened forest degradation in Nyungwe, further amplifying its future vulnerability towards fire. The incidence and severity of fires in protected areas are likely to be exacerbated due to anticipated prolonged droughts induced by climate change. Fires are also known to have been spread by the local population wanting to smoke bees from wild hives.

An early warning system needs to be developed, including strengthening fire preparedness and response capacities. Fire preparedness and response could also be promoted as part of community management of protected area buffer zones.

Introduction of exotic species

The introduction of exotic plant and animal species in protected areas poses a potential threat to indigenous wildlife species. For instance, in Akagera National Park, the spread of the water hyacinth (*Eichhornia crassipes*) in its lakes may over the long term undermine biological diversity as well as reduce water quality. This water plant is also found in other lakes, rivers and wetlands of Rwanda.

In Nyungwe National Park, exotic tree species (pine, eucalyptus and black wattle) planted in the buffer

zones and along the asphalt road that runs through the park have established themselves in the natural forest, although natural regeneration appears to be sporadic and limited. Finally, the introduction of a carnivorous fish (*Protopterus aethiopicus*) into Lake Muhazi to control a burgeoning mollusk population may be impacting local fish populations in the lake and perhaps elsewhere.³⁵

Efforts to address the problems posed by exotic species should be intensified.

Strengthening wildlife and protected area governance

The strengthening of wildlife and protected areas is linked with the establishment of an effective policy, legal and institutional framework to ensure sustainable management of Rwanda's biodiversity. The ongoing development of a protected area policy and wildlife framework law will need to take into account the following key issues:

- institutional placement of ORTPN;
- existing institutional gap in the management of wildlife outside protected areas; and
- compensation for damages sustained by local communities from wildlife.

Institutional placement of ORTPN

The recent placement of ORTPN under a development agency – the RDB – is a novel approach that has the advantage of underlining the economic value of conservation. In light of this restructuring, ensuring effective management of protected areas by ORTPN will require a strong science-based approach and close collaboration with other institutions in charge of natural resources management.

Address the existing institutional gap in the management of wildlife outside protected areas

It is unclear whether there is an institutional mandate governing the management of wildlife outside protected areas, most of which are found in the remaining wetlands, lakes and water dams around the country but which generally have limited legal protection status. For instance, the management of hippo and crocodile populations living in lakes, rivers and dams is considered to be the responsibility of REMA. However, existing legislation governing the functions and responsibilities of REMA does not seem to accord it this responsibility.

There are a number of important wildlife areas that currently do not have formal legal protection. These include: (i) Akanyaru and Nyabarongo wetlands, which are important bird areas; and (ii) a few relict Afro-montane forest patches, which have historical and cultural significance (for further discussion on these forests, see Chapter 8).



Wildlife and protected area management is the responsibility of ORTPN, which was recently moved to the Rwanda Development Board, highlighting its economic importance



Managing human-wildlife conflicts outside of protected areas, particularly those involving hippopotamus and crocodile populations is an important issue that needs to be resolved

Compensate local communities for damages sustained from wildlife

Another problematic issue has to do with the compensation of damages caused by wildlife that stray outside protected areas. Animals have been known to raid crops and damage agricultural fields of local communities. For such instances, there is a law that prohibits the killing of wildlife except in self-defense, but no compensation is given to the local population for sustained damages. Protected area authorities (ORTPN) only provide financial contributions to medical bills and burial costs when there is loss of life or injury resulting from animal attacks. The compensation issue deserves greater attention because it has implications on people's willingness to take part in the conservation of wildlife and protected areas.

Promoting regional wildlife cooperation

Transboundary cooperation is critical for the successful management of Rwanda's national parks, as they are all adjoined to protected areas in neighbouring countries. Two key issues should be addressed: (i) encouraging transboundary park management; and (ii) combating illegal activities in the parks and trade in wildlife species and products.

Encouraging transboundary park management

Well-known transboundary collaboration already exists from the mountain gorilla conservation programme operated between Rwanda (Volcanoes National Park), DR Congo (Virunga National Park) and Uganda (Mgahinga National Park). This is currently the most advanced transboundary park management programme in which Rwanda is actively participating. While the groundwork for this collaboration is in place, it needs to be further activated by providing technical assistance to support the implementation of existing instruments and promote joint investment in park infrastructure projects.

A new United Nations (UN)-led initiative is currently being proposed to strengthen and expand on the transboundary management of natural resources in the Greater Virungas landscape. While the scope of this initiative includes natural resources in general, it will also specifically address wildlife tourism and traded wildlife products.

Similar efforts to strengthen transboundary cooperation have been initiated between Nyungwe National Park and Kibira National Park in Burundi, but need to be fully implemented. In addition, cooperation between Akagera National Park and Burigi Game Reserve in Tanzania should be promoted to help establish a wildlife corridor between the two protected areas. This corridor could help to solve the problem of biological isolation faced by Akagera National Park.

Sustainable and regulated trade in wildlife species and products

There is a need for transboundary cooperation to reduce illegal trade in wildlife species and products. Poaching, of large mammals in particular, is reportedly taking place in all three national parks, which is carried out by both locals and hunters from neighbouring countries. While tight controls are necessary, it is nevertheless possible to regulate trade in wildlife to ensure that it sustainably contributes to economic development. Incentives also need to be devised to promote the shift to a legalized wildlife trade regime.

In Nyungwe National Park, large mammals have been the main targets of poaching. As a result, forest duiker densities are low, the buffalo was extirpated in the 1990s and the last elephant shot in 1999. As larger mammal populations decline, hunters now target smaller animals, such as giant rats and squirrels.³⁶



While not considered to be a major trafficking centre, illegal elephant ivory was nevertheless found to be on sale in random checks in Kigali and Gisenyi

In Akagera National Park, the most poached species are buffalo, topi, impala, bushbuck, waterbuck and hippo, whose meat are sold locally for income generation or traded in exchange for goods (e.g. alcohol, food) through organised barter arrangements. In Volcanoes National Park, the most hunted species include buffalo, bushbuck and duiker.

The volume of illegal trade is largely unknown. Based on UNEP interviews and a visit to Kigali City and Gisenyi local markets, this problem exists and warrants greater attention. There seems to be limited recognition of illegal trade in wildlife and wildlife products in the country, a considerable amount of which reportedly originates outside of Rwanda's borders. The recent establishment of the Environment Crime Unit under the National Police is a positive step towards combating illegal wildlife trade.

10.6 Conclusions

The government has made considerable progress towards wildlife conservation and management of protected areas and natural reserve during the post-conflict period. Nevertheless, Rwanda needs to continue its efforts in reducing threats to wildlife and protected areas, not only to protect biodiversity but also to harness these resources to fuel economic development and reduce poverty. Wildlife tourism has already demonstrated that it can be a significant contributor to national economic development, but the basic building blocks to sustainably manage it need to be further supported.

The challenge is to develop sustainable and economically viable livelihood options that directly improve well-being and alleviate poverty amongst local communities living adjacent to protected areas and other important wildlife habitats. The future of wildlife conservation equally depends on strengthening transboundary cooperation.

10.7 Recommendations

R10.1 Review institutional arrangements for wildlife and protected area management. An overall institutional review of wildlife and protected area management should be carried out. This should include an appraisal of the placement of ORTPN under the RDB to draw lessons learnt from this

novel arrangement and ensure its effectiveness. Clarification of the institutional roles of ORTPN and MINIRENA with respect to management of buffer zone pine plantations and the management of wildlife outside protected areas should also be examined.

Lead agencies: ORTPN-RDB, MINIRENA. International Partner: UNEP. Cost estimate: USD 0.05 million. Duration: 1 year.

R10.2 Resolve human-wildlife conflicts through community awareness programmes.

A comprehensive review of human-wildlife conflicts is needed in order to identify effective strategies that reduce such conflicts as well as explore opportunities that could lead to mutual beneficial coexistence. Drawing on solutions that have worked elsewhere in the region should also be taken into consideration. The review should also consider possible ways for expanding local compensation for damages incurred by wildlife, possibly to be linked with the existing Revenue Sharing Programme of ORTPN-RDB.

Lead agencies: ORTPN-RDB, MINALOC, MINAGRI, RADA, RARDA. International Partner: UNEP. Cost estimate: USD 0.15 million. Duration: 2 years.

R10.3 Reinforce the protected area network.

This could be accomplished through the following initiatives: (i) support the recruitment and training of staff working in protected areas and their provision of equipment; (ii) strengthen the cooperation between local governments and protected area authorities; (iii) support the concept of using wildlife and community health as a platform for resolving illegal activities in protected areas; (iv) conduct scientific research on the factors (e.g. fires) contributing to the spread of the invasive vine *Sericostachys scandens* and its impact on protected areas, with a view to acting on technical recommendations; (v) develop an early warning system for wildland fires and build fire preparedness and response capacity; and (vi) undertake a feasibility study on revising national park boundaries, especially that of Akagera National Park given its tourism potential and problems associated with human-wildlife conflicts. The launch pad for the third proposed initiative already exists through The Mountain Gorilla Veterinary Project.

Lead agencies: ORTPN-RDB, MINALOC. International Partners: Mountain Gorilla Veterinary Project, WCS, UNEP. Cost estimate: USD 1 million. Duration: 3 years.

R10.4 Develop alternative and sustainable income generating activities for communities living around protected areas. These activities should be directed at the household level and focused on improving household incomes. An evaluation is needed of production and marketing chains for local enterprises and/or products and the viability of such enterprises before they are introduced. This initiative would also provide assistance to community associations to organise and benefit from savings and credit schemes. The participation of non-governmental organisations (NGOs) and community-based organisations in identifying alternative livelihoods should be encouraged. Finally, there must be a review of revenue sharing policies to ensure that more resources from mountain gorilla tourism go to local communities.

Lead agencies: ORTPN-RDB, MINICOM. International Partner: UNDP. Cost estimate: USD 1 million. Duration: 2 years.

R10.5 Promote national parks as important leisure areas for the growing middle class in order to increase domestic tourism. In collaboration with private sector partners, a government campaign raising national awareness to visit protected areas needs to be carried out to spur the nascent domestic tourism industry. A national strategy should be developed to help create a tourism culture within the country, for instance, through the establishment of a natural history museum in Kigali as well as information centres based in the national parks. Tapping into the regional tourism market and encouraging private infrastructure investments to improve services in the sector should also be pursued.

Lead agency: ORTPN-RDB, MINICOM. Cost estimate: USD 1.5 million. Duration: 3 years.

R10.6 Strengthen intercountry cooperation in the management of transboundary protected areas. There is a need to reactivate and enhance cooperation on the Virunga parks, for instance, through the provision of technical assistance to support implementation of existing instruments and promote joint investment in infrastructure projects. This will need to take into account ongoing

activities, particularly under the International Gorilla Conservation Programme (IGCP). Support is also needed to operationalise the recent agreement with Burundi covering Nyungwe and Kibira National Parks. In addition, dialogue should be initiated with Tanzania to undertake a feasibility study and pursue the establishment of a wildlife corridor between Akagera National Park and Kimisi Game Reserve in Tanzania.

Lead agencies: ORTPN-RDB, REMA. International Partner: UNEP. Cost estimate: USD 3 million. Duration: 4 years.

R10.7 Fully quantify and recognise the contribution of protected areas and wildlife to the national economy. This should include the indirect, positive or supportive services that wildlife and protected areas provide to other sectors of the economy and human well-being in general. As a starting point, a full evaluation and quantification should be undertaken of Nyungwe National Park's contribution in the form of ecosystem services, with due consideration to ongoing evaluation studies such as by the Wildlife Conservation Society (WCS)-Protected Areas Biodiversity (PAB). In addition, an economic evaluation is needed of Virunga National Park's role in soil and water conservation and carbon sequestration.

Lead agencies: MINIRENA, REMA, ORTPN-RDB. International Partner: FAO. Cost estimate: USD 0.5 million. Duration: 2 years.

R10.8 Promote regulated and sustainable trade in wildlife and wildlife products. There is a need to better understand the key driving forces behind illegal wildlife trade, its extent and trade routes. Combating illegal wildlife trade should be carried out in cooperation with neighbouring countries, including resolving the future of confiscated lowland gorillas currently being held at a temporary shelter at the Volcanoes National Park headquarters. Addressing illegal wildlife trade will also require establishing institutional mechanisms to address this problem, including building the capacity of the courts, the police and the Rwanda Revenue Authority as well as providing incentives to promote a regulated wildlife trade regime.

Lead agencies: ORTPN-RDB, REMA. International Partner: UNEP. Cost estimate: USD 0.5 million. Duration: 4 years.

Energy and the Environment

Exploring solutions to its energy crisis, Rwanda launched a pilot plant to exploit methane gas in Lake Kivu in 2009. The lake's enormous gas reserves have the potential of satisfying Rwanda's electricity needs and also supplying the wider region over the longer term

© Alex Kabuto, Kibuye Power 1



Energy and the Environment

11.1 Introduction

Over the past three decades, Rwanda's energy sector has suffered from considerable neglect. Investment in the energy sector has been minimal, partly due to the lack of capital and know-how in government as well as in the private sector. The impact of this underdevelopment is all too apparent. The vast majority of the population still has no access to electricity and are highly dependent on biomass, mainly fuelwood and charcoal, for cooking energy. Moreover, the country relies on petroleum imports to fuel its industries and transport. Alternative energy sources are limited and expensive, reinforcing dependency on less efficient and polluting sources of energy. Nevertheless, over the past several years the government has made an invigorated push to tackle the energy crisis.

As the population increases, together with rapid urbanisation and planned economic growth, the energy supply deficit in Rwanda will continue to amplify. Swift and concerted action is therefore needed to tackle increasing energy demands over the short and long term. In the short term, measures to augment wood supplies as well as improve fuel use efficiency are needed. The key to meeting Rwanda's energy requirements in the long term, however, lies in harnessing the country's natural assets to develop renewable energy and in maximising transboundary energy cooperation.

11.2 Assessment activities

Fieldwork included visits to a number of power generating plants, including hydro, thermal, solar and biogas plants. The UNEP team also visited waste collection and recycling enterprises, *imidugudu* resettlement sites, charcoal and brick-making kilns and various factories. Rapid household appraisals were also conducted during field visits.



The great majority of Rwanda's households, both in rural and urban areas, rely on fuelwood for cooking energy

Table 35. Field sites visited by province

Province	Field sites
Kigali	<ul style="list-style-type: none"> - Imidugudu sites - Biogas plant at Kimironko prison - Briquette sawdust factory (Briqueterie Rwandaise de Ruliba) - Kigali solar power plant in Mount Jali - Wood market in Kigali City - Kabuye sugar factory
Northern	<ul style="list-style-type: none"> - Thermal power plant in Musanze District - Mukungwa peat sites - Mukungwa hydropower plant - Ntaruka hydropower plant
Southern	<ul style="list-style-type: none"> - Biogas plants in Muhanga
Western	<ul style="list-style-type: none"> - Rubavu District: micro-hydro power plant, Kibuye gas power plants, charcoal market
Eastern	<ul style="list-style-type: none"> - Nyagatare micro-hydro power plant

Stakeholder consultations were held with the following government institutions: Ministry of Infrastructure (MININFRA), Rwanda Environment Management Authority (REMA), Ministry of Finance and Economic Planning (MINECOFIN), National University of Rwanda (NUR), Rwanda Utilities Regulatory Agency (RURA) and the Institute of Scientific and Technological Research (IRST).

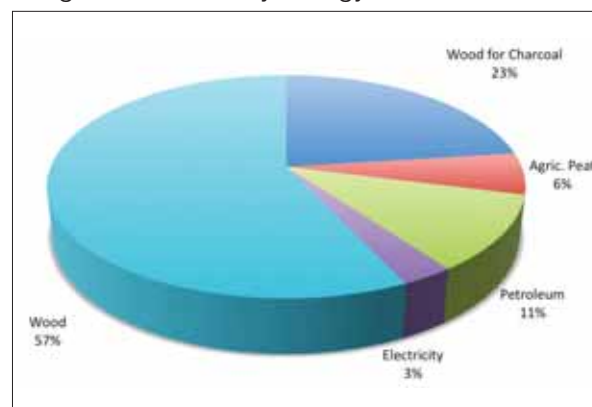
Other stakeholders consulted were the *Coopérative pour la conservation de l'environnement* (COCEN),¹ Kigali Institute for Science and Technology (KIST), Electrogaz, KOSAN (waste management cooperative), Kibuye Power, African Development Bank (AfDB), the Belgian Technical Cooperation (BTC), German Technical Cooperation (GTZ), Nile Equatorial Lakes Subsidiary Action Program (NELSAP) and private enterprises.

11.3 Overview of the energy sector

The energy sector in Rwanda remains underdeveloped and highly dependent on biomass, the predominant energy source (86%) for the majority of the population. Out of the total population, 96 percent is dependent on biomass – mainly fuelwood and to a much lesser extent charcoal – for their daily energy supply, which is used essentially for cooking.²

Petroleum (11%) and hydroelectric power (3%) make up the remaining energy supply balance.

Figure 18. Primary energy balance, 2007³



Electricity comprises a very small portion of the energy balance in Rwanda. Until 2000, only 2 percent of the population had access to electricity. Despite substantial improvement since 2000, only 5 percent of the population had access to electricity in 2008, of which over 99 percent were urban residents⁴. Electricity is available mainly in Kigali and to a limited extent in a few other cities. The remaining population is dependent on batteries, kerosene and other fuels⁵ to meet lighting energy needs.

Vision 2020 sets ambitious goals for the development of the energy sector. It targets a 50 percent reduction in household use of biomass. To achieve this target, a major assumption is made about the capacity of households to shift to alternative sources of energy. In this regard, Vision 2020 further aims to increase electricity access to 16 percent by 2012 and 35 percent by 2020.⁶



Only 5 percent of the population has access to electricity, concentrated almost entirely in urban areas. The government has had to contract additional diesel generating capacity from private suppliers, such as the one shown above in Gikondo, Kigali, to deal with electricity shortages

Table 36. Energy balance (2007)⁷

[TOE] 2007	Wood	Agric. res.	Wood for charcoal	Peat	Gasoline	Diesel	Fuel oil	Kerosene	Lpg	Methane	Electricity	Total
Gross Supply												
Domestic production	907,008	99,878	364,469	301							47,073	1,418,729
Imports					53,499	88,682	14,802	20,715	202		15,308	193,208
Total	907,008	99,878	364,469	301	53,499	88,682	14,802	20,715	202		62,381	1,611,938
Total %	56%	6%	23%	0%	3%	6%	1%	1%	0%		4%	100%
Conversion & losses												
Electricity conversion						42,364						42,364
Elec. T&D											17,810	17,810
Charcoal Conversion			295,976									295,976
Total			295,976			42,364					17,810	356,150
Net supply												
	907,008	99,878	68,493	301	53,499	88,682	14,802	20,715	202		62,381	1,315,962
Exports												
Demand												
Households	816,307	79,903	65,068					20,715	215		33,428	1,015,637
Industries	90,701	19,976	3,425	301			14,802				8,914	138,118
Services											2,229	2,229
Transport					53,499	46,318						99,817
Total	907,008	99,878	68,493	301	53,499	46,318	14,802	20,715	215		44,571	1,255,800
Total %	72%	8%	5%	0%	4%	4%	1%	2%	0%		4%	100%

Notes:

Agric. res. = agricultural residues.

TOE = tonne of oil equivalent or the amount of energy released by burning one tonne of crude oil.

Elec. T&D = electric transmission and distribution.

This overview section provides a broad review of the energy sector in Rwanda, including how it has been impacted by past conflicts in the country. It elaborates on the following: (i) current energy sources; and (ii) consumer demand and access to energy. Table 36 provides detailed information on the composition of the different energy sources and consumer demand.

11.4 Energy sources

Biomass⁸

Current sources of biomass energy include fuelwood, charcoal, agricultural crop residues, briquettes and biogas. Firewood, which has been significantly impacted by mass displacement linked to past conflict in Rwanda, is by far the most important source of biomass energy in the country. It is followed by charcoal, which is mainly used in urban centres.

With rapidly diminishing wood biomass, agricultural crop residues have increasingly served as alternatives, mainly by rural households as was evidenced in a recent Integrated Ecosystem Assessment study carried out in Bugesera.⁹ Crop residues include maize and millet, as well as rice and coffee husks. Demand for coffee and rice husks has considerably increased since the 2004

government ban on the use of wood in industries, particularly by brick and tile producers. The ban resulted from improvements in the policy and regulatory environment, as well as a recognition of the need to establish forest management plans that would reverse post-conflict deforestation rates.

Biogas is also another source of biomass energy that utilises animal dung and human waste. A programme by MININFRA and funded by GTZ plans to install 15,000 biogas plants by 2012 using animal dung to provide gas for cooking and lighting to rural households with two or more cows. Progress has been constrained, however, by difficulties for potential users to secure loans from banks, with only 300 units constructed so far.

Unfortunately, the potential benefits of biogas plants are offset by comparatively high costs of installation in Rwanda. One unit costs about USD 1,100 compared with successful programmes of similar-sized biogas plants in Nepal, Cambodia and India, which only cost from USD 300 to 500. Further scope for reducing costs of biogas plants in Rwanda should be examined to make them more attractive for wider dissemination. One promising initiative is the use of large biogas plants in several public institutions, such as prisons, which use human excreta to meet from 30 to 40 percent of its cooking energy needs with proper management.



Small-scale farmers that keep penned livestock - from which dung can be easily collected - are good candidates for installing household biogas units



Biogas from underground digesters is piped to the Remera prison kitchen. Large-scale biogas plants have proven an effective means in dealing with the sanitation and fuelwood problems created by the sharp rise in Rwanda's prison population following the 1994 events

Case study 11.1 Biogas plants in prisons

Large-scale biogas plants are currently operating in nine prisons in Rwanda and were installed by KIST. The prisons are large (some with more than 7,000 inmates) and previously consumed large quantities of wood for cooking. The biogas plants process toilet wastes from prison inmates and generate biogas for cooking. The digesters are placed underground so that sewage is not visible and no foul odour escapes; 50 percent or more of cooking stoves in these nine prisons have now been converted to use biogas, thus achieving substantial savings on fuelwood costs. In addition, waste products from these biogas plants are disposed of in an environmentally sustainable manner. After treatment, the dried slurry that is generated as a waste product is used as a crop fertiliser.

In 2005, the Rwandan Prison Biogas Project won the Ashden Award, an international award for promoting sustainable energy. Biogas plants are also currently operated in some schools in Rwanda.



COCEN manager demonstrates the compressing of waste into fuel briquettes (top)

Cooperative members sorting and drying organic household waste for briquette production (bottom)

Case study 11.2 Briquetting by local cooperatives

COCEN is a successful women's cooperative in Kigali that is engaged in the production of briquettes from municipal solid waste. Most of its 147 members are poor women, and profits are shared on a membership basis. Supported with seed funding by United Nations Development Programme (UNDP) under the Global Environment Facility (GEF) Small Grants Programme, COCEN is now a well-established enterprise that has been contracted by the Kigali Municipality to collect household waste from 4,500 households and ten restaurants.

The waste is collected at cost by COCEN and transported to a central facility where organic material (about 75%) is separated from metal and plastics (25%). COCEN also purchases waste from other associations that collect waste but do not have the capacity to process it. The organic waste material is sorted into two waste streams, one that is suitable for briquetting and the other for composting. The material for briquettes is dried under the sun for three to four days and then used for briquette making.

Producing briquettes is another (though very minor) source of biomass energy. Briquettes use crop residues or woody biomass, but they are not carbonised; therefore, they tend to replace fuelwood but not charcoal. Some industries (e.g. brick makers), schools, prisons and households produce their own briquettes. However, according to a USAID (2005) study, its overall potential for increased production is low. Briquettes are also generally more expensive than the wood that they may replace, and production quality is usually difficult to control.

As the feasibility of switching to alternative, non-biomass fuels is low due to cost and access issues (discussed further below), household dependency on biomass is likely to continue in the foreseeable future. It should be noted that harnessing biomass energy represents an important economic activity and source of employment for a large number of people in Rwanda, including through charcoal production.

Petroleum

All petroleum products are imported through ports in Kenya and the United Republic of Tanzania (Tanzania). Over 70 percent of petroleum imports are used in the transportation sector and the rest for power generation. Petroleum products include

gasoline, diesel, fuel oil, kerosene and liquefied petroleum gas (LPG). MININFRA is currently working with a private company to explore oil reserves in the western part of the country, which will require environmental regulation and monitoring.

Electricity

The installed electricity generation capacity in Rwanda is 52.39 MW, of which 24.89 MW is derived from hydropower and the rest is derived from thermal power based on diesel. Ntaruka and Mukunga are the two major hydroelectric power plants, supplying almost half of the country's electricity needs. Gisenyi and Gihara are the two other large hydropower plants.¹⁰

In addition, the government rents diesel power generators from Aggreko, an emergency power multinational, which produces 15 MW. A small portion of electricity comes from a solar power plant, which contributes 250 kW, and one pilot methane gas power plant that provides 4.2 MW.¹¹

Electricity is also sourced across the border. Rwanda has a 12 MW share in the Rusizi II hydropower plant, which is co-owned by the Democratic Republic of the Congo (DR Congo), Rwanda and Burundi. Supplementary power is also imported from the DR Congo and Uganda.



Hydropower accounts for nearly half of the country's electricity supply. Falling water levels in the lakes supplying Ntaruka and Mukunga power plants triggered a major electricity crisis in 2004

Map 19. Rwanda electricity distribution network



Additional sources of electricity are expected to come from several methane gas power plants and a number of small- and large-scale hydropower plants that are in the pipeline. Several hydropower plants are already under construction. Total generating capacity is expected to reach 130 MW by 2012.¹²

Methane gas

A significant potential source of energy is methane gas from Lake Kivu, which is a transboundary resource shared with the DR Congo. A gas power plant is currently being piloted that should start generating power in late 2008. There is an estimated 59 billion cubic meters of methane gas in Lake Kivu, of which 50 percent is presently considered to be recoverable. It is estimated that this resource may eventually be able to generate up to 700 MW of electricity over an approximate period of 50 years, of which Rwanda has a roughly 50 percent share with the DR Congo.¹³

Solar energy

Rwanda has some donor-supported programmes to provide solar lighting to schools and health centres. It also reportedly runs the largest solar plant in Africa. However, solar power generation is currently limited due to high costs of importing and installing solar power equipment.

11.5 Energy consumption

Household sector

Out of the 96 percent of households currently dependent on biomass, 88 percent use firewood while the remaining 8 percent use charcoal. From 2005 to 2006, about 72 percent of households in Kigali and 20 percent in other urban areas – the upper income segment – used charcoal. Rural households rely mainly on firewood.

Charcoal usage has increased over time, from 2.7 percent in 1989 to 15.1 percent in 1999.¹⁵ This increase reflects an emerging trend, as charcoal becomes more readily available and affordable to households with growing incomes, especially those based in urban centres, which have increased significantly in the post-conflict era.

High dependency on biomass energy will likely continue over the short and medium term, primarily because alternative fuels, such as kerosene and LPG, are costly and access to electricity is very limited especially in rural areas. In addition, electricity prices are too high to make it an attractive energy source for cooking and heating.



Charcoal usage is concentrated in Kigali and other urban centres, while most rural households continue to rely on fuelwood for their cooking needs

Table 37. Fuel consumption for cooking in Rwanda¹⁴

Fuel type	Kigali	Other urban	Rural	National
Firewood	23.1%	73.7%	95.5%	93%
Charcoal	72.4%	19.6%	1.1%	6.7%
LPG	0.2%	0.1%	0	0
Kerosene	0.8%	0.3%	0	0.3%
Electricity	0.2%	0.3%	0	0



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The transportation sector is the biggest consumer of imported petroleum products. Minibus share taxis are the most common means of public transport

Transportation sector

Oil demand is expected to increase as Rwanda's economy grows and the transportation sector and road network expands across the country. Given the limited options for using alternate fuels for transport, this sector likely will remain dependent on petroleum.

Industrial and other sectors

Big industries are the major consumers of electricity and heavy fuel, though increasingly some are exploring cheaper and more readily available alternate fuels, such as briquettes, bagasse,¹⁶ coffee and rice husks. Other main consumers of electricity include public institutions and the service sector.



The brick industry is one of the main consumers of electricity and heavy fuel, but also has been adept at using a range of energy sources including coffee husks, saw dust and briquettes

11.6 Governance

In the aftermath of the 1994 genocide Electrogaz, which served as the only source of electricity supply, continued to function but at a very low capacity, with frequent power shortages. Investment in the sector has generally been very limited, with the last power plant constructed in 1982. Reorganization of the sector took place with the formulation of an energy policy in 2004,

which is presently under review. Current energy policy has three major thrusts:

- improving access to modern energy sources, such as hydropower and alternative energy sources;
- increasing energy supply to urban and rural areas; and
- meeting energy needs through renewable and environmentally sustainable energy sources.



A 50 percent reduction in household biomass use is targeted for 2020

The draft Gas and Electricity Laws are presently under development and will be the two main instruments for promoting private investment and regulating the energy sector. The Gas Law aims to: (i) accelerate development of Lake Kivu methane gas for electrification projects; (ii) attract private investment into the gas sector; (iii) ensure a fair and competitive gas marketplace, in which consumer rights are protected; and (iv) minimise government investment in the gas sector, thus freeing up public resources to meet other priorities. The Electricity Law has similar provisions for the electricity sector.

The lead government institution overseeing the energy sector is MININFRA, which is responsible for developing national policies on energy as well as water and sanitation and currently supervises the implementation of these policies and facilitates resource mobilisation and investment in the energy sector. Recently, the Energy and Water Board (EWB) has been established, with the primary mandate to implement the National Energy and Water and Sanitation Policies. Having both administrative and financial autonomy, the EWB will promote and coordinate programmes with respect to conventional and renewable

energy, amongst other responsibilities. However, the EWB is not yet operational at the time of writing this report.

The energy market in Rwanda was liberalised in 1999. As a result, the national power utility Electrogaz no longer has a monopoly on the generation, transmission and distribution of electricity as well as on water and gas. It will eventually be subsumed under the EWB. Electrogaz remains the only provider as there is a lack of private competitors. Private sector investment in the energy sector is being promoted through legal and regulatory frameworks that aim to establish a favourable environment for private business. Currently, there are a number of investors in the Lake Kivu methane gas power projects and in some smaller hydropower projects.

Other key public bodies in the energy sector include RURA and the Unit for the Promotion and Exploitation of Lake Kivu Gas (UPEGAZ). RURA is a multisector regulatory body dealing with public utilities, including electricity. UPEGAZ is a specialist unit within MININFRA that is responsible for developing methane gas production in Lake Kivu.

11.7 Overview of key issues

Rwanda faces a triple energy crisis, comprising: (i) domestic cooking energy; (ii) a major electricity deficit; and (iii) rising fuel costs. The majority of households remain highly dependent on biomass energy for cooking, exerting significant pressure on the country's limited wood supply. Notably low electricity generation capacity is a reflection of longstanding underinvestment in the energy sector as a whole. Finally, soaring oil prices place a major strain on Rwanda's economy because of its limited foreign exchange capacity, with important implications on household incomes. While these challenges are difficult, they are not insurmountable, given Rwanda's natural assets and the potential for drawing on considerable regional energy resources.

Six key issues are highlighted in the energy sector, namely:

- improving household cooking energy supply and consumption;
- addressing the major electricity deficit;
- soaring fuel prices and its impacts;
- investing in renewable energy;
- strengthening energy governance; and
- expanding regional energy cooperation.

Improving household cooking energy supply and consumption

According to some recent statistics, the gap between household demand and supply of biomass is as high as 42 percent. This energy gap is driven by growing demand and has major implications for sustaining biomass supply. However, it is important to recognise that although significant, fuelwood is not the main driver of deforestation; rather, the leading causes are agricultural clearance and human resettlement (discussed further in Chapters 5 and 8).¹⁷ As the feasibility of households switching to alternate fuels is low, the focus should be on two key areas: (i) sustainably managing wood supplies; and (ii) improving fuel use efficiency.



Following the ban on the use of firewood in brick kilns, fuel options remain crude, ranging from sawdust (above) to more polluting sources such as heavy fuels. While alternative technologies are more expensive, there are opportunities for improving the efficiency of traditional brick making

Sustainably managing wood supplies

Virtually all fuelwood and charcoal in Rwanda are obtained from planted trees (e.g. tree plantations, trees and shrubs on private or communal lots), with only a relatively small portion originating from protected natural forests.¹⁸ There is also a growing charcoal trade with neighbouring countries, which is inadequately regulated.

Measures to sustain and improve the wood supply in Rwanda should be prioritised by augmenting tree plantation and agroforestry yields.¹⁹ According to one study, tree plantation yields

could be increased by two to four times current levels depending on site conditions and tree species, with proper and efficient management.²⁰ The potential role of communities in the sustainable management of tree plantations is discussed in Chapters 8 and 10.

Sustainably managing wood supplies has important social implications, particularly for women and children. Since women and children are responsible for wood collection, they are generally the most affected when wood supplies are depleted. As a result, they may have to walk longer distances in search of wood and carry heavier loads (see Case study 11.3).



Augmenting wood supplies from tree plantations through improved silvicultural operations has the potential of substantially augmenting wood supplies



A heavy load: Women are largely responsible for securing household fuel needs

Case study 11.3 Women and the fuelwood crisis

In rural areas, fuelwood is either purchased or gathered from private woodlots and public spaces. Forest protection is relatively well enforced, prohibiting public access. In Rwanda, as in many developing countries, fuelwood collection falls on women and girls.

Interviews with three women living in different parts of the country provided interesting insights on how fuelwood shortages affect women's lives, health and personal safety. First, the scale of the fuelwood problem varies between rural and urban areas, as well as across different parts of the country. Second, the life experiences of these women underscore the importance of developing alternative energy sources to not only lessen pressure on forest resources but also reduce the burden on women.

Kigali urban area

Céline lives in the outskirts of Kigali City with her family. Her extended family, which supports her with supplementary income, owns three cows but has no land. With their help as well as a 30 percent subsidy from government, Céline acquired a domestic biogas plant for USD 1,100. Using animal dung, the biogas plant generates sufficient energy to cover the entire cooking requirements of Céline's family and lights a gas bulb in her kitchen.

Previously, Céline had been dependent on purchasing fuelwood for cooking, spending up to FRW 40,000 or USD 71 per month. Now, she even earns an additional income by selling the biogas waste slurry as fertiliser. Céline's savings on fuelwood combined with this additional revenue have enabled her to pay for her children's education.

Two tales from the Eastern Province

Both Consolatrice and Genérose live in the dryland savanna landscapes of the Eastern Province. Consolatrice lives in Mirama *imidugudu* in the northern district of Nyagatare near Uganda, while Genérose resides in Bukora *imidugudu* in the southern district of Kirehe bordering Tanzania.

Married to the village head, Consolatrice's family depends entirely on subsistence farming. Typically, she spends half a day, every other day, collecting fuelwood. After acquiring an improved cooking stove, Consolatrice has been able to reduce her family's fuelwood consumption. Along with other women, she also participates in a tree nursery programme and carries out reforestation activities, which earns them a paid income as well as fuelwood.

Genérose, on the other hand, is a widow with seven children, who had been a refugee in Tanzania. When Rwandan refugees were expatriated back to their country, her Tanzanian husband chose to remain. As a result Genérose was forced to abandon all her possessions, including cattle. On resettlement, she received one hectare of land, which provides a subsistence living for her and the children. Genérose experiences great difficulties sourcing sufficient fuelwood for her family in a heavily deforested savanna landscape. Moreover, lacking resources, she cooks in an outside tent without an improved stove, amplifying her fuelwood needs. As head of her household and without alternative income, she is forced to rely on her children to carry out household chores including fuelwood collection and struggles to keep them in school.

Improving fuel use efficiency and reducing indoor house pollution

To moderate fuelwood demand, there is a need to achieve greater efficiency in using fuelwood. A step towards this direction is an ongoing initiative by the government to promote the use of improved stoves. The improved stove programme has been launched in many districts and coverage is reportedly quite high, ranging from 60 to 100 percent.²¹ However, a recent random survey indicated a number of problems with the improved stoves, revealing that levels of actual usage may be much lower than initially thought.²²

A more in-depth evaluation of the improved stove programme is required in order to assess the extent of fuel use efficiency and actual savings on fuelwood. Based on other studies cited in the literature, improved stoves may only be 25 percent more efficient than the traditional three-stone, open fire stoves. If that is the case, it may be worthwhile to find out whether the efficiency of stoves could be further enhanced by improving existing models and introducing highly efficient, third generation models that are currently being developed and promoted, including by major international companies.

A critical observation made by UNEP was the high health risks associated with indoor house pollution. It was observed that even the improved stoves did not

have a chimney to take out the smoke. As a result, indoor air pollution appeared to be very high and potentially damaging to health, especially to women and children who are most often exposed to the smoke for prolonged periods. Air pollutants from burning solid fuels can cause lung disease and other respiratory infections and impair immune systems.²³ Further studies should look at how chimneys or smoke hoods could be integrated in the design of improved stoves, as has been successfully carried out in neighbouring countries such as Kenya.

Addressing the major electricity deficit

In January 2004, Rwanda experienced its most serious electricity crisis yet. Long, daily power cuts were triggered by falling water levels in the natural lakes supplying the country's two major hydroelectric plants, Ntaruka and Mukunga. The failing yields and energy crisis of 2004 exemplified the major electricity deficit in the country.

Since the early 1980s, no substantial investment has been made in the electricity sector; and whatever limited hydropower facilities existed suffered neglect during the conflict and its immediate aftermath. As a result, access to electricity is very limited and overwhelmingly concentrated in urban areas. Per capita electricity consumption in 2000 stood at the remarkably low level of 30 kW.



Indoor house pollution from traditional biomass use for cooking poses particular health risks to women and children

Aiming for greater coverage

Rwanda has an ambitious target of increasing electricity access to 35 percent by 2020. This represents a seven-fold increase from the current coverage rate of 5%. The principal beneficiaries of this coverage expansion will be urban residents; the majority of the rural population would likely remain without electricity access. A bolder plan is, therefore, needed to provide electricity to the majority of the population.

One option to improve access is to decentralise power generation by developing renewable energy sources and promoting private investment, including through independent power producers (IPPs) (these two areas are discussed further below). Decentralising power generation offers a good opportunity to provide the majority of the Rwandan population with electricity, especially rural villages far from existing electric power grids.

Increasing efficiency in current power production and distribution systems

Although limited in terms of capacity, current electrical power production could be improved and made more efficient. Transmission losses are high at about 10 percent. Electrogaz has set a target to reduce transmission losses to 7 percent by 2010. Distribution losses are also high at 18 percent, even though it has been reduced from 22 percent in 2005-2006.

The government responded proactively to the hydropower generation crisis of 2004, by prohibiting cultivation on lakeshores and reservoirs and protecting critical wetlands. Watershed management activities to control siltation and secure hydropower generation should be continued and expanded.

Promoting energy efficient technologies

Adoption of energy efficient technologies should also be promoted, particularly in urban areas where electricity is available. One such initiative is the World Bank-supported project to promote compact fluorescent lamps (CFLs) and replace less efficient incandescent lamps. This project was developed in response to electricity shortages and the need to reduce operating costs and aims to install 800,000 CFL bulbs by 2012.

Soaring energy prices

Energy prices are high in Rwanda. This is mainly due to high fuel importation costs and the very limited energy supply and infrastructure. Petroleum imports consume a major portion of foreign exchange, amounting to 40 percent of the country's import bill in 2002, which is likely to have increased with rising fuel prices.²⁴ Rising fuel costs will place additional strain on Rwanda's economy given its limited capacity to generate foreign currency. To cut import costs, the use of petroleum products in electricity generation needs to be systematically reduced.

Households are the most vulnerable to high energy prices. Given that a large segment of the total population (57%) is below the poverty line and that most people are located in rural areas, capacity to access and pay for modern energy sources (i.e. electricity, LPG, etc.) is very low.²⁵ Table 38 (page 242) shows the average household monthly expenditure for different fuel types in comparison to the cost of charcoal.

The table shows that fuelwood is the cheapest fuel available to households, followed by briquettes and charcoal. Electricity and LPG are the most expensive fuel. Kerosene prices, while still higher than the cost of charcoal, remain relatively stable. It should be noted, however, that establishing the comparative costs of different types of fuel is complicated by fluctuating market prices and conflicting estimates.²⁶



Petroleum imports account for 40 percent of the country's fuel bill. To cut costs, the use of heavy fuels and diesel in electricity generation needs to be systematically reduced

Table 38. Average household monthly expenditures for different types of fuel²⁷

Type of fuel	Price FRW / unit	Price FRW / MJU	Budget FRW / HH / year	Cost compared to charcoal %
Fuelwood (traditional)	57	21.0	93,589	57%
Fuelwood (improved)	57	16.1	71,992	44%
MSW briquettes	70	25.0	111,650	68%
Charcoal (traditional)	233	36.5	163,100	100%
Charcoal (improved)	233	28.1	125,462	77%
LPG	2470	116.0	518,253	318%
Papyrus charcoaled briquettes	150 – 174	32.5 – 32.7	145,000 – 168,355	89% – 103%
Charcoal dust briquettes	160 – 180	29.1 – 32.7	129,900 – 146,160	80% – 90%
Kerosene (per liter)	623	40.1	179,214	110%
Electricity (per kWh)	132	56.5	252,234	155%

Notes:
MJU = megajoule.
HH = households.

Investing in renewable energy

Meeting Vision 2020 targets to reduce household biomass use and improve access to electricity will be a major challenge, given the limited options for alternative energy sources. Developing alternative, renewable energy sources are, therefore, critical to meeting growing energy demands over the long term. However, enabling households to shift towards alternative energy sources will depend on the cost (affordability) and accessibility.

Presently, the development of renewable energy is almost entirely dependent on donor support. Renewable energy represents a potentially economically viable option to provide energy in areas far from the grid. Considering its potential importance, the government needs to be more proactive in this field.

Methane gas

The pilot programme to harness the vast deposits of methane gas in Lake Kivu should be supported and accelerated. However, both the precautionary and polluter pays principles of environmental management should be considered. This is emphasised given the uncertainties surrounding the potential environmental impacts of methane gas exploration.

Biogas

In order to reduce household dependency on wood supplies, the biogas programme should be



It is critical that methane gas development is subject to stringent environmental impact assessments, given the underlying gas explosion hazard

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Biogas can be used as an alternative cooking fuel to wood as well as generate electricity for off-grid households. As it burns cleanly, biogas would also alleviate the problem of indoor air pollution

accelerated in rural areas, particularly where there is sufficient supply of animal dung. According to a study in 2005, all households with two or more cattle should be eligible to participate in such a programme.²⁸ Based on this study, the biogas programme could increase coverage up to 110,000 households by 2011, as compared with its current target of 15,000 households. Further review is needed to substantially reduce the cost of biogas plants (e.g. through increase of subsidies) and make it more affordable.

Solar power

Rwanda has considerable potential to develop solar power, given the high levels of daily solar radiation available (estimated from 4 to 6 kW/m²). In addition to providing power to the national grid, solar power could be harnessed for lighting, water heating and cooking. Solar power could be especially effective in providing lighting to households who are far from the electric grid. Solar water heating may also be cost effective and replace existing fuels, such as kerosene, charcoal, electricity and LPG, which are normally used for water heating. Although Rwanda has embarked on several solar



The solar power plant at Jali Hill in Gasabo District is one of the largest in Africa

power initiatives, the government currently taxes solar equipment, which is a noteworthy obstacle to expanding markets for solar power production. This policy should be reviewed.



At its experimental plant in Kigali, IRST is undertaking cutting edge research to improve biodiesel production from seed crops

Agrofuels

Establishing decentralised, local grids that use agrofuel oils to generate power should also be explored. Agrofuels, which are processed from oil-producing crops such as *Jatropha*, are of specific interest to Rwanda as they can provide cheaper energy than conventional sources, such as hydropower. The use of agrofuel oils, for example, to run diesel generators and produce electricity is a fairly established technology. One initiative in India, for instance, uses *Jatropha* oil to provide a 24-hour power supply at very affordable prices to poor villages without previous access to electricity. Another project in Mali installed biodiesel generators powered by *Jatropha* oil to service local communities.²⁹ Rwanda, which has already initiated experimental work using *Jatropha*, could initiate a pilot programme drawing on the aforementioned experiences.

Considering that the government plans to locate 70 percent of the population in rural grouped settlements (*imidugudu*), establishing a local grid to service an *imidugudu* may not be a major obstacle. Future assessments, however, need to be carried out regarding the feasibility and viability of using agrofuels, including the possibility



Biodiesel powered vehicle at the IRST experimental plant in Kigali

of importing agrofuel oils from neighbouring countries. Evaluation of both the positive and negative impacts of agrofuels needs to be carried out, as they are both crop and site dependent, to ensure long-term environmental sustainability.

Other potential renewable energy sources

Wind and geothermal energy are other potential energy sources in Rwanda that have not yet been explored. Potential sources of geothermal energy may be found in the Volcanoes and Lake Kivu regions. Further research is needed to explore these potential energy sources and their economic and environmental viability.

Strengthening energy governance

Strengthening energy governance must address four main areas: (i) establishing a specialised agency on sustainable energy; (ii) promoting foreign private investment; (iii) carefully evaluating peat and papyrus as alternative energy sources; and (iv) improving energy efficiency in the industry and transportation sectors.

Establishing a specialized department on sustainable energy

Currently, energy is one of five sectoral mandates of MININFRA. As a result, there is a risk that key issues relating to the energy sector are not given adequate attention. A specialised sustainable

energy department under MININFRA needs to be established to deal with: (i) renewable energy; (ii) energy efficiency and management; and (iii) rural electrification. The current focus of MININFRA is on developing infrastructure to meet energy needs, with limited attention given to addressing biomass energy and identifying alternative renewable sources of energy. As discussed previously, the newly established EWB will have the primary responsibility for developing and promoting rational energy use and renewable energy sources, but is not yet operational.

With limited options for alternative energy sources in the short term, a sound biomass policy is needed that focuses on increasing the productivity and sustainable harvest of wood resources (i.e. tree plantations and agroforestry). To accelerate this development, MININFRA should work closer with other government ministries, namely the Ministry of Natural Resources (MINIRENA) and REMA. Building REMA's capacity to address the environmental aspects of energy issues is also essential, which should contribute towards the development of sector specific regulations.



Charcoal from the southern Huye District bound for sale in Kigali. Effective regulation of the trade is critical for forest management and protection

Promoting foreign private investment

A more concerted effort is needed to promote foreign private investment, as exemplified in the development of Lake Kivu's methane gas. As private capital within the country is limited, attracting foreign investors should help address the existing 60 percent financing gap in infrastructure development and mobilise resources for efficient, environmentally friendly technologies for power production. Government should bolster confidence-building measures that create a more conducive environment for private investment in the energy sector, for instance, by providing tax breaks or incentives in biogas and solar power production.

Carefully reviewing peat and papyrus as alternative energy sources

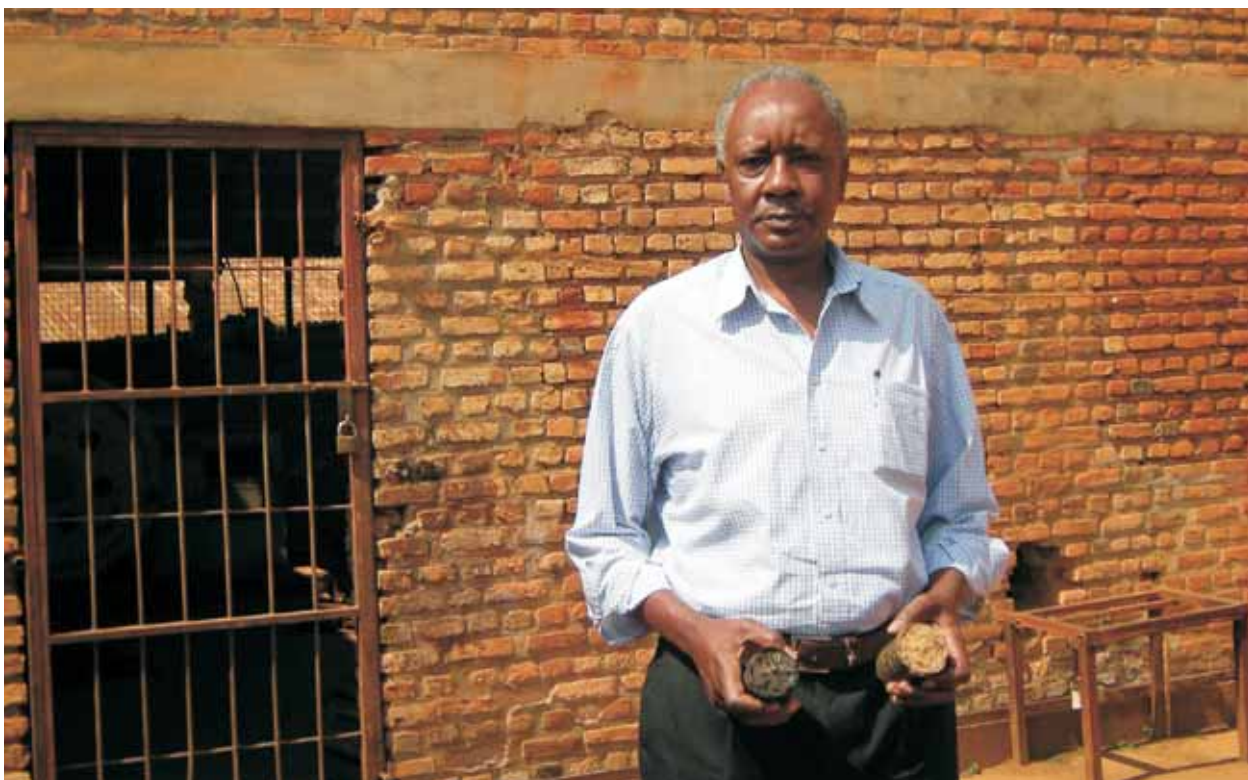
Peat and papyrus, both found in wetlands, are presently under examination as potential energy sources. Peat reserves are estimated at about 155 million tonnes and are concentrated in several key locations.³⁰ While a private company is already using some peat as a domestic fuel on a pilot basis, there are government proposals to harvest peat on a large scale for electricity generation.

On the other hand, papyrus in the Kigali region reportedly covers an area from 20,000 to 25,000 hectares. This amount, which reportedly can yield 280,000 tonnes of dry biomass per year with carbonised briquettes, is under consideration as a partial substitute for charcoal in Kigali.

Proposals to exploit peat and papyrus as energy sources need to be cautiously examined, however, considering the potential negative impacts on critical wetland services. Peat mining and papyrus harvesting also release toxic pollutants into the air, soil and water.³¹ Moreover, the economic viability and energy contribution from these sources is considered to be of minor consequence within the context of the country's overall energy balance.

Improving energy efficiency in the industrial and transportation sectors

As the industrial and the transportation sectors, respectively, are the largest consumers of electricity and petroleum, measures to improve energy efficiency should be taken. In this regard, appropriate policies and financing can ensure that these sectors develop efficiently and reduce energy



A private sector entrepreneur plans to switch from manufacturing sawdust (right) to peat briquettes (left)



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Discussions are underway between Rwanda and the DR Congo on potential cooperation to develop Lake Kivu's methane gas reserves

costs. Such measures would include: (i) banning importation of inefficient second-hand vehicles and industrial machinery; (ii) promoting public transport; (iii) accelerating plans to establish rail links and oil pipelines to Indian Ocean ports; and (iv) exploring the use of cleaner and cheaper alternative fuels such as compressed natural gas (CNG) from Lake Kivu methane. These measures would also help address the growing air pollution problem in Kigali.

Expanding regional energy cooperation

Apart from renewable energy, the key to securing Rwanda's electricity requirements over the long term is dependent on the joint development of the Great Lakes' considerable regional energy potential. Major regional energy projects are currently ongoing under NELSAP. These efforts, which include hydropower projects and building a regional grid, should be intensified,

while applying the necessary environmental precautions.

Rwanda needs to catalyse partnerships with its neighbours to source cheaper electricity and meet a major part of its requirements in a sustainable manner. Rwanda has already signed onto the East African Community (EAC) energy policy that should help the country access the regional electricity grid, share expertise, promote cooperation to reduce investment costs and accelerate public-private partnerships.

11.8 Conclusions

The energy sector in Rwanda is at a crossroads, as the country searches for new ways to meet growing energy demands. Household dependency on biomass can be expected to continue because alternative energy options are costly and remain inaccessible. In addition, rapid urbanisation and planned economic growth will likely accentuate

the major electricity deficit. Rising fuel prices will exert a major strain on the country's economy, as energy imports outpace export earnings.

In this context of surging energy demand coupled with a supply deficit, Rwanda faces two major opportunities to overcome these challenges and provide affordable, clean and more efficient energy sources. Renewable energy in the country has the potential to significantly increase access to electricity and meet other energy needs. However, improved governance and policy support is needed to develop renewable energy sources and make them affordable, especially to the rural population. Another key opportunity lies in the development of the vast energy potential of the Great Lakes region. Rwanda needs to expand and accelerate cooperation with its neighbours, to source cheaper electricity and meet its future energy needs.

11.9 Recommendations

R11.1 Sustainably manage wood and non-wood biomass energy supplies. Cooking energy demand can only be met over the short term by increasing the availability of biomass. Promoting agroforestry and appropriate silvicultural interventions (i.e. trimming, tending, etc), particularly in eucalyptus plantations, needs to be carried out to significantly increase the annual increment in wood supplies and help reduce cooking energy costs. Augmenting non-wood biomass energy sources, such as briquettes, should also be supported. This recommendation should be undertaken in conjunction with R7.2 in Chapter 8: Forest Resources.

Lead agencies: MINIRENA, MINAGRI. International Partners: FAO, UNDP. Cost estimate: USD 3 million. Duration: 3- 4 years.

R11.2 Upgrade the current Improved Stove Programme. In the short term, additional improvements to the current Improved Stove Programme should be undertaken in terms of (i) increasing the efficiency of improved stoves; and (ii) reducing indoor air pollution by integrating smoke hoods and other technological innovations in stove design. Also in this regard, further studies are required to identify the causes of limited stove adoption observed so far with the aim of

addressing constraining factors. Coverage rates should be increased in both rural and urban areas.

Lead agencies: MINALOC, MININFRA, CITT. International Partners: UNEP, UNDP, CITT. Cost estimate: USD 2.5 million. Duration: 3 years.

R11.3 Promote regional energy cooperation to facilitate increased supply and distribution. Transboundary cooperation in the Great Lakes region should be expanded on a much larger scale to sustainably tap into its considerable energy resources. Additional partnership investment projects need to be developed that provide mutual benefits to all participating countries. Efforts to establish a region-wide grid should be intensified, given that several financing sources (e.g. AfDB, NELSAP, etc.) are currently committed to fostering regional cooperation. In addition, current plans to establish rail links to Mombasa and Dar-es-Salam and pipelines for transporting oil products should be accelerated, which would help reduce energy costs. Investment projects should be subject to regional energy standards that need to be established to facilitate cooperation within the EAC.

Lead agencies: MININFRA, MINAFET, REMA. International Partner: AfDB. Cost estimate: USD 0.25 million. Duration: 1 year.

R11.4 Develop an energy pricing reform strategy. Appropriate energy prices are a prerequisite for promoting resource efficiency, attracting investments in the energy sector and stimulating economic growth. At the same time, it is important that the environmental and social considerations are accounted for in the costs. A study to reform energy pricing, including tariffs on such energy products as LPG and solar, should be carried out with a view to increase energy conservation and use of renewables.

Lead agencies: MININFRA, RURA. International Partner: UNEP. Cost estimate: USD 0.1 million. Duration: 1 year.

R11.5 Promote solar home systems (SHS) to provide lighting to households in areas where other electricity sources are not feasible.

Currently, solar power technology is very costly in Rwanda; therefore, this option may be promoted in areas that do not have access to grid electricity. Part of the cost may have to be subsidised to make it affordable to the poor. A subsidy of 25 percent could be considered to kick-start the market, initially targeting 20,000 households.

Lead agency: MININFRA. International Partners: UNDP, CITT. Cost estimate: USD 2 million. Duration: 3 years.

R11.6 Operationalise the EWB and strengthen its capacities to ensure efficient and sustainable development of the energy sector. Capacity-building should focus on promoting the following areas over the short and medium term: (i) renewable energy; (ii) energy efficiency and management; and (iii) rural electrification. In addition, building the capacities of government agencies, including REMA and MINIRENA, needs to be undertaken to improve coordination and regulation of the energy sector.

Lead agency: MININFRA, EWB. International Partner: UNDP. Cost estimate: USD 1 million. Duration: 2 years.

R11.7 Promote the use of CNG in the transportation sector. The potential of using CNG from Lake Kivu methane gas for transport should be explored, especially because CNG is expected to be cleaner and cheaper than petrol. A CNG programme would require investments in a number of areas, from developing supply to ensuring distribution and adoption; namely, establishing a compression facility and gas stations, procuring cylinders and installing retrofits in existing vehicles to use CNG fuel, amongst others. A pilot programme should be initiated, though investment costs for developing a long-term programme will depend on its size, with costs partially recovered from users. Implementation, however, will require operationalisation of the methane gas project and significant infrastructure investment (i.e. installation of pipelines to Kigali).

Lead agencies: MININFRA, ISAR, CITT, REMA. International Partner: UNDP. Cost estimate: USD 5 million. Duration: 3 years.

R11.8 Mobilise foreign and national private investment to increase electricity supply. Given the growing demand for electricity and the current financing gap in this sector, a strategy is needed to attract foreign capital investment in the energy sector, as exemplified by power generation from Lake Kivu methane gas. The aim is to encourage IPPs, including national investors, to bring state-of-the-art, environmentally friendly technologies in the sector, which would ensure a competitive environment that could help reduce electricity costs.

Lead agencies: MININFRA, RURA, REMA. International Partner: UNDP. Cost estimate: USD 0.2 million. Duration: 1 year.

R11.9 Accelerate the biogas programme. Presently, MININFRA is implementing a biogas programme targeting 15,000 households. This programme should be accelerated to increase coverage of all households owning two or more cattle as well as target large institutions (e.g. schools, hospitals) that could generate sufficient waste. It should also aim to reduce biogas installation costs in order to expand coverage and ensure affordability.

Lead agencies: MINALOC, MINAGRI, MINEDUC, MININFRA, CITT. International Partner: UNDP. Cost estimate: USD 10 million. Duration: 4 years.

R11.10 Explore the feasibility and long-term viability of using agrofuel oils to generate electricity. Agrofuel oils have considerable potential as a renewable energy source that could improve access to electricity, especially in rural areas. Both negative and positive environmental costs of agrofuel should be factored in decision making, taking into account the types of crop as well as appropriate sites. Potential collaboration with neighbouring countries to obtain agrofuel oils on a sustainable basis should be explored. Adopting agrofuels on a small-scale pilot basis will assess its economic viability in Rwanda and enable households to more readily adopt the new technology once it is operational.

Lead agencies: MININFRA, MINALOC, MINAGRI, ISAR, IRST. International Partners: UNEP, UNIDO. Cost estimate: USD 2 million. Duration: 3 years.

Urban Environment and Health Issues

*Rwanda's rapid post-conflict urbanisation
is one of the highest in Africa. As most
of this growth has been unplanned, it has
created a range of environmental problems*

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Urban Environment and Health Issues

12.1 Introduction

The rebuilding of Rwanda following the 1994 conflict has witnessed unprecedented rates of urbanisation, partly driven by the resettlement of returnees. This has occurred, however, without adequate physical planning. Within this context of rapid and unplanned post-conflict development, urban environment and health issues have become an emerging problem.

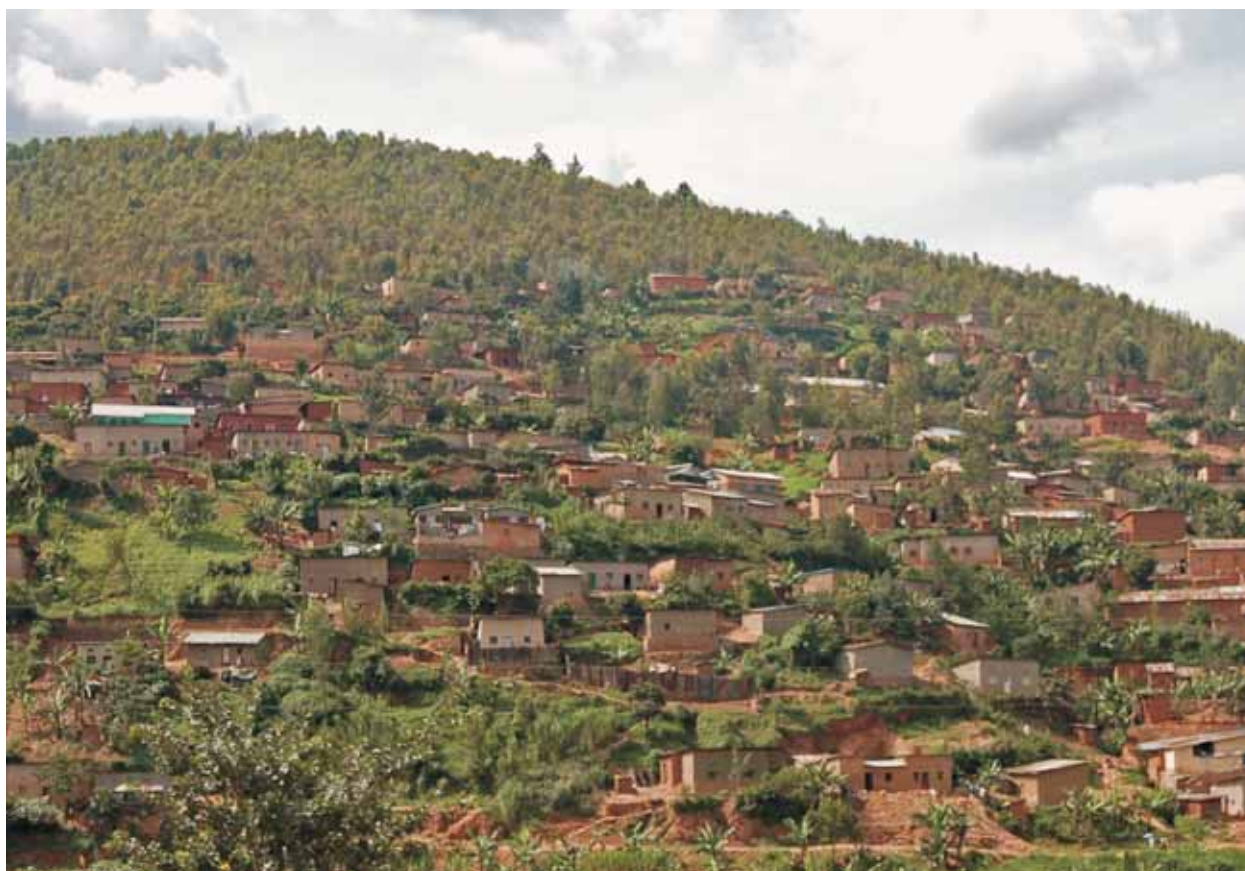
The most pressing environmental problems with significant implications on public health, especially for the urban poor are: (i) inadequate and unsafe drinking water; (ii) poor drainage and sanitation conditions; (iii) solid waste disposal hazards; and (iv) construction in inappropriate and hazardous areas due to unplanned urban development. In terms of scale, these problems

are most acute in Kigali, the capital city. Problems relating to industrial pollution are discussed in Chapter 13.

National and local authorities recognise these challenges, and significant progress has been made in developing policies and improving conditions in urban areas. Nonetheless, important gaps remain in urban environmental governance, and substantial investment is required in urban planning and major infrastructure, particularly for water and sanitation as well as waste management services.

12.2 Assessment activities

UNEP conducted field visits in major urban areas, including Kigali, Gisenyi (Rubavu District), Ruhengeri (Musanze District) and Gitarama (Muhanga District). Most of the fieldwork was carried out in Kigali given the population concentration and the problems identified in the desk study and pre-assessment activities.



Crowded informal settlements inhabited predominantly by the urban poor are mushrooming on steep hillsides in Kigali's outskirts

Table 39. Field sites visited by province

Province	Field sites
Kigali	<ul style="list-style-type: none"> - Nyanza waste dumpsite - Kagarama - Gacuriro housing estate: wastewater treatment facility - Batsinda housing estate - Water sampling points in the Gikondo catchment area included: Kimihurura, Kimicanga, Kiyovu (south), Kinamba, Nyabugogo, Kamuhanda, Yanze, Nyanza, Kagarama, Nyandungu, Nyagatovu, Kibagabaga, Kamukina, Nyacyonga, Nyabarongo
Northern	- Musanze: waste dumpsites
Southern	- Muhanga: liquid and solid waste disposal sites
Western	<ul style="list-style-type: none"> - Rubavu: waste dumpsites - Lake Kivu



UNEP expert collecting water sample from a drainage ditch

To supplement the scope of this assessment, water sampling was undertaken to examine two main aspects: (i) effects of land use in the Gikondo/Kicukiro area on drinking water quality; and (ii) potential groundwater contamination from the Nyanza solid waste disposal site. Additional random samples were taken around Kigali City to examine ambient water quality conditions.

Additional data on drinking water quality were obtained from the National Laboratory of the National University of Rwanda (NUR). This facility was previously responsible for analysing drinking water sources prior to the establishment of the public utility Electrogaz.

Consultations were undertaken with government stakeholders, including: Rwanda Environment Management Authority (REMA); Ministry of

Finance and Economic Planning (MINECOFIN); National University of Rwanda (NUR); Ministry of Trade and Industry (MINICOM) and Ministry of Infrastructure (MININFRA).

Other discussions were held with the following: solid waste management (SWM) community-based organisations (CBOs); industry managers from Electrogaz, Textile Industry (UTEXRWA), Brewery Industry (BRALIRWA S.A.), Rwanda Foam Factory, Gisenyi Mining Cooperative, and Enviroclean Technologies; United Nations Industrial Development Organization (UNIDO) and the World Bank.

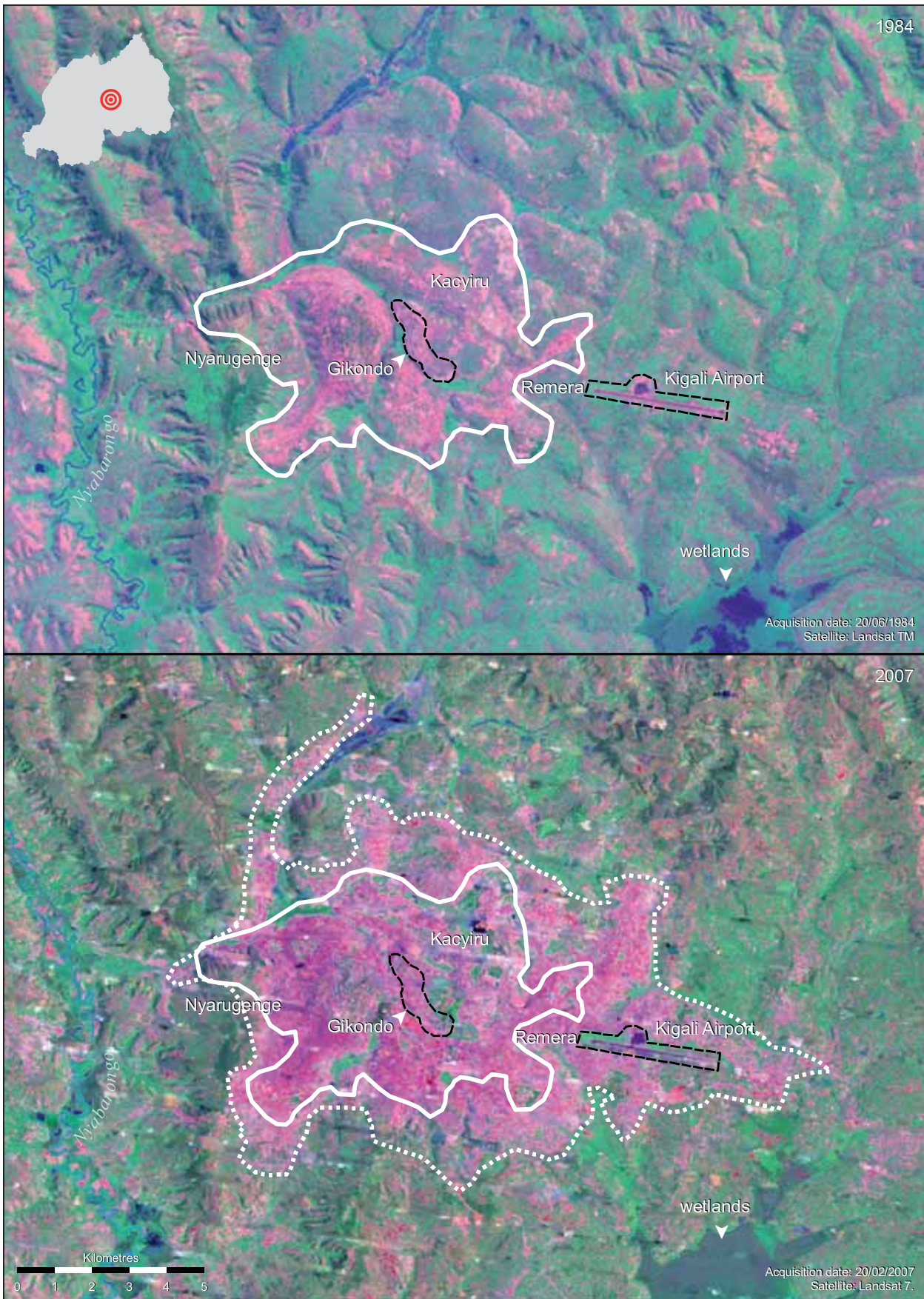
This chapter examines the potential contamination of drinking water and groundwater sources in urban areas. Pollution of surface water and sediments by industry (including mining) is taken up in Chapter 13.

12.3 Overview of demographics and major urban centres

Rapid urbanisation

Rwanda remains largely a rural population with only 19 percent of people living in urban areas. However, between 1991 and 2002, Kigali City experienced growth rates of 9 percent per year, while the former provinces of Gitarama and Kibuye have experienced figures in excess of 20 percent.¹ This intense urban growth rate of 12 percent per year on average is the highest in Africa.² The government aims to further increase the urban population to 30 percent by 2020.

Figure 19. Rapid urbanisation of Kigali: 1984-2007





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Modern urban schemes are able to satisfy only one-tenth of housing demand, with the remaining housing needs addressed through informal channels

Table 40. Population by urban area, 1991-2002⁶

Province /city*	Population 1991	Population 2002	Percentage change in population 1991-2002	Percentage of urban population 2002
Kigali City	235,664	603,049	8.9	100
Gitarama	17,490	137,995	20.7	16.1
Butare	38,442	137,334	12.3	18.9
Gikongoro	8,506	32,427	12.9	6.6
Cyangugu	9,693	59,070	17.9	9.7
Kibuye	4,393	46,640	24	9.9
Gisenyi	22,156	67,766	10.7	7.8
Ruhengeri	29,286	71,511	8.5	8.0
Byumba	11,947	66,268	16.9	9.4
Kibungo	13,617	90,414	18.8	12.9

* This table reflects figures according to former provincial and city names, as recent figures based on the new administrative structures are not available.

Rapid urbanisation in Rwanda is a recent phenomenon in the post-conflict period. Urban growth since 1994 may be attributed to the repatriation of returnees and rural migration in search for employment and security as a result of the past conflict.³ During this period, the redrawing of administrative boundaries also increased the size of urban areas, incorporating populations in previously peri-urban and rural areas.⁴

Major urban centres

While urban growth rates are high, the level of urbanisation across Rwanda is still low. There are ten major urban centres in Rwanda, namely Kigali, Huye

(former Butare), Muhanga (former Gitarama), Rubavu (former Gisenyi), Musanze (former Ruhengeri), Gicumbi (former Byumba), Ngoma (former Kibungo), Rusizi (former Cyangugu), Nyamagabe (former Gikongoro) and Karongi (former Kibuye). Secondary urban centres are Nyanza, Nyagatare, Rwamagana, Ruhango and Nyamata.

Kigali is by far the largest, with an estimated 603,049 inhabitants in 2002. Aside from Kigali, only Gitarama and Butare have more than 100,000 inhabitants. Recent estimates suggest Kigali has grown to 800,000 people, which coincides with the growth rate experienced during the 1991-2002 period.⁵

Table 41. Growth of City of Kigali over the last 17 years⁷

Year	Total number of people	Total area of the city (km ²)	Population density (people/km ²)
1991	140,000	112	1,250
1996	358,200	112	3,198
2001	605,000	314	1,927
2006	870,127	730	1,192



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Kigali's economic boom has made it the focus of internal migration

A high proportion of inhabitants in urban areas is in the 15-30 year old age group, which reflects the rural to urban migration trend and those seeking employment opportunities. In addition, there is a high ratio of males to females (112:100) in urban areas. Because women are traditionally based in households, more men migrate to urban centres in search of employment due to limited income generating opportunities in rural areas.⁸

The geography of the Kigali urban area consists of a complex system of wetlands, with varying soil, vegetation and hydrological characteristics. Due to urban expansion, these wetlands are under increasing pressure from land use by industry, commercial and residential development. Altering these wetlands significantly reduces the range of their ecosystem services, including flood control. A recent study concluded that only 24 percent or 2,645 ha of Kigali's original wetland area remains.⁹

12.4 Governance

In the post-conflict period, there has been little attention given to urban development issues in Rwanda.¹⁰ However, both the Government of Rwanda (GoR) and local authorities are now shifting greater attention to urban development around the country given the elevated growth rates in other urban centres (Table 40, page 255).

Vision 2020 sets long-term targets for urban development, which include:

- development of urban land use master plans for every major urban centre;
- 70 percent of the population living in grouped settlements (*imidugudu*), with the remaining 30 percent in urban areas;¹¹
- urban areas with sufficient sewerage and disposal systems;

12 URBAN ENVIRONMENT AND HEALTH ISSUES

- increased access to safe water from 64 to 86 percent;
- improved access to sanitation services from 38 to 65 percent; and
- increased proportion of the urban population residing within 200 m of an improved water source from 69 to 100 percent.

Provisions for urban environmental management are currently addressed under the Environmental Policy for Rwanda and the Environment Law. The Environment Law contains key provisions that have implications for urban planning and development, including SWM and urban wastewater management. The main institutions responsible for the implementation of the Environmental Policy and the Environment Law are REMA and the Ministry of Natural Resources (MINIRENA).

The National Land Policy and Land Law, the Human Settlement Policy, the Urban Development Policy and Law, and the Water and Sanitation Policy and Law also contain provisions for environmentally sustainable urban planning and development. The National Land Centre (NLC) implements the Land Policy and Land Law, while MININFRA plays a major role in formulating

urban development policies and regulations as well as in infrastructure development, including for water and sanitation. The recently established Rwanda Building and Housing Development Board (RBHDB), which is under the auspices of MININFRA, will implement housing and urban development policies and strategies and programmes of the urban housing subsector.

As part of the decentralisation process, urban municipalities will be charged with developing urban land use master plans under the supervision of MININFRA (Case study 12.1). In addition, local authorities will be responsible for domestic SWM and the sustainable management of groundwater resources.

Nevertheless, legal and institutional mandates for the environmental governance of urban development remain weak. Developing adequate capacity is needed to support the implementation of the Environmental Policy and Law, as well as other related national urban policies and legal instruments discussed previously, into urban sector administration. Moreover, decentralised authorities responsible for urban management will also require significant capacity support. These issues are elaborated further under “Key issues”.



Aerial view of Musanze, Western Province. All urban centres are required to develop urban master plans



Kigali modern housing estate

Case study 12.1 Kigali City Master Plan

Unplanned development has been a characteristic feature of the rapid, post-conflict urbanisation taking place in Rwanda. The Kigali City Council (KCC) has made concerted efforts to rectify this situation through the adoption of a new urban master plan.

The Kigali City Master Plan is based on a potential expansion of the city area to accommodate up to three million people within the next 50 years. One of its key aims is to tackle the major environmental and health concerns facing the city. It sets a strategic direction for dealing with slums, solid and liquid waste, and improving other social services. The KCC has embarked on an important awareness-raising initiative to promote the plan's objectives. However, the capacity to operationalise this master plan through the development of local land use plans remains an important constraint for going forward.

Developing artificial wetlands

One particular initiative being considered in the Kigali City Master Plan is developing artificial wetlands to minimise urban drainage impacts and restore important biological conditions. Characterised by steep rolling hills, the Kigali City region contains a complex system of wetlands in the valley landscape, which functions as a natural drainage area. These natural wetlands have come under increasing land use pressures from industrial, agricultural, commercial and residential development, which threaten important ecosystem functions that wetlands provide, including regulating drainage flows and filtering pollutants.

Sharp decline in urban wetlands will have an impact on urban environmental health. The major challenge, therefore, is to maintain and improve existing wetland conditions in urban areas. However, the feasibility of developing artificial wetlands in an urban context and the associated social, economic, and environmental impacts are still not fully understood and will require further research to assess their practicability.

Master plans in other urban areas

Master plans have been developed in other urban administrative centres, such as in Karongi District (Kibuye) and Rusizi District (Cyangugu). However, it was not possible to assess to what extent these plans address key environmental issues related to solid and liquid waste management, water quality especially downstream and reducing slum occupation.



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Kigali's population is expected to reach three million within the next 50 years

12.5 Overview of key issues

High population growth and population displacement due to the 1990-1994 conflict contributed to rapid urbanisation and unplanned urban development. As a result, environmental problems have emerged in major urban centres, with important consequences for public health and living conditions. Decentralisation of government services further adds to the challenges of urban development in Rwanda.

Urban environmental problems are most acute in Kigali City. While other urban centres registered even higher growth rates, UNEP observed during the course of its field visits that the smaller concentrations of people do not cause the same magnitude of environmental impacts as seen in the capital. Key urban environmental issues identified by UNEP include:

- inadequate and unsafe drinking water;
- poor sanitation conditions;
- inadequate SWM;
- construction in inappropriate and hazardous areas; and

- strengthening urban planning and development.

By far, the most significant issue concerning the urban environment relates to water and sanitation. In Kigali, access to a safe and clean water supply was ranked as the most important issue for households, ahead of education and healthcare.¹²

Inadequate and unsafe drinking water

In this context of rapid post-conflict urbanisation, the challenge of meeting the population's water needs remains a daunting task. This problem may be examined in two interrelated ways: (i) access to safe drinking water; and (ii) water quality.

Access to safe drinking water

Access to safe drinking water is a fundamental condition of environmental health, particularly in Rwanda where 80 percent of diseases are waterborne.¹³ Public water supply is currently delivered through Electrogaz, the government-owned utility that supplies water to all urban centres in Rwanda.



Securing water is a major effort for the urban poor of whom only 50 percent have access to clean drinking water

However, this public water supply is insufficient to meet the needs of growing urban populations. Between 2001 and 2006, Electrogaz increased water supply in urban areas other than Kigali, resulting in more people receiving ‘safe’ water. But the total percentage of people with access to clean water in fact dropped due to urban population increases.¹⁴ Access to safe water in urban areas was 76 percent in 2005, as compared with the national average of 71 percent.¹⁵

Table 42. Percentage of households with access to drinking water sources in Kigali and in other urban centres¹⁶

Water source	City of Kigali	Other urban
Free public standpipe	5.4	25.5
Protected spring	5.0	12.3
Purchased from vendor	53.1	26.5
Supplied by Electrogaz	18.0	9.5
River/stream/lake/pool	5.7	12.7
Unprotected spring	4.7	4.6
Bore hole	6.3	7.0
Plain well	0.5	1.1
Other	1.2	0.8

Apart from supply, the distance to a water source is another aspect for evaluating access. The Demographic and Household Survey revealed that 47.9 percent of the urban population travel on average 14.3 minutes to reach a water source.¹⁷

What this survey does not highlight is that the burden of water collection often falls mainly on women and children. In addition to travelling such distances, UNEP observed that the time spent waiting at water points appeared to be considerable. The time and energy invested by women and children for water collection reduce their opportunities to obtain education and pursue more productive activities. In addition, by walking long distances, women and children may become more exposed to violence and abuse.

Access to water is complicated by poverty and the urban poor’s capacity to pay. In Kigali, only 50 percent of the urban poor have access to potable or clean drinking water, while the other half collects water from natural and unprotected sources. In addition, a significant portion of the urban poor receives only from 50 to 80 percent of their daily water requirements.¹⁸ UNEP interviews during field visits revealed that residents attempted to reduce household expenses by collecting water from unprotected sources (e.g. nearby wells, springs, bore holes) and save on cooking fuel costs by not

boiling water, thereby increasing their exposure to waterborne diseases.¹⁹ Chapter 9 provides further discussion on water supplies and accessibility.

Water quality

Data on drinking water quality from the NUR were combined with results from UNEP's in-field water testing. The UNEP assessment found that deteriorating water quality is a major concern. Biological contamination was found to be a significant problem in both improved water and natural water sources, indicating that groundwater is under significant stress. An increasing level of heavy metal concentration in groundwater indicates that contamination sources are present and, in time, these may lead to groundwater resources becoming unfit for human purposes. More detailed testing, however, is needed and may reveal greater contamination than initially observed.

Biological contaminants

Bacteriological testing showed the presence of total coliforms in 90 percent of water samples (17 out of 19 samples) and *Escherichia coli* bacteria in 47 percent of water samples (nine out of 19) tested by UNEP. Total coliforms represents a group of

species that may be faecal or naturally occurring, whereas *E. coli* are known species from human excreta. *E. coli* are extremely pathogenic and can cause significant health-related problems.²⁰

Chemical, physical and other contaminants

UNEP also tested for heavy metals in groundwater. Sampling sites were known to be places where water is being used for domestic purposes including drinking. Results for samples taken in the Gikondo catchment are shown in Case study 12.2. Additional samples from other areas did not exceed World Health Organization (WHO) drinking water guidelines (Appendix 5). However, the presence of arsenic, chromium, selenium and nickel in water samples is of concern and signifies concentrations beyond expected ambient background levels in groundwater. Further monitoring is necessary to fully assess the extent of heavy metal contamination.

The figures also showed the presence of major salts, specifically calcium and magnesium, in drinking water from natural sources, which results in hardness and affects the taste of water. Potability of water with less than 600 mg/L of total dissolved solids, however, is generally considered to be good.²¹



Biological contamination was found to be a significant problem in both improved (left) and unprotected water sources (right)



Location of drinking water collection points tested in the Gikondo catchment

Case study 12.2 Assessing water quality in Kigali and its relationship to the Gikondo urban catchment

The geography of Kigali City is made up of a number of water catchments that have been transformed by urban development. These changes in land use bring with it a range of hazards that has the potential to contaminate water resources. Potential contaminants include: organic and inorganic compounds, petroleum products, heavy metals, pesticides, suspended solids, sediments, higher temperatures, waste and debris.

The Gikondo catchment area was assessed in order to examine the relationship between urban catchments and drinking water quality. Gikondo is an area with residential development but also has the greatest concentration of industrial and commercial establishments in Kigali. Drinking water collection points tested in the catchment are identified in the image above.

The results show that the quality of drinking water collected from selected points is generally poor. Biological contamination (in 17 out of 19 water samples) was found to be in excess of recognised standards. Testing for heavy metals show that WHO drinking water standards were **not** exceeded at the locations tested. However, elevated levels of chromium, nickel, selenium and zinc show that anthropogenic influences on groundwater quality are occurring.

The low pH values, low dissolved oxygen and high nitrate levels also indicate poor water quality. Nitrate levels are below WHO drinking water quality standards (50 mg/L), but surpass the United States Environmental Protection Agency (USEPA) drinking water quality standards (10 mg/L).

12 URBAN ENVIRONMENT AND HEALTH ISSUES

Findings revealed high sulfate levels in a few sampling points. Sulfate intake in excess of 500 mg/L is not recommended, because it may have gastrointestinal effects in humans.²² With respect to nitrate levels, all sites had concentrations below 50 mg/L, which is the WHO guideline value for drinking water.

Poor sanitation conditions

Access to improved sanitation

Slightly more than half (56%) of the urban population has access to improved sanitation.²³ However, only 15 percent of households is serviced

with wastewater treatment facilities, with pit latrines representing the most common form of liquid sanitation in both urban and rural areas (Box 12.1).²⁴ High dependency on pit latrines is a reflection of poor urban planning as well as the lack of sewage systems and wastewater treatment facilities.

Household surveys show that access to private pit latrines is relatively high for Kigali but significantly lower for other urban areas (Table 43). The problem of using pit latrines in urban areas is the increased potential for bacteriological and nutrient contamination of groundwater, especially where there are high densities of people such as in unplanned slum settlements.

Table 43. Household access to sanitation

Type of toilet facility	Urban household access to sanitation (%)		
	All urban ²⁵	Kigali ²⁶	Other urban ²⁷
Water closet system	2.3	6.0	2.8
Private latrine	65.3	80.3	63.1
Public latrine	30.6	11.6	26.9
In the bush	0.8	2.1	7.0
Other	1.0	0.1	0.1



Pit latrines are normally dug between 10 and 20 metres deep with a private shelter constructed over the pit. They are used until they are filled with waste, and then the pits are emptied through the construction of another pit nearby. A connecting hole is then dug to connect the two pits. The problem in Kigali is that there is insufficient space for multiple pit construction. As a result, pits can often overflow. Moreover, high population density and small housing plots in hilly parts of the city will often result in pit collapse, especially during periods of heavy rain that carries waste overland to drainage and wetland areas lower in the landscape

Lack of wastewater treatment facilities

The potential health hazards posed by pit latrines illustrate the significant lack of wastewater treatment facilities in Kigali as well as in other urban centres. Many septic systems are being installed in new suburbs, but these need to be managed on a regular basis to de-sludge the contents of the tanks. In Kigali, suction trucks collect the waste sludge, which is typically dumped in open areas at the Nyanza dumpsite. In Muhanga District, a liquid waste disposal pit was found to be directly in contact with the groundwater, near the local river, although this site reportedly has not been used recently. It was not possible to fully assess sanitation conditions in other urban areas. Generally, based on UNEP's site visits, liquid waste management practices were very poor, and significant effort is required to improve the situation.



Waste from septic tanks is typically openly dumped into the environment



Only 15 percent of the urban population is serviced with modern wastewater treatment facilities

Box 12.1 A visit to the Vision 2020 housing estate's wastewater treatment facility

UNEP visited one modern wastewater treatment facility at the Vision 2020 housing estate that is being operated by a private developer. This facility was recently flooded due to residents directing stormwater through the wastewater system. In addition, the manager stated housing construction did not include grease traps (plumbing devices to intercept or separate grease, fats, etc). This has placed an added strain on the system. While the system functions well, it needs proper management, which is dependent on the willingness of households to pay for this service.

Health risks, especially to women and children

The occurrence of waterborne diseases is seasonal, with the highest incidence usually occurring at the start of the wet season as the rains and run-off mobilise faecal matter and pollution that have accumulated during the dry season. Diarrhoeal disease alone accounts for 10 percent of all deaths and 18 percent of deaths in children under five.²⁸

Given the high incidence of waterborne diseases, the poor sanitation of liquid human waste is no doubt a key factor. In Masaka, a small urban centre near Kigali, bacteriological contamination of water from poor urban sanitation led to an outbreak of cholera in 2006. The suspected cause was water from the Nyabarongo River that was used as a surrogate domestic supply when the Electrogaz water supply had become insufficient.

Poor sanitation conditions particularly affect women, who are responsible for both household

cleanliness and sanitation as well as water collection. Limited access to water supplies does not allow for an improvement in household sanitation, resulting in a greater incidence of disease. The impact of poor sanitation is, therefore, proportionately higher for women and children, a problem that can only be resolved by strengthening women's role in decision making on sanitation issues.

Inadequate SWM

Improvements in SWM have occurred since 2005, with the introduction of municipal by-laws prohibiting the dumping of household waste outside individual private property. While solid waste collection has significantly improved, there are health risks to garbage collectors, who were observed by UNEP to be mostly women. Poor solid waste disposal poses significant safety and health risks, particularly of groundwater contamination.



Inadequate urban sewerage and drainage affect the urban poor the most as they are at increased risk of waterborne diseases



Despite an improved waste management and collection system, solid waste disposal remains a major problem as shown here at the Nyanza dumpsite overlooking Kigali

Waste collection

Typically, households register for SWM services with a local CBO. Municipal authorities license these CBOs to provide waste collection services for a designated area. In some instances, the local administration or a private contractor is responsible for waste collection in commercial areas, but also in residential areas if there is no CBO coverage. Although these CBOs appeared to operate in a number of urban centres, it was not possible to assess the extent of geographic coverage in all of the centres.

Many of the CBOs are operated by women's associations. Each CBO is responsible for a section of the urban area under the *umurenge*²⁹ administration. These CBOs are registered with the local administration, which actively supports them to ensure that they maintain their coverage and achieve cost recovery for their services.

The collected waste is directly transported to dumpsites in vehicles. In some instances, for example in Kigali, waste is brought to transfer areas to sort and recycle the organic waste into compost and briquettes. Also in Muhanga District, much of organic waste is taken from a collection point and used in generating biogas, significantly reducing the amount of waste in the environment. While there are efforts to recycle, waste recovery rates in Rwanda are still relatively low.



CBOs are contracted by municipalities to collect household waste and haul it to the dumpsite

In Kigali, estimates of CBO coverage are well over 90 percent, with each household paying approximately 2000-3000 FRW (USD 3-5) per month for weekly collection services. It is probably only the most poor who dispose of their waste in public areas.³⁰ However, CBOs still use rudimentary methods for garbage collection with little protection against disease.

Waste disposal

Site visits to solid waste disposal sites in Kigali and the Musanze, Muhanga, and Rubavu Districts showed that solid waste is dumped in open locations with simple management techniques that are likely to cause both environmental and health impacts. By far, the worst situation is in Kigali, given its larger population, though in other urban centres the management of waste is also far from satisfactory.

In Kigali, approximately 400 to 600 tonnes of garbage per day are delivered to the Nyanza dumpsite, of which 70 to 80 percent is organic waste. However, the main problem is the open dumping of liquid waste from septic tanks and waste tanks of industrial facilities. During interviews, a number of industry managers stated that wastewater pits were often cleaned by suction trucks and this material taken to Nyanza for disposal.



Dry organic waste is separated from wet organic waste, which is composted for use in urban horticulture activities



Some of the CBOs have established waste separating and recycling operations to convert organic waste to briquettes for use as cooking fuel



Both site operators and scavengers are active in managing waste at the Nyanza dumpsite. Waste scavengers play an important role in waste management by recycling materials but face multiple challenges, including occupational safety risks

The Nyanza site has been operating for at least 40 years in various locations, with the current site in operation since the mid-1980s. Examination of the Nyanza facility revealed that there is no dedicated system for the management of liquid household and industrial wastes. Industry waste includes the liquid and solid components collected in wastewater tanks of various industries, such as tanneries and paint factories. Many of these wastes contain chemicals considered toxic and hazardous to human health and the environment.

Outside Kigali, it is mostly trucks that deliver waste to open and unregulated waste disposal areas. In some cases, such as in Musanze District, waste is delivered on foot in wheelbarrows or plastic bags. In such instances, the burden of work typically falls on women, who UNEP observed had little hygiene protection and were thus at high risk of contracting diseases. In Kigali, open dumping grounds encourage scavengers to collect material in order to generate some income from re-using and recycling waste, thus putting their health at significant risk.

Hazardous healthcare waste (HHCW)

There was generally a high level of awareness in the health sector regarding the problems associated with HHCW, mostly due to the potential infection of HIV from poor waste disposal. Some efforts were visible to ensure that HHCW is not being dumped into the environment. For instance, the major hospitals in Kigali have a dedicated incinerator and also receive some waste from smaller medical centres. In Rubavu District, the hospital implements a system of waste separation, in which bio-HHCW is composted in a dedicated facility and other HHCW is burned in an incinerator.

All district hospitals and smaller medical centres are required to incinerate their HHCW. However, some problems were observed:

- poor incineration techniques or equipment resulting in lower combustion temperatures, excessive smoke and reduced effectiveness of incineration;

12 URBAN ENVIRONMENT AND HEALTH ISSUES

- lack of maintenance or poor equipment that release air pollutants associated with incineration; and
- limited level of compliance by smaller clinics to appropriately dispose of HHCW.

As health facilities improve in regional centres, there will likely be an increase in the amount of HHCW. Therefore, suitable policy frameworks and financial resources need to be considered for improving healthcare waste management. Once adequate policy is in place, incentives for involving the private sector in large-scale HHCW initiatives should be explored. Attention should also be given to adopting non-combustion technologies, such as steam-sterilisation, which may be more cost effective and have lower environmental impacts.

Environmental and health risks

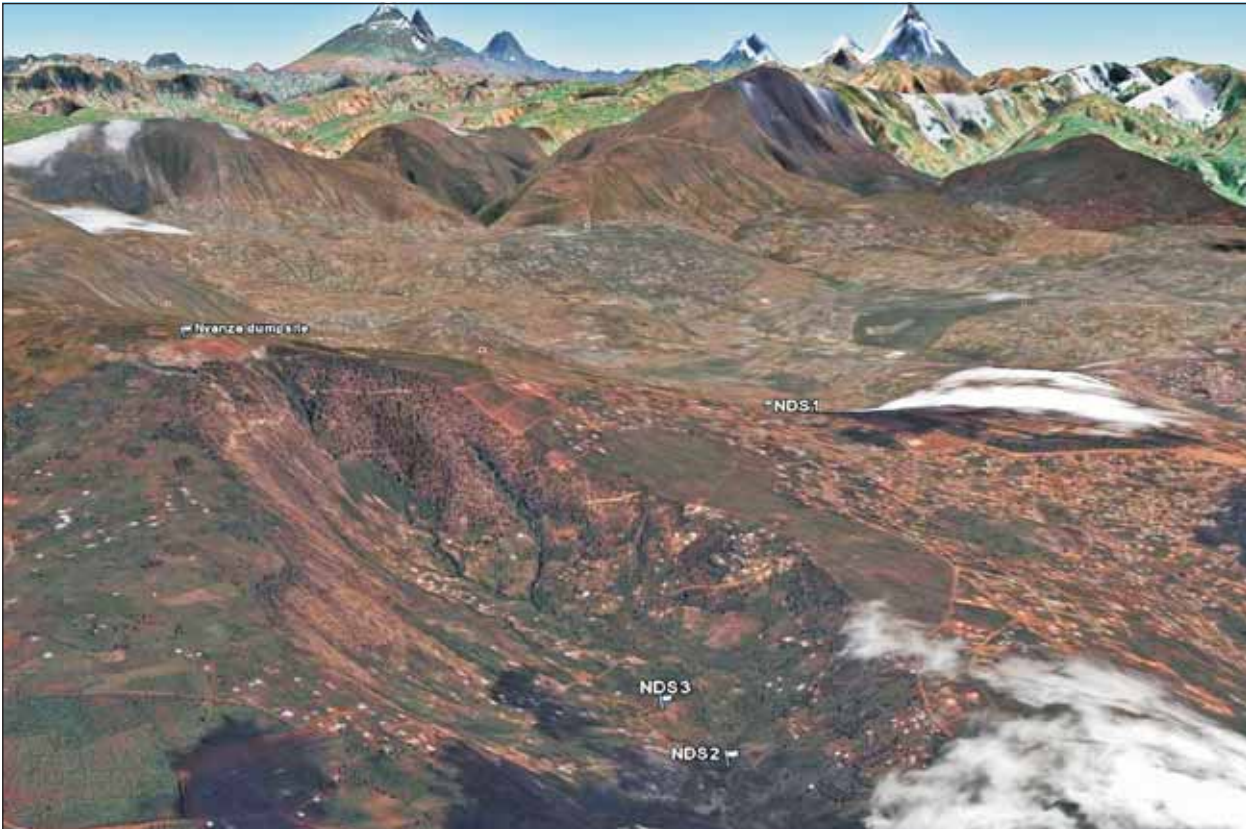
The major environmental and health concerns associated with inadequate SWM relate to the

spontaneous combustion of waste and the escape of leachate from dumpsites. In many open disposal areas, fires can burn and smoulder over a prolonged period thereby releasing methane, carbon monoxide, nitrogen oxide (NO_x), sulfur oxide (SO_x) and dioxins into the atmosphere.

The main problem, however, is leachate and its potential for groundwater and surface water contamination. Leachate is the liquid that drains from a landfill site; its chemical properties are determined by waste composition. In the case of Nyanza, this is mostly organic waste, which will result in high levels of carbon, nitrogen and pathogenic organisms. The disposal of industrial waste, over a period of time, may also result in more toxic chemicals in the leachate. UNEP examined possible groundwater contamination from the Nyanza landfill in the peri-urban centre of Kagarama and found serious problems, which are described in Case Study 12.3.



Despite generally high levels of awareness, poor healthcare waste incineration methods were encountered



Nyanza dumping site in relation to downstream drinking water collection points

Case Study 12.3 Nyanza dumping ground and water quality

The Nyanza dumping ground is located in a suburban area and is the main disposal site for Kigali City. When operations started in the 1980s, Kigali's population was no more than 150,000 people, and the site was well outside the city.

Today, Nyanza receives solid waste from close to one million people, amounting to an estimated 400 to 600 cubic metres per day. Household liquid waste (including sewage) as well as industrial waste are dumped together, making this landfill a possible source of toxic pollutants.

Management practices at Nyanza are rudimentary. Open dumping of both solid and liquid waste occurs at an elevated point in the landscape. At approximately 1,700 metres above sea level, the Nyanza dumping site receives around one metre of rainfall annually. Without any control measures in place, and given Nyanza's elevated location, a significant amount of leachate will emanate from this landfill, eventually reaching ground and surface waters.

The closest downstream water users are located in Kagarama, a peri-urban area that is 1.5 km east of Nyanza, at an elevation of 1,400 m above sea level. To assess leachate contamination, water samples were collected from Nyacyonga River and from groundwater wells. Water quality testing showed that both pH levels (at 5.7 and 6.0, respectively) and dissolved oxygen content were very low (1.6 mg/L and 3 mg/L, respectively).

The slightly acidic water indicates that pollution could be a problem. Low dissolved oxygen is probably due to high levels of bacterial contamination, as both total coliforms and *E. coli* were detected in the water. Heavy metal testing failed to show elevated levels above WHO drinking water quality guidelines. Water was also tested for polycyclic aromatic hydrocarbons (PAHs), but no detectable limits were found.

In addition, sediment samples were collected from the Nyacyonga River downstream of the dumping site and from the spring that is the source of surface water flow. While some heavy metals were detected, these levels do not indicate significant contamination. Some contamination with PAH 16 was shown, with the highest reading attributed to naphthalene. Naphthalene is found in petroleum and other industrial products.

The results highlight that increasing chemical concentrations are occurring in groundwater sources. The only possible source of this contamination is the leachate from the Nyanza dumping site. Undoubtedly, there is some impact of leachate on the environment of Kagarama, which requires more in-depth analysis to fully understand its extent and risk.

Construction in inappropriate and hazardous areas

Signs of unplanned urban development are clearly visible, particularly in Kigali in the form of sprawl. Informal housing and slum settlements, in turn, have significantly increased vulnerability to disasters, especially for the urban poor.

Unplanned housing

While urbanisation has been growing, planned housing development in urban areas is remarkably low at 6.5 percent. In Kigali, it is estimated that 83 percent of the population is located in informal settlements, covering approximately 62 percent of its land area.³¹

The emergence of informal settlements and slum dwelling has been a characteristic feature of the post-conflict period. In Kigali, returnees have been a key driver of this phenomenon. Furthermore, as rural areas become less viable, there is increased urban migration, which often results in unplanned

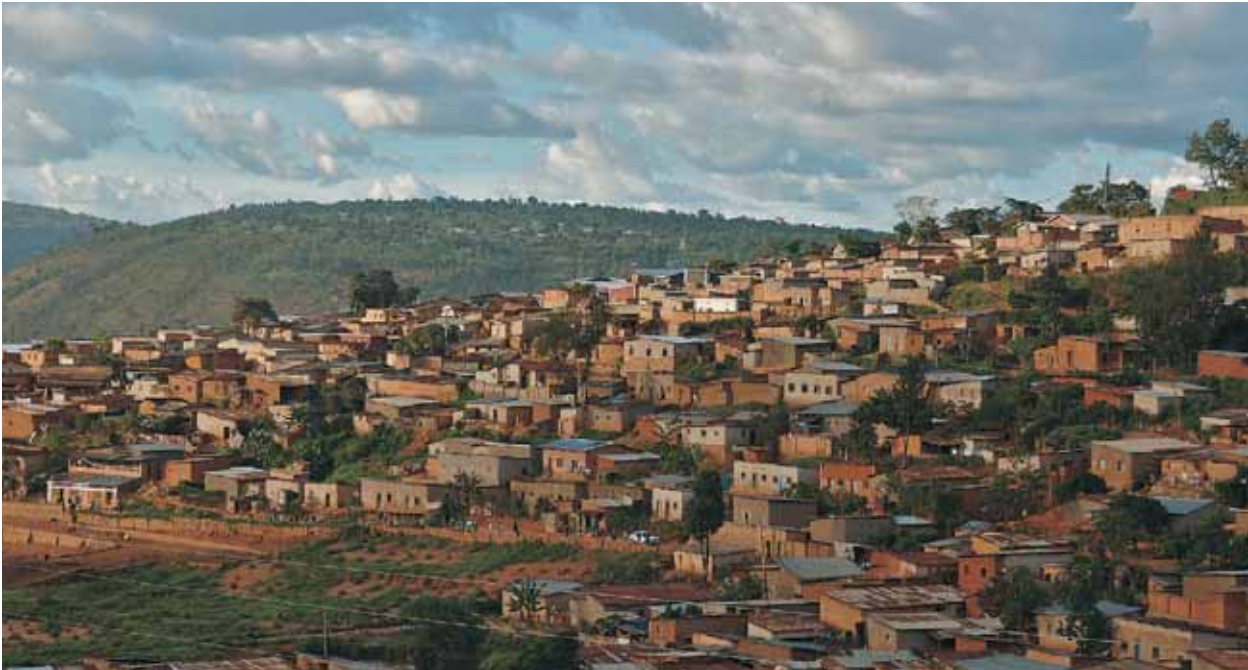
Table 44. Proportions (in percentage) of housing units and corresponding resident population by type of housing and place of residence³²

Type of housing	Urban	
	Households	Population
Total	100.0	100.0
Grouped housing (<i>imidugudu</i>)	8.9	8.9
Former grouped housing	6.0	5.8
Isolated housing	40.3	40.5
Planned housing	6.5	7.9
Spontaneous / unplanned housing	35.0	33.5
Other type of housing	3.2	3.4

housing development. In 2001, the percentage of urban populations living in slum conditions was estimated at 87.9 percent.³³ Population densities for Kigali are approximately 85 persons/ha, but

Figure 20. Urban sprawl in northern Kigali





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It is estimated that 90 percent of urban housing demand is met through informal settlements

are likely to be significantly higher for slum areas at around 190 persons/ha.³⁴ The incidence of informal settlements, especially in Kigali City, is further driven by unplanned urban development and poor land administration systems. As a result, informal urban and peri-urban land sales are common, which in turn exacerbate poor housing development and living conditions.

Increased disaster vulnerabilities

Unplanned and informal settlements generally occur in areas where land is cheapest and usually the most inappropriate. In Kigali, construction on slopes greater than 10° has major implications for the environment and human safety. It is estimated that 19 percent of Kigali's housing infrastructure has been developed on land that is less than ideal. Housing construction in hazardous areas increases people's vulnerability to disasters, particularly from landslides, flooding and erosion, which in the past have caused losses in human lives and property in Kigali.³⁵ Poor drainage systems in these areas compound the risk of major flooding especially during the rainy season.

High population densities and construction on steep slopes increase rainfall run-off, which affects the quality of receiving waters downstream. The lack of measures and infrastructure to slow down water

within the urban landscape, particularly in Kigali, results in significant levels of silt and soil erosion. The Nyabugogo and Nyabarongo river system contains significant levels of turbidity and movement of particulate matter coming from Kigali. It is estimated that erosion from the Gikondo catchment is in the range of 500 to 600 tonnes/ha.³⁶

Strengthening urban planning and development

Improving environmental governance in urban development will require a two-pronged strategy: (i) strengthen and enforce policies and legislation that deal specifically with urban planning and housing development; and (ii) capacity-building and resource mobilisation to support implementation of environmental policies and laws pertinent to urban planning and development.

Legal and policy requirements and enforcement

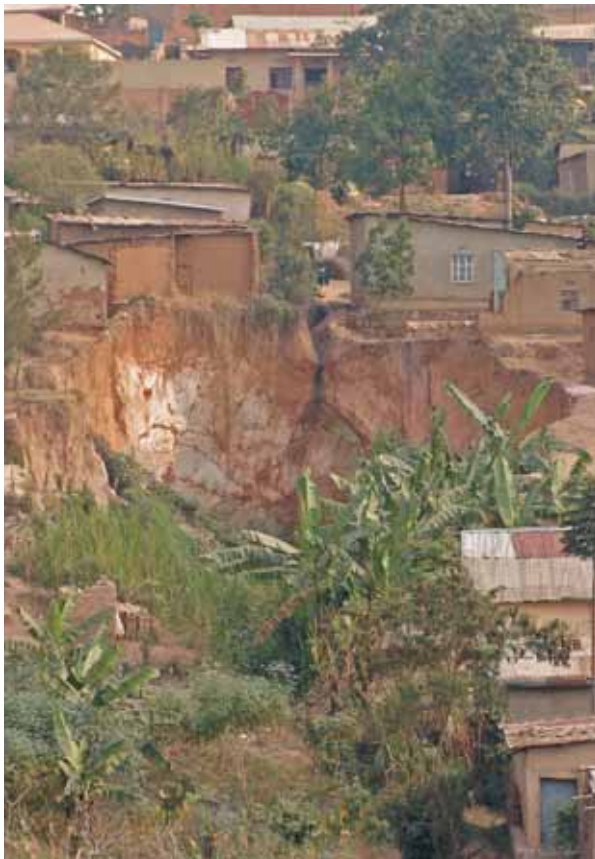
There is a need for strengthening and enforcing environmental controls on urban planning. As discussed earlier, urban municipalities are now tasked to develop urban master and land use plans. Environmental impact assessments (EIA) need to be applied to all such urban plans to

ensure that environmental issues, particularly water and sanitation, are effectively addressed. Pollution management, especially relating to water resources and waste management, is also another area requiring significant policy and regulatory support.³⁷

A national urban strategy is needed to help address key environmental issues in urban areas, particularly in the context of ongoing decentralisation. An important challenge will be to ensure the coherence of policies and legislation and their implementation at national and local levels. This applies in particular to the development of SWM policy and law.

Capacity-building and financial mobilisation

Commensurate capacity development through technical and financial assistance is needed to support policy and legislative enforcement. This applies to national level authorities, such as the KCC, MININFRA/RBHDB, REMA, NLC and Ministry of Local Government, Community



Housing construction on steep slopes has accentuated people's vulnerability to natural hazards, including landslides and floods

Development and Social Affairs (MINALOC)/ Human Settlement Task Force as well as local authorities. REMA needs to ensure compliance of pollution management guidelines and make sure that standards for outfalls are within regulatory limits. For urban municipalities, such as Kigali, the issue is mobilising financial resources to implement their new urban master plans.

12.6 Conclusions

Comprising about a fifth of the population, urban centres in Rwanda are rapidly growing. Given the country's severe land scarcity problems, increasing urbanisation could help relieve demographic pressures on agricultural lands.³⁸ Yet, with greater numbers of people living in urban areas, the prevalence and severity of urban environmental problems could worsen.

Improved urban planning and development in Rwanda is, therefore, crucial to address burgeoning urban populations. Planned urbanisation requires concerted efforts to improve employment opportunities and reduce unplanned sprawl, while dealing with the emerging social and environmental challenges. Addressing water and sanitation issues including SWM are the foremost priority. The implications for public health particularly affect the urban poor and women. An effective response will require major investments in water and sanitation infrastructure.

Rapidly urbanising areas also face emerging concerns, such as air pollution. The increase of vehicles on roads, household dependency on charcoal and pollution from industry will add to deteriorating air quality in major cities, particularly Kigali. Overcoming urban environmental problems is well recognised in policy directions set by the GoR. The next step is to develop an appropriate mix of issue-specific legal and policy instruments, together with sufficient institutional capacity support and financing, both at national and local levels.

12.7 Recommendations

R12.1 Development of urban land use master plans. This would include assessing and mapping of urban areas vulnerable to disasters as well as site identification, cadastral mapping and strategic plans for possible population relocation. Urban

land use master plans would provide a blueprint for urban planning and infrastructure development in order to avoid unplanned urban settlement and slums, especially in places with known disaster risks. In particular, urban planning should reassess future informal development on slopes greater than 17° including provision of suitable hazard management techniques. These efforts should contribute towards developing policy approaches for disaster risk reduction in urban areas.

Lead agencies: MININFRA, MINALOC, KCC, RBHDB, district authorities. International Partner: UN-HABITAT. Cost estimate: USD 5 million. Duration: 5 years.

R12.2 Develop a programme for liquid waste management to minimise the exposure of the urban population to contaminated groundwater. The focus would be to develop infrastructure based on urban master plans that establish a proper water drainage system and liquid waste management system to reduce contamination of groundwater. The programme would promote the construction of improved and modern latrines in urban areas, the development of liquid water treatment plants and the identification of simple, low-cost technologies to purify water in conjunction with awareness-raising activities to promote technology adoption.

Lead agencies: MININFRA, MINIRENA, KCC, RBHDB, district authorities. International Partner: WHO, UNICEF, World Bank. Cost estimate: USD 5 million. Duration: 3-5 years.

R12.3 Develop a SWM policy that aims to put environmental controls on waste and its management. The objective would be to develop a comprehensive SWM policy that would cover household, industrial and HHCW.

Proposed lead agencies: MINIRENA, REMA. International Partner: World Bank. Cost estimate: USD 0.25 million. Duration: 1 year.

R12.4 Build capacities of government and the private sector to undertake environmentally sustainable urban planning and development. Urban planning and development is a new concept in Rwanda and, therefore, would require capacity-building at all levels and in

related sectors. Technical assistance is especially needed for urban housing development and the application of EIAs for urban land use plans. This recommendation aims to address a gap in the Environment Law that stipulates the integration of environmental safeguards in urban planning but does not provide guidance on how this should be carried out. As EIAs will also be undertaken by private sector experts under the supervision of the Rwanda Development Board (RDB) and REMA, they will equally benefit from technical capacity-building.

Lead agencies: REMA, RDB, MININFRA, MINALOC, MINIRENA, KCC, RBHDB, district authorities. Cost estimate: USD 1 million. Duration: 2 years.

R12.5 Assess the feasibility of various waste disposal interventions including landfilling and installation of municipal solid waste incinerators. A comparative feasibility assessment should consider the capital, operational, technical expertise and cost-recovery aspects of both landfilling and incineration options. Given the land scarcity problem in Rwanda, establishment of incinerators to dispose of solid waste may be a potential option despite their high costs and technological complexity. Negative environmental impacts of incineration, including gaseous emissions and disposal of toxic combustion ash, would also need to be factored in the feasibility assessment.

Lead agencies: MINICOM, MINIRENA, MINISANTE, REMA, KCC, RBHDB, district authorities. Cost estimate: USD 0.25 million. Duration: 6 months.

R12.6 Undertake a detailed site contamination and risk assessment of Nyanza dumpsite, including implementation of mitigating actions. This should include eliminating the uncontrolled disposal of household liquid septic waste at Nyanza and implementing an immediate ban on dumping of industrial waste. The assessment would obtain a detailed understanding of the risk that the Nyanza site poses as a source of potential contamination. Findings would be used to develop options for reducing future impacts, minimising use of this site and eventually decommissioning the site. In this regard, suitable

alternatives are needed for waste disposal over the short and long term, with the aim of discontinuing the direct disposal of household septic waste at the Nyanza site. A wastewater station, providing both primary and secondary treatment, needs to be constructed and operated on a cost recovery basis. There should also be an immediate ban on dumping industrial waste at Nyanza, which would require developing temporary waste storage facilities until a hazardous waste management facility could be established.

Lead agencies: KCC, MININFRA, MINIRENA, REMA, RBHDB. International Partner: World Bank. Cost estimate: USD 1 million. Duration: 3-5 years.

R12.7 Develop and implement a water quality control and monitoring programme. A survey of drinking water collection points in urban areas should be undertaken to establish a water quality monitoring programme. This programme would ensure the safety and potability of drinking water across urban areas and the protection of groundwater in Kigali. Generated information could be used to identify interventions targeting communities at risk (e.g. Gikondo and Kagarama) to minimise potential health impacts.

Proposed lead agencies: MINIRENA, RURA, RBHDB, KCC. International Partner: WHO. Cost estimate: USD 1 million. Duration: 1 year.

R12.8 Undertake a comprehensive review of CBOs involved in solid waste collection services. This review would evaluate the management practices of CBOs, assessing their coverage, operations, health and safety. The aim would be to develop a management system that applies best practice standards and ensures the long-term viability of waste collection systems in urban areas.

Lead agencies: MINALOC, MIFOTRA, RBHDB, district authorities. International Partners: ILO, UNIDO, UNDP. Cost estimate: USD 0.5 million. Duration: 1-1.5 years.

R12.9 Develop an environmental programme to protect the sustainability of urban water resources. This would include policy guidance for Electrogaz to undertake suitable monitoring procedures for water supply sources. Electrogaz

is currently upgrading water supply for urban centres. In Kigali, the Nyabarongo underground water supply project should seek to improve supply across the city. An environmental assessment is needed for developing this supply and evaluating its possible longer-term impacts.

Lead agencies: REMA, MINIRENA, Electrogaz, RBHDB. International Partner: World Bank. Cost estimate: USD 1.5 million. Duration: 3-5 years.

R12.10 Develop guidelines on management of urban wetlands and wastewater treatment. Policy direction is needed to protect urban lakes and wetlands. This initiative would identify the main wetland functions that should be maintained and set the guidelines for urban and commercial development near wetlands. These required controls should then be integrated into urban planning policy and law. Under the Environment Law, there is a need to develop subsidiary standards for wastewater systems based on the type of technology and systems adopted in urban areas.

Lead agencies: REMA, MINIRENA, RBHDB. International Partners: UN-HABITAT, UNEP. Cost estimate: USD 0.25 million. Duration: 1-1.5 years

R12.11 Undertake a feasibility assessment for the development of constructed wetlands in the urban environment of Kigali. This would assess the potential economic, social and environmental impacts of artificial wetlands and provide a basis for decision making on their possible construction.

Lead agencies: REMA, KCC, RBHDB. International Partner: UNEP. Cost estimate: USD 0.25 million. Duration: 1-1.5 years.

R12.12 Prepare an air quality monitoring programme for Kigali and develop appropriate policy responses to alleviate air pollution problems. A better understanding is needed regarding the major types and sources of air pollutants and the impacts they are likely to cause in Kigali. This study would serve as a basis for developing future strategies to address the problem.

Lead agencies: REMA, MINALOC, KCC, RBHDB. International Partner: UNEP. Cost estimate: USD 0.25 million. Duration: 1 year (continuing).

Industry and Mining

*Predicted growth in the industrial and
mining sectors requires better regulation to
address potential environmental impacts*

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Industry and Mining

13.1 Introduction

Substantial growth and expansion are forecasted for the industrial and mining sectors over the next decade. Historically, agro-based manufacturing was based on coffee, tea and sugar, which experienced a remarkable decline due to the 1990-1994 conflict. Following independence, mining activities were taken over by the government until the mid-1990s, when the minerals industry also collapsed. Since 2000, industry and mining have been reviving, diversifying and are expected to increase their share in the country's economy.

Industrial and mining development, however, poses significant challenges to environmental management. Weak control and substandard operating practices have already negatively impacted on the environment, which could be exacerbated

once industrial development intensifies. Another key issue is alleviating poverty amongst the scattered small-scale miners while pursuing growth and minimising damage to the environment.

Improving environmental governance of the industrial and mining sectors is, therefore, a priority issue, in order to regulate and manage the potential environmental impacts of planned growth. Recent efforts by government to establish better regulations and promote cleaner production are positive steps in the right direction.

13.2 Assessment activities

As industry is located mostly in Kigali, UNEP's fieldwork concentrated on visiting industries within and around the capital, mainly in the districts of Kicukiro, Nyarungenge and Gasabo. In addition, site visits to a number of mines were conducted close to Rubavu and Muhanga and in Sharonji.



Seriously impacted by the 1990-1994 conflict, agro-manufacturing based primarily on tea and coffee has made a major come back

Table 45. Field sites visited by province

Province	Field sites
Kigali	<ul style="list-style-type: none"> – Paint and foam factories; food processing; beverages and tobacco enterprises; textile factory (UTEXWRA); Rwanda Leather Industry; and chemicals, fertiliser, plastics and petroleum products enterprises – Sampling points in the Gikondo Valley (Kicukiro District) included: Kimihurura, Kimicanga, Kiyovu (south,) Kinamba, Nyabugogo, Kamuhanda, Yanze, Nyanza, Kagarama, Nyandugu, Nyagatovu, Kibagabaga, and Kamugina
Northern	– Quarry site for gravel extraction near Musanze
Southern	– Community coltan mine sites near Muhanga
Western	<ul style="list-style-type: none"> – Rubavu District: BRALIRWA brewery – Karongi commercial wolfram mine site – Community coltan mine site in Rubavu – Community quarry site – Pozolane quarry sites (two)

*Water quality testing of the Nyabarongo River*

Consultations were undertaken with several government stakeholders, including: Rwanda Environmental Management Authority (REMA); Ministry of Finance and Economic Planning (MINECOFIN); National University of Rwanda (NUR); Ministry of Trade and Industry (MINICOM) and Ministry of Infrastructure (MININFRA).

Other meetings were held with the following: waste management community-based organisations (CBOs); Electrogaz, a government-owned utility that supplies water, gas and electricity; UTEXWRA; BRALIRWA; Rwanda Foam Factory; Gisenyi Mining Cooperative; Enviroclean Technologies and the United Nations Industrial Development Organization (UNIDO).

The UNEP assessment team established an in-field water/soil monitoring strategy in order to obtain a rapid overview of pollution issues associated with the industrial and mining sectors. Field investigations included monitoring of surface water, groundwater and surface drainage sediments and examined a range of chemical parameters from the Kagina source to the Gatsata/Gatuna Road Bridge. Monitoring results for groundwater are provided in Chapter 12. This chapter focuses on industrial pollution to surface waters and sediments.

13.3 Overview of the industrial and mining sectors

Significant growth in the industrial sector as a whole has occurred in the last five years. Vision 2020 aims to increase the industrial sector's contribution to the gross domestic product (GDP) from 8 percent in 2007 to 26.5 percent by 2020.¹ It further aims to increase current growth rates of industrial production from 7.6 to 12.5 percent.²

There is strong desire by government to create a positive investment climate for industry. The main target areas are:

- food and food products;
- wood-based industry;
- leather and leather products;
- handicrafts industry; and
- high value opportunities, such as pharmaceutical, electrical equipment and electronics, and metals industries.



Manufacturing is comprised mainly of small and medium-scale enterprises

Both the manufacturing industry and mining still make up relatively small components of total GDP. Manufacturing has averaged 6.2 percent in annual growth in USD terms, while mining and quarrying averaged 17 percent.³

13.4 Key industries

The industrial sector in Rwanda is still relatively small and underdeveloped. Manufacturing accounted for 13 percent of employment in 2007, while

Table 46. Total number and share of employment by industry type⁶

Type of industry	Number of employment			Share
	Large industries	SMEs	Total	%
Basic metals and metal products	101	523	624	1
Textiles and textile products	658	2,660	3,318	7
Wood products, including furniture	20	6,848	6,868	15
Chemicals, fertilisers, plastics and petroleum products	69	849	918	2
Food processing, beverages and tobacco	6,396	20,474	26,870	59
Rubber processing and products	138	466	604	1
Paper and paper products, printing and publishing	46	183	229	0
Non-metallic mineral products	1,151	976	2,127	5
Handicraft	0	2,546	2,546	6
Others	0	1,803	1,803	4
Total	8,579	37,328	45,907	100

extractive industries only accounted for 1 percent.⁴ Manufacturing is comprised of mostly small and medium enterprises (SMEs) accounting for 81 percent of employment in the sector, while large enterprises make up 19 percent.⁵ Total employment by industry type is dominated by the food processing, beverages and tobacco industry, followed by wood products and textile products. This reflects the primarily agrarian basis of Rwanda's economy.

Manufacturing industry is concentrated in Kigali and the western districts of Rubavu and Nyabihu. The conglomeration of industry within the Gikondo Valley area in Kigali City has arisen from the unplanned nature of urban land use in Rwanda. Locating industry in this area began in the 1960s when the city was small, and environmental considerations were not widely appreciated.⁷ Over the years, industrial development in Gikondo expanded in an unchecked and unplanned manner. Today, the Gikondo Valley contains about 65 percent of Rwanda's industry⁸ and is the main source of industrial pollution in the country (Case study 13.1).

Located in Rubavu District, BRALIRWA is by far the largest industry in the country, employing over 1,000 people. There are also other large-scale enterprises located in Kigali, but not in the Gikondo area, including the UTEXWRA and Rwanda Leather Industry.



Large companies employ around one-fifth of the industrial labour force



Rwanda's brewery in Rubavu is the country's largest company

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Figure 21. Levels of ORP and DO for surface water in the Gikondo Valley

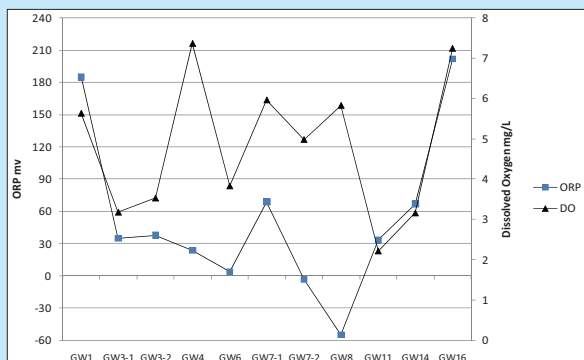
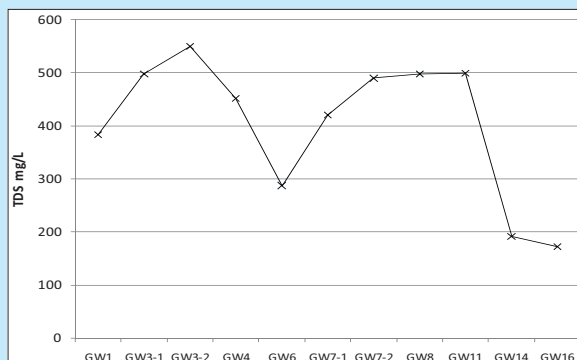


Figure 22. Concentration of TDS



Case study 13.1 Gikondo: A pollution hotspot

The Gikondo Valley is a U-shaped wetland area comprising the urban districts of Kicukiro, Nyarugenge and Gasabo in Kigali. Most of the catchment's natural state has been considerably altered. Industrial development in the Gikondo Valley is estimated to cover 80.73 ha, which is a significant part of the wetland area.⁹ In addition, unplanned residential development covers much of the valley slopes.

The Gikondo wetlands forms part of the Gikondo/Nyabugogo complex that feeds the Nyabarongo and Akagera river system that empties into Lake Victoria. This urban catchment probably has the greatest potential of causing significant environmental impacts due to its unplanned and mostly unmanaged waste releases.

The profile of industry groupings located in Gikondo includes mostly those involved in chemicals, fertilizers, plastics and petroleum, followed by the agro-processing industries (Table 47).

The UNEP assessment concluded that there are no significant point sources of pollution. The majority of industries located in Gikondo are not actively engaged in manufacturing but act as storehouses for various business activities. However, there are several operating industries that present potential sources of pollution, including a paint factory, foam factories, metal processing plant, among others. It is also highly likely that chemical pollutants are released from petrol stations, garages and underground fuel storage tanks.

Sampling results

Assessment results discussed here focus on industrial pollution of surface water and sediments. Contamination of drinking water is discussed in Chapter 11.

UNEP tested for levels of oxygen reduction potential (ORP) and dissolved oxygen (DO) in surface water. The level of ORP shows the ability of water to either oxidize or reduce chemical species through the exchange of electrons.¹¹ Testing revealed that DO levels in water samples were generally less than 6 mg per litre, which is considered poor quality for supporting aquatic organisms. Figure 21 suggests that the water source of the Gikondo wetland (GW1) has a high oxidation potential. As the water flows through the industrial and residential areas it receives chemicals that oxidize and reduce oxygen levels in water, with the exception of one site (GW4). The fact that ORP and DO levels are related is likely due to the introduction of chemicals from anthropogenic or human-derived sources. However, longer-term monitoring is required to establish conclusive trends.

Table 47. Industries located in the Gikondo industrial area¹⁰

Industry	Number of enterprises
Chemicals, fertilisers, plastics and petroleum products	23
Food processing, beverages and tobacco	15
Paper and paper products, printing and publishing	8
Basic metals and metals products	7
Rubber processing and products	3
Non-metallic mineral products	2
Total	58



The lack of a bund capable of containing fuel spillage from storage tanks indicates inadequate contingency planning to deal with acute pollution events

Case study 13.1 Gikondo: A pollution hotspot (continued)

The elevated levels of dissolved solids support these initial findings regarding increasing chemical inputs into Gikondo's surface waters. Higher levels of total dissolved solids (TDS) were found as water moves through the landscape, decreasing as it leaves the Gikondo/Nyabugogo area and joins the Nyabarongo River. TDS is comprised of the major inorganic salts, including calcium, magnesium, potassium, sodium, bicarbonates, chlorides and sulfates.

Assessment results did not show significant levels of heavy metal contamination in surface water and sediments. However, several samples showed concentrations above natural levels, particularly chromium, copper, nickel and zinc.

Water samples showed elevated levels of chromium, nickel and arsenic, suggesting the increasing influence of anthropogenic sources, but World Health Organization (WHO) drinking water standards were not exceeded. Given the presence of petrol stations and garages in the Gikondo/Nyabugogo area, water samples were tested for polycyclic aromatic hydrocarbons (PAH), which are normally found in gasoline. Tests showed slight increases of acenaphthene, fluorene and phenanthrene in areas closer to the Nyabugogo commercial centre, but these concentrations were not significant.

In the GW14 vicinity, sediment samples were also tested for a hydrocarbon suite, given the number of garages and vehicle parking areas. Extractable petroleum hydrocarbons in the range C10-C14 were found to be significant (in concentration of 230 mg/kg). This could be due to the presence of biodegraded diesel at this location.

Sediment samples also noted the presence of volatile organic compounds (VOCs) with high levels of toluene, a chemical that has a wide range of industrial applications and is also found in gasoline. Because there are no standards for determining soil contamination in Rwanda, Dutch Standards for environmental pollutant reference levels were applied. Two samples (GW3 and GW14) showed levels of toluene close to or exceeding reference levels (96 and 480 µg/kg, respectively).

Sampling results indicate that release of chemical pollutants is occurring from a range of anthropogenic sources. It is highly likely that pollutants are coming from industries as well as garages and underground fuel storage tanks. However, based on UNEP's findings, the catchment area has not been overloaded with excessive pollutants, as yet. In addition, concentrations of pollutants are not significantly elevated to cause transboundary pollution, especially towards Lake Victoria.¹²

The main concern here is the elevated concentrations of various chemical pollutants found in surface waters and sediments, which could potentially become a growing problem in the future given Rwanda's plans for industrial development. Sampling was undertaken on a Saturday, when there was no industrial activity, which would have under-reported pollution levels. Therefore, more rigorous monitoring is required to determine chemical concentrations over a period of time and to fully assess the magnitude of the water pollution problem in Gikondo.

Full test results are provided in Appendix 5. Cross-referencing with a number of environmental studies on Gikondo was also done, including those carried out under the Kigali Industrial Environment Management Program (KIEMP) in 2006.¹³

13.5 Mining

Presently, the mining industry is underdeveloped, in terms of equipment and infrastructure. Mining production has steadily increased between 1999 and 2004, accounting for nearly 45 percent of Rwanda's increase in exports.¹⁴ More growth is envisioned for the mining sector. Government aims to substantially increase exports from USD 38 million in 2005 to USD 106 million in 2012 and to increase employment from 25,000 to 37,000.¹⁵

This chapter covers large-scale mining (LSM), quarrying activities (i.e. for gravel and sand), the potential for peat mining and Communities and Small-Scale Mining (CASM).

LSM of minerals

The majority of mining concessions are for extracting three main mineral ores, mostly undertaken by LSM operators. The two most predominant minerals are cassiterite and coltan,

which commonly occur together in ore deposits. Coltan is the mineral from which the precious metals columbium and tantalum are extracted. Cassiterite is the ore that produces tin. Rwanda is considered to be part of the coltan/cassiterite belt of the Great Lakes region, which explains the high number of permits for exploitation of these minerals in the country. To a lesser extent, wolframite, the ore of tungsten, is also mined. Some mining of precious gems and gold occurs, although these are a small proportion of the mining sector.¹⁶

Quarrying

In addition to mining for minerals, a significant amount of quarrying also occurs. There is limited information available on the status of quarrying activities. However, given the high demand on materials for post-conflict reconstruction activities, it is safe to assume that there has been a commensurate increase in quarrying activities to supply sand, cement and gravel as well as clay for brick manufacturing.



Large-scale quarrying for road materials



Small-scale mining of cassiterite ore (tin) in western Rwanda

Peat mining

Rwanda also holds deposits of peat, although their extent is unknown. An estimated area of approximately 800 km² spread over various locations is widely quoted.¹⁷ Proposals to develop commercial peat mining are currently being examined. Known peat deposits exist in Nyaborongo Valley, Akanyaru mire, Kagera Valley, Akagera National Park, Lake Kivu and a number of smaller peatland areas.¹⁸

Table 48. Amount of production of key mineral commodities in 2006

Commodity	Quantity
Cement	100,000 tonnes
Columbium (niobium) and tantalum	280,000 kg
Natural gas	170,000 m ³
Tin	700 tonnes
Tungsten	400 tonnes

Peat is under consideration as an alternative energy source for household consumption to replace wood and charcoal but its contribution to the national energy balance is considered to be minimal (see Chapter 11).

CASM

There is very little information about the number and type of CASM miners, who are usually local residents engaging in mining, either formally or informally through organised community mining cooperatives.

CASM miners and cooperatives usually employ low-scale technology and often leave severe negative impacts on the local environment. These activities are poorly managed and closely interrelate with poverty, poor health and safety considerations, environmental degradation and conflict (Case study 13.2, next page).



Women generally undertake the more menial tasks in community-based mining

Case study 13.2 Small-scale mining and interlinkages with poverty and environmental degradation

CASM is widespread throughout the Great Lakes region. It is driven in part by poverty and the livelihood opportunities presented by small-scale mining. Most miners are seeking an alternative to dwindling livelihood options from subsistence agriculture.

A key characteristic of CASM is its high labour input that generally involves semi- or unskilled workers, employing low levels of mechanization. During the UNEP field visits, it was observed that women and children typically undertake the more menial and poorly paid support activities.

The type and level of CASM activity are driven by the commodity market and global demand. Gold has been a popular resource for CASM workers but, since 2000, increasing prices for cassiterite and coltan have made these minerals attractive.¹⁹

CASM activities in Rwanda may be formally organised into cooperatives that need to be registered with the Rwanda Geology and Mines Authority (OGMR). However, there are minimal government controls, and accessibility issues make it difficult to monitor mining activities and the impacts on workers' welfare and the environment.

There are a number of social and environmental issues related to CASM activities. Poverty remains a key feature of mining cooperatives with many workers earning less than USD 1 per day. Welfare and labour conditions are poor, and there is a high occupational safety risk associated with mining activities. Mining activities generally lack appropriate equipment and are often undertaken in a haphazard manner, which can result in mine shaft failures and loss of life.²⁰

Because of poor governance controls and the limited skills and resources of miners, the management of environmental impacts is virtually non-existent. Washing of tailings with natural water in the landscape contributes to erosion and water pollution problems. The knowledge and ability to employ best practice techniques are extremely low amongst miners, which in turn result in low levels of productivity and efficiency.

13.6 Governance

As noted earlier, the government is strongly pushing for industrial growth and has established a legal framework and commercial strategy favouring private investment. Implementation of this policy has resulted in the privatisation of public enterprises and the creation of new agencies, such as the Rwanda Development Board (RDB), Public Utility Regulation Agency and the Rwandan Bureau of Standards, to facilitate private investment.

There is increased recognition by government of the need to integrate environmental considerations in regulating industry and mining. Given that environmental management is a relatively new concept in Rwanda, however, environmental governance of the industrial sector as a whole is still weak. Under the Environment Law, the development of environmental impact assessment (EIA) regulations and standards to control pollution from both industry and mining is currently under way (see Chapter 14).

Industry

To guide future industry development, the government has an ambitious plan that would regionalise industry through the construction of designated industrial parks. This would shift industry's current focus away from Kigali towards

the development of other regional centres and create more employment opportunities in other areas.

Within the Rwanda Industrial Master Plan (RIMP), it is recognised that without promoting environmentally sustainable production, several target growth areas will have difficulty gaining market access in some countries. Currently, environmental management and pollution controls in the industrial sector are below standards considered suitable in most countries. For instance, there are no consistent or appropriate methods of wastewater treatment within industry, which amplifies the risk of an acute pollution event occurring as industries increase productivity and output in a growth-oriented economy. Also, there are no standards in Rwanda for determining soil contamination, making it difficult to assess the extent of chemical pollution.

Mining

To date there has been no environmental regulation of the mining sector, including both large-scale and artisan mining operations. Mining and quarrying are currently governed under the Law of 27/04/1971, which has been modified based on the Mining Code and Decree and Law No. 34/76 of 1976. These laws will soon be replaced by a new mining law currently being drafted, which will integrate EIAs and is supposed to streamline mineral exploration and production processes.



Under Vision 2020 industrial output is planned to increase several fold



The new mining law should strengthen environmental governance of the sector, which has previously been lacking

The agency responsible for mining is OGMR, operating under the auspices of the Ministry of Natural Resources (MINIRENA). Its responsibilities include: (i) coordinating research and surveying of mineral resources; (ii) developing standards and monitoring large-scale commercial and artisanal miners, including the promotion of best technologies; and (iii) regulating mining activities.

CASM is presently promoted under the Co-operative for the Promotion of Artisanal Mining Industries (COPIMAR).²¹ The new mining law being drafted does not clearly recognise CASM, but it does specify “commercial small-scale mining”, which can be undertaken with the provision of a mining license. Certain conditions need to be met, however, which require financial and technical capacity in order for licenses to be issued. It is uncertain whether community mining cooperatives, which possess limited technical skills and resources, would qualify for mining licenses.

13.7 Overview of key issues

Because the industrial sector as a whole is relatively small and underdeveloped, environmental damage from industry and mining has so far been limited. However, with the new thrust towards industrial development, the potential for increased pollution is considerable, if left unchecked.

Environmental issues are discussed separately for industry and mining. Those relating to industry include:

- release of industrial wastewater;
- relocation of industry from the Gikondo wetland area; and
- limited monitoring and regulation of industry.

Environmental issues related to mining are:

- threat to wetlands, land resources, forest ecosystems and biodiversity;
- Interlinkages with poverty and socio-economic issues; and
- limited monitoring and regulation of mining operations.

13.8 Environmental issues specific to industry

Release of industrial wastewater

Ongoing, chronic pollution from a range of industries is occurring, especially within the Gikondo Valley, though not yet at excessive levels. Several industries in the Gikondo area continue to release waste (i.e. oils and chemicals) and wastewater directly into drainage systems that eventually drain into the Nyabugogo River. Other large-scale industries in Kigali, but not in the Gikondo area, also add to the general pollution load flowing into the Nyabugogo River. Industrial sources of pollution include, amongst others, food processing and beverage industries, tannery works, paint manufacturers, printing houses, foam manufacturers and metal processing plants (Box 13.1).

Elevated levels of biological and chemical contamination of water and soils near surface drainage were found especially within the Gikondo Valley. The UNEP assessment, however, did not find significant levels of heavy metal contamination of surface water and soils. Nonetheless, UNEP findings represent a 'snapshot', which does not rule out the potential for significant water pollution. A more rigorous monitoring programme is required to determine chemical concentrations over a period of time. Further discussion on assessment results is presented in Case study 13.1, page 282 and 283. Contamination of drinking water sources is addressed in Chapter 12.



Industrial wastewater is drained from holding tanks and its untreated contents disposed of at the Nyanza dumpsite



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There is a need to control effluent discharge from coffee washing stations, which are expected to more than double in number

Box 13.1 Wastewater from coffee washing stations

Coffee washing stations around the country potentially pose a major source of industrial wastewater pollution. A United States Agency for International Development (USAID)-commissioned study (2008) found that coffee washing or depulping stations often operate without adhering to recognised standards and best practices for effluent discharge. Containing high levels of carbohydrates and organic matter, the wastewater is released untreated directly into streams. The wastewater reduces available oxygen in receiving waters due to the high biological oxygen demand (BOD) and chemical oxygen demand (COD) loads, affecting downstream water quality including those used for drinking purposes. The effluent discharge can have a significant impact on freshwater ecosystems and aquatic life and may stimulate growth in harmful micro-organisms or pathogens due to its anaerobic characteristics.

The government aims to double the number of coffee washing stations to more than 250. To prevent potential negative impacts on streams and wetlands throughout the country, pollution standards for coffee wastewater effluent need to be developed, monitored and enforced.²²



Brewery effluent released into Lake Kivu

Current efforts by MINICOM, supported by REMA, to promote cleaner production are a step in the right direction. Improved business practices were consequently apparent in several locations based mostly in Kigali.²³ Several industry managers cited improvements in chemicals storage and management as well as solid waste disposal controls.

In most industries, however, poor management of liquid waste and run-off from drainage remains a problem. Industry managers cited plans to construct or install new wastewater management facilities but none had been carried out at the time of fieldwork.

Relocation of industry from the Gikondo wetland area

Gikondo is presently the major source of industrial pollution in the country. Government strategy to develop designated industrial parks in other urban centres and relocate industry outside of Gikondo would effectively address this growing pollution problem. However, this move is expensive and progress has been slow due to a range of issues that remain unresolved. A related debate is whether wetland rehabilitation of

Gikondo is viable from an economic and environmental perspective.

Presently, there is little motivation by industry to invest in wastewater management. High costs and the uncertainty of relocation are disincentives for industry to improve wastewater disposal practices. Therefore, a firm and quick resolution of this pending relocation issue should be taken in order to send clear signals to industry to improve business operations.

Limited monitoring and regulation of industry

Over the long term, there is a need to develop regulations and standards to govern the management of pollution from industry, including implementation of EIAs of future as well as existing industries. At present, there is limited monitoring of wastewater discharged into the environment. Weak controls on wastewater treatment and disposal increase the risk of acute pollution events, especially as industry increases productivity in a growth-oriented, post-conflict economy. To properly assess the magnitude of the pollution problem, more detailed and continuous monitoring is required, focusing on key heavy metals, hydrocarbons and some industrial chemicals.

In addition, sustained monitoring is needed to check the potential increase in greenhouse gas emissions, primarily from cement, lime and tin production, which release carbon dioxide (CO₂). For instance, annual cement production increased from 10,000 tonnes in 1994 to 100,786 tonnes in 2002.²⁴ However, CO₂ emissions from industry still constitute a very small percentage (1% as of 2002) out of total CO₂ emissions, in contrast with the energy sector (92%).²⁵

13.9 Environmental issues specific to mining

Environmental impacts of mining have so far been localised but can be severe. The UNEP visits to various mines and quarries showed significant environmental impacts that were left unmanaged (Box 13.2).

It was not possible to undertake a comprehensive assessment of the environmental impacts of mining. However, significant research exists that substantiates UNEP findings. For instance, a study undertaken in the Gatumba Mining District in the southwest of Rwanda examined the quality of soils and chemical trace elements in an open-cast mining area.²⁶ The study

Box 13.2 Environmental impacts of mines and quarries observed during the field visits.

- destruction of natural habitat and biodiversity at mine sites;
- degradation of adjacent habitats through emissions and discharges;
- damage to neighbouring agricultural and protected lands;
- siltation of wetlands and riparian areas from the release of processing slimes;
- adverse changes in river regime and ecology due to pollution, siltation, sedimentation and flow modification;
- land degradation due to inadequate rehabilitation after closure and the abandonment of mine works;
- land instability and ground subsidence;
- poor drainage from mine sites, including processed water discharge and mine tailings;
- direct dumping of mine/community solid waste; and
- sediment run-off from mine sites.



There is a need to develop regulations to improve occupational safety and pollution control in industry

identified elevated toxic elements, most notably arsenic and cadmium, in fluvial soils on the lower slopes of mining areas. While this work did not identify significant pollution of drinking water, it pointed out the potential for chemical build-up in soils on the lower slopes that can be released into water sources.

Threat to wetlands, land resources, forest ecosystems and biodiversity

Wetlands are under examination as a potential resource for peat mining. Harvesting peat from these fragile ecosystems to meet fuel needs may lead to considerable environmental damage. Wetlands fulfil a number of important functions, including absorbing water from surface run-off and natural water filtration. Once the surrounding land is modified and the wetland area reduced, their ability to perform these regulatory services is markedly diminished.

The amount of land area required to harvest peat is substantial; it has been estimated that 40,000

ha would be required to fuel a single gasification plant.²⁷ Peat mining would also require drainage, followed by vegetation removal, drying of surface soil and extraction of peat by mechanical means. While the potential for peat mining does exist in Rwanda, the associated environmental impacts should be considered including:

- changes to wetland and groundwater hydrology;
- impacts on biodiversity from vegetation and habitat loss;
- land subsidence from peat removal and therefore possible risks of flooding and waterlogging of adjacent lands;
- release of toxic metals and organic pollutants from the peat;
- eutrophication of surface waters, which promotes excessive plant growth (i.e. algae) and reduces DO content in waters; and
- increase of suspended solids in water bodies.



Soil erosion from mining activities leads to increased turbidity and trace elements in water resources



Clay soils extracted from wetland areas for brick manufacturing

Interlinkages with poverty and socio-economic issues

Environmental degradation in mining is closely interlinked with poverty in local communities. Most CASM miners are seeking an alternative to dwindling livelihood opportunities. Because of low levels of technical skills and resources, CASM mining practices remain substandard. They do not take occupational safety or labour conditions into consideration, nor do they mitigate against negative environmental impacts. Mine tailings are often washed out directly into the environment, leading to erosion and pollution problems. In particular UNEP observed that women and children, who are involved in mining, are the most vulnerable group as they are exposed to abuse and high occupational safety risks.

There is a need to develop creative mining policies to address the interlinkages between the social, economic and environmental aspects of mining, especially at the local level. This would include

a clear regulatory framework that encourages community livelihoods development in the context of national ownership of mineral resources. Assisting community mining cooperatives to develop sound environmental management practices is critical. Finally, there is a need to further understand the role of women and children in mining and the protection measures necessary to reduce their vulnerability.

Limited monitoring and regulation of mining operations

As with industry, there is a need to establish regulations and standards to govern the management of pollution from mining. The draft mining law requiring EIAs for future operations is an encouraging step. At the same time, this EIA obligation needs to be applied to existing mines. Undertaking strategic environmental assessments (SEAs) is also essential to inform policy options for developing alternative energy sources, such as in the case of peat mining.



There is a need to develop innovative responses to deal with the social and environmental aspects of community and small-scale mining

While it is relatively feasible to bring environmental controls on investment into LSM, it is less practicable to do the same with CASM. It is unknown how many cooperatives and artisan miners are informally undertaking mining activities in Rwanda. The new mining law needs to formally recognise CASM and address their technical and resource limitations in qualifying for mining licenses. If regulatory criteria cannot be met, it is possible that CASM activities

will increase in an informal manner, resulting in continued poor environmental management and limited revenues.

There is a need to strengthen the regulatory framework to manage cross border trade in mineral resources. To be effective, this requires a coordinated response involving the relevant authorities of the concerned countries.²⁸

13.10 Conclusions

Government is planning substantial expansion in the industrial and mining sectors. The push for industrial and mining development, however, will create new pressures on environmental resources and result in growing sources of pollution. The potential threat this poses to water quality and human health is significant. Planned growth in both sectors will, therefore, require a commensurate increase in the level of environmental management. Urgent mitigation measures are needed to address potential threats, including disaster preparedness for serious industrial and mining accidents.

The focus now should be on strengthening environmental governance, in both the industrial and mining sectors, by developing clear regulations and standards and building enforcement and compliance capacities. The new mining law and government efforts to promote cleaner

production are clearly positive steps, but require further legal and technical support. In particular, EIA procedures should become an integral part of regulating industry and mining, while implementing SEAs would help inform policy and decision making processes.

13.11 Recommendations

The following list of prioritised recommendations distinguishes between the industrial and mining sectors.

Industry

R13a.1 Undertake an extensive review of industrial facilities located in the Gikondo area with the aim of providing technical guidelines and mobilising financial support for future relocation. In consultation with stakeholders from industry, this review should develop an inventory of potential contamination sites in



Community quarry site used by the brewery in Rubavu for waste disposal

Gikondo and determine possible incentives for industry to improve pollution management and participate in relocation. All businesses should be surveyed and all industrial sites visited in the Gikondo area. Review findings would then be used as a basis for outlining an environmental governance policy for industry and mobilising funds to facilitate relocation.

Lead agencies: MINICOM, REMA, KCC. International Partners: UNIDO, UN-HABITAT, UNDP, UNEP. Cost estimate: USD 0.5 million. Duration: 2-4 months.

R13a.2 Undertake environmental rehabilitation of the Gikondo wetland area. Following the abovementioned relocation of industries, the next step should be to mobilize funds to undertake environmental rehabilitation of the Gikondo industrial area.

Lead agencies: REMA, KCC, MINICOM. International Partners: UNIDO, UNEP, World Bank. Cost estimate: USD 10 million. Duration: 3-5 years

R13a.3 Develop planning codes for proposed industrial parks. Implementation of RIMP would result in developing designated industrial areas near urban centres of Rwanda. It would be necessary to carefully review the proposed locations of these industrial parks, which could be achieved by developing environmental planning codes for industrial zones, in conjunction with land use planning systems currently being undertaken.

Lead agencies: REMA, MININFRA, MINICOM, NLC. International Partner: UNIDO. Costs estimate: USD 0.1 million. Duration: 1 year.

R13a.4 Undertake EIA on proposed industrial land use zones. Application of EIA prior to the development of industrial zones would provide for sound planning controls on the types of industries that intend to locate in each industrial zone.

Lead agencies: REMA, MININFRA, MINICOM, local authorities. Cost estimate: USD 0.25 million. Duration: 2 years.

R13a.5 Establish common facilities in industrial parks to promote cleaner production and resource efficiency. Creating common or shared industrial facilities would assist in improving

controls on industrial development. Shared facilities also reduce investment costs, which are an economic incentive for industry participation in pollution control. Such facilities would include a common wastewater effluent treatment, solid waste management (SWM) facilities and electricity generation plants.

Lead agencies: REMA, MININFRA, MINICOM, local authorities. International Partner: UNIDO. Cost estimate: USD 3 million. Duration: 3 years.

R13a.6 Strengthen and build the capacity of the National Cleaner Production Centre (NCPC). This centre would actively promote cleaner production and provide support services to industry. This should build on UNIDO support for the establishment of sector-specific Resource Efficiency and Cleaner Production (RECP) centres. Key sectors requiring technical advice include construction and mining.

Lead agencies: MINICOM, REMA. International Partners: UNIDO, UNEP, UNDP. Cost estimate: USD 1 million. Duration: 3-5 years.

R13a.7 Develop regulations and standards for industry under the Environment Law. Environmental standards for industry would include: (i) effluent emission standards; (ii) ambient water and air quality standards; and (iii) standards for pollution control and management. A particular focus should be given to the management and protection of water resources.

Lead agencies: REMA, MINIRENA. International Partner: UNEP. Cost estimate: USD 0.1 million. Duration: 1-3 years.

R13a.8 Develop environmental management guidelines and regulations that minimise the adverse impacts of small- and medium-scale business. This is primarily aimed at addressing the high incidence of oil and fuel spillage from petrol stations and garages in Gikondo. Better control is required to minimise off-site drainage by introducing double-skinned underground storage tanks, safe disposal or recycling of waste oils, amongst others.

Lead agencies: REMA, MINIRENA. International Partner: UNEP. Cost estimate: USD 0.05 million. Duration: 1 year.



It is recommended that EIAs be applied to planned mining operations and EMPs developed for existing operations

Mining

R13b.1 Develop environmental guidelines and appropriate technologies to improve management of mining and quarrying activities.

This would involve establishing mining codes and integrating suitable technologies to improve the environmental performance of mining and quarrying operators, especially in the areas of wastewater management, rehabilitation of quarries, clay mining of wetland areas, amongst others.

Lead agencies: REMA, MINIRENA, OGMR.
International Partner: UNEP. Cost estimate: USD 0.25 million. Duration: 1-1.5 years.

R13b.2 Assess the major social and environmental impacts associated with CASM. The purpose is to gain a better understanding of the social, economic and environmental issues that are interlinked with CASM activities. It would include a review and mapping of all registered CASM cooperatives and their current activities. The findings would provide a basis for developing innovative strategies

to address poverty issues and improve CASM practices. Targeted support projects would be developed for registered or legal community mining cooperatives.

Lead agencies: OGMR, REMA, MINIRENA.
International Partners: UNDP, World Bank. Cost estimate: USD 0.5 million. Duration: 1-1.5 years.

R13b.3 Subject all LSM activities – current and future – to EIA in accordance with the Environment Law and the draft mining law once approved. There are few large mining companies that have been operating for many years in Rwanda, but an EIA of these operations has never been conducted. The new mining law makes EIA a requirement for the licensing and approval of new mining applications. It is recommended that environmental management plans (EMPs) should be applied to all existing LSM operations.

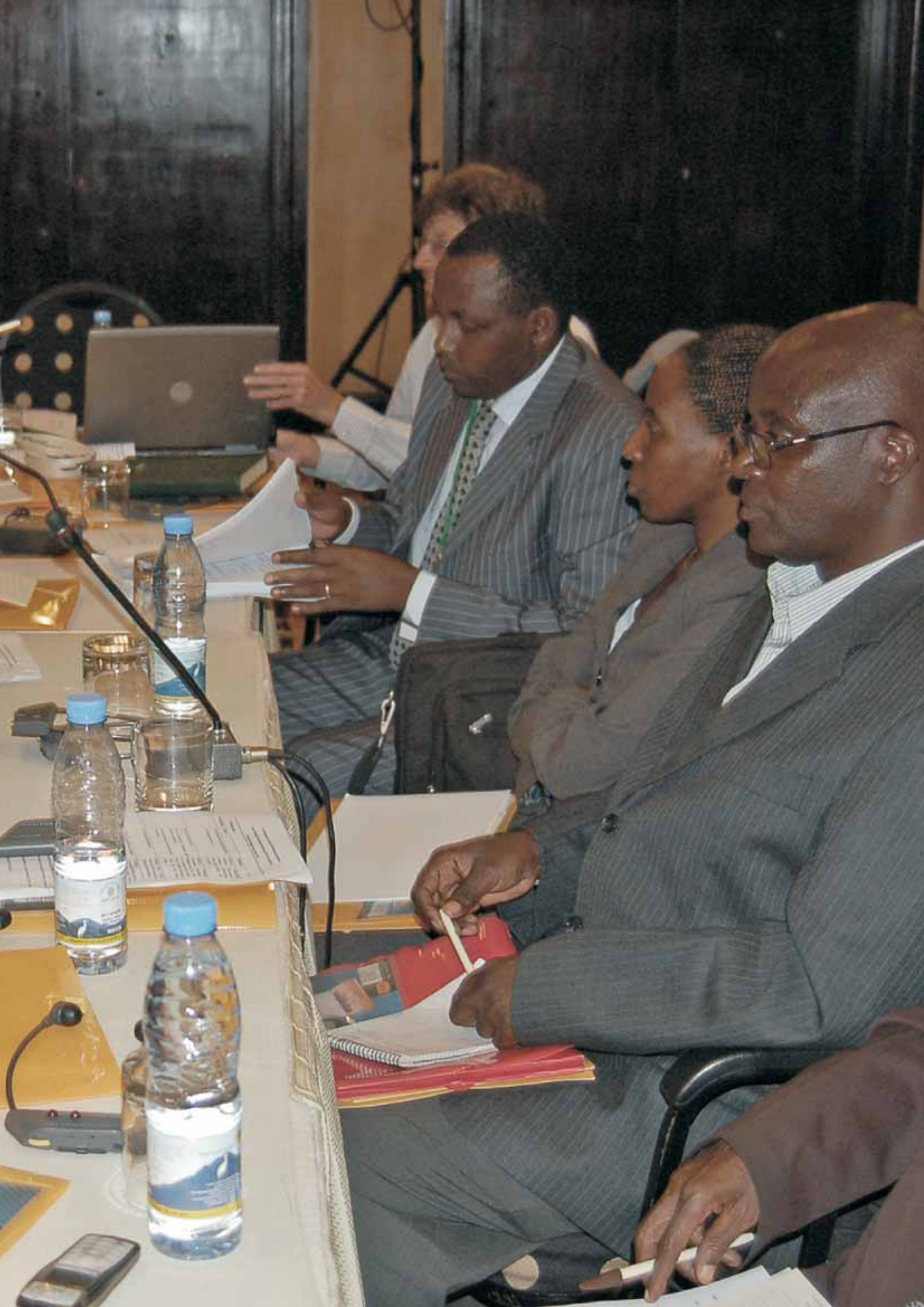
Lead agencies: REMA, OGMR, MINIRENA.
International Partners: World Bank, UNDP, UNEP.
Cost estimate: USD 0.25 million. Duration: 2 years.

IV. Policy and institutional responses

Environmental Governance

*Wide stakeholder engagement during
the PCEA consultation workshops
permitted a critical examination of the
report's findings and recommendations*

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Environmental Governance

14.1 Introduction

Environmental governance in Rwanda has emerged stronger in the reconstruction and development phase of post-conflict Rwanda. Solid policies and legislation, along with relatively robust institutions have been rapidly established to restore, conserve and sustainably manage environment and natural resources.

This re-emergence has been made possible by two key factors. First, there is a sense of urgency and importance attached to restoring and sustainably managing the environment, owing to hard lessons from environmental calamities that the population and government have witnessed in the post-conflict period, including severe and destructive floods and landslides, extensive droughts associated with scarcity of water and food insecurity, and a decline in economic productivity. These events have elicited a strong response from government and development partners, and the active participation of the population. Second, there is strong government commitment to environmentally sustainable development in Rwanda despite the challenges. This is evidenced by the number of key policy and legal instruments that have established the basis for creating an effective environmental governance framework. These instruments include the National Environmental Policy and the Organic Law on Environment, which raised the profile of the environment in national development discourse. In addition, decentralisation has widened the scope of environmental governance, allowing the possibility for improved environmental decision making and management at local levels.

This chapter describes the historical context and highlights important milestones of environmental governance in Rwanda after the conflict. It elaborates on the key challenges that underlie social and investment constraints, as well as legislative and institutional gaps. Finally, the chapter underscores the importance of reinforcing regional environmental cooperation for national development, through improved governance of shared ecosystems.

14.2 Assessment activities

Consultations were undertaken with the following government institutions: Rwanda Environment Management Authority (REMA); Ministry of Natural Resources (MINIRENA); Ministry of Finance and Economic Planning (MINECOFIN); Rwanda Office of Tourism and National Parks (ORTPN); Ministry of Local Government, Community Development and Social Affairs (MINALOC), as well as district environment officer in Nyarugenge District in Kigali City.

Other stakeholders consulted included: United Nations Development Programme (UNDP), Mutara Fishing Society, Wildlife Conservation Society (WCS), Centre for Geographic Information Systems and Remote Sensing at the National University of Rwanda (CGIS/NUR) and the National Land Centre (NLC).

14.3 Overview of environmental governance

Environmental governance in Rwanda evolved during the colonial period, when nature reserves were gazetted and extensive afforestation took place across the country. However, the environment was not a top priority, and environmental governance during this period was generally characterised by 'resource mining' rather than 'resource management'. As a result, natural resource extraction was the dominant development strategy.

Although political violence began as early as the 1950s, it was the 1990-1994 conflict and genocide that debilitated environmental governance in Rwanda. These tragic events not only destroyed the formal institutions, but also broke up the informal structures and traditional systems that Rwandans had used to care for their environment in their search for livelihoods. This had major implications for the country's natural resources, resulting in widespread environmental degradation in the post-conflict period.

Since 1998, however, Rwanda has made great strides in terms of establishing an effective environmental governance framework. Strong and high-level political commitment to pursuing sustainable development exists, which provides a unique opportunity for strengthening environmental governance in the country.

Environmental governance vacuum in the initial post-conflict period

Severe state failure following the 1994 genocide resulted in the collapse of natural resource administration. During the post-conflict emergency phase (1994-1998), environmental concerns were largely overlooked as the country struggled to recover from the war and genocide. Environmental action plans, such as the National Strategy and Action Plan for the Environment and the Strategy and Action Plan for Biodiversity were drafted during this period but, not implemented. At the time, although some environmental structures at the central level existed, they were hardly functional as no financial resources were allocated and human resources were insufficient to implement environmental management activities. Priority was placed on addressing the urgent problem of resettling the massive numbers of returnees and internally displaced persons (IDPs), restoring security throughout the territory, installing basic public administration systems, and resuscitating the economy.

As a result, substantial environmental degradation ensued, including major losses of protected areas, forests and wetlands as well as the rapid growth of slums in urban areas. Environmental impacts of the post-conflict period are discussed in the previous chapters.

Creation of an effective environmental governance framework

Alarmed by the growing environmental crisis that emerged in the immediate post-conflict phase, the government established a new legal and institutional framework for environmental management during the post-conflict recovery period (1998-2005). This framework paved the way for raising national consciousness of the environment and reinforced political commitment towards environmentally sustainable national development.

The National Environment Policy

The National Environment Policy of 2003 was the first landmark instrument, establishing the framework for the sustainable management of natural resources in Rwanda. This policy outlines strategic directions with regard to land use management, the management and utilisation of natural resources, as well as the integration of environmental considerations in social and economic development at all levels (national, provincial and other local levels). In addition, it promotes wider participation in environmental management especially at the local level, including individuals (such as women and young people) and communities.



Issuance of land titles by the NLC; ongoing land tenure reform will have important implications on land use management

Moreover, the National Environment Policy stipulates the necessary institutional and judicial arrangements to enable policy implementation, including: (i) the National Environment Council, a political decision making body; (ii) REMA; (iii) the Rwanda National Environment Fund (FONERWA); (iv) the Environmental Tribunal, an instrument for conflict resolution; and (v) local environment committees.

Other policies relevant to environmental management adopted during this period include: National Land Policy (2004); National Forest Policy (2004); National Water and Sanitation Policy (2004); and National Energy Policy (2004).

The Organic Law N° 04/2005 of 8 April 2005 determining the modalities of Protection, Conservation and Promotion of Environment in Rwanda

Another landmark instrument was the Organic Law (Environment Law) enacted in 2005. It outlines the fundamental principles related to the protection, conservation and sustainable management of the environment. It also guarantees equal rights to resources by present and future generations as well as their environmental obligations. One important aspect of the Organic Law is that it entrusts the state with the responsibility to protect, conserve and promote the environment.¹

Creation of REMA

The National Environment Policy and the Organic Law N° 16/2006 led to the creation of REMA in 2006, which raised the importance of environmental management in Rwanda. REMA is currently under the auspices of MINIRENA,² and is recognised as the key authority in environmental monitoring, regulation and enforcement.³ The main responsibilities of REMA are to:

- implement government environmental policy;
- advise government on policies, strategies and legislation related to the management of the environment as well as the implementation of environment related international conventions;
- provide a comprehensive assessment of the environment and the state of natural resources in Rwanda, to be published once every two years;

- examine and approve EIA reports undertaken at all levels;
- undertake research and other relevant activities related to the environment and disseminate findings;
- ensure adequate monitoring and evaluation of existing and future development programmes that are likely to have significant environmental impacts;
- participate in the preparation of strategies and action plans related to disaster risk reduction and prevention;
- provide advice and technical support to entities engaged in natural resource management and environmental conservation; and
- prepare and disseminate guidelines relating to principles and laws governing environmental management.

Other important environmental milestones

The integration of environmental considerations in the broader development framework under the Economic Development and Poverty Reduction Strategy (EDPRS) (2008-2012) is also an important milestone, as it paves the way for prioritising the financing of environmental interventions.

Various environment-related legislative and regulatory instruments have also been formulated since 2003, with a view to reducing environmental degradation, including: (i) a ministerial order regulating cutting of trees before their maturity; (ii) a ban on fuelwood use in brick and tile production; (iii) requiring authorisation for cutting and transporting mature trees; (iv) site selection and construction requirements for coffee-washing stations; and (v) a law banning the importation, manufacture and use of polythene bags and other plastic materials. Overall, these regulations are strictly enforced in Rwanda.

A significant development is the formulation of a five-year Environment and Natural Resources Sector Strategic Plan (ENRSSP) launched in April 2009. This document articulates the main priorities for the environment and natural resources sector and the strategies to be undertaken over the period 2009-2013, which will be implemented



MINIRENA and REMA are the two institutions responsible for environmental and natural resources management

under the EDPRS. Important next steps will be to support its operationalisation and transform the strategic plan into annual work plans based on prioritised projects and activities, which should also help harmonise donor support with national priorities.

To facilitate the implementation of the ENRSP, MINIRENA is leading the development of a Sector Working Group (SWG) for the environment and natural resources sector, with support from UNDP and UNEP. The SWG will bring together multiple stakeholders, including government ministries, international development partners as well as civil society. A first meeting was held in May 2009 with the objective of establishing a sector-wide approach (SWAp) in order to help prioritise environmental issues, strengthen sector coordination and mobilise and streamline financial support.

Decentralisation and environmental governance

The GoR has adopted a policy of decentralisation as a mechanism to promote good governance and

poverty reduction by empowering communities to participate in the design and implementation of the development process. The Decentralisation Law restructured and established additional local levels of government. Below the provincial level are districts, which are made up of sectors and which in turn are made up of cells. This law aims to strengthen district governments and decentralises environmental management responsibilities. For the first time, decentralisation has enabled the recruitment of environment officers and the establishment of environment committees at the sub-national level.

The decentralisation process has improved planning and coordination of environmental activities, especially at the district and lower levels. All 30 districts now have at least one environment officer, who is currently placed under the infrastructure sector at the district level and has been provided with some budget allocation from the central government.

Decentralisation reforms provide positive leverage for widening environmental governance

to include key stakeholders, especially those at the community level, in environmental decision making and management. Environment committees, which have already been created in some districts, are an important governance structure to facilitate stakeholder participation in natural resource management.

14.4 Overview of key issues in environmental governance

The key issues elaborated in this chapter are presented with an understanding that environmental governance in Rwanda is still undergoing major changes, and that environmental governance structures are still emerging. Also, government may already be addressing some of the issues discussed here. Therefore, the purpose of this section is to highlight the key challenges of environmental governance and ways for moving forward.

Key issues discussed in this section are:

- strengthening coordination in environmental management;
- building technical capacity and mobilising national financial resources;
- raising greater environmental awareness and improving access to information; and
- reinforcing regional and international environmental cooperation.

Strengthening coordination in environmental management

Pursuing an integrated environmental vision

There is strong and high-level government support for environmentally sustainable development in Rwanda, which has been significantly reinforced by REMA's creation. REMA's coordination efforts heavily rely on projects supported from multiple funding sources.⁴

REMA faces a major challenge to effectively coordinate the small, and short-term projects under its watch, and to carry out its mandate as the key government authority in charge of environmental management, for instance in implementing environmental policy or developing coherent strategies.

The environment and natural resources sector as a whole requires strengthening to consolidate and harmonise national environmental priorities and help guide donor funding support. An important opportunity has been created through the ENRSSP, which provides a roadmap based on a common environmental vision. This national strategic plan for the environment and natural resources sector will work towards clearly articulated goals and will establish priorities for action by different government institutions with a mandate to protect and manage natural resources. In order to ensure effective planning and prioritisation in the sector, an effective SWG mechanism is essential. This institutional mechanism will especially be critical for prioritising the implementation of the recommendations of this assessment and mobilising financial resources. Supporting the development and adoption of the SWAp framework should be a priority for the United Nations (UN) and all development partners, especially with respect to donor programming.

Addressing legal and institutional challenges

While considerable work is under way to streamline environmental policies and legislation, there is ambiguity in several key areas. There is a need to raise awareness and sensitize the population and stakeholders on institutional mandates and responsibilities with regard to wildlife management issues outside of protected areas. One example is the ambiguity over the management of hippopotamus populations outside of protected areas, which are assumed in some quarters to be REMA's responsibility because there are no clear provisions in existing policies and laws. The main issues regarding the hippopotamus populations found in aquatic systems outside of protected areas are discussed in Chapter 10.

Multiple terms are used to describe wetlands, which are also known as swamps or marshes, depending on their intended use, i.e. whether for land conversion or conservation. Given the strategic importance of wetlands to national development and human well-being in general, there is a need to establish a national policy on sustainable wetland management and determine institutional mandates and responsibilities. REMA completed an inventory of wetlands of critical importance in 2008. On the basis of

this information, draft management plans for specific wetlands and ministerial regulations for use and management of wetlands have been prepared. These plans will designate wetland areas for agricultural use and conservation. At a broader level, a national land use master plan is under preparation by the NLC, to guide land use planning in the country.

Cross-sectoral collaboration and coordination

It is important to emphasise that the sustainable management of Rwanda's environment will require an institutional arrangement that recognises and promotes cross-sectoral coordination in planning and implementation of all activities that have a bearing on the environment.

Building technical capacity and mobilising national financial resources

Capacity-building at national and sub-national levels

Strategic environmental assessments (SEAs) are supposed to be applied to policies or programmes, while environmental impact assessments (EIAs) should be carried out to assess projects or plans, including private sector investments. These assessments should then determine whether to implement new policies, programmes and projects and proceed with the proposed development activities.

In early 2009, the Environmental Impact Assessment function of REMA was transferred to the Rwanda



The mandate of the newly established RDB includes environmental functions such as reviewing and approving EIAs

Development Board (RDB), which was created by bringing the various inter-related services for business development under one roof to facilitate the development process. The RDB will now review and approve EIAs. While this is a novel approach that could help integrate environment and economic development, given the RDB's mandate to 'fast-track development' and promote foreign investment, there is a potential for a conflict of interest to develop in the administration of the EIA process. It will, therefore, be important to strengthen measures for the new institutional arrangement to ensure its technical rigour and effectiveness.

At the sub-national level, particularly in districts, considerable investment in capacity-building is needed to make environment officers and environment committees fully functional. During the UNEP assessment, district environment officers expressed the need for stronger support from central government institutions in order to be more effective. In addition, there are concerns that the placement of the Environment Office under the infrastructure sector at the district level could downgrade environmental issues and, therefore, might warrant further review. With regard to environment committees, at present they are barely functional nor have they fully understood their roles and responsibilities.

Mobilising national financial resources

An important component of building institutional capacities in environmental management is developing secure and sustainable sources of financing. In the post-conflict period, financing of environmental management has almost entirely relied on external or donor resources, with minimal though increasing national budgetary support. While donor support is critical, it is often guided by the international environmental agenda and does not necessarily reflect national priority issues. Mobilising internal sources of financing will be critical in consolidating environmental governance in the country.

In a bid to establish mechanisms for reliable and sustainable financing for environmental management, the Organic Law on Environment provides for the establishment of a National Environment Fund (FONERWA). This Fund, however, is not yet operational and needs to be activated. Technical support will be needed in designing investment options and sustainable resource mobilisation strategies for FONERWA,

as well as institutional arrangements for managing the fund. Another approach to secure predictable and sustainable sources of financing has been to integrate environmental considerations in the EDPRS, which is supported by the UNDP-UNEP Poverty Environment Initiative (PEI). It remains to be seen whether these initiatives will provide sustainable financing mechanisms.

Raising greater environmental awareness in the country and improving access to information

The serious extent of environmental degradation and the frequent natural hazard-induced disasters (e.g. drought, floods, landslides) that marked the post-conflict period have raised national consciousness about the importance of conserving the environment. However, general public awareness and understanding of environmental issues and their linkages with poverty and development need to be further enhanced, especially at local government level, where planning and implementation takes place, as well as at the community/farmer level.

Despite increased efforts, on the whole, environmental awareness tends to be event-based and associated with specific projects. For instance, the country actively celebrates key events, such as World Environment Week or Tree Planting Day, with vigorous mobilisation and media coverage during such occasions. Longer-term campaigns to follow up and address key environmental issues are lacking. However, plans to raise environmental awareness in schools and institutions at all levels, including mainstreaming into the formal education curricula, are already under way.

Establishing a national environmental education programme

There is a need to widen the scope of environmental education and awareness in Rwanda by developing a comprehensive national programme that will coordinate environmental education and deliver consistent messages. This programme could also draw on the special role of the media in educating society on public policy issues and in monitoring the implementation of policies, programmes and projects at all levels. Media practitioners need additional training in communicating messages that are consistent and effectively target intended audiences.

Promoting wider civil society participation in environmental governance

Participatory environmental management is a new approach in Rwanda. Civil society is still growing and would, therefore, require substantial support and capacity-building to effectively participate in environmental management. Civil society includes non-governmental organisations (NGOs), community-based organisations (CBOs), and faith-based organisations (FBOs).

NGOs, in particular, have a proven track record in many African countries as effective implementation partners, particularly at the local level. In Rwanda,

they were instrumental in delivering emergency humanitarian aid in the immediate post-conflict period, and have continued to play a significant role in post-conflict reconstruction and development including rural development, reconciliation and peacebuilding, and environmental rehabilitation and conservation. Both NGOs and CBOs can play an important role in environmental decision making and advocacy as well as in monitoring environmental policies, programmes and projects at different levels.

It is also important that government proactively engages the private sector in delivering



Enhancing civil society engagement can play an important part in solving environmental challenges

environmental solutions through public-private partnerships to promote financial sustainability, appropriate technology transfer, innovation and best business practices. For instance, as discussed in Chapter 11, there is great opportunity for private sector investment in developing alternative, renewable energy sources in rural areas, for instance, through solar power and biogas technology.

Management of environmental information

Current management of environmental information is a major challenge to sound environmental decision making in Rwanda. Environmental data accumulated over the years was destroyed during the genocide, and available environmental information is now scattered across ministries and agencies, and modalities to facilitate information access are not clearly established. In addition, information is often based on different or even conflicting parameters and standards, which makes data comparability difficult and data integration virtually impossible. Recent initiatives at REMA and other institutions also need to be systemically developed and coordinated to enhance relevance and coherence.

Improving the management of environmental information – both horizontally at the sector level and vertically across administrative units – would greatly facilitate informed decision making at different levels and across sectors. In this regard, there is a need for an environmental information system (EIS) that would enable environment-related data to be collected, collated, stored and accessed by a wide range of users.⁵ This system de-emphasises the importance of technology and the need for centralised data. Rather, it focuses on the value of interagency collaboration and coordination in the management of information, a role that REMA is well placed to fulfil.

A promising start was made to develop a knowledge coordination mechanism known as the Spatial Data Infrastructure in 2006. However, it has yet to be implemented, and technical and financial support are needed to reactivate this important knowledge management process. It should be emphasised that rapid developments in Rwanda's information and communication technology infrastructure can help improve access to environmental information.

Reinforcing regional and international environmental cooperation

Rwanda is actively participating in many international environmental conventions as well as regional initiatives, which appear to be proceeding well. There are multiple opportunities to undertake transboundary projects as well as technical cooperation with neighbouring countries, particularly on energy, water, forestry, wildlife and protected areas as well as climate change. Transboundary cooperation in the management of natural resources would not only significantly contribute to Rwanda's development, but also promote greater integration and stability in the Great Lakes/East Africa region.

The range of international conventions in which Rwanda participates and their status of implementation are summarised in Table 49.

With respect to regional cooperation, Rwanda is a member of the Nile Basin Initiative (NBI). Rwanda is implementing one of the NBI programmes, known as the Nile Equatorial Lakes Subsidiary Action Program (NELSAP), and two NBI-related transboundary projects, the Kagera River Basin Transboundary Integrated Water Resources and Development Project (TKTIWRDP) and the Rusumo Hydropower Project, both of which involve Rwanda and its neighbouring countries.

In addition, since 2006 the country has been a member of the East African Community (EAC) and signatory to its protocols, including the Lake Victoria Basin Commission (LVBC), which promotes coordinated development and management of transboundary ecosystems in the Lake Victoria Basin.

14.5 Conclusions

Despite major setbacks in the immediate post-conflict period, the future outlook for environmental governance in Rwanda looks positive. Rwanda is moving towards developing one of the most effective environmental governance regimes in Africa. Nonetheless, there remain considerable challenges to environmental governance in a country that is facing high population pressure, poverty and acute land scarcity, as well as significant human and institutional capacity gaps.

Table 49. List of international conventions, treaties and protocols in Rwanda and their status of implementation

Convention	Date signed / ratified** / entry into force***	Implementation progress
United Nations Convention on Biological Diversity ⁶	29 May 1996***	<ul style="list-style-type: none"> – First national report submitted in 1998 – Second national report submitted in 2005 – Third national report submitted in 2006
The Cartagena Protocol on Biosafety ⁷	20 October 2004***	<ul style="list-style-type: none"> – Draft National Biosafety Framework developed in 2005 – Draft GMO (Genetically Modified Organism) Regulatory Framework
United Nations Framework Convention on Climate Change (UNFCCC) ⁸	16 November 1998***	<ul style="list-style-type: none"> – First national communication report submitted in June 2005 – National Adaptation Programmes of Action (NAPA) submitted in 2006 – A second communication report in process
The Kyoto Protocol to the Framework Convention on Climate Change	15 February 2005***	
United Nations Convention to Combat Desertification (UNCCD) ⁹	20 January 1999***	<ul style="list-style-type: none"> – First national report submitted in 1999 – Second national report submitted in 2002 – Third national report submitted in 2004 – Subregional UNCCD Implementation Report submitted in 2004 – Subregional Action Programmes submitted in 2007
Vienna Convention for the Protection of the Ozone Layer Montreal Protocol on Substances that Deplete the Ozone Layer ¹⁰	11 October 2001** 11 October 2001**	<ul style="list-style-type: none"> – Implementation Plan ongoing since 2003 – A focal point established in REMA
Stockholm Convention on Persistent Organic Pollutants (POPs)	05 June 2002 (accession)	<ul style="list-style-type: none"> – National Implementation Plan of POPs submitted in 2007 – Developed a database on POPs
The Ramsar Convention on Wetlands of International Importance especially for Waterfowl Habitats ¹¹	01 April 2006***	<ul style="list-style-type: none"> – National Implementation Status report submitted in 2008
The Bonn Convention On Conservation of Migratory Species of Wild Animals ¹²	01 January 2005***	<ul style="list-style-type: none"> – Agreement on the conservation of Gorillas and their habitat signed in 2008; Action plan is under negotiation
Convention on the Prior Informed Consent (PIC) Procedure for certain hazardous chemicals and pesticides in international trade ¹³	7 January 2004**	<ul style="list-style-type: none"> – Designated National Authority (DNA) – Import Responses on Pesticides and Pesticide Formulations – Technical assistance activities – National focal point for the Strategic Approach to International Chemical Management (SAICM) – National Chemical Management Profile
Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) ¹⁴	18 January 1981***	<ul style="list-style-type: none"> – Annual Report on CITES submitted in 2008
BASEL Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal	7 January 2004 (accession)	<ul style="list-style-type: none"> – National Reports submitted in 2007 and 2008

Given Rwanda's present development context, the government and the rest of the country recognise that the long-term goal is to transform

Rwanda from an agrarian-based to an industrial, service-oriented and knowledge-based economy. Sustaining long-term economic growth, however,

will depend on the sustainable management of the country's natural resources and will, therefore, require robust environmental governance.

Translating the ENRSSP into a plan of action will be critical in pursuing a common environmental vision. Rwanda should also seize the opportunities of decentralisation by strengthening participatory governance mechanisms to improve environmental management, especially at local levels. Raising public environmental awareness will further enhance environmental decision making at the sub-national level.

Moreover, availability of adequate and reliable financing will be critical to the realisation of the country's sustainable environmental management vision. Finally, transboundary cooperation, especially within the Great Lakes region, will not only support future development in Rwanda but also enable efficient and sustainable management of shared ecosystems.

14.6 Recommendations

R14.1 Support the implementation of the ENRSSP. An environmental action plan to deliver the targets set by the ENRSSP should be developed based on prioritised activities over the short and medium term (1-5 years). This should be complemented by an investment programme for financing the implementation of the identified priorities. Leveraging of resources from other ongoing programmes should also be considered.

Lead agency: REMA. Cost estimate: USD 0.35 million. Duration: 1 year.

14.2 Ensure implementation of SEAs and EIAs. This would involve training of policymakers and technical staff in public institutions in the implementation of SEA and EIA. In addition, economic incentives would be introduced to enhance private sector compliance in undertaking SEAs and EIAs. A technical review should also be conducted to evaluate REMA and RDB's effectiveness in enforcing EIA requirements and propose recommendations for satisfactory implementation.

Lead agencies: RDB, REMA, MINEDUC, MINIRENA, MIFOTRA, private sector. Cost estimate: USD 0.25 million. Duration: 2 years.

14.3 Strengthen the decentralisation of environmental management in the country.

Training would be provided primarily to environment officers and environment committees, as well as councils at all local levels from district downwards. A core component of this training would be to improve understanding of their respective roles and responsibilities, and in the formulation and enforcement of local policy and legal instruments. In addition, REMA would be tasked and equipped to provide the necessary support needed at district and other local levels.

Lead agencies: REMA, MINALOC. International Partners: UNDP, UNEP. Cost estimate: USD 0.30 million. Duration: 3 years.

14.4 Establish a sustainable and predictable mechanism for financing environmental programmes and activities.

Activate FONERWA as stipulated under the law, including development of operational modalities. The Fund would provide the mechanism to mobilise and manage environmental investments generated from both external and internal resources. It is critical that capitalization funds for the FONERWA are mobilized.

Lead agencies: MINECOFIN, MINIRENA, REMA. IP: UNEP, Development partners. Cost estimate: USD Multi-million. Duration: Multi-year.

R14.5 Support the development of a Rwandan Environment Information Network (REIN).

REIN would function as a forum of information producers and users that would operate horizontally (at the national level) as well as vertically (from the national to the district level). The forum would undertake the following activities: assess availability of environmental information in the country, identify existing gaps, set data standards, assign responsibility for the provision of datasets, resolve issues related to ownership, establish modalities for sharing information, improve the use and dissemination of information as well as ensure coordination between relevant key actors. Lessons learnt from other African countries can be drawn upon to establish the network. As a starting point, the recommendations of the Spatial Data Infrastructure Workshop held in 2006 should be acted upon and taken forward.

Lead agencies: REMA, MININFOR, MINIPRESIREP, RDB/RITA. International Partner: UNEP. Cost estimate: USD 0.25 million. Duration: 2 years.

14.6 Develop and implement a comprehensive environmental education programme at the national level. This programme would seek to raise environmental awareness in the country and provide consistent environmental messages. Environmental education would be integrated as part of the school curriculum at primary and secondary levels as well as in community self-help activities and in monthly ‘*umuganda*’¹⁵ discussions. Environmental awareness initiatives would be implemented in collaboration with different stakeholders, including NGOs, CBOs, faith-based organisations, print media, radio and television networks.

Lead agencies: REMA, MINEDUC, MINIPRESIREP, MIGEPROF, MINICYOUTH. International Partner: UNEP. Cost estimate: USD 0.25 million. Duration: 3 years.

14.7 Reinforce coordination between institutions dealing with natural resources, protected areas and nature reserves and harmonise relevant policies and laws. This would work towards implementation of current policy and legal

frameworks. Better streamlining policies and laws would allow different agencies to take responsibility for integrating environmental components as part of their institutional mandate and mode of operation.

Lead agencies: MINIRENA, REMA, ORTPN, NLC. International Partner: UNEP. Cost estimate: USD 0.05 million. Duration: 6 months.

R14.8 Strengthen technical and organisational capacities of the recently established environmental NGO Forum. This initiative would enable civil society organisations to grow and contribute towards improving environmental management in Rwanda. NGOs would be supported as partners in developing and delivering innovative environmental interventions together with communities and other local stakeholders. The Forum would also build NGO capacities to undertake policy advocacy, environmental monitoring and promote greater public awareness about the environment. This should also include resuscitating and strengthening community institutions for sustainable natural resources management.

Lead agency: REMA. International Partner: UNEP, UNDP. Cost estimate: USD 0.25 million. Duration: 3 years.

V. Conclusions

Conclusions and Recommendations

*Conserving natural ecosystems and
rehabilitating degraded landscapes
is one of the key challenges facing
Rwanda as it pursues a development
path driven by rapid economic growth*

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Conclusions and Recommendations

15.1 Introduction

Rwanda is in many respects an exceptional post-conflict success story. It is now on a solid development track with the ambitious goal of catapulting within one generation from a low- to middle-income country by 2020. This ‘big push’ is in large part driven by the desire to make up for lost time and the arrested development of the conflict years and its aftermath.

While rapid economic growth is imperative to lift the majority of the population out of poverty and improve their quality of life in the long term, it is dependent on the continuous provision of goods and services by the country’s ecosystems. It is, therefore, crucial to seize the opportunities available for reducing serious environmental risks, which are likely to be magnified by potential climate change and accentuated disasters, and augment the sustainability of this accelerated development process. At the same time, equal priority should be accorded to implementing strategic environmental interventions aimed at averting the deepening of extreme poverty and strengthening social cohesion and peace.

15.2 Main findings

Following a review of the wide range of issues discussed in this report, key findings have been deduced that highlight the magnitude and complexity of the environmental challenges that need to be addressed. These closely intertwined challenges are discussed below:

- 1. The 1990-1994 conflict and genocide caused significant environmental impacts whose implications are felt to this day and which will extend many years into the future.** The main damage has been caused by massive population displacement and resettlement of returnees leading to potentially irreversible losses. These include considerable reductions in the surface area of national parks, forests and other vegetation cover as well as encroachment on wetlands.

The initial breakdown in natural resource governance and the loss of long-term environmental data sets, collapse of research and monitoring programmes as well as the shortfall in human expertise are enduring impacts of the conflict.

- 2. Rwanda’s extensively altered environment is under multiple, severe and mutually reinforcing pressures driven by “high population growth, declining resources and poverty”.** Major human-induced stressors are longstanding problems largely caused by natural resource overexploitation and include land degradation, deforestation and wetland and biodiversity loss. Environmental degradation and population expansion over and above projected growth rates can potentially suppress development gains and undercut progress towards the goals of Vision 2020. It is, therefore, important that environmental considerations are integrated into policies that aim to reduce population growth rates and promote off-farm rural income-generation sources. Furthermore, environmental conservation and rehabilitation can positively contribute to national reconciliation and peacebuilding initiatives.
- 3. An enabling environmental governance framework has been created at the institutional, policy and legal levels, which needs to be strengthened with sustained capacity-building and technical and financial assistance.** Environmentally sustainable development, including ecosystem rehabilitation, enjoys strong and high-level government support. Environmental considerations are well embedded in national development plans. The ongoing decentralisation process provides a unique opportunity to promote community-based environmental management at the local level, which until now has been weak. At the same time, environmental governance structures, including at the local level, need to be reinforced through the operationalisation of the Environment and Natural Resources Sector Strategic Plan (ENRSSP), resource mobilisation and capacity-building to ensure compliance and enforcement.

4. **Major environmental data and research gaps are seriously hampering environmental governance.** Environmental monitoring systems across key sectors are inadequate to support informed decision making, including the development of indicators to assess progress towards Vision 2020 and the Millennium Development Goals (MDGs). Most notable is the destruction of the hydrological and meteorological networks, absence of standard water quality and soil erosion monitoring programmes, lack of harmonised forestry inventories and inadequate research on several vital topics such as household use of wood and non-wood forest products, renewable energy sources and national-scale climate change assessments. Furthermore, where detailed data exists, they are often inaccessible due to the lack of a common information management structure.
5. **The poorest segment of society is disproportionately vulnerable to rapid social change and is at risk of crossing biophysical thresholds beyond which there is sudden and potentially irreversible environmental collapse.** While Rwanda has made substantial gains in improving human well-being and combating poverty, the benefits are not distributed equally. There is now a growing income gap between the top and bottom 20 percent of the population. The fast-track towards Vision 2020 risks creating profound social transformation and places new pressures on the country's environmental capital. The poorest and most vulnerable groups – including the 35.2 percent female-headed households, the 30 percent of farmers cultivating less than 0.2 ha of land, those living on marginal and environmentally sensitive parts of the landscape as well as child-headed households – are in danger of being locked out of this accelerated development process and further entrapped in the downward cycle of resource overexploitation, environmental degradation and poverty. Targeted pro-poor environmental interventions should be strengthened to raise their coping capacity and improve livelihoods.
6. **Poor soil conservation and cultivation practices are driving land degradation, including soil erosion and depletion of soil nutrients.** Frequent soil tillage, particularly on steep slopes, has led to very high erosion rates, validated by field measurements of sedimentation rates and preliminary results from Geographic Information System (GIS)-based soil erosion modelling. Overcultivation without an appropriate mix of organic and chemical inputs has depleted soil fertility and led to very low productivity levels. While planned agricultural intensification is necessary to raise yields, it will likely increase nutrient and pesticide pollution in freshwater, substantially increase water withdrawals for irrigation and reduce agricultural biodiversity. A comprehensive package based on 'conservation agriculture' including soil conservation measures as well as promotion of off-farm alternative livelihoods needs to be developed, with a special focus on assisting the poorest farmers, to alleviate pressure on land resources.
7. **Positive but qualified progress in forestry and protected area management.** Although reforestation efforts have raised forest cover to around 20 percent of Rwanda, most of this consists of exotic tree plantations. These are known to provide a more limited range of ecosystem services and biodiversity value compared to the 5.3 percent of the land under natural forest. A significant economic potential exists from the harvesting of mature plantations that are at risk of being damaged by natural hazards. At the same time, this asset offers a good opportunity for improving local community engagement in forest management. Similarly, while the formally designated national park area has more than doubled in the post-conflict period and specific successes have been achieved such as the conservation of the endangered gorilla, these trends mask the substantial downsizing of the overall protected area network and significant decline in wildlife populations. A more concerted effort is needed to improve the management of nature reserves and protected areas.
8. **Per capita freshwater availability is below the limit of water scarcity, and biologically contaminated water remains a leading cause of sickness and death.** A more than five-fold expansion in water use is projected by 2020, which could further reduce per capita water availability even further. It is important to emphasise, however, that growing water scarcity is not absolute and can be remedied with an appropriate combination of

governance, technological, ecosystem restoration and market-based responses. Furthermore, low-cost investments in safe drinking water and sanitation would significantly improve the health and economic productivity of the majority of Rwandans.

9. Wetlands are targeted for heavy exploitation, putting at risk key ecosystem services including their role as major sources for renewable freshwater supplies.

Around 60 percent of Rwanda's wetlands have already been converted for agriculture. A substantial proportion of the remaining wetlands is threatened with reclamation under the drive for agricultural intensification as well as peat mining. Furthermore, inefficient implementation of existing policies and legislation have created loopholes that may undermine critical wetland services, including water replenishment and purification, flood control and drought mitigation as well as their role in food production and as wildlife habitat. Ongoing development of a wetlands master plan should help establish guidelines on their management and use. Applying environmental impact assessments (EIAs) on proposed development projects should safeguard the sustainable use of this critical resource.

10. A persistent fuelwood energy crisis prevails, and associated indoor house pollution poses a serious health hazard, particularly for women and children.

With 96 percent of households dependent on wood and charcoal for cooking, the growing firewood demand is a significant but not the leading driver of deforestation. Augmenting tree plantation supplies, accelerating the agroforestry and biogas programmes and more-efficient stove programmes equipped with smoke hoods would help ease firewood demand and reduce indoor air pollution. Lack of accurate data on the role of agroforestry in firewood supply, however, is an important constraint on planning activities. Decentralised renewable energy sources offer a good opportunity to provide the majority of the Rwandan population with clean lighting electricity.

11. Massive post-conflict urbanisation has caused significant environmental stress.

The overwhelming majority of urban residents live in informal and unplanned settlements. Poorly

planned urban development raises significant challenges to human well-being, including inadequate and inequitable access to safe drinking water, sanitation and solid waste management services. Efforts to develop urban master plans need to be reinforced to mitigate and reduce environmental stress from rapid urbanisation. Problems associated with industrial pollution loadings are relatively small and localised, but are growing as the industrial sector expands.

12. Climate change is happening in Rwanda and together with more frequent weather-related disasters is projected to affect – directly and indirectly – all economic sectors and long-term development goals.

While many of the potential problems associated with climate change are presently not clearly separable from short-term variations, they are likely to have important implications on food security, water and energy supplies and critical infrastructure. The poor, particularly women, are most vulnerable due to their dependence on climate-sensitive livelihoods. Strengthening of Rwanda's adaptive and disaster risk reduction capacities is seriously curtailed by the lack of an accurate national-scale climate change assessment.

13. Regional environmental cooperation offers a promising strategy to sustainably manage Rwanda's growing resource demands and reinforce environmental conservation.

Compared to many of its neighbours, land-locked Rwanda has limited natural resources to drive its development. Transboundary cooperation to tap into the resource endowments of the Great Lakes region on a sustainable basis would significantly contribute to meeting increasing resource demands. Positive steps that are under way include the Nile Equatorial Lakes Subsidiary Action Program (NELSAP) as well as cooperation on the Virunga parks. There is a need, however, to expand and scale up environmental cooperation into a consolidated programme that would include sustainable trade in raw and value-added natural resources (timber, charcoal, minerals), harnessing the energy potential of shared rivers and the vast methane deposits in Lake Kivu, and management of transboundary parks. Engaging in regional knowledge networks to learn about and share successful practices on natural resources management is equally important.

15.3 Recommendations

Based on the report’s main findings, three priority areas have been discerned to help decision makers pursue an environmentally sustainable course towards Vision 2020. These macro-level solutions in turn have provided a systematic basis for pulling together the 89 detailed sectoral recommendations from Chapters 4 through 14 into a more structured and coherent plan. Table 50 categorises the report’s technical recommendations under the three priority areas.

1. Ecosystem conservation and rehabilitation to combat poverty

Achieving the targets of Vision 2020 and improving the quality of life of Rwandans depend, either directly or indirectly, on the continuous supply of goods and services by the country’s ecosystems. Natural forests and wetlands, particularly in the Congo-Nile and Byumba highlands, comprise Rwanda’s strategic ecosystems. They provide the major source of renewable freshwater and energy generation, improve erosion control as well as regulate regional climate and natural hazards. Fully conserving the existing natural forest and wetlands resource base as well as rehabilitating degraded forest, wetland and rangeland ecosystems can greatly contribute to Rwanda’s fight against poverty through job creation and provision of alternative livelihoods.

Communities need to be mobilised around the rehabilitation and sustainable management of ecosystems in a manner that provides demonstrable benefits at the village and household levels. Targeted environmental rehabilitation interventions could help improve the quality of growth by delivering immediate benefits to the poorest segments of society. Restoring ecosystem integrity would also help build the coping capacity of the very poor in view of Rwanda’s high vulnerability to climate change and disasters.

2. Capacity-building to strengthen environmental governance

Rwanda has made substantial progress in establishing the policy, legal and institutional frameworks to address environmental issues in the country. Considerable investment in capacity-

Table 50. Total number of recommendations under the three priority areas and their corresponding costs

Priority area	Total number of recommendations	Total estimated cost (USD millions)
Ecosystem conservation and rehabilitation to combat poverty	35	92.15
Capacity-building to strengthen environmental governance	47	47.90
Enhance and promote regional environmental cooperation	7	7.30
Total	89	147.35

building efforts, however, is still required to ensure adequate compliance and enforcement, support the ongoing decentralisation process and bolster environmental governance within key economic sectors.

Priority areas include: (i) technical assistance in natural resource management; (ii) environmental monitoring, scientific data collection and information management; (iii) environmental policy and law, including development of implementing regulations; (iv) strategic environmental assessment (SEA) and environmental impact assessment (EIA) to ensure integration of environmental considerations in national policy making and development projects; (v) environmental education and awareness raising; and (vi) promotion of public-private partnerships and strengthening the role of environmental non-governmental organisations (NGOs) and media.

Recent endorsement of an Environment and Natural Resources strategy should contribute towards a coherent and long-term environmental vision and consolidation of the current project approach to environmental management. Support for the development of the environment Sector Working Group (SWG) and a sector-wide approach (SWAp) is critical for effective prioritisation and planning in the sector and alignment of donor funding.

3. Enhance and promote regional environmental cooperation

This assessment underscores the importance of regional environmental cooperation in sustainably managing the resource demands of Rwanda's rapidly growing population across core development sectors. Key areas include: (i) promoting joint investments in the energy and water sectors; (ii) sustainable trade in forest resources; (iii) transboundary management of protected areas; and (iv) regional level initiatives in responding to the challenges of climate change and food security. Drawing on the experiences and successes of neighbouring countries in the sustainable use and management of natural resources through technical cooperation, information exchange and technology transfer would help save precious time and resources. Cumulatively, transboundary and regional environmental initiatives could substantially contribute to advancing interstate dialogue and trust and reinforce regional integration and peacebuilding.

15.4 Implementation and financing of the recommendations

The total cost of the 89 technical recommendations is estimated at approximately USD 147.35 million with expenditure spread over a five-year period (Table 51). It should be noted that this overall cost is derived from broad calculations that would need to be re-evaluated during the project development phase in consultation with national partners. It does, however, provide a reliable indication of the level of investment required to address the priority environmental challenges facing the country in the short term.

It is critical that this report's findings are nationally owned and implementation of its recommendations is nationally driven. This can be done by using its analysis and results to support the implementation of the five-year ENRSP (2009-2013) that has been recently developed under the leadership of the Ministry of Natural Resources (MINIRENA). Furthermore, to promote national buy-in, all national stakeholders should prioritise this report's recommendations through

a transparent and participatory manner. This process should be facilitated through the SWG based on SWAp as called for under the ENRSP. Both UNEP and the UN Country Team through the United Nations Development Assistance Framework (UNDAF) Environment Thematic Group are ready to assist the Government of Rwanda (GoR) in taking this proposal forward.

As the government has a limited revenue stream, resources to implement the recommendations will need to be mainly mobilised from development partners in the short to medium term. At the same time, for sustainability purposes, the government should to the extent possible cover project operational costs. Other means for raising capital should also be explored, including public-private partnerships and market-based financing. A Rwanda National Environment Fund (FONERWA), whose establishment is sanctioned by law but which is not yet operational, provides a suitable financial mechanism to coordinate the proposed investments and which Rwanda's development partners are urged to support. Another complementary funding option is through the newly established One UN Fund, particularly for those projects where it may offer a value-added advantage for implementation.

15.5 The way forward

As part of the One UN pilot, UNEP – a non-resident agency – deployed for the first time a representative to Kigali in 2008 to provide advisory environmental support to the UN system in Rwanda as well as to follow up on the implementation of this assessment's recommendations. In consultation with national and UN partners, and should funds allow, UNEP intends to develop a country programme that could include a number of the listed recommendations where it has a clear comparative advantage. This country programme will also integrate the various ongoing UNEP projects in Rwanda to help establish a more strategic and coherent presence.

It should be noted, however, that for many of the sectoral recommendations, neither UNEP nor its government counterparts at MINIRENA and REMA have the mandate or executing capacity. Therefore, the full involvement of line ministries

15 CONCLUSIONS AND RECOMMENDATIONS

Table 51. Summary of recommendations (continues on next page)

Ecosystem conservation and rehabilitation to combat poverty		Estimated cost (USD millions)	Tentative duration (years)
Population displacement, resettlement and the environment			
R5.1	Promote biogas plants and other renewable energy options in <i>imidugudu</i> .	5	3
R5.2	Implement “cash-for-environment” projects.	3	3
R5.3	Provide alternative, environment-friendly income-generation opportunities for <i>imidugudu</i> residents.	5	3
R5.4	Develop pilot projects for rainwater harvesting in <i>imidugudu</i> .	2	2
R5.7	Promote biogas plants and other renewable energy options in refugee camps.	0.5	1
Disasters and climate change			
R6.4	Pilot micro-finance projects targeting disaster affected areas.	1.5	5
R6.5	Establish Clean Development Mechanism (CDM) projects based on run-of-the-river hydropower plants in rural areas.	10	5
Agriculture and land degradation			
R7.1	Promote integrated conservation agriculture.	5	5
R7.3	Establish national-scale monitoring of soil erosion.	1.5	5
R7.5	Phase out tillage cultivation on steep slopes.	1.25	5
R7.6	Monitor the environmental impact of accelerating fertiliser use.	0.15	Continuous
R7.7	Promote the conservation of agricultural biodiversity.	0.5	2
R7.8	Reduce the prevalence of livestock disease and improve pasture quality.	2.5	5
Forest resources			
R8.1	Promote participatory forest management.	1	2
R8.2	Increase the extent of agroforestry, including small private woodlots.	3	3
R8.4	Rehabilitation of the Mukura montane rainforest.	0.5	3
R8.5	Restoration of gallery forests.	1	2
R8.9	Establish a biodiversity inventory of the Sanza relict forest and possibly other unknown relict forests.	1	2
Water resources			
R9.3	Develop a national wetlands programme.	2	2
R9.5	Scale-up rainwater harvesting projects at household and community levels to improve water supply.	2	3
Wildlife and protected area management			
R10.4	Develop alternative and sustainable income-generating activities for communities living around protected areas.	1	2
R10.5	Promote national parks as important leisure areas for the growing middle class in order to increase domestic tourism.	1.5	3
R10.7	Fully quantify and recognise the contribution of protected areas and wildlife to the national economy.	0.5	2
Energy and the environment			
R11.1	Sustainably manage wood and non-wood biomass energy supplies.	3	3-4
R11.2	Upgrade the current Improved Stove Programme.	2.5	3
R11.9	Accelerate the biogas programme.	10	4
R11.10	Explore the feasibility and long-term viability of using agrofuel oils to generate electricity.	2	3
Urban environment and health issues			
R12.1	Development of urban land use master plans.	5	5
R12.2	Develop a programme for liquid waste management to minimise the exposure of the urban population to contaminated groundwater.	5	3-5
R12.5	Assess the feasibility of various waste disposal interventions including land filling and installation of municipal solid waste incinerators.	0.25	0.5
R12.6	Undertake a detailed site contamination and risk assessment of Nyanza dumpsite, including implementation of mitigating actions.	1	3-5
R12.7	Develop and implement a water quality control and monitoring programme.	1	1
R12.8	Undertake a comprehensive review of community-based organisations (CBOs) involved in solid waste collection services.	0.5	1-1.5
Industry and mining			
R13a.2	Undertake environmental rehabilitation of the Gikondo wetland area.	10	3-5
R13b.2	Assess the major social and environmental impacts associated with Communities and Small-Scale Mining (CASM).	0.5	1-1.5
Total estimated cost for ecosystem conservation and rehabilitation to combat poverty		92.15	

Table 51. Summary of recommendations

Capacity-building to strengthen environmental governance		Estimated cost (USD million)	Tentative duration (years)
Conflict, Peacebuilding and the Environment			
R4.1	Improve public awareness of land tenure reform arrangements, including processes of distributing and demarcating land.	1	5
R4.2	Implement an environmental and technical assistance project in the four refugee camps.	0.5	2
Population displacement, resettlement and the environment			
R5.5	Develop an environmental management master plan for <i>imidugudu</i> .	0.5	1
R5.6	Strengthen environmental planning capacities of designated authorities for resettlement schemes.	2	2
R5.8	Pilot the use of constructed wetlands for wastewater treatment in urban <i>imidugudu</i> .	3	2
Disasters and climate change			
R6.1	Strengthen governance capacities and establish institutional mechanisms for cross-sectoral coordination on climate change and disaster reduction.	5	3
R6.2	Strengthen the institutional and technical capacities of the Rwanda Meteorological Service (RMS).	1.5	2
Agriculture and land degradation			
R7.2	Improve agricultural research and data collection systems and capacity.	3	3
R7.4	Increase investment in agricultural extension services.	3	3
Forest resources			
R8.3	Assessment of the extent of trees and shrubs outside forest areas.	0.5	1
R8.6	Assessment of the wood market.	0.2	1
R8.7	Strengthen the capacity of forest guards to protect relict forests and control logging operations in tree plantations.	1	2
R8.8	Establish a central forestry data bank under the Rwanda National Forest Authority (NAFA).	1	2
Water resources			
R9.1	Develop a national Integrated Water Resource Management (IWRM) plan.	1	2
R9.2	Pilot IWRM projects at the catchment level.	1	2
R9.4	Support the re-establishment of a national water monitoring programme.	3.5	3
Wildlife and protected area management			
R10.1	Review institutional arrangements for wildlife and protected area management.	0.05	1
R10.2	Resolve human-wildlife conflicts through community awareness programmes.	0.15	2
R10.3	Reinforce the protected area network.	1	3
Energy and the environment			
R11.4	Develop an energy pricing reform strategy.	0.1	1
R11.5	Promote solar home systems (SHS) to provide lighting to households in areas where other electricity sources are not feasible.	2	3
R11.6	Operationalise the Energy and Water Board (EWB) and strengthen its capacities to ensure efficient and sustainable development of the energy sector.	1	2
R11.7	Promote the use of compressed natural gas (CNG) in the transportation sector.	5	3
R11.8	Mobilise foreign and national private investment to increase electricity supply.	0.2	1
Urban environment and health issues			
R12.3	Develop a solid waste management policy that aims to put environmental controls on waste and its management.	0.25	1
R12.4	Build capacities of government and the private sector to undertake environmentally sustainable urban planning and development.	1	2
R12.9	Develop an environmental programme to protect the sustainability of urban water resources.	1.5	3-5
R12.10	Develop guidelines on management of urban wetlands and wastewater treatment.	0.25	1-1.5
R12.11	Undertake a feasibility assessment for the development of constructed wetlands in the urban environment of Kigali.	0.25	1-1.5
R12.12	Prepare an air quality monitoring programme for Kigali and develop appropriate policy responses to alleviate air pollution problems.	0.25	1 (continuing)

15 CONCLUSIONS AND RECOMMENDATIONS

Table 51. Summary of recommendations (continued)

Capacity-building to strengthen environmental governance		Estimated cost (USD million)	Tentative duration (years)
Industry and mining			
Industry			
R13a.1	Undertake an extensive review of industrial facilities located in the Gikondo area with the aim of providing technical guidelines and mobilising financial support for future relocation.	0.5	0.1-0.3
R13a.3	Develop planning codes for proposed industrial parks.	0.1	1
R13a.4	Undertake an EIA on proposed industrial land use zones.	0.25	2
R13a.5	Establish common facilities in industrial parks to promote cleaner production and resource efficiency.	3	3
R13a.6	Strengthen and build the capacity of the National Cleaner Production Centre (NCPC).	1	3-5
R13a.7	Develop regulations and standards under the Environmental Law for industry.	0.1	1-3
R13a.8	Develop environmental management guidelines and regulations that minimise the adverse impacts of small- and medium-scale business.	0.05	1
Mining			
R13b.1	Develop environmental guidelines and appropriate technologies to improve management of mining and quarrying activities.	0.25	1-1.5
R13b.3	Subject all LSM activities – current and future – to EIA in accordance with the Environment Law and the draft mining law once approved.	0.25	2
Environmental governance			
R14.1	Support the implementation of the ENRSSP.	0.35	1
R14.2	Ensure implementation of SEAs and EIAs.	0.25	2
R14.3	Strengthen the decentralisation of environmental management in the country.	0.3	3
R14.4	Establish a sustainable and predictable mechanism for financing environmental programmes and activities.	Multi-million	Multi-year
R14.5	Support the development of a Rwandan Environment Information Network (REIN).	0.25	2
R14.6	Develop and implement a comprehensive environmental education programme at the national level.	0.25	3
R14.7	Reinforce coordination between institutions dealing with natural resources, protected areas and nature reserves and harmonise relevant policies and laws.	0.05	0.5
R14.8	Strengthen technical and organisational capacities of the recently established environmental NGO forum.	0.25	3
Total estimated cost for capacity-building to strengthen environmental governance		47.90	

Enhance and promote regional environmental cooperation		Estimated cost (USD million)	Tentative duration (years)
Disasters and climate change			
R6.3	Strengthen national and regional volcanological and seismic monitoring in the countries of the Albertine Rift Valley.	1.5	3
Agriculture and land degradation			
R7.9	Engage in regional and international agricultural research.	1	3
Forest resources			
R8.10	Initiation of sustainable and regulated trade in forest products with neighboring countries.	1	2
Water resources			
R9.6	Develop a strategy to promote water management cooperation in the Congo Basin.	0.05	1
Wildlife and protected area management			
R10.6	Strengthen intercountry cooperation in the management of transboundary protected areas.	3	4
R10.8	Promote regulated and sustainable trade in wildlife and wildlife products.	0.5	4
Energy and the environment			
R11.3	Promote regional energy cooperation to facilitate increased supply and distribution.	0.25	1
Total estimated cost to enhance and promote regional environmental cooperation		7.30	

and agencies, UN organisations, development partners and civil society organisations is necessary to bring the suggested recommendations to fruition. To bring stakeholders together and facilitate synergies, it is necessary that the aforementioned sector wide environmental coordination mechanism – SWG/SWAp – is established to move this process forward. At the same time, UNEP intends to assist the GoR catalyse support to carry out as many of the recommendations as feasible, which should be primarily channelled through FONERWA.

For sustainability purposes, it is critical that domestic investment and the share of the environment sector in the national budget are increased. Given Rwanda’s limited ability to raise additional revenue, however, a substantial part of the funding gap will need to be met by development partners, including through in-kind technical assistance and capacity-building. Equally important is the need to ameliorate the quality and

delivery of international environmental assistance by improving the coordination of donor projects, which have largely been stand-alone initiatives, and up scaling them into coherent programmes that better respond to national priorities and needs. Due care should also be exercised to assure that international projects do not overburden the absorptive capacity of national institutions or inadvertently destabilise their mandates and roles.

As part of the One UN reform process, it is equally important that UN agencies consolidate their presently fragmented environmental projects into a coherent and effective programme at the country level. UNEP as co-chair of the UNDAF Environment Thematic Group, together with the United Nations Development Programme (UNDP), will assume a lead role in taking this process forward and ensuring that environmental issues are adequately mainstreamed and integrated across the work of the UN system in Rwanda.

Table 52. Summary and total cost of recommendations (USD millions)

Issue and sector	Number of recommendations	Ecosystem conservation and rehabilitation to combat poverty	Capacity-building to strengthen environmental governance	Enhance and promote regional environmental cooperation	Total cost
Conflict, peace-building and the environment	2	-	1.50	-	1.50
Displacement and resettlement	8	15.50	5.50	-	21.00
Disasters and climate change	5	11.50	6.50	1.50	19.50
Agriculture and land degradation	9	10.90	6.00	1.00	17.90
Forest resources	10	6.50	2.70	1.00	10.20
Water resources	6	4.00	5.50	0.05	9.55
Wildlife and protected areas	8	3.00	1.20	3.50	6.70
Energy	10	17.50	8.30	0.25	26.05
Urban environment	12	12.75	3.50	-	16.25
Industry and mining	11	10.50	5.50	-	6.00
Environmental governance	8	-	1.70	-	2.15
Total	89	92.15	47.90	7.30	147.35

Note:

– Indicates data not applicable.

VI. Appendices

Appendix 1

List of Acronyms and Abbreviations

ACEN	Association for the Conservation of the Environment
AfDB	African Development Bank
AIDS	acquired immunodeficiency syndrome
ANP	Akagera National Park
ARECO	Rwanda Ecological Association
AU	African Union
BDCA	Belgian Development Cooperation Agency
BOD	biological oxygen demand
BRALIRWA	<i>Brasseries et Limonaderies du Rwanda</i> /Rwanda Breweries
BTC	Belgian Technical Cooperation
CARPE	Central African Regional Program for the Environment
CASM	Communities and Small-Scale Mining
CBFF	Congo Basin Forest Fund
CBFP	Congo Basin Forest Partnership
CBO	community-based organisation
CDC	community development committee
CDM	Clean Development Mechanism
CEFDHAC	<i>Conférence sur les Ecosystèmes de Forêts Denses et Humides d'Afrique Centrale</i>
CEPGL	Economic Community of the Great Lakes Countries
CF	compact fluorescent lamp
CGIS	Centre for Geographic Information Systems and Remote Sensing
CIRAD	Agricultural Research Centre for International Development
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
CITT	Centre for Innovations and Technology Transfer
CNG	compressed natural gas
COD	chemical oxygen demand
COJEPE	<i>Coopérative des Jeunes Entrepreneurs pour la Protection de l'Environnement</i>
COMESA	Common Market for Eastern and Southern Africa
COMIFAC	Conference of Ministers in Charge of Forests in Central Africa
COPIMAR	Co-operative for the Promotion of Artisanal Mining Industries
CO ₂	carbon dioxide
DEM	Digital Elevation Model
DHS	Demographic and Health Survey
DMU	Disaster Management Unit
DO	dissolved oxygen
DR Congo	Democratic Republic of the Congo
EAC	East African Community
EDPRS	Economic Development and Poverty Reduction Strategy
EIA	environmental impact assessment
EICV	<i>Enquête Intégrale sur les Conditions de Vie des Ménages</i> /Household Living Conditions Survey
EIS	environmental information system
ELECTROGAZ	<i>Société de Production et de Distribution d'Électricité, d'Eau et de Gaz</i>
ENRSSP	Environment and Natural Resources Sector Strategic Plan
EPH	extractable petroleum hydrocarbons
EWB	Energy and Water Board
FAO	Food and Agriculture Organization
FLEGT	Action Plan for Forest Law Enforcement, Governance and Trade
FONERWA	Rwanda National Environment Fund

FRW	Rwandan Franc
GCMs	General Circulation Models
GDP	gross domestic product
GEF	Global Environment Facility
GFRP	Global Food Crisis Response Programme
GIS	Geographic Information System
GNI	gross national income
GoR	Government of Rwanda
GPS	Geographic Positioning System
GTZ	German Technical Cooperation
GWP	Global Water Partnership
HAR	HELPAGE Rwanda
HDR	Human Development Report
HHCW	hazardous healthcare waste
HIPC	Highly Indebted Poor Countries Initiative
HIV	human immunodeficiency virus
ICCN	International Centre on Conflict and Negotiation
ICRAF	World Agroforestry Centre
IDA	International Development Association
IDP	internally displaced person
IFAD	International Fund for Agricultural Development
IGCP	International Gorilla Conservation Programme
ILO	International Labour Organization
IP	international partner
IPCC	Intergovernmental Panel on Climate Change
IPP	independent power producer
IRST	Institute of Scientific and Technological Research
ISAE	Institute of Agriculture and Animal Husbandry
ISAR	Rwanda Agricultural Research Institute
ISDR	International Strategy for Disaster Reduction
ISO	International Organization for Standardization
IUCN	International Union for Conservation of Nature
IWRM	Integrated Water Resources Management
KCC	Kigali City Council
KCCEM	Kitabi College of Conservation and Environmental Management
KIEMP	Kigali Industrial Environment Management Program
KIST	Kigali Institute of Science and Technology
KTIWRMDP	Kagera River Basin Transboundary Integrated Water Resources and Development Project
LDC	Least Developed Country
LPG	liquefied petroleum gas
LSM	large-scale mining
LVBC	Lake Victoria Basin Commission
MCERTS	Monitoring Certification Scheme
MDG	Millennium Development Goal
MEA	Multilateral Environment Agreement
Mg	magnesium
MIFOTRA	Ministry of Public Service and Labour
MIGEPROF	Ministry in the Office of the Prime Minister in Charge of Gender and Family Promotion
MIGESPOC	Ministry of Sports and Culture
MINADEF	Ministry of Defence
MINAFET	Ministry of Foreign Affairs and Cooperation
MINAGRI	Ministry of Agriculture and Animal Resources
MINALOC	Ministry of Local Government, Community Development and Social Affairs

MINEAC	Ministry of East African Community
MINECOFIN	Ministry of Finance and Economic Planning
MINEDUC	Ministry of Education
MINICAB	Ministry in the Office of the Prime Minister in Charge of Cabinet Affairs
MINICOM	Ministry of Trade and Industry
MINIJUST	Ministry of Justice
MININFOR	Ministry of Information
MININFRA	Ministry of Infrastructure
MININTER	Ministry of Internal Security
MINIPRESIREP	Ministry in the President of the Republic Office
MINIRENA	Ministry of Natural Resources
MINISANTE	Ministry of Health
MINISTEC	Ministry in the Office of the President in Charge of Science, Technology, Research and Information Communication Technologies
MINITERE	Ministry of Lands, Environment, Forestry, Water and Mines
MINIYOUTH	Ministry of Youth
NAFA	Rwanda National Forest Authority
NAP	National Agricultural Policy
NAPA	National Adaptation Programme of Action
NBI	Nile Basin Initiative
NCPC	National Cleaner Production Centre
NDO	National Demining Office
NDP	National Decentralisation Policy
NDS	Nyanza Dump Site
NELSAP	Nile Equatorial Lakes Subsidiary Action Program
NEPAD	New Partnership for Africa's Development
NESSP	National Environment Sector Strategic Plan
NGO	non-governmental organisation
NHRC	National Human Rights Commission
NISR	National Institute of Statistics Rwanda
NLC	National Land Centre
NUR	National University of Rwanda
NURC	National Unity and Reconciliation Commission
ODA	Official Development Assistance
OFDA	Office of U.S. Foreign Disaster Assistance
OGMR	Rwanda Geology and Mines Authority
ORP	oxygen reduction potential
ORTPN	Rwanda Office of Tourism and National Parks
PAB	Protected Areas Biodiversity
PAFOR	Forestry Management Support Project
PAH	polycyclic aromatic hydrocarbons
PAPSTA	Support Project for the Strategic Transformation of Agriculture
PAREF	Rwanda Reforestation Programme
PCEA	post-conflict environmental assessment
PEI	Poverty and Environment Initiative
PES	Payment for Ecosystem Services
PGNRE	National Water Resources Management Project
PPP	purchasing power parity
PRSP	Poverty Reduction Strategy Paper
PSTA	Strategic Plan for the Transformation of Agriculture
RAB	Rwanda Agricultural Board
RADA	Rwanda Agricultural Development Authority
RARDA	Rwanda Animal Resources Development Authority

RBHDB	Rwanda Building and Housing Development Board
RDB	Rwanda Development Board
REIN	Rwandan Environment Information Network
REMA	Rwanda Environment Management Authority
RHODA	Rwanda Horticulture Development Authority
RIMP	Rwanda Industrial Master Plan
RITA	Rwanda Information Technology Authority
RMS	Rwanda Meteorological Service
RNRB	Rwanda Natural Resources Board
RoR	Republic of Rwanda
RPF	Rwandan Patriotic Front
RURA	Rwanda Utilities Regulator Agency
SDC	Swiss Agency for Development and Cooperation
SEA	strategic environmental assessment
SHS	solar home systems
SMEs	small and medium enterprises
SOM	soil organic matter
SOMIRWA	Rwandan Mining Company
SRTM	Shuttle Radar Topography Mission
SWAp	sector-wide approach
SWG	Sector Working Group
SWM	solid waste management
TDS	total dissolved solids
TKTIWRDP	Transboundary Integrated Water Resources and Development Project
TOC	total organic content
TSS	total suspended solids
UN	United Nations
UNAMIR	United Nations Assistance Mission for Rwanda
UNDAF	United Nations Development Assistance Framework
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNFCCC	United Nations Framework Convention on Climate Change
UN-HABITAT	United Nations Human Settlements Programme
UNHCR	United Nations High Commissioner for Refugees
UNICEF	United Nations Children's Fund
UNIDO	United Nations Industrial Development Organization
UPEGAZ	Unit for the Promotion and Exploitation of Lake Kivu Gas
USAID	United States Agency for International Development
USD	United States dollar
USEPA	United States Environmental Protection Agency
USLE	Universal Soil Loss Equation
UTEXWRA	<i>Usine Textile du Rwanda</i> /Rwanda Textile Factory
UXO	unexploded ordnance
VOC	volatile organic compound
WB	World Bank
WCMC	World Conservation Monitoring Centre
WCS	Wildlife Conservation Society
WFP	World Food Programme
WHO	World Health Organization
WWF	World Wildlife Fund

Weights and measures

cm	centimetre
cum	cubic metres
ha	hectare
hr	hour
kcal	kilocalorie
kg	kilogram
km	kilometre (measurement)
km²	kilometre squared (area)
kW / kWh	kilowatt
l/L	litre
m	metre
m³	cubic metre
MCM	million cubic meters
mg	milligram
mg/L	milligram per litre
mm	millimetre
MW	megawatt
ppm	parts per million
sq	square
µg	microgram
µg/kg	microgram per kilogram
µg/L	microgram per litre
yr	year
°	degree
°C	degrees Centigrade

Appendix 2

List of References

- Adegbidi, A., Gandonou, E. et al. (2004). "Measuring the productivity from indigenous soil and water conservation technologies with household fixed effects: A case study of hilly mountainous areas of Benin." *Economic Development and Cultural Change*. 52(2), pp. 313-346.
- Adisa, J. (1996). "Zaire: A worse case scenario?" In *The comfort of strangers: The impact of Rwandan refugees on neighbouring countries*. United Nations Centre for Human Settlements (UNCHS) and Institut français de recherche en Afrique (IFRA). Nairobi.
- African Economic Outlook. (2007). "Rwanda." Organisation for Economic Co-operation and Development and African Development Bank. n.p.
<http://www.oecd.org/dataoecd/27/19/38562991.pdf>
- Association pour la Conservation de la Nature au Rwanda (ACNR) and Birdlife International. (2007). "Report on socio-cultural and economic characteristics and livelihood of populations around Akagera National Park in Rwanda." ACNR. Kigali.
- Bailis, R., Berrueta, V., Chengappa, C., Dutta, K. et al. (2007). "Performance testing for monitoring improved biomass stove interventions: Experiences of the Household Energy and Health Project." *Energy for Sustainable Development*. 11(2), pp. 57-70.
- Balasubramanian, V., Sekayange, L. (1991). "Effects of tree legumes in hedgerows on soil fertility changes and crop performance in the semi-arid highlands of Rwanda." *Biological Agriculture & Horticulture*. 8(1), pp. 17-32.
- Balolebwami, J-C. (2008). "Etude sur le charbon de bois à Goma en République Démocratique du Congo et à Gisenyi au Rwanda." Africa Conservation Fund. Goma.
- Barbier, C. (1992). *Evaluation du plan d'action pur la conservation de l'aménagement des forêts naturelles de la Crête-Zaire-Nil*. Ministry of Agriculture and Animal Resources, Republic of Rwanda. Kigali.
- Barnes, D.F., Openshaw, K., Smith, K.R., van der Plas, R. (1994). World Bank Technical Paper No. 242: "What makes people cook with improved biomass stoves? A comparative international review of stove programs". World Bank. Washington, D.C.
- Belgian Development Cooperation Agency. (2007). "Programme d'appui à la reforestation au Rwanda. Dossier technique et financier." n.p. Kigali.
- Bigagaza, J., Abong, C., Mukarubuga, C. (2002). "Land scarcity, distribution and conflict in Rwanda." In J. Lind and K. Sturman (Eds.), *Scarcity and surfeit: The ecology of Africa's conflicts*. African Centre for Technology Studies and Institute for Security Studies. South Africa. pp. 51-82.
- Biswas, A., Tortajada-Quiroz, H. (1994). *Environmental impacts of the Rwandan refugees*. United Nations Development Programme (UNDP). New York.
- Bloesch, U. (2002). *The dynamics of thicket clumps in the Kagera savanna landscape, East Africa*. Shaker. Aachen.
- Bloesch, U. (1992). *Le bambou, espèce à promouvoir au Rwanda*. Ministry of Agriculture and Animal Resources/Intercooperation, Republic of Rwanda. Kigali.

- Bloesch, U., Troupin, G., Derungs, N. (2009). *Les plantes ligneuses du Rwanda: Flore, écologie et usages*. Shaker. Aachen.
- Borchers, M., Annecke, W. (n.d.). Sustainable Energy Africa policy brief: "Poverty-environment-energy linkages in Rwanda". Prepared for the United Nations Environment Programme (UNEP). Nairobi. <http://www.unpei.org/PDF/Rwanda-Pov-env-energy-linkages.pdf>
- Brinn, P. et al. (2004). "Assessment of Rwanda's land registration, land information management, land use planning and land management systems." United Kingdom Department of International Development and NRI study report. n.p.
- Bruce, J.W. (2007a). Humanitarian Policy Group Working Paper: "Drawing a line under the crisis: Reconciling returnee land access and security in post-conflict." Overseas Development Institute. London.
- Bruce, J.W. (2007b). Humanitarian Policy Group background briefing paper: "Returnee land access: Lessons from Rwanda". Overseas Development Institute. London.
- Bush, G., Kanobayita, A., Rukingama, E., Masozera A. (2005). "Mainstreaming poverty-environment linkages in the European Community's development assistance." Draft report for the World Wildlife Fund Macroeconomics Program Office and the Rwanda Environment Management Authority, Republic of Rwanda. Kigali.
- Byers, A.C. (1992). "Soil loss and sediment transport during the storms and landslides of May 1988 in Ruhengeri prefecture, Rwanda." *Natural Hazards*. 5(3), pp. 279-292.
- Byers, A.C. (1990). "Preliminary results of the RRAM Project soil loss and erosion control trials Rwanda, 1987-1988." Proceedings of the International Symposium: Research Needs and Applications to Reduce Erosion and Sedimentation in Tropical Steeplands. IAHS-AISH Publication No. 192. International Association of Hydrological Sciences. Fiji.
- Byiringiro, F., Reardon, T. (1996). "Farm productivity in Rwanda: Effects of farm size, erosion, and soil conservation investments." *Agricultural Economics*. 15(2), pp. 127-136.
- Centre for Research on the Epidemiology of Disasters. (2008). "Emergency event database." Université Catholique de Louvain, Ecole de Santé Publique. Accessed on 10 October 2008. <http://www.emdat.be/Database/CountryProfile/countryprofile.php>
- Chaâbane, Y. (2000). "Rwanda, IDPs and other affected populations in Rwanda." United Nations Office for the Coordination of Humanitarian Affairs (OCHA). <http://www.who.int/disasters/repo/5823.doc>
- Chemonics International, Inc. (2003). "Rwanda environmental threats and opportunities assessment." Report submitted to USAID Rwanda. Chemonics International Inc. Washington, D.C.
- Christensen, J.H., Hewitson, B., Busuioc, A., Chen, A., Gao, X., Held, I., Jones, R., Kolli, R.K., Kwon, W.-T., Laprise, R., Magaña Rueda, V., Mearns, L., Menéndez, C.G., Räisänen, J., Rinke, A., Sarr, A., Whetton, P. (2007). "Regional climate projections." In S. Solomon, D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor and H.L. Miller (Eds.), *Climate change 2007: The physical science basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge University Press. Cambridge, United Kingdom and New York.

Christophersen, K.A., Butare, A. (1999). *Rwanda energy sector rehabilitation study on safeguarding the biomass supply. Biomass energy assessment*. Ministry of Natural Resources, Republic of Rwanda. Kigali.

CIRAD. (1992). *Forêt naturelle de Mukura. Inventaire de prospection*. Ministry of Agriculture and Animal Resources, Republic of Rwanda. Kigali.

Clay, D., Reardon, T. et al. (1998). "Sustainable intensification in the highland tropics: Rwandan farmers' investments in land conservation and soil fertility." *Economic Development and Cultural Change*. 46(2), pp. 351–377.

Clay, D.C. (1996). MSU International Development Working Paper: "Fighting an uphill battle: Population pressure and declining land productivity in Rwanda". C. Liedholm and M.T. Weber (Eds). Michigan State University. East Lansing, Michigan.

Cohen, M.J., Shepherd, K.D. et al. (2005). "Empirical reformulation of the universal soil loss equation for erosion risk assessment in a tropical watershed." *Geoderma*. 124, pp. 235-252.

Convention on Biological Diversity webpage on Rwanda. Accessed on 14 September 2008.
<http://www.cbd.int/countries/?country=rw>

Convention on Biological Diversity webpage on the Cartagena Protocol. Accessed on 6 October 2008.
<http://bch.cbd.int/about/countryprofile.shtml?country=rw>

Convention on International Trade in Endangered Species of Wild Fauna and Flora website. Accessed on 29 September 2008.
<http://www.cites.org/>

Convention on International Trade in Endangered Species of Wild Fauna and Flora webpage. "List of contracting parties." Accessed on 29 September 2008.
<http://www.cites.org/eng/disc/parties/alphabet.shtml>

Convention on Migratory Species. (2009). "Parties to the Convention on the Conservation of Migratory Species of Wild Animals and its Agreements as of 1 January 2009."
http://www.cms.int/about/Partylist_eng.pdf

Coutin, N., Murerehe, S. (2006). "Rapport de mission environnement." Mission conduite conjointement de HCR Rwanda et GTZ TOR. n.p.

Croix Rouge Rwandaise. (2007). *Bulletin de la Croix Rouge Rwandaise*. Volume 90, December.

Delmas G, Courvallet, M. (1994). *Public health engineering in emergency situations*, 1st edition. Médecins Sans Frontières. Paris.

Diao, X., Fan, S. et al. (2007). IFPRI Discussion Paper: "Agricultural growth and investment options for poverty reduction in Rwanda". International Food Policy Research Institute, Development Strategy and Governance Division. Washington, D.C.

Diao, X., Hazell, P. et al. (2007). *The role of agriculture in development: Implications for Sub-Saharan Africa*. International Food Policy Research Institute. Washington, D.C.

Dowsett-Lemaire, F. (1990). "Physionomie et végétation de la Forêt de Nyungwe, Rwanda." *Tauraco Research Report*. 3, pp. 11-30.

Drechsel, P., Steiner, K.G. et al. (1996). "A review on the potential of improved fallows and green manure in Rwanda." *Agroforestry Systems*. 33(2), pp. 109-136.

"Dutch standards on environmental pollutant reference levels used in environmental remediation." Accessed on 13 October 2008.

http://en.wikipedia.org/wiki/Dutch_standards

EAESI. (2005). "Rwanda national paper." Presentation at the Forum of Energy Ministers for Africa (EAESI/FEMA), East African Energy Scale Up Initiative, 24-25 June. UNDP. Nairobi.

EarthTrends. (2003). Country reports: "Forests, grasslands and drylands - Rwanda". World Resources Institute. Washington, D.C.

EIS-AFRICA. (2001). *Environmental information systems development in Sub-Saharan Africa: Approaches, lessons and challenges*. EIS-AFRICA. Pretoria.

Energy Sector Management Assistance Programme. (1991). Mid-term progress report, 141/91: "Commercialization of improved charcoal stoves and carbonization techniques". ESMAP and World Bank. Washington, D.C.

European Commission and Republic of Rwanda. (2006). *Environmental profile of Rwanda*. n.p. Kigali.

Ewango, C.E.N. (2001). "Flore et végétation de la forêt naturelle de Nyungwe, Rwanda." *Systematics and Geography of Plants*. 71, pp. 1009-1015.

Food and Agriculture Organization of the United Nations. (2008a). ProdSTAT database. <http://faostat.fao.org/site/567/default.aspx>.

Food and Agriculture Organization of the United Nations. (2008b). "Rwanda country profile." *Aquastat*. Accessed on 1 October 2008.

<http://www.fao.org/nr/water/aquastat/countries/rwanda/indexfra.stm>

Food and Agriculture Organization of the United Nations. (2007). "State of the world's forests." FAO. Rome.

Food and Agriculture Organization of the United Nations (2005a). Forestry Paper 147: "Global forest resources assessment". FAO. Rome.

Food and Agriculture Organization of the United Nations. (2005b). "Rwanda country profile." *Aquastat*. Accessed on 1 October 2008.

<http://www.fao.org/nr/water/aquastat/countries/rwanda/indexfra.stm>

Food and Agriculture Organization of the United Nations. (2000). *Etat des ressources forestières au Rwanda*. Ministry of Agriculture and Animal Resources, Government of Rwanda. Kigali.

Food and Agriculture Organization of the United Nations. (1998). "A manual for the planning, design and construction of forest roads in steep terrain." FAO. Rome.

Forests Monitor. (2007). *The timber trade and poverty alleviation: Upper Great Lakes region*. Forests Monitor. Cambridge.

- Garret, G. (2008). "Walikale, artisanal cassiterite mining and trade in North Kivu. Implications for poverty reduction and security." Confidential draft prepared for Resource Consulting Services. n.p.
- Gasana, J., Twagilimana, L., Hallenbeck, W., Brenniman, G. (1997). "Industrial discharges of metals in Kigali, Rwanda, and the impact on drinking water quality." *Environmental Contamination and Toxicology*. 58, pp. 523-526.
- Global Witness. (2005). *Under-mining peace: Tin- the explosive trade in cassiterite in eastern DRC*. Global Witness Publishing, Inc. Washington, D.C.
- Habarurema, E., Steiner, K.G. (1997). «Soil suitability classification by farmers in southern Rwanda.» *Geoderma*. 75(1-2), pp. 75-87.
- Habiyambere, T. (1998). *Etude des politiques et lois forestières des Pays d'Afrique Centrale – Cas du Rwanda*. CEFDHAC. n.p.
- Hamilton, A.C. (1982). *Environmental history of East Africa: A study of Quaternary*. Academic Press. London and New York.
- Hanek, G., Leendertse, K., Farhani, B. (1991). "Socio-economic investigations of Lake Kivu fisheries." UNDP/FAO Project Fisheries Development of Lake Kivu RWA/87/012. n.p.
- Hartmanshenn, T. (1995). PhD thesis: "Der tropische Bergwald von Gishwati in Rwanda im Spannungsfeld zwischen Ökonomie und Ökologie". Johannes Gutenberg-University. Mainz.
- Hilhorst, D., van Leeuwen, M. (2000). "Emergency and development: The case of imidugudu and villagization in Rwanda." *Journal of Refugee Studies*. 13(3), pp. 265-280.
- Hiroaki S., Kinya Y., Kizungu, B. (2000). "Follow-up survey of environmental impacts of the Rwandan refugees on eastern DR Congo." *Ambio*. 29 (2), pp. 122-123.
- Homer-Dixon, T., Percival, V. (1996). "Environmental scarcity and violent conflict: The case of Rwanda." *Journal of Environment and Development*. 5, pp. 270-291.
- Huggins, C., Musahara, H. (2004). Conference paper: "Land reform, governance and the environment: The case of Rwanda". 4th Regional Session of the Global Biodiversity Forum (GBF) for Africa, White Sands Hotel and Resort, 9-11 June 2004. African Centre for Technology Studies. Dar es Salaam, United Republic of Tanzania.
- Hughes, R.H., Hughes, J.S. (1992). *A directory of African wetlands*. IUCN/UNEP/WCMC. Gland, Switzerland.
- Incorporated Research Institutions for Seismology (IRIS). (2002). "Special report: Nyiragongo Volcano." 21 January. Accessed on 21 October 2008.
<http://www.iris.edu/news/events/congo/congo.htm>
- Institute of National Museums of Rwanda. (2008). "National Museum of Rwanda." Accessed on 4 October 2008.
<http://www.museum.gov.rw/>
- International Council on Mining and Metals. (2007). *Metals environmental risk assessment guidance*. ICM. London.

- International Development Association. (2007). *Rwanda: Recovery, rehabilitation and hope*. World Bank. Washington, D.C.
- International Federation of the Red Cross. (2008). "Rwanda: Floods." Disaster Relief Emergency Fund operation MDRRW003, update No. 1. n.p.
- International Fund for Agricultural Development (IFAD). (2008). "Rwanda statistics." <http://operations.ifad.org/web/ifad/operations/country/home/tags/rwanda>
- International Mire Conservation Group. (2004). "Rwanda." 31 January. <http://www.imcg.net/gpd/africa/rwanda.pdf>
- International Union for Conservation of Nature. (2008). "The IUCN Red List of Threatened Species." Accessed on 14 September 2008. <http://www.iucnredlist.org/>
- Kabalira, S. (2007). Master's thesis: "La protection juridique de la flore sauvage dans les pays des grands lacs: Cas du Rwanda. Mémoire présenté en vue de l'obtention du Master en Droit International et Comparé de l'Environnement". Université de Limoges. Limoges.
- Kalimba, I., de Langen, M. (2007). "Infrastructure provision as part of slum upgrading: The case of Kigali, Rwanda." ENHR International Conference on Sustainable Urban Areas, 25-28 June. UNESCO-Institute for Water Education. Rotterdam.
- Kamanzi, S. (2007). *Infrastructure sector*. Ministry of Infrastructure, Republic of Rwanda. Kigali.
- Kameri-Mbote, P. (2007). "Environmental conflict and cooperation in the African Great Lakes region." Report of the regional consultations, 22-23 August. United Nations Environment Programme (UNEP) and Woodrow Wilson International Center for Scholars. Nairobi.
- Kigali City official website. (n.d.) "Kigali city moves forward with the implementation of the master plan." Accessed on 2 October 2008. <http://www.kigalicity.gov.rw/spip.php?article490>
- Kigali Institute of Sustainable Technology. (2005). "Report on the National Seminar on Sustainable Consumption and Production." n.p. Kigali.
- Kimaru, G., Jama, B. (2006). ICRAF Working Paper: "Improving land management in eastern and southern Africa: A review of practices and policies". World Agroforestry Centre. Nairobi, Kenya.
- Kleine-Ahlbrandt, S. (2004). "Learning lessons from IDP resettlement: Villagisation in north-west Rwanda." *Forced Migration Review*. 21 (September), pp. 23-25.
- Kondylis, F. (2007). Households in Conflict Network Working Paper 28: "Agricultural outputs and conflict displacement: Evidence from a policy intervention in Rwanda". Institute of Development Studies. Falmer-Brighton.
- Lake Victoria Environmental Management Project (LVEMP). (2002). "Integrated water quality/Limnology study for Lake Victoria: Final report." World Bank. Washington, D.C.
- Lambin, E.F., Turner II B.L. et al. (2001). "The causes of land-use and land-cover change: Moving beyond the myths." *Global Environmental Change: Human and Policy Dimensions*. 11, pp. 261-269.

- Lamprey, R.H. (2002). "Akagera-Mutara aerial survey, Rwanda: Final report, February-March 2002." GTZ. Kigali. 110 p.
- Le Roux, H. (2004). "Evidence and analysis: The role of natural resources in fuelling and funding conflict in Africa." September. Paper submitted to the Commission for Africa. London.
- Liben, L. (1961). "Les bosquets xérophiles du Bugesera (Rwanda)." *Bulletin de la Société Royale de Botanique de Belgique*. 93, pp. 93-111.
- Lindholm, T. (n.d.). "Peat mining in Finland in relation to other mire uses and its landscape role." Finnish Environment Institute, Expert Services Department, Nature Division. Helsinki. http://www.pole-tourbieres.org/docs/Lamoura_Lindholm.pdf
- Lomberg, Bjorn (2001), *The Skeptical Environmentalist: Measuring the Real State of the World*. Cambridge: Cambridge University Press.
- Loveridge, S., Orr, A. et al. (2007). *Agriculture and poverty in Rwanda: A comparative analysis of the EICV1, EICV2, and LRSS Surveys*. Natural Resources Institute, Michigan State University and Oxford Policy Management. Oxford.
- Löw, P. (2008). *Weather-related disasters dominate*. Worldwatch Institute. Washington, D.C.
- Making Medical Injections Safer. (2007). "Small-scale incinerator construction: Recommendations from the Rwanda experience." <http://www.who.int/management/Small%20Scale%20Incinerators%20-%20Rwanda.pdf>
- Mamdani, M. (2002). *When victims become killers: Colonialism, nativism, and the genocide in Rwanda*. Princeton University Press. Princeton, New Jersey.
- Marge. (2008a). *Biomass energy strategy (Best), Rwanda. Volume 1 – Analysis*. GTZ. Kigali.
- Marge. (2008b). *Biomass energy strategy (Best), Rwanda. Volume II – Strategy*. GTZ. Kigali.
- Maryland Department of Health and Mental Hygiene. (2006). "Reporting for the week ending 01/14/06 (MMWR Week # 02)." *Bioterrorism Bulletin 2006*. http://bioterrorism.dhmh.state.md.us/bt_reports/2006/BT11406.pdf
- Masozera, M. (2008). "Valuing and capturing the benefits of ecosystem services of Nyungwe watershed, Southwest Rwanda." World Conservation Society-Protected Area Biodiversity internal report. Kigali. 49 p.
- Masozera, M. (2002). Master's thesis: "Socio-economic impact analysis of the conservation of the Nyungwe Forest Reserve, Rwanda". University of Florida. Gainesville.
- Matungulu, K., Muhoro Ndung'u, Mulisa, A. (2006). "The social-economic and ecological assessment report for Gikondo Valley wetland and industrial zone." Report prepared by the Kigali Industrial Environment Management Programme. Rwanda Environmental Management Authority (REMA) in collaboration with UNHABITAT, UNEP and UNDP. Kigali.
- Meadows, Donella and Dennis Meadows, eds. (1972), *The Limits to Growth: A Report for the Club of Rome's Project on the Predicament of Mankind*. New York: Universe Books.
- Médecins Sans Frontières. (1994). Project proposal: "Management of water supply and distribution to Rwandese refugees, Goma, Zaire". MSF. Paris.

- Mehta, H., Katee, C. (2005). *Virunga Massif Sustainable Tourism Development Plan*. Prepared for ICCN/ORTPN/UWA/IGCP.
http://www.igcp.org/pdf/VirungaTourismMasterPlan_%20Final%20Report.pdf
- Meybeck, M., Helmer, R. (1989). "The quality of rivers from pristine to global pollution." *Palaeogeography, Palaeoclimatology, Palaeoecology*. 75, pp. 283-309.
- Mihigo, A. (1999). *Collecte et analyse de données pour l'aménagement durable des forêts – joindre les efforts nationaux et internationaux*. Food and Agricultural Organization (FAO). Kigali.
- Mo Ibrahim Foundation. (2008). "The Ibrahim Index of African Governance 2008." Accessed on 3 October 2008.
<http://www.moibrahimfoundation.org/>
- Morgan, R.P.C. (1995). *Soil erosion and conservation*. Longman Group. Essex, United Kingdom.
- Musahara, H. (2007). Nile Basin Initiative policy brief: "Sustainable use of water and natural resources in the Nile Basin". Nile Basin Initiative. Entebe, Uganda.
- Mutamba, J., Izabiriza, J. (2005). *The role of women in reconciliation and peacebuilding in Rwanda: Ten years after genocide 1994-2004*. National Unity and Reconciliation Commission (NURC). Kigali.
- National University of Rwanda. (1981). *Rwanda atlas*. NUR. Kigali.
- Nearing, M.A. (1997). «A single continuous function for slope steepness influence on soil loss.» *Soil Science Society of America Journal*. 61, pp. 917-919.
- New Partnership for Africa's Development. (2005). *Rwanda NEPAD Magazine*. Issue No. 004, December 2005. Kigali.
- Ngarambe, V. (2006). "Community-level land, forests, and water conservation: Study on mitigating soil erosion in Rwanda through Micro-Grants Funds." Nile Transboundary Environmental Action Project (NTEAP). Kigali.
- Nile Basin Initiatives. (2007). "Kagera River Basin monograph – basin development report." Report published by NELSAP with assistance from BRL, Ingénierie. Kigali.
- Nsengimana, S. (2009). Personal communication. 28 April. Kigali.
- Ojoyi, M.M. (2006). *Sustainable use of papyrus Cyperus papyrus at Lake Victoria wetlands in Kenya: A case study of Dunga and Kusa swamps*. Sustainability Institute and Tecnologico' de Monterrey. Mexico.
- Omamo, S.W., Diao, X. et al. (2006). Research report No. 150: "Strategic priorities for agricultural development in Eastern and Central Africa". International Food Policy Research Institute. Washington, D.C.
- Osodo, P., Rwamugema, H. (2001). *Report of the evaluation of the Government of Rwanda – UNICEF Water and Environmental Sanitation Programme*. UNICEF Rwanda Country Office and Republic of Rwanda. Kigali.
- Oz Architecture, EDAW, Tetra Tech, ERA and Engineers without Borders. (2007). *Kigali Conceptual City Masterplan*. Prepared for the Ministry of Infrastructure, Republic of Rwanda. Kigali.

- Pajunen, H. (1999). "Geology of peat deposits in Rwanda and Burundi." *Africa Geoscience Review*. 6(1), pp. 53-64.
- Place, F., Hazell, P. (1993). "Productivity effects of indigenous land tenure systems in sub-Saharan Africa." *American Journal of Agricultural Economics*. 75(1), pp. 10-19.
- Plumptre, A.J., Davenport, T.R.B., Behangana, Kityo M. et al. (2006). "The biodiversity of the Albertine Rift." *Biological Conservation*. 134, pp. 178-194.
- Plumptre A.J., Masozera M., Fasching, P.J. et al. (2002). Wildlife Conservation Society Working Paper 19: "Biodiversity Surveys of the Nyungwe Forest Reserve in S.W. Rwanda". WCS. New York.
- Plumptre, A., Masozera, M., Vedder, A. (2001). *The impact of civil war on the conservation of protected areas in Rwanda*. Biodiversity Support Program. Washington, D.C.
- Private Sector Federation (PSF), Chamber of Industries. (2008). List of industries in Rwanda. Unpublished document. Kigali.
- Prunier, G. (1995). *The Rwanda crisis, 1959-1994: History of a genocide*. Hurst. London.
- Ramsar Convention on Wetlands website. "Contracting parties to the Ramsar Convention on Wetlands." Accessed on 5 September 2008.
http://www.ramsar.org/key_cp_e.htm
- Reetsch, A., Naramabuye, F., Pohl, W., Zachmann, D., Trumper, K., Flugge, J., Nieder, R. (in press). *Properties and quality of soils in the open-cast mining District of Gatumba, Rwanda. Etudes Rwandaises*. n.p.
- Reliefweb. (2008). "Democratic Republic of the Congo/Rwanda earthquake." Accessed on 10 September 2008.
<http://www.reliefweb.int/rw/rwb.nsf/db900SID/SKAI-7BJMPA?OpenDocument>
- Reliefweb. (2002). "DR Congo and Rwanda: Volcanic eruption in Goma, Appeal No. 02/02: Final report." Accessed on 10 September 2008.
<http://www.reliefweb.int/rw/rwb.nsf/db900SID/ACOS-64BRMM?OpenDocument>
- Republic of Rwanda. Ministry of Agriculture and Animal Resources. (2009a). *Agriculture sector performance report, fiscal year 2008*. Kigali.
- Republic of Rwanda. Ministry of Agriculture and Animal Resources. (2009b). "Agricultural statistics 2001-2009."
<http://amis.minagri.gov.rw/content/about-amis>
- Republic of Rwanda. Ministry of Agriculture and Animal Resources. (2009c). *Crop assessment report 2008*. Kigali.
- Republic of Rwanda. Ministry of Infrastructure. (2009d). "Water and sanitation". PowerPoint presentation at the Water and Sanitation Workshop in April, Rubavu District.
- Republic of Rwanda. Ministry of Agriculture and Animal Resources. (2008a draft). *Environmental impact assessment and environmental management plan, Second Rural Sector Support Project*. Kigali.
- Republic of Rwanda. Ministry of Agriculture and Animal Resources. (2008b draft). *Resettlement Policy Framework, Second Rural Sector Support Project*. Kigali.

Republic of Rwanda. Ministry of Trade and Industry. (2008c draft). *Industrial Master Plan 2009-2020*. Kigali.

Republic of Rwanda. (2008d draft). Ministry of Agriculture and Animal Resources. *Strategic Plan for the Transformation of Agriculture in Rwanda – Phase II. (PSTA II)*. Kigali.

Republic of Rwanda. Ministry of Natural Resources. (2008e draft). *Etablissement d'un inventaire national rapide des marais et élaboration de 5 avant-projets d'arrêtés ministériels relatifs aux marais (4 modules)*. Kigali.

Republic of Rwanda. Ministry of Infrastructure. (2008a). *Note conceptuelle sur la mise en application de la politique d'habitat rural groupé 'Imidugudu'*. Kigali.

Republic of Rwanda. Ministry of Infrastructure. (2008b). *Strategic Plan of Habitat and Urbanism Sub-sector for EDPRS Implementation*. Kigali.

Republic of Rwanda. Ministry of Natural Resources. (2008c). "State of the environment 2005-2006." Experco International, Canada, draft report. Kigali.

Republic of Rwanda. Ministry of Agriculture and Animal Resources. (2008d). *Strategic Plan for the Transformation of Agriculture in Rwanda – Phase II. (PSTA II). Final report*. Kigali.

Republic of Rwanda. Ministry of Lands, Environment, Forestry, Water and Mines and Rwanda Institute of Science in Agriculture. (2008e). *Inventaire des ressources ligneuses du Rwanda. Vol. II*. ISAR. Ruhunde.

Republic of Rwanda. Ministry of Infrastructure. (2008f). "Biomass Strategic Workshop proceedings, 30 April." Novotel. Kigali.

Republic of Rwanda. Ministry of Natural Resources. (2008g). *Etablissement d'un inventaire national rapide des marais et élaboration de 5 avant-projets d'arrêtés ministériels relatifs aux marais (Module 2)*. Kigali.

Republic of Rwanda. Ministry of Natural Resources. (2008h). *Etablissement d'un inventaire national rapide des marais et élaboration de 5 avant-projets d'arrêtés ministériels relatifs aux marais (4 modules)*. Kigali.

Republic of Rwanda. Ministry of Infrastructure. (2008i). *Recruitment of consultancy company for Rural Energy Survey*. Kigali.

Republic of Rwanda. (2008j). *Rwanda water and sanitation expenditure review report 2007*. Kigali.

Republic of Rwanda. Ministry of Agriculture and Animal Resources (2008k). "The agricultural sector." Accessed 1 October 2008.
<http://www.minagri.gov.rw/>

Republic of Rwanda. Ministry of Defence. (2008l). *Demining in post-conflict peacebuilding*. May. Kigali.

Republic of Rwanda. Disaster Management Unit. (2007-2008). "Minutes of meetings." Kigali.

Republic of Rwanda. Ministry of Finance and Economic Planning. (2007a). *Economic Development and Poverty Reduction Strategy 2008-2012*. Kigali.

Republic of Rwanda. Ministry of Lands, Environment, Forestry, Water and Mines and Rwanda Institute of Science in Agriculture. (2007b). *Cartographie des forêts au Rwanda. Vol. I*. ISAR. Ruhunde.

Republic of Rwanda. Ministry of Infrastructure. (2007c). *Financing EDPRS priority sectors: Progress and challenges*. Kigali.

Republic of Rwanda. Ministry of Infrastructure. (2007d). *National urbanisation policy*. Kigali.

Republic of Rwanda. National Institute of Statistics. (2007e). *Millennium Development Goals: Country report 2007*. Kigali.

Republic of Rwanda. Ministry of Lands, Environment, Forests, Water and Mines (2007f). “Third national report of the Convention on Biological Diversity.” Kigali.

Republic of Rwanda. (2007g). *Organic Law No. 04/2005 of 08/04/2005 – Determining the Modalities of Protection, Conservation and Promotion of Environment in Rwanda*. Kigali.

Republic of Rwanda. (2006a). *Law N° 16/2006 Determining the Organisation, Functioning and Responsibilities of Rwanda Environment Management Authority*. Kigali.

Republic of Rwanda. Ministry of Lands, Environment, Forestry, Water and Mines. (2006b). *National Adaptation Programme of Action to Climate Change*. Kigali.

Republic of Rwanda. Rwanda Environmental Management Authority. (2006c). *National Programme for Adaptation on Climate Change*. Kigali.

Republic of Rwanda. Ministry of Agriculture and Animal Resources. (2006d). *The Bugesera Agricultural Development Support Project (PADAB)*. Kigali.

Republic of Rwanda. Ministry of Agriculture and Animal Resources and Ministry of Finance and Economic Planning. (2006e). *Enquête agricole 2005: Rapport provisoire*. Unpublished report. Kigali.

Republic of Rwanda. Ministry of Agriculture and Animal Resources. (2006f). *Agricultural survey*. Kigali.

Republic of Rwanda. National Institute of Statistics. (2006g). *Poverty update report: Integrated Living Conditions Survey 2005/6 (draft)*. Kigali.

Republic of Rwanda. National Institute of Statistics. (2006h). *Demographic and Health Survey 2005*. Kigali.

Republic of Rwanda. Ministry of Commerce, Industry, Investment Promotion, Tourism and Cooperatives. (2006i). *National Industrial Sector Promotion Policy*. Kigali.

Republic of Rwanda. (2005a). *Organic Law No. 08/2005 of 14/07/2005: Determining the Use and Management of Land in Rwanda*. Kigali.

Republic of Rwanda. (2005b). *Organic Law No. 04/2005 of 08/04/2005: Determining the Modalities of Protection, Conservation and Promotion of Environment*. Kigali.

Republic of Rwanda. Ministry of Lands, Environment, Forestry, Water, and Mines. (2005c). “Unité forêt.” Cited in Republic of Rwanda. Ministry of Natural Resources (2008 draft). *State of the Environment 2005-2006*. Kigali.

- Republic of Rwanda. Ministry of Natural Resources. (2005d). *Projet de Gestion Nationale des Ressources en Eau: Composante B – Water Data Management: Summary report*. SGI Ingenierie SA. Geneva.
- Republic of Rwanda. Ministry of Natural Resources. (2005e). *Projet de Gestion Nationale des Ressources en Eau: Composante D – Etudes techniques, rapport generale*. SGI Ingenierie SA. Geneva.
- Republic of Rwanda. Ministry of Lands, Environment, Forestry, Water and Mines. (2005f). *Initial national communication under the United Nations Framework Convention on Climate Change*. Kigali.
- Republic of Rwanda. Ministry of Finance and Economic Planning. (2005g). *Poverty Reduction Strategy. Annual progress report July 2005*. MINECOFIN. Kigali.
- Republic of Rwanda. Ministry of Lands, Environment, Forests, Water and Mines. (2005h.) *Deuxième rapport national sur la Convention de la Diversité Biologique*. Kigali.
- Republic of Rwanda. Ministry of Lands, Environment, Forestry, Water and Mines. (2005i). *National communication on climate change*. Kigali.
- Republic of Rwanda. Ministry of Agriculture and Animal Resources. (2004a). *National Agricultural Policy*. Kigali.
- Republic of Rwanda. Ministry of Infrastructure. (2004b). *National Human Settlement Policy in Rwanda*. Kigali.
- Republic of Rwanda. Ministry of Agriculture and Animal Resources. (2004c). *Strategic Plan for the Transformation of Agriculture in Rwanda – Phase I. (PSTA I)*. Kigali.
- Republic of Rwanda. Ministry of Natural Resources. (2004d). *Sectoral Policy on Water and Sanitation*. Kigali.
- Republic of Rwanda. Ministry of Infrastructure. (2004e). *Energy sector strategies (2005-2010)*. Kigali.
- Republic of Rwanda. Ministry of Infrastructure. (2004f). *Energy Policy for Rwanda*. Kigali.
- Republic of Rwanda. Ministry of Natural Resources. (2004g). *National Land Policy*. Kigali.
- Republic of Rwanda. (2003a). *The Constitution of the Republic of Rwanda*.
- Republic of Rwanda. Ministry of Lands, Environment, Forestry, Water and Mines. (2003b). *National Land Policy*. Kigali.
- Republic of Rwanda. Ministry of Lands, Environment, Forestry, Water and Mines. (2003c). *National Strategy and Action Plan for the Conservation of Biodiversity in Rwanda*. Kigali.
- Republic of Rwanda. Ministry of Lands, Environment, Forests, Water and Mines. (2003d). “Etudes relatives à la protection intégrée et conservation des ressources naturelles des zones humides critiques du Rwanda: Evaluation de la diversité biologique des zones humides.” Experco des Grands Lacs. Kigali.
- Republic of Rwanda. Ministry of Agriculture and Animal Resources. (2002a). *Schéma Directeur d'Aménagement des Marais, de protection des Bassin Versant et de la Conservation des Sols*. Kigali.
- Republic of Rwanda. Ministry of Finance and Economic Planning. (2002b). *National Investment Strategy*. Kigali.

- Republic of Rwanda. National Census Service (2002c). *The general census of population and housing*. Kigali.
- Republic of Rwanda. Ministry of Local Government, Community Development and Social Affairs. (2002d). *Decentralization Policy*. Kigali.
- Republic of Rwanda. Ministry of Finance and Economic Planning. (2000a). *Rwanda Vision 2020*. Kigali.
- Republic of Rwanda. Ministry of Finance and Economic Planning (2000b). *Household Living Conditions Survey*. Kigali.
- Republic of Rwanda. Ministry of Local Government, Community Development and Social Affairs. (2000c). *Implementation Strategy for National Decentralisation Policy*. Kigali.
- Republic of Rwanda. Ministry of Agriculture and Animal Resources. (1998). *Stratégie et plan d'action pour la sécurité alimentaire*. Kigali.
- Republic of Rwanda. Ministry of Agriculture and Animal Resources. (1992). "Soil map of Rwanda." Kigali.
- Republic of Rwanda. Ministry of Agriculture and Animal Resources. (1991). *Commission de l'agriculture*. Kigali.
- Republic of Rwanda. National Meteorological Services. (1990-2007). "Unpublished data on average annual temperatures and Kigali." Kigali.
- Republic of Rwanda. National Meteorological Services. (1961-1990). *Annual Bulletin Climatologique*. Annual publication. Kigali.
- Republic of Rwanda. Ministry of Finance and Economic Planning. (n.d.). "Energy and water." Accessed on 13 September 2008.
<http://www.privatisation.gov.rw/eng/indexe.htm>
- Republic of Rwanda. Ministry of Finance and Economic Planning. (n.d.). "The mining sector." Accessed on 13 September 2008.
<http://www.privatisation.gov.rw/eng/indexe.htm>
- Republic of Rwanda. Ministry of Natural Resources. (n.d.). "Rwanda environment policy." Kigali.
http://www.minirena.gov.rw/IMG/pdf/POLITIQUE_ENVIRON.__Anglais_.pdf
- Republic of Rwanda. Ministry of Natural Resources and United Nations Environment Programme/United Nations Development Programme (UNEP/UNDP). (2008). Project Identification Form (PIF): "Reducing vulnerability to climate change by establishing early warning and disaster preparedness systems and support for integrated watershed management in flood prone areas." 22 October. Global Environment Facility (GEF) Secretariat. Kigali.
- Republic of Rwanda, United Nations Development Programme et al. (2007). *Guidelines for mainstreaming environment in the Economic Development and Poverty Reduction Strategy. Poverty Environment Initiative*. Rwanda Environment Management Authority (REMA). Kigali.
- Republic of Rwanda and United Nations Development Programme (UNDP). (2003). *Millennium Development Goals status report 2003*. UNDP. Kigali.

Rwanda Investment and Export Promotion Agency. (n.d.). "Investment in natural gas." Accessed on 10 September 2008.
<http://www.rwandainvest.gov.rw/Naturalgas.htm>

Ripley, E.A., Redmann, R.E., Crowder, A.A. (1996). *Environmental effects of mining*. CRC Press. Ontario.

Roose, E., Ndayizigiye, F. (1997). "Agroforestry, water and soil fertility management to fight erosion in tropical mountains of Rwanda." *Soil Technology*. 11(1), pp. 109-119.

Rotterdam Convention webpage. "Country profiles". Accessed on 3 October 2008.
<http://www.pic.int/reports/countryprofiles.asp>

Rowntree, K.M. (1982). "Rainfall erosivity in Kenya – some preliminary considerations." Proceedings of the Second National Workshop on Soil and Water Conservation in Kenya, 10-13 March. University of Nairobi, Kenya Institute for Development Studies and Faculty of Agriculture. Nairobi.

Rugege, D. (2006). "Mapping of wetlands and other fragile aquatic ecosystems in Kigali City region." Draft report prepared for the Rwanda Environmental Protection Authority, MINIRENA, Republic of Rwanda. Kigali.

Rurangwa, E. (2002). "Perspective of land reform in Rwanda." Paper presented at the FIG XXII International Congress, 19-26 April. Washington, D.C.

Rutungwa, V. et al. (2007). "Soil use and management strategy for raising food and cash output in Rwanda." Wageningen University and Research Centre. Wageningen.

Rutungwa, V., Neel, H. (2006). "Yield trends in the long-term crop rotation with organic and inorganic fertilisers on Alisols in Mata (Rwanda)." *Biotechnologie, Agronomie, Société et Environnement*. 10, pp. 217-228.

Sachs, J. (2005). "Climate change and war." 1 March. *TomPaine.com*
http://www.tompaine.com/print/climate_change_and_war.php

Sano, J.C. (2007). Msc thesis: "Urban environmental infrastructure in Kigali City Rwanda: Challenges and opportunities for modernised decentralised sanitation systems in poor neighbourhoods". Wageningen University. Wageningen.

Satterthwaite, D. (2003). "The links between poverty and the environment in urban areas of Africa, Asia and Latin America." *The Annals of the American Academy*. 590 (November), pp. 73-92.

Saunders, C. (1997). "Where have all the flowers gone...and the trees...and the gorillas?" *UNHCR Refugees Magazine*. Issue 110.

Sebastian, B. (2003). "Rwanda forests: Their abrupt destruction and the recovery programme." Paper submitted to the XII World Forestry Congress 2003. Quebec City. Accessed on 16 September 2008.
<http://www.fao.org/DOCREP/ARTICLE/WFC/XII/0171-B3.HTM>

Sendege, Norbert, Acting Director-General of Rwanda Agricultural Development Authority (RADA). (2009). Personal communication (verbal). May. Kigali.

Shaxson, F., Kassam, A. et al. (2008). Background paper: "Underpinning conservation agriculture's benefits: The roots of soil health and function". Workshop on Investing in Sustainable Crop Intensification: The Case for Improving Soil Health, 22-24 July. Food and Agriculture Organization (FAO). Rome.

- Simon, J. (1998). *The ultimate resource 2*. Princeton University Press. Princeton.
- SNC-Lavalin International Inc. (2006 draft). "Strategic/sectoral, social and environmental assessment of power development options in the Nile Equatorial Lakes region, Supplemental analysis – Climate change and potential impacts on hydro generation." Interim report – Climate change and impacts on runoff. n.p.
- SNV. (2005). "Development of a national biogas sector in Rwanda." Paper presentation, 20 May. Kigali.
- Sondorp, E., Prescott, G., Elema, R. (1995). *External valuation of the refugee emergency program, Goma/katale, North Kivu, Zaire*. Médecins Sans Frontières. Paris.
- Sperling, L. (2001). "The effect of the civil war on Rwanda's bean seed systems and unusual bean diversity." *Biodiversity and Conservation*. 10(6), pp. 989-1009.
- Sustainable Energy Africa (SEA). (2006). Poverty and Environment Initiative (PEI) concept note: "Mainstreaming environment in energy: Strategies to address poverty in Rwanda." PEI Rwanda. Kigali.
- Theuri, D. (2007). *Energy sector costing to meet Rwanda's Economic Development and Poverty Reduction Strategy (EDPRS) and the East Africa Community Regional Access to Modern Energy Services Strategy*. United Nations Environment Programme (UNEP). Nairobi.
- Thieme, M. et al. (2005). *Freshwater ecoregions of Africa and Madagascar: A conservation assessment*. Island Press. Washington, D.C.
- Tiemessen, A. (2005). "Post-genocide Rwanda and villagisation: The human insecurity of dwindling land entitlements." Paper prepared for the Annual International Studies Association (ISA) Convention in Honolulu, Hawaii, 1-5 March.
- Troupin, G. (1966). *Etude phytocénologique du Parc National de l'Akagera et du Rwanda Oriental. Recherche d'une méthode d'analyse appropriée à la végétation d'Afrique Intertropicale, No. 2*. Institut National de Recherche Scientifique. Butare.
- Turkelboom, F., Poesen, J. et al. (2008). «The multiple land degradation effects caused by land-use intensification in tropical steeplands: A catchment study from northern Thailand.» *CATENA*. 75(1), pp. 102-116.
- Twagiramungu, F. (2006). "Environmental profile of Rwanda." Report commissioned by the European Commission for the Republic of Rwanda. Kigali.
- United Nations. (2008). *One UN Programme Rwanda Common Operational Document 2008-2012*. United Nations. Kigali.
- United Nations. (2000). *Common country assessment 1999-2000*. United Nations. Kigali.
- United Nations Convention to Combat Desertification website on Rwanda. Accessed on 23 September 2008. <http://www.unccd.int/php/countryinfo.php?country=RWA>
- United Nations Department of Economic and Social Affairs. (2008). *World urbanization prospects 2007*. United Nations Population Division. New York.
- United Nations Development Programme. (2007). "Turning Vision 2020 into reality: *From recovery to sustainable human development*." *National Human Development Report*. UNDP. Kigali.

United Nations Development Programme. (2005). "East African energy scale-up initiative – Rwanda national paper." UNDP. Nairobi.

United Nations Development Programme. (1999). *Rwanda Human Development Report*. UNDP. Kigali.

United Nations Environment Programme. (2009). "From conflict to peacebuilding: The role of natural resources and the environment." UNEP. Nairobi.

United Nations Environment Programme Ozone Secretariat webpage on Rwanda. n.d. Accessed on 21 October 2008.

http://ozone.unep.org/Ratification_status/ratif_by_country.shtml?cntryname=Rwanda

United Nations Environment Programme/World Conservation Monitoring Centre. (2009). UNEP/WCMC Species Database: "CITES-listed species". UNEP. Cambridge.

United Nations Environment Programme/United Nations Development Programme/Rwanda Environment Management Authority (REMA). (2007). "Pilot integrated ecosystem assessment of Bugesera." Poverty and Environment Initiative Project. UNEP/UNDP. Kigali.

United Nations Framework Convention on Climate Change website on Rwanda. Accessed on 3 October 2008. <http://maindb.unfccc.int/public/country.pl?country=RW>

United Nations High Commissioner for Refugees. (2008a). "Global report 2007." UNHCR. Geneva.

United Nations High Commissioner for Refugees. Kigali Branch Office. (2008b). "June fact sheet." UNHCR. Kigali.

United Nations High Commissioner for Refugees. (2007). "Annual statistics report." UNHCR. Geneva.

United Nations High Commissioner for Refugees. (2006). "Annual statistics report." UNHCR. Geneva.

United Nations High Commissioner for Refugees. (1995a). *The state of the world's refugees: In search of solutions*. Oxford University Press. Oxford.

United Nations High Commissioner for Refugees. (1995b). "Refugees and the environment." UNHCR. New York.

United Nations High Commissioner for Refugees. (1993). *State of the world's refugees: The challenge of protection*. Penguin Books. New York.

United Nations International Strategy for Disaster Reduction. (2009). "UNISDR terminology on risk reduction."

<http://www.unisdr.org/eng/terminology/UNISDR-Terminology-English.pdf>

United Nations Office for the Coordination of Humanitarian Affairs (OCHA). (2007). "Rwanda. Humanitarian country profile." *IRIN humanitarian news and analysis*. March. Accessed on 10 September 2008.

<http://www.irinnews.org/country.aspx?CountryCode=RW&RegionCode=GL>

United Nations World Water Assessment Programme. (2006). *Water: A shared responsibility*. UN World Water Development: Report 2. United Nations Educational, Scientific and Cultural Organization (UNESCO). Paris. Berghahn Books. New York.

- United States Agency for International Development (USAID). (2002). “Democratic Republic of Congo – Volcano fact sheet No.7.” Democracy, Conflict, and Humanitarian Assistance (DCHA) Office of U.S. Foreign Disaster Assistance (OFDA). 25 January. Washington, D.C.
- United States Agency for International Development (USAID)/ARD, Inc. (2005). “Solid waste recycling and biomass energy production.” Cited in Marge. (2008). *Biomass energy strategy (BEST), Rwanda. Volume 1 – Analysis*. GTZ. Kigali.
- United States Committee for Refugees and Immigrants. (2008). “World Refugee Survey 2008.” 12 June. USCRI. Washington, D.C. Accessed on 1 November 2008. <http://www.refugees.org/article.aspx?id=2114>
- United States Environmental Protection Agency. (2000). *Guiding principles for constructed treatment wetlands: Providing for water quality and wildlife habitat*. USEPA. Washington, D.C.
- Uwizeye, J.C., Hammill, A. (2007). “Reducing the vulnerability of Rwanda’s energy sector to the impacts of climate change.” Workshop report on the UNEP GEF pilot project implemented by KIST with support from IISD and ACTS. CITT (KIST). Kigali.
- Vanderplas, R. (2004). “Biomass energy in Rwanda – An update.” Prepared for MININFRA (Poverty Reduction Strategy Credit). World Bank. Washington, D.C.
- Vedder, A., Hall, J., Harcourt, A., Wilson, R. (1992). “Burundi and Rwanda.” In J. Sayer, A. Harcourt and N.M. Collins (Eds.), *The conservation atlas of tropical forests: Africa*. International Union for Conservation of Nature (IUCN) and Simon and Schuster. New York.
- Verpoorten, M. (2008). “Household coping in war and peacetime: Cattle sales in Rwanda, 1991-2001.” *Journal of Development Economics*. In press.
- Waller, D. (1993). *Rwanda: Which way now?* Oxfam Country Profiles, Oxfam Publications. Oxford.
- Wassmer, P. (1981). PhD thesis: “Recherches géomorphologiques au Rwanda: Etude de l’érosion des sols et de ses conséquences dans la Préfecture de Kibuye”. Université Louis Pasteur. Strasbourg.
- Waters, T. (1997). *The Rwandan demographic crisis or why current repatriation policies will not solve Tanzania’s (or Zaire’s) refugee problems*. California State University. Chico.
- Watson, R.T. and the Core Writing Team (Eds.). (2001). *Third assessment report of the Intergovernmental Panel on Climate Change*. Cambridge University Press. Cambridge.
- Weber, M. (1989). PhD thesis: “Conservation and development on Zaire-Nile divide: An analysis of value of conflicts and convergence in the management of Afromontane forests in Rwanda”. University of Wisconsin. Madison.
- Weggoro, N.C. (2007). “EAC regional strategy for scaling up access to modern energy services and biofuels in East Africa.” Presentation at the first high-level biofuels seminar in Africa. Addis Ababa.
- White, F. (1983). *The vegetation of Africa: A descriptive memoir to accompany the UNESCO/AETFAT/UNSO vegetation map of Africa*. United Nations Educational, Scientific and Cultural Organization (UNESCO). Paris.
- Wildlife Conservation Society. (2008). “Nyungwe National Park.” October. Accessed 2 November 2008. <http://archive.wcs.org/globalconservation/Africa/rwanda/nyungwe.html>

Wildlife Conservation Society. (2006). *Biodiversity survey of Mukura forest*. Rwanda Ecological Association (ARECO). Kigali.

Williams, S.D., Ntayombya, P. (1999). *Akagera: An assessment of the biodiversity and conservation needs*. Field Conservation and Consultancy, Zoological Society of London, Regent's Park London, in collaboration with the Ministry of Agriculture and Animal Resources, Republic of Rwanda. London.

Wolf, A.T., Priscoli, J.D. (2006). *Resolving international water resource conflicts*. Cambridge University Press. Cambridge.

World Bank. (2008). *Millennium Development Goals indicators - Rwanda*. World Bank. Washington, D.C. Accessed on 4 October 2008. http://ddp-ext.worldbank.org/ext/ddpreports/ViewSharedReport?&CF=&REPORT_ID=1305&REQUEST_TYPE=VIEWADVANCED

World Bank. (2008a). "Development economics LDB database: Rwanda at a glance." http://devdata.worldbank.org/AAG/rwa_aag.pdf

World Bank. (2008b). *Country Assistance Strategy for the Republic of Rwanda: IDA, IFC, MIGA*. Report No. 44938-RW. http://www-wds.worldbank.org/external/default/WDSCContentServer/WDSP/IB/2008/09/04/000334955_20080904035214/Rendered/PDF/449380CAS0P1001ONLY10IDA1R200810257.pdf

World Bank. (2008c). *World Development Indicator Database*. World Bank. Washington, D.C. Accessed on 2 October 2008. <http://web.worldbank.org/WBSITE/EXTERNAL/DATASTATISTICS/0,contentMDK:22151356~pagePK:64133150~piPK:64133175~theSitePK:239419,00.html>

World Bank. (2007). "Poverty alleviation and economic growth in Rwanda through S&T." Accessed on 23 September 2008. http://www.betuco.be/rwanda/Science_and_Technology_for_Economic_Growth.pdf

World Bank. (2006). *Millennium Development Goals*. World Bank. Washington, D.C.

World Bank. (2005). "Urban infrastructure and management project." Project Appraisal Document. World Bank. Washington, D.C.

World Bank. (2000). *The nexus between violent conflict, social capital and social cohesion: Case studies from Cambodia and Rwanda*. World Bank. Washington, D.C.

WorldChanging Team. (2007). "Eye on Mali: Jatropha oil lights up villages." 5 June. Accessed on 10 September 2008. <http://www.worldchanging.com/archives/006814.html>

World Health Organization. (2008). "Data and statistics." Accessed on 11 October 2008. <http://www.who.int/research/en/>

World Health Organization. (2006a). "Particulate matter, ozone, nitrogen dioxide and sulfur dioxide." *Air Quality Guidelines Global Update 2005*. WHO. Geneva.

World Health Organization. (2006b). "Air quality guidelines for particulate matter, ozone, nitrogen dioxide and sulfur dioxide: Summary of risk assessment." *Air Quality Guidelines Global Update 2005*. WHO. Geneva.

- World Health Organization. (2006c). "Country health system fact sheet: Rwanda." http://www.afro.who.int/home/countries/fact_sheets/rwanda.pdf
- World Health Organization. (2006d). *Guidelines for drinking water quality: incorporating first addendum. Volume 1: Recommendations*, 3rd edition. WHO. Geneva.
- World Health Organization. (2005). "Indoor air pollution and health. Fact sheet No. 292." WHO. Geneva. Accessed on 11 October 2008. <http://www.who.int/mediacentre/factsheets/fs292/en/index.html>
- World Health Organization and United Nations Children's Fund. (2008). Joint Monitoring Programme for Water and Sanitation. *Progress on drinking water and sanitation: Special focus on sanitation*. UNICEF. New York. WHO. Geneva. pp. 50-57.
- World Resources Institute. (2003). "Earth trends: Country profiles." WRI. Washington, D.C. Accessed on 22 October 2008. <http://earthtrends.wri.org>
- World Wide Fund for Nature website. (2005). Accessed on 6 November 2008. http://www.panda.org/about_our_earth/ecoregions/albertine_montane_forests.cfm
- World Wildlife Fund and Poverty and Environment Initiative (PEI). (2006). "Environmental sustainability in Rwanda's Economic Development and Poverty Eradication Strategies: Towards mainstreaming environment in the EDPRS." Unpublished report.
- Wyss, W. (2006). Swisspeace Working Paper No. 1: "A thousand hills for 9 million people. Land reform in Rwanda: Restoration of feudal order or genuine transformation?" Swiss Peace Foundation. Bern.
- Yager, T.R. (2006). "The mineral industry of Rwanda." *US Geological Survey Minerals Yearbook*. US Geological Survey. Washington, D.C.

List of desk studies and corresponding authors

Commissioned by UNEP in collaboration with the Rwanda Environment Management Authority (REMA)

- Bahizi, O. *Population, poverty and environment in Rwanda*.
- Habiyambere, T. *Forestry sector in Rwanda*.
- Kandasamy, R. *Energy and environment in Rwanda*.
- Mahundaza, J. *Assessment of agriculture and land degradation in Rwanda*.
- Mpambara, A. *Wildlife and protected areas*.
- Mulisa, A. *Industry, mining and infrastructure*.
- Mutabazi, A. *Natural disasters and climate change*.
- Ngendahayo, R. *Water resources in Rwanda*.
- Nyakurama, R. *Urban environment and environmental health report*.
- Nyonzima, S. and Sabuhoro, E. *Population displacement, resettlement and the environment*.
- Rubasha, H. *A report on conflict, peacebuilding and the environment*.
- Twesigye, C. *Environmental governance in Rwanda*.

Appendix 3

Endnotes

Chapter 1. Introduction

- 1 UNDP (2007).
- 2 Ibid.
- 3 Result 4 of the UNDAF elaborates on three specific outcomes, including creating an “effective system for environmental management and ecosystem conservation” (Outcome 1). This report is included under this UNDAF outcome and, specifically, to provide input into the development of an “information management system for natural resources” (Output 1.2). It is explicitly included in the UN Common Operational Document, which defines how the UN will operationalise the UNDAF, and is also listed in the Rwanda UN 2008 Workplan (item 1.2.6).

Chapter 2. Country Context

- 1 RoR (2008k); Rutunga (2007).
- 2 RoR (2004g).
- 3 NUR (1981); RoR (2005d and 2005e).
- 4 FAO (2005b).
- 5 Ibid; USAID (2003).
- 6 WWF (2005).
- 7 White (1983).
- 8 RoR (2006b).
- 9 Ibid; Chemonics International Inc. (2003)
- 10 Ibid.
- 11 Ibid.
- 12 Mehta and Katee (2005)
- 13 RoR (2008h).
- 14 Thieme (2005).
- 15 RoR (2008h).
- 16 RoR (2000b).
- 17 RoR (2002c).
- 18 RoR (2006h).
- 19 RoR (2002c).
- 20 RoR (2004g).
- 21 UNDP (2007).
- 22 These figures were obtained from the national census (1978, 1991, and 2002).
- 23 RoR (2006h).
- 24 Ibid.
- 25 Ibid.

- 26 A number of government surveys have been undertaken to provide a better understanding of household living conditions, namely the EICV-1 conducted in 2001/2002, followed by the EICV-2 in 2005/2006 as well as the DHS conducted in 2005.
- 27 UNDP (2007).
- 28 UNDP (2007).
- 29 RoR (2007a), RoR (2000a), World Bank (2008), World Bank (2008a), World Bank (2008c), IFAD (2008)
- 30 Rwanda is one of the first countries to voluntarily complete a significant governance review under the New Partnership for Africa's Development (NEPAD) and the African Union (AU) (UNDP 2007; IDA 2007; Mo Ibrahim Foundation 2008).
- 31 A National Land Commission has been established to undertake land reform and promote tenure security. Mass land registration will start in 2009.
- 32 World Bank (2007).
- 33 UNDP (2007).
- 34 World Bank (2008b).
- 35 IDA (2007).
- 36 RoR (2006g).
- 37 RoR (2008d draft).
- 38 World Bank AAG (2008a).

Chapter 3. The Assessment Process

- 1 The grandparent isotope of ^{210}Pb is a gas, radon-222, which escapes from surface soil layers into the atmosphere, where it decays rapidly to polonium-218 and is precipitated as dust and in rainfall. Further rapid radioactive decay creates ^{210}Pb , which becomes chemically fixed to sediment particles. ^{210}Pb decays comparatively slowly compared with its parent and grandparent isotopes.
Radioactive decay of ^{210}Pb is very difficult to measure since the process only emits a low-energy β -particle that is difficult to detect and for which there is high background interference. However, its granddaughter isotope is polonium-210, which emits a higher energy α -particle with low background interference and which is, therefore, comparatively easy to detect. It is assumed that the concentration of Pb and Po are equal in undisturbed sediments and a measure of the concentration of ^{210}Po thus indicates the level of ^{210}Pb .

Chapter 4. Conflict, Peacebuilding and the Environment

- 1 Article 7 Report, Convention on the prohibition of the use, stockpiling, production and transfer of anti-personnel mines and on their destruction; Republic of Rwanda, Ministry of Defence and Rwanda National Demining Office. April 2005.
- 2 Landmine and Cluster Munition Monitor. Country Profiles: Rwanda. (2010) of Rwanda, Standing Committee on Mine Clearance, Mine Risk Education and Mine Action Technologies, Geneva, 25 April 2007.
- 3 RoR (2008n).
- 4 Ibid.
- 5 By the end of 1994, about 700,000-800,000 Rwandan refugees were living in the five camps (Katale, Kahindo, Kibumba, Mugunga, and Lac Vert) in the DR Congo. This figure excludes the wave of Rwandan refugees who fled immediately after the 1994 genocide, since the majority returned to Rwanda and eventually regained their homes.

6. Kalpers (2001, p. 5).
7. See Conca and Dabelko (2002); Matthew and Gaulin (2002); Matthew, Halle and Switzer (2002); and UNEP (2009).
8. RoR (2004b).
9. IPCC (2007).

Chapter 5. Population Displacement, Resettlement and the Environment

- 1 UNHCR (2008a).
- 2 UNHCR (2007, 2006); UNHCR (2008b).
- 3 USCRI (2008).
- 4 RoR (2008a).
- 5 RoR (2008b).
- 6 RoR (2004).
- 7 RoR (2005b).
- 8 UNHCR officials advised that an adult refugee requires 30 kilograms of wood per month in this region, where wood is needed for cooking and heating. UNEP site visits to refugee camps in Rwanda revealed, however, that refugees currently receive less than 10 kilograms per month.
- 9 SHER Consulting-Engineers, Summary Report, 2005.

Chapter 6. Disasters and Climate Change

- 1 A disaster is a serious disruption of the functioning of a community or a society causing widespread human, material, economic or environmental losses that constrain the ability of the affected community or society to cope using its own resources. Hazards refer to natural or human-induced processes or phenomena that may constitute a damaging event or cause serious socio-economic disruption (adapted from ISDR 2009).
- 2 <http://www.emdat.be/Database/CountryProfile/countryprofile.php>
- 3 Centre for Research on the Epidemiology of Disasters (2008).
- 4 RoR, UNEP/UNDP (2008).
- 5 RoR (2006b); DMU (2007-2008); Croix Rouge Rwandaise (2007).
- 6 Reliefweb (2008).
- 7 Reliefweb (2002).
- 8 USAID (2002)
- 9 This is based on UN figures.
- 10 This is based on UN and USAID/Office of US Foreign Disaster Assistance (OFDA) field reports (2002).
- 11 Ibid.
- 12 IRIS (2002).
- 13 Ibid.
- 14 RoR and UNEP/UNDP (2008).
- 15 RoR (1961-1990); RoR (1990-2007).
- 16 RoR (2006b).

- 17 RoR (1961-1990); RoR (1990-2007).
- 18 Rainfall data are only available for Kigali Airport (National Meteorological Service/MININFRA).
- 19 RoR (1961-1990); RoR (1990-2007).
- 20 Reliefweb (2002).
- 21 RoR (1961-1990); RoR (1990-2007).
- 22 Risk is the probability of harmful consequences or expected losses resulting from a disaster event (ISDR 2009).
- 23 This report develops a moderate scenario of greenhouse gas emissions known as the A1B scenario (Christensen, J.H., et al. 2007).
- 24 This study uses data (the A1B scenario) from the IPCC's Third Assessment Report (2001) and looks at climate model results using only the best-performing global General Circulation Models (GCMs) (SNC-Lavalin International Inc. 2006 draft report).
- 25 Based on feedback from the Rwanda PCEA Second National Consultations Workshop, 22 out of about 200 meteorological stations have been fully rehabilitated.

Chapter 7. Agriculture and Land Degradation

- 1 RoR (2009a).
- 2 Ibid.
- 3 Ibid.
- 4 RoR (2009c). Figures have been obtained for seasons 2008A, 2008B and 2009A.
- 5 RoR (2008d); RoR (2006h).
- 6 RoR (2006h).
- 7 RoR (2009c).
- 8 RoR (2008d).
- 9 Ibid.
- 10 RoR (2009a); RoR (2008d).
- 11 Regional average combines figures for Burundi, the United Republic of Tanzania and Uganda (RoR 2007).
- 12 FAO (2008a).
- 13 RoR (2009a); RoR (2008d).
- 14 Cited in RoR (2008d).
- 15 However, according to the Acting Director-General of RADA Norbert Sendege the current area under irrigation is 12,000 ha.
- 16 The main agricultural crops targeted for commercial production include: rice, maize, beans, Irish potatoes, floriculture, sericulture, coffee, tea, horticulture and wheat (RoR 2008d).
- 17 It defines four overarching programmes and 17 subprogrammes. These four main programmes relate to: (i) physical resources and food production: the intensification and development of sustainable production systems; (ii) producer organisation and extension: support to the professionalization of producers; (iii) entrepreneurship and market linkages: promotion of commodity chains and the development of agribusiness; and (iv) institutional development: strengthening public and private sectors and the regulatory framework for agriculture.
- 18 Land leases may range from 20 to 99 years, which may be renewed and allows for land transactions (i.e. right of buying, selling, mortgages. inheritance).
- 19 Ngarambe (2006).

- 20 Land degradation occurs in arid, semi-arid and dry sub-humid areas and includes impacts on rain-fed cropland, irrigated cropland, or range, pasture, forest and woodlands and is caused by the following natural or human-induced processes: (i) soil erosion caused by wind and/or water; (ii) deterioration of the physical, chemical and biological or economic properties of soil; and (iii) long-term loss of natural vegetation.
- 21 RoR (2008d).
- 22 Unfortunately, no data are available in Rwanda to measure accelerated soil erosion and its impact on groundwater supplies.
- 23 Waterbreaks (or waterbars) are often used to prevent run-off flowing down an unsurfaced road over long distances. However, waterbreaks are only effective at low traffic densities; heavy or frequent vehicle movements flatten them and fill the waterbreak with sediment. The use of side-ditches, on the other hand, enables the road surface to remain firm and dry by lowering water tables. Provided that a road ditch has been well profiled and has an established grass cover, it should require very little maintenance (FAO 1998).
- 24 MINECOFIN (2007).
- 25 Shaxson, et. al. (2008).
- 26 Balasubramanian and Sekayange (1991).
- 27 Byers (1990).
- 28 Roose and Ndayiziye (1997).
- 29 Experiments with green manure in Rwanda have failed to produce conclusive evidence that increases in crop yields sufficiently compensate for the loss of productive area and labour inputs required (Drechsel, et. al. 1996).
- 30 Rutunga and Neel (2006).
- 31 Kimaru and Jama (2006).
- 32 During field visits to the Ruhengeri Prefecture, UNEP saw many farms on lower slopes with contoured bunds planted with *Pennisetum* sp. On steeper slopes, farmers had planted hedges and constructed temporary earth terracettes and contour trenches.
- 33 RoR (2006e).
- 34 Clay, et.al. (1998).
- 35 Place and Hazel (1993) found a far stronger relationship between investment in farm improvements and land tenure in Rwanda than in either Ghana or Kenya.
- 36 Adegbidi, et.al. (2004).
- 37 Clay, et.al. (1998).
- 38 The World Bank established a new USD 1.2 billion rapid financing facility known as the Global Food Crisis Response Programme (GFRP).
- 39 The development of commercial agriculture will not necessarily lead to greater productivity or reduced land degradation. Byiringiro and Reardon (1996) found a strong inverse relationship between farm size and land productivity in Rwanda. Smaller farms were not more eroded than larger farms and had twice the soil conservation investments. Huggins and Musahara (2004) further pointed out that it is not certain whether the policy of resettlement (*imidugudu*) and the consolidation of landholdings have resulted in greater productivity.
- 40 In addition to knowledge of their crops, Rwandan farmers also have a sound understanding of the ecological variations on their land. Habarurema and Steiner (1997) reported that soils in the mountainous regions of Rwanda show fine scale variation in productive potential, which is not captured in conventional soil classification but which is well known amongst experienced farmers. They showed that farmers use this knowledge to maximise production and minimise risk.

- 41 As mentioned in the overview, most Rwandan households farm multiple plots (five on average) as a risk-minimising strategy. While this approach may appear inefficient in a market-oriented production system, it gives farmers greater access to different types of land with different soil and moisture characteristics (Huggins and Musahara 2004).
- 42 Sperling (2001).
- 43 RoR (2002a)
- 44 Turkelboom, et.al. (2008).
- 45 Loveridge, et.al. (2007).

Chapter 8. Forest Resources

- 1 This tree nursery is supported by *Coopérative des Jeunes Entrepreneurs pour la Protection de l'Environnement* (COJEPE).
- 2 RoR (2005c).
- 3 Plumptre, et al. (2006).
- 4 For further reading on this subject, see Dowsett-Lemaire (1990) and Ewango (2001).
- 5 Dominant species are *Dombeya goetzenii*, *Macaranga kilimandscharica* and *Neoboutonia macrocalyx*, as well as trees and shrubs of the *Rubiaceae* family. For a discussion on the former floristic composition of Gishwati and Mukura forests, see Hartmanshenn (1995) and CIRAD (1992). For the current state of Mukura forest, see WCS (2006).
- 6 Woody species of the highly encroached understorey include: *Acanthus pubescens*, *Clerodendrum johnstonii* subsp. *Johnstonii*, *Drypetes gerrardii* var. *tomentosa*, *Maesa lanceolata*, *Polyscias fulva*, *Rhamnus prinoides*, *Teclea nobilis*, *Xymalos monospora*, and small trees and shrubs of the *Rubiaceae* family.
- 7 For instance, *Macaranga kilimandscharica* and other secondary species such as *Annona senegalensis*, *Maesa lanceolata*, *Polyscias fulva*, and *Xymalos monospora* (FAO 2000).
- 8 Primary species include *Chrysophyllum gorungosanum* and *Entandrophragma excelsum* and other timber species include *Alangium chinense*, *Albizia gummifera* and *Strombosia scheffleri* (FAO 2000).
- 9 Typical gallery forest species are *Acacia kirkii* subsp. *mildbraedii*, growing only in Mutara and along the lake depression of the Akagera River, and *Pterygota mildbraedii*, a conspicuous tree up to 40 m high that was formerly abundant in Gisaka.
- 10 Typical tree species are: *Albizia petersiana*, *Drypetes gerrardii* var. *tomentosa*, *Haplocoelum gallaense*, *Psydrax parviflora* subsp. *parviflora*, *P. schimperiana*, *Tarenna graveolens*, *Teclea nobilis*. The understorey is often dominated by *Strychnos lucens* and *S. usambarensis*, while the thorny shrub *Carissa edulis* is frequent along the forest edge.
- 11 Bloesch (2002).
- 12 Nsengimana (2009). Serge Nsengimana is a representative of ACNR (*Association pour la Conservation de la Nature au Rwanda*) and provided this data during the Rwanda PCEA Second National Consultations Workshop held in Kigali, April 2009.
- 13 *Ficus* tree species include: *F. sur*, *F. thonningii*, *F. vallis-choudae*. Other tall canopy trees include *Celtis africana*, *Ekebergia capensis*, *Markhamia lutea* and *Sapium ellipticum*.
- 14 Other planted species include: *Cupressus lusitanica*, *Acacia melanoxylon*, *Acacia mearnsii*, *Grevillea robusta*, *Callitris robusta* and *Casuarina equisetifolia*.
- 15 Indigenous tree species include: *Entandrophragma excelsum*, *Maesopsis eminii*, *Podocarpus falcatus*, *Polyscias fulva* and *Symphonia globulifera*.
- 16 RoR (1991).

- 17 Different agroforestry systems have been promoted since the 1980s by ICRAF and by several bilateral donors, especially the GTZ (*Projet-Agro-Pastoral* Nyabisindu).
- 18 Mihigo (1999).
- 19 FAO (2007); data from 2005
- 20 RoR (2007b)
- 21 RoR (2002e)
- 22 Ibid; Note that these figures only reflect **forest cover** changes. However, surface area coverage of national parks and forest reserves has been expanded since 2002. As of 2008, Volcanoes spans 16,000 ha, Nyungwe 101,300 ha, Akagera 108,500 ha, Gishwati 6,100 ha and Mukura 2,000 ha.
- 23 FAO (2007).
- 24 Habiyambere (1998).
- 25 This occurred despite the Forest Law in 1988 stipulating the full protection of natural vegetation within 10 m from the riverbed.
- 26 Bloesch, et al. (2009).
- 27 Marge (2008a).
- 28 Ibid.
- 29 Bloesch (1992).
- 30 These stands produce a total volume of about 4,000,000 m³ of wood. Based on an assumption that pine stands have an average growing stock of about 200 m³ per ha (Barbier 1992), these stands correspond to a total value of about FRW 20,000,000,000 or USD 36 million. This is based on a calculation of FRW 5,000 per cubic metre (Mbonyimana, personal communication).
- 31 Marge (2008a).
- 32 The management of public resources in general is considered insufficient (RoR 2007a).
- 33 Seven foresters have finished their masters at Moi University (Kenya) and Sokoine University (United Republic of Tanzania), and another who is supported by PAFOR is about to obtain the degree.
- 34 FAO (2007).

Chapter 9. Water Resources

- 1 FAO (2008b).
- 2 Ibid.
- 3 MINIRENA (2008a).
- 4 The Ramsar Convention is an intergovernmental treaty that provides the framework for national action and international cooperation for the conservation and wise use of wetlands and their resources.
- 5 RoR (2008drafte).
- 6 According to one source, rivers cover 72.6km² (FAO 2008b).
- 7 RoR (2005e).
- 8 FAO (2008b).
- 9 RoR (2005d).
- 10 RoR (2008j). However, the coverage rate is expected to have increased to 80 and 92 percent in 2008 and 2009, respectively, but has not been confirmed.
- 11 UN-WATER (2006).
- 12 African Economic Outlook – Rwanda (2007) cites per capita water availability of 1,104 m³ from 2004 to 2007.

- 13 RoR (2009d).
- 14 RoR (2005e).
- 15 Communication in May 2009 with Norbert Sendege, the acting Director-General of the Rwanda Agricultural Development Authority (RADA).
- 16 RoR (2005e).
- 17 Adapted from RoR (2005e).
- 18 RoR (2005e).
- 19 Sampling references were those used by Meybeck and Helmers (1989) in their study of pristine rivers and streams as well as by the Uganda study (Lake Victoria Environmental Management Programme 2002).
- 20 RoR (2005e).
- 21 UN-WATER (2006).
- 22 RoR (2009d); Rwanda Demographic and Health Survey (2005) cited in WHO/UNICEF (2008). Another source cites 69 percent of the rural population with access to improved water sources from 2000 to 2006 (World Bank 2008b).
- 23 Rwanda Demographic and Health Survey (2005) cited in WHO/UNICEF (2008).
- 24 RoR (2005e). Another source cites per capita water consumption at eight litres per day (Osodo and Rwamugema 2001).
- 25 RoR (2008j).
- 26 RoR (2005e).
- 27 Ibid.
- 28 Ibid.
- 29 Ibid.
- 30 Rwanda Demographic and Health Survey (2005) cited in WHO/UNICEF (2008).
- 31 WHO/UNICEF (2008).
- 32 RoR (2005e).
- 33 Ibid.
- 34 Ibid.
- 35 Nile Basin Initiative website (<http://www.nilebasin.org/>).

Chapter 10. Wildlife and Protected Area Management

- 1 See for instance, Chemonics International, Inc. (2008) and the IUCN website.
- 2 Weber (1989).
- 3 Ibid; Masozera (2002).
- 4 Plumptre et al. (2002).
- 5 Hamilton (1982).
- 6 The Convention on Wetlands, signed in Ramsar, Iran, in 1971, is an intergovernmental treaty that provides the framework for national action and international cooperation for the conservation and wise use of wetlands and their resources.
- 7 Chemonics International, Inc. (2008).
- 8 IUCN (1997, 2008), Chemonics (2008), Williams and Ntayombya (1999), Plumptre (2002).
- 9 CITES (2009).
- 10 Word Resources Institute (2003).

- 11 IUCN (2008).
- 12 Chemonics International, Inc. (2008).
- 13 Chemonics International, Inc. (2003).
- 14 Lamprey (2002).
- 15 Chemonics International, Inc. (2008).
- 16 ACNR and Birdlife (2007b).
- 17 CITES is an international agreement between governments that aims to ensure that international trade in specimens of wild animals and plants does not threaten their survival.
- 18 RoR (2005); Chemonics International, Inc. (2008).
- 19 Wildlife Conservation Society (2008).
- 20 Plumptre et al. (2002); Vedder et al. (1992).
- 21 Masozera (2002); Plumptre et al. (2002).
- 22 Chemonics International Inc. (2008).
- 23 Ibid.
- 24 RoR (2005h).
- 25 Chemonics International, Inc. (2008).
- 26 Ibid.
- 27 RoR (2005h).
- 28 RoR (2007a).
- 29 Chemonics International, Inc. (2003).
- 30 ORTPN statistics cited in Chemonics International, Inc. (2008).
- 31 See for instance Masozera (2008). There are also ongoing studies by the Wildlife Conservation Society and Protected Areas Biodiversity on carbon evaluation for carbon asset development through forest conservation and reforestation in the Congo-Nile Divide Forest Region.
- 32 Masozera (2008).
- 33 There is debate surrounding the spread of *Sericostachys scandens*, which is believed by some experts to have been already present at the beginning of the twentieth century when elephants and buffaloes still roamed the area.
- 34 Wildlife Conservation Society (2008).
- 35 Chemonics International Inc. (2003).
- 36 Ibid.

Chapter 11. Energy and the Environment

- 1 Known formerly as Association for the Conservation of the Environment (ACEN).
- 2 RoR (2008f).
- 3 Ibid.
- 4 Uwamahoro (2008)
- 5 Wood is also used for lighting and heating, according to the EICV-2 survey (Theuri 2007).
- 6 RoR (2007a); RoR (2000a).
- 7 Marge (2008a).

- 8 The main reference for this section was Marge (2008a).
- 9 UNEP/UNDP/ REMA (2007).
- 10 UNEP interview with Electrogaz, August 2008; USAID (2005).
- 11 Ibid.
- 12 RoR (2007a)
- 13 RoR (2009e)
- 14 Theuri (2007).
- 15 ESMAP (1991); Christoperson and Butare (1999).
- 16 Bagasse is the biomass that remains after sugarcane has been crushed and its juice extracted.
- 17 Bush et al. (2005); Marge (2008a).
- 18 Marge (2008a); Butare (2000).
- 19 Agroforestry includes trees and shrubs planted in agricultural fields. Agroforestry is discussed in Chapter 8.
- 20 Marge (2008a).
- 21 Ibid.
- 22 RoR (2008i).
- 23 Air pollutants include carbon monoxide, sulphur oxides, nitrogen oxides, aldehydes, particulates and polyaromatic compounds.
- 24 RoR (2000a).
- 25 UNDP (2007).
- 26 For instance, Marge (2008a) indicated that LPG was 300 percent more expensive than fuelwood. In contrast, another study concluded that in 2005 LPG was slightly cheaper compared to fuelwood (EAESI 2005).
- 27 Marge (2008a).
- 28 SNV (2005).
- 29 WorldChanging Team (2007).
- 30 RoR (2005f).
- 31 Peat mining releases carbon dioxide, dust and noise. Papyrus harvesting produces smoke and is high in sulphur, which can contaminate run-off into lakes and rivers. Both peat and papyrus harvesting can also have potentially adverse impacts on wetlands, its hydrology and biodiversity (for further reading, see Ojoyi (2006); Lindholm (n.d.); European Commission and RoR (2006).

Chapter 12. Urban Environment and Health Issues

- 1 RoR (2005, p. 4).
- 2 UNESA (2008).
- 3 RoR (2005).
- 4 United Nations Department of Economic and Social Affairs (2008, p. 4).
- 5 RoR (2007d, p. 5).
- 6 RoR (2005).
- 7 Statistics from Kigali City Council City, 2007
- 8 RoR (2002c)

- 9 Rugege (2006, p. 21).
- 10 World Bank (2005, p. 1).
- 11 RoR (2007a).
- 12 Oz Architecture (2007, p. 23)
- 13 RoR (2007e).
- 14 According to one source, access to safe water in urban areas decreased between 2000 and 2005 from 88 to 81.6 percent (UNDP 2007).
- 15 RoR (2006h). Another source cites a higher figure (81.6%) (UNDP 2007, p. 12).
- 16 RoR (2006g).
- 17 RoR (2006h).
- 18 Sano, J.C. (2007, p. 50).
- 19 According to a national study, between 2001 and 2006, the use of unprotected sources in Kigali increased due to costs of water supplied by public points (RoR 2006g, p. 22)
- 20 WHO (2006d, pp. 229-230).
- 21 Ibid, p. 218.
- 22 Ibid, p. 438.
- 23 WHO (2006c).
- 24 UNDP (2007, p. 51).
- 25 RoR (2005).
- 26 RoR (2006g).
- 27 Ibid.
- 28 As reported in the DHS, the prevalence of diarrhoea does not vary markedly between urban and rural areas (WHO 2006c).
- 29 The *umurenge* is a level of government administration that is one higher than the *akagari*, the smallest politico-administrative unit in Rwanda. People participate in the *umurenge* through their elected representatives.
- 30 Ibid.
- 31 Oz Architecture (2007, p. 23).
- 32 RoR (2005).
- 33 UNDP (2007, p. 104).
- 34 Kalimba and de Langen (2007, p 5).
- 35 Kigali City official website (n.d.).
- 36 Matungulu, K., Muhoro Ndung'u and Mulisa, A. (2006, p. 22).
- 37 This issue also applies to air pollution management.
- 38 Huggins and Mushara (2004, p. 8).

Chapter 13. Industry and Mining

- 1 This figure includes mining.
- 2 RoR (2006h, p. 11).
- 3 RoR (2008c draft).
- 4 Ibid, p. 4

- 5 Ibid, p. 58.
- 6 Ibid.
- 7 KIEMP (2006, p. 8).
- 8 Private Sector Federation (PSF), Chamber of Industries (2008).
- 9 Rugege (2006, p. 17).
- 10 RoR (2008c draft).
- 11 The more positive the level of ORP (measured in millivolts), the greater the ability for chemical species to release electrons into solution and the introduction of new chemical species through the process of oxidation. On the other hand, DO is a measure of the oxygen in water. As chemical species oxidize, they reduce the amount of oxygen in water. DO may also be depleted through biological activity; therefore, chemical oxidation should not be considered the only reason for reduced DO levels. Higher levels of ORP will then reflect reduced levels of oxygen in the water due to the oxidation process of chemicals. Chemical species are atoms, molecules, molecular fragments, ions, etc. as they exist in dissolved solution.
- 12 This view is supported by Gasana, et al. (1997).
- 13 The other study consulted was Gasana, et al. (1997).
- 14 Yager (2006, p. 1).
- 15 RoR (2007a, p. 39).
- 16 Yager (2006).
- 17 International Mire Conservation Group (2004).
- 18 Pajunen (1999).
- 19 USGS (2005).
- 20 Garret (2008, p. 17).
- 21 Global Witness (2005, p. 24).
- 22 Chemonics International, Inc. (2008).
- 23 Through the interagency support programme funded by UNDP/UNEP/UN-Habitat, REMA has conducted cleaner production training with a range of industries in Kigali. For further information, consult the desk study on industry and the Report on the National Seminar on Sustainable Consumption and Production, Kigali Institute of Sustainable Technology (2005).
- 24 RoR (2005f).
- 25 Ibid.
- 26 Reetsch et al. (in press).
- 27 Ripley (1996, pp. 253-254).
- 28 Global Witness. (2005).

Chapter 14. Environmental Governance

- 1 RoR (2005g).
- 2 In December 2009, the Ministry of Natural Resources was divided into the Ministry of Environment and Lands (MINELA) and the Ministry of Forests and Mining (MINIFOM).
- 3 REMA is comprised of three structures: the Board of Directors, the Directorate, and the National Consultative Committee. The Prime Minister appoints the Board of Directors, of which 30 percent must be women. The National Consultative Committee is composed of members of the Board; the director of REMA; the 12 Cabinet ministers; representatives of research institutions, NGOs, the Rwandese Association of Local

Government Authorities, and the private sector; governors of provinces; the mayor of the City of Kigali; the commissioner general of the National Police; the commissioner general of Rwanda Revenue Authority; the directors of Rwanda Bureau of Standards, Rwanda Investment and Export Promotion Agency, National Agency of Tourism and National Parks, Rwanda Utility and Regulatory Agency, and the Rwanda Office for Information; the chairpersons of the National Council of Women and the National Youth Council.

- 4 These projects include: PEI; Integrated Management of Critical Ecosystems (IMCE); Protected Area Biodiversity (PAB); Nile Trans-Boundary Project (NTB); Institutional Support Project (PAIGED); Ozone Project; Lake Victoria Environmental Management Project (LVEMP); Decentralisation of Environmental Management Project (DEMP); and Synergy Project.
- 5 An EIS consists of four components: (i) data domain (availability, access, quality, etc.); (ii) data standards (including metadata, exchange protocols, compatibility and inter-operability); (iii) technology (procedures and techniques, equipment, software, analytical skills); and (iv) institutional framework (environmental data policy, data producers and their mandates, users, resources, networking, decision-support context, etc.).
- 6 Convention on Biological Diversity webpage on Rwanda.
- 7 Convention on Biological Diversity website on The Cartagena Protocol webpage.
- 8 United Nations Framework Convention on Climate Change webpage on Rwanda.
- 9 United Nations Convention to Combat Desertification webpage on Rwanda.
- 10 United Nations Environment Programme Ozone Secretariat webpage on Rwanda.
- 11 Ramsar Convention on Wetlands website. “Contracting parties to the Ramsar Convention on Wetlands.”
- 12 Conservation of Migratory Species (2009).
- 13 Rotterdam Convention website.
- 14 Convention on International Trade in Endangered Species webpage.
- 15 *Umuganda* is a nation-wide community work programme. Community-based work is mandatory every last Saturday of the month for everyone in Rwanda.

Appendix 4

GIS Soil Erosion Model

The Universal Soil Loss Equation (USLE) has the form:

$$A = R \times K \times LS \times C \times P$$

Where:

A = an estimate of current average annual sheet and rill erosion ($t\ ha^{-1}\ yr^{-1}$)

R = rainfall erosivity factor ($MJ\ mm\ ha^{-1}\ h^{-1}\ year^{-1}$)

K = soil erodibility ($t\ h\ MJ^{-1}\ mm^{-1}$)

LS = L is a slope length factor that is combined with S, a slope steepness factor, to give a unitless terrain factor

C = a unitless vegetation cover factor

P = a dimensionless soil conservation practices factor

In order to apply this model at a country scale in Rwanda the following data was required:

R: rainfall erosivity

Rowntree (1982), in a study based in Kenya, suggested the Fournier Index is a more effective method of estimating local erosivity in tropical catchments than conventional methods based on maximum rainfall intensity. This Index is calculated as:

$$F = \frac{p^2}{P}$$

Where:

F = the Fournier Index value

p = total rainfall in the wettest month in mm

P = annual precipitation in mm

As the network of rainfall recording stations is sparse at the moment in Rwanda, we will need to extrapolate point measurements to large areas of the country. This can best be done using remotely sensed rainfall data. The required data inputs are: (i) monthly and annual rainfall data from as many meteorological stations across the country as possible; (ii) monthly/annual rainfall data from a remotely sensed source. The output should be a Geographic Information System (GIS) data layer giving Fournier Index values for the whole country.

K: soil erodibility

Soil erodibility, the average long-term rate of soil loss in response to specific rainfall erosivity, may have been measured directly by scientists from the University of Ghent and the Ministry of Agriculture and Animal Resources (MINAGRI). If this data is not available, then K factors can be estimated based on soil type from a first approximation in the standard nomograph (Morgan 1995). Relative soil erodibility estimates can then be used to create a GIS layer based on the national *Carte Pédologique*.

The disadvantage of estimating rather than using direct measures of erodibility is that there is no simple conversion available to translate relative soil erodibility scores into standard erosivity units. The final calculation of soil erosion will, therefore, be expressed in relative rather than absolute values and will require field calibration in order to determine erosion in tonnes $ha^{-1}\ yr^{-1}$.

S: slope steepness factor

Slope angles can be extracted from a digital elevation model (DEM). Shuttle Radar Topography Mission (SRTM) data is freely available at a 90m contour interval, but higher resolution is required for this analysis. A digitised version of the 1988 *Carte Topographique du Rwanda* (1:50,000) with a 25 m contour interval would be the most appropriate data source. The slope factor should then be calculated according to the protocol described in Nearing (1997). This function has been shown to fit empirical data for slopes >25° better than the more widely used linear functions.

$$S = -1.5 + \frac{17}{(1 + e^{(2.3 - 6.1 \sin \theta)})}$$

Where:

θ = the slope angle in degrees

The required data input is a DEM of the whole country at a contour interval of 30m or less. The output will be a raster GIS layer showing S slope steepness factor.

L: slope length factor

Slope length factor is the most difficult parameter to estimate accurately and without bias. Cohen et al. (2005) successfully used a method based on slope variance to estimate erosion risk in a catchment in Kenya. This method has the advantage of being computationally straightforward, but will require field calibration. For each pixel in the DEM, the slope aspect is calculated. Slope aspect variance is then estimated based on a 49 cell array centred on the target pixel. Large variance will be correlated with short slope lengths while low variance implies constant slope direction and, therefore, long slope length factors.

The required data input is a DEM of the whole country at a contour interval of 30m or less. The output will be a raster GIS layer showing slope aspect variance. This can then be correlated with the slope length factor based on field measurements at a minimum of 50 sites.

C: vegetative cover factor

The most straightforward method for estimating C factors would be to use existing vegetation and land use cover maps such as AFRICOVER (<http://www.africover.org/index.htm>) or higher resolution products, if available. These can be classified according to the values ascribed by Cohen et al. (2005) for a mixed agricultural/natural vegetation in eastern Kenya.

Cover class	% vegetation cover	C factor score
1	0–20%	0.8
2	20–40%	0.5
3	40–60%	0.2
4	60–80%	0.1
5	80–100%	0.01

The required data input is a vegetation/land use cover map. The output will be a raster GIS layer of C factor scores.

P: Soil conservation practice factor

While there are a number of countrywide initiatives to reduce soil erosion, including measures such as radical and progressive terracing, this factor is not included in the model. The output of the model will, therefore, represent a “worst case scenario” that will provide a better basis for future planning decisions. Once the model is fully operational, it will be possible to use it to examine the costs and benefits of soil conservation measures in different parts of the country.

Appendix 5

Sampling Results

Chapter 7. Agriculture

Results of the Geographic Information System (GIS) soil modelling to be provided.

Soil erosion data available in Rwanda

The only long-term soil erosion monitoring work currently taking place seems to be that conducted by the Institute of Agriculture and Animal Husbandry (ISAE) in Busogo. ISAE maintains a run-off plot experiment under different crop and soil amendment regimes, but the results of this work are not yet published.

Some modelling work has been completed at the Geographic Information Systems and Remote Sensing Centre (CGIS) of the National University of Rwanda (NUR). Soil loss within the catchments of 17 inland lakes has been modelled and results validated using rainfall simulation. CGIS has also carried out mapping of soil degradation in the Rusumo basin using a digital elevation model. Soil erosion data under different forms of land use are presented in Table 1 below.

Table 1. Rates of soil erosion measured in Rwanda under different forms of land use

Land use/location	Soil erosion (t ha ⁻¹ yr ⁻¹)	Source
Bare soil cultivated along the slope	300-700	(Roose and Ndayizigiye 1997)
Bare soil (clean till) Nyarutovu	859	(Byers 1990)
Bare soil (clean till) Ruhondo	207	(Byers 1990)
Bare soil (clean till) Nyakinama	211	(Byers 1990)
Bare soil (clean till)	478	(Wassmer 1981)
Traditional crops (cassava, sweet potato, maize, beans and peas)	20-150	(Roose and Ndayizigiye 1997)
Traditional crops Nyarutovu	453	(Byers 1990)
Traditional crops Ruhondo	35	(Byers 1990)
Traditional crops (average of 2 plots) Nyakinama	190	(Byers 1990)
Agroforestry (average of 5 plots) Nyarutovu	54	(Byers 1990)
Agroforestry (average of 6 plots) Ruhondo	31	(Byers 1990)
Agroforestry (average of 6 plots) Nyakinama	93	(Byers 1990)
Perennial crops – bananas	20-60	(Roose and Ndayizigiye 1997)
Perennial crops – coffee plantation	0.1-1	(Roose and Ndayizigiye 1997)
Maize and potato	<12	(Wassmer 1981)
Nyamutera River basin, Ruhengeri (basin-wide average)	203	(Byers 1992)

Chapter 9. Water Resources

Table 1. Results of water quality testing

Sample No.	Location	Type of Source	pH	Cond $\mu\text{S/cm}$	Temp	Sal.	TDS mg/l	Oxygen mg/l	Ox-Sat	Nitrate as NO ₃ (mg/l)	TOC mg/l	TSS mg/l	Kjeldahl Nitrogen (mg/l)
16	Groundwater from handpump (Gacaca)	Groundwater	6,36	71	24,1	-	29	3,67	53%	6,6	<0,3	<6	<5
5	Mutobo/Rubinde Intake for Water Supply	Spring	7,53	322	17,3	-	130	6,06	84%	6,8	3	<6	<5
6	Mutobo/Mutobo Intake for Water Supply	Spring	7,78	440	17,2	-	180	4,96	68%	6,6	<0,3	<6	<5
1	Kamirabzovu; Rugezi Wetland, East	Stream	8,77	100	18,8	-	41	6,28	90%	6,8	9	26	<5
2	Kamirabzovu; Rugezi Wetland, West	Stream	7,45	35	18,1	-	14	3,52	49%	<0,3	28	<6	<5
3	Kamirabzovu; Rugezi Wetland, Mixed	Stream	6,87	36	17,7	-	15	3,83	52%	0,5	27	<6	<5
19	Ruhondo (small stream)	Stream	8,22	80	25,8	-	42	6,63	102%				
4	Burera/Ntaruka (Upstream Dam)	Lake	7,87	119	20,8	-	49	5,74	8%	<0,3	4	<6	<5
8	Kivu Lake at Gisenyi (Beach)	Lake	9,60	1.008	23,6	0,3	414	6,82	97%	1,5	7	46	<5
10	Ruhondo Dam (Upstream)	Lake	9,29	295	22,7	-	121	7,95	115%	<0,3	4	7	<5
13	Lake Mugesera (water intake for Kigali)	Lake	9,34	436	23,7	-	179	6,95	98%	<0,3	21	30	<5
14	Lake Mugesera (next to fishing village)	Lake	9,29	429	25,3	-	176	7,16	102%	<0,3	21	31	<5
15	Lake Hago inside Akagera Nat. Park	Lake	8,70	149	23,5	-	60	5,76	79%	<0,3	20	14	<5
17	Lake Rumira, Bugesera	Lake	8,41	160	25,5	-	83	9,14	133%	<0,3	11	22	<5
7	Sebeya River / Elgz (Bridge)	River	7,78	108	19,9	-	44	7,12	98%	7,2	<0,3	500	<5
9	Sebeya River / Nyundo (next to main road)	River	8,85	122	14,1(?)	-	50	8,25	100%	7,7	6	660	<5
11	Mukungwa	River	9,44	450	22,2	-	185	7,34	101%	7,3	4	90	<5
12	Ngabarongo near Kigina (at bridge)	River	9,17	148	24,5	-	60	6,88	100%	4,7	3	370	<5
18	Nyabarongo at Kanzenze	River	8,42	199	22,4	-	103	6,32	87%	4,8	4	320	<5
20	Nyabarongo at Cyome (bridge)	River	8,56					7,18	102%				
21	Nyabarongo at Zubko (bridge)	River	8,77					6,61	93%				

Chapter 12. Urban Environment and Health Issues

Table 1. Selected physical, chemical and biological parameters of drinking water samples

Identifier	Temp °C	pH	DO mg/L	NO ₃ ppm	TDS mg/L	Coliforms Total	E-coli
GW1-1	23.19	6.14	5.63	24.74	383	Yes	Yes
GW1-2	23.63	6.01	3.04	24.24	400	Yes	Yes
GW2-1	23.91	5.98	4.21	17.27	626	No	No
GW5-1	24.42	6.28	4.95	11.45	302	Yes	No
GW9-1	23.8	5.79	5.28	27.78	403	-	-
GW9-2	24.48	7.37	6.49	3.93	500	Yes	Yes
GW10-1	23.95	4.32	6.23	28.78	436	Yes	Yes
GW12-1	24	5.14	3.48	24.63	308	Yes	No
GW13-1	23.9	5.53	2.40	30.25	334	Yes	Yes
GW15-1	23.93	5.50	4.98	20.27	224	Yes	No
GW15-2	23.59	5.52	5.27	20.05	224	Yes	No
WHO*	Nil	Nil	Nil	50	Nil	-	-

*WHO 2006 Guidelines for Drinking Water Quality, First Addendum to Third Edition.

Table 2. Heavy metal concentrations for selected drinking water collection points

Identifier	As ug/L	B ug/L	Cd ug/L	Cr ug/L	Cu ug/L	Pb ug/L	Ni ug/L	Se ug/L	Zn ug/L
GW1	<0.75	<20	<0.22	7	<1.6	<0.4	2.4	<1	7
GW2	<0.75	<20	0.87	10	2	<0.4	10	6	42
GW5	<0.75	<20	<0.22	10	<1.6	<0.4	<1.5	<1	<5
GW9	<0.75	<20	0.25	9	<1.6	<0.4	<1.5	<1	17
WHO*	10	500	3	50	200	10	70	10	Nil

*WHO 2006 Guidelines for Drinking Water Quality, First Addendum to Third Edition.

Table 3. Heavy metal analysis of known drinking water collection points in Kigali

Source	As	B	Cd	Cr	Cu	Pb	Ni	Se	Zn
	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L
NDS2	0.84	<20	<0.22	8	<1.6	<0.4	<1.5	2	<5
NDS3	<0.75	<20	<0.22	<1	<1.6	<0.4	5.6	<1	<5
RS4	2.0	<20	<0.22	8	<1.6	<0.4	1.5	5	<5
WHO*	10	500	3	50	200	10	70	10	Nil

*WHO 2006 Guidelines for Drinking Water Quality, First Addendum to Third Edition.

Table 4. Detected chemicals in sediment samples

Source	As mg/kg	Cr mg/kg	Cu mg/kg	Pb mg/kg	Ni mg/kg	Zn mg/kg	PAH 16 mg/kg
NDS2	10	32	22	14	8.9	25	0.270

Chapter 13. Industry and Mining

Table 1. Heavy metal concentrations for four water sample points

Source	As ug/L	B ug/L	Cd ug/L	Cr ug/L	Cu ug/L	Pb ug/L	Ni ug/L	Se ug/L	Zn ug/L
GW1	<0.75	<20	<0.22	7	<1.6	<0.4	2.4	<1	7
GW4	<0.75	<20	<0.22	5	<1.6	<0.4	<1.5	3	<5
GW7	<0.75	<20	<0.22	2	<1.6	<0.4	<1.5	<1	<5
GW11	1.7	<20	<0.22	<1	<1.6	<0.4	2.3	3	<5

Table 2. Heavy metal concentrations in surface drainage sediments

Source	B	As	Cd	Cr	Cu	Pb	Hg	Ni	Se	Zn
	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
GW3*	<3.5	14	0.2	33	11	21	<0.4	5.2	<3	98
GW14	<3.5	25	0.2	80	21	20	<0.4	7.2	<3	120

* This is a composite sample reading from two samples in the same location.

Table 3. PAH 16 and selected VOC concentrations in sediments

Source	PAH16 µg/kg	cis 1-2 Dichlorethene µg/kg	Toluene µg/kg
GW3	460	28	96
GW14	400	20	480

Appendix 6

Soil Erosion Rates by Districts (based on GIS Modelling CGIS/UNEP)

Erosion rates (tonnes/ha/yr)	Bugesera District		Burera District		Gakenke District		Gasabo District		Gatsibo District	
	Area (sq. km)	(% district area)	Area (sq. km)	(% district area)	Area (sq. km)	(% district area)	Area (sq. km)	(% district area)	Area (sq. km)	(% district area)
0-30	6	0.47	3	1	–	–	0	0	20	1
30-50	271	21	92	14	4	1	11	2	429	27
50-100	677	52	349	54	327	46	267	62	716	45
100-150	253	20	140	22	370	52	150	35	372	24
150-300	–	–	0.06	0.01	1	0.14	0	0	0	0
Water bodies	69	5	59	9	2	0.32	1	0.34	45	3
Erosion rates (tonnes/ha/yr)	Gicumbi District		Gisagara District		Huye District		Kamonyi District		Karongi District	
	Area (sq. km)	(% district area)	Area (sq. km)	(% district area)	Area (sq. km)	(% district area)	Area (sq. km)	(% district area)	Area (sq. km)	(% district area)
0-30	1	0.07	0	0	–	–	0.39	0.06	1	0.07
30-50	54	7	41	6	14	2	32	5	12	1
50-100	506	61	338	50	294	51	302	46	316	32
100-150	267	32	284	42	273	47	320	49	458	46
150-300	0.13	0.02	0	0	1	0.09	–	–	7	1
Water bodies	2	0.28	1	0.08	–	–	1	0.18	199	20
Erosion rates (tonnes/ha/yr)	Kayonza District		Kicukiro District		Kirehe District		Muhanga District		Musanze District	
	Area (sq. km)	(% district area)	Area (sq. km)	(% district area)	Area (sq. km)	(% district area)	Area (sq. km)	(% district area)	Area (sq. km)	(% district area)
0-30	32	2	0.02	0.01	15	1	–	–	0.03	0.01
30-50	780	40	26	15	310	26	5	1	46	9
50-100	797	41	86	52	650	55	318	49	401	76
100-150	155	8	53	32	157	13	324	50	65	12
150-300	–	–	–	–	–	–	0	0	–	–
Water bodies	167	9	1	1	31	3	1	0.22	18	3
Erosion rates (tonnes/ha/yr)	Ngoma District		Ngororero District		Nyabihu District		Nyagatare District		Nyamagabe District	
	Area (sq. km)	(% district area)	Area (sq. km)	(% district area)	Area (sq. km)	(% district area)	Area (sq. km)	(% district area)	Area (sq. km)	(% district area)
0-30	3	0.36	–	–	–	–	29	2	–	–
30-50	150	17	10	2	43	8	451	23	1	0.08
50-100	465	54	300	44	302	57	947	49	414	38
100-150	190	22	366	54	185	35	477	25	647	59
150-300	–	–	1	0.08	0.05	0.01	–	–	28	3
Water bodies	56	6	2	0.28	1	0.28	12	1	0	0
Erosion rates (tonnes/ha/yr)	Nyamasheke District		Nyanza District		Nyarugenge District		Nyaruguru District		Rubavu District	
	Area (sq. km)	(% district area)	Area (sq. km)	(% district area)	Area (sq. km)	(% district area)	Area (sq. km)	(% district area)	Area (sq. km)	(% district area)
0-30	0	0	0	0	0.43	0.32	–	–	0.12	0.03
30-50	16	1	25	4	13	10	3	0.26	31	8
50-100	441	38	391	58	86	64	344	34	283	73
100-150	484	41	254	38	32	24	592	59	26	7
150-300	9	1	0	0	0	0	57	6	0	0
Water bodies	224	19	0.38	0.06	2	2	–	–	47	12
Erosion rates (tonnes/ha/yr)	Ruhango District		Rulindo District		Rusizi District		Rutsiro District		Rwamagana District	
	Area (sq. km)	(% district area)	Area (sq. km)	(% district area)	Area (sq. km)	(% district area)	Area (sq. km)	(% district area)	Area (sq. km)	(% district area)
0-30	–	–	0	0	–	–	0.18	0.02	1	0.17
30-50	10	2	24	4	8	1	28	2	27	4
50-100	282	45	244	43	364	38	391	34	354	52
100- 50	334	53	295	52	489	51	238	21	273	40
150-300	–	–	2	0.41	36	4	0.15	0.01	–	–
Water bodies	1	0.14	1	0.15	42	4	498	43	27	4

Note : (–) Not applicable

Appendix 7

List of Contributors

UNEP Assessment Team

Mr. Hassan Partow, Project Coordinator
 Mr. Urs Bloesch, Forestry Expert
 Mr. George Bouma, Industry and Mining, Urban Environment Expert
 Mr. Nick Brown, Agriculture and Land Degradation Expert
 Ms. Marisol Estrella, Report Editor
 Mr. Karl-Friedrich Glombitza, Population Displacement and Resettlement Expert
 Mr. Per Bogelund Hansen, Freshwater Resources Expert
 Mr. Henrik Larsen, Climate Change and Disasters Expert
 Mr. Richard Mathew, Environment, Conflict and Peace-building Expert
 Ms. Clara Nobbe, Gender Expert
 Mr. Jyoti Painully, Energy Expert
 Mr. Richard Ngendahayo, Logistics Coordinator
 Mr. Kenneth Chulley, Technical and Research Assistant
 Mr. Frank Turyatunga, Environmental Governance and Wildlife and Protected Areas Expert

UNEP Post-Conflict and Disaster Management Branch (Geneva)

Henrik Slotte, Chief of Branch
 Asif Ali Zaidi, Operations Manager
 Muralee Thummarukudy, Project Coordinator
 David Jensen, Policy and Planning Coordinator
 Andrew Morton, Programme Manager, Haiti
 Silja Halle, Programme Officer

Natalie Barefoot, Programme Officer
 Mario Burger, Senior Scientific Advisor
 Zuzana Burivalova, Research Assistant
 Altan Butt, Operations Assistant
 Michael J. Cowing, Project Coordinator
 Tom Delrue, Programme Officer
 Peter Dugbaek, Associate Programme Officer
 Marisol Estrella, Programme Officer
 Lucile Gingembre, Associate Programme Officer
 Hannoa Guillaume-Davin, Project Advisor
 Dennis Hamro-Drotz, Associate Programme Officer
 Julie Marks, Strategic Communications Advisor
 Reshmi Meyer, Communications Assistant
 Bessma Mourad, Senior Research Assistant
 Mani Nair, Administrative and Financial Assistant
 Satu Ojaluoma, Administrative Officer
 Elena Orlyk, Project Assistant
 Hassan Partow, Project Coordinator
 Matija Potocnik, Graphic Arts and Media Assistant
 Joanne Stutz, Programme Assistant
 Nita Venturelli, Administrative and Project Assistant
 Anne-Cécile Vialle, Associate Programme Officer
 Dawit Yared, Project Assistant

UNEP Regional Office for Africa

Mr. Mounkaila Goumandakoye, Director and UNEP Regional Representative
Mr. Robert Wabunoha, Sub-Regional Coordinator for Eastern Africa
Ms. Jeanette Clover, Senior Programme Officer

Cartographic, GIS and Remote Sensing Outputs

Mr. Yves Barthélemy, Remote Sensing and GIS Expert
Dr. Felicia Akinyemi, Deputy Director, CGIS, Butare
Mr. Jean Pierre Bizimana, CGIS
Mr. Stefan Kappeler, Head, CGIS, Kigali Office
Mr. Eugene Kayijamahe, GIS specialist, Butare
Mr. Adrie Mukashema, GIS Specialist and CGIS Focal Point, CGIS, Butare
Ms. Rachel Murekatete, CGIS
Mr. Elias Nyandwi, Research Assistant/Environment System Analysis Specialist, CGIS, Butare.
Dr. Michele Schilling, CGIS, Butare
Ms. Marie Christine Simbizi, Assistant Researcher, CGIS, Butare

UNEP Reviewers

Mr. Andrew Morton, Programme Manager, Haiti, UNEP/DEPI/PCDMB
Ms. Belinda Bowling, Environmental Law Expert, UNEP/DEPI/PCDMB
Mr. David Jensen, Policy and Planning Coordinator, UNEP/DEPI/PCDMB
Mr. Muralee Thummarukudy, Project Coordinator, UNEP/DEPI/PCDMB
Mr. Johannes Refisch, EC Project Manager, UNEP Great Ape Survival Project (GRASP)
Mr. Joseph Bartel, Forestry Expert, UNEP/DEPI/PCDMB
Mr. Lawrence Agbemabiese, Programme Officer, Energy Branch, UNEP-DTIE
Ms. Louise Sorensen, Task Manager, UNDP-UNEP Poverty and Environment Initiative
Mr. Mike Cowing, Project Coordinator, UNEP/DEPI/PCDMB
Mr. Mohamed Abdel-Monem, Programme Officer of Natural Resources, UNEP Regional Office for Africa
Mr. Niklas Hagelberg, UNEP/DEPI Freshwater & Terrestrial Ecosystems Branch
Mr. Roy Brooke, Programme Officer, Joint UNEP-OCHA Environment Unit
Mr. Thomas Chiramba, Head, UNEP/DEPI Freshwater Ecosystems Unit

Special Thanks

Ministry of Environment and Lands / Rwanda Environmental Management Authority

Hon. Amb. Stanislas Kamanzi, Minister, Ministry of Environment and Lands
Ms. Caroline Kayonga, Permanent Secretary, Ministry of Environment and Lands
Dr. Rose Mukankomeje, Director General, Rwanda Environmental Management Authority

National Experts (desk study) and Reviewers*

Mr. Oscar Bahizi, Population, Poverty and Environment Expert
Mr. Thaddée Habiyambere, Forestry Expert
Mr. Ravikumar Kandasamy, Energy Expert
Mr. Justice Mahundaza, Agriculture and Land Degradation Expert
Mr. Aimée Mpambara, Wildlife and Protected Areas Expert*
Mr. Alex Mulisa, Industry and Mining Expert*
Mr. Alfonse Mutabazi, Climate Change and Disasters Expert
Mr. Richard Ngendahayo, Freshwater Resources Expert
Mr. Steven Niyonzima, Population Displacement and Resettlement Expert
Mr. Ronah Nyakurama, Urban Environment Expert
Mr. Herbert Rubasha, Environment, Conflict and Peace-building Expert
Mr. Charles Twesigye-Bakwatsa, Environmental Governance Expert*

National Counterparts (field mission)

Mr. Yves Cyubahiro, Ministry of Natural Resources
 Mr. Innocent Gashugi, Rwanda Environmental Management Authority
 Mr. Thaddée Habiyambere, Forests Expert
 Mr. Emmanuel Kabera, Rwanda Environmental Management Authority
 Mr. Ravikumar Kandasamy, Energy Expert
 Mr. Mardoché Birori, Chief, Water Analysis Laboratory, National University of Rwanda
 Mr. Fabrice Mugabo, National University of Rwanda
 Mr. Frédéric Munyansanga, Ministry of Natural Resources
 Mr. Jacques Musango Karumiya, Environment Professional, Ministry of Natural Resources
 Mr. Pierre Niyibizi, Ministry of Natural Resources
 Mr. Emmanuel Twagirayezu, Ministry of Agriculture
 Mr. François Twagirayezu, Ministry of Infrastructure
 Mr. Charles Uramutze, Coordinator, National Adaptation Programmes of Action to Climate Change Project

United Nations in Rwanda

Mr. Aurélien Agbénonci, United Nations Resident Coordinator/Resident Representative, UNDP
 Mr. Anthony Ohemeng-Boamah, Country Director, UNDP
 Mr. Safiou Easo Ouro-Doni, Deputy Country Director / Operations, UNDP
 Mr. John Musemakweri Head, Sustainable Livelihood/Environment Unit, UNDP.
 Mr. Henri Esseqqat, Energy Programme Officer, UNDP.
 Mr. Toshikazu Mito, Programme Officer, UNDP
 Mr. Robin Ogilvy, Programme Specialist, UNDP
 Ms. Sujitha Sekharan, Manager, Implementation Service Center, UNDP
 Mr. Laurent Gashugi, Assistant Representative, FAO
 Mr. Sabin Murererehe, Consultant, Wood Energy Programme, FAO
 Mr. Francois Abiyigoma, Programme Assistant, UNHCR
 Mr. Theophiles Vodounou, Senior Programme Officer, UNHCR
 Mr. John Bosco Ruzibuka, Assistant Representative, UNFPA
 Mr. Emmanuel Kalenzi, Head of Operations, UNIDO
 Ms. Monique Sevumba ; Programme Manager, UN-HABITAT
 Mr. Cyuma Mbayiha, Consultant, UNIFEM
 Mr. Ahmed Zakaria, Deputy Country Director, WHO
 Mr. Jean-Pierre Ruhira, National Programme Officer, WHO

Others

Mr. Albert Butare, Minister of State in charge of Energy, Ministry of Infrastructure
 Mr. Dismas Bakundukize, Forest Officer, Forestry Management Support Project
 Mr. François Bizumungu, Research and Monitoring Manager,
 Mr. Yves Cyabuhiro, Water Resources Management Expert, Ministry of Natural Resources
 Mr. Paul Eva, External Links and Donor Coordination, Ministry of Infrastructure
 Mr. Syldio Gakwisi, Rwanda Meteorological Services,
 Ms. Donatha Gihana, Head of Gender Cluster Secretariat, Office of the Prime Minister
 Mr. Claudien Habimana
 Mr. Patrice Hakizimana, Director General, Rwanda Agricultural Development Authority
 Mr. Gerard Hendriksen, Senior Advisor, Ministry of Infrastructure
 Mr. Emmanuel Kabera Projects Management Officer, Rwanda Environmental Management Authority
 Mr. Rao Kamavarapu, Transport Economist, Transport Programmes and Projects Management Cell, Ministry of Infrastructure
 Mr. Jean Kanyamuhanda, Coordinator, Transport Programmes and Projects Management Cell, Ministry of Infrastructure
 Mr. Trenee Kanywabahizi, Tour Guide, Akagera National Park
 Mr. Antoine Kapiteni, Coordinator, Integrated Management of Critical Ecosystems, Ministry of Natural Resources

Mr. Peter Karake, Deputy Coordinator, Head of Planning and Research; Disaster Management Unit, Rwanda Police Headquarters
Mr. Norbert Karegire, Community Conservation Warden, Akagera National Park
Dr. Charles Karemangingo, Rector, Institute of Agriculture and Animal Husbandry
Ms. Umutoni Liliose, Strategy and Policy Unit, Office of the President
Mr. Jacques Musango Karumiya, Environmental Protection Expert, Ministry of Natural Resources.
Mr. Camille Marara, Director, Urban Planning, Ministry of Infrastructure
Mr. Niyibizi Mbanzabigwi, Head, Solar and Wind Energy, Ministry of Infrastructure
Mr. Félicien Mbonyimana, Antenne Forestry Management Support Project, Gikongero
Dr. Jonas Mugabe, Deputy Director General, National Agricultural Research Institute
Mr. Robert Shema Muganga, Coordinator, National Water Resources Management Project.
Mr. Odillo Mukiza, Engineer, Ministry of Natural Resources
Dr. Athanase Mukuralinda, Director, Land and Forestry Research Center and Head of Agro-Forestry Programme
Mr. Emmanuel Munanira, Protection Makera Forest
Mr. Frédéric Munyansanga, Expert, in charge of Reforestation and Agroforestry, Ministry of Natural Resources
Mr. David Musemakweli Executive Director, Governance and Advisory Council, Ministry of Local Government
Ms. Jacqueline Musoni, Environmental Education Officer, Rwanda Environmental Management Authority
Mr. Amini Mutaganda, Scientist, National Agricultural Research Institute
Dr. Francois Naramabuye, Head, Centre for Environmental and Entrepreneurship Scheme Dev., National University of Rwanda
Mr. Clement Ndibwami, Public relations, Institute of Scientific and Technological Research
Mr. Jean Nduwamungu, Director, Land and Forestry Research Center, National Agricultural Research Institute.
Mr. Bonaventure Nduwayezu, Antenne Forestry Management Support Project, Gisenyi
Dr. Jean-Baptiste Nduwayezu, Director General, Institute of Research Science and Technology
Mr. Peter Nihemuka, Administrator
Mr. Pierre Niyibizi, Forest Protection Service
Mr. Epimaque Nsanzabaganwa, Acting Director, Department of Planning & Capacity Building
Mr. Jean-Claude Nyamarere, Director Forest Protection Service
Prof. Antoni Rayar, Dean, Faculty of Agriculture, Institute of Agriculture and Animal Husbandry
Mr. Guy Roulette, Délégué à la Co-gestion, Aforestation Support Program
Mr. Theophile Ruberangeyo, Coordinator, Sub sector Rural Habitat & Urbanism
Mr. Venuste Ruigana, Soil erosion specialist, Rwanda Agricultural Development Authority
Mr. Dieudonne Rumaragishyika, Deputy Mayor, City of Kigali
Mr. Eugene Rurangwa, Director General and Registrar of Titles, National Land Centre
Mr. Athanase Ruriki, Director Forestry, Forestry Management Support Project
Mr. Frank Rutabingwa, Director General, Rwanda National Forestry Authority
Dr. Theogene Rutagwenda, Director General, National Agricultural Research Institute
Mr. Fidele Ruzigandekwe, Executive Director, Rwanda National Office of Tourism
Mr. Anastase Rwigema, Deputy Director, Centre for Innovation and Tech. Transfer, Kigali Institute of Science and Technology
Mr. Patrick Safari, Director, Planning, Policy and Capacity Building unit, Ministry of Natural Resources
Mr. John Ntaganda Semafara, Coordinator, Rwanda Meteorological Services
Mr. Emanuel Twagirayezu, Soil Conservation Expert, Ministry of Agriculture
Mr. Francois Twagirayezu, Expert, Habitat & Urbanisme, Ministry of Infrastructure
Ms. Francine Umurungi, Director of Trade and Industry, Ministry of Commerce, Industry, Investment Promotion, Tourism and Cooperatives
Mr. Yussuf Uwamahoro, Energy Sector Coordinator, Ministry of Infrastructure
Ms. Claire Marie Uwase, Director of Chamber of Industry, Private Sector Federation
Mr. Jean-Claude Uwizeye, Senior Biogas Technician, Ministry of Infrastructure
Mr. Charles Vanpraet, Consultant, Aforestation Support Programme

Mr. David Bakora, National Land Center
 Mr. Leobard Banamwana, Environmentalist, Nyabihu District
 Ms. Anastase Barahira, Village Head, Rwimikoni, Manyan-ge Sector, Bugesera District
 Mr. Lamin G. Barrow, Country Programme Officer, African Development Bank
 Mr. Kuriuripuhuc Beata, Head, Association for the Conservation of the Environment
 Mr. Claude Bigirimana, Member Refugee Committee Nyabiheke
 Mr. Michael Biryabarema, Director, Office of Geology and Mines of Rwanda
 Mr. John Bosco Bizimana, Enviroclean Technologies
 Mr. Patrick Buda, Warden, Monitoring and Research, Akagera National Park.
 Mr. Alexis Byamana, President, HELPAGE
 Mr. Alfred D. Byigero, Director of Energy, Rwanda Utilities Regulatory Agency
 Mr. Sam G. Dargan, Managing Director, Great Lakes Energy
 Mr. François Gikumba, President, Refugee Committee, Kiziba Refugee Camp
 Mr. Innocent Hakizimana, Agronomist, Nyabihu District
 Mr. Innocent Harerimana, Chargé Environnement et Ressources Naturelles, District Rubavu
 Mr. Rogers Hategekimana, Warden, Community Conservation, Nyungwe National Park
 Mr. Innocent Hitayezu, Oxfam GB
 Mr. Alexis Kabuto, General Manager, Kibuye Power Ltd
 Mr. Michael Kabutura, Consultant
 Mr. Patrick Kagina, Chief of Security, Cellule Rwisirabo
 Mr. Jean Bosco Kanyesheja, Director Water Department ELECTROGAZ
 Mr. Charles Kanyamihigo, Director, Electricity Department, ELECTROGAZ
 Mr. Edward Karanga, Care International, Nyagatare
 Mr. Clover Karangwa, Farmer, Rubona, Nyagatare District
 Ms. Françoise Kayigauba, Advisor, Nile Equatorial Lakes Subsidiary Action Plan
 Mr. J. Marie Vianney Kayonga, Director, Énergie Domestique
 Mr. Grachina Koseru, Manager of Finance, Rwanda Foam Factory
 Mr. Blaise Manege, Member Refugee Committee Nyabiheke
 Mr. Erik Van Malderen, Délégué à la Cogestion, Belgian Technical Cooperation
 Mr. Ferdinand Masabo, General Secretary Refugee Committee Nyabiheke Refugee Camp
 Mr. Aphrodise Mboniyintwali, Independent Consultant
 Ms. Seraphine Mukagakwaya, Farmer Rutete, Sector Rweru, Bugesera District.
 Mr. Larry Vincent Mpaka, Head of Generation and Power Operations, ELECTROGAZ
 Mr. Joe Mugarura, Financial Manager, Rwanda Leather Industries Ltd
 Mr. Damas Muhororo, Mayor Kayonza District
 Ms. Valérie Mukakalara, Farmer, Nyagashanga, Nyagatare District
 Ms. Dancilla Mukakamari, National Coordinator, Rwanda Ecological Association
 Ms. Felicité Mukarurema, Village Head, Gahama, Nyange Sector, Musanze District
 Ms. Alice Mukaryiranga, Bukora, Kirehe District
 Mr. Felix Mulindahabi, Research Officer, Wildlife Conservation Society
 Mr. Patrick Munyanganzo, Protection and Production Manager, Mutara Fishing Society
 Mr. Eric Tamba Murenzi, Agriculture and Livestock Professional, Nyagatare District
 Mr. Felix Mwiseneza, Member Refugee Committee Nyabiheke
 Mr. Rao Narsimha, Chief Engineer, Kabuyu Sugar
 Mr. Deckers Ngarukiye, Chief Engineer and Projects Manager, BRALIRWA S.A
 Mr. Charles Ngirabatware, Mayor, Nyabihu District
 Ms. Marthe Nimugire, Head of Water Testing Laboratory, ELECTROGAZ
 Ms. R. Nishimwe, Environment and Natural Resources Officer, Nyarugenge District.
 Mr. Jean de Dieu Nkizingabo, Agronomist, Bugesera District
 Mr. John Nkubana, Executive Director, Ameki Colour
 Ms. Jacqueline Nsabimana, Secrétaire Comptable, Kiziba Refugee Camp
 Mr. Lambert Ntagwabira, Executive Secretary, Cyuve Sector, Musanze District
 Mr. Peter Ntthemuka, AG. Chief Park Warden, Nyungwe National Park
 Ms. Penina Nyirabyseruka, Farmer, Bukora, Kirehe District
 Mr. Maurice Pigaht, Project Coordinator, German Technical Cooperation
 Dr. Loraine Ronchi, Economist, Agriculture and Rural Development, World Bank

Mr. Antoine Joyeux Rugari, Operations Manager, Rwanda Leather Industries Ltd
Mr. Felician Rurangwa, Executive Secretary, Bigogwe Sector, Nyabihu District
Mr. Charles Ruranirwa, Farmer Rutete, Secteur Rweru, Bugesera District
Mr. Celestin Safari, Gisenyi Mining Cooperative
Mr. Celestin Sebutinja, Spinning and Weaving Manager, UTEXRWA
Dr. Lucy Spelman Project Coordinator, Mountain Gorilla Veterinary Project
Mr. Teddie Uwamariya, Farmer Nemba, Secteur Rweru, Bugesera District
Mr. Prosper Uwingeli, Chief Park Warden, Volcanoes National Park.
Mr. Fidele Uwizeye, Mining Officer, Ministry of Natural Resources
Mr. Gitau Wamukai, Chief Executive Officer, Rwanda Leather Industries Ltd
Mr. Matthias Weingart, Country Director, Swiss Agency for Development and Cooperation
Mr. Olivier Twizeyimana, RHODA
Mr. Guido Rutagongwa, HELPAGE
Mr. Karangwa Paul, The New Times
Mr. Asaphson Agaba, Prime Ministry
Mr. Tony Polatajko, DFID
Mr. Joseph Katarwa, MINISANTE
Mr. J. Pierre Kavarugania, MINIRENA
Ms. Liliane Utamuriza, RURA
Ms. Lydia Kunda Ndayi, RURA
Ms. Bizimana Arlette, RURA
Mr. Jean Bigagaza, RURA
Mr. Karambizi Sylvestre, UNR
Mr. Innocent Kabenga, NELSAP
Mr. Marcel Musemman, Business Daily News Paper
Mr. Maximilien Remyi Osengumu, MINECOFIN
Mr. Musmi Jacqueline, REMA
Mr. George Kalisa, The New Vision
Mr. Célestin Ali Mana, ARECO
Mr. Atrayee Basu, MININFRA
Ms. Beatrice Batumuliza, Africa Press Agency
Ms. Ruzibiza Violette, RURA
Ms. Murekatete Emmanuella, RURA
Mr. Emile Seruboga, RURA
Mr. Hakorimana Célestin, RURA
Mr. Emmanuel Niyonteze, Maison de la Presse du Rwanda
Mr. Innocent Galingana, New Times
Mr. Dieudonné Sebashongore, KIST
Mr. Nelson Gatsimbure, Consultant
Mr. Jean Byrée Ayiringin, Consultant
Mr. J.B Bwanakeye, RURA
Ms. Colette Ruhamyia, KIST
Mr. Gashugi Leonard, RISE
Ms. Teke Melek, MININFRA
Mr. Charles Pepinster, MININFRA
Mr. Erik Van Nohleren, MININFRA
Mr. Yves Couvreur, REMA
Mr. Liberal Seburikoko, DFID
Ms. Fina Kayisanabo, USAID
Ms. Marie Laetitia Busokeye, REMA
Mr. Francois Twagirayeza, MININFRA
Mr. Assumpta Mukaminiza, Kigali city
Mr. Zanyamibwa Patrick, ARECO- Rwanda
Mr. Ganza Simplicie, RURA
Mr. Sibomutanguha, UNHCR
Mr. Ndayisaba Alexis, JICA
Mr. Alphonse Businge, RNP

15 CONCLUSIONS AND RECOMMENDATIONS

Ms. Segahwege Astrid, NISR
Mr. Duhuze Remy, REMA
Mr. Sosthene Kabayiza, MINADEF
Mr. Twahirwa Anthony, METEO
Ms. Clover Jeanette, UNEP
Mr. Harerimana Donath, ELECTROGAZ
Mr. Bizimungu Francis, RDB/ORTPN
Ms. Umuhoza Francine, ELECTROGAZ
Mr. Viateur Ngiruwonsanga, WF
Mr. Gakwandi James, MEDIA
Mr. Paul Ouedraogo, REMA
Ms. Nkusi Uwimana Agnes, OMURABYO
Mr. Alexis Bamage, PANAPRES
Mr. Mapendo Clement, SYMPOSI
Ms. Umuhoza Laetitia, REMA
Mr. Mugwaneza Innocent, Umwezi Newspaper
Mr. Paul Scholte, REMA/PAB
Mr. Mpayana Raphael, REMA/PAB
Mr. Valens Mwumvaneza, World Bank
Mr. Shyaka Eugene, Rwanda Newline
Mr. H. Kiswoh, ORTNP/RDB
Mr. Nkundanyirazo E., MINAGRI
Mr. Nsengyunu Barakabuye, WCS
Mr. Gapusi R. Jean, ISAR
Mr. Djumia Marcel, Société Civile
Ms. Scorphine M. Nkesi, DCE
Ms. Usabyumukiza Naomie, Le Receif
Ms. Martine M. Kagabo, REMA/PAIGER
Mr. Guissepe Daconto, Care International
Mr. Niyonzima Steven, UNIDO
Mr. Nanboko Dunia, Société Civile
Ms. Kayigamba Françoise, NELSAP
Mr. Kabuyenge J-Pierre, NUR
Mr. Muganza Canising, SYMPOSIA
Mr. J. Thryée Byiringiro, Freelance Journalist
Mr. Barbee Albrecht, UNIFEM
Mr. Gerard Hendriusen, MININFRA
Mr. Demoor Arbaud, EU
Mr. Maxime Rwendeye, UNIFEM
Mr. Ruzigana Silas, MININFRA
Mr. Didier Sagashya, NLC
Mr. Karera Tiler, USAID
Mr. Nabide Isah Kiti, NBI/NELSAP
Mr. Ahimana Celestin, ARECO-Rwanda
Mr. David Stone, ProAct
Mr. Valentine Ndibalema, UNHCR
Mr. Benjamin Nyandu, Freelance Journalist
Mr. Martin Sibó, ORINFOR
Mr. Edouard Munyamaliza, CIDA
Mr. Gakire Fidele, MPH Press
Mr. Janvier Ntalindwa, SIDA
Mr. Biseruka Karim, Voice of Africa
Mr. Mukara Eric, City Radio
Mr. Elias Nizeyimana, Radio Flash
Mr. Bihabi Ndi Nuhu, Voice of Africa
Ms. Tushabe Rachel, REMA
Mr. Kisioh Humphrey, ORTPN-RDB

Further information

Copies of this report may be ordered from:
SMI (Distribution Services) Limited
P.O. Box 119
Stevenage
Hertfordshire SG1 4TP, UK
Tel: +44 1438 748111
Fax: +44 1438 748 844

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www.unep.org

United Nations Environment Programme
P.O. Box 30552 Nairobi, Kenya
Tel: +254 (0)20 762 1234
Fax: +254 (0)20 762 3927
Email: unepub@unep.org



Rwanda's remarkable turnaround from a devastated, war torn country into a promising showcase of African development is an exceptional story. Under its long-term national development plan, Vision 2020, Rwanda aims to lift itself from a least developed into a middle-income country by 2020. It is within the context of finding an environmentally sustainable path to Vision 2020, that the Government of Rwanda requested UNEP to carry out a countrywide post-conflict environmental assessment.

Although 16 years have elapsed since the 1994 genocide, its environmental consequences continue to pose serious challenges. The most significant impacts stem from massive population displacement and resettlement, including considerable reductions in the surface area of national parks, forests and wetlands. The initial breakdown in natural resource governance, the loss of environmental data and monitoring capacity, and the shortfall in human expertise are enduring impacts of the conflict. At the same time, Rwanda's extensively altered environment faces multiple long-standing problems driven by high population growth, poverty and natural resource over-exploitation including land degradation, deforestation and biodiversity loss.

Three priority areas for intervention are identified which include: ecosystem conservation and rehabilitation to combat poverty; capacity-building to strengthen environmental governance; and enhance and promote regional environmental cooperation.

This multi-disciplinary report by UNEP covers eleven themes and aims to offer an independent, critical analysis of the most pressing environmental issues facing Rwanda. The assessment assumes a forward-looking approach and proposes scientifically based recommendations to tackle concrete problems.

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