



RWANDA STATE OF ENVIRONMENT AND OUTLOOK Our Environment for Economic Development



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Our Environment for Economic Development



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Our Environment for Economic Development



Table of Contents

Foreword	i
Preface	ii
Editorial and Production Team	iii
Acknowledgments	iv
Acronyms	v
Background and Introduction	1
Overview of Rwanda	1
State of the Environment Reporting	2
PART 1: ENVIRONMENT, PEOPLE AND DEVELOPMENT	5
Chapter 1: Environment and Economic Development.....	7
The State of the Economy based on Macro-Economic Indicators	7
Economic Growth and the Environment	10
Importance of Natural Resources in the Economy	10
Poverty and Environment	13
Conclusion	15
Chapter 2: Population, Health and Human Settlements.....	17
The State of Population in Rwanda	17
Human Settlement	18
Environmental Health	21
Strategies to Improve Settlements and Human Welfare	24
Conclusions and Recommendations	26
Chapter 3: Land Use and Agriculture	27
Overview of the Agriculture Sector	27
The State of Land Use and Agricultural Development in Rwanda	28
Agriculture and National Economic Development.....	32
Key Environmental Issues Associated with the Agricultural Sector	33
Addressing the Threats to Agriculture	37
Chapter 4: Industry and Mining.....	41
Industrial Sector in Rwanda	41
Challenges Facing the Industrial Sector	43
Strategies to Encourage the Development of the Industrial Sector	46
Conclusions and Recommendations	48
PART 2: STATE OF THE ENVIRONMENT	49
Chapter 5: Biodiversity and Genetic Resources	51
Current State of Biodiversity	51
Threats to Biodiversity	54
Opportunities Provided by Biodiversity	56
Strategies to Improve Rwanda's Biodiversity	57
Conclusion and Recommendations	58

Chapter 6: Forest and Protected Areas	59
Current Status of Forestry Resources in Rwanda	59
Opportunities from the Forest Sector	62
Threats to Harnessing the Opportunities provided by Forests	63
Strategies to Harness Opportunities from the Forest Sector	65
Conclusion	66
Chapter 7: Water and Wetlands Resources	67
Introduction	67
Status of Water and Wetland Resources	67
Value of Wetlands and their Role in Economic Development	75
Threats to Water and Wetland Resources	77
Strategies for Improving Water and Wetlands Resources	80
Conclusion	81
Chapter 8: Energy Resources	83
Introduction	83
The Energy Crisis in Rwanda	83
Sources of Energy in Rwanda	84
Opportunities Provided by the Energy Sector	89
Challenges Faced by the Energy Sector	93
Responses to Improve the Energy Situation	93
Conclusion and Recommendations	95
Chapter 9: Climate Change and Natural Disasters	97
Rwanda's Climate	97
Climate Change in Rwanda	98
Vulnerability to Natural Disasters	99
Responses	103
Conclusions and Recommendations	104
PART 3: ENVIRONMENTAL GOVERNANCE – NOW AND IN THE FUTURE	105
Chapter 10: Exploring The Future Of Rwanda's Environment Using Scenarios	107
Introduction	107
The Scenario Building Process	107
Exploring Rwanda's Environmental Futures	112
Conclusion: The Interlinkages and Policy Lessons	120
Chapter 11: Policy Analysis And Options For Action	123
Introduction	123
Policy Options for Action	123

Foreword



Rwanda's economy and the livelihoods of her people are dependent on the environment and natural resources such as water, land, air, minerals, plants and animals. These natural resources are increasingly under pressure from unsustainable use resulting in environmental degradation as well as decline in ecosystem goods and services. The national environmental assets provide opportunities to achieve economic development and make good progress towards Vision 2020, EDPRS and the targets of the Millennium Development Goals. Rwanda's socioeconomic transformation cannot be realized without primarily addressing environmental challenges.

We cannot afford to lose our natural heritage through environmental degradation. Our very survival and that of future generations depends on the sustainable use of our environmental resources. Our challenge, as a country is to utilize natural resources to the benefit of sustainable development. To achieve this objective will require utilization of resources in ways that promote environment and natural resource conservation and improved management of all forms of pollutants, soil erosion, deforestation and general degradation of national resources.

The Government of Rwanda acknowledges these facts and has put in place measures to safeguard our environment while realizing economic growth. These measures include the adoption of a National Environmental Policy followed by the enactment of an organic law determining the modalities of protection, conservation and promotion of environment and the establishment of the Rwanda Environment Management Authority (REMA) in April, 2005. All these efforts are focused on overall support for sustainable national development.

This Rwanda's first comprehensive State of the Environment report provides a baseline environmental data and indicators. The report was adequately informed by national policies and strategies and will in turn support national environmental governance to the benefit of improved environmental management and envisaged contribution to national social and economic growth and overall human wellbeing. Additionally, the report draws inspiration from and will feed into other regional and global environmental reports such as the African Environmental Outlook (AEO) and the Global Environmental Outlook (GEO).

I am very pleased to present you this state of environment report, first of its kind, which provides information and knowledge on the state of the environment; serves as a guidance document for policy-makers and other stakeholders on how to improve environmental performance; and establishes the evidence base for monitoring the implementation of environmental priorities in national sustainable development. On behalf of the Government of Rwanda and on my own behalf, I would like to sincerely acknowledge African Development Bank and United Nations Environment Programme for their support in preparing this report. I would also like to commend REMA's team and all experts, national and regional and other partners whose dedication and contribution made this publication possible.

It is my hope that information provided by this report will inspire us in our road towards a wealthy state grounded in sustainability of our national development. I wish you a good reading.

A handwritten signature in black ink, appearing to be 'V. Karega', written in a cursive style.

Mr. Vincent Karega

Minister of State in Charge of Environment and Mines, Ministry of Natural Resources

Preface



Achievement of national sustainable development goals and effectively supporting poverty reduction initiatives will require Rwanda to integrate environment and natural resources management principles into the national planning for economic development. Environmental assessment and reporting is therefore a key contribution towards the role of environment in development by providing a reliable information base for environmental management and decision making.

This Rwanda's first comprehensive State of the Environment (SoE) report is produced in fulfillment of article 3 of law No 16/2006 (03/04/2006) that obligates REMA to take stock and conduct comprehensive supervision of the environmental management, in order to prepare a report on the state of environment and natural resources in Rwanda that shall be published every two years.

The development of this state of environment report was characterized by a highly participatory approach from the selection of the themes through drafting of the report and validation of the final product. The broad representation at various fora included participants at the District and Central levels of Government, development partners and nongovernmental stakeholders all of whom were intended to guarantee ownership of the report by key national stakeholders.

This report was developed using an Integrated Environmental Assessment and reporting approach. The cause - effect linkages of human and natural actions and their impacts on the environment and human wellbeing in the country were assessed. More pertinently, the links between environmental state-and-trends with policy responses will likely guide decision making in support of sustainable development. In addition, the assessment "looked" into the future using various plausible scenarios to highlight how a range of interlinked actions may enhance or undermine Rwanda's natural wealth and thus economic growth. This report establishes an authoritative baseline for the realization of Rwanda's Vision 2020, EDPRS and MDGs. It highlights the role of natural resources in national economic growth. In this regards the report shows how the achievement of EDPRS and MDG may be jeopardized by environmental degradation, especially in water and energy resources, sanitation in the absence of informed decisions and actions.

REMA is extremely indebted to ADB and UNEP for their financial and technical support in the production of this report. Your support not only provided the resources but also contributed to the building of our national capacity in environmental reporting. I want to express my heartfelt gratitude to those who pioneered environment management in Rwanda. The support received from the Government of Rwanda leadership in general and the Ministry responsible for environment in particular, since the establishment of REMA has contributed to a great recognition of our country in environmental governance not only in our region but also worldwide.

Information provided by this report is undoubtedly valuable. However, to the real value lies in the potential to take us as individuals and as a nation to actions poised to restore our environment. It is my sincere hope that as we read the report, we will be inspired to support concrete actions towards a Green, Clean, Healthy and Wealthy Rwanda.

A handwritten signature in black ink, reading "Mukankomeje Rose".

Dr. Rose Mukankomeje

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Acronyms

AfDB	African Development Bank
CITES	Convention on International Trade in Endangered Species
COMESA	Common Market for Eastern and Southern Africa
DRC	Democratic Republic of Congo
EDPRS	Economic Development and Poverty Reduction Strategy
EIA	Environment Impact Assessment
FAO	Food and Agricultural Organisation of the United Nations
GDP	Gross Domestic Product
GHG	Green House Gases
GNP	Gross National Product
HIV/AIDS	Human Immune Virus/Acquired Immune Deficiency Syndrome
ICS	Improved Cooking Stoves
ICT	Information Communication Technology
IDA	International Development Agency
IMF	International Monetary Fund
ISAR	Institut des Sciences Agronomiques du Rwanda
MDG	Millennium Development Goals
MINAGRI	Ministry of Agriculture
MINECOFIN	Ministry of Finance and Economic Planning
MININFRA	Ministry of Infrastructure
MINIRENA	Ministry of Natural Resources
MINISANTE	Ministry of Health
MINITERE	Ministry of Lands, Environment, Forestry, Water and Mines
NAFA	National Forestry Authority
NBI	Nile Basin Initiative
NEPAD	New Partnership for Africa's Development
OCIR-Café	Rwanda Coffee Authority
OCIR-Thé	Rwanda Tea Authority
ODA	Overseas Development Assistance
OECD	Organisation for Economic Corporation and Development
OGMR	Rwanda Office of Geology and Mines (<i>French acronym</i>)
ORTPN	Rwanda Office of Tourism and National Parks (<i>French acronym</i>)
PRSP	Poverty Reduction Strategy Paper
REMA	Rwanda Environment Management Authority
SEA	Strategic Environmental Assessment
SOE	State of the Environment
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme

Background and Introduction

Overview of Rwanda

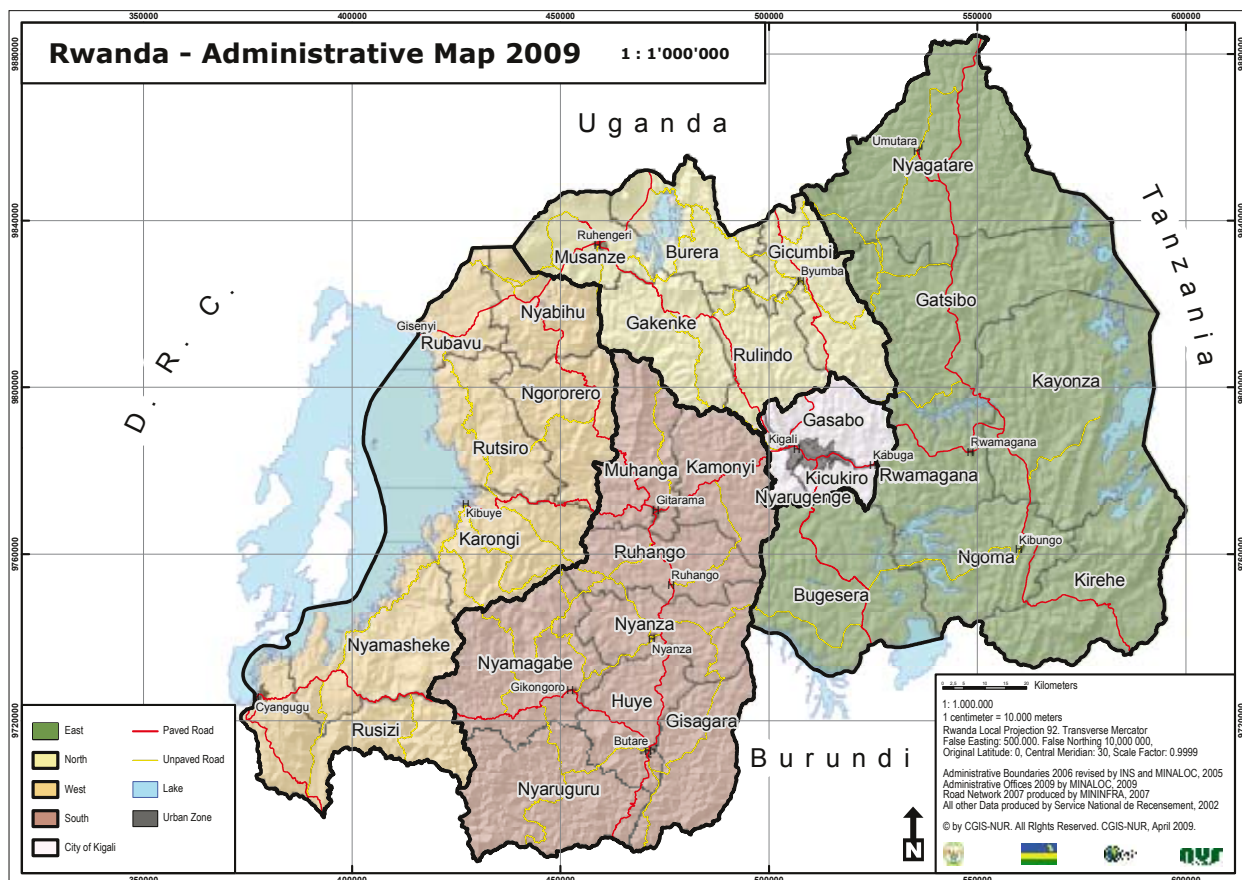
Rwanda is located in Central Africa between latitudes 1°04' and 2°51' south and longitudes 28°45' and 31°15' east. Its surface area is 26,338 km². The average population density in 2002 was 321 people per km² (INSR and ORC Macro 2006) and the physiological density (people per area of arable land) was in excess of 500 people per km² (UNDP and UNEP 2006). Figure 1 shows the administrative divisions of Rwanda.

The Rwandan relief is hilly and mountainous with an altitude averaging 1700 meters. The highest point on Mt Karisimbi is 4507 meters above sea level. Rwanda has volcanic mountains at the northern fringe and undulating hills in most of the central plateau. However, the eastern part of the country is relatively flat with altitudes well below

1500 meters. This relief pattern gives Rwanda a mild and cool climate that is predominantly influenced by altitude. Average annual temperatures are about 18.5°C and average rainfall is about 1,250 mm per annum. The lowlands of the southwest in Bugarama plain with an altitude of 900m are part of the tectonic depression of the African Rift Valley.

The country is predominantly agricultural with few options that would reduce the pressure on land resources. Agriculture contributes 47 per cent of the GNP and accounts for 71 per cent of the country's export revenue. It is the main source of income for 87 per cent of the population (MINAGRI 2006). Only 52 per cent of the land surface area is arable, representing approximately 1,385,000 hectares (ROR 2004). High population density in fragile ecosystems exposes the country's natural resources to degradation.

Figure 1: Administrative divisions of Rwanda





High population density and land scarcity has forced people to settle right along the ecologically fragile river banks leading to soil erosion and wetland degradation

The major problems facing the environment are pressures from the growing population on the natural resources such as land, water, flora and fauna and other non-renewable resources (MFEP 2000). This is most evident in land degradation, soil erosion, decline in soil fertility, deforestation, wetland degradation, loss of biodiversity and pollution (ROR 2004).

State of the environment reporting

Context and process

State of the environment (SOE) reporting provides information on the current state of the natural resources, underlying causes of environmental change and the responses to the changes. The aim of SOE reporting is to improve

understanding of environment and sustainable development issues; and to contextualize and clarify environmental trends in order to inform decision-making. One of the fundamental characteristics of this sort of reporting is the identification of the linkage between the biophysical and socio-economic considerations within a sustainable development context.

Traditional SOE reports have the objective of providing information on environment state and trends as its key variables. However, over the past three decades this has evolved to include an assessment of the environment in a more integrated manner. Integrated environmental assessment tries to show the cause-and-effect linkages of human and natural actions and their impact on the environment. In turn, it highlights the impacts of the resultant changes in the environment on human well-being.

SOE reporting has been a legal requirement in Rwanda since 3rd April 2006. The law establishing the Rwanda Environment Management Authority (REMA) - Law No. 16/2006 in article requires REMA to *take stock and conduct comprehensive supervision of the environment, in order to prepare a report on the state of natural resources in Rwanda that shall be published every two years.*

This report is the first comprehensive SOE report for Rwanda. It is an integrated assessment and will provide a baseline for future reporting. It will also feed into other regional and global environmental reports such as the Africa Environment Outlook and the Global Environment Outlook.

The entire SOE process, from themes proposal and identification through to validation of the final report was a participatory process. It was a joint effort of REMA, lead agencies, major governmental and non-governmental stakeholders, the private sector and national experts in the different thematic areas. The participatory approach was an important component of the SOE development process from the themes proposal and identification to the validation of the final report. This report builds on the outcomes of the desk studies taken by the UNEP - Post Conflict Environmental Assessment.

REMA supervised the entire process which was made possible through support from the African Development Bank (AfDB) under the projet d'Appui Institutionnel à la Gestion de l'Environnement (PAIGER), the United Nations Environment Programme (UNEP) through the African Environment Information Network (AEIN) and the Government of Rwanda.

Methodology

The format used for the analysis is the driver-pressure-state-impact-response (DPSIR) framework. This format highlights a chain of causal links starting with **driving forces** (economic and human activities) through **pressures** (emissions, waste) to **states** (physical, chemical and biological) and **impacts** on ecosystems, human health and functions, eventually leading to political **responses** (policies, legal and institutional frameworks) (UNEP 2006).

As much as possible, the report has compiled and analysed data and indicators to demonstrate positive or negative change. Attempts have also been made to establish a baseline to inform any future assessments. This report builds on the outcomes of the desk studies undertaken by UNEP-Post Conflict Environmental Assessment.

The report has used data from different sources such as policy and strategic initiatives including national planning and budget processes. By use of the integrated analysis approach, it aims to reinforce the cross-cutting nature of environment management further bringing together differing sectoral mandates in support of sustainable development.

The end result of this assessment will be more than just knowing about the state of the environment. It will provide policy-makers and other stakeholders some guidance on how to better manage the environment.

Format and content of the report

This SOE report is divided into three parts. Part 1 sets the stage for the report by providing an overview of the economy, the people and the role that the environment plays in supporting development and vice versa. It also discusses two economic themes that are particularly important to livelihoods: Land Use and Agriculture, and Industry and Mining.

In the second part, the focus turns to the natural resources that underpin economic growth and social development. It is set along five thematic areas: Biodiversity and Genetic Resources, Forest and Protected Areas, Water and Wetlands Resources, Energy Resources and Climate Change and Natural Disasters.

The third part of the report highlights the strategies (policies, legislation and institutions) the Government has put in place to support the sustainable development. It also takes a look into the future through the use of scenarios.

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ENVIRONMENT, PEOPLE AND DEVELOPMENT



Chapter 1: Environment and Economic Development

About 57 per cent of Rwandans, a majority of them women, live in abject poverty, surviving on less than US \$1 per day. In most instances, this category is prone to conditions where many children do not receive even a basic education. Additionally, many households do not have access to basic sanitation or water supplies. In recognition of the strong linkages between poverty and environment, one of the Millennium Development Goals (MDG 7) seeks to integrate the principles of sustainable development into country policies and programmes, and reverse the loss of environmental resources (ROR 2007) Box 1 highlights MDG 7 and its targets.

The livelihoods and food security of the poor often depend directly on ecosystems, and the diversity of goods and services derived from these ecosystems. Healthy ecosystems provide a range of 'invisible services' that are essential for sustainable development. Achievement of national and international sustainable development goals and effective support to poverty reduction initiatives will require Rwanda to integrate environment and natural resources management principles into the national planning process for economic development.

The economy is also linked to the environment in many important ways. All economic activities including production, consumption and waste disposal subsist in the environment. It has become abundantly clear that the state of environment determines the level of prosperity not only in the short term but also for future generations. This underlines the need to examine both economic and environmental indicators to determine the impact on the environment of a range of economic activities in Rwanda and conversely, how wise use of environmental resources can increase economic growth.

The State of the Economy Based on Macro-Economic Indicators

In Rwanda the real GDP at constant prices of 2001 grew by 6 per cent in 2007 against 5.5 per cent in 2006. GDP growth during the last 5 years has reflected a positive trend

even if there was a decrease of 1.6 per cent between 2005 and 2006. This growth emanated from the recovery of the tertiary and secondary sectors which recorded an increase of 11.4 and 9.2 per cent respectively of the value added in 2007 compared to the previous year (NBR 2008).

The primary sector is not the major contributor to economic growth because high population densities on rural land coupled with poor farming methods have resulted into alarming soil losses with adverse effects on agricultural production and productivity. The value added for 2007 in constant prices of 2001 for the primary sector declined by 0.5 per cent. The tertiary sector maintained the first position in the structure of GDP with 48 per cent of the GDP at constant prices of 2001, followed by primary sector (31 per cent) and then secondary sector with 15 per cent of the GDP in 2007 (NBR 2008).



Waste from economic activities such as near this wetland this garage in Gastata can result in environmental pollution

Box 1: Millennium Development Goal 7

Goal: Ensure environmental sustainability

Targets:

- Integrate the principles of sustainable development into country policies and programmes; reverse loss of environmental resources
- Reduce by half the proportion of people without sustainable access to safe drinking water
- Achieve significant improvement in the lives of at least 100 million slum dwellers by 2020.

Source: UNEP 2006

Table 1: Developments in resources and uses of GDP (in billion RWF at constant 2001 prices)

Resources description	2003	2004	2005	2006	2007	% (2007)
RESOURCES						
Primary sector	307	309	325	328	326	31.34
Secondary sector	110	123	130	142	158	15.19
Tertiary sector	361	389	425	459	501	48.17
Impute bank service charges	(14)	(17)	(18)	(22)	(26)	
Import taxes	61	64	69	74	81	
GDP	825	869	930	981	1 040	
Economic growth (%)	0.3	5.3	7.1	5.5	6.0	
USES						
Final consumption	808	858	922	981	1 051	
Investment	116	129	145	151	152	
Export (G&NFS)	72	89	95	102	95	
Less: Imports ((G&NFS)	170	207	232	242	258	
MEMORANDUM ITEM						
Current GDP per capita (Rwf)	114 530	132 836	151 334	181 288	199 881	
Current GDP per capita (USD)	214	230	271	331	365	

Source: NBR 2008

This current structure of GDP for which the tertiary sector is a major contributor to the economy is a good indicator that the pressure on natural resources may be remarkably reduced to allow environment conservation. However, this aspect has not considered population pressure which is a second driver. GDP per capita at current prices improved by 6.6 per cent: rising from 181.3 to 199.9 thousand Rwanda Francs. In terms of US \$ there was an increase of 10.3 per cent: from US \$ 331 to 365 in 2006 and 2007 respectively. This is shown in Table 1.

Inflation

Modern economists generally tend to agree that inflation does not favour rapid economic growth and the benefits of lowering inflation are great if the policy makers are willing to support sustainable economic growth. During the period from 2003 to 2007 the consumer price index continued to rise on monthly and annual average. In 2007 annual overall inflation reached 9.1 per cent against 8.9 per cent in 2006 (NBR 2008). In terms of import indices, the volume and the value indices increased by 43.84 and 47.04 per cent, in 2006 and 2007 respectively. Among imported goods, energy and lubricants registered the greatest rise of 99.46 per cent in value. Fuel led with a rise of 106.32 per cent in value against a rise of 5.33 per cent in volume (NBR 2008).

Generally, inflation in Rwanda emanated from local products and services. The cause of this was bad weather conditions which affected the production of foodstuffs. This fact goes to show how environmental services which are linked to climate variability can significantly impact the national economy. With imported goods, inflation depends on prices on the international market and Rwanda has no control over those. Those prices affect particularly the supply of petroleum, cereals and bread. It is clearly evident that economic factors at the household as well as macroeconomic levels are very much linked to environmental goods and services and there is thus every justification for environmental factors to form key considerations in economic planning for effective poverty reduction and enhanced economic growth.

Products and services affected by inflation may exert pressure on the environment by reducing the real value of financial resources earmarked for environmental rehabilitation as well as user and pollution charges and by accentuating pressure on the environment by an increase in investment in agriculture for food production. Also, the increase in prices of housing, water, electricity, gas and other fuels can lead to a situation where achieving MDG 7 will not be easy for those with low income.

Table 2: Development of Rwanda public external debt (in US \$ million)

Description	2002	2003	2004	2005	2006	2007
Debt burden (US \$ millions)	1400.2	1522.2	1501.8	1439.7	361.7	430.3
per cent of GDP	85.3	93.4	91.9	70.7	15.0	18.7
NPV of debt (US \$ millions)	395.933	398.4	452.0	283.1	162.7	225.3
NPV of debt to export ratio (%)	270.3	288.6	239.4	149.8	65.6	82.9

Source: NBR 2008, UNDP 2007



Increases in prices of clean fuels like electricity or gas and increased demand for building poles increases pressure on forests

External Debt

Rwanda, like most developing countries, has experienced debt distress over the last two decades arising from increased external borrowing (to finance mainly high energy costs like crude oil), fiscal deficits, and development programs, among others. Table 2 shows Rwanda's public external debt.

In May 2005, Rwanda became the 18th country to benefit under the Heavily Indebted Poor Country Initiative. This debt relief, offered under the Heavily Indebted Poor Country framework, has played a role in increasing the domestic fiscal space available to Rwanda, since the debt burden fell from 93.4 to 15 per cent of GDP. In addition to the Paris Club country loans in 2005, the implementation of the G8 countries decision to cancel the total debt due to the International Monetary Fund (IMF) and an important part of debt stock due to International Development Association (IDA) and the African Development Bank (AfDB) Group by the heavily indebted poor countries did reduce Rwanda's public external debt stock from US \$1523.4 million in 2005 to US \$449.8 million in 2006 and US \$503.2 million in 2007 (NBR 2008).

Foreign aid and investments are still important due to the balance between the local revenue and the needs for investments. In 2007, tax revenue was 242 billion RWF from

the country's revenue collections which included income tax, (corporate profit tax, sole trader profit, tax on loans and pay as you earn), value added tax, customs duty and excise duty. International donors provided the rest of the budget equivalent to 251 billion RWF (51 per cent with 86 per cent of the foreign aid in form of donor grants). In 2007, the public external debt of Rwanda was mostly loans from multilateral institutions, such as World Bank, AfDB and the IMF and represented 85.51 per cent of total public external debt. The remaining 14.49 per cent was from bilateral partners (NBR 2008).

The analysis on inflation demonstrated that Rwanda may not be able to achieve the MDGs if inflation on key sectors of housing, water and energy continues to rise. Even so with debt service, these same sectors will continue to dominate the external loans that will impact on the overexploitation of the resources needed for them.

In order to reduce the dependency on foreign aid, efforts are underway to diversify exports but products are still based on natural resources. Some of the new products include handicrafts (*agaseke*) specifically for women; and new crops such as passion fruit, pineapple and flowers. Rwanda will, in parallel, continue to diversify sources of revenue collection into areas such as urban construction and real estate. Other solutions are to increase the electricity generation capacity to facilitate more investments in the industry sector when financial resources permit.

Budget allocation

Government budget allocated to sectors with a bearing on the environment has been very limited in the past few years and focused on supporting other sectors such as agriculture (including marshland reclamation), energy (addressing the energy crisis and introduction of alternative sources of energy) and access to water. This was mainly linked to the fact that during the implementation of the Poverty Reduction Strategy Paper (PRSP 1 between 2003 and 2005) environment was not considered as sector but only a cross cutting issue. It is therefore not easy to evaluate the resources allocated

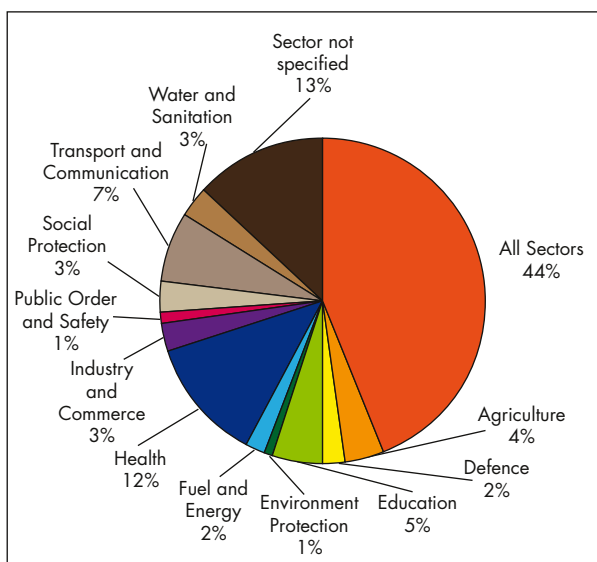
to environment before the year 2003 when the ministry in charge of environment (MINITERE) was created.

From 2003 to 2007, the budget allocated to environment grew from 0.06 per cent to 1.15 per cent. This situation will remain the same during the current Economic Development and Poverty Reduction Strategy (EDPRS) period as mentioned in the budget framework paper 2008 (MINECOFIN 2007). The share of environment, land and forestry will not exceed 1.8 per cent of the total expenditure and not 4.9 per cent in the Capital Development and Productive Sectors expenditure - the first priority type of expenditure in the EDPRS (ROR 2007).

In 2005, the overall aid directed to environmental protection constituted only 1 per cent of the total overseas development assistance (ODA) disbursed in that year. However, due to its cross-cutting nature, some funds from health (12 per cent), energy (2 per cent), agriculture (4 per cent) and water and sanitation (3 per cent) may have contributed to environment management depending on how well mainstreamed environment was in those sectors. Figure 1 highlights this issue.

It is worth noting that there has been no actual public expenditure review to track spending on environment to date and therefore the information on cross-sectoral spending on environmental priorities is not available. In the course of implementing the EDPRS, REMA plans to conduct a comprehensive public expenditure review as well as environmental fiscal reform as a means to finance environment.

Figure 1: FY 2005 ODA Disbursements by sector



Source: RDP 2008

Economic growth and the environment

Rwanda's economy and the livelihoods of her people are dependent on natural resources such as water, land, air, plants and animals. These natural resources are increasingly under pressure from unsustainable use resulting in environmental degradation. The challenge is to utilize natural resources to develop the economy while at the same time conserving the environment to avoid the adverse impacts of pollution, soil erosion, deforestation and general degradation.

Over the past years, Rwanda's economic growth, as shown by trends in real GDP, has been on the increase, mainly due to good performance of the tertiary and secondary sectors. This could be taken as an indicator that economic growth is not putting much pressure on natural resources. However the same growth, if not controlled may lead to an increase of pollution loading which may affect the environment.

The EDPRS of 2007 assigns the highest priority to accelerating economic growth to create employment and generate exports. With two thirds of the population aged less than twenty-five years, particular emphasis is placed on creating jobs for young people. The annual GDP growth rate is planned to rise from 6.5 to 8.1 per cent by 2012. Exports growth is scheduled to increase at 15 per cent per annum compared to the current rate of 10 per cent. This accelerated pace of growth will be made possible through a large increase in the investment rate which will rise from 15 to 23 per cent of GDP by 2012 (ROR 2007).

Importance of natural resources in the economy

The productive sector requires basic inputs such as labour, capital, land and entrepreneurs. In the case of Rwanda, both land and capital can be defined broadly to include natural resources used in the productive process including organic matter, soil, water, forests, fisheries and energy. Industrial processes, too, depend on natural resources for instance minerals, petroleum products, animals and plants which are used as raw materials or inputs for production. Box 2 explains the three-sector hypothesis which is used to describe Rwanda's economy in the sections that follow.

Box 2: The three-sector hypothesis

The **three-sector hypothesis** developed by Colin Clark and Jean Fourastié is an economic theory which divides economies into three sectors of activity:

- The **primary sector of the economy** involves changing natural resources into primary products. Most products from this sector are considered raw materials for other industries. Major businesses in this sector include agriculture, agribusiness, fishing, forestry and all mining and quarrying industries.
- The **secondary sector of the economy** includes those economic sectors that create a finished, usable product: manufacturing and construction. This sector generally takes the output of the primary sector and manufactures finished goods or where they are suitable for use by other businesses, for export, or sale to domestic consumers.
- The **tertiary sector of economy** (or service sector) involves the provision of services to businesses as well as final consumers. Services may involve the transport, distribution and sale of goods, or may involve the provision of a service, such as pest control or entertainment.

Source: Wikipedia 2009

The primary sector

A sector by sector analysis shows that the primary sector has realized poor performance in comparison with other sectors due to unfavorable climatic conditions and poor traditional farming methods. With agriculture being the main source of livelihood and employment particularly among the rural population, the poor performance of the primary sector has a serious impact on the economy.

An analysis of the value added for the primary sector shows that there is no one trend direction. Between 2003 and 2004, there was a stagnation followed by an increase in 2005. More recently, in 2007, the value added for the primary sector declined by 0.5 per cent, with a decrease of 1.96 per cent for agriculture and an increase of 38.9 per cent for mining.

In 2007, production of food crops experienced a decline of 3.3 per cent compared to the two previous years mainly due to delayed rain season in some parts of the country. The same trend was experienced for export crops which decreased by 16.4 per cent also attributable to bad climatic conditions and also to the lack of maintenance of coffee factories. The forestry sector slightly increased for the 5 years period, the situation which indicates low level of forest exploitation resulted from recent measures taken to protect environment by limiting forests exploitation. This is shown in table 3.

Mining and quarrying activities registered positive developments over the last five years. There was exceptional performance between 2006 and 2007 where an increase of 40 per cent of the value added and 37.3 per cent of

Table 3: Value Added for the primary sector (in billion RWF, at constant 2001 prices) and production (in thousand tons)

Description	2003		2004		2005		2006		2007	
	VA	Prod.	VA	Prod.	VA	Prod.	VA	Prod.	VA	Prod.
Agriculture	303.5	7,015.242	303.8	6,975.525	318.5	7,458.737	322.0	7,393.841	318.1	7,166.833
Food crops	263.8	6,818	259.2	6,751	275.7	7,227	275.7	7,138	272.2	6,905
Exports crops	7.1	29.672	11.2	42.9414	8.5	35.0745	11.0	43.601	9.2	35.338
Animal production	18.6	160.273	19.1	173.458	19.6	188.483	20.1	202.973	21.3	216.840
Forestry	11.0		11.2		11.5		11.8		12.1	
Fishing	3.0	8.144	3.1	8.126	3.2	8.180	3.2	9.267	3.2	9.655
Mining	3.4	1.765	5.0	3.931	6.6	5.365	5.6	5.459	7.9	7.494
Total	306.8	7,017.007	308.8	6,979.456	325.0	7,464.102	327.6	7399.3	326.0	7,174.327

Source: NBR 2008

the volume of the main minerals production (tin, colombo-tantalite and wolfram) was observed. To this effect, the price of wolfram at the international market encourages the extraction of this mineral and its volume attained an increase of 87 per cent rising from 1 436 tons in 2006 to reach at 2 686 tons in 2007. The production of all other minerals has increased compared to 2006, such as 28.7 per cent for colombo-tantalite and 19.1 per cent for tin.

Secondary sector

The secondary sector is made up mainly of manufacturing industries: construction, public works, electricity, gas and water. Only manufacturing industries and construction including public works realized a good performance during the previous five years with an outstanding performance during 2006-2007. Value added (at constant 2001 prices) experienced a growth of 11.4 per cent in 2007 compared to that of 2006, as a result of outstanding performance in manufacturing industries and construction and public works which recorded 7.9 per cent and 15.9 per cent respectively in 2007 (NBR 2008).

As indicated earlier, the industry sector depends mainly on natural resources due to the use of local raw materials for the manufacturing, construction and public works sub-sectors. Most agro-processing industries use natural resources to transform crops or output of primary sector production; for instance, grain milling, fruits, legumes, bakeries, milk, alcoholic and non-alcoholic beverages, sugar production, wood, paper, tobacco, cement, full washed coffee and tea factories. In addition most of those industries use fuel wood as the main source of energy especially tea factories some of which even have their own forest plantations. The construction

sub sector also uses local material such as quarries, clays, and wood.

In terms of production the top 5 industries associated with significant pressure on the environment include: cement, modern beer, soft drinks, sugar and bakeries. The importance of natural resources is further demonstrated by the value added generated by local enterprises that is having a positive impact on the rural economy. An example is Urwibutso enterprise in the Rulindo District that makes Agashya juice (passion juice): value addition in 2007 was 59 per cent equivalent to 1,314,704,891 RWF.

Tertiary sector

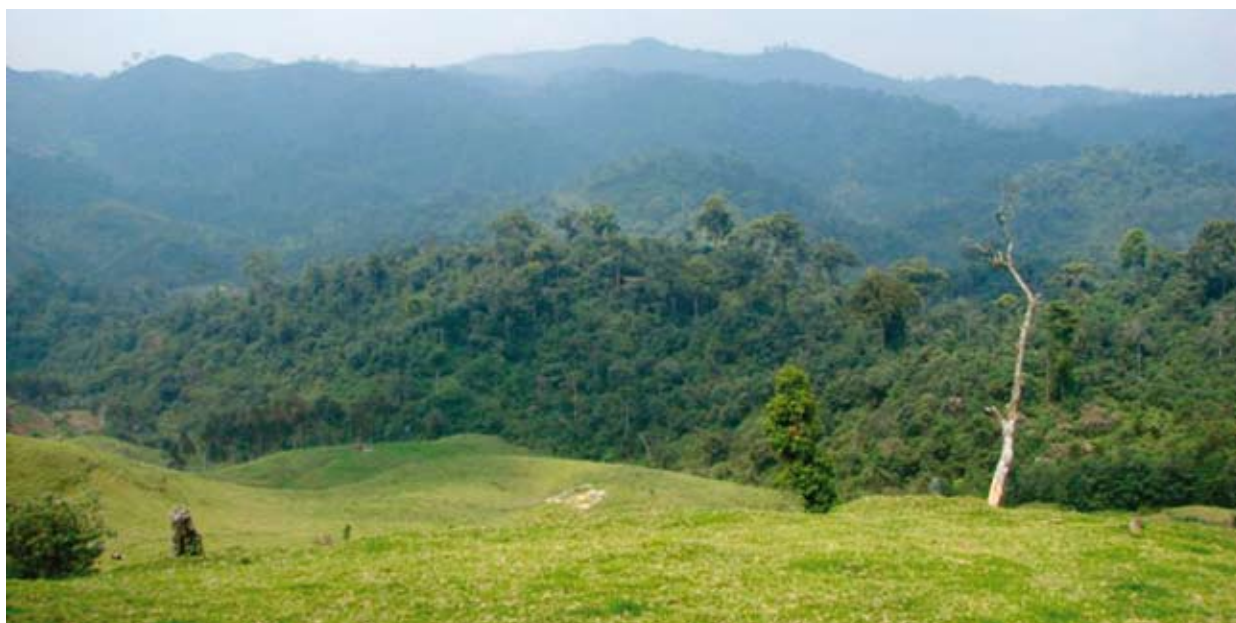
Value added by tradable services in 2007 rose by 11.4 per cent at constant prices of 2001. The two sectors of transport and communication; and finance and insurance also continued their value added growth of 34.6 and 20.4 per cent respectively. Commercial services had registered a growth of 8.9 per cent of its value added. Table 4 shows value added in the tertiary sector from 2003 to 2007.

Rwanda has a substantial advantage in the tourism sector that offers many investment opportunities. In fact the sector has grown steadily to become the second source of exports (behind coffee but ahead of tea and mining). The Government has developed a strategy for the development of tourism that focuses on high-end eco-tourism and invites investment into the sector. It includes improving planning for wildlife and national park conservation; promotion of research and monitoring of wildlife, including restocking national parks with relevant wildlife; involvement and engagement of local communities, and also provides for

Table 4: Value added in tertiary sector (in billion of RWF, at constant prices of 2001)

Description	2003	2004	2005	2006	2007
Tradable services	293	320	350	376	420
Domestic trade	86	92	101	106	116
Property and business services	80	82	89	94	96
Transport, storage & communication	47	53	59	63	85
Finance and Insurance	30	35	59	63	85
Others	50	57	63	66	67
Education	33	40	47	49	47
Health	16	17	16	17	19
Non-tradable services	68	70	74	83	82
Public administration	60	62	64	71	71
NPIs & NGOs	8	8	10	11	11
Total	361	389	425	459	501

Source: NISR et al. 2008



Rwanda's hilly landscape provides awesome views for tourists

the channelling of tourism revenues towards the protection of the natural resource base. If well implemented, this strategy will allow the development of tourism that is ecologically friendly and environmentally sustainable.

To achieve sustainable economic growth and social development, therefore, the Government is implementing the Economic Development and Poverty Reduction Strategy. It has a three pronged approach: sustainable growth for jobs and exports; Vision 2020 that aims to reduce poverty through a pro-poor national growth agenda; and a third tier that aims to improve Rwanda's international standing and reputation through improved governance. Environment and natural resources use form the foundation for all other sectoral activities and is thus envisaged to be a fundamental component of sustainable national development for the EDPRS (ROR 2000).

Poverty and Environment

Where are the poor?

The EDPRS puts the upper poverty line at 56.9 per cent and those living in extreme poverty at 36.9 per cent (ROR 2007). Rural areas are relatively poorer than urban areas. Poverty in rural areas is 62.5 per cent compared to 13 per cent for Kigali City and 41.5 per cent for other towns. Extreme poverty in rural areas is 40.9 per cent of the population (ROR 2007). Poverty also strikes hard in rural areas where

45 per cent cannot meet their food needs (ROR 2006). In terms of inequality, the Gini coefficient compared to the situation of 2000 has shown an increase from 0.47 to 0.51. This indicates that there is still inequity in access to national revenue including access to natural resources, especially to the land (ROR 2007).

Causes of poverty

The five major causes of poverty as identified in Ubudehe survey conducted in 2005, are the lack of land, soil infertility, weather conditions, lack of livestock (often linked to soil infertility) and ignorance (ROR 2007). The first four causes are directly linked to the environment. The same survey identified also sickness, polygamy and lack of access to water among other causes of poverty. Table 5 highlights some of the causes of poverty.

Exit strategies out of poverty were identified as paid employment, commerce and livestock. Unfortunately the primary sector continues to dominate as a source of employment in Rwanda. This, therefore, does not facilitate the acceleration of poverty reduction with the desired speed. According to Integrated Household Living Conditions Survey (EICV2), the major employer for the population over 15 years is the primary sector which employs 83.3 per cent of active population in urban and rural areas. It's followed by the tertiary and secondary sectors employing 12.12 and 2.9 per cent of the active population in rural and urban areas (NISR *et.al.* 2008).

Table 5: Major causes of poverty identified

Causes	Causes (Kinyarwanda)	Share of respondents (%)
Lack of land	Kutagira isambu	49.5
Poor soils	Ubutaka butera	10.9
Drought/weather	Izuba ryinshi	8.7
Lack of livestock	Kutagira itungo	6.5
Ignorance	Ubuji	4.3
Inadequate infrastructure	Ibikorwa remezo bidahagije	3.0
Inadequate technology	Ikoranabuhanga ridahagije	1.7
Sickness	Uburwayi	1.7
Polygamy	Ubuharike	1.2
Lack of access to water	Kubura amazi	1.1
Population pressure	Ubwiyongere bw'abaturage	0.7
Others	Izindi	10.6
Total		100.0

Source: ROR 2007

Poverty, soil erosion and food security

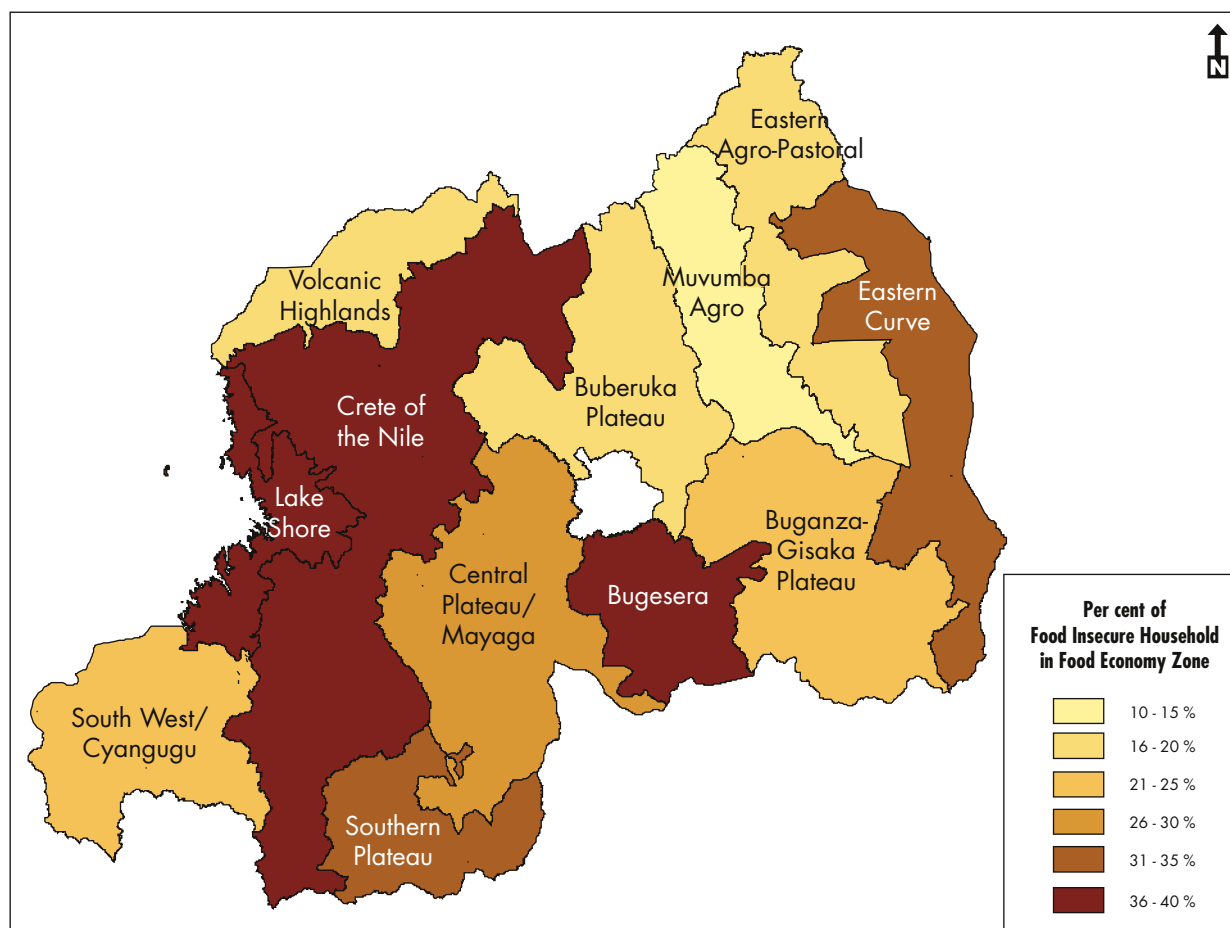
Rwanda is among three countries in Africa, experiencing unusual heavy soil losses. About half of Rwanda's farm land has shown evidence of modest to severe erosion. Besides being acidic, most of the soils are exhausted from continuous farming by farmers who have limited, if any alternatives. Several studies have shown the immediate effect of erosion on land productivity. A loss of an inch of top soil results into considerable reduction of productivity for the farmers. Extensive soil erosion also has the potential to convert land to waste land. In 1986, the agricultural survey and statistic

service estimated that 10 tonnes/ha of arable land is carried away by erosion every year. The deterioration of soil reduces food availability for people who depend solely on agriculture. Indeed it is estimated at about 40,000 people each year fail to be fed due to soil erosion (ROR 2004)

The Integrated Household Living Conditions Survey (EICV2) further shows that 45 per cent of children under-five are stunted, 23 per cent are underweight and only 44 per cent of the population has sufficient access to proteins per day (NISR *et.al.* 2008).



Progressive terraces being used to reduce soil loss through erosion

Figure 2: Food insecurity (per cent of food insecure households by food economy zone)

Adapted from NISR and WFP 2006

Figure 2 shows food insecurity by different regions in Rwanda and indicates a high correlation between food insecurity, population density and poverty. Some of these include the region of Congo-Nile ridge where soil erosion and degradation is prevalent; the region of Bugesera which has experienced long periods of drought and low levels of rainfall; and the southern plateau and where land is scarce with extremely high population density.

Poverty is also associated with environmental degradation. Equally, with reduced environmental products, poverty will deepen increasing the pressure on environment even more. Thus a vicious cycle characterizes the relationship between poverty and the environment, with the poor as both victims and agents of environmental degradation. The prevalence of rural poverty has important implications for agriculture and environment in that it is unlikely that the rural population can afford agricultural intensification of their holdings and this further limits production.

Conclusion

Rwanda's economy and the livelihoods of her people are dependent on the natural resources. However, the natural resources, especially land, are increasingly under pressure from population pressure and unsustainable use. This leads to environmental degradation and may jeopardize economic growth and efforts for poverty alleviation if nothing is done.

Efforts towards sustainable economic growth are underway and include Government policy is to increase crop and livestock production and raise productivity through land consolidation, crop processing industries, introduction of new high value crops under the green revolution programme and modernization of livestock to improve productivity and reduce pressure on environment.



Tea plantation at the edge of Nyungwe National Park

With regards to pollution control and management, the introduction of environmental impact assessment and environmental audits by the organic law on environment, and introduction of cleaner production program in industries are tools towards a sustainable economic growth.

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Chapter 2: Population, Health and Human Settlements

The state of population in Rwanda

A country's population and how it is geographically distributed can influence the state of the environment through the rate of growth and household formation, access to basic services and infrastructure, age distribution and employment opportunities, rural and urban environment and wealth of natural resources. The impact of human needs on available resources, in the context of emerging economies, poses a strain on available public infrastructure, limited land and natural resources, for instance forests and water bodies.

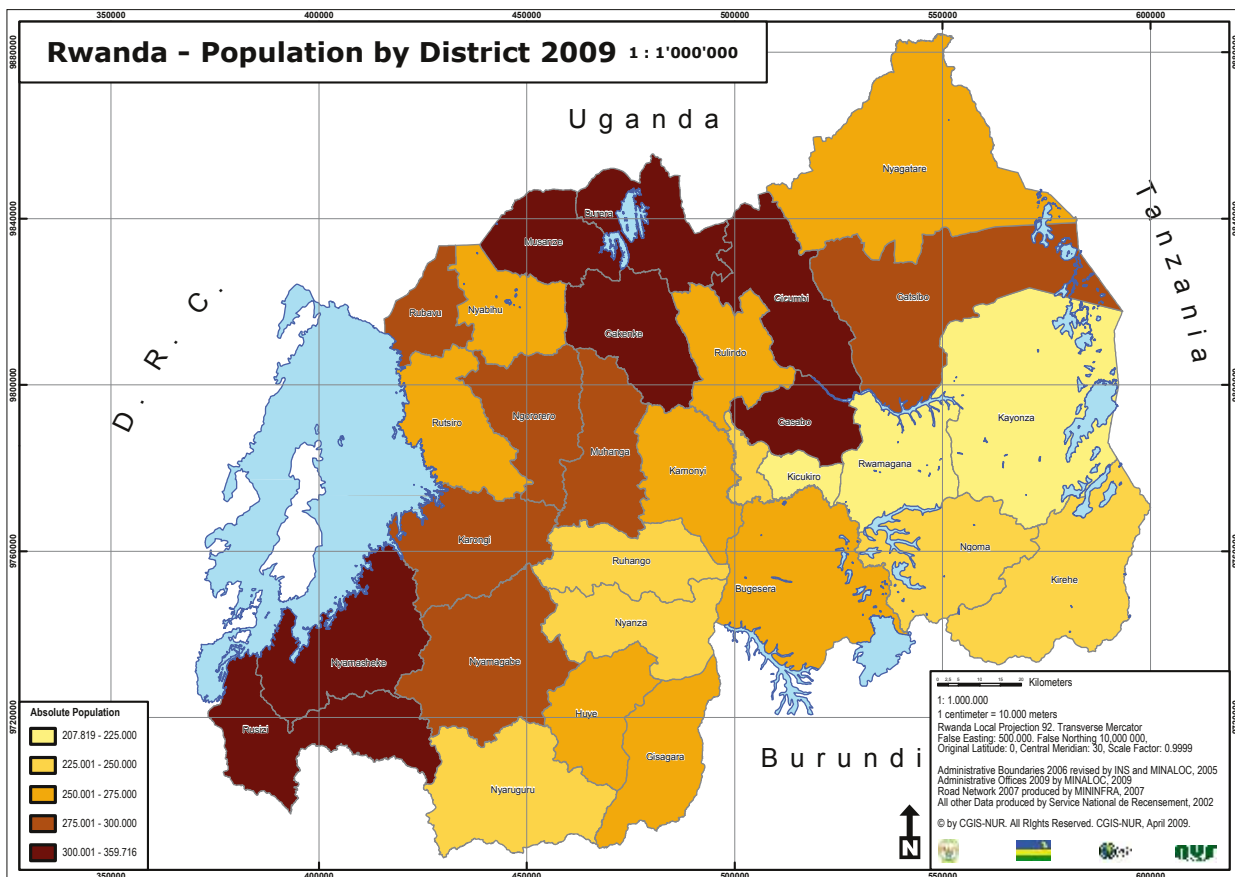
With an annual growth rate of 2.9 per cent, the population of Rwanda is currently estimated at 9.2 million (2006) with

an urban population of up to 17 per cent. The population is expected to grow to around 16 million by 2020 unless family planning, education and outreach strategies are intensified (ROR 2000). Rwanda is the most densely populated country in Africa, with about 397 inhabitants/km². The Government aims to reduce this to 2.2 per cent by 2012.

Population density is the key to understanding the impact of people on the environment in Rwanda. The ensuing rise in population density has put pressure on the physical environment and induced labour migration between rural areas as well as from the countryside to the towns.

The population is relatively young with 67 per cent of the total population below the age of 25 most of whom are unemployed (MINECOFIN 2003). This situation has created

Figure 1: Population by district in 2009



a high dependency ratio amongst the population. The success of future strategies thus lies in the youth who represent the majority of the country's active labour force.

Since the livelihoods of about 90 per cent of people are inextricably linked to land, population growth is the underlying driver for the increased demand for natural resources. Growth rates are indicative of large scale in-migration, in this case mainly from the north and south to the north east in search of virgin lands for cultivation. This issue has been largely experienced in the former Umutara province, now part of Eastern province.

Rwanda is administratively divided into five provinces to include Kigali City, 30 districts and 415 sectors. The population distribution according to the new provinces is shown in table 1 and figure 1 shows the population by district.

Table 1: Population distribution per province

Province	Population (%)
Kigali city	9.6
Southern	25.5
Western	24.1
Northern	18.4
Eastern	22.3
Total	100

Source: NISR et.al. 2008 – EICV2

Household composition and size

Household composition and size provide information on shared infrastructure, economic resources available per dwelling, and growth opportunities per household. This allows estimates on potential impact on the environment.

The average size of households is 4.6 persons with a rural-urban ratio of 4.5:4.8. These figures show that the average household size does not differ so much in each case (NISR and ORC Macro 2006).

The impact on the environment in the rural area can be seen through absence of basic infrastructure and therefore the proliferation of alternative coping methods. In this case poor sanitation, encroachment on forests, poor infrastructure and social services are evident around the country. These lead to hygiene-related diseases, deforestation, malnutrition and poverty-related derivatives. In urban areas, the impact can generally be seen on existing infrastructure as there are more inhabitants per area.

Fertility reduction

Fertility is one of the principal components of population dynamics. Fertility reduction is thus a major thrust of Rwandan population policy. Slowing down population growth requires innovative measures, including the strengthening of reproductive health services and family planning and ensuring free access to information, education and contraceptive services. The fertility rate is estimated at 6.1 children per woman (4.9 for urban women, and 6.3 for rural women) and the EDPRS target is to reduce this to 4.5 by 2012 (ROR 2007). Some of these measures include sensitizing the population about family planning and encouraging Rwandans to have a minimum number of children that they will be able to provide quality life.

The Government realises that if a minimum quality of life for Rwandans is to be maintained, planned investment in social services and amenities will be required. This will only be possible if population growth is controlled in order to meet development targets.

Human settlement

The state of human settlement

Rwanda lacks a human settlement development framework. This has largely contributed to the expansion of unplanned residential areas in urban centres, poor land management, environment degradation and impoverishment of the rural population deprived of basic infrastructure and income generating activities other than agriculture.

The aftermath of the 1994 genocide rendered many Rwandans homeless and those who had earlier been deprived of their inheritance to Rwandan soils began to return from exile. These ensuing factors introduced a new aspect that required interventions in human settlement. Ad-hoc measures included construction of settlements, makeshift camps, designs for 'Tent Temporary and Permanent' housing schemes, provision of service land for development in urban areas, stepping up on housing finances, Government interventions in providing public infrastructure, services and amenities, among others. The challenge now is how to cope with emerging urban environmental problems with the present prevailing infrastructure.

The future of human settlement

Under Vision 2020, the development of human settlements will be planned and development inspired by concentration of infrastructure and urban utilities (ROR 2000). The EDPRS flagship 'Vision 2020 Umurenge' provides a development framework that sectors should follow during infrastructure planning and deployment to ensure sustainable development (ROR 2007). Many districts are already incorporating this framework into local planning.

Many urban neighbourhoods currently have inadequate provision of basic infrastructure which poses a very big environmental health challenge to local Governments. The current human settlement policy addresses in part the planning needs for sustainable growth, promotes the grouping of development to facilitate infrastructure provision and promotes the role of the private sector in sustainable development of urban centres. For instance in urban centres, new areas have been opened up for urbanization, housing supply programmes implemented, and a decentralization framework defined to ensure proper urban management by local administrative structures.

Rural-urban population issues

A distribution study of the population by geographical location shows that population density is highest where urban areas or trading centres and social infrastructure exist. The population living in urban areas increased from 16.1 to 16.5 per cent between 2000 and 2005. In absolute terms this is an increase of almost 300,000 people (see table 2).

Comparing the age distribution, it is observed that there are more infants in the rural area than in the urban area. This implies that rural-urban migration is actually on the increase whereas fertility rate is higher in the rural areas.

In 2003, when the Vision 2020 document was published, the urban population was estimated at 10 per cent, recent statistics from the National Institute of Statistics puts it at almost 17 per cent in 2007 (NISR 2007). It is not clear whether the urban growth is related to economic development strategies or rural-urban migration. Both have a specific effect on the environment. Urban growth for economic development provides additional amenities on top of what already exists and this reduces physical pressure on the environment. Rural-urban migration may pose a situation where minimal amenities are being shared by a larger population. In Rwanda urban growth may present both situations. An expanded urban population is normally accompanied by increased consumption, increased amount of wastes and pollution.

The major reasons for rural-urban migration are the search for convenient access to services, infrastructure, amenities and employment. Eighty three per cent of the population in Rwanda is rural with 53 per cent of them women (NISIR 2006). In the urban areas, this trend is reversed with more men than women. This suggests that there are more men migrating to urban areas than women. This is especially true for young men between 16 and 30 years who migrate for jobs, education, and the city experience.

In order to control rural-urban migration, the Government has resorted to adopting strategies that bring services, infrastructure and amenities to the people. Not only is this enshrined in the Rwanda constitution, but has also been translated into the Decentralisation policy, Vision 2020, EDPRS, Vision 2020-Umurenge and other policy documents.

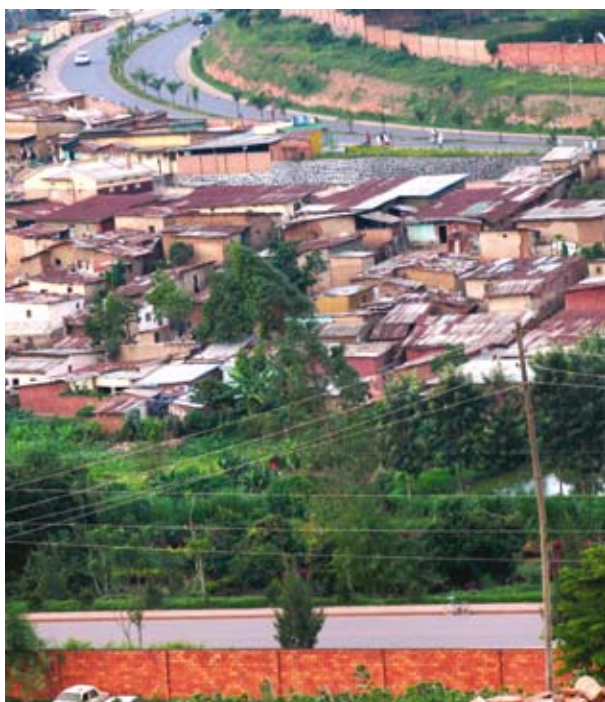
Urban centres

There are about 18 urban centres in Rwanda. The major towns include: Kigali city, Huye, Nyamagabe, Rusizi,

Table 2: Change urban rural population structure in 2000 and 2005

Stratum	EICV1		EICV2	
	Estimated population	Share (%)	Estimated population	Share (%)
City of Kigali	663,000	8.3	703,000	7.4
Other urban	618,000	7.8	865,000	9.1
Rural	6,683,000	83.9	7,893,000	83.4
Total	7,963,000	100	9,460,000	100

Source: NISR 2007



Informal settlements are sometimes located in inappropriate areas such as near highways. They have no access roads and limited social amenities.



A view of some of the Imidugudu houses built in 1996. This estate, with a total of 300 homes, is in Kabuga sector, 15 km from Kigali.

Karongi, Musanze, Rubavu, Muhanga, Byumba, Kibungo and Kayonza. Others include: Nyagatare, Kabuga, Nyanza, Ruhango, and Rwamagana

Rwanda does not have a specific definition of an urban area. The District Development Plans describe urban areas in specific districts in terms of growth points or trading centres. In this report trading centres will be used as a category of urban centres as they constitute growth points along major transport corridors and highways.

Currently there is unprecedented population growth in urban areas. Like in most developing countries, the demographic dynamics in urban areas have a similar pattern. Rapid urbanization attracts the rural settlers to migrate to development growth points. Rwanda has not been an exception. There is a marked increase in the number of urban poor as seen in the growing number of destitute in towns and cities. This pattern leads to informal settlements on land that is considered unsuitable for development (hills or valleys) with almost no amenities or basic infrastructure available. This exerts further pressures on the already inadequate infrastructure in urban centres threatening the urban environment. The need for urban facilities is therefore very high as is the need to control the rate of rural-urban migration.

Settlements and access to services

In 1996, the Government passed the national human settlement policy. It came to be known as the Imidugudu concept. The rationale was to focus on group settlement and in so doing, solve the problem of land scarcity and environment management at the same time.

In urban areas there are no master plans or land use plans to guide development. Although the Government has been trying to address these issues infrastructure and service provision is still wanting. Some of the issues include: lack of adequate water, electricity supply and sanitation systems, inadequate garbage collection methods, poor drainage, poor roads, inadequate public transport network and insufficient housing supply. Waste management is also a big problem.

Sanitation facilities in urban areas do not meet urban standards. For instance in 2006, only 5.4 per cent of urban households had flush toilets (NISR and ORC Macro 2006). Storm water drains and evacuation systems are very poor and often consist of simple channels made by the people. Most of the drains in the cities are inappropriate and cause further problems due to their conception and construction. Though there is a system of collection and transport of solid wastes, there is no waste segregation system and the management

of dumping sites is still a serious problem. Untreated industrial effluents are released in the environment in their raw state without treatment.

In rural areas, in 2006, 70.8 per cent of households had traditional pit latrines while 24.1 had the ventilated improved pits (VIP) (NISR and ORC Macro 2006). There is need for hygiene promotion and construction of improved latrines at family and public level. Though there is a demand for such sanitation facilities, the population doesn't have adequate financial means to provide required sanitation standards.

Environmental sanitation is an essential factor contributing to the health, productivity and welfare of people especially those living in urban areas. It is identified in Vision 2020 as a key element underlying health and human development. The programme also identifies environmental protection and the improved management of human settlements as key factors to support rural and urban development.

Environmental health

Environmental health is aimed at developing and maintaining a clean, safe and pleasant physical environment in all human settlements, to promote the social, economic and physical well-being of all sections of the population. It comprises a number of complementary activities, including the construction and maintenance of sanitary infrastructures, the provision of services, public education, community and individual actions, regulation and legislation.

The objective of Vision 2020 is to have a satisfactory state of health for both urban and rural population - without being exposed to pollution; to have all swamps cleaned up with a view to reducing the presence of malaria vectors in particular; for each town or development pole to have a unit for the treatment and disposal of solid wastes; and for households to develop awareness and practice minimum hygiene and sanitation measures.

Due to the inadequacy of excreta treatment and management systems in urban areas in the urban poor, in particular, are faced with public health problems, environmental pollution and aesthetic degradation. Research in 2006 showed that 19 per cent of urban households used spring water and 12 per cent draw water from uncovered public wells (NISR and ORC Macro 2006). Such water resources are easily

contaminated once wastes are indiscriminately discharged untreated into the environment. Such contaminated waters sources may put people in urban and peri-urban areas at risk. Though washing water may not necessarily have to comply with drinking water standards, contact with waters carrying heavy pathogenic loads could potentially lead to the transmission of enteric infections. Water from open drains and streams within the urban or peri-urban perimeter are often used by farmers to grow vegetables for the urban market. The use of untreated waste water for irrigation brings with it substantial occupational and consumer risks. Used domestic water mainly from septic tanks, latrines, animal waste and refuse-infested drinking water can cause diseases such as typhoid, cholera, gastro-intestinal infections and dysentery. Indeed polluted waters and poor sanitation is responsible for about 80 per cent of the disease burden of Rwandans (ROR 2008).

Health indicators

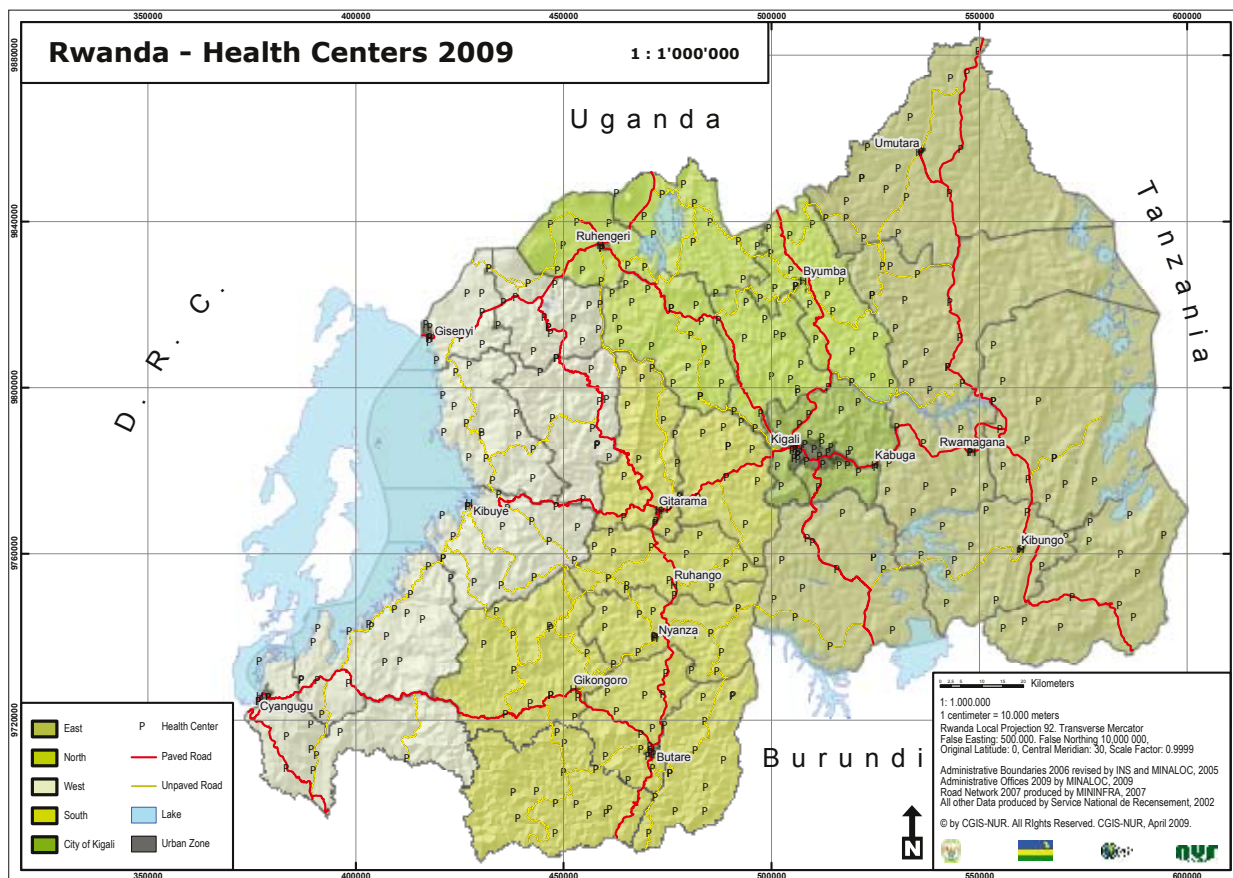
Health indicators could be better. In 2006, infant mortality was estimated at 86 for every 1000 live births and the under-5 mortality rate was 152 per 1000 children born. This was a significant decline since 2000. Maternal mortality remains high, at 750 deaths for every 100,000 live births. However, this has declined considerably since 2000 when maternal mortality rate was 1,071 for every 100,000 births (NISR and ORC Macro 2006).

There are also other gradual and long-term diseases that may affect general health and well being. This does not only affect the social and economic life of productive population, but is additional expense on the Government health budget.

Urban air pollution resulting from dust particles and vehicle emission is increasingly growing; and there is no recorded framework to combat health implications. During the dry season, there is a marked increase in air borne diseases due to dust particles emission; this is particularly challenging since it calls for heavy investments in physical infrastructure. Vehicular emissions are also growing in the urban setting. But there is a lack of documented information on this issue.

HIV prevalence is estimated at 3 per cent of adults. Rwanda is now striving to take the necessary precautionary steps so that increasing rates of infection do not erode the impressive gains made in the last five years. Some of the achievements include national campaigns to reduce the stigma of HIV and the accompanying discrimination and the establishment of

Figure 2: Distribution of health centres in 2009



Map production: REMA

Voluntary Counselling and Testing Centres (VCTs). There are now 234 health centres with Voluntary Counselling and Testing (VCTs) and the treatment of people living with HIV has increased. Seventy two per cent of pregnant people living with HIV are estimated to be receiving a complete course of anti-retrovirals (ARVs). However, concern remains in several areas including: low condom utilisation among youth and groups at higher risk of HIV exposure, the rural versus urban ratio of HIV prevalence and increasing transmission amongst married couples and the cultural norms associated with this. Figure 2 shows the distribution of health centres around the country in 2009.

Waste management

Waste water and solid waste management in Rwanda takes different forms: from public toilets to selected area based sewerage management plants. The technology employed varies from site to site depending on the terrain, newness of neighbourhood and level of urbanization, among

others. The concept of providing public toilets, especially in commercial or public areas is so under developed and poses a hygienic challenge.

Generation of solid, liquid and gaseous wastes has been increasing at the same level as industrial development. The complexity of wastes, along with the rising socio-economic development, has introduced large portions of non-degradable wastes to the environment. These include plastics, scrap metals and other goods.

Data on waste generation, source of waste and quantities disposed of in existing sites are not available. A certain amount of the total waste generated in urban centres is collected and disposed of at the designated disposal sites. The rest of the waste, composed of chemicals including heavy metals, salts, detergents and medical wastes, is either dumped in unsuitable areas or disposed off in rivers that traverse the urban centres and other wetlands.

In the rural areas, the district development plans are emphasizing that each household (100 per cent) should have a well managed dumpsite by 2012; these are the same targets in the EDPRS. For urban areas other than Kigali, information was not available regarding how solid waste is disposed however; key district informants mentioned burning and localized dumping areas.



Solid waste is often disposed of in unsuitable areas such as in this wetland in Gastata

Environmental challenges in Kigali

Kigali does not have a development master plan and there is thus a lack of consistency in the physical development of the city. Commercial areas, low, middle or high class residential areas have evolved in a built up areas that are unplanned. As a result, environmental and sanitation issues such as solid waste, excreta disposal, industrial effluents have become problematic. Table 3 shows how Kigali has expanded and grown over the last 17 years.

Table 3: Growth of Kigali over the last 17 years

Years	Total number of people	Total area of the city (km ²)	Population density (No. of 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

Source: City of Kigali 2008

In 1994, the available public utilities were projected for a population of only 200,000 people. Today Kigali is home to approximately 1 million people all scrambling to live on the minimum water, energy and social facilities. In fact over the past 17 years, Kigali has never had enough amenities to serve its ever growing population. The provision of basic infrastructure has always lagged behind the expansion of the city and its inhabitants. This has led to urban sprawl and an environment that is characterized by erosion, uncontrolled dumping of solid waste, raw excreta disposal to open environment and accruing pollution and health hazard problems.

Solid waste management in Kigali

The city authorities, in conjunction with private sector participation, have done their best to collect solid wastes from their points of generation in the bid to keep the Kigali free of solid wastes. However a big challenge still exists at the points where the solid wastes are finally disposed of. These disposal sites (already overflowing) are currently non-sanitary, posing serious risks to human health and the environment and their proper handling is currently beyond the capacity of the City Authority.

Currently the city has an overrun dumpsite at Nyanza in Kicukiro District and is currently investing in studies to propose a sanitary landfill that meets all engineering requirements. The Nyanza dumpsite has many layers of covered wastes, and is now methane gas hub. Urgent attention is required to address this area before any catastrophe occurs. Processing of the potential energy reserve would provide some urban energy solutions.

Liquid waste management in Kigali

Kigali has neither a central treatment facility for sewage nor a system of sewers. There has never been any strict sanitation policy in the past - only individuals deciding what systems to use based on their financial abilities.

Septic tank systems with soak pits is the most used technology by the urban-rich, while those who cannot afford them resort to the traditional deep pit-latrines despite their impact on ground water resource especially in an urban environment. Almost all the septic tanks are emptied and desludged separately when full. House owners employ private companies to do the desludging for a fee. Some septic tanks are not accessible by the desludging vehicles so manual methods are employed. The sludge in urban areas is not appropriately treated and is usually disposed of in an unhygienic way in a dumpsite. Sewage from large installations like schools, hotels, prisons and hospitals are disposed of daily untreated and indiscriminately into drains, ditches, open urban spaces or even the Nyabugogo swamp. This swamp has become the de facto dumpsite for all municipal wastes including those from industries that may be hazardous or carcinogenic in nature.

The emerging practice is to encourage real estate developers to provide central sewerage systems for their housing units. An example of this application can be seen in two estates in Kigali: Vision 2020 at Gaculiro in Gasabo District with a waste treatment plant and Nyarutarama Estate at Nyarutarama in the same District with stabilization ponds. Most of those new central systems are mechanical and might

become a source of problems in the future if a sustainable solution is not found.

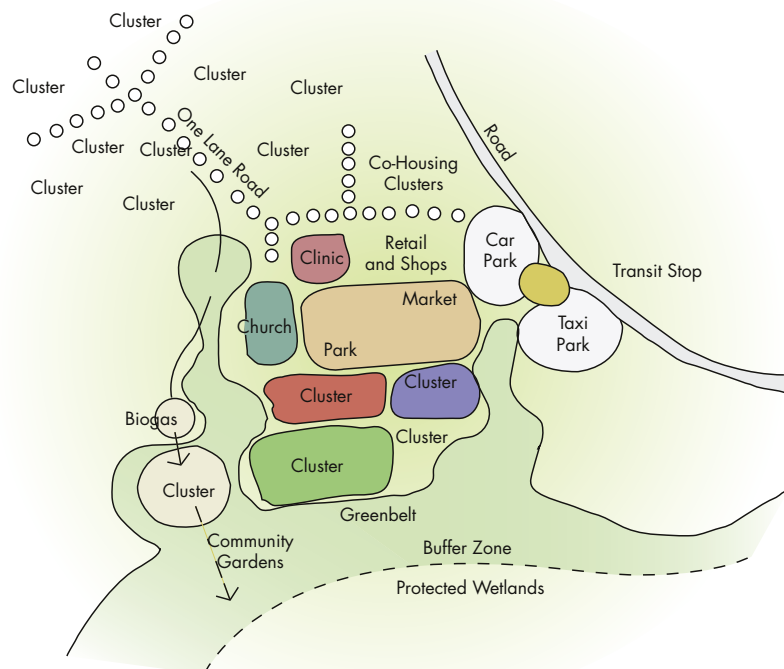
Today, efforts by the city and stakeholders, have managed to produce a conceptual master plan, with strategic details and physical development plans still to be developed. In addition, a draft sanitation master plan has proposed with sanitation management technologies. It takes into consideration the fact that the physical landscape of Kigali will not allow the establishment of a unique city sewerage central system.

Strategies to improve settlements and human welfare

Land and urban planning

The current laws governing settlement planning date as far back as 1981 (*Loi sur l'aménagement urbain et du territoire loi No 4/81 of 29th January 1981*). Although still in use, it is outdated since it does not take into consideration contemporary policy like decentralization. Further, in practice it is not followed and there are hardly any implementing decrees for it.

Figure 1: A conceptual view of the community centre approach to developing the proposed Kigali city master plan



Source: City of Kigali 2008

At national level, a land use and development master plan is under development under the stewardship of MINIRENA. However other ministries have also embarked on sector specific master plans even before the completion of the land use and development master plan. The irrigation master plan; and the land use and agriculture master plan are some examples.

Kigali has recently concluded a conceptual master plan for the next 50 years. In this master plan, the proposed approach to development is the community centre approach. This approach will enable provision of shared services to a greater population in an environmentally sustainable way. It also includes innovative technologies such as a collective biogas unit which can generate energy from waste. Figure 1 is a conceptual view of the master plan drawn after discussion with the staff of the City of Kigali. Some completed plans include the Rwamagana master plan which was concluded in 2007. There are also master plans for administrative areas of Kibuye, Gisenyi and Cyangugu that existed before the 2006 administrative changes.

Implementing the human settlements policy

The national human settlement policy adopted in December 1996 focuses on urban planning, restructuring of unplanned residential areas in towns and the regrouping of the rural population. The implementation of this policy made it possible to address emergency situations, including the construction of numerous housing units that were required between 1995 and 2001. During this period more than 265,000 houses were built under the resettlement programme mainly in the regrouping settlement centres or *imidugudu* (ROR 2004b).

Improving environmental health and sanitation

High priority has been put on environmental sanitation as well as the development and implementation of environmental health standards. Efforts are also being made to put greater emphasis on environmental sanitation in the allocation of development resources. The 5-year district development plans now include targets for environmental health. Notable is the goal to increase to 100 per cent, household ownership of proper latrines by 2012, 100 per cent ownership of unique household solid waste decomposing dumpsites by 2012, sensitization of population on proper hygiene, and an increase in access to drinking water, among others. In addition to these targets, the district development plans spell out an infrastructure development plan, including energy and

water supply, for the next five years that reflects national strategic plans.

The Ministry of Natural Resources has adopted immediate measures to address this situation. Improved toilets or EcoSan systems are being piloted in selected urban areas to provide public toilets. In Kigali, the public toilet situation is appalling and the district mayors are defining a framework to provide these facilities. As recently as October 2008, Nyarugenge District of Kigali had installed a few public toilets in selected areas. These are being established in partnership with the private sector. In the rural areas, the district development plans include plans for construction of public toilets.

Generally, the surroundings in Rwandan urban centres are clean. This cleanliness is the result of the existing general cleaning programmes adopted by residents and local Government. However there is a need to establish an effective legislative and institutional framework for waste management including urban solid waste management. Waste management provides an opportunity for the involvement of the communities but also can be an investment opportunity for the private sector.

Institutional reform

The water and sanitation sector has been undergoing reforms to better streamline results-oriented practices. The water and sanitation policy document of October 2004 provides more information on water and water supply than on sanitation. Clearly, the sanitation sector is under documented. The management of sanitation sub-sector policy is currently the responsibility of the Ministry of Natural Resources (MINIRENA) and the service development and provision was recently transferred to the Ministry of Infrastructure (MININFRA). A National Water and Sanitation Authority, with the mandate of distribution of potable water and installation and management of sanitation infrastructures has just been created by the Government

There is institutional conflict regarding responsibility for environmental health and sanitation. Environmental health is the responsibility of MINISANTE although the implementation framework is defined under REMA. Waste water and solid waste management are being handled by decentralized Governments and the role of MINIRENA in providing sanitation facilities outside Kigali is clear. The implementing structures and laws thus have to be harmonized to clarify the situation.



New urban settlement areas in Gisozi-Gasabo District (Kigali City)

Conclusions and recommendations

Rwanda has a young but fast growing population. The population was 9.2 million in 2006 and is expected to reach 16 million by 2020 unless family planning, education and outreach strategies are intensified. With a population density of 397 inhabitants per square kilometer, Rwanda is the most densely populated country in continental Africa. The ensuing rise in population density has put pressure on the physical environment and induced labour migration between rural areas as well as from the countryside to the towns.

Rwanda's overarching challenge is how to meet the needs of an ever growing population, who depend on natural resources for virtually every provision – energy, water, housing, transport, and employment. Integrating environment and sustainable natural resources management principles, is one of the underlying strategies of the Population Policy which was reviewed in 2008. As population pressure is one of the key drivers of environmental degradation and poverty (REMA *et. al.* 2007, ROR 2004a), the implementation of the population policy especially aspects that address high fertility rates, gender and reproductive health, migration and human settlements, constitute important triggers for sustainable natural resources management is important.

In this regard, the EDPRS prioritizes the planning and development of improved rural and urban human settlement consistent with the contemplated sustainable land use and environmental protection scheme (ROR 2007). This will allow the issues of land use and environmental health to be addressed.

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Chapter 3: Land Use and Agriculture

Overview of the agriculture sector

The agricultural sector has been given a high priority in the Government's planning for development. The current national thrust is for the sector to move from subsistence to commercial mode of production. This strategy aims to increase household incomes and lead to a 50 per cent reduction in poverty over twenty years (ROR 2008). With its projected contribution to economic growth, modernisation of agriculture is seen as one of the six pillars of Vision 2020 along with sustainable land-use management and basic infrastructure (ROR 2000). Agriculture is also explicitly recognised in the EDPRS as one of the four priority sectors that will both stimulate economic expansion and make the greatest contribution to poverty reduction (ROR 2007). The other sectors are health, education and road maintenance

By 2020, agriculture is envisaged to contribute 33 per cent to GDP whereas industry, including agro-processing, is expected to grow from current levels of 14 per cent to 26 per cent of GDP (ROR 2000). The key national and agricultural sector-related targets presented in the Vision 2020 document, are listed in table 1.

The agriculture sector which currently contributes significantly to national GDP (32.6 per cent) has of recent experienced remarkable growth as the 5-year trends in table 2 illustrate. Food production has increased as a result of the expansion of maize and wheat farming. There was also a rebound in cassava yields following depressed production in 2006 and 2007 due to the cassava mosaic epidemic. The Crop Intensification Programme and improved crop diseases prevention and treatment measures in 2007 and 2008 have, in the main, been responsible for growth in food and export crops production. This places the sector in a good position to achieve its EDPRS targets.

Table 1: Selected national and agriculture-related goals in Vision 2020

Indicator	2000	2010	2020
Population (million)	7.7	10.1	12.71
GDP/capita (constant 2000 US\$)	220.0	400.0	900
Poverty (per cent)	64.0	40.0	30
Agricultural GDP growth (per cent)	9.0	8.0	6
Agriculture as per cent of GDP	45.0	47.0	33
Agricultural as per cent total population	90.0	75.0	50
Land under 'modernised' agric (per cent)	3.0	20.0	50
Fertiliser application (kg/ha/annum)	0.5	8.0	15
per cent banks' portfolio to agric. sector	1.0	15.0	20
Soil erosion protection (per cent total land)	20.0	80.0	90
Coffee exports (tonnes)	19,000.0	44,160.0	n.a.
per cent of coffee production fully washed (2001)	1.0	63.0	n.a.
Coffee export earnings (US\$ m) (2002)	22.0	*117.1	n.a.
Tea export earnings (US\$ m) (2003)	26.8	91.0	n.a.
Agricultural exports	n.a.	n.a.	5-10 times yr 2000 value

* The Rwanda Investment and Export Promotion Agency (RIEPA) projects coffee export earnings to reach US\$85 million in 2008, from a base of US\$38 million in 2005, largely on the basis of improved quality or greater proportion of specialty coffee in the total exports (RIEPA 2006).

Table 2: Trends in Sector Performance and GDP Growth Estimates (2004-2008)

GDP	2004	2005	2006	2007	2008*	5 Yr 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	2.7	2.6
Forestry	2.6	2.6	2.6	2.6	2.7	2.6
Total GDP growth	5.3	7.2	7.3	7.9	11.2	7.2
Agriculture as per cent of GDP	34.9	34.2	32.2	30.0	31.0	32.6

*Data for 2008 is a projection as agreed with IMF.

Source: MINECOFIN 2009

The state of land use and agricultural development in Rwanda

Arable land

Rwanda is a small country with an area of 26,336 km². The total arable land is about 1.4 million hectares, which is 52 per cent of the total surface area of the country. However the actual area cultivated has exceeded 1.6 million ha in recent years. Another 0.47 million ha is under permanent pasture, so well over 70 per cent of the country's total land surface is exploited for agriculture (ROR 2008).

Rwanda has about 165,000 ha of marshlands of which 93,754 ha (57 per cent) have been cultivated. However, only 5,000 ha have been developed and can be cultivated throughout the year while the rest are arbitrarily cultivated

by peasants grouped in organizations or by cooperatives without any technical study (ROR 2008).

Land use

Land use is largely influenced by a number of factors, the main ones being climate, socio-economic (culture and population dynamics) and Government policies.

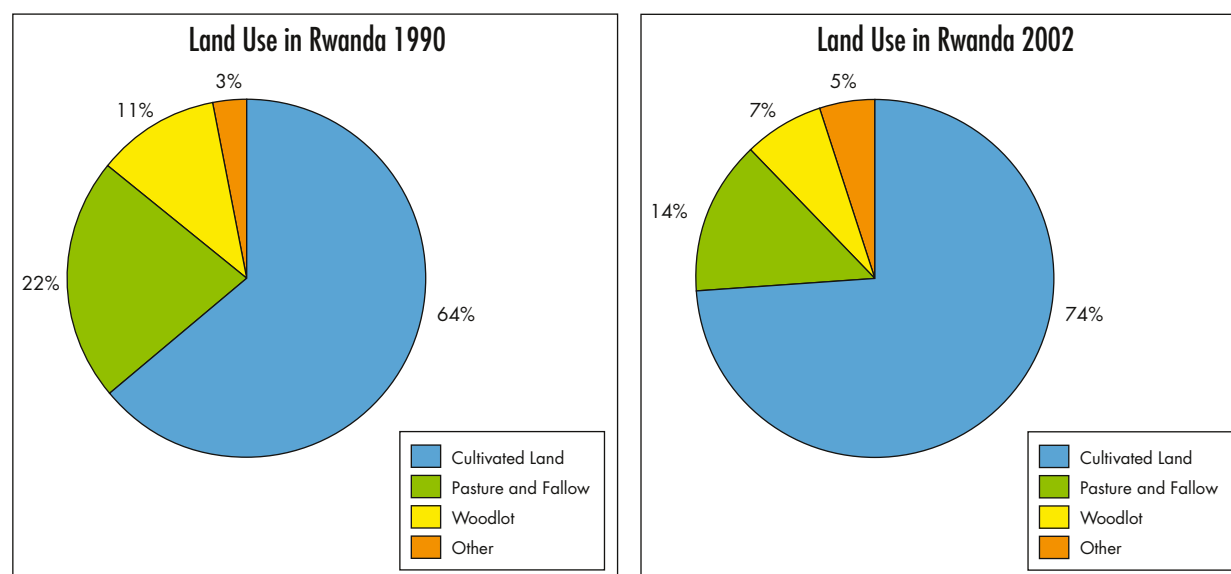
Figure 1 shows the land use in Rwanda in 1990 and 2002. Cultivated land increased from 782,500 to 899,133 ha or from 64 per cent to 74 per cent in absolute terms between 1984 and 2002 (Mpyisi *et.al.* 2003). This increase occurred at the expense of pasture, fallow and woodlots. The share of pasture and fallow decreased from 22 per cent in 1990 to 14 per cent in 2002 and woodlots decreased from 11 per cent in 1990 to 7 per cent in 2002. These trends persist today and this implies that the land is being farmed intensively with no fallow at all.



Land used for agriculture in Nyabihu District



Dry lands in the Eastern Province mostly used as grazing land and threatened by overgrazing

Figure 1: Land Use in Rwanda 1990 and 2002

Source: Mpyisi et al. 2003

Land reform

The Vision 2020 and the medium term strategy (the EDPRS) have focused on land administration and land use management as key areas for the land reform process that will support sustainable development. These efforts have come up against significant challenges such as population pressure in both urban and rural areas which have led to land degradation. Presently, there are efforts to develop a national land use master plan which will subsequently be translated into local plans to guide zoning for activities including agriculture, urbanization, resettlement, public infrastructures, and biodiversity conservation.

The realization of these efforts will likely provide appropriate interventions for land degradation which will lead to enhanced agricultural productivity. Additionally, the appropriate location of activities informed by land suitability assessments will ensure that resettlement patterns, public infrastructure and the overall urbanization process provides the right kind of interventions for urban environment issues in particular and proper national planning targeted at promoting environmental management in support of sustainable development.

Changes in crop distribution

Besides the change in land use and cultivated area, there have been changes in terms of crop distribution by area occupied. The changes in cropping pattern have implications on the environment in the areas concerned. For instance,

areas where bananas and coffee were replaced with tubers such as cassava are likely to become susceptible to soil erosion because of loss of cover. Figure 2 shows some of the changes in crop distribution.

The area occupied by legumes and cereals remained fairly constant over the period 1990-2002 (although there was some increase in absolute terms). However, the area under tubers increased significantly from 25 to 33 per cent of total farmland over the same period. Many areas have experienced gains of over 100 per cent in Irish potatoes, for instance Butare and Gikongoro provinces. The traditional epicenter of Irish potato production, Ruhengeri, lost about 50 per cent of its production during the same period. The increase in cassava production was dramatic in Gikongoro where it showed a ten-fold gain, while the eastern zone (Gitarama, and Kibuye) more than doubled their output.

The area under bananas has dropped from 26 to 23 per cent of cultivated land between 1990 and 2002. Kibuye was the only part of the country with increased banana production. The reduction was most dramatic in the Kigali Rural province, where output fell by 91 per cent. The areas surrounding Kigali Rural also experienced substantial declines. Good rains and greater attention from farmers is having a positive effect on banana production in areas of decline. Upward trends in banana will likely continue as many farmers rely heavily on them as part of their cropping system.

Figure 2 i): Crop distribution by area, 1990

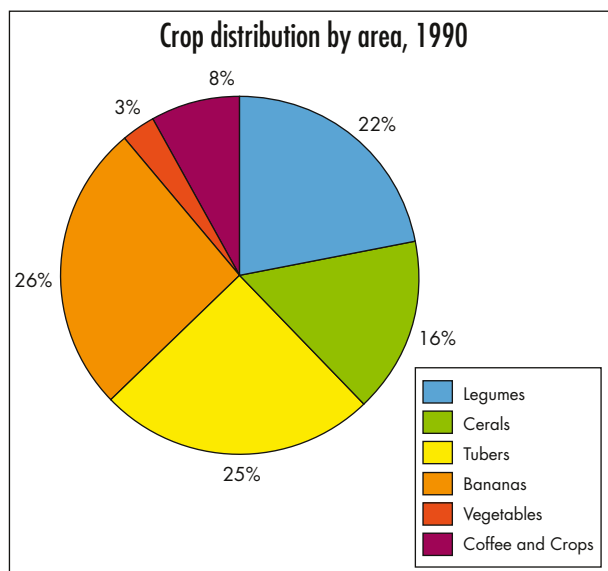
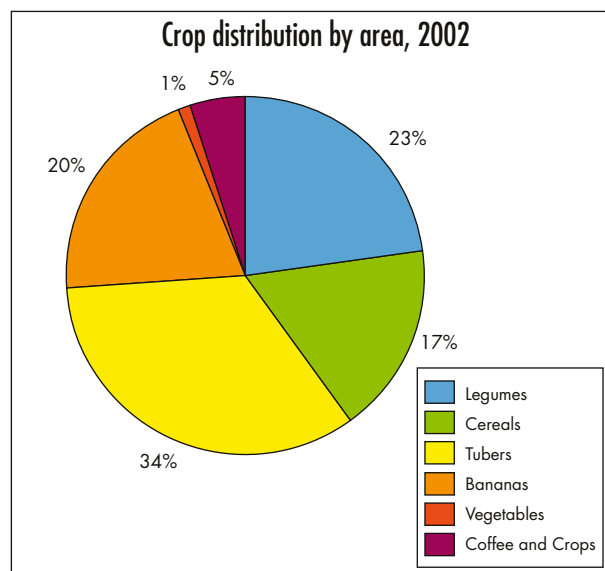


Figure 2(ii): Crop distribution by area, 2002



Source: FSRP/MINAGRI 2003 – allocation of land holdings



Growing bananas on the hillsides

Agricultural production

Production of food and cash crops increased considerably between 2000 and 2005. The increase in production can partly be explained by expansion of cultivated area or by improved yields. This has been part of the sector strategy to ensure food security, income generation and poverty reduction. Livestock rearing has also been encouraged as an important category for income generation and nutrition for farm and non-farm families. Increasing production can come at the expense of further limiting the available land for agriculture, especially in light of the aggressive efforts

to intensify agriculture. Improved methods of environment management will be required to ensure that agricultural practice is sustainable.

Food crops hold a very dominant position in Rwandan agriculture. However, since 1990 the largest percentage increases in area sown, by a large margin, have been fruit and vegetables (increasing more than fourfold), followed by Irish potatoes and wheat (increasing almost threefold) (ROR 2008). Table 3 shows the area harvested under principal crops up to 2007.

Table 3: Area harvested of principal crops, 1990 and 1997-2007

Crop/ Year	1990	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Sorghum	133,421	108,894	114,639	129,261	174,195	165,444	171,608	179,991	179,307	196,732	170,298	159,670
Maize	98,522	76,481	71,212	72,673	89,053	105,560	104,628	103,100	106,976	109,400	114,836	140,141
Wheat	9,313	6,275	5,700	5,172	10,043	10,748	12,046	0,727	22,191	24,157	22,972	27,161
Rice	6,816	3,233	4,144	4,919	4,266	5,090	6,423	7,666	12,167	13,922	14,033	15,037
Cereals	248,072	194,883	195,695	212,025	277,557	286,842	294,705	311,484	320,641	344,211	322,139	342,009
Beans	262,563	238,525	234,923	228,215	333,205	343,966	358,002	356,899	319,349	313,019	356,381	355,725
Peas	45,896	33,562	28,750	26,796	29,993	32,125	31,228	34,752	32,175	34,796	31,141	36,545
Groundnuts	9,365	3,459	7,045	7,397	13,463	14,767	15,900	16,823	18,884	16,011	16,197	19,488
Soybeans	26,867	13,756	17,858	19,073	29,543	29,555	31,289	36,067	36,707	42,119	42,364	55,423
Pulses, oilseeds	344,691	289,302	288,576	281,481	406,204	420,413	436,418	444,541	407,115	405,945	446,082	467,181
Irish potatoes	42,055	42,000	28,264	29,770	108,983	117,403	124,972	134,034	133,418	135,622	139,750	114,164
Sweet potatoes	175,893	149,342	148,858	179,941	174,663	197,727	195,370	147,290	163,069	148,526	138,725	146,763
Colocase, yams	52,137	42,914	46,158	49,049	21,320	25,669	25,334	27,158	27,098	26,537	25,251	31,722
Cassava	131,768	82,188	76,314	118,492	120,463	136,238	130,457	134,386	133,875	115,694	118,860	143,225
Roots & tubers	401,853	316,444	299,594	377,252	425,429	477,037	476,134	442,869	457,460	426,379	422,586	435,874
Bananas, plantains	400,570	349,906	405,264	410,323	360,470	363,249	358,863	358,418	363,383	361,251	366,296	351,958
Fruit/ vegetables	18,374	n.a.	19,310	20,889	41,692	44,042	47,420	58,225	48,160	81,777	84,830	83,959
Total above	1,413,560	1,150,535	1,213,783	1,301,970	1,511,352	1,591,583	1,613,540	1,615,538	1,596,759	1,619,563	1,641,933	1,680,981
Coffee										33,000	38,559	
Tea						9,786	9,572	9,588	9,542	11,750	12,306	
Pyrethrum						2,385	2,665	3,191	3,394	3,191		

Sources: Compiled from statistics available from MINAGRI, MINECOFIN, OCIR Café and OCIR Thé

There has been increased production in major export crops between 2001 and 2005 and this trend is continuing. The tea sector has experienced strong recovery from last year's stagnation, with production increasing by 3.6 per cent. Furthermore, the price achieved per kg sold rose by 21.8 per cent, indicating that efforts by the Public Office in Charge of Tea (OCIR-Thé) to increase the quality of tea grown is beginning to produce results. This strategy should continue to inform OCIR-Thé's work in 2009 (MINGARI 2009).

The production of coffee increased 16 per cent from 16.0 to 18.6 MT between 2000 and 2005 with 2004 the peak year of production at 28.7 MT. In 2005, although production of coffee fell 35 per cent, its quality improved. Standard coffee rose from 19.2 to 45 per cent between 2000 and 2005, ordinary coffee decreased from 74.4 per cent in 2000 to 49 per cent in 2005 and the share of fully washed coffee increased from 0.1 per cent to 6 per cent over the same

period. Following a downturn in coffee production in 2007 (as a consequence of the cyclical nature of coffee production as well as the uprooting of certain varieties), 2008 shows a substantial recovery in production (over 33 per cent compared to 2007). Production levels are not yet as high as they were in 2006, but as production is of increasingly high quality this has partly made up for the reduction in volume produced. This policy direction is reflected in the average price received for Rwanda's coffees, which has increased by 10 per cent since 2007 and 21 per cent since 2006 (MINAGRI 2009).

Production of pyrethrum fell by 24 per cent. Horticulture production (flowers, fruits and vegetables) increased by 2,737 per cent with exports averaging 59 tonnes per week, mainly for regional markets. Export volumes from high value horticulture for international markets remain significantly lower, around 2.5 tonnes per week.

Table 4: Trends in livestock and livestock products, 2000-2007

	2000	2001	2002	2003	2004	2005	2006	2007
Livestock ('000 head)								
Cattle	755	814	960	992	1,007	1,077	1,122	1,147
Goats	757	917	920	1,271	1,264	2,664	2,688	2,738
Sheep	233	267	301	372	687	690	695	704
Pigs	177	197	208	212	327	456	527	571
Poultry	2,043	1,278	1,056	2,432	2,482	2,109	1,776	1,868
Rabbits	339	495	489	498	520	427	418	423
Livestock products (mt)								
Milk	57,853	63,484	97,981	112,463	121,417	135,141	146,840	158,764
Meat	22,807	25,608	35,748	39,126	48,681	49,861	52,226	54,780
Fish	6,996	7,308	7,612	8,144	8,126	8,180	9,267	9,655
Eggs	1,471	920	1,015	2,432	2,452	2,452	2,236	1,620
Honey	n.a.	760	819	908	1,029	1,671	1,676	n.a.

Source: ROR 2008

Livestock numbers have increased by 60 per cent over the PRSP1 period, (2001-2005) reaching pre-1990 levels in 2003/2004. During that period cattle increased by 43 per cent, goats 67 per cent, sheep 195 per cent, pigs 93 per cent, poultry 44 per cent and rabbits 67 per cent. These increases were due to improvements in quality and disease control. The number of poultry declined due to bird flu (Table 4).

The increase in cattle numbers has contributed to a significant increase in milk production and subsequent increase in average consumption of milk per capita from 6.8 l/year in 1999 to 20 l/year in 2007 (MINAGRI 2008). Although production of livestock products has increased, demand still outstrips supply, especially for milk and eggs, which contributes to food insecurity (lipid and protein intake). Hides and skins production increased 60 per cent.

Agriculture and National Economic Development

The agricultural sector is very important to the economy of Rwanda. The agriculture sector grew at an average of 9.5 per cent over the 1996 to 2000 period; however this growth declined to an average of 4.8 per cent annual growth in 2001-2006 that was just half the growth registered in the previous 5-year period (ROR 2007). The agricultural sector contribution to the overall GDP growth for 2007 was 6.3 per cent. The slow growth of the sector in 2001-2006 is explained by the corresponding modest growth of 3.5 per

cent for food crops and 1.9 per cent for export crops over the period 2002-2005 due to bad weather. Agricultural production in 2008 was generally impressive at 14.8 per cent. There were also increases in food and export crop production of 16.4 and 13.5 per cent respectively. This served as a major input towards national growth levels of 8.5 per cent (MINAGRI 2009).

In 2001, the contribution of the agricultural sector to GDP was about 46 per cent in real terms and it accounted for 80 per cent of exports. It was thus the main national source of foreign currency and survival for the population (ROR 2004). In 2003, the share of the sector declined to 43 per cent of GDP and by 2006 was 36.4 per cent of GDP compared to 43 per cent of the service sector.

Despite the decline in share of GDP, agriculture still remains important (ROR 2007). It provides employment for 86.3 per cent of the country's working population (NISR *et. al.* 2008), with about 80 per cent of adults working in agriculture as the main occupation (NISR *et.al.* 2008). However, in the urban areas, the figure is much lower. For instance those working in agricultural-based sector in Kigali are only 15 per cent (NISR *et. al.* 2008). Currently, the agricultural sector contributes about 30 per cent to Rwanda's growth and as such has positioned itself as a sector key to national development and is crucial to achieving the goals set out in the EDPRS and Vision 2020.

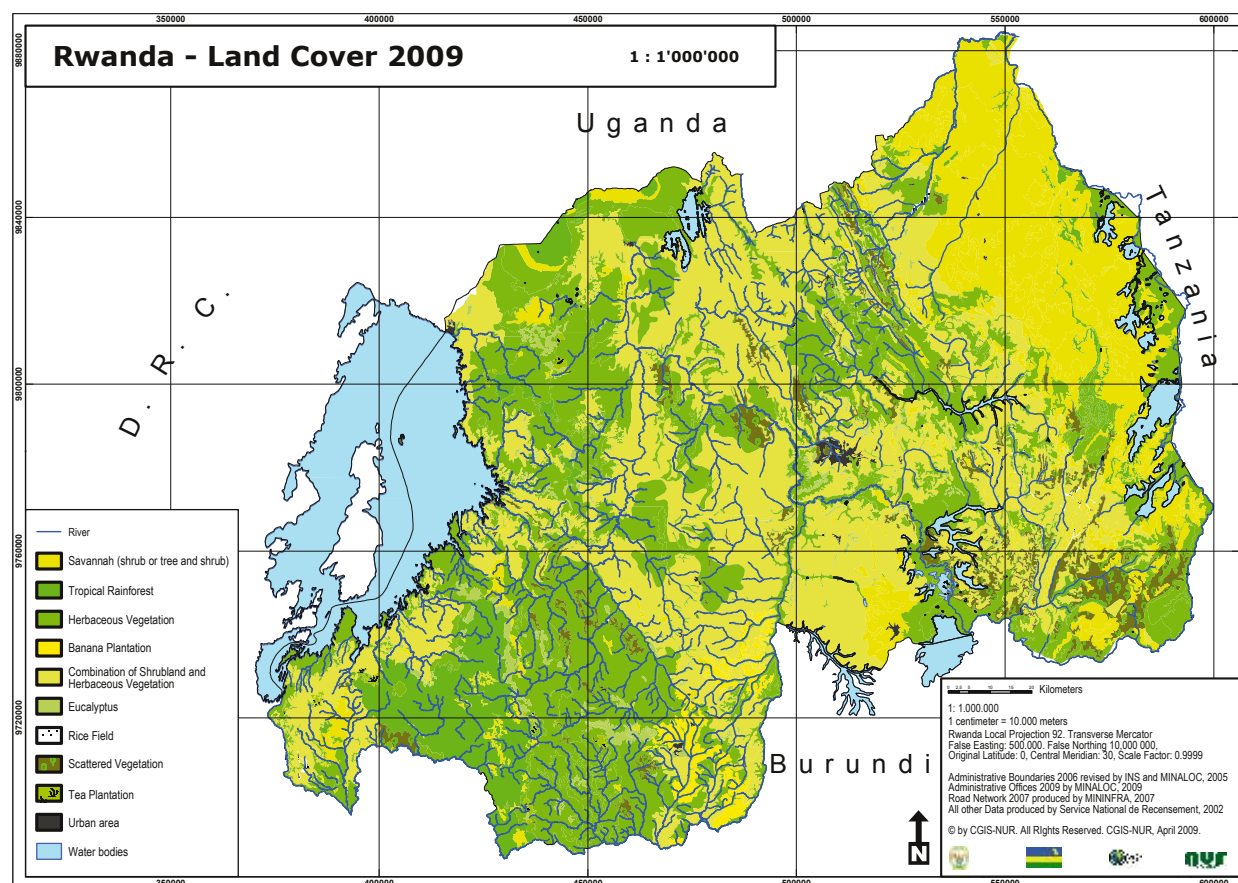
Key environmental issues associated with the agricultural sector

The main issues putting pressure on agricultural productivity include high population density on the limited land resource. This has led to land fragmentation and reduction of farm sizes, continued intensive cultivation of land with no fallow and soil erosion, over cultivation without restoration of soil nutrients, weak extension and research services and increased vulnerability to climatic shocks like drought or heavy rains. The use of fertilizers and agricultural chemicals has polluted water; and agricultural activities and general mismanagement of the wetlands have further degraded and destroyed them.

Population pressure

High population density has fuelled a shortage of arable land, led to decreasing farm size, shortage of arable land and the adoption of intensive agricultural practices on land with declining soil fertility. As a result of land shortages, even the most fragile areas are not spared. For instance the ecologically sensitive areas of Ruhengeri, Gisenyi have the highest population densities (see figure 3). This has increased pressure on the ecosystems resulting in the current degraded state (loss of biodiversity; over-cultivation; soil erosion; declining productivity) and more poverty. In the southern parts (Gikongoro and Butare), the main poverty-environment issue is soil erosion and soil infertility, largely due to over cultivation, use of inappropriate technology and lack of external inputs. In the pastoral and agro-pastoral rangelands of the east, population pressure is not as high but water shortages (for

Figure 3: Land Use and Land Cover, Poverty Incidences and Population Density



Map production: REMA

both humans and livestock), drought and overstocking are the main concerns, often leading to encroachment into the protected areas (Akagera National Park).

The cattle grazing areas of Umutara are prone to bush fires, treading and overgrazing. Overgrazing has been a big problem in the drier Umutara region, particularly soon after the genocide of 1994. Most returning refugees who settled in the region had large herds of cattle and overgrazing and accompanying soil erosion was a problem due to the limited carrying capacity of the dry region. The number of cattle in Umutara region in 1995 was estimated at about 800,000 head. The Government has developed policies and created awareness on improved livestock keeping, including gradual substitution of the local breeds, a reduction in numbers through substitution with improved breeds, improvement of pastures and the zero-grazing system.

Overgrazing and bush fires have been the greatest culprit for reduction of biodiversity as they result in the extermination of the most grazed species as well as pyrophilic (fire-resistant) species with low bromolytic (nutritive) such as *Eragrostics*, *Sporobolus* and *Digitalia* (Twagiramungu 2006). In this respect, the One Cow per Family (*Gira Inka*) programme has been effective in promoting improved cow breeds among Rwandans not only to improve nutrition and income through milk production and sales, but also to provide organic manure to improve crop production. This system has been extended to other animals such as goats, which are expected to significantly reduce overgrazing and related environmental degradation problems.

National and regional availability of land

Generally landholdings are very small with more than 60 per cent of households cultivating less than 0.7 ha, 50 per cent cultivating less than 0.5 ha, and more than 25 per cent cultivating less than 0.2 ha (ROR 2008). This constraint is aggravated by the fact that most farms have multiple, scattered plots, many of them tiny. The small size of farms emanates from high population pressure on a small land area. Moreover, cultural and inheritance patterns of dividing land among sons has also aggravated the situation (ROR 2007).

There are regional disparities in the availability of arable land. The largest average farm sizes are in Umutara averaging 1.14 ha and the lowest average sizes are in Cyangugu with 0.34 ha. The small farm sizes mean that the majority of rural populations cannot produce enough food. Without the

adoption of better farming methods like terracing and contour ridges to stop soil erosion, agriculture will continue to be unsustainable. To address this issue, Vision 2020 requires that the use of national space is organised based on an overall land-use plan. Table 5 shows the average land holdings per household by province in 2006.

Soil erosion

Agriculture practiced on the slopes of hills and mountains, coupled with deforestation has caused extensive land degradation and soil erosion. About 40 per cent of Rwanda's land is classified by the FAO as having a very high erosion risk with about 37 per cent requiring soil retention measures before cultivation. Only 23.4 per cent of the country's lands are not prone to erosion (ROR 2008).

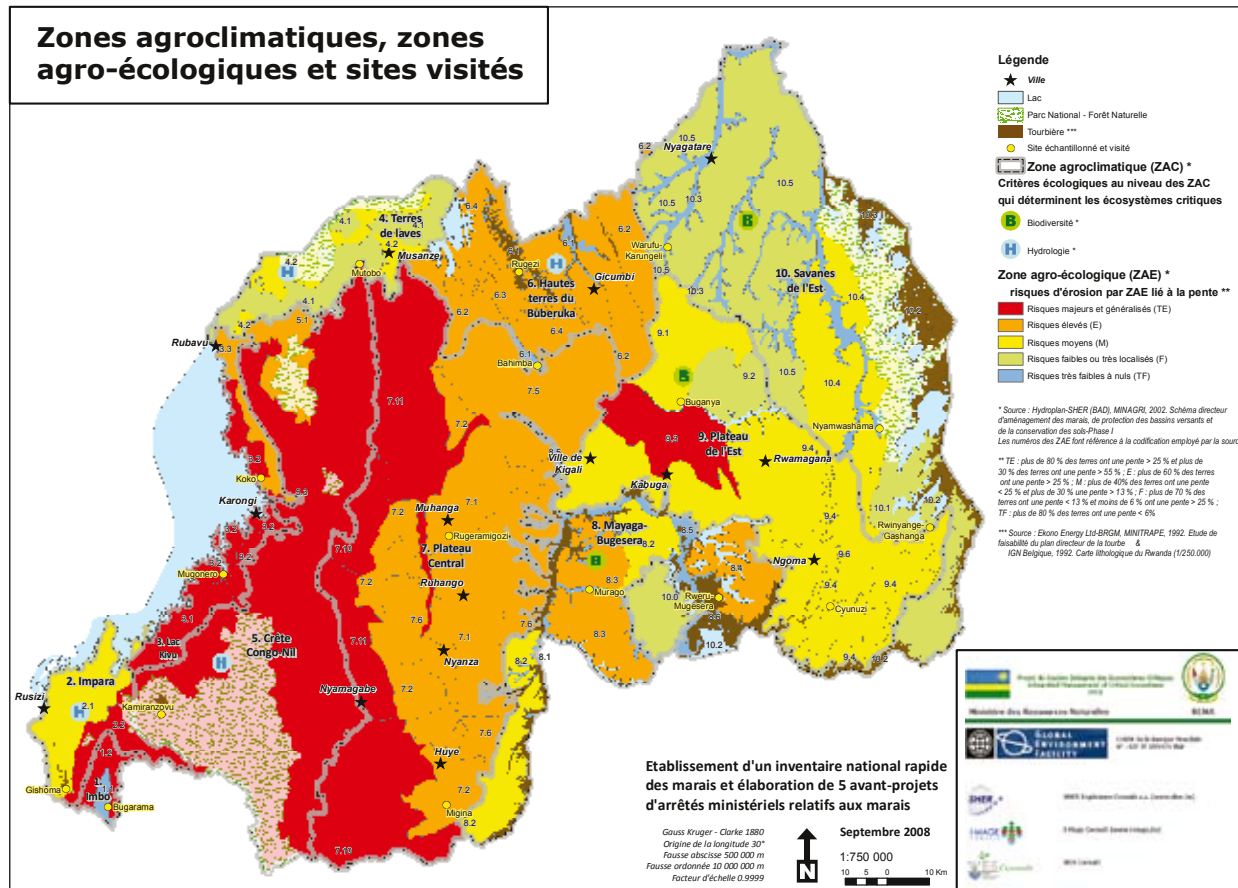
Table 5: Distribution of land size per household by province 2006

PROVINCES	Average land size per household (ha)	Total land (ha)
Kigali Ville and Kigali Ngari	0.69	127 076
Gitarama	1.09	178 284
Butare	0.36	33 455
Gikongoro	0.41	41 564
Cyangugu	0.34	38 935
Kibuye	0.68	58 250
Gisenyi	0.56	94 791
Ruhengeri	0.54	101 111
Byumba	1.04	153 400
Umutara	1.14	96 122
Kibungo	0.95	139 875
Rwanda	0.72	1 062 861

Source: NISR and MINAGRI 2007

Although, it is generally agreed that slopes of more than 5 per cent need erosion control measures, the reality is that most cultivation is carried out on steep slopes without any recommended soil control measures (ROR 2007). Indeed it is not unusual to find crops grown on steep slopes of up to and above 55 per cent. Only 31.2 per cent of the agricultural land area is equipped with anti-erosion techniques. About 36.5 per cent of the country has protective grass strips. The provinces of Butare and Gikongoro have the most of these - 70.5 and 65.3 per cent respectively. This is mainly due to the efforts of non-Governmental organisations such as Food for Work, World Vision, Catholic Relief Services (CRS) and Care International. Areas with least land protection were

Figure 4: Agro-climatic zones and risk of soil erosion



Map production: REMA

found in the former provinces of Cyangugu (77.1 per cent), Umutara (66.7 per cent) and Kibungo (51.2 per cent) (Kelly *et.al.* 2001). Table 6 shows classification of soils according to the risk of being eroded due to the slope.

Soil erosion has compromised ecosystem integrity, eroded riverbanks and led to nutrient loading of water bodies. It has also led to reduced soil fertility in the acid-soil mountainous areas resulting in lowered agricultural yields. The impact of reduced productivity of arable land through the constant loss of top soil and nutrients is already evident at all levels in Rwanda. For instance up to 80 per cent of households in hilly areas such as Ruhengeri are already experiencing a decline in productivity related to soil erosion (Musahara 2006). Overall the country is estimated to be losing 1.4 million tonnes of soil per year. This is equivalent to a decline in the country's capacity to feed 40,000 people per year.

Most of the soil lost through erosion ends up in the stream network and marshlands (Musahara 2006). This is evident in the siltation of the various rivers and associated wetlands.



Marshland converted in agriculture land in Masaka – Gasabo District

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Table 6: Classification of soils according to the risk of being eroded due to the slope

Risk class	Very high	High	Average	Low	Very low
Surface (ha)	357.529	436.563	763.005	340.376	136.625
per cent of soils	17.6	21.5	37.5	16.7	6.7

Source: REMA 2006

Research shows that the Nyabarongo river system carries 51 kg/second of soil at Nyabarongo-Kigali, 44 kg/s at Nyabarongo-Kanzenze and 26 kg/s at Akagera-Rusumo (ROR 2008).

Domestic and industrial energy demands have also indirectly contributed to soil erosion. Much of the country's energy requirements are met by crop residues as well as fuel wood. The use of crop residues limits the extent to which they can be used to conserve soil moisture and fertility. Deforestation on the other hand leads to extensive soil erosion and in some instances floods and landslides.



Siltation is evident from the brown colour of many of Rwanda's rivers and streams

Soil nutrient replacement

Before the war and genocide in 1994, about 95 per cent of farmers used organic manure on 70 per cent of cultivated

area. The post-war figures for use of organic matter (primarily manure) shows a decline compared to pre-war figures. Organic manure is currently used by only 69 per cent of farms on 59 per cent of cultivated area compared with 95 per cent and 70 per cent before the war. There has been little change in the use of inorganic fertilizers. Nine per cent of farmers used pesticides on 5 per cent of cultivated land during the 2000A season. The numbers for fertilizers and lime, show that 5 per cent of farms applied fertilizers to 3 per cent of the cultivated area. These numbers are slightly lower than those for 1991 (7 per cent of farms and 5 per cent of area), however, the standard deviations for both the pre- and post-war data sets are very large and there is no statistically significant difference in fertilizer use between the two periods (Kelly *et.al.* 2001). Table 7 shows the use of inputs on cultivated land in 1991 and 2000.

The use of fertilizer is likely to increase in future as the Government has taken a policy decision to subsidize it and improve distribution through the use of private sector. In 2007 about 21,600 tonnes of mineral fertilizers were ordered and 13,260 tonnes were received and distributed. About 4,200 tonnes of mineral fertilizers were distributed under crops intensification program (MINAGRI 2008).

Climate-related threats

Climate-related shocks like drought and flooding are becoming more regular. The poor are particularly vulnerable to these shocks. The eastern and south eastern regions (Umutara, Kibungo, Bugesera and Mayaga) are most affected by prolonged drought while the northern and western regions (Ruhengeri, Gisenyi, Gikongoro and Byumba) experience

Table 7: Input use and investments on cultivated land: 1991A vs. 2000A

Type of Investment	Farms using inputs (%)		Cultivated area (%)		Specified input covered	
	1991A	2000A	1991A	2000A	1991A	2000A
Chemical fertilizer/lime	7	5	5	3	5	3
Pesticides	NA	9	NA	5	NA	5
Organic manure	95	69	70	59	70	59

Adapted from (Kelly *et.al.* 2001)



© REMA

Flooded farmland in Bigogwe, Nyabihu District in the former Gishwati Forest area

abundant rainfall that usually causes erosion, flooding and landslides (Twagiramungu 2006). These extreme climate events have adverse environmental impacts on agricultural productivity. For instance, the 2008A and 2008B harvests were both negatively affected by serious droughts that came in at the beginning of the planting season. The droughts destroyed just-planted seeds and in some instances delayed planting so that crops became vulnerable to dry spells late in the season in ways that affected overall productivity (MINAGRI 2009).

Addressing the threats to agriculture

Agriculture is recognised in the EDPRS as one of the priority sectors that will both stimulate economic expansion and make the greatest contribution to poverty reduction and food security. However, as demonstrated in the discussion above, a number of factors are threatening these efforts.

The Government has put in place a number of strategies to address these threats. These are discussed below.

Soil erosion and nutrient loss control

The Government is aggressively pursuing measures for soil erosion control. These measures include terracing, increasing soil cover and integrated management approaches such as agro-forestry and zero-grazing. There have been increases in the area under radical terracing. However, small scale farmers lack the capacity to respond to the control of soil erosion because the anti-erosion measures are expensive. Some of the achievements are highlighted in Box 1.

The intensive agricultural policy is geared towards increasing the use of mineral and organic fertilizers, pesticides and selected seeds. As part of the strategy to reduce soil nutrient loss, the Government is currently subsidising fertilizers. However, since the misuse of agro-chemical products have harmful consequences on human and ecosystem health, the policy has to be accompanied with training on the control and management of the negative impact of agro-chemicals.

Box 1: Achievements in protection of soil

According to the March 2009 Joint Sector Review for the Agriculture sector, the area under agriculture (both traditional and commercial farming) underwent protection measures and progress was noted in the following areas:

- Area of land protected against soil erosion: 45 per cent (2008) to 50 per cent (2009)
- Area of marshland developed for agricultural use: 12,000 ha (2008) to 14,000 ha (2009)
- Arable land irrigated increases from 1 per cent (approx. 15,000 ha) to 1.6 per cent (approx. 24,000 ha)
- Irrigated hillside area increases from 130 ha in 2006 to 1,100 ha in 2012 using upland irrigation measures
- Proportion of farming households using improved farm methods: chemical fertilizer use increases from 15 per cent (2008) to 18 per cent (2009); organic fertilizer use increases from 10 per cent (2008) to 13 per cent (2009)
- Percentage of livestock in intensive systems increases from 30 per cent (2008) to 38 per cent (2009).

Source: MINAGRI 2009



Radical terracing on steep slopes in Rwanda

Expanding arable land through irrigation

There is potential for arable land expansion through the use of irrigation. The EDPRS aims to increase the area of hillside agricultural land under irrigation from a baseline of 130 ha in 2006 to 1,101 ha in year 2012. This has implications for environmental management and thus creates urgent need to develop technical expertise within the agriculture and environment sectors to ensure that Strategic Environmental Assessments (SEA) and Environmental Impact Assessments (EIA) are incorporated into the crop intensification programme to guarantee that adequate soil and water management measures are undertaken.

At present, Rwanda does not have irrigation-related environment problems like salinisation and concomitant loss of land for cultivation. However, there are some problems, albeit not serious, related to use of agro-chemicals, such as fertilizers in the sugar and tea industry. Table 8 shows the modes of farming based on rain-fed, irrigated and drainage farming according to the old provinces.

Strengthening policy implementation

Land resources are governed by law No. 11/82 (1982). This law however was not based on the land policy and is thus not comprehensive enough to deal with all land issues. Further, the implementation of both is currently done in a piecemeal manner with inadequate supporting resources.

Both the policy and law have the potential to address some of the issues like land fragmentation, farm size and land tenure. For instance they both provide the opportunity for land to be privately owned ensuring long-term land security that guarantees economic benefits through sale of land or using it as collateral for bank loans. Equally, an efficient land administration system is needed that is easily accessible at the local level for land transactions. Land administration and land use management along with land consolidation will continue to facilitate growth in agricultural productivity, investment in land especially for women and environmental management in support of sustainable development. The security of long-term tenure rights is important for encouraging soil conservation practices and other on-farm investments, as well as providing an inheritable asset for future generations.

Implementation of SEA at policy and strategic levels and EIA particularly for exploitation of wetlands for agricultural purposes, hill side irrigation and integrated water resources management measures will all provide scope for sustainable development with overall benefits to national environmental protection. Integration of SEA into policy and strategic planning for the agriculture sector will need to be followed by action planning facilitated by an effective coordination mechanism involving both agriculture and environment sectors through existing mechanisms such as the rural cluster. Successful implementation will also require technical services and actions to be disseminated through extension services, a sector of the economy that is yet to grow to levels where it will have impact both for enhanced agriculture production and environment management.

Table 8: Rain-fed agriculture, irrigated and drainage farming

Provinces	Rainfall		Irrigation		Drainage		Not Declared	
Kigali Ville and Kigali Ngari	120 322	96.3	1479	1.7	5274	1.9	0.0	0.0
Gitarama	173 013	90.1	135	1.9	5136	8.0	0.0	0.0
Butare	32 701	97.2	0	0.0	754	2.8	0.0	0.0
Gikongoro	40 995	97.3	369	1.6	199	1.1	0.0	0.0
Cyangugu	37 892	95.1	744	3.7	299	1.2	0.0	0.0
Kibuye	56 560	95.8	53	0.6	1460	3.3	176.8	0.3
Gisenyi	94 175	97.1	0	0.0	616	2.9	0.0	0.0
Ruhengeri	99 884	99.4	1125	0.2	102	0.4	0.0	0.0
Byumba	152 810	98.2	413	1.0	177	0.8	0.0	0.0
Umutara	95 641	97.3	210	0.8	270	1.9	0.0	0.0
Kibungo	139 763	99.2	96	0.5	17	0.3	0.0	0.0
Rwanda	1 043 756	97.0	4624	1.0	14304	2.0	176.8	0.0

Source: NISR and MINAGRI 2007

The environment action plan (1996), national strategy for biodiversity (2000), national environment policy (2003) and the environmental law (2005) provide important tools to deal with environment management for sustainable development and agricultural development in particular. The environment law outlines major principles of management and protection, deals with the management and use of agriculture land, governs issues of imports and exports of animals and plants and provides for mandatory environment assessment for development projects and has provisions related to the protection of wetlands and other critical ecosystems.

Agricultural policies and laws and strategies, particularly those that are supportive of value adding to agricultural practices including agro-processing will continue to be rationalized in the foreseeable future. Extension services need to be strengthened and extension-research linkages tailored to solving the farmers' problems. The on-going review of agricultural organizations with the objective of decentralization, offers the opportunity to improve management, effectiveness and to bring extension and research to the farm level. The Agricultural Sector Wide Approach (SWAP) should encourage a more integrated approach to the sectoral programmes.

Improving population control and farming methods

The current population control methods continue to have inadequate impact and population pressure on land continues. There is also little concerted effort to create off farm employment. The current EDPRS flagships focus on improving policy on privatization and job creation which

is likely to enhance off-farm options with overall benefits for environmental management.

The long term programme for soil and water conservation and degradation continues, but is yet to yield measurable results. There exist opportunities for effective adoption of the conservation measures that contribute to sustainable agriculture. The annual agricultural report for 2007 shows an increase in the area under radical terracing between 2006 and 2007 due to the introduction of IMIHIGO which provided an opportunity to enhance improved farming methods through use of terraces and improved agro-forestry practices capable of renewing and regenerating the soil. This has not only increased the area protected against erosion but also the land under cultivation.

Developing the marshes

The development plan for MINAGRI (1987-1997) regarded marshes as being important for agricultural production. The 1987 Bill on the development of marshlands promoted the development of marshes as a method for safeguarding the environment. It also recommended undertaking an environmental impacts study in accordance with the decision of the Ministry responsible for environment. The study was never done and consequently there has been mismanagement of the marshlands leading to a number of them drying and thus being unsuitable for agriculture.

The national environmental strategy and the National Environment Plan of 1991 then advocated for a compromise between the need to safeguard and the necessity to develop areas. It was necessary to harmonize the actions, establish a



Soil erosion control by radical terracing and agro-forestry

classification of marshes between areas requiring protection, areas requiring development and reserved areas, reduce to the minimum disruptive effects of developmental activities (through EIA) and controlling the use of chemical inputs in the marshes and on the slopes. In line with this, the Ministry of Agriculture has, since 1997, minimised the procedures for the distribution of plots in the marshes. Further, REMA has recently undertaken a wetland inventory which categorises wetlands for conservation and other developments (REMA 2008).

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Chapter 4: Industry and Mining

Industrial sector in Rwanda

Industrialization and human resource development are part of the Government of Rwanda's strategy for achieving the Vision 2020 (ROR 2000). Despite the developments in the last 5 years, however, Rwanda's industrial base remains generally weak and uncompetitive. Assessments conducted in 2001 showed an increase in the establishment of a wide variety of small scale commercial and industrial operations particularly garages and artisanal mining operations.

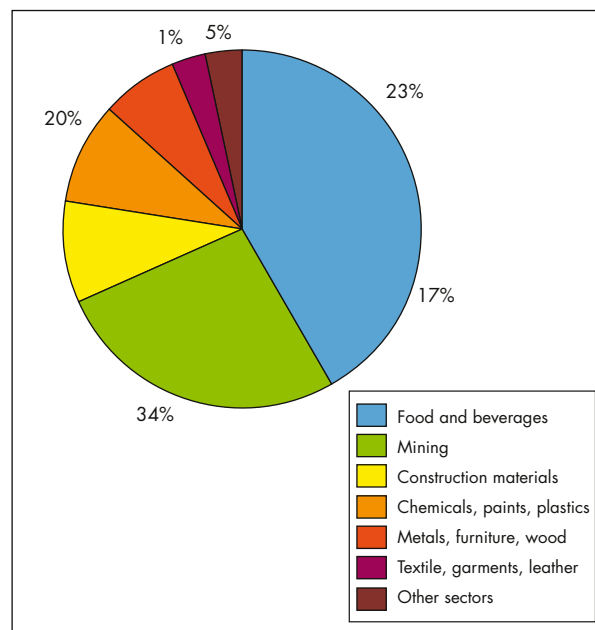
As is typical in developing countries, most of the industries are located in urban areas. About 63 per cent of industries are located in and around Kigali. The median age of establishments located in Kigali is 9 years, while for those located outside Kigali the median age is just 4 years (NISR 2006). This implies that development of the industrial sector in Rwanda, particularly in locations outside Kigali, is basically a very recent phenomenon. Currently, there are efforts to conduct a comprehensive national distribution of industries which will pave the way for an industrial master plan based on suitable zones for location of industries by type.

The industrial base, although fragile and underdeveloped, is vital to the country's economic growth. The potential for employment in such factories provides urban-based opportunities likely to reduce over-dependence on rural farmland. Thus, if mining activities are carried out in a sustainable manner, the potential for significant socio-economic as well as environmental benefits through employment and reduction of pressure on the land through off-farm alternatives is great.

Types of industry

The large establishments are primarily engaged in production and/or processing of wood, beer, soft drinks, tobacco, cement, textiles, tea and coffee. Others include chemicals, construction, printing, paper, engineering and methane gas. Thus, the economy is heavily dependent on the primary sector, with industry strongly tied to processing of primary products. Chapter 1 on Environment and Development discusses the primary sector in greater detail. Figure 1 shows the distribution of industries by sector.

Figure 1: Distribution of industry per sector



Industry and economic growth

Industry grew by only 10 per cent in 2007 as compared to 11 per cent in 2006 (NISR 2008). Its contribution to GDP appears to have stagnated at 14 per cent where it has been since 2001. These trends are shown in tables 1 and 2. Much of the growth in the industry sector is hampered by poor infrastructure in terms of roads and energy.

Most recently, Rwanda has made significant progress in rebuilding its economic and social infrastructure as well as positioning itself internationally as an attractive tourist destination. Tourism is increasingly transforming itself as an entry point for new and growing industrial capacity in the country.



A quarry

Table 1: Gross Domestic Product by Kind of Activity at constant 2001 prices growth rates

Sector/Activity	2001	2002	2003	2004	2005	2006	2007
Agriculture	9	15	-5	0	5	1	1
Industry	13	5	3	13	8	11	10
Mining and quarrying	172	-24	-21	49	30	-14	38
Manufacturing of which: food	25	-3	-1	23	2	7	7
Beverages and tobacco	1	18	-10	2	11	7	1
Textiles and clothing	4	0	-3	6	-1	5	14
Wood, paper and printing	6	22	22	1	25	13	27
Chemicals, rubber, plastics	7	11	10	4	3	13	-2
Non-metallic minerals	24	15	5	0	-2	4	-3
Furniture and others	6	10	23	0	-11	33	24
Electricity, gas and water	-10	15	8	-16	17	28	4
Construction	10	3	8	20	9	13	12
Services	7	9	5	8	9	11	13
Adjustments	9	16	-4	1	6	6	2

Source: NISR 2008

Table 2: Gross Domestic Product by Kind of Activity at constant 2001 prices percentages

Sector	2001	2002	2003	2004	2005	2006	2007
Agriculture	37	35	38	39	39	39	36
Industry	14	14	13	14	14	14	14
Mining and quarrying	1	0	0	1	1	1	1
Manufacturing of which: food	7	7	6	6	6	6	5
Beverages and tobacco	2	2	2	2	2	2	2
Textiles and clothing	0	0	0	0	0	0	0
Wood, paper and printing	0	0	0	0	0	0	0
Chemicals, rubber, plastics	0	0	0	0	0	0	0
Non-metallic minerals	1	1	1	1	1	1	1
Furniture and others	1	1	1	1	1	1	1
Electricity, gas and water	0	1	0	0	0	1	1
Construction	6	6	6	7	7	7	7
Services	43	44	42	41	41	41	45
Adjustments	6	7	7	7	7	6	5

Source: NISR 2008

Mining

Mining is an activity that involves excavation of the surface and subsurface for the purpose of exploiting and processing minerals. These minerals are for economic and industrial development in local and foreign markets. Mining is a non-renewable resource activity with great potential. However, although it utilises a small area of the land it can have significant and often irreversible environmental impacts.

With increasing investments in the mining industry since 2004, there have been proportionate increases in the contribution of the sub-sector to national revenue stream. Mining and quarrying activities expanded by an estimated 55 per cent over 2004, largely boosted by increased



Rubavu mining site shows some of the often irreversible impacts on the environment

Table 3: Development of the mining sector GDP and of the major export crops

Year	Export crops (FRW)	Mining and quarrying products (FRW)	Ratio mining GDP/export crops GDP (%)
1999	7 700 000 000	700 000 000	9.0
2000	7 500 000 000	1 200 000 000	16.0
2001	8 500 000 000	5 600 000 000	66.0
2002	6 500 000 000	2 500 000 000	38.0
2003	6 800 000 000	2 600 000 000	38.0
2004	12 000 000 000	8 100 000 000	67.5
2005	16 300 000 000	9 900 000 000	60.7
2006	22 500 000 000	10 800 000 000	48.0
2007	14 800 000 000	20 700 000 000	139.9

Source: NBR and NISR (2008)

cassiterite tin production. Value added in this sector increased from RWF 89 billion in 2003 to RWF 100 billion in 2004. The mining and quarrying sector is estimated to directly employ around 50,000 people in Rwanda. Quarrying has of recent expanded to include other materials such as sand and stones to meet the growing demands of the booming construction industry as well as road construction. Currently, quarry products contribute 11 per cent of the internally generated revenues up from 3-4 per cent of the 1990 levels. Growth in the industrial sector reached nearly 7 per cent over 2004, despite the negative effects of the double energy crisis (rising fuel costs and electricity shortage) and new competitive pressures arising from the COMESA free trade area entry in Jan 2004 (MINECOFIN 2006).

More recently, in the 2006-2007 fiscal year, the mining sector experienced intensive privatization that led to growth. The Mining and Exploration Authority (REDEMI) which has been under Government management is currently undergoing privatization with 17 out of a total of 20 concessions already under private ownership. Seven foreign companies have already received permits to conduct research and exploration for gold, nickel, cobalt, platinum, copper and wolfram (PSF 2009). Following the research stage, the companies will formally report results on the reserves prior to being granted concessions for mining. Table 3 illustrates the growing importance of the mining and quarrying activities as contributors to Rwanda's economic growth.

Mineral revenues were US\$ 71 million and 93 million for 2007 and 2008, respectively which have exceeded earlier projected targets. Sector regulations including new data on investors and enhancing value addition in metallic ores are some of the justifications for the overall performance levels in the sector.

Challenges facing the industrial sector

Inadequate energy supply

Challenges to rapid industrialization of Rwanda are mainly linked to serious inadequacy of national energy supplies. Electricity has been identified as the biggest challenge to the growth and performance in Rwanda (NSIR 2006). Energy is discussed in greater detail in Chapter 8 on Energy Resources.

Most of the agro-processing industries including tea processing and coffee washing stations, use fuel wood as a source of energy. Rwandans also use a lot of wood for fuel wood. Estimates from 1992, the last year for which figures are available put the amount at 3,510 million kg of wood fuel (Chemonics International Inc 2008). Most of this wood is consumed by homes, though large quantities are also consumed by a variety of commercial users, such as tea factories. This poses issues of land degradation through accelerated erosion with adverse environmental and agricultural productivity impacts. Issues of land degradation are discussed in Chapter 3 on Land use and Agriculture.

Inadequate pollution control

Kigali provides a large proportion of the city's industrial employment but consequently a larger portion of the urban environmental problems. A significant number of factories which form the industrial base in Kigali are located in a low-lying area called the Gikondo-Nyabugogo wetland. The factories, as well as the densely populated homesteads located on the adjacent hill slopes, have no proper liquid-waste disposal systems, and consequently pollute soils, groundwater and the surface water. Many of the factories



Poor handling and dumping of industrial raw material and chemicals

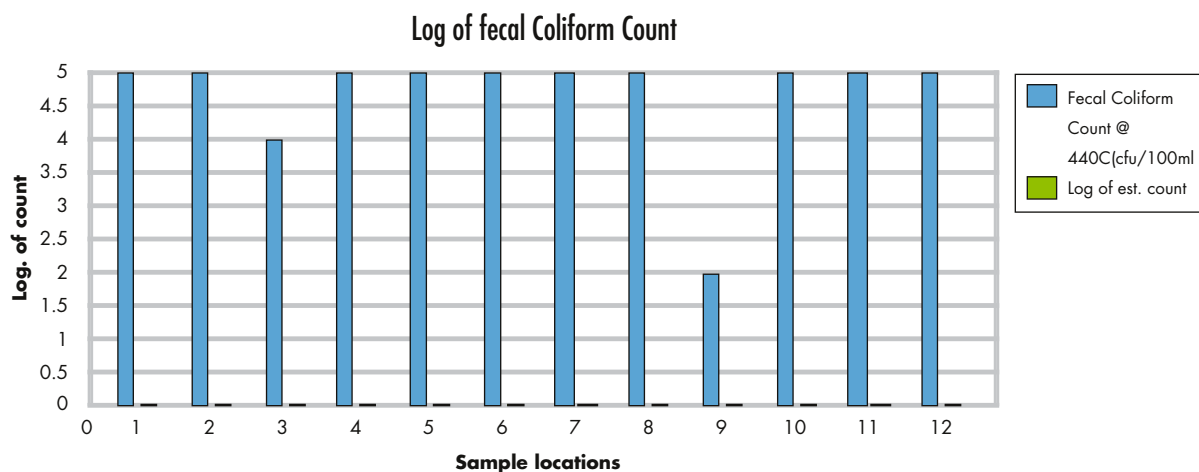
use out-dated technologies that are associated with energy demands and waste generation to levels that have adverse impact on the environment, and render the operations expensive and unsustainable.

Industries, petroleum depots and garages have to date been established in unplanned locations which renders pollution control untenable. Lack of planning has resulted in locating industries in the proximity of residential areas which constitute an additional threat to human health and environment. On the other hand, almost all the industries, garages and workshops are located in valleys or marshes bordered by heavily populated areas.

The industrial effluents and by-products are discharged in the water bodies. A number of industries in the Kigali City wetland system include the textile industry, the iron industry which makes iron sheets, paint factories and the Kabuye sugar factory among others. These industries have been responsible for water pollution by the chemical discharges from the industries. The pollutants are for the most part toxic to humans and animals and in some instances and also interfere with the environment by polluting soils. Figure 3 and table 4 show results of water and soil quality samples taken from the Gikondo industrial zone profile stretching from Kicukiro to Nyabugogo.



A quarry in Ngororero-Nyabarongo. The colour of the water is an indicator of pollution

Figure 3: Microbial pollution in sample locations in Gikondo industrial zone

Source: KIEM 2006

Table 4: Results for composite soil samples from Gikondo valley

Variables	Number for composite topsoil's samples from transects							
	1	2	3	4	5	6	7	8
pH (H ₂ O)	6.79	6.90	7.76	7.07	6.43	7.19	6.08	7.30
pH (KCl)	6.46	6.35	7.11	6.42	5.73	6.54	5.40	6.58
Delta pH	-0.33	-0.55	-0.65	-0.65	-0.70	-0.65	-0.68	-0.72
per cent C	1.47	1.17	0.53	0.87	0.98	0.50	0.92	0.56
per cent N	0.11	0.12	0.07	0.07	0.07	0.05	0.10	0.05
C/N ratio	13.4	9.7	7.6	12	14	10	9.2	11.2
P (ppm)	3.06	29.75	8.75	10.06	7.44	5.69	9.62	7.00
Ca ⁺⁺ (meq/100g)	28.05	10.42	8.43	9.69	8.45	6.43	6.86	5.50
Mg ⁺⁺ (meq/100g)	2.14	1.92	1.31	1.41	1.59	1.06	1.80	1.33
K ⁺ (meq/100g)	0.05	0.15	0.02	0.12	0.18	0.10	0.30	3.12
Na ⁺ (meq/100g)	0.63	0.37	0.85	0.46	0.31	0.34	0.42	0.67
H ⁺ (meq/100g)	0.30	0.32	0.27	0.15	0.20	0.22	0.15	0.27
Fe (ppm)	42,000	51,150	56,100	51,150	60,000	34,350	30,750	49,350
Zn (ppm)	140	182	186	216	208	134	106	120
Cr (ppm)	232.5	250	242.5	285	290	277.5	275	312.5

Source: KIEM 2006

The polluted waters from the industrial park in the Gikondo-Nyabugogo wetland system discharge into the Nyabarongo River and its tributaries. The Nyabarongo feeds into the Akagera River, which flows into Lake Victoria. Thus, the industrial effluents and other pollutants created in the Gikondo-Nyabugogo wetland system pose environmental challenges that extend well beyond the national borders of Rwanda.

Impacts of mining

Mining activities often impact significantly on the environment. For instance, sand harvesting and quarrying are already showing some significant environmental impacts, including resource depletion, energy consumption, waste generation

and emissions of air pollutants. The dangers to human life and health associated with mining include the displacement of people, land use changes, dust and noise pollution.

In fact, the preparation of ores which uses a lot of water constitutes a major pollutant of stream water in Rwanda. For example, the waters draining the mining sectors of Rutongo and Gatumba pollute the rivers of Nyabarongo and Nyabugogo by sediments of clay and sand which they transport over long distances. It is this considerable mineral load which partly gives them the brown colour that is characteristic of the rivers in Rwanda. Mining and quarrying produce massive rejects which appear in nature in the form of enormous lots of earth

and rocks. Erosion from rain water transports the mineral residue towards the valleys where streams are filled and covered by the residue which may be toxic to biodiversity.

Strategies to encourage the development of the industrial sector

In order for Rwanda to benefit fully from the privatization policy and encourage more investments, the current aggressive industrialization policy as well as other development directional areas must be clearly integrated with a sustainable environmental management framework.

Implementing and mainstreaming environmental legislation

The National Environment Policy of 2003 and Environment Law (No. 4/2005) of 2005 are in place to ensure protection of the ecosystems from degradation and pollution as well as guide rehabilitation of degraded ecosystems. Articles 67 and 68 require all activities likely to have significant environmental impacts to undergo Environmental Impact Assessment (EIA). Effective interventions to pollution from industry and mining will depend on measures such as institutionalization of EIA and Strategic Environmental Assessment (SEA) for policies currently under review such as the small and medium enterprise (SME) policy, the investment policy, the mining policy, and the energy policy.

The mining sector will need to integrate environmental issues the management of mines beyond the adaptation of the EIA process. The institutionalisation of EIAs is a first step towards creating a more environmentally sustainable sector, but for this to be effective the number of initiatives should be followed with the formulation of additional legislation on mine closure, the preparation and implementation of Environmental Action Plans, formulation of environmental standards; and building of capacity for law enforcement.

The new Industrial Policy focuses on five main strategic objectives, namely: enhancement of the performance of the existing manufacturing sector and development of industrial parks and free export zones to facilitate establishment of new industries; development of new product lines; and promoting resource-based manufacturing, among others.

Key environmental interventions in the EDPRS include the rehabilitation of degraded wetlands and other protected areas to ensure the preservation of biological diversity. It is planned to put in place a framework to implement the National Programme for Adaptation on Climate Change (NAPA) and develop a Clean Development Mechanism.

Cleaner production

The Rwanda Cleaner Production Centre has been established and is promoting the cleaner production approach in Rwanda. Box 1 describes cleaner production. Under the Cleaner Production pilot programme, 10 enterprises were participating in the programme and they are listed in Table 5.

Another module on Cleaner Production was undertaken under the Lake Victoria Environmental Management Project II and primarily targeted training the private sector and touring neighbouring countries to learn from best practices. All these efforts are beneficial towards sustainable industrialization and they will be further augmented by a full project on Cleaner Production once it is implemented through the ministry with the mandate for industrial activities – Ministry of Trade and Industry (MINICOM).



Mining in the Nyabarongo river

Box 1: What is cleaner production?

The cleaner production approach is a preventive, integrated strategy that is applied to the entire production cycle to:

- **Increase productivity** by ensuring a more efficient use of raw materials, energy and water
- **Promote better environmental performance** through reduction at source of waste and emissions
- Reduce the environmental impact of products throughout their life cycle by the design of environmentally friendly but **cost-effective products**.

The net effect is to give enterprises in developing and transition countries a more competitive edge, thereby facilitating their access to international markets.

Source: UNIDO 2009

Table 5: Rwandan industries that participated in the pilot Cleaner Production in Rwanda 2005 – 06

Industry	Location
Ameki Color	In Gikondo wetland
Inyange Dairy	Around Gikondo wetland
Nyabisindu Dairy	Outside Gikondo wetland
Rwanda Foam	In Gikondo wetland
Rwanda Leather (Saban Tannery)	Around Gikondo wetland
Sakirwa	Around Gikondo wetland
Sulfo Industries	Around Gikondo wetland
Chillington	In Gikondo wetland
Utexrwa	In Gikondo wetland
Mironko Plastic Industries (Did not fully participate)	Around Gikondo wetland

Source: REMA

Improving the mining sector

In order for the mining sector to meet its goals within the EDPRS, a number of measures including building domestic mineral extraction and processing capacity; developing a service hub for mineral processing for the sub region and enhancing locally produced construction materials need to be undertaken. These will have the potential to promote private sector participation in exploration, mining and processing, and promote value addition of quarry products to reduce the importing of construction materials.

There are plans to identify potential areas of significant mineral deposits to be mapped by 2012. The new geological surveying programmes conducted by the Geology and Mines Authority (OGMR) will assist in attaining this objective which will provide valuable information to investors. Assisting cooperatives of small miners to acquire knowledge and skills and access appropriate technology will ensure that the mining strategy incorporates a pro-poor component. Programmes will be developed to train women in the skills required by the mining industry. These goals need to be undertaken in

the context of good environment management practices. For example at times, mining of gold and more recently colombo-tantalite has led to creation of large mining camps in the forests, some containing more than 3,000 people, with consequent impacts on the environment (Chemonics International Inc. 2008).



A mining site with settlement in the background

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Conclusions and recommendations

The industry, mining and infrastructure sectors are very important for economic growth and social development. While acknowledging their contribution to the national development, the sectors are associated with varying levels and severity of environmental degradation and major source of pollution. It is therefore critical that the development of these sectors take cognizance of development demands and inputs in a balance with the need for environmental protection in order to ensure that sustainable development is targeted as the ultimate goal. This will be achieved through more efficient production processes and preventive strategies. Cleaner technologies and procedures can be important mechanisms for reducing impacts on natural resources and the environment.

Compliance with Government regulations and policies remains one of the most forceful drivers of environmental performance for most companies, as it requires them to take mandatory actions or meet set standards. Strengthening the efforts for integration of environmental issues in the sector, whether through conducting SEAs, undertaking of EIAs, the use of standards, or other regulatory mechanisms, will certainly contribute to sustainable growth of Rwanda's economy and move Rwanda closer to poverty reduction. Some mitigation measures against the environmental hazards from industry, mining and infrastructure, in support of sustainable economic growth and poverty reduction the sector could, amongst others, do the following:

Support operationalisation of the existing policy and legal instruments including SEA for policy reviews and EIA for effective project implementation and expedite the development of the tools where they are lacking.

- Reinforce the regulatory environment to guide the private sector in contributing to the financing of environmental management and protection, especially where it concerns preventive actions that mitigate the impact of their development activities.
- Guide the establishment of cleaner production and consumption mechanisms in the sector.
- Facilitate the promotion of the potential of the environmental management within the sector for private investment and Private-Public Partnerships (PPP) development. Areas such as solid waste management, waste water treatment and

sanitation offer a lot of opportunities for attracting private investors.



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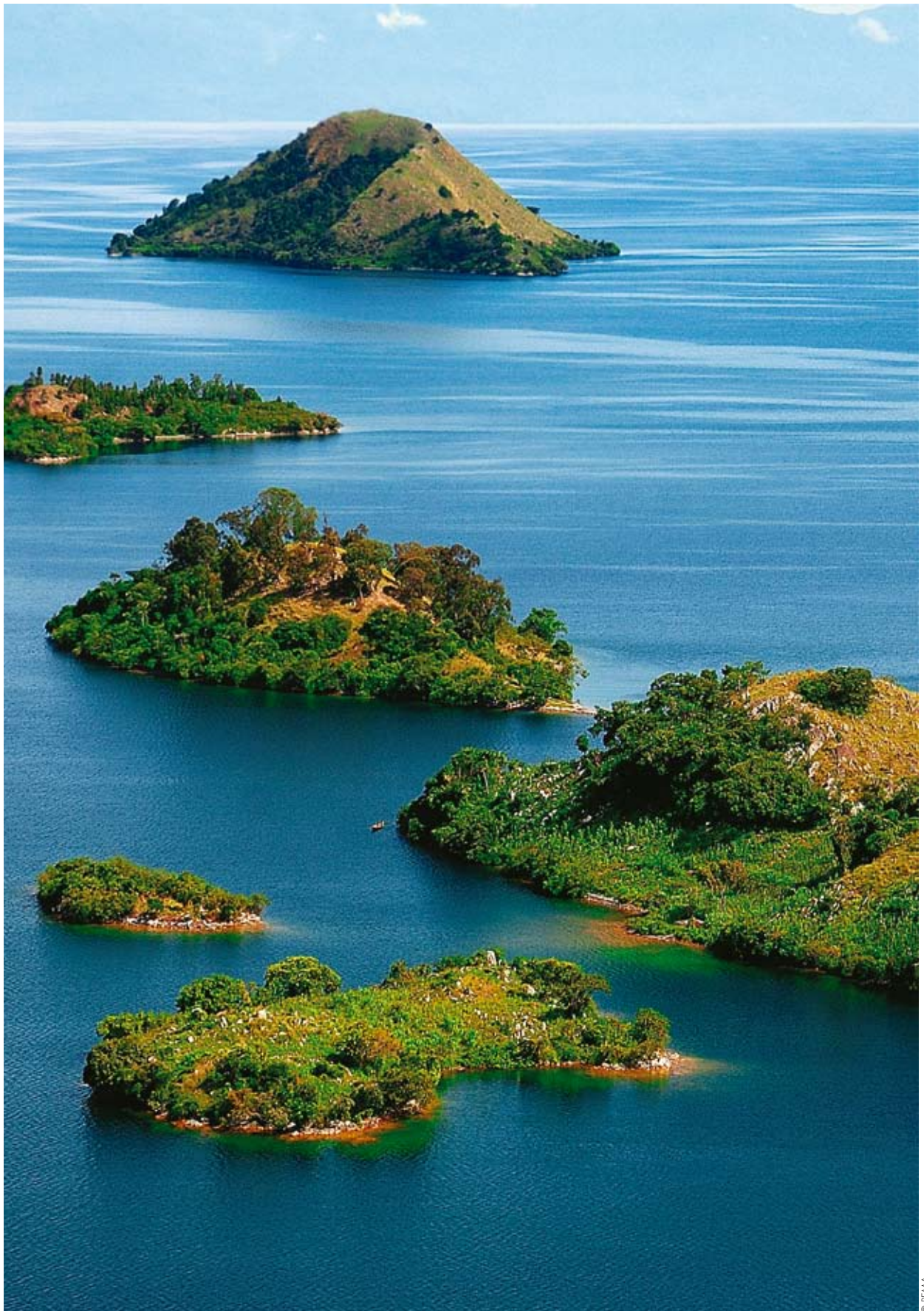
Mine sites requires increased attention for the safety of the workers and for the protection of environment

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STATE OF THE ENVIRONMENT



Chapter 5: Biodiversity and Genetic Resources

Current state of biodiversity

Biodiversity can be defined as the variability of life expressed at the ecosystem, species and genetic levels. It provides a large number of goods and services that sustain our lives. Biodiversity is the combination of life forms and their interactions with each other and with the rest of the environment that has made the earth a uniquely habitable place for humans (SCBD 2000). The biodiversity we see today is the fruit of billions of years of evolution, shaped by natural processes and, increasingly, by the influence of humans.

Although Rwanda is a small country, it has a remarkable variety of ecosystems and of flora and fauna. Its location at the heart of the Albertine Rift eco-region in the western arm of the Africa's Rift Valley is a contributory factor. This region is one of Africa's most biologically diverse regions. It is home to some 40 per cent of the continent's mammal species (402 species), a huge diversity of birds (1,061 species), reptiles and amphibians (293 species), and higher plants (5,793 species) (Chemonics International Inc. 2003, MINITERE 2005).

Ecosystem and habitats

The Albertine Rift is considered to have the highest species richness in Africa. It is considered a biodiversity hotspot containing more endemic mammals, birds, butterflies, fish and amphibians than anywhere else in Africa. Habitats supporting such an array of biodiversity are very varied. Being at the heart of the Albertine Rift, Rwanda's habitats are equally varied, ranging from afro-montane ecosystems in the northern and western regions to lowland forests, savannah woodlands and savannah grasslands in the southern and eastern regions. There are other habitats around volcanic hot springs and old lava flows, especially in the northern and western part of the country. Rwanda also has several lakes and wetlands which are rich in different species. Though not yet well surveyed, all these ecosystems host a rich variety of fauna and flora and micro-organisms.

Besides these natural ecosystems, as an agrarian country, Rwanda agro-ecosystems comprise cultivated land, agro-pastoral areas, grassland, grazing and fallow land (MINITERE 2003a).

Species Diversity

Flora

Rwanda harbours very diverse flora due to a considerable geo-diversity and a climatic gradient from west to east. The number of vascular plants is estimated at around 3000 species originating from the different bio-geographical regions (Fischer and Killmann 2008).

Rwanda constitutes the eastern limit for plants from the Guineo-Congolian region. An example of these plants is the *Thonningia sanguinea* (Balanophoraceae), widespread in Western and Central Africa. It is only found in the Cyamudongo forest in western Rwanda. Plants from the afro-montane region are confined to higher altitudes, such as the orchid *Disi robusta* found in Nyungwe forest. The Eastern African savannah elements comprise the Zambezi floral region, and most these plants are found in the Akagera National Park and its surroundings (Fischer and Killmann 2008).

About 280 species of flowering plants from Rwanda are considered to be endemic to the Albertine Rift. Of these endemic species, about 20 are restricted to Rwanda, 50 species confined to Rwanda and Eastern Congo and 20 species found only in Rwanda and Burundi. Twenty one species are found additionally in the forests of western Uganda, eastern Congo, Rwanda and Burundi. Examples of these distribution types are *Impatiens bequaertii* (Balsaminaceae), *Impatiens mildbraedii* (Balsaminaceae), *Monathotaxis orophila* (Annonaceae) or *Liparis harketii* (Orchidaceae) (Fischer and Killmann 2008).

Rwanda has 56 local endemic flowering plants, out of which 47 are confined to Nyungwe National Park (including Cyamudongo forest). Examples of these plants are the recently discovered species *Impatiens nyungwensis* Eb.Fisch., Detchuvi & Ntaganda, (Balsaminaceae) *Afromomum wuertii* Detchuvi & Eb. Fisc (Zingiberaceae), *Diaphanthe delepierreana* Lebel & Geerinck (Orchidaceae) and *Ypsilopus liae* Delpierre and Lebel (Orchidaceae) all endemic to Nyungwe National Park (Fischer and Killmann 2008). The number of these newly discovered species shows that the number of plant species found in Rwanda is far from being totally known.

The afro-montane ecosystems comprised of the Volcanoes and Nyungwe National Parks, Gishwati and Mukura Natural Forests, and other small forests found at the Congo-Nile Ridge, is varied and rich in plant species.

The biodiversity in the lowlands of the eastern part of Rwanda comprises mainly savannah with grasses, bushes and trees, mountain rainforests in the Akagera National Park and gallery forests in the eastern part of Rwanda. Gallery forest around lakes and other water bodies are mainly found in the Akagera complex, where they cover almost 163 hectares (Twarabamenye and Gapusi 2000 in MINITERE 2003a). The flora of these forests comprise 66 species including *Acacia kirkii*, *Acacia polyantha*, *Acacia sieberana*, *Albizia gummifera*, *Cordia Africana*, *Crotonmacrostachis*, *Dombeya burgessia*, *Dombeta kirkii*, *Erythria absysiica*, *Newtonia buchananii* and *Techlea nobilis*. There are also some rare or threatened species such as *Impantiens irvingii*, *Markhamia lutea*, *Eulophia guineensis* and *Pterygota mildbraedii*, considered a fossil plant (MINAGRI 1998).



An Acacia tree in Akagera National Park

Most of the plant species found in these forests are used in traditional medicine and some plants reveal important biochemical extracts. This is the case with *Blighia unijugata*, *Grewia forbesi*, *Rhus vulgaris*, *Pterygota mildbraedii* and *Ficus* species (MINITERE 2003a).

With more than 104 flower species, wetlands and aquatic ecosystems are also rich in biodiversity. Some lakes such as Kivu, Bulera and Ruhondo are poor in macrophytes (MINITERE 2003a). About 50 species of plankton are found in these ecosystems distributed in the following families: *Chlorophyceae*,

Cynophyceae, *Pyrophytes*, *Bacillariophyceae*, *Cynophyceae*, *Pyrophytes*, *Euglenophyceae*, and *Diatomophyceae*. There are reports of colonization of *Nymphaea nouchalii* and *Nymphaea lotus* in the lakes of the eastern region. The Water hyacinth (*Eicchornia crassipes*) presents a big threat to the biodiversity of these lakes. The flora is dominated by *Cyperus papyrus*. Some of these lakes are associated with gallery forests with the dominating species being those of the genus' *Phoenix*, *Bridelia*, *Ficus*, *Aeschynomene* and *Echinochloa*. Ferns are also found and in some places there are *Echinochloa pyramidalis*.

The agro-ecosystems have food crops species like *Sorghum*, *Phaseolus vulgaris*, *Eulisine corocan*, *Colocasia antigonum*, *Zea mays*, *Oryza sativa*, *Triticum sp.*, *Hordeum vulgare*, *Pisum sativum*, *Soja hispada*, *Arachis hypogea*, *Ipomea durcis*, Irish potatoes, *Manihot esculenta* and the banana (*Musa*). There are also commercial crops like coffee, tea and pyrethrum. The agricultural production systems also accommodate many related wild species, the most common being *Eragrostis sp.*, *Bidens pilosa*, *Digitaria sp.*, *Conyza sumatrensis*, *Cyperus sp.* There are also plant forage crops including *Tripsacum laxum*, *Setaria sp*, *Desmodeum sp*, *Pennisetum purpureum*, *Mucuna pruriensis*, *Cajanus cajan*, *Calliandra calothyris*, *Leucaena diverifolia*, and *Sesbania sesban* (MINITERE 2003a).

Tree species found in Rwanda include *Ficus thoningii*, *Euphorbia tirucalli*, *Erythrina abyssinica*, *Verminia amygdalena*, *Dracaena afromontana*, among others. The first afforestation efforts took place between 1920 and 1948 during which time Eucalyptus was introduced. Other species introduced later included *Pinus sp*, *Callistris sp*, *Grevillea robusta*, *Cedrella sp*, and *Cupressus*. (MINITERE 2003a).

Fauna

Rwanda shelters 151 different types of mammal species, eleven of which are currently threatened and none of which are endemic. Among them are the primates (14 to 16), with half of the remaining world population of mountain gorillas (*Gorilla gorilla berengei*). The gorillas are found in the Volcanoes National Park. Others includes the owl-faced monkey (*Cercopithecus hamlyni*), the mountain monkey (*Cercopithecus hoesti*) in Nyungwe, the Chimpanzee (*Pan troglodytes*) in Nyungwe and Gishwati, and the Golden monkey (*Cercopithecus mitis kandii*) found in Volcanoes National Park. There are also 15 species of antelope, and a wide diversity of species such as buffalo, zebra, warthog, baboon, elephant, hippopotamus, crocodile, tortoise and



A family of Mountain Gorillas

rare species such as the giant pangolin (Chemonics International Inc. 2003, MINITERE 2005).

Rwanda is one of the top birding countries with 670 different birds having been recorded. Four of species of birds in Rwanda are threatened with extinction: the shoebill (*Balaeniceps rex*) found in Akagera; Grauer's rush warbler (*Bradypterus graueri*) found in Volcanoes National Park in Nyungwe and in the swamps of Rugezi; the Kungwe apalis (*Apalis argentea*) found in Nyungwe; and the African or Congo barn owl (*Phodilus prigoginei*) found along Lake Kivu (Chemonics International Inc. 2003).

Animal races bred in Rwanda are mixed with native and non-native races. These include cattle (*Ankole*, *Sahiwal*, *Frison*, *Alps brown* and the *Australian Milk Zebu*), goat (*Alpine* and *Anglonubian*), sheep (*Karakul*, *Merinos* and *Dorper*), pig (*Large white* and *Landrace*, *Piétrain*), poultry (*Leghorn*, *Rhodes Island Red*, *Derco*, *Sykes* and *Anak*), fish (*Tilapia* and *Clarias*) (MINITERE 2003 a).

Fish species found in aquatic ecosystems comprise *Haplochromis*, *Synodontis*, *Barbus*, *Labeo*, *Tilapiines*, and *Clarias* species. *Raimas moorei* and *Limnothrissa miodon* were introduced into Lake Kivu at the end of the 1950s (MINITERE 2003a).

Conservation status of biodiversity

This rich biodiversity is mainly conserved in protected areas (three national parks, natural forests, wetlands). These cover almost 10 per cent of the national territory while the rest of the country is densely populated.

The Volcanoes National Park is home to about 30 per cent of the global population of Mountain Gorilla (*Gorilla gorilla beringei*). It has other 115 mammals' species, including the golden monkey (*Cercopithecus mitis kandii*), elephants, buffaloes, 187 bird species, 27 species of reptiles and amphibians and 33 arthropod species. CITES consider *Rana anolensis*, *Chameleo rudi* and *Leptosiphos grauer* endangered (MINAGRI 1998, Chemonics International Inc. 2003). It has also 245 plants, 17 of which are threatened; and 13 species of orchids including *Disa starsii*, *Polystachya kermessia*, *Calanthes sylvatica*, *Chamaengis sarcophylla*, *Cyrtorchis arcuata*, *Habenaria praestans*, *Stolzia cupuligera*, *Eulophia horsfallii*, among others (Chemonics International Inc. 2003).

Nyungwe National Park has 75 species of mammals, including 13 species of primates with some on the IUCN Red list such as the Eastern Chimpanzee (*Pan troglodytes schweinfurthii*), owl-faced guenons, (*Cercopithecus hamlynii*) and the Angolan Colobus monkey (*Colobus angolensis ruwenzorii*). The national park is also considered an African Important Bird Area (IBA) with 285 bird species comprising 25 endemic to the Albertine Rift (Plumpre *et. al.* 2002, Fischer and Killmann 2008). Of the 1,200 plant species inventoried in the Nyungwe National Park - 265 species were trees and shrubs and of these 24 are endemic to the Albertine Rift. Among the plant species in the park, 5 species of trees and 6 species of grass are endemic to the park. These include *Oricia renieri*, *Pentadesma reyndersii*, *Pavetta troupinii*, *Psychotria palustris* and *Tarenna rwandensis*. The flora of the park also comprises 148 species of orchids, of which 19 are endemic (MINITERE 2005). The following species of orchids found on the CITES list are also found in the park: *Diaphananthe biloba*, *Disa eminii*, *Disperis kilimanjarica*, *Euggelingia ligulifolia*, *Eulophia horsfallii*, *Polystachya fabriana*, *Polystachya hastate* and *Tridactyle anthomaniaca* (MINITERE 2005).

The wildlife in the **Akagera National Park** comprises 90 species of mammals, 530 bird species and 35 fish species. The most threatened species are rhinoceros, large carnivores, particularly lions. Many species in the Akagera National Park are protected by the CITES convention such as *Loxodonta africana* (African elephant), *Sincerus caffer* (buffalo), *Panthera leo* (leopard) and *Tragelaphus spekii* (sitatunga). (MINITERE 2003a, MINITERE 2005). The flora of the Akagera National Park is diverse and 6 species of orchids are recorded. The grass savanna is dominated by *Themeda triandra* and *Hyparrhenia* sp. accompanied with normal species like

Sporobolus pyramidalis and *Botriochloa insculpta*. Acacias are the most trees found in the forest savannah, and the following species are recorded: *Acacia senegal*, *A. Sieberiana*, *A. polyacantha campylacantha*, *A. gerardii* and *A. brevispica*. Species of *Combretum* are also found in the park (MINITERE 2005).



Buffaloes in Akagera National Park

Natural forests are rich in fauna species. Gishwati forest includes species such as *Pan troglodytes schewinfurthii*, *Colobus angolensis ruwenzorii*, *Potamochoerus porcus*, *Cephalophus nigrifrons*, *Dendrohyrax arboreus*, *Felis serval* and *Felis aurata* (MINAGRI 2002 in Munanura *et. al.* 2006). The Tree squirrel (*Funisciurus pyrhopus*), Rwenzori sun squirrel (*Heliosciurus ruwenzori*), Ground hog (*Thryonomys swinderianus*) and the jackal species (*Canus spp.*) are found in Mukura forest. Makura is also rich in birds with 59 species recorded, among them 7 Albertine Rift endemic species: *Tauraco johnstoni*, *Apalis personata*, *Apalis Ruwenzori*, *Cynnyris regia*, *Zoothera tanganjicae*, *Bradypterus graueri* and *Parus fasciiventer* (Munanura *et. al.* 2006).

Rugezi wetland is habitat to an endangered bird and hosts 60 per cent of the global population of Grauer's swamphen (*Bradypterus graueri*). It is also habitat to 19 bird species, including two species of *Threskiornithidae*, protected by CITES. Apart from *Clarias liocephalus* and *Haplochromis sp.*, the wetland is not rich in fish species. A low number of mammals are also identified: several species of *Muridae*, *Tragelaphus spekei* and *Aonyx capensis*. (MINITERE 2003a). The orchid *Disa stairsii*, a specie protected by CITES is also found in Rugezi wetland (MINITERE 2003b).

Apart from these places of in-situ conservation, there are also some cases of ex-situ conservation mainly for flora. These include herbaria in some institutions (Institute of Scientific and

Technological Research (IRST) and Karisoke Research centre), an arboretum and seed bank as follows:

- Institut des Sciences Agronomiques du Rwanda (ISAR) has an arboretum in Huye District (Ruhande) established in 1933 containing 205 mostly indigenous plus other introduced species. It is considered the best arboretum in Africa.
- ISAR has also a seed centre started in 1978 which projected Rwanda into the Organisation for Economic Corporation and Development (OECD) seed scheme in 1993. There are only two other African countries in this entry which includes Madagascar in 1998. Ghana and Uganda are being considered for entry possibly by Sept 2008. This seed centre also serves as a gene bank collection containing both crop and tree species and also medicinal species. The collections are kept at 4oC.
- There is a national herbarium at IRST which is supposed to include all plants species in Rwanda. Karisoke Research Centre has also a herbarium.

Threats to biodiversity

With the highest population density in Africa, coupled with its dependence on agriculture, the major threats to the biodiversity and genetic resources in Rwanda are mainly linked to population pressure and the problem of land scarcity. Other threats to the biodiversity are linked to human activities such as loss of habitat by conversion of natural habitats, mining, agriculture and the introduction of alien species.

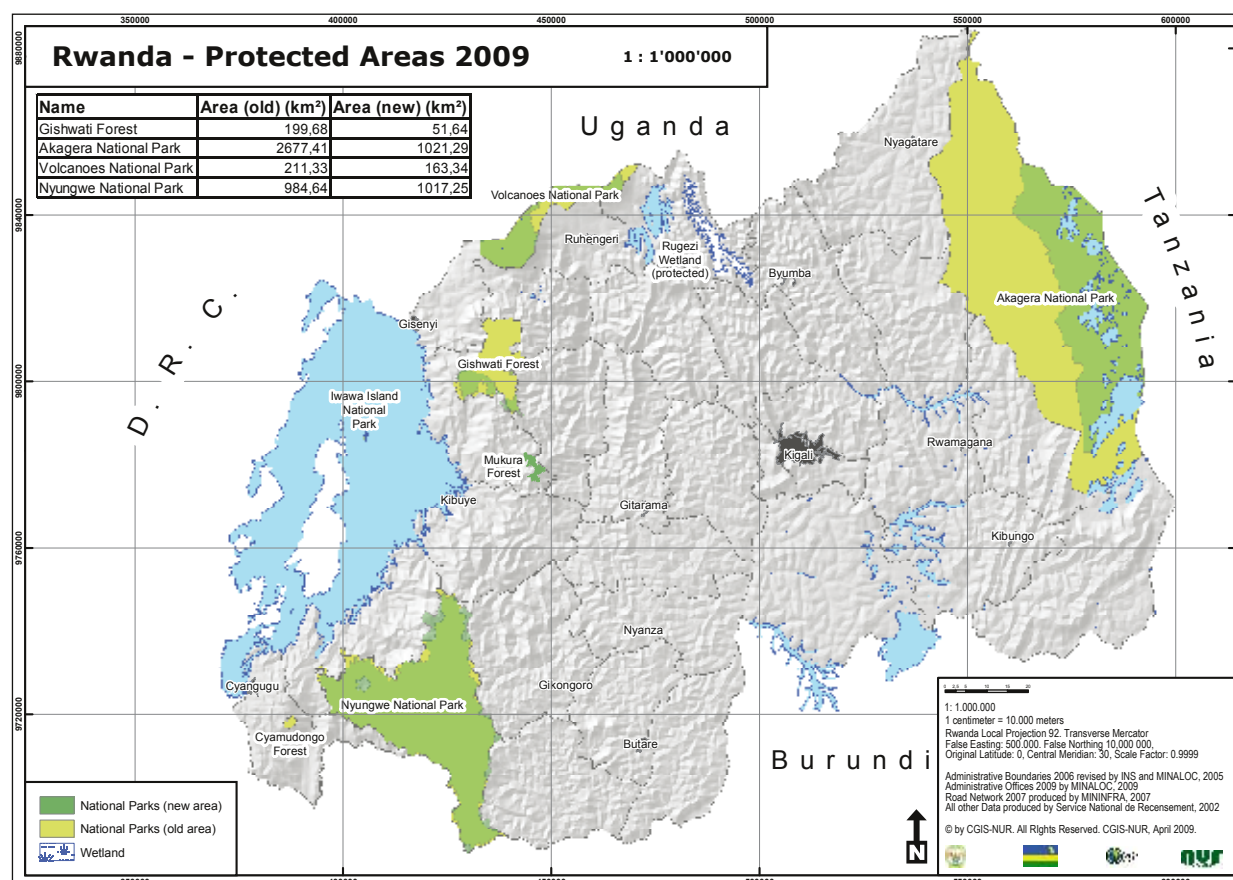
Habitat loss

The high population density has resulted in a sustained conversion of ecosystems and habitat that is threatening biodiversity in Rwanda. For instance, the total surface area of national parks in the country, have been reduced since 1960s in search for land for cultivation and settlements. In some cases these reductions resulted from illegal encroachments or legal authorization by the Government. However, even in cases of the authorized reduction of protected areas, no consideration was given to ecological facts. This is the case for the new boundaries of the Akagera National Park and the settlement in Gishwati Natural Forest. This has led to a number of environmental problems. Table 1 below shows a decline in the number of animals in the Akagera National Park while figure 1 highlights the decline in land under protected area status.

Table 1: Trends in numbers of wildlife in Akagera National Park

Species	1990	1997-1998	% change	2002	% change
Buffalo	10,000	2260	-77	791	-78
Eland	325	103	-68	114	+11
Impala	30,000	5660	-81	1890	-67
Reedbuck	1890	n/a		74	-96
Topi	7500	2020	-73	713	-65
Warthog	1500	380	-75	383	+1
Waterbuck	1600	350	-78	191	-54
Zebra	3800	3050	-20	652	-79

Source: Chemonics International Inc. 2003

Figure 1: Reduction in protected areas in Rwanda

Source: MINITERE - GCIS 2007

Loss of genetic resources

The intensification of agriculture and husbandry affects the natural habitats of species. Threats to the natural genetic resources (which are more resistant to the local conditions) also arise from breeding with improved and high productive varieties. This phenomenon if not addressed will mainly affect the cattle, where natural cattle varieties are running the risk of genetic erosion.

Another risk associated with genetic resources, which is not well documented, is linked to bamboo cutting in Nyungwe and Volcanoes National Parks. This problem is being aggravated by the on-going campaign for the use of bamboo, in the successful handicraft market. Over the last two years, it has increased in the traffic of bamboos from the two parks.

Related to genetic resources, is the problem of illegal detention of wildlife and in some cases traffic of wildlife mainly from the

DRC. The illegal detention of wildlife concerns mainly the 'Royal Crane' kept in private gardens, some tortoises and other birds and reptiles. This phenomenon is a threat to these species as in most cases they cannot reproduce outside their natural habitat. There is urgent need for national legislation on the access to genetic resources, especially for research purpose. In this way Rwanda will be able to protect its natural genetic resources from being trafficked without Government consent.



A royal crane photographed in a private garden in Kigali

Introduction of alien species

The water hyacinth *Eichhornea crassipes* which was introduced as an ornamental plant. It has since invaded lakes in Rwanda from Muhazi to Rweru from the River Nyabarongo, and even reached Lake Victoria through Akagera River. The water hyacinth has invaded several lakes in the Akagera complex. Lake Mihindi has now been completely covered by this plant (MINITERE 2003). The water hyacinth is a major biodiversity problem in the inland water ecosystem of the Lake Victoria Basin. *Lantana camara*, also introduced as an ornamental plant, has become a weed and in some areas a habitat for tsetse flies.

Other documented introductions include fish such as *Astatoreochromis alluandi*, *Schilbe mystus* and *Cyprinus carpio* introduced into Lake Mugesera; these have spread to all the water bodies of the Akagera complex. There is also *Protopterus aethiopicus* introduced in Lake Muhazi in 1989 which is considered by many as invasive (Chemonics International Inc. 2003, MINITERE 2003b).

In the last few years, uncontrolled introduction of plants has been taking place. In some instances they are propagated without undertaking enough studies on their ecology. Such plants include Macadamia, Moringa, Neem, mulberry-trees,

and recently *Jatropha* for bio-fuels. These introductions are made without meeting the phytosanitary and confinement requirements in ISAR field trials. This may lead to the introduction of invasive species or other pathogens in Rwanda.

Opportunities provided by biodiversity

There are a multitude of anthropocentric benefits from biodiversity in the areas of agriculture, science and medicine, industrial materials, ecological services, in leisure, and in cultural, aesthetic and intellectual value. There are many benefits that are obtained from natural ecosystem processes. Some ecosystem services that benefit society are air quality, climate moderation (global, regional and local CO₂ sequestration), water purification, disease control, biological pest control, pollination and prevention of erosion. Along with those come non-material benefits that are accrued from ecosystems: spiritual and aesthetic values, knowledge systems and the value of education that we obtain today.

Economic and livelihood support

Through domestication and direct harvesting from the wild, Rwandans derive food, medicines and a wealth of other products from biodiversity and genetic resources. The range of agro-biodiversity found around the country contributes significantly to livelihoods, food security and poverty alleviation due to their superior adaptation to the local environmental conditions and are likely to contribute more even in the future. For instance the value of ecological goods and services provided by Nyungwe forest is estimated at a minimum US\$ 285 million a year, with the major beneficiaries being ELECTROGAZ, Regideso Burundi, the Public Offices in Charge of Tea and Coffee (OCIR), the Rwanda Tourism Board Offices (ORTPN), tour operators, the rice farmers' cooperative in Bugarama and the global community (Masozera 2008).

With a large number of flowering plants and its richness in orchid species, Rwanda can develop its horticulture sector. In 2009 flowers are projected to earn the country US \$0.57 million in exports and over the three year period (2008-2010) the value of flower exports is projected to increase by an average of 23 per cent per year (MINECOFIN 2007).

There are also emerging opportunities for biodiversity including the carbon credit market. Stored carbon in Nyungwe Forest is valued at an estimated US\$ 162 million

a year, whereas watershed protection services, water supply for irrigation, human consumption and industries, as well as flood protection are worth at an estimated US\$ 117 million annually (Masosera 2008). The monetary value of biodiversity maintenance amounts to US\$ 2 million, and recreation and tourism is good for at minimum US\$ 3.3 million a year.

Tourism opportunities

Nature-based tourism is one of the fastest growing tourism sectors worldwide and in Africa (UNEP 2006). Although a non-traditional export sector for Rwanda, tourism has the potential to contribute significantly to the country's export base. From a negligible base of a less than US\$5 million in 2002, tourism receipts hit US\$33 million in 2006 and are on track to exceed this figure in 2007 (ROR 2007). It is worth noting that Rwandan tourism is mainly based on visits in national park, with the Volcanoes National Park, the most visited park. The rich biodiversity of Rwanda, including bird-watching provide an opportunity for the development of the tourism sector in Rwanda.



An antelope in Akagera National Park

Research and medicinal purposes

Genetic resources can be used as biochemical precursors in the synthesis of pharmaceutical and agricultural products and in cosmetics. Examples of genetic resources of interest includes the *Prunus africana* found in Nyungwe which serves as a basis for prostate cancer, *Aloe vera* which widespread in Rwanda and is used in the pharmaceutical and cosmetic industry, and other medicinal trees and plant species. As shown before, the biodiversity of Rwanda has not been exhaustively studied and there are opportunities for research in new taxa or new species and also for bio-prospecting. For example there are some components of biodiversity used for traditional medicine or other uses that need to be documented.

Strategies to improve Rwanda's biodiversity

Policy, legislation and institutional framework

The relative importance of biodiversity is clearly captured in the EDPRS policy matrix which includes a policy indicator for the rehabilitation of national ecosystems (MINIRENA 2009). This places the biodiversity programme at the highest level of national support with the involvement of varied national institutions. Different institutions are involved in biodiversity and genetic resources management and conservation. These include ministries, parastatals, institutions of higher learning and a number of national and international NGOs. These institutions are however hindered by a lack of local capacity and expertise in biodiversity. However, efforts are being made to reinforce their capacity.

With regard to the legal framework, there is a need to have a law that addresses the status of wildlife outside national parks, which is regulated only by the decree of 26/04/1974, which gives a list of protected animal species. This list has recently been updated by a Ministerial Order (2008). However, it is not clear which institution has the responsibility for the animals outside the protected areas, as ORTPN is responsible for wildlife in national parks only. It is expected that the ongoing preparation of the wildlife act will help in clarifying this aspect.

Improving the biodiversity knowledge base

In order to improve on the conservation of biodiversity, Rwanda has prepared policies, strategies and laws related to the management of environment and biodiversity. The country is also a signatory to many international treaties such as the Convention on Biological Diversity, the Convention on International Trade in Endangered Species and the Ramsar Convention, among others. Localisation of these conventions is necessary if they are to be effectively and efficiently implemented and enforced at the national level.

In the case of biodiversity, decision makers have been grappling with a range of challenges in the face of incomplete or conflicting data. In order to enhance the process evidence-based policy, specific interventions have targeted improving the knowledge base of the national biodiversity stock. The current activities in that area include the Karisoke Research Center (KRC) which maintains databases on gorilla behaviour, demography, group composition and group ranging activities

first begun by Dian Fossey in the late 1960s. The center also supports more focused short-term studies on gorillas, such as a Tourism Impact Study and a variety of other gorilla studies. It supports a number of other studies on the key aspects of biodiversity (fauna and flora) of the Volcanoes National Park and the entire Virunga Volcanoes area, endemic bird and primate species, amphibians, and key habitats.

In addition, REMA is planning to undertake inventories of biodiversity in Rwanda in 2009. This will be with support from the United Nations Educational, Scientific and Cultural Organisation (UNESCO).

Conclusion and recommendations

Rwanda has a rich biodiversity and there is a need to have an effective framework for its conservation, not only to comply with international obligations, but because it is the basis of the Rwandan livelihoods and provides opportunities for economic development. In order to get the best opportunities for the rich biodiversity, it is important to broaden the focus and not only rely on few species and protected areas. For this, Rwanda needs to have an effective legal framework on biodiversity, including a legal framework for access to genetic resources. Rwanda does not have a legal framework for access and sharing of benefits from the use of these genetic resources. This is an open door for possible bio-piracy. There is also need to have sustained capacity building not only in conservation related fields but in new tools such as environmental valuation and modelling.

There is a need to have a cost-efficient legal and institutional framework for biodiversity management. Without a policy and law on biodiversity and wildlife, it is difficult to protect and regulate the use of the rich biodiversity in Rwanda. This legislation will need to include wildlife outside national parks, the regulation of research on biological resources, bio-prospecting, and other elements such as the protection of traditional knowledge. Enforcement of existing laws, especially on species introduction, will need to be improved.

There are also some areas of the country that are habitat to threatened species or rich with biodiversity that need to have a certain status of protection. These include some wetlands considered as Important Birds Areas, some areas with very

rare and threatened plant species such as Mashyuza and Nyarubuye (Fischer 2008). The knowledge base of national biodiversity is limited and there is a need to close that gap. This will require the building of capacity in fields such as taxonomy, ethno-biology and ecology.

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Chapter 6: Forest and Protected Areas

Current Status of Forestry Resources in Rwanda

Rwanda forests and woodlands can be classified into four categories: the natural forests of the Congo Nile Ridge comprised with Nyungwe national park Gishwati, and Mukura; the natural forests of the Volcanoes national park; the natural forests in the savannah and gallery-forest of the Akagera national park and remnants of gallery-forests and savannahs of Bugesera, Gisaka and Umutara; and forest plantations dominated by exotic species (*Eucalyptus sp*, *Pinus sp*, *Grevillea robusta*) and trees scattered on farmlands (agroforestry) and along anti-erosion ditches.

According to a recent mapping inventory, carried out for forests with a surface of 0.5 hectares or higher and with coverage of more than 20 per cent, the forests of the country were estimated at 240,746 ha in 2007. This translates to approximately 10 per cent of the surface of the national dry lands (23,835 km²) (MINITERE and CGIS-NUR 2007). However forest resources in Rwanda include also small woodlots and agro-forestry resources.

Table 1 shows the forest classification in Rwanda, based on the national inventory of forest in Rwanda. This classification shows that humid natural forests constitute the majority of the forest cover in Rwanda (33 per cent), followed by Eucalyptus plantations and degraded natural forests at 26 and 15.7 per cent respectively (MINITERE and CGIS-NUR 2007).



Savannah in the Akagera National Park

Forest cover

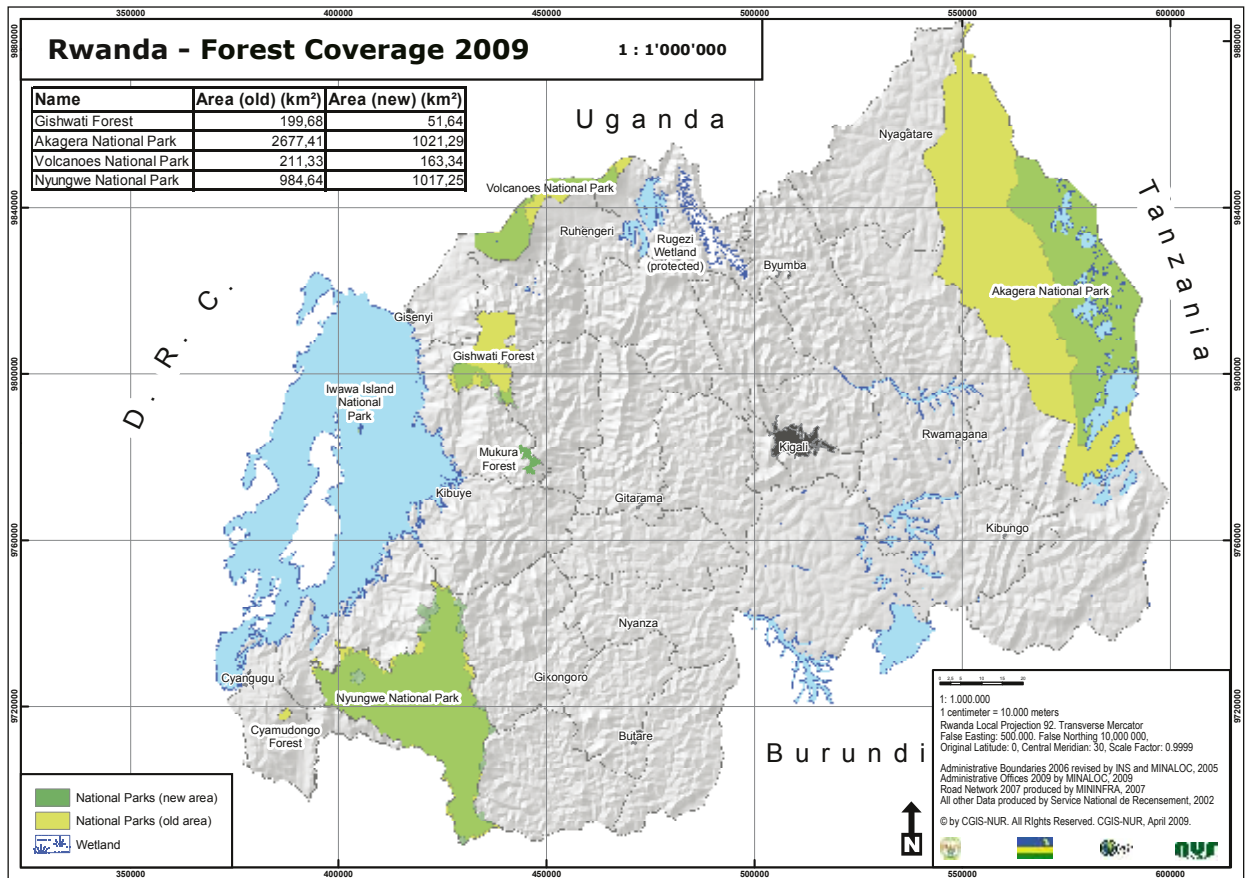
Statistics from the Forest department show that forests were estimated to cover 659,000 ha in 1960 (ROR 2004). This reflects a loss of approximately 64 per cent of forests in between 1960 and 2007, which is more than 1.3 per cent per year. The rapid increase in population is increasing pressure on forests in terms of encroachment and deforestation. Figure 1 shows the change in forest cover between 1988 and 2005.

Table 1: Surface areas of the forest cover in Rwanda in 2007

Category of forests	Areas (Ha)	Afforested areas versus the total forests (%)	Afforested areas versus total areas of the national dry lands (%)
Humid natural forests	79 797.86	33.15	3.35
Degraded natural forests	38 003.51	15.79	1.59
Bamboos	4 381.47	1.82	0.18
Savannahs	3 726.81	1.55	0.16
Plantations of Eucalyptus	63 560.75	26.40	2.67
Young plantations of Eucalyptus and coppices	39 204.82	16.28	1.64
Plantations of Pinus	12 071.31	5.01	0.51
Total	240 746.53	100.00	10.10

Source: (MINITERE and CGIS-NUR 2007)

Figure 1: Forest coverage of Rwanda in 1988 and 2005



Source: MINITERE-CGIS 2007

Protected areas

According to the Convention on Biological Diversity, a protected area is defined as a *portion of land, aquatic or sea environment which is geographically delimited, dedicated especially to the protection and the preservation of biological diversity and its natural and cultural resources; hence this geographically area must be legally indicated, regulated and be managed by effective, legal means or others.* This definition shows that a protected area must be defined by a legal instrument indicating its limits and have to be managed in an effective manner, which means that somebody or an identified entity is responsible for the management of the area.

According to this definition of protected areas, Rwanda has four types of protected areas which includes national parks (Akagera, Nyungwe and Volcanoes National Park); forest reserves (Gishwati, Iwawa Island and Mukura forest reserves); forests of cultural importance (Buhanga forest); and wetlands of global importance (Rugezi-Bulera-Ruhondo wetland complex). Besides those forests with a legal status of

protected areas, there are other forests of cultural importance (Busaga forest in Muhanga District) and other remnant natural forests which are more or less protected by law. In fact the current law on forests prohibits human activities in natural forests. Table 2 provides a summary of the status of major forest protected areas and other natural forests in Rwanda.



Remnant of Gishwati natural forest

Table 2: Summary on the conservation status of major forest protected areas and other natural forest

Name	Managing authority	Area (ha)	Conservation status and threats
National Parks			
Akagera National Park	ORTPN	108,500	<ul style="list-style-type: none"> ▪ the park has a management plan for the period 2006-2010 setting the community-based approach conservation as a priority ▪ threats include poaching, existence of water hyacinth weed in lakes, bush fires during the dry season, illegal grazing and fishing ▪ isolation constitutes a significant threat to species with small population size such as lions, elephants and rhinoceros
Nyungwe National Park	ORTPN	101,900	<ul style="list-style-type: none"> ▪ management plan 2006-2010 ▪ there is a need to have a management plan for harvesting trees planted in buffer zone ▪ threats include poaching, mining, bamboo harvesting, bushfires associated with bee-keeping and the <i>Sericostachys scandens</i>
Volcanoes National Park	ORTPN	16,000	<ul style="list-style-type: none"> ▪ management plan 2005-2009 ▪ promotion of community based conservation and eco-tourism ▪ threats include poaching, agriculture encroachment, wood cutting for firewood and construction, bamboo harvesting, water collection, medicinal plant collection and beehive placement
Forests reserves			
Gishwati Forest	MINIRENA/ NAFA Districts,	700	<ul style="list-style-type: none"> ▪ the clear-cutting the forest has resulted in recurrent landslides and floods ▪ threats include encroachment for farming and grazing land ▪ efforts are being made to restore the forest and the conservation efforts are focused on the restoration through enrichment with local species, demarcation of boundaries of the reserve with stones or a live fence of fast growing species and promotion of community-based conservation, ▪ natural self-rehabilitation and a natural regeneration of primary; and high value species are progressively colonizing the forestland (<i>Carapa grandiflora</i>, <i>Entandrophragma excelsum</i>, <i>Symohonia globulifera</i>) are being observed as a result of protection efforts.
Mukura Forest	MINIRENA/ NAFA Rutsiro Districts	1600	<ul style="list-style-type: none"> ▪ a management plan for for 2007-2011 prepared by a local NGO (ARECO-Rwanda Nziza) ▪ threats include agriculture, fuel wood collection, beekeeping, collection of liana, and cattle grazing in the forest.
Other natural forests			
Busaga forest	MINIRENA/ NAFA Muhanga District	150	<ul style="list-style-type: none"> ▪ some informal management actions taken by district authority includes a creation of a live fence of <i>Eucalyptus spp</i> around the forest between 1988 and 1999 of about 30 ha to prevent the population from encroaching to the forest; and creation of another live fence in 2002 around the forest using a thorny leguminous (<i>Caesalpinia spp</i>) over an area of about 30ha (ARED, 2008). ▪ important wildlife fauna and flora biodiversity is also important (snakes, monkeys, birds, jackals, etc.).
Buhanga forests	MINIRENA/ NAFA Musanze District	100	<ul style="list-style-type: none"> ▪ the conservation of the forest is mainly due to its cultural interests which consider the forest as sacred. ▪ the forest has acquired a status of protected area in 2005 by a Cabinet Decision and there are plans to develop eco-tourism in the forest.
Gallery Forests in Eastern Province	MINIRENA/ NAFA Districts	+/-160	<ul style="list-style-type: none"> ▪ threats include encroachment for agriculture, bushfires, search for medicinal plants, fuel wood collection and conflicts between the population and the wildlife fauna of the forest that is damaging their crops, ▪ informal management actions for conservation are taking place including awareness raising in school, preparation of strategic plan for the management of the forest, sensitization of the local population, and research activities especially in Makera forest (74 ha in Kirehe Districts)

Note: ORTPN – The Office of Tourism and National Parks
 MINIRENA – Ministry of Natural Resources
 NAFA – National Forestry Authority

Opportunities from the forest sector

Forests ecosystems provide goods and services such as wood for fuel and construction, water catchment protection, water purification, tourism, non-timber forest products such as medicinal plants, honey and materials for handicrafts.

The national economy

At present, the contribution of the forestry sector to the national economy remains unknown and existing statistics from past years underestimate the contribution of the forestry sector to the national GDP. However, in 1991 the National Commission on Agriculture reported that despite the importance of forest plantations, their contribution to the GDP as recorded in the national accounting system was only 1.9 per cent in 1987 (CAN 1991). In the same vein, the Food Security Strategy and Action Plan of 1997 (MINAGRI 1998) points out that the total contribution of agriculture to the GDP was in the order of 36.6 per cent of which silviculture represented only 0.6 per cent.

Energy

Wood remains the main source of domestic energy for more than 90 per cent of Rwandans. In 1997, fuel wood consumption was estimated at 7.1 million m³ of wood and approximately 5 per cent of this volume was consumed by the small scale industry. Charcoal is usually used in towns and its annual production was estimated at 46,000 tonnes, 80 per cent of which were sold in Kigali (MINAGRI 1998).



Collecting fuel wood inside Akagera National Park

Agriculture

Forests indirectly support agriculture through the provision of ecological services. The current deficit of wood in the country is affecting agricultural production. The degradation of soil fertility is partly the consequence of fuel wood shortage in rural areas leading farmers to use crop residues as fuel instead of as organic manure. Studies have pointed out that this practice takes 1.7 ha of organic manure per hectare per year. Losses of fertility resulting from such practices at national level are equivalent to 40,000 tonnes of fertilizers and 33,000 of lime (CAN 1991).

Wood supply

Wood products are used for construction and furniture, among others. There are a number of exotic species available on the local market. The most used include *Eucalyptus* (45 per cent), *Grevillea* and *Cypress*. Imported wood species include *Libuyu*, *Muvula* and *Markhamia*. They are commonly used for furniture and originate mainly from the eastern part of the Democratic Republic of Congo.

The Government is conscious that forests for timber need to be sustainably utilised. There are thus restrictions on access to both natural and plantation forests. Even though exploitation of natural forests is forbidden, clandestine activities take place in the form of skimming off of tree species of high commercial value. Species endangered by this form of exploitation are among others, *Podocarpus usambarensis*, *Entandrophragma excelsum* and *Carapa grandiflora*. In 2003, utilization of poles in construction works was totally prohibited in towns to limit exploitation of wood in young forest plantations.

Non-timber forest products

Non-wood forest products are products of biological origin other than wood derived from forests, other wooded lands and trees outside forests. In Rwanda, they are commonly found in the following categories: plants used in traditional human and veterinary medicine, fodder, honey and melliferous plants, fruits, tree seeds, essential oils, handicraft material, mushrooms, ornamental plants, game and fish and ecotourism. The literature shows a list of 59 woody plants used in traditional human medicine and a list of 39 woody plants used in traditional veterinary medicine as well as related diseases in both cases (Mbarubukeye and Niang 1996 in Murekezi 1999).

Beekeeping is another non-timber forest product with potential for growth especially in light of Rwanda's climate and quality

biotopes (natural forests, forest plantations). However there is still scope for development. Research indicates that about 27 melliferous plants have been identified in Nyungwe natural forest (Murekezi 1999). Local beekeepers are thought to be the main cause of the bush fires that rage during the dry season.

Tourism

The tourism sector, which is based on visits to protected areas, has been experiencing good performance since 2002. The Volcanoes National Park is the flagship of Rwandan tourism. This is due to the gorillas which are a major tourism draw, attracting more than 16,000 tourists in 2007. At about US \$ 500 each to join organized treks, this makes gorilla tourism one of Rwanda's largest foreign exchange earners. In 2007, earnings from tourism were estimated at US \$42 million (ORTPN *pers. Comm.* 2008).

Clean Development Mechanism projects

There are opportunities for the forest sector to access funds under the Clean Development Mechanism (CDM) of the Kyoto protocol for carbon trading. However, there is a need to develop the national capacity and to have a clear strategy to harness these opportunities.

Threats to harnessing the opportunities provided by forests

Though the forest sector offers many opportunities for national economic growth, it has some challenges which need to be overcome to allow Rwanda to tap into these opportunities. The main threats to forests are mainly governance issues, inadequate legal framework and population pressures that result in encroachment and deforestation for settlement, agriculture and grazing land. These activities are likely to impact on forest ecosystem services such as timber provision, fuel wood, regulation of water flow, climate moderation, soil erosion control and fertility.

Governance and the legal framework

Governance of the forest sector has gone through deep crisis with regards to consequences of the war and the genocide. For instance the death and exile of forest professionals and end of all development projects due to the withdrawal of

donors had great impact on the sector. Currently there is a general shortage of human resources in terms of competence and number. This situation is more acute than that during the post-independence period. It is expected that the newly created National Forest Authority will strengthen the forest sector.

Supervision of forests is an area that also needs attention. This is especially for the smaller natural forests which are left to the responsibility of already understaffed local authorities, making them vulnerable to encroachment and degradation. It is thus essential that forest management plans or conservation strategies be developed.

There is need for the legal framework to be updated. The forestry law of 1988 is obsolete as it has been overtaken many of the in-country reforms including administrative reform, decentralisation, and the new administrative appellation. There is also need for better overall enforcement of the law.

Encroachment and human activities

Forest encroachment through various human activities are a threat to Rwandan forests. These activities include illegal logging, charcoal production, and bushfires. A national forest inventory in 2007 identified illegal tree cutting (78.3 per cent), charcoal making (4.9 per cent), livestock grazing (2.5 per cent), farming activities (1.9 per cent), bushfires (1.9 per cent), stem debarking (0.6 per cent), mining (0.5 per cent) and beekeeping (0.4 per cent) as the main threats (MINITERE-ISAR 2007).

Forest encroachment is not a new phenomenon. Most occurred in the years that followed independence in 1962, and during the war and the post-war period (1990-1994 and 1995-1996). Some of these are highlighted below:

- In Nyungwe, aerial photographs showed that the forest has experienced an annual average decrease of 750 ha (1 per cent) due to encroachment for agricultural activities between 1958 and 1972 (Muderevu 1974 in Combe 1977). Figure 2 highlights this forest loss. Major deforestation also took place inside the forest through illegal tree felling as well as skimming of precious tree species which led to impoverishment of the forest almost beyond recovery, following cutting of seed trees required for natural regeneration of those species.
- The Volcanoes National Park has been constantly under threat due to pressure from the farming population due to the fertile volcanic soils in its immediate vicinity. The

population density here is the highest of the country. It has also been subject to repeated degazetting by the administration without any legal supporting document. In 1958, 700 ha were cleared to settle the population and between 1969 and 1973, 1,050 ha were converted into agricultural lands to grow pyrethrum (ORTPN 2004).

- In 1997, the Government of Rwanda decided to reduce the Akagera National Park to an area of 108,500 ha or approximately a third of its original area to settle returnees in the aftermath of the war and genocide (ORTPN 2005).
- The Gishwati forest which covered an area of 28,000 ha in 1960 has experienced encroachment for agriculture and pasture lands from the 1980s and for settlement of returnees after 1994. The forests cover currently 700 hectares.
- Mukura forest reserve with an area of about 2,100 ha in 1990, the area of the Mukura forest reserve was progressively reduced to 1,600 ha in 2006 (Munanura et. al. 2006) due to encroachment for agriculture influenced by the installation of a refugee camp in its immediate vicinity.
- It is estimated that during the war, approximately 15,000 ha of forest plantations were completely destroyed and 35,000 ha damaged (MINAGRI, 1998).

Figure 2: This Landsat image of Nyungwe national park, taken on July 19, 1986, shows that the land around the park has been cleared for farmland. The surrounding land is light green in contrast with the park's lush green forest canopy. The park's boundaries are outlined in red. Lake Kivu is above the park.

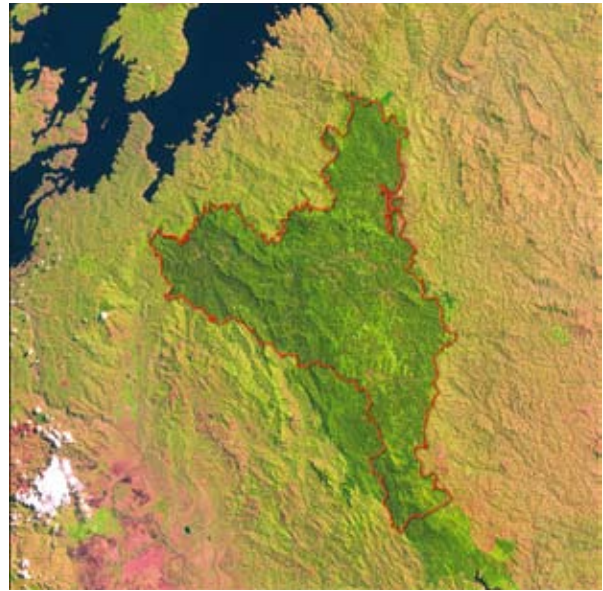


Image courtesy the University of Maryland Global Land Cover Facility and the Wildlife Conservation Society

Source: NASA

<http://earthobservatory.nasa.gov/IOTD/view.php?id=4314>



In early 1990s, this part of Akagera National Park was rich grazing for ungulates such as buffalo. Now it is being used for human settlement.

Charcoal making

One of the most obvious benefits of forests and woodlands is the provision of energy for heating and cooking in the form of charcoal. Charcoal making uses traditional kilns, which are common because of the low capital required. But they are not efficient and result in severe degradation of forest resources.

The demand for charcoal in urban areas is contributing to the pressures on forests. Charcoal making to supply Kigali has resulted in the disappearance of the shrubby savannahs and gallery-forests in Bugesera. Over 50,000 ha of woody savannahs were registered in 1983, dropping to less than 10,000 ha by 1988 (MINAGRI 1988). A field visit conducted by REMA and the Office for Tourism and National Parks (ORTPN) to assess the status of the buffer zone of Nyungwe National Park showed cases of charcoal making in the buffer zone combined with clear tree cutting of the forests.



Deforestation for charcoal production. The bare ground leave the soil open to erosion by wind and water.

Other threats to forests

- In Nyungwe, between 1996 and 2003, **forest fires** destroyed the equivalent of 12,800ha, or approximately 13 per cent of the total area of the forest (ORTPN 2005). Bushfires are also frequently reported in Akagera National Park in dry seasons.
- **Mining activities** have been recorded in Nyungwe National Park and Gishwati reserve forest and lead to forest destruction.
- **Poaching** in Nyungwe resulted in extermination of some big mammals - the buffalo and the elephant. According to the literature, the disappearance of large ungulates appears to have upset Nyungwe's ecological balance. Nyungwe's elephant population preferred a certain vine

(*Sericostachys scandens*). Now without the elephants, the vines have grown to the extent that they are actually threatening to strangle standing trees. The absence of large ungulates also appears to have hampered forest regeneration in burned areas. Because there are no grazing animals to stem the proliferation of ferns and grass that appear after a fire, they remain to hamper seed dispersal and germination (Chemonics International 2003).

- The introduction of **exotic species** (eucalyptus and pines) planted in buffer zones or near natural forests are threatening these natural forests
- In Nyungwe and Volcanoes National park, the **illegal harvesting** of bamboos for handicraft and construction is becoming a threat to these forests.

Strategies to harness opportunities from the forest sector

Institutional strengthening

Analysis of the forestry sector shows some weaknesses vis-à-vis institutional capacity. There is need for institutional development at the central administration level - the ministry and the National Forest Authority (NAFA) and at the local level - district and sector. Provision of adequate resources and qualified staff to NAFA, districts and sectors is of paramount importance to ensure sustainable management of forest resources.

In line with this, it will be necessary to improve coordination mechanisms for different actors in the forestry sector. These will include the ministries, authorities, research institutions and non-governmental organizations. Information flow will also have to be improved. Forestry extension at national level, research and documentation of best practice are among some of the strategies that can be used.

The development of human capacity in forestry is an area that has been identified for attention. It involves the education of foresters at technical and professional levels to address the needs of the public and private sectors. In this regard, the National University of Rwanda has started a master's degree in agro-forestry. There are also other capacity building programmes being implemented through regional and international cooperation.

Promotion of agroforestry

There are efforts to promote the use of improved technologies in agroforestry. In the context of land scarcity, efforts are being made to develop high performing species that integrate better with crops. Agroforestry techniques are among the solutions that can quickly restore the national landscape which, at present shows the tendency for desertification. It may also be necessary to carry out an inventory of available wood resources in the agroforestry system in order to better plan activities of this specific sub sector.

Conversion of old forest plantations

The Rwandese forest landscape is dominated by Eucalyptus plantations which in the long run have greatly contributed to the reduction of fuel wood and service wood deficit. The great majority of plantations of this species were created before independence and are presently in poor condition due to soil degradation and poor management. There is need to convert these plantations and replace them with selected species matching respective ecological zones and types of soils. Some species for consideration include: *Acacia mearnsii*, *Acacia melanoxylon* and some species of Eucalyptus like *Eucalyptus saligna*, *E. maideni*, *E. microcorys* and *E. grandis*.

Protect and conserve small natural forests

In order to save the remnant of this heritage, the ministry in charge of forestry with its partners in environment (REMA, ORTPN, districts and donors) should intervene to carry out an inventory to locate all those forests and develop a management plan to identifying priority actions to be implemented for their conservation.

Conclusion

Though often underestimated forest resources play an important role in the national economic growth and need to be given necessary attention. The lack of understanding of the impact of population growth on the forests resources has led to severe deforestation accompanied with a host of environmental problems in different parts of the country.

Efforts to restore the degraded forests are on-going and results are encouraging. In this regard, out of the 30 districts, 15 have already prepared their District Forest Management Plans with funds from the African Development Bank, the Embassy of the Netherlands, Switzerland and FAO. Other districts are in

various states of completion. The Government of Rwanda has set a target of increasing the national forest cover from the present 10 per cent to 30 per cent of the national territory by the year 2020. In order to reach this target, there is a need to combine efforts to increase the number of existing protected forests and to add to the number of tree plantations.

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Chapter 7: Water Resources and Wetlands

Introduction

Generally water resources have a direct influence on the quality of life of the people, their health and their overall productivity. Thus, water is essential, not only to human life but for animals, agriculture, industrial development, hydropower generation, transport, socio-economic development and poverty eradication.

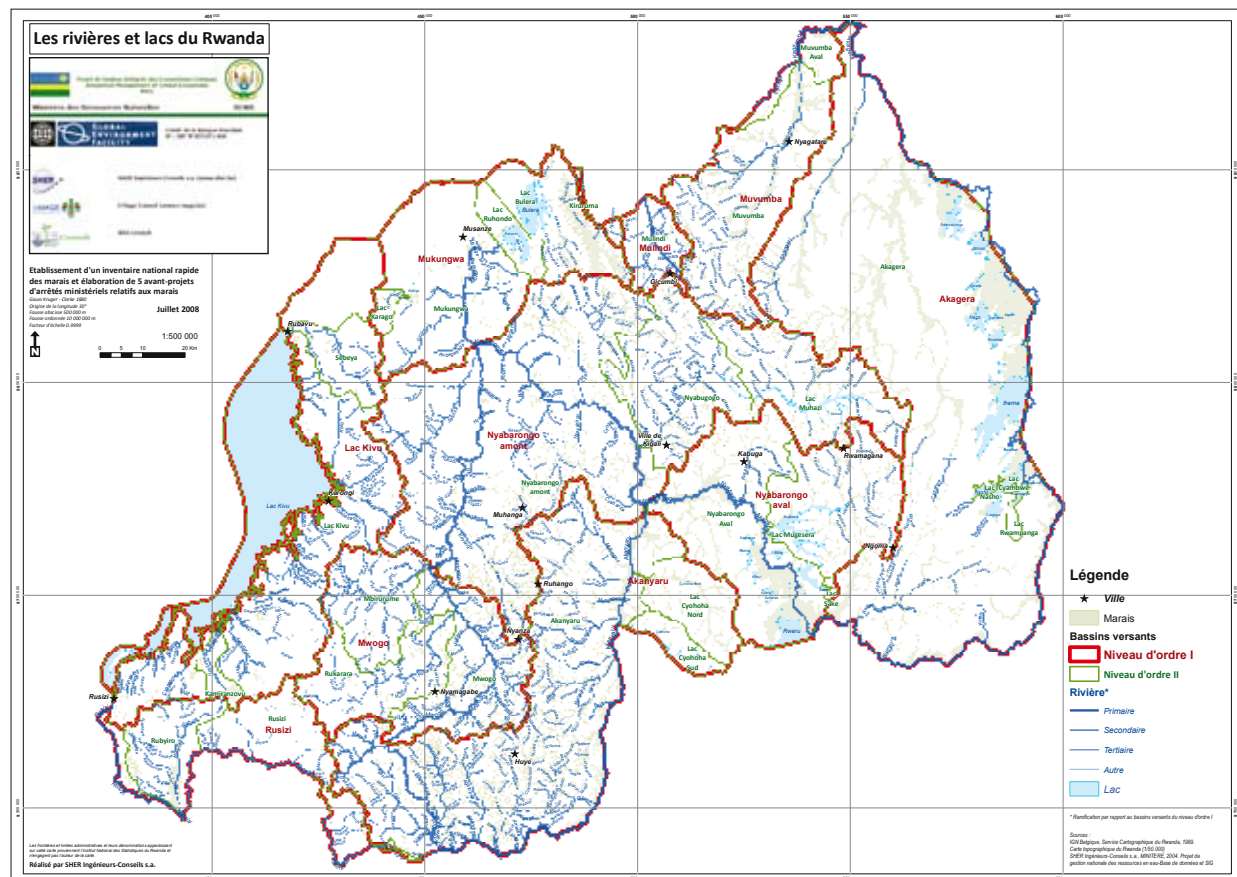
In Rwanda the abundance of water resources is reflected by the existence of a network of wetlands in various parts of the country. Wetlands and aquatic lands are generally represented by lakes, rivers and marshes associated with these lakes and rivers (MINITERE 2005). The water resources are mainly influenced by rainfall and evaporation and hence climate information and preparedness are essential in the management of water resources (NBI 2005).

Status of water and wetland resources

Rwanda is divided into two major drainage basins: the Nile to the east covering 67 per cent and delivering 90 per cent of the national waters and the Congo to the west which covers 33 per cent and handles all national waters (Chemonics International Inc. 2003, MINITERE 2005, NBI 2005). This is shown in Figure 1.

The country's hydrological network includes numerous lakes and rivers and its associated wetlands. A recent inventory of marshlands in Rwanda conducted in 2008 identified shows 860 marshlands, covering a total surface of 278 536 ha, which corresponds to 10.6 per cent of the country surface, 101 lakes covering 149487 ha, and 861 rivers totalling 6462 km in length (REMA 2008).

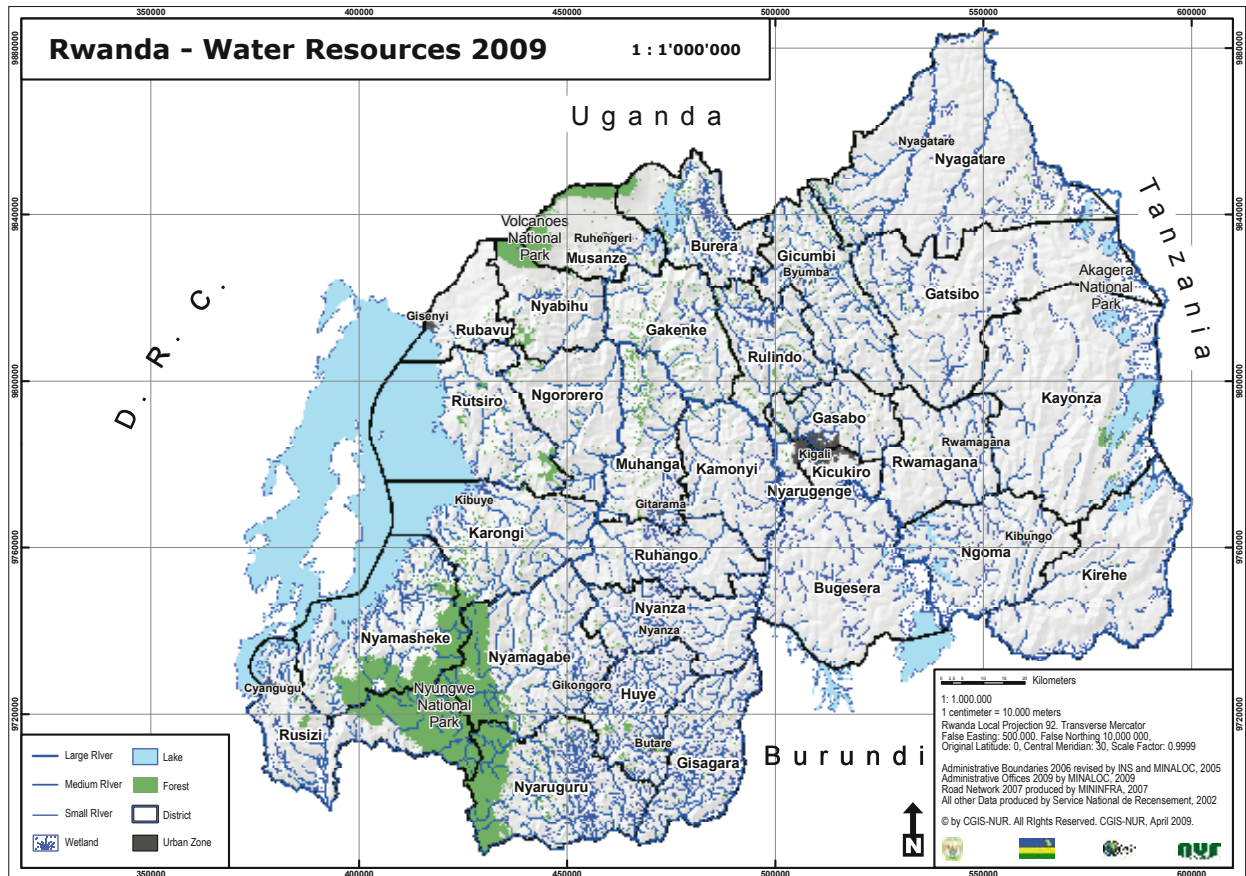
Figure 1: Water resources in Rwanda by drainage basin



The major lakes include Kivu, Bulera, Ruhondo, Muhazi, Cyohoha, Sake, Kilimbi, Mirayi, Rumira, Kidogo, Mugesera, Nasho, Mpanga, Ihema, Mihindi, Rwampanga and Bisoke. The major rivers include the Akagera, Akanyaru, Base, Kagitumba, Mukungwa, Muvumba, Nyabarongo, and

Ruvubu in the Nile Basin and Koko, Rubyi, Ruhwa, Rusizi, Sebeya in the Congo Basin (Chemonics International Inc. 2003, Kabalisa 2006, NBI 2005). Table 1 gives more information on the major lakes and figure 2 shows the water resources network of Rwanda.

Figure 2: Rwanda's water resources network in 2009



Map production: REMA



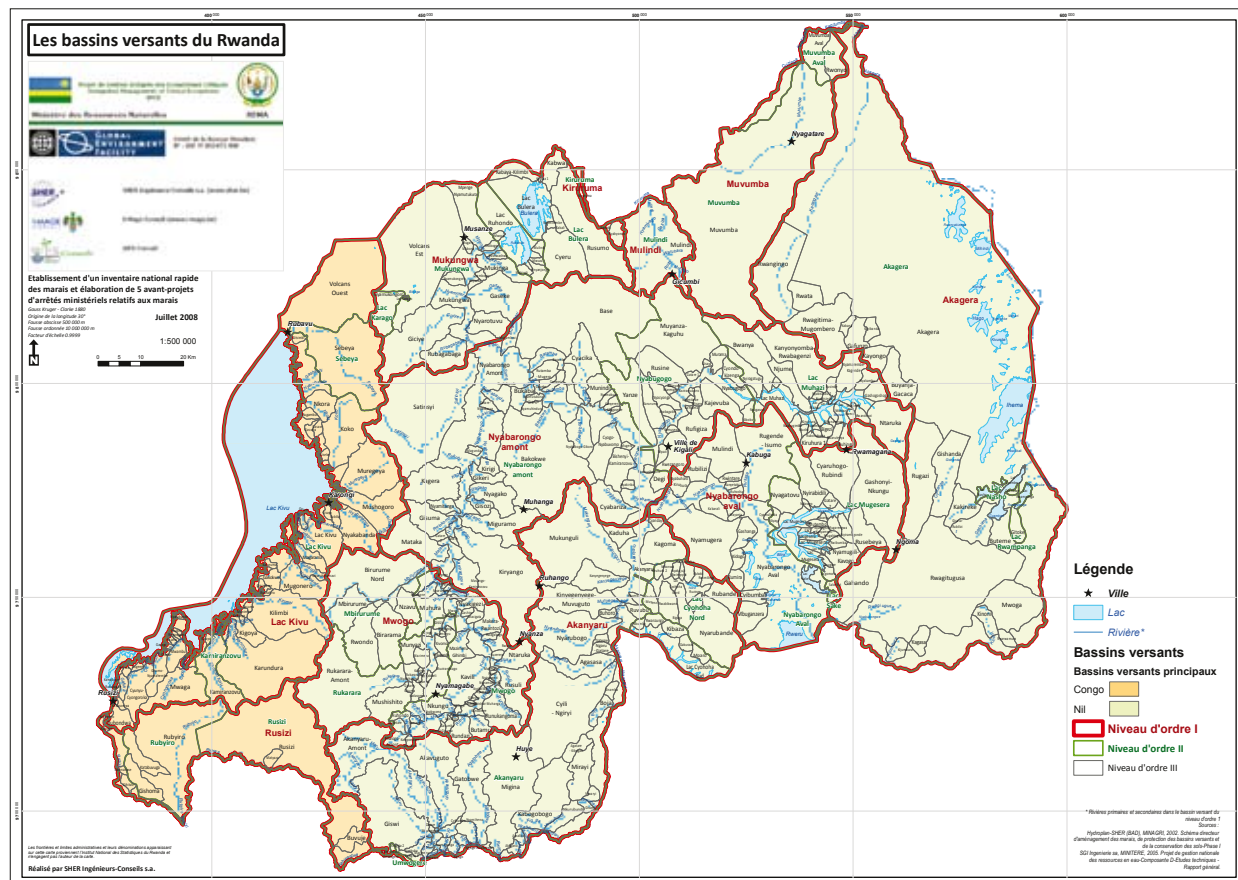
Constructions at the shores of Lake Kivu in the Western Province

Table 1: Major Lakes in Rwanda

Group	Lakes	Area (ha)	Characteristics
	Kivu	102,000	<ul style="list-style-type: none"> Depth: 478 – 480 m Low oxygen content
Lakes on the north	Bulera, Ruhondo and smaller ones like Karago	5500 (Bulera), 2800 (Ruhondo)	<ul style="list-style-type: none"> High altitude lakes Relatively acidic Deep lakes Low biodiversity and phytoplankton
Lakes of the centre	Muhazi	3,400	Av. Depth: 3 – 5m
Lakes of Bugesera	Rweru, Cyohoha south, Cyohoha north, Kidogo, Gashanga, Rumira, Kilimbi, Gaharwa	+/- 12,000	<ul style="list-style-type: none"> Av. Depth: 3-5m High PH High turbidity High P and organic content.
Lakes of Gisaka	Mugesera, Birira and Sake	8,000	
Lakes of Nasho Basin	Mpanga, Cyambwe and Nasho	4,300	
Lakes of Akagera National Park	Ihema, Kivumba, Hago, Mihindi, Rwanyakizinga	+/- 14600	

Source: Adapted from Kabalisa 2006, MINITERE 2005, NBI 2005

Figure 3: Ground water potential in Rwanda



Map production: REMA

Ground water

Data on ground water and aquifers in Rwanda is incomplete. However information available estimates that the discharge for the available resource is 66m³/second and there are about 22,000 recognized sources which have a discharge of 9.0 m³/second (NBI 2005, Kabalisa 2006). Figure 3 shows the ground water potential in the country.

Surface water stock estimates

Table 2 shows the catchments of some of the major rivers and their tributaries. The catchment surface areas give an approximate indication for management options for integrated water resources management at the catchment or sub-catchment level.

Table 2: Watersheds with their corresponding rainfall figures

Name of catchment	Surface area (Km ²)	Average rainfall (mm)
Rusizi	650	1,300
Lake Kivu	2,900	1,200
Sebeya	300	1,400
Nyabarongo upstream	2,700	1,500
Nyabarongo downstream	4,450	1,200
Mukungwa	1,500	1,300
Akanyaru upstream	2,650	1,200
Akagera upstream	5,000	900
Akagera downstream	4,550	800
Muvumba	1,450	1,000
Mulindi	200	1,100

Source: MINITERE 2005

The natural renewable water resources, according to AQUASAT 2005, for the year 2000 were estimated to be 6.3 km³/yr, compared to 5 km³/yr for 1993, a marked increase in the resource. Per capita annual renewable water resources also increased from 638.2 m³/person/yr in 1993 to 815 m³/person/yr in 2000). Total renewable sources are a summation of several sources. Therefore in light of population increase and subsequent increase in withdrawals over the years, other factors such as the long rainy season and increased inflow from outside the country could explain these increases.

However the reduction of total annual withdrawals from 0.768 km³/yr in 1993 to 0.15 km³/yr in 2000 even with the increase in the total renewable resources indicates a reduced capacity to utilise the available water resources. Simply

put, the amount of available water increased in 2000 but less was used, even though the population had increased, as compared to 1993 where the amount available was less. As a result of this reduction in water withdrawals and population increase from 1993 to 2000 the per capita annual withdrawals falls from 141 to 17.4 m³/person/yr in that period (AQUASAT, 2005).

A closer look at percentage withdrawals according to the main three contributing sectors - agriculture, industry and domestic - shows a shift in the relative water use trends between the sectors. The agricultural sector used more water in both years with 94 per cent in 1993 as compared to 68 per cent in 2000. This reduction does not reflect the difference in the actual water consumed (that is 0.722 km³ in 1993 and 0.102 km³ in 2000). The other two sectors show an increase in percentage water consumption in both years but the actual consumption for domestic sector increases while that of the industrial sector slightly lower at 5 per cent (0.031 km³) in 1993 and 24 per cent (0.036 km³) for the domestic sector; and 2 per cent (0.015 km³) in 1993 and 8 per cent (0.012 km³) for the industrial sector (AQUASAT 2005).

The FAO information systems on water and irrigation in April 2005, estimated that the total annual renewable resources were 5.2 km³/yr; and the preparation of the National Management of the Water Resources Project (PGNRE), estimated that industrial water consumption was 0.013 km³/yr (PGNRE 2005). Table 3 shows the use of water resources and water for the years 1993 and 2000.

Water availability and use

The pressures on water resources primarily result from utilizing the natural resources to meet basic needs as well as social-economic development. The effects of water resources use is demonstrated in the changes in the quantity and quality of water. All aspects of human activities in Rwanda have produced varying impacts and degrees of modification to the available water resources and these impacts are manifest at the catchment and sub-catchment levels as the following examples illustrate.

Domestic water use

The figures from ELECTROGAZ show that the water demand in Kigali city is 55,080 m³ per day, whereas nominal production is 30,525 m³ per day. This illustrates a deficit in the drinking water requirements for Kigali. It is estimated that water demand over the next decade will double in Kigali

Table 3: Water resources and water use for the years 1993 and 2000

Freshwater withdrawal	1993	2000
Total annual renewable water resources(Km ² /yr)	5	6.3
Per capita annual renewable water resources (m ³ /person/yr)	638.2	815
Total annual withdrawals (Km ² /yr)	0.768	0.15
Per capita annual withdrawals (m ³ /person/yr)	141	17.4
Sectoral withdrawal as per cent of total annual withdrawal		
Agricultural	94	68
Domestic	5	24
Industry	2	8

Source: AQUASAT 2005

and rural areas and more than double for the semi-urban settlements. Table 4 shows the estimated consumption of water in 2005 and the project water demand for 2020.

Table 4: Potable water needs

Types of settlements	Estimated consumption (l/home/day)	Projected needs for 2020 (l/home/day)
Kigali	48	90
Semi-urban	35	90
Rural	10	20

Source: MINITERE 2005



Rainwater harvesting in Rubavu District. Such technologies help increase access to potable water

Industrial water use

The study on the Knowledge and Management of Water data done under the preparation of the National Management of the Water Resources Project (PGNRE) indicates that industrial water requirements will be between 300,000 and 900,000 m³/yr by 2020 in urban areas. The study also

projects that coffee washing stations will consume 130.000 m³/yr by the year 2010 in the rural areas (PGNRE 2005). Table 5 shows the number of industries that contribute to water withdrawals.

Table 5: Types of industries that contribute to water withdrawal

Industry types	Number
Agro-processing	40
Chemical industries	29
Printeries and paper industries	14
Metal works	10
Mining	7
Non metals & fabrication	6
leather and tanning	3
Textile	2
Electricity, gas and water supply	1

Source: MINITERE 2005

Agriculture water use

Rwanda's agriculture is rain-fed and is therefore exposed to vagaries of climate fluctuation. Many areas which use poor farming methods without integrating soil and water resources conservation tend to have weak agricultural productivity. In such instances, soil moisture becomes the limiting factor for crop growth (Kabalisa 2006).

In 2000, the total national water withdrawal for agriculture was estimated at 150 million m³/year and the share of agriculture estimated at 68 per cent. Rice growing (on 8,500 ha) constituted the crop that used most irrigation at about 25,500,000 m³ (Kabalisa 2006).

The Government is making efforts to promote irrigation including hillside irrigation, especially in the drylands of the eastern province, to increase food security. This is in light of research that projects the agricultural water requirements for

Table 4: Projected water demand by different sectors

Sector	2005 Water demand m ³ per year	2020 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

Source: MINITERE 2005

2020. It shows that the eastern region will require more water than at present, while the Congo-Nile ridge region which will have enough rainfall will only require the development of rain harvesting systems to allow the utilisation of water in drier seasons (Kabalisa 2006). Figure 4 shows the agricultural water requirements in 2020.

Status of wetlands in Rwanda

The marshlands are the most physically and chemically heterogeneous of all aquatic ecosystems in Rwanda. They are in effect seasonal wetlands. The water table is near or above the lowest ground surface during the wet season and they do not have large flood plains (generally less than 200m wide) or great length (Chemonics International Inc. 2003).

The most recent inventory of wetlands was conducted in 2008 by REMA through the Integrated Management of Critical Ecosystems (IMCE) project funded by GEF and World Bank. This inventory showed that Rwanda has 860 marshlands

and 101 lakes covering a total surface of 278,536 ha (10.6 per cent of the country surface area), and 149,487 ha, respectively (REMA 2008). This inventory also found 861 rivers totalling 6,462 km in length. 41 per cent of the inventoried marshlands are covered by natural vegetation, 53 per cent are under cropping, (which represents about 148 344 ha) and about 6 per cent are fallow fields.

The biggest marshlands are associated with and clustered around the rivers. Rugezi and Kamiranzovu are high altitude wetlands, most of the others are low altitude.

Wetland types

Seven types of swamps are found in Rwanda. They are classified on the basis of: relief, altitude, soil type, vegetation, hydrology and size of the swamp, slope of the watershed and population density. Table 6 highlights some of the main types of wetlands and their features.



Construction in a wetland at the banks of Nyabugogo River in Kigali

Table 6: Types of swamps in Rwanda, functions, vegetation and corresponding agro-climatic zones

No	Type	Altitude	Type of Soil	Type of Vegetaion	Function	Some examples	Agroclimatic Zones	Observations
1	High altitude swamps	> 1800	Peaty (developed peat)	<i>Miscanthus violaceus</i> , <i>Cyperus latifolius</i> , <i>Lobelia</i> , <i>Ericaceae</i> , <i>Sphagnum</i>	Water reserve, Water source swamp, biodiversity reserve	Kamiranzovu, Rugezi	Crete Z/N(5) Buberuka HL (6) Volcanic land (4)	Source, biodiversity and water reserve Swamp
2	Volcanic highland Swamps	1550-1800						Swamps closed by basaltic flows
2.1	Buberuka volcanic highlands	>1800	Peaty	Reclaimed - under crop	Unique Ecosystem in Rwanda	Mutobo	Buberuka HL (6)	
2.2	Cyangugu Volcanic Highlands	1550-1800	Peaty	<i>Cyperus papyrus</i> , <i>Syzygium</i>	Water reserve, water source mash, filter Swamp	Gishoma, Mushaka	Impala (2)	
3	Central plateau Swamps	1400-1800	Mineralized soil (Clay sandy, limono sandy)	<i>Cyperus latifolius</i> ,	Water reserve, Agricultural production	Mwogo Runukangoma Ruziramigozi Rwasave, Base Nyabugogo	Central Plateau I (7)	This group consists of a number of important Swamps often drained by agriculture and livestock
4	Swamps of Kanyaru-Nyabarongo and Akagera Basins	1500-1200	Organic with less developed peat	<i>Cyperus papyrus</i> , <i>Phoenix reclinata</i> , <i>Syzygium cordatum</i>	Water reserve, water source Swamp Swamp Dam	Ngenda, Rwabosoro, Sake, Mugesera	Mayaga-Bugesera (8)	All the Swamps around lakes in Bugesera and in the Akagera National Parc, peaty
5	Swamps in the East	1500-1200	Vertisol	<i>Typha domingensis</i> <i>Polygonum pulchrum</i>	Water reserve	Rwagitima, Kanyonyomba Ntende	Eastern Plateau (9) Eastern savannah (10)	This type of Swamp appears in Umutara and part of Byumba
6	Swamps of Bugarama depression.	<1000	Mineralized and vertisol Swamps	<i>Typha</i> , <i>Pragmites mauritianum</i>	Agriculture production	Bugarama, Muganza	Imbo (1)	This type is unique in Rwanda and is conducive to rice cultivation
7	Swamps on the edge of Lake Kivu	1400-1500	Mineralized Swamps	<i>Cyperus papyrus</i> <i>Cyperus latifolius</i> <i>Typha</i>	Biodiversity	Mugonero, Koko	Impala	

Source: Adapted from REMA 2008

Vulnerability of swamps

Given the importance of wetland ecosystems in terms of ecosystem and provisioning services a vulnerability criterion has been developed to assist with management. These criteria are described below and summarised in table 7.

Biodiversity criterion (B): Swamps are special ecosystems containing specific flora and fauna. The destruction of such ecosystems results in the reduction or loss of biodiversity. Some elements of the fauna of the swamps are recognized by law as endemic and classified by CITES in order to ensure their protection. These elements of wildlife enjoy full protection and it is forbidden to hunt them without scientific or administrative license for hunting issued by authorized services. Currently, such animals are found in swamps and lakes of the Bugesera depression. It is also worth mentioning that these ecosystems are periodically home to migratory birds and can be considered as ecosystems of international importance under Ramsar Convention.

Criterion of the presence of peat (P): This criterion is very important for high-altitude swamps and those of Bugesera depression. These swamps are vulnerable, because they consist of layers of organic material constantly waterlogged and therefore unstable. The development of these types of swamp usually causes landslides and the gravity will depend on the slope and the subsidence accompanied with drainage, with regular risks of self combustion. High altitude peat swamps are generally water reservoirs for areas located downstream. The draining of peat lands may cause such significant negative impacts downstream (the case of Rugezi in 2004).

Hydrological criterion (H): This criterion is very important because it concerns the water conditions that determine the health of the swamp ecosystem. Thus, some swamps, especially those of high altitude, are sources of major rivers (like Kamiranzovu swamp in the Nyungwe national park and the Rugezi swamp in Bulera District). The drainage of these swamps may lead to drought in downstream or other forms of imbalance in the environment like increased erosion or disruption of the climate.

Swamps dams are also affected by this criterion. Swamp dams are the portion of swamp serving as a stopper, located between a lake and a river downstream. It prevents the water upstream from flowing downstream, leading to the creation of a lake or water reservoir. These types of swamps play the role

of stopper between the upstream lakes and rivers downstream. Their exploitation may lead to the disappearance of such lakes for instance Lake Cyohoha North.

Swamps that serve as water catchments for the water supply of towns and cities are also vulnerable because their drainage can cause disruptions in water supply, with important socio-economic impacts like water-related diseases or the interruption of production in industry that relies on the use of water as part of their processes.

Central plateau swamps are the exception. They are generally large and receive water from high altitudes and watershed runoff. Such types of swamps have no water problem and can be exploited for production through appropriate land management.

Close to a park or a natural reserve (P): Swamps along the boundaries of the Akagera National Park are home to wild animals, especially hippos, buffaloes, giraffes, impalas and sitatunga. They also serve as areas for watering animals in the park. In light of that these swamps are regarded as critical ecosystems. These swamps are also considered as buffer zones between the park and the neighbouring populations.

Cross-border Criterion (Cr): Cross-border swamps are considered as those which straddle several sectors, districts or countries. They deserve special attention from all parties concerned. Indeed, most efforts to understand and safeguard natural resources and cross-border ecosystems are often circumscribed within the limits of administrative entities (sectors, districts and countries). However, if there are no joint management efforts, the effects of mismanagement of a part affect the whole swamp. This joint management is more difficult in the case of swamp belonging to several countries. For this reason, these swamps should have a special status.



Mpenge River in Musanze District - Northern Province

Table 7: Swamps according to the vulnerability criteria

Criteria	Sub criterion level 1	Sub criterion level 2	Decision	Examples	Observation - Justification
Hydrology	Water source swamp		Protected	Kamiranzovu, Gishoma, Rugezi	Water supply in downstream
	Swamp dam	Lake > 100ha	Protected (Need to confirm by studies per swamp)	Some sections in Rweru-Mugesera, Akagera-Nyabarongo complexes	Maintain water in the lake upstream.
	Water supply in towns and cities		Maintain the level of ground water and prevent pollution by putting in place specifications governing activities in the catchment area.	Swamps exploited by Electrogaz (Nyabarongo) and water wells (Cyunuzi)	Water supply in cities and towns
Peaty swamp of high and average altitude	Source, water reservoir, biodiversity		No drainage nor exploitation	Kamiranzovu, Rugezi, Akagera-Nyabarongo	Hydrological interest and biodiversity
Biodiversity	Endemic species, protected species, Ramsar sites, rare ecosystems		Protected	Kamiranzovu, Rugezi, Rweru-Mugesera, Nyabarongo, Mutobo	Tourist and scientific interest
Cross-boundary Swamp	National, regional, international	Inter-district/sectors, international	Joint management	Akanyaru, Akagera	Share responsibilities and benefits
Park/reserve proximity	> 100ha		Protected	Nyamwashama	Buffer zones and watering
Swamps partially in use	> 30 per cent natural vegetation	>15ha	Protected	Warufu, Murago (Lake Cyohoha), Cyunuzi, Buganya	Maintain water level
	> 70 per cent natural vegetation	<15ha	Protected		

Source: Adapted from REMA, 2008

Value of wetlands and their role in economic development

Wetlands are known to be the world's most productive ecosystems. Some of the wetland functions that humans benefit from include nutrient cycling, sediment and pollution retention, flood mitigation and groundwater recharge. In addition to these indirect benefits, wetlands are sources of wildlife, fish, wood and several non-timber products that are widely used by neighbouring populations. Most importantly, wetland soils can have great agricultural potential when properly used.

Wetlands in Rwanda have been used in different ways and have a great role to play in the national economy. Main functions of wetlands in Rwanda include agriculture production, hydrological functions, biodiversity reservoirs, peat reserve, mitigation of climate change, leisure and tourism and cultural value.

In Rwanda where many rural households face food insecurity, poverty and vulnerability, these goods and services make an important contribution to livelihood. In particular, the conversion of wetlands to agricultural production has increased rapidly over the last two decades due the acute scarcity of agricultural land. To a great degree, the Rwandan Government supports this wetland development with the aim to boost agricultural production, revitalize the rural economy

and reduce poverty. Figure 5 shows the wetlands of Rwanda indicating some of the services they provide, and the risks they experience.

Agriculture and fisheries

Approximately, 92,000 of the total 165,000 hectares are used for agriculture. This is mainly because 90 per cent of the country's population is still engaged in agricultural activities (MINAGRI 2008). Most of the Rwanda marshlands are under traditional cropping. However, some have been developed through extensive drainage or irrigation. Some of these wetlands have been reclaimed increasingly for rice production and sugar cane growing. Wetland grasslands provide critical areas for livestock grazing, especially during the dry season.

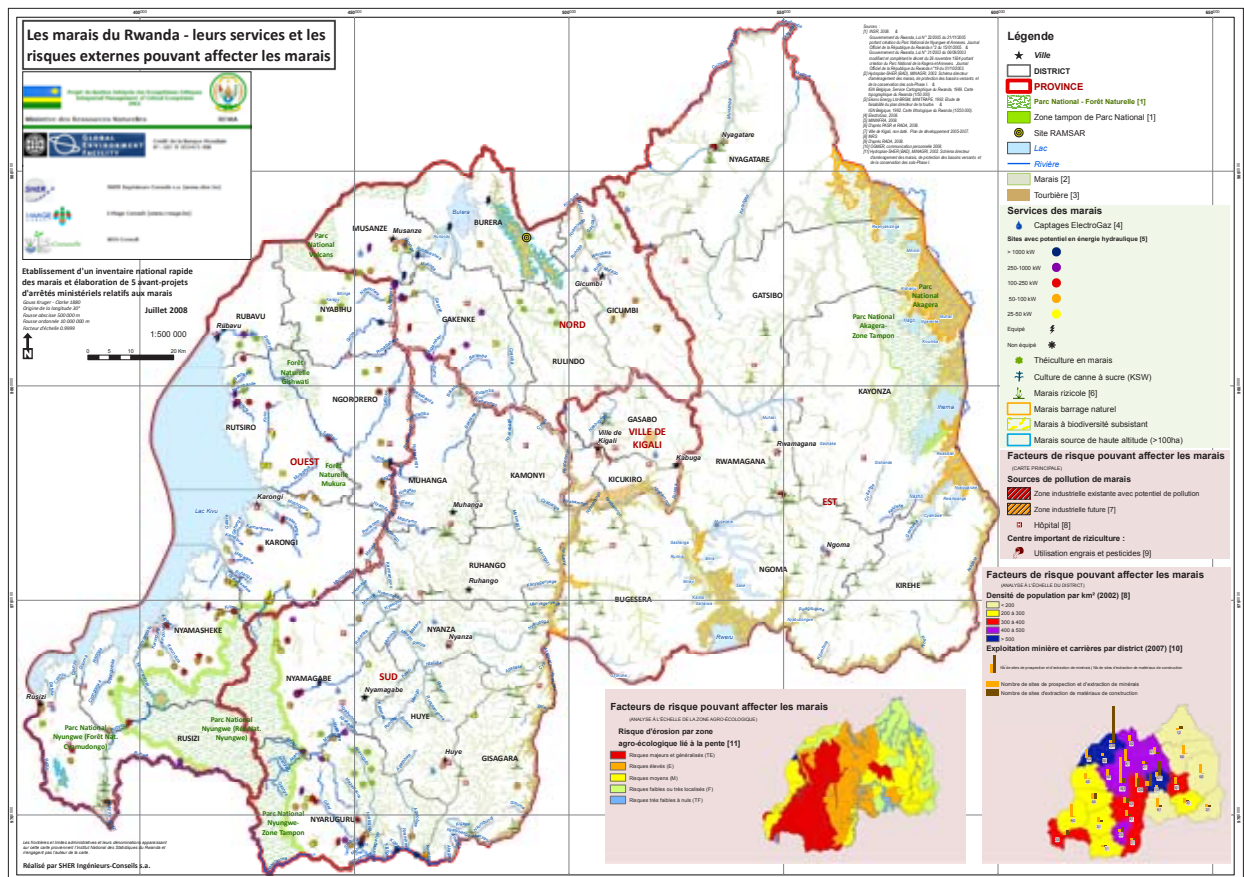
Wetlands constitute an important fish habitat and may support large populations of fish. Many local communities depend on these fish sources for their livelihood. Experimental fishing is being trialled in Lake Ihema.

Biodiversity

High altitude marshlands host a higher amount of vegetation species compared to other marshlands: 51 species in Rugezi, 44 species in Kamiranzovu. This may result from specific ecological conditions first, and then from their size and protected status. Other marshlands that host large biodiversity include the marshlands of Akagera and associated lakes, Akanyaru-Nyabarongo and associated lakes, Kamiranzovu (part of Nyungwe Forest) and Rugezi marshland, which is the only Ramsar site (REMA 2008)

Outside of the national parks where the fauna is formally protected, the lakeside and marshy Rweru-Mugesera complex hosts the most diverse mammals' species. Crocodiles, varans (sand crocodiles) and snakes are also well represented there. The lakeside and marshy Akanyaru complex, Nyabarongo and Akagera National Park are especially rich habitats for ornithological fauna. Rwanda hosts a number of migrating birds species protected by CITES. These migrating species have been observed in Murago, Gishoma, Rweru-Mugesera complex, on the lakeshore of Lake Ihema. Some species

Figure 5: Wetlands of Rwanda – services provided and threats experienced



mentioned on IUCN list and endangered species have been seen in Kamiranzovu, Murago, Rweru-Mugesera and on the lakeshores of Lake Ihema (REMA 2008).

Water reservoirs and water purification

Wetlands also provide an important, water treatment and purification. Large amounts of water enter the wetlands. The wetlands treat and purify this water before it is passed onto the lake or connecting river. Thus, wetlands facilitate the movement of large volumes of water into the underground aquifers, thereby recharging the water table. A high water table supports healthy plant growth, and it can be drawn for human consumption and industrial activities.

Wetlands prevent surface run-off by limiting water flow and overflowing of riverbanks downstream, preventing erosive flood conditions. They also remove sediments, nutrients, toxic substances and other pollutants in surface run-off. This improves water quality and prevents siltation of downstream watercourses.

Threats to water and wetland resources

Enormous pressure, over the recent years, has been exerted on the water and wetlands resources through various emerging and increasing uses driven by the growing population. Some of these threats include agricultural intensification, pollution, invasive species, overuse and an inadequate institutional framework to manage the wetlands. Some of these threats, in the case of water, have affected both the quantity and quality of water available. Climate change is also contributing to degradation of swamps. With decreasing amounts of rainfall, the hydrological regime of wetlands is being threatened.

Inadequate institutional framework for wetlands management

Most interventions in water resources management so far, both local and international have addressed the development of urban and rural water supply. There have been only minimal efforts specifically targeting issues of quality and quantity of water as a resource. Where such interventions have existed, changing mandates and relocations of Government departments have greatly affected their implementation.

Over-exploitation

Over time the country's water needs and utilisation have increased as intensification in the agricultural and industrial sectors has increased thus raising the water demand. In fact, water scarcity is a major threat for rain-fed agriculture depending on type of crops grown. Other competing sectors that contribute to increased water use include domestic and hydro-power generation.

The over-exploitation of plant and animal biodiversity in wetlands is also an issue impacting negatively on the services of the swamps. The reduction of vegetation cover leads to evaporation of water by direct radiation, a reduction of the function of sediments retention and flood control, a gradual erosion of biodiversity. The following plant species are exploited from wetlands:

- *Cyperus papyrus*, *Cyperus latifolius*, *Vossia cuspidata* used for roofing,
- *Cyperus papyrus*, *Cyperus latifolius*, used for mat making,
- *Cyperus papyrus*, used in making false ceilings,
- *Cyperus denudatus* for rope making, and
- Medicinal plants are collected by traditional healers and sold on local markets or home treatment.

The hunting of certain animals of the swamps exerts a pressure on these animals and they disappear or migrate towards other habitats sometimes less indicated to shelter them. Uncontrolled fishing especially in Lakes Ihema and Mugesera is at the origin of the disappearance of certain species of fish and birds.

Other products exploited from wetlands include clay, sand and peat. Clay is used for making bricks and tiles for building. Peat is used as fuel in prisons, industries and schools as an alternative energy source to wood. There are no clear guidelines for peat harvesting.

Land use practices

Wetlands in Rwanda are mainly threatened by reclamation and degradation, especially those outside national parks. Human activities threatening wetlands in Rwanda include settlements and road construction, drainage, unplanned conversion to agriculture, industrial pollution sewage and excessive harvest of products. Land use practices such as trampling of stocks, human disturbances, burning of vegetation, soil excavation processes have devastated vegetation cover to such an extent that the soil surface of areas has become susceptible to erosion.



Building in a wetland

Increased housing developments associated with urbanisation, directly affects the soils' physical characteristics thus lowering water infiltration and increasing runoff and soil erosion with increased potential for floods. This has happened in Kigali and to a lesser extent in other provincial towns across the country. Roofing of housing complexes and paving of roads and other access routes has reduced the surface area available for soil infiltration. During the rainy season much of the run-off flows to the valleys below with minimal infiltration which is one of the main ground water recharge pathways. In cases of the existence of open sewers and exposed drainage canals, the rain water carries along with it the domestic waste directly into the marshlands below as is the case for the Gikondo and Nyabugogo wetlands for Kigali. The direct impact of reduced soil infiltration is increased run-off, soil erosion on bare soils and siltation of water ways in the lower slopes or marshlands. Soil erosion is discussed in more detail in Chapter 3: Land use and agriculture.

Also associated with urbanisation is watershed destruction and increasing incidences of dumping of untreated effluent in rivers and marshlands (MINIFRA 2003). In urban areas wetlands are most likely to be used as dumping sites for

wastes or wetlands may be converted to other forms of land use, such as residential and industrial development, road construction, or aquaculture. The Gikondo industrial area located in Gikondo-Nyabugogo wetland greatly affects the ability of the wetland to clean wastewater and control siltation of streams (REMA 2006).

Agriculture intensification

Given the land shortage in Rwanda, wetlands have been put under intensive cultivation for crops such as sugarcane, rice, flowers, sweet potatoes, and Eucalyptus. Other uses include conversion of wetlands into livestock grazing areas. This has however, been reduced due to the zero-grazing policy being enforced by Government. Approximately 30 per cent (90,000 ha) of the swamps area is already being used for agriculture. Of these, 5,000 ha are used all year round (MINIRENA 2008).

Cultivation of swampland affects their chemical, physical and hydrological nature. The use of chemical fertilisers, fungicides and insecticides has modified the chemical composition of these hydrologically-connected water resources. These chemicals seep through the wetlands and join other water

sources most of which form rural domestic water supply points such as wells and streams. Spillages from industrial processes also pollute water and wetlands, for instance, during the washing of coffee.

The physical and hydrological modifications mainly relate to erosion due to inappropriate agricultural practices. Drains and channels constructed to divert or to increase water out-flow from wetlands lower the water table and can lead to loss of biodiversity through drying out of the wetlands

Pollution

A study on water quality conducted by the National University of Rwanda in 2002 confirmed that water quality is an issue in this country. Many of the parameters sampled showed measurements higher than WHO recommended standards for drinking water quality (see table 8). Adopted from NUR 2002.

Water resources have been subjected to heavy and unchecked pollution as most of the untreated waste (both domestic and industrial) is directly deposited or ends up in these resources. This has rendered water unsuitable for direct consumption and increased the cost of treatment before utilisation. Most buildings in the urban areas do not have

waste water treatment systems or facilities. The untreated waste is stored in septic pits which are regularly emptied. During construction most of the pits were not cemented or lined with impermeable material. This localized handling of waste contributes to ground water contamination through soil infiltration and in some cases also pollutes surface water sources in the downstream areas.

The main cause for this situation is the absence of adequate waste water management strategies for urban and peri-urban settlements. The situation is worse in slum areas where the sewage pits are constructed in areas with high water table and often close to marshlands or streams. Many industrial establishments also do not have waste treatment facilities and simply discharge their effluent directly into streams, marshlands or lakes. Some have waste water treatment systems which are not operational. This unchecked pollution has considerably contributed to the deterioration of water resources in the Gikondo, Nyabugogo and Nyabarongo marshlands in Kigali. A study conducted on the metals discharged by industries and their impact on drinking water quality in Kigali showed that these factories deposit approximately 0.12 mg/l of metals in the tributaries of the Nyabarongo river (Baligira 2007).

Table 8: Water quality test results for selected rivers

No	Parameters	pH	NO ₂ -	PO ₄ ³	Ca	Mg	Turbidity
	Units		mg/l	mg/l	mg/l	mg/l	FTU
	WHO Standards	6.5 -9.5	3	5	300	0.1	5
	Sample Sites						
1	Ruhwa	7.41	0.037	.95	2.6	3.9	3
	Ruhwa + Rusizi	8.8	0.028	1.775	8	29	32
2	Sebeya	7.02	0.048	0.31	7.2	3.19	363
	Mwago	6.41	0.077	0.425	6	1.45	46
3	Rukarara	6.56	0.120	0.475	2	0.87	59
	Mwago + Rukarara	6.53	0.115	0.600	4	0.58	48
4	Nyabarongo	6.95	0.088	0.800	6.4	1.16	273
	Mukungwa	8.43	0.032	0.170	12.8	17.4	7
5	Nyabarongo + Mukungwa	8.22	0.058	0.350	12.8	11.6	91
	Nyabarongo	8.10	0.037	0.600	11.2	6.96	200
6	Nyabugogo	6.8	0.183	0.500	12.8	3.48	41
	Nyabarongo + Nyabugogo	8.0	0.059	0.550	6.4	9.28	109
7	Nyabarongo	7.95	0.045	0.610	6.76	12.76	210
	Akanyaru	6.59	0.057	0.330	6.76	2.32	101
8	Nyabarongo + Akanyaru	7.58	0.047	0.420	6.76	8.12	180
	Akagera	7.29	0.093	0.600	6.76	4.64	76
9	Ruvubu	6.4	0.073	0.400	6.76	2.32	31
	Akagera + Ruvubu	7.17	0.088	0.725	6.76	2.90	73

Adopted from NUR 2002

Other sources of pollution include the use of agricultural inputs such as industrial fertilisers, pesticides or herbicides. The most common fertiliser used in Irish potato farming is Diammonium Phosphate (DAP) while Mancozeb is the most commonly used fungicide. Rice growing mainly uses NPK (17-17-17) resulting in heavy deposition of phosphorous and nitrogen in the marshland waters (MINITERE 2005). Rice growing is done in reclaimed marshlands that still have hydrological connections to other marshlands that form sources of water for some rivers and lakes. Coffee growing contributes to water pollution both during the growing phase and processing (washing) stage.

Invasive species

Water hyacinth, an aquatic weed is threatening lakes and rivers in Rwanda. It grows rapidly to form thick mats on water surfaces, increases swamps areas, reduces water supply and undermines transport, hydroelectric power production, fisheries and fish breeding. It can also affect human health by harbouring mosquitoes (malaria), snails (bilharzias), and snakes (Chemonics International Inc. 2003). Water hyacinth has covered large sections of most of the lakes in the eastern province making them difficult to navigate. In some case the weeds have contributed to the drying up of shallow seasonal lakes.

Strategies for improving water and wetlands resources

Reform of the water sector

Water resources management has over the years focused on water supply with little emphasis on the water resources management issues such as the monitoring of water resources, evaluation of aquifers and others. With the reform of the water sector, transferring the water supply and sanitation functions to the Ministry of Infrastructure (MININFRA) with MINIRENA retaining the resources management and regulation functions, a better management of water resources is envisaged (MINIRENA 2008). Under the EDPRS, water resources utilization for growth is expected to increase, as more land will be put under irrigation; more hydro-power generation potential will be exploited; and more industrial activities is anticipated (especially the water-intensive washed coffee processing). Strategic natural water bodies will be exploited for recreation including hotels and other recreation facilities. All these potentially imply more water abstraction that requires a rational management regime (MINIRENA 2008).



Protection of river banks is essential for the integrity of the water and wetlands resources

Improving wetlands management

Rwanda does not have a wetlands policy and wetlands are currently being managed under the Environmental Organic Law and the Land Law. Conservation of wetlands is vital particularly in protecting and promoting wetlands normal functions. Using a watershed approach appears to be the best strategy for the management and rehabilitation of wetlands in Rwanda. Such an approach would be designed to (i) restore the protection benefits; (ii) limit negative effects on transboundary water resources; and (iii) conserve biodiversity in both natural and modified environments (Chemonics International Inc. 2003). It is this approach which is proposed for four major complex wetlands considered to be critical ecosystems, Kamiranzovu wetland in western province, Rweru-Mugesera wetland in Eastern province, Rugezi-Ruhondo wetland shared by Musanze and Gicumbi in Northern provinces, and Akagera wetland shared by Kibungo and Umutara in Eastern province, under a GEF/WB project (Integrated Management of Critical Ecosystems).

Although wetlands management is prioritised in some Districts Development Plans, distances along river shores of respectively 10 metres for crops and 20 metres for housing are not always respected. Around some marshlands, buffer zones of 50 metres have been delineated and agro-forestry species have been planted, still annual crops often continue to be planted between trees and even between the wooded strips and in the marshlands and the buffer zones cannot serve their purpose of erosion control and protection against flooding.

Experience has demonstrated that initiatives aimed at wetland conservation and management must be recognized as a long term process that aims at building a strong knowledge base. Uses that involve some level of modification of the original state of wetlands must be accepted as management options, subject to ensuring the maintenance of essential hydrological, ecological or other system functions. Capacity for wetlands management must be built at all levels to address institutional sustainability, ownership, user rights and access.

Improving water management

With regards to water management, there is a need to establish a comprehensive database which will allow control and maintenance of data integrity and at the same time allow regular update of information on national water quality and quantity. Only 22 out of an existing 69 hydrological stations

have been in operation since the beginning of 2008. The rest are not fully functional. This state highlights the need for immediate action as follows:

- The stations have to be under the overall supervision of a permanent institution with the mandate and capacity to regularly collect and process information on water.
- An inventory needs to be conducted to ascertain the conditions of the existing stations. The inventory will point out the stations that need repairs and re-equipping especially since the change in water levels and general water resource conditions rendered some stations irrelevant and unproductive.
- A survey needs to be conducted to locate other appropriate (new) sites for the establishment of water monitoring stations in addition to the existing ones.
- The stations should all be equipped to also measure water quality parameters without limiting the measurements to water level, discharge rate and turbidity (in a few cases) as is currently being done.

Addressing water pollution

To address the problem of water pollution, there is a need to establish standards and regulations to control industrial waste. Efforts should be made to implement cleaner production methods for all industries and this could preferably be coupled with the 'polluter pays' principle that will ensure that all polluting industries take responsibility of their actions and take on a more positive role towards the reduction of pollution of water resources and the environment as a whole. Relevant institutions like REMA, the Rwanda Utilities Regulatory Authority and the Rwanda Bureau of Standards should be sufficiently equipped with skills and the resources to monitor the enforcement and compliance of all industries with the regulations.

Conclusion

Water directly influences the quality of people's life, their health and productivity. Access to clean and safe water is vital for good health and for various economic activities. Although Rwanda possesses abundant water resources, the distribution of drinkable water is still inadequate. Wetlands provide an important function of water treatment and purification and serve as sources of water for the lakes and connecting rivers in the country. But they, too, are under pressure from many sources.



Soil compaction in wetlands for construction affects their ecological properties as it is the case in Gikondo-Nyabugogo wetland

Over the years, there have been various challenges in the water sector in Rwanda. A number of responses including the reform of the water sector and improved management of water and wetlands resources including development of standards and regulations are being implemented and should lead to improvements. Relevant institutions like REMA, RURA and RBS should be sufficiently equipped with skills and the resources to monitor the enforcement and compliance of all industries with the regulations.

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Chapter 8: Energy Resources

Introduction

Rwanda has considerable opportunities for energy development – from hydro sources, methane gas, solar and peat deposits. Untapped resources for power generation amount to about 1,200 MW. Most of these energy sources have not been fully exploited. As such, wood is still the major source of energy for 94 per cent of the population and imported petroleum products consume more than 40 per cent of foreign exchange.

Energy is a key component of the economy. It is thus recognised that the current inadequate and expensive energy supply constitutes a limiting factor to sustainable development. Rwanda's Vision 2020 emphasizes the need for economic growth, private investment and economic transformation supported by a reliable and affordable energy supply as a key factor for the development process. To achieve this transformation, the country will need to increase energy production and diversify into alternative energy sources.

The Vision 2020 energy target is to have at least 35 per cent of the population connected to electricity (up from the current 6 per cent) and to reduce the rate of wood use in national energy consumption from the current 94 to 50 per cent (ROR 2000). Additionally, the PRSP aims to ensure a energy consumption growth rate of nearly 10 per cent per year, and a rural electrification rate of 30 per cent giving electricity access to 35 per cent of the population by 2020 (ROR 2007).



Deforestation for charcoal leaves whole swathes of land bare

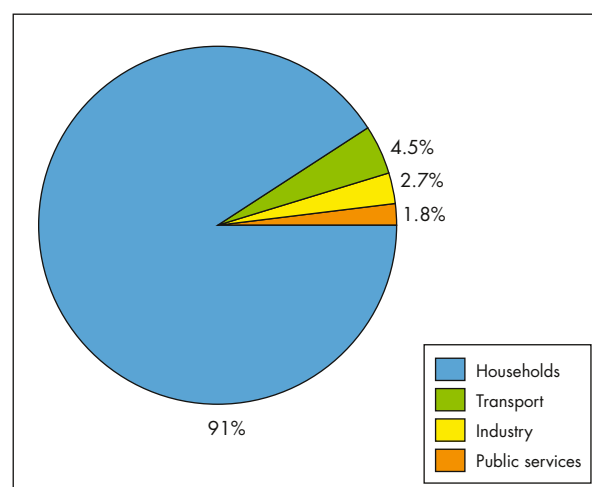
The energy crisis in Rwanda

Several indicators point to an energy crisis in Rwanda including: accelerated deforestation, a biomass energy deficit and deterioration in electricity generation and distribution systems.

The major part of the energy consumed in Rwanda today still comes from wood (80.4 per cent). Yet studies carried out as far back as 1981/82 and 1989/90 already showed a gap of 3,000,000 m³ of wood for energy needs only (Privatisation Secretariat undated). As a result, there is massive deforestation across the country with consequent effects on the environment. Deforestation is discussed in greater detail in Chapter 6: Forests and Protected Areas.

The installed electricity generation capacity is extremely low at 72.445 MW from all categories (MININFRA 2009a). Only 2 per cent of the population has access to electricity, and there is a gap in national production of electricity of more than 50 per cent which is filled by electricity imported from the Democratic Republic of Congo and Uganda (Privatisation Secretariat undated). Figure 1 shows the energy demand by sector, while table 1 shows the current electricity generating capacity in the country.

Figure 1: Energy demand in Rwanda



Source: Privatisation Secretariat undated

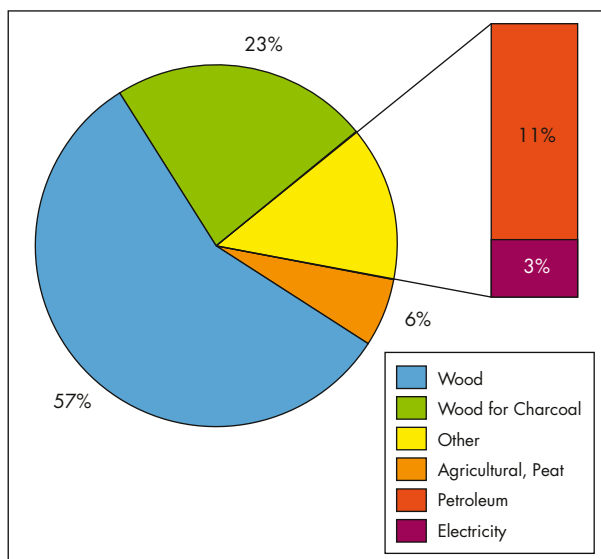
Table 1: Current electricity generation capacity

Category	Name	Installed capacity (MW)	Available capacity (MW)
In house hydropower	Ntaruka	11.76	6
	Mukungwa	12.5	11
	Gihira	1.8	1.8
	Gisenyi	1.2	1.2
Imported hydropower	Rusizi 1 (SNEL)	3.5	3.5
	Rusizi 2 (SINELAC)	12	8
Micro hydropower	Nyamyotsi	0.075	0.075
In house thermal power	Jabana	7.8	7.8
	Gatsata 2	4.77	0
	Gatsata 1	1.8	0
Rental thermal power	Aggreko 1 (Gikondo)	10	10
	Aggreko 2 (Mukungwa)	5	5
Solar power	Kigali solar	0.25	0.25
Total		72.445	54.625

Source: MININFRA 2009a

Sources of energy in Rwanda

The energy sector in Rwanda is made up of three sub-sectors: power, hydrocarbon and new and renewable sources of energy. Amongst the renewable sources of energy are biomass, solar, peat, wind, geothermal and hydropower. Biomass is the most used and dominates both the demand and supply sides of the Rwandan economy. The current national energy balance of 86, 11 and 3 per cent of all energy consumed

Figure 2: Primary Energy balance 2007

Source: MININFRA 2008a

is used in the form of biomass, hydrocarbons and electricity, respectively. This is shown in figure 2.

Biomass or primary energy balance

Biomass is used in the form of firewood, charcoal or agricultural residues mainly for cooking purposes in Rwandan households, and also in some industries (MININFRA 2008a). In the rural areas, biomass meets up to 94 per cent of national needs; with the balance being met by other options such as kerosene, diesel, dry cells, grid and non-grid electricity, biogas, solar, wind and other renewable energies. Biomass is already in short supply with the country facing a biomass deficit of over 4 million m³ per year.

Although fuel wood consumption is expected to increase in the short-term, the long-term strategy of the EDPRS is to reduce fuel wood consumption from 94 to 50 per cent by the end of 2020. Table 2 indicates an expected increase in consumption by 20 per cent between 2005 and 2010. Measures to address this include a plan to increase the area under forest from 20 to 23.5 per cent by 2012. This will be accompanied by a concurrent decrease in wood consumption from 8.9 to 6.2 million m³.

Rwanda is expected to continue using firewood which will be capped at 25 per cent for Kigali, 40 per cent for other urban areas and 90 per cent for rural areas and be suppressed progressively with the introduction of LPG and other alternatives including solar and thermal applications. However due to uncertainty in introduction of LPG and solar

thermal applications, the high levels of production for Improved Cooking Stoves will be maintained and the market influenced to evolve with the entry of the new fuels and technologies. The East African Community Scaling-Up strategy is to undertake a serious campaign to introduce Improved Cook Stoves (ICS) on a sustained business model to keep the supply and demand balanced. The firewood ICS are cheaper than the charcoal ICS at US \$3 compared to US \$6 respectively.

Impacts of biomass use on the economy and environment

Studies indicate that about 80 per cent of firewood used in the country is foraged (no cost for end users) and very little goes through the market economy (Theuri 2007). This has implications for providing alternative interventions and is likely to hamper efforts towards development of environmental friendly alternatives. But there are also implications on time spent in collecting this fuel. Theuri (2007) estimates that households in Kigali spend the shortest time to access wood fuel, about half an hour; while other urban and rural spend about one and half hours and 2 hours respectively.



A traditional kiln for burning charcoal – they are quite inefficient using a lot of wood contributing to deforestation

The continued lack of alternative energy sources such as LPG or electricity are leading to increased pressure on the available forest resources for firewood and charcoal. Charcoal is the preferred fuel for urban households and demand is pushing up the price. In 2003, the charcoal market had a turnover of US \$30 million (World Bank 2006). The current trend towards increased urbanization and the declining state of forest resources points to the need to design effective policies to address some of the pressing challenges in the energy sector.

The power sub-sector

ELECTROGAZ has been the sole integrated electricity supplier in the country. Rwanda imports electricity through cross-border interconnections of about 15.5 MW from the DRC and SINELAC and about 3MW from Uganda (MININFRA 2009a). Electricity is imported from Ruzizi I (a power plant belonging to DRC), Ruzizi II (a community power plant belonging to Rwanda, Burundi and the DRC) and from Uganda. In spite of these imports, there is a gap in electricity generation of about 50 per cent. By 2004 this amounted to about 380 MWh of electricity supplied (UNDP 2007). Figure 3 shows the electricity demand and supply by Electrogaz in 2004 and table 3 shows the electricity balance for Rwanda.

Electricity shortage has necessitated regular load shedding. Load shedding is when power distribution companies switch off electricity supply to some clients. Frequent power shortage has resulted in individuals, manufacturing entities and firms purchasing their own generators. This has led to an increase in production costs of industry, a subsequent increase in consumer goods and increased emissions to the environment. Power shortages have also led to a 250 per cent increase in power prices – from 48 to 120 Rwf per unit of power (UNDP 2007). At the times of this energy crisis, there was also a shortage of charcoal. Most of the shortage is caused

Table 2: Wood Consumption Projections (baseline, t/yr)

Year	2005	2006	2007	2008	2009	2010
Firewood urban	81.916	86.831	92.041	97.564	103.417	109.622
Wood for charcoal urban	1.643.655	1.732.734	1.836.698	1.946.900	2.063.714	2.187.537
Firewood rural	2.805.431	2.871.907	2.939.317	3.007.623	3.076.787	3.146.761
Wood for charcoal rural	123.409	126.333	129.298	132.303	135.346	138.424
Industry, institutions	336.652	344.629	352.718	360.915	369.214	377.611
Total	4.982.063	5.162.434	5.350.072	5.545.305	5.748.478	5.959.956

Source: Vanderplas 2004

by deforestation due to exploitation of forests for biomass energy.

In order to meet demand Electrogaz purchased a number of diesel powered generators. By the second quarter of 2006 the cost of paying for the diesel was estimated to approximately US \$65,000 per day. Although electricity is consumed mainly in urban areas, there are cost implications of these expenditures to the rest of the economy. Kigali alone consumes about 60 per cent of the entire generated electricity (UNDP 2007).

The hydrocarbon sub-sector

Rwanda is completely dependent on imported petroleum products. Hydrocarbons serve as a source of electricity by powering diesel generators, and are also used in the transport sector. About 42 per cent of the electricity produced in Rwanda is produced by diesel generators. Information on the petroleum sector is scanty and is therefore not included here.

Methane gas

One of the biggest inputs into the electricity grid in the near future will be power generated from methane gas extracted from the bottom of Lake Kivu. It is estimated to contain about 55 billion m³ of dissolved methane gas (MININFRA 2009b). Lake Kivu offers the best alternative for energy because of its relatively low construction cost and low estimated operating costs and is a key Government priority.

The first efforts to utilise the methane deposits were undertaken in the late 1950s with 1.5 million cubic meters of gas being supplied annually to the nearby Balirwa Brewery in Gisenyi. The plant was shut down in 2004.

According to a rough estimate, the methane potential in the Lake is equivalent to 40 million tons oil equivalent, which means an estimated 700 MW can be produced by power plants continuously at least over a period of 55 years assuming an extraction rate of one billion cubic meters of methane per year (MININFRA 2009b).



Diesel generators in Gikondo - Kigali City



Methane gas power plant in Lake Kivu



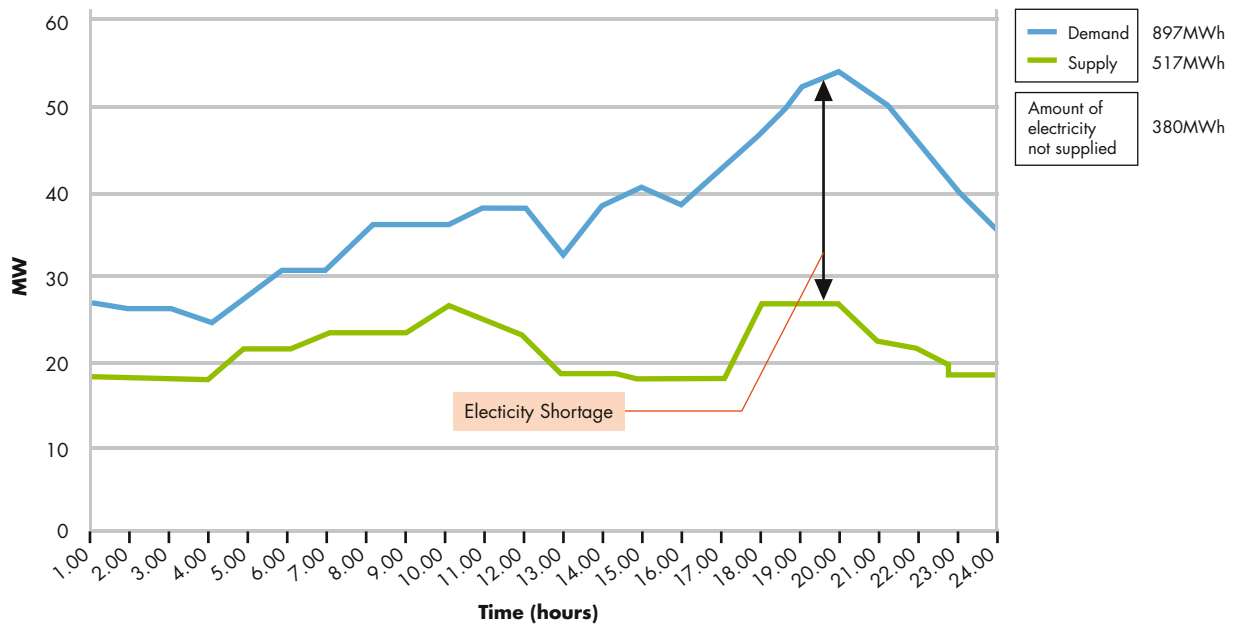
Diesel generators used to produce electricity were hired by the government to compensate power shortage resulting in the degradation of Rugezi wetlands and were run at 65,000 USD a day for fuel

Table 3: electricity Balances of Rwanda (in GWh)

	2004	2005	2006	2007	2008	2009	2010
Demand (GWh)	274	294	306	402	412	427	438
Domestic Generation							
Gihira	5.5	6.7	6.9	6.9	6.9	6.9	6.9
Gisenyi	4.5	4.3	4.4	4.4	4.4	4.4	4.4
Jabana	3.6	31.0	36.0	36.0	36.0	18.0	18.0
Gatsata I-III	2.7	0.5	4.4	4.4	4.4		
Gatsata IV		23.7	34.2	0.0	0.0		
Ntaruka	21.2	15.6	14.6	14.6	14.6	14.6	14.6
Mukungwa	53.1	35.8	35.7	30.5	48.4	48.4	48.4
Rental Power I (10MW)		15.3	61.0	45.8			
Rental Power II (10 MW)							
New Thermal (UERP Phase 2)				36.8	105.6	210.6	252.4
Gas methane					110.0	220.0	220.0
<i>Total</i>	<i>90.6</i>	<i>132.9</i>	<i>197.2</i>	<i>179.4</i>	<i>220.3</i>	<i>302.9</i>	<i>344.7</i>
Imports							
Rusizi I	20.0	22.5	22.6	22.6	11.5	11.5	11.5
Rusizi II	91.4	64.4	66.0	61.5	42.1	42.1	42.1
Kabale (UEB)	4.2						
Micro Hydro (UERP Phase 1)			12.2	12.2	12.2	12.2	12.2
<i>Total</i>	<i>115.6</i>	<i>86.9</i>	<i>100.8</i>	<i>96.3</i>	<i>65.8</i>	<i>65.8</i>	<i>65.8</i>
Energy Supplied to transmission System	206.2	219.8	298.0	275.7	286.1	368.7	410.5
Export to Gisoro	(2.2)	(2.6)	(2.6)	(2.6)	(2.6)	(2.6)	(2.6)
Energy supplied to Domestic Consumption	204.0	217.2	295.4	273.1	283.5	366.1	407.9
HV Transmission							
Losses (GWh)	4.1	4.3	5.9	5.5	5.7	7.3	8.2
Losses in %	2.0 %	2.0 %	2.0 %	2.0 %	2.0 %	2.0 %	2.0 %
Delivered to MV	199.9	212.8	289.5	267.6	277.8	358.8	399.7
MV Transmission							
Losses (GWh)	4.0	4.3	5.8	5.4	5.6	7.2	8.0
Losses in %	2.0%	2.0%	2.0%	2.0 %	2.0 %	2.0 %	2.0 %
Delivered to LV	195.9	208.6	283.7	262.2	272.3	351.6	391.7
LV Distribution							
Technical losses	11.6	10.4	14.2	13.1	13.6	17.6	19.6
Technical losses (%)	5 %	5 %	5 %	5 %	5 %	5 %	5 %
Non technical losses (Theft) (GWh)	29.5	23.8	21.6	14.9	10.3	13.4	14.9
Non technical losses (Theft) %	16.0 %	12.0%	8.0%	4.0%	4.0%	4.0%	4.0%
Billed Consumption	154.8	174.3	253.7	239.5	253.9	327.8	365.3

Source: Core International Inc (2005) Rwanda Electricity and Water Tariff Analysis, USAID.

Available at <http://www.globalregulatorynetwork.org/Files/PDFs/RwandaTariffReport.pdf>

Figure 3: Electricity demand and supply by Electrogaz (July 2004)

Source: UNDP (2007)



Diesel generators rented by the Government of Rwanda to compensate the electricity shortage

Prior to current efforts to extract methane gas, extensive studies were conducted to evaluate potential environmental impacts and these included evaluation of leakage levels that would potentially contribute to global warming (MININFRA 2003). The results of the studies have guided the equipment design and other social and environmental management measures in the area.

Peat, geothermal and wind energy

Peat

Rwanda has peat reserves estimated at 155 million tonnes and therefore has the potential to replace wood, charcoal and fuel oil (MININFRA 2008b). It is estimated that about a third is commercially extractable and can be used for direct use as source of heat or for production of electricity. While power production from peat is still in a planning stage, the use of peat as burning fuel has already been tested in community institutions, for brick making and in the cottage industry (MININFRA 2009a). However the environmental impacts of commercial exploitation will need to be considered before peat can serve as a realistic energy alternative. Table 4 shows the development potential from the energy sources available in Rwanda.

Geothermal

Rwanda possesses geothermal resources in the form of hot springs along the belt of Lake Kivu with a power generation potential of about 170-320 MW. Preliminary technical exploration studies are currently being conducted.

Wind

The potential of wind as a source of energy is currently being investigated. A national wind atlas is going to be developed with the support of the Belgian Government.

Table 4: Sites for potential development of energy

Identified sites	Capacity
Hydropower (in MW)	
Nyabarongo	27.5
Rukarara	9
Mukungwa II	3
Rusomo falls (shared)	60
Ruzizi III (shared/under exploitation)	500 /72
Microhydro power (in MW)	
Many locations all over Rwanda	30 - 500
Methane (inMW)	
Lake Kivu	170-340
Peat (in Million tonnes)	155
Solar (in KWh /m²/ day)	5.5
Wood- estimated (in Million tonnes)	2.3

Source: Electrogaz 2008

Opportunities provided by the energy sector

Reducing environmental impacts through improved energy supply

Energy consumption is intricately linked to environment and natural resources; and there are opportunities for improved environment management through more efficient energy use. The Government recognizes the need for alternative, renewable energy sources, as a means of reducing tremendous pressure on woody biomass. Providing adequate, affordable energy is essential for eradicating poverty, improving human welfare, and raising living standards. Table 5 highlights some of the socio-economic and environmental opportunities that will be provided by energy development.



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Charcoal being taken to market

Table 5: Socioeconomic and environmental impacts on energy sector

Energy sources	Socio economic impacts (positive and negative)	Environmental impacts (positive and negative)
Hydro power	<ul style="list-style-type: none"> ▪ SOGEMR Gaseke (425kW) project plant created employment in rural area of 50-100 people for about 6 months. This encouraged the private sector to take part in the power production sector (MININFRA 2008b) ▪ An interconnection project in Rubavu and Rutsiro District supported by the Belgium Government will help about 728 households directly and 9000 households respectively (MININFRA 2008b) ▪ Rural electrification will help the children and adults to access ICT, which is one of the prime goals of the Government (ROR 2004). ▪ Rural electrification will help in the agricultural sector through irrigation and mechanization (ROR 2004). ▪ Runyombyi (50kW) in the South district will improve the quality of health care, education and income of about 50,000 people (EAESI 2005). ▪ Chogati micro hydro power project will improve health care, education and income of about 3500 people (EAESI 2005). 	<ul style="list-style-type: none"> ▪ Rural electrification in the schools and hospitals will help to reduce the deforestation, which helps to reduce the emissions of green house gases (GHG) (ROR 2004). ▪ UERP project increased environmental awareness among the public and it also contributed to indirectly reduce GHG emissions through its energy conservation programme.
Fossil fuel	<ul style="list-style-type: none"> ▪ The urgent need of power generation through thermal (diesel) led to the increase in production costs. ▪ LPG and Kerosene are considered to an alternative to biomass. It will reduce the time children and women spend searching for firewood 	<ul style="list-style-type: none"> ▪ LPG distribution and consumption in Kabuga -Kigali Ngali province project through the women organization will help 5000-6000 people from Indoor Air pollution (EAESI 2005)
Biomass	<ul style="list-style-type: none"> ▪ About 300,000 people are involved in the biomass business - farmers, charcoal producers, transporters and commercial people. Also those involved in public and private plantations business are focusing on the rural areas, buying land and generating income (MININFRA 2008b) ▪ There will be a high possibility of rural income generation in particular women through small business development. ▪ About 84 people are currently employed in the SNV biogas program which is expected to grow. Many entrepreneurs are involved in construction, maintenance of biogas systems and training. Around 110 families have already benefited from this program (Dekveler <i>et.al.</i> 2005, MININFRA 2007). Kigali city council is trying to incorporate biogas plants in Imudugudus and as an alternative for biomass. ▪ The municipal solid waste management project started with the Muhima association with USAID ARD Inc helps the city. It employs 350 people. The compost is used as fertilizer and it is a cheap fuel for the poor (EAESI 2005). It generates income of US \$6000 per annum. ▪ Community-assisted Access to Sustainable Energy (CASE) project focuses on poor and peri urban people and is likely to reduce the gap between biomass supply and demand for 24,000 households in Nyamagabe, Nyaruguru, Gisagara and Huye Districts ▪ Biomass (organic wastes) briquetting from residues by women NGO in Rugenge, Kigali, Rwanda can generate employment for HIV/AIDS patients 	<ul style="list-style-type: none"> ▪ Mass dissemination of Improved Cook Stoves (ICS) in rural households and tree planting will reduce firewood consumption ▪ Improved carbonization techniques will contribute in reducing trees cutting and ensure environmental protection. ▪ Usage of peat will lead to reduction of GHG (Dekveler <i>et.al.</i> 2005) ▪ Controlled papyrus exploitation and carbonization contributes highly to environmental protection ▪ Methane gas fly freely in the atmosphere absorb more heat than CO₂ so the exploitation of it will reduce its negative environmental impact ▪ Biogas replacing firewood and animal dung contributes to combat deforestation and soil depletion. It also replaces fossil fuel in lighting and thus reducing the emission of GHG. Bio-slurry is used as fertilizer. In addition it improves the living standards of women relieving them from the burden of wood collection for cooking. ▪ Briquetting from saw dust helps to keep the urban environment clean ▪ Briquetting from organic waste helps to keep the city clean, produces composite fertilizers and reduce deforestation (EAESI 2005) ▪ Improved cook stoves help to reduce indoor air pollution and improves the health of the women and children.
Solar	<ul style="list-style-type: none"> ▪ Solar photovoltaic system can help to provide electricity to rural schools and hospitals (268 health centres) to improve the health facility and education ▪ Solar water heater project can help to reduce the energy consumption 	<ul style="list-style-type: none"> ▪ All solar projects on photovoltaic power generation, rural electrification, and water heater can help to reduce the GHGs.

Energy sources	Socio economic impacts (positive and negative)	Environmental impacts (positive and negative)
Methane gas	<ul style="list-style-type: none"> ▪ It can supply gas and power to the neighboring villages ▪ The bye product during the power generation, Ammonia can be used as fertilizer and it can increase the productivity of agriculture(ROR 2004) 	<ul style="list-style-type: none"> ▪ Tapping of methane can reduce the impact of free emission of it to the atmosphere, which causes more damage.
Transboundary projects	<ul style="list-style-type: none"> ▪ Improved employment due to construction and operation ▪ Risk of increase in communicable diseases but migration can minimize these effects ▪ The Rusizi III option can give a potential agricultural boom due to irrigated lands and increase human pressure to resettlement and refugee movement in over populated areas ▪ The Rusumo falls project will affect around 3000 people in that region and around 250 km² of existing wetlands will be flooded. ▪ The overall regional options will improve the socio-economic conditions including alleviation of daily chores such as wood gathering, reduces water related conflicts and provide more reliable electric supply. 	<ul style="list-style-type: none"> ▪ Rusumo falls hydro project expects highland and resettlement requirements, proliferation of water hyacinth, increased waterborne diseases and downstream impacts on the Akagera National Park. ▪ Studies show that the Northern part of the study area got most of the power development options and this will have a positive impact on the climate change (NBI 2007). ▪ The Rusizi III run-of-river option expects that there would be no change in the flow regime and the reduction in nutrient flow will improve water quality and vegetation resources. ▪ The Rusumo falls project expects that reduction in flood flows and slight increase in dry season flow, no change of evaporation, reduction in wetlands could have an impact on migratory birds, potential presence of migratory fish. ▪ The overall regional options reduce pressure on deforestation, green house gases emissions and other air pollutants and it can help to have a better environmental planning and management on management of aquatic resources.



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A woman making an energy saving stove



Improved cook stoves reduce the amount of smoke generated reducing the impacts of indoor air pollution

Transboundary power projects

The need for transboundary power projects is obvious in Rwanda because the country does not have enough capacity to produce electricity that can support the desired social and economic development. The nationally produced electricity has been found to be unsustainable due to seasonal variations in rainfall which sometimes result in low water levels and therefore reduced electricity generation. As already indicated Rwanda is importing electricity from SINELAC as a result of regional power partnerships with Burundi and the Democratic Republic of Congo, and from Uganda.

The Government is committed to bridging this existing gap between demand and local production through the importation of electrical energy. With the emergence of the East African regional integration, there are opportunities for coordinated distribution of energy resources based on national energy balance. Table 6 shows trends in national

hydropower production with comparisons between imports and exports for 2006-2008.

Opportunity to enhance efficient utilization of energy

The recent energy strategic plan targets enhancing energy efficiency by reducing losses of technical nature from 23 to 15 per cent, and commercial losses from 12 to 5 per cent over the EDPRS period. Energy saving devices and appliances will also target to increase supply from 0 to 30 MW by the year 2012. Projects such as the rehabilitation of the transmission and distribution network, putting in place a system of investment and operational guidelines, conducting energy audit of the national power utility, distribution of 800,000 Compact Fluorescent Lamps (CFL) to households and commercial users will provide opportunities for enhanced efficiencies with real benefits for environmental protection.

Table 6: National production, importation and exportation comparisons (in kWh)

	2006		2007		2008	
	kWh	%	kWh	%	kWh	%
National production	168,292,098	73.06	165,360,523	66.51	194,015,217	70.16
Export	2,033,200	0.88	2,146,300	0.86	2,154,950	0.78
Import	64,097,400	27.83	85,409,140	34.35	84,658,127	30.61
Total - national	230,356,298		248,623,363		276,517,394	

Source: Electrogaz 2008

Challenges faced by the energy sector

Energy efficiency in the transport sector

About 75 per cent of all imported petroleum is consumed within the transport sector; and transport costs are quite high. In Rwanda transport costs are estimated to be at least two and half times higher than in the neighboring countries (see table 7). The development of the sector, therefore, has both direct and indirect implications for the total energy consumption and socio-economic growth.

The energy challenge within the transport sector is to ensure efficient and safe use of petroleum products. Efficient petroleum use is determined by the standard of vehicles, the quality of the transport systems and the use of most energy efficient transport means. It is worth noting that all motor vehicles are imported and a majority of them are used cars which would otherwise need standard assessments to ascertain emission levels meet air quality standards. There is insufficient standardization and quality control of petroleum products and inadequate enforcement and uncoordinated safety measures. Data on transport emissions and resultant pollution effects is virtually absent except for a national inventory on greenhouse gases emissions carried out under the UNFCCC in 2002. This study indicated that the carbon-dioxide and methane gas emitted by petroleum products were 259.68 Gg and 0.042 Gg respectively. The carbon-dioxide emissions, mainly from the transport sector, are significant and these calls for more focused attention to ensure appropriate corrective measures are in place. The uncontrolled environmental pollution caused by vehicles is potentially dangerous especially in urban settlements like Kigali where the number of used cars are increasing at an extremely high rate.

Table 7: Transport and energy costs in Rwanda compared to neighboring countries

Country	Transport costs (% of border price of imports, cif)	Energy costs (US\$/Kwh)
Rwanda	48	0.22
Uganda	35	0.08-0.10
Burundi	23	
Kenya	17	
Tanzania	17	

Source: ROR 2007

Improving institutional capacity

Institutional coordination is still constrained by capacity limitations and knowledge gaps. For instance, there is not much awareness of the renewable energy alternatives and technology is very low in the country. Also the country is failing to benefit from the clean development mechanism because of a lack of knowledge on how to exploit the opportunities. There is also need for effective institutional coordination that promotes synergistic efforts towards a coherent national energy strategy particularly in favour of environmental protection.

The low consumption of commercial energy has had adverse impacts on economic growth, which is manifested in low levels of agricultural mechanization and industrialization. In the recent past Government has encouraged private sector in power generation. There is also need to put in place effective strategies to build capacity, particularly for the private sector in conducting Environmental Impact Assessment (EIA). This has become evident with the development of the sector guidelines for environmental regulation which will, in all likelihood come with technical challenges to national environmental management.

Responses to improve the energy situation

Improving access to electricity

Access to electricity by 2006/7 was 4.7 per cent of the total population and is expected to grow up to 30 per cent in 2020. Per capita consumption of electricity is also expected to grow from 30kWh to 100kWh in 2020 (ROR 2007) as a result there is going to be a great demand in this sector. This increasing demand for modern energy has necessitated the search for alternative sources such as the micro-hydro potential and solar energy. The development of methane gas of Lake Kivu also represents a primary option because it could substitute traditional sources of energy, particularly the biomass-based wood and charcoal.

The EDPRS 2008-2012 forecasts that by 2012, 200,000 households are expected to have access to electricity compared with 70,000 now. This includes 300 administrative centres, 1000 schools and 180 health centres. The production capacity is planned to increase from 45MW to 130 MW by 2012 from 50MW excess power from hydro-electricity,

25MW of energy from methane gas power generation. ROR 2007 expects that from the year 2000 to 2020, the annual electricity consumption rate is going to increase from 30kWh to 100kWh. On the other hand, the EAESI (2005) estimates that the electricity access will rise from the current 4 to 35 per cent in 2020. It expects to achieve this by extending the grid to cover new settlements and through decentralizing generation using solar, hydropower or using diesel generators. When extending the grids priority will be given to services, markets, district headquarters, imudugudus, trading centres, factories, agro-processing facilities, health centres. Tables 8 and 9 show the hydro- and micro-hydro power projects that are planned or currently under construction.

Implementing the energy policy

The goal of National energy policy (ROR 2004) is to meet the energy challenges and needs of the Rwandan population for sustainable national development. Rwanda has already set forth energy policy options to develop the sector and at the same time to contribute to reduction of greenhouse gas emissions. These options aim especially to: increase access rate to modern energy resources such as hydropower, new

and renewable energies; produce large quantity and quality of energy for urban and rural areas while improving security of electricity and petrol products supplies; and meet needs of domestic energy while protecting environment. The Ministry of Infrastructure has identified the priority policy actions as:

- Developing Lake Kivu methane and bringing on line more hydro power.
- Deliver a programme of rural electrification on the basis of enhanced distribution networks, micro hydro, and solar power.
- Implement a wood and charcoal efficiency and substitution strategy to counter the deforestation crisis.
- Specifically, with regards to rural policy, the Government of Rwanda has emphasized that the rural energy and electrification form an integral part of Rwanda's overall rural transformation and poverty reduction strategy.

The National Energy Policy incorporates the MDGs in encouraging wider application of alternative energy sources for domestic and agricultural purposes, promoting small and medium-sized enterprises (SME), job creation, economic

Table 8: Hydro-power projects planned/under construction

Hydro power projects (National/Regional)	Capacity in MW	Operating/Funding	To be started/ completed
National			
Nyabarongo	27.5	Exim Bank, India	October 2008/2011
Rukarara	9.5	GoR	2006/ Mid 2009
Regional			
Rusumo falls	60	World Bank	2009/ 2014
Ruzizi III	82	European Union	Under feasibility study
Ruzizi IV	205	European Union	Under feasibility study

Source: MININFRA 2007

Table 9: Micro-hydro power projects planned/ under construction

Funding organizations	Number of Micro-hydro projects	Capacity in MW	Under study/ planned/ under construction
GoR	8	6.35	To be commissioned by mid 2009
European Commission	5-10	3	Under study
Netherland Government through GTZ	6	Approx 1.5	Through PPP program, under construction
Belgium Government	3	2.3	Under study
UNIDO	4	0.6	1 completed, 3 expected to be in operation by June 2008

Source: MININFRA 2007



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Energy saving stoves that are easy and cheap to build are part of the strategy to increase wood and charcoal efficiency

growth, decentralized power generations, promotion of efficient biogas conversion, improve use technologies, focusing on rural development through electrification of rural economic centres. It also focuses on the introduction of financial, legal and administrative institutions to develop appropriate rural energy system (EAESI 2005).

To achieve the set goals for sustainable development will require comprehensive policy reviews in support of environmentally friendly alternatives that include utilization of energy alternatives. The application of tools such as Strategic Environmental Assessment (SEA), the Environment Impact Assessment (EIA) as well as the operationalisation of legislative framework and other regulatory instruments all present opportunities for effective contribution of energy options towards poverty reduction and sustainable national economic growth.

Conclusion and recommendations

The energy sub-sector plays a vital role in facilitating growth in other sectors such as agriculture, ICT, education and health; and in the provision of services in the public sector. The Government thus aims to ensure security of supplies by increasing production from several sources (hydro-electricity, methane gas, solar power, biomass and petroleum).

Other initiatives include improving cost-effectiveness and reflective tariffs as well as operational efficiency of the sector; increasing energy diversification and strengthening the governance framework and institutional capacity of the sub-sector. Some key recommendations are listed below:

- To establish a truly sustainable energy system Rwanda requires technological breakthroughs that radically alter how the country produces and uses energy. Institutional co-operation and co-ordination is imperative to achieve this goal.

- Regulatory measures for improvements in licensing, storage facilities and safety standards and pricing need to be addressed. Furthermore, it is necessary to improve mass transport systems to reduce fuel consumption, traffic congestion and pollution. The exploration for possibilities of fuel switch to other energy forms should be encouraged. The switch to unleaded fuel must be effected.
- The Energy and Agricultural Policy must be coordinated to promotion of environmentally friendly technologies and methods through collaboration with other ministries and institutions.
- There is a need to establish an institutional framework that can mobilize, co-ordinate and facilitate private and public initiatives for renewable energy/technologies usage in rural areas.
- It is necessary to create awareness and understanding of available renewable technologies, practices and resources.
- There is a need to promote efficient conversion and end-use energy technologies and practices in order to minimize health hazards primarily affecting women and children, and environmental degradation.
- Rural energy is diverse and characterized by various actors and interests. A sustainable institutional framework that can cope with the diversity, manage and co-ordinate various efforts, is a key factor for successful development of rural energy.
- Resolve the issue of fuel wood imbalance by a) planting of more trees, b) reducing demand for fuel wood in the domestic and institutional usage and maintenance of generation and transmission equipment by fully trained staff.

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Chapter 9: Climate Change and Natural Disasters

Rwanda's climate

Climate is the average prevailing weather conditions for a specific geographical region over a period usually exceeding 30 years. Due to its high altitude, Rwanda enjoys a tropical temperate climate. The average annual temperature ranges between 16 and 20°C, without significant variations. Rainfall is abundant although it has some irregularities. Winds are generally around 1-3 m/s (Twagiramungu 2006). With an economy heavily dependent on rain fed agriculture, climate is of particular importance.

Temperature

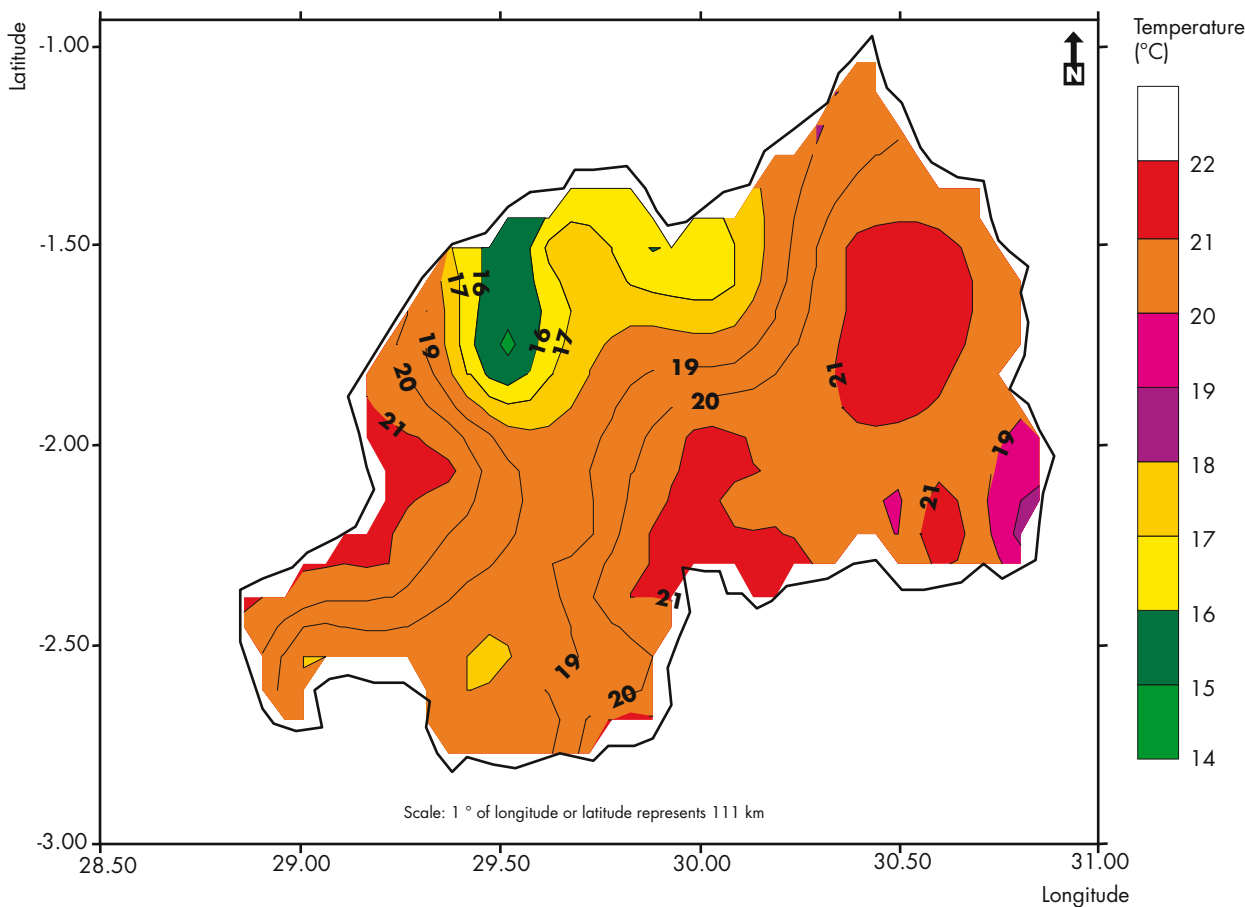
Rwanda's average temperature varies according its topography. Low temperatures are observed in the regions of

high altitude with average temperatures ranging between 15 and 17°C. In some parts of the volcanic region, temperatures can go below 0°C. Moderate temperatures are found in areas with intermediary altitude where average temperatures vary between 19 and 21°C. In the lowlands (east and southwest), temperatures are higher and the extreme can go beyond 30°C in February and July-August. Figure 1 shows the temperatures across the country in relation to topography (Twagiramungu 2006).

Rainfall

The rainfall patterns are characterized by four seasons, a short rainy season from September to November and a longer season between March and May. Between these seasons are two dry periods, a short one between December and

Figure 1: Temperature variation in relation to the topography



Source: Kalisa J. (undated)



Crop failure in eastern province due to the 2005 drought



Dried out river bed during the drought

February and a long one from June to August. Rainfall ranges from about 900 mm in the east and southeast to 1500 mm in the north and northwest volcanic highland areas.

The rainfall is generally well distributed throughout the year, with some spatial and temporal variability. Eastern and southeastern regions are more affected by prolonged droughts while the northern and western regions experience abundant rainfall that at times cause erosion, flooding and landslides. The spatial variability has been attributed to the complex topography and the existence of large water bodies within the Great Lakes Region.

Climate change in Rwanda

The meteorological stations that are currently operational are not representative enough to provide a true picture of climate variability. However, observations and analysis from existing data shows that over the last 30 years, some parts of Rwanda have experienced unusual irregularities in climate patterns including variability in rainfall frequencies and intensity, persistence of extremes like heavy rainfall in the northern parts and drought in the eastern and southern parts.

Variability in rainfall

Analysis of rainfall trends show that rainy seasons are tending to become shorter with higher intensity. This tendency has led to decreases in agricultural production and events such as droughts in dry areas; and floods or landslides in areas experiencing heavy rains. Heavy rains have been observed especially in the northern and the western province. These

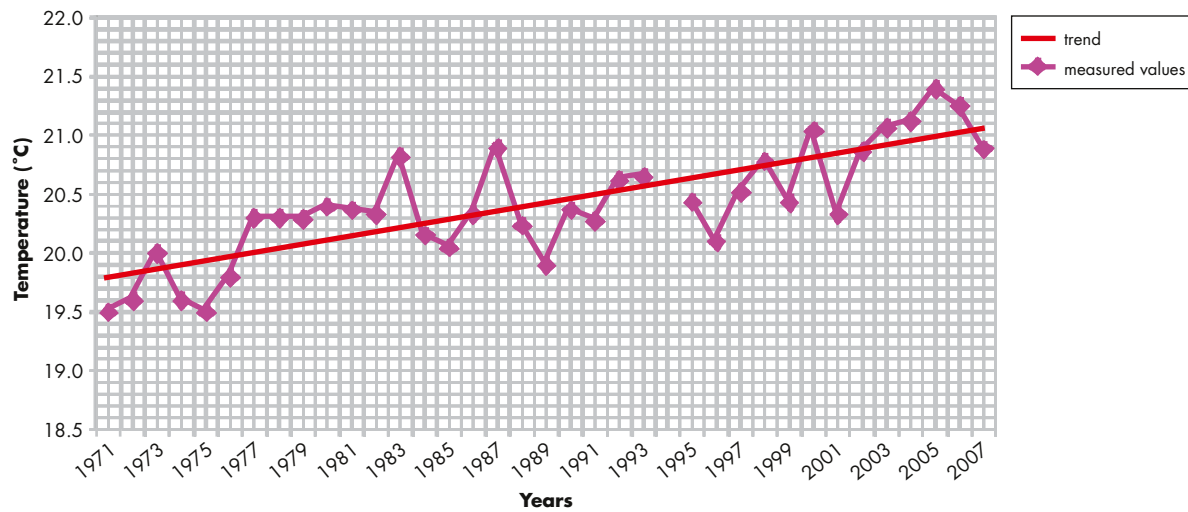
heavy rains coupled with a loss of ecosystems services resulting from deforestation and poor agricultural practices have resulted in soil erosion, rock falls, landslides and floods which destroy crops, houses and other infrastructure (roads, bridges and schools) as well as loss of human and animal lives.

On the other hand the eastern region of the country has been experiencing rainfall deficits over the last decades. Observations between 1961 and 2005 showed that the period between 1991 and 2000 has been the driest since 1961. These observations showed a marked deficit in 1992, 1993, 1996, 1999 and 2000 with rainfall excesses in 1998 and 2001 (MINITERE 2006).

The data shows that total annual precipitation during 2006 was higher than the average precipitation over the previous 30 years which implies a tendency towards increased precipitation (MINITERE 2006). This tendency was observed from three meteorological stations (Kigali, Kamembe (southwest) and Gisenyi (northwest)).

Variability in temperature

Observations show an increase in the average temperature in Rwanda over the last twenty years. This is shown in figure 2. Data for 2006, showed that temperatures were higher than the 32-year average for the dry seasons (January, February, July, August, September and October) and were lower than the 32-year average temperatures for the rainy seasons (March, April, May, November and December) (MINITERE 2006).

Figure 2: Annual Temperature between 1971 and 2007

Source: Meteorological Station at Kigali International Airport

Vulnerability to natural disasters

With its geographical location in the East African Rift Valley near the Nyiragongo volcanoes and the effect of the Inter Tropical Convergence Zone (ITCZ) on the continent, Rwanda is vulnerable to natural disasters emanating from climatic or seismic disturbances. Some of these disasters include drought, torrential rains, floods, landslides, earthquakes,

volcanic eruptions and epidemics. In the past 10 years, these disasters have practically occurred throughout the country. Such disasters are exacerbated by poor farming practices, deforestation and environmental degradation among others.

Even though disasters experienced in Rwanda are not always linked to climate change, a single disruption of the usual climatic trend leads to terrible consequences due to the over-reliance on agriculture in a context of overpopulation.



Cattle graze in the forest in Akagera National Park, especially during periods of drought

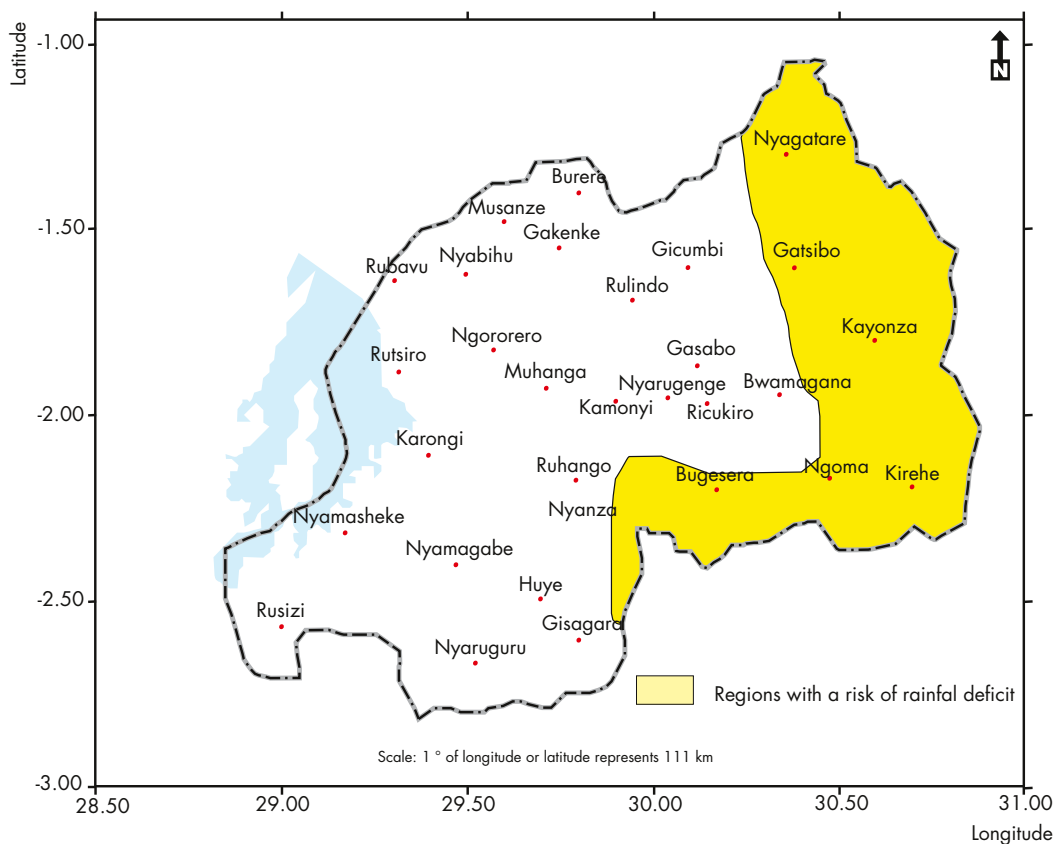
Box 1: Impacts of drought in Bugesera

Bugesera experienced severe droughts in 1999, 2006 and more recently in November 2008. The livelihoods of people in Bugesera are dependant on agriculture. So long dry spells have great impacts on their livelihoods and welfare. Crop failure during the 2000 drought meant that the entire region had to depend on external food supplies. The length and intensity of land degradation have also weakened the lands' resilience. When combined with overgrazing and poor cultivation practices, drought has led to deterioration in pasture and arable land to the point where they have been abandoned. Changing climatic conditions has been associated with declining food crop production due to low moisture content. Cassava, the main food and income-generating crop is now a rare commodity; and the production of beans has also been negatively affected by the low soil moisture.

Little effort has been made to mitigate the problems of rainfall unpredictability. There is an emergence of pests and diseases, possibly because of changing environmental conditions, crop pests were reported to have increased.

Source: WFP/FEVVS-NET 2003, REMA 2007

Figure 3: Map showing rainfall deficit risk zone in Rwanda



Source: MININFRA 2004

Droughts

Figure 3 shows the rainfall deficit risk zone of Rwanda. It includes Bugesera, Nyagatare, Gatsibo, Kayonza, Ngoma and Kirehe Districts in the eastern province and the eastern parts of Nyanza and Gisagara Districts in southern province. These districts are characterized by high frequency of

rainfall deficit, late rainfall onsets, early rainfall cessations, a significant number of dry spells and are prone to drought. Prolonged droughts are frequent in the east and southeast such as Bugesera, Mayaga and Umutara. They tend to be cyclical and can be persistent. Droughts are often responsible

for famine, food shortages, a reduction in plant and animal species and displacement of people in search of food and pasture. At times this has led to conflicts over different land uses such as with protected areas. For instance drought has on several instances forced herders to move their herds from Mutara closer to or into the Akagera National Park during the dry season (Chemonics International Inc 2003). Box 1 highlights some of the impacts of drought in Bugesera.

Floods

Heavy rainfall, in combination with natural factors like topography, is having great impact in some areas. Floods and landslides are the main disasters in the high altitude regions mainly during the rainy seasons. Indeed in light of Rwanda's topography, the potential for flash flooding in many parts of the country is ever present.

The results of human activities (poor farming practices, deforestation and environmental degradation) have aggravated the impacts of floods on people, agriculture and

the physical infrastructure. The 'flood and landslide risk zones' derived from the analysis of frequencies of daily rainfall exceeding 50 mm, are located in the southern, northern and western provinces (MINITERE 2006). These zones have been largely deforested, and now experience heavy rains which have caused extensive flooding and landslides, rock falls, soil erosion, destruction of crops, houses and infrastructure (roads, bridges and schools) as well as losses of human and animal lives. Cases of floods and landslides are often associated with outbreaks of water-borne and water-related diseases like malaria, diarrhoea, cholera and viral infections mainly through the contamination of wells and ground water. Box 2 describes some of the impacts caused by the decline in Gishwati forest and figure 4 shows satellite imagery of the changes in forest cover.

In September 2008 the heavy rains and winds adversely affected 8 among 12 sectors of Rubavu District: Gisenyi, Rubavu, Rugerero, Nyamyumba, Nyundo, Cyanzarwe, Nyakiriba and Kanama.

Figure 4: Changes in the extent of Gishwati forest



The 1978 satellite image shows the Gishwati Forest Reserve as a dark-green carpet of dense forest nearly covering the entire protected area. The 2006 image shows that most of the forest has been cleared and what is left is in degraded condition

Box 2: Floods in Gishwati forests

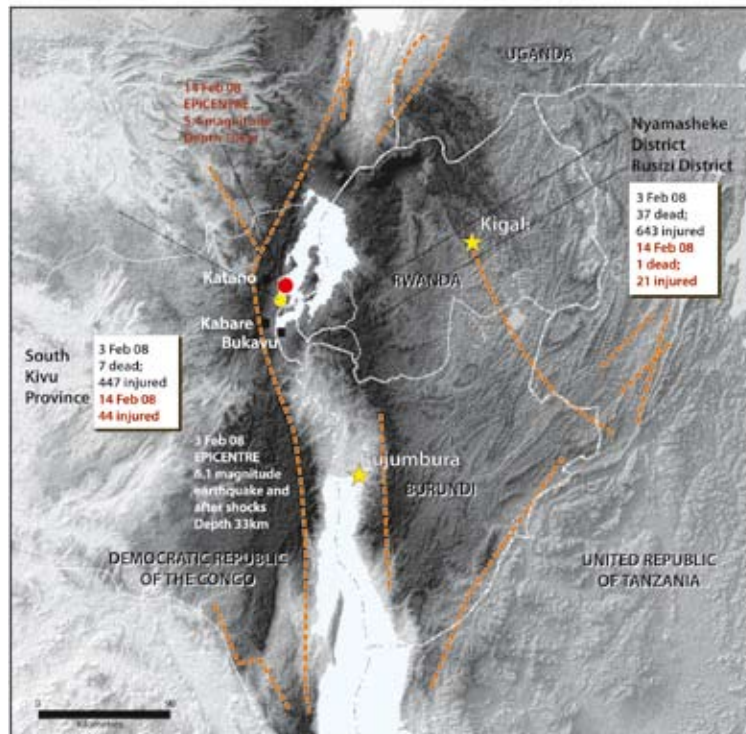
Like in any other tropical forests, Gishwati forests helps maintain soil quality, limit erosion, stabilize hillsides and modulate seasonal flooding. It has also protected down stream water resources from accelerated siltation. The loss of the forest in many areas has resulted in tremendous environmental consequences such as accelerated soil erosion and consequent direct loss of agricultural productivity of the farmers. This ecological function is particularly important to the poorest people who rely on natural resources for their everyday survival. Degradation has also led to more floods in Gishwati and electricity shortage in Cyangugu due to siltation of Sebeya River. The rehabilitation and remediation cost of Gishwati is estimated at US\$ 3.6 million. Agricultural loss due to degradation was estimated to be up to RWF 120,000 for the next harvesting season. The overall cost of activities to partly rehabilitate Gishwati is estimated at RWF 2 billion for 5 years.



A farm and a house near Gishwati forest damaged by floods

Source: WFP/FEVS-NET 2003, REMA 2007

Figure 5: February earthquake in Rwanda and the Democratic Republic of Congo: Epicentre and fault lines



Source: Relief Web. <http://www.reliefweb.int/rw/rwb.nsf/db900sid/CMAS-7BUL8X?OpenDocument&rc=1&cc=rwa>

Earthquakes

Rwanda is located in a tectonic region whose epicentre is located in Lake Kivu. The northwest part of the country is occupied by a volcanic chain that is seismically active. This location makes Rwanda, especially the western region, susceptible to earthquakes.

Indeed recently, two earthquakes of magnitude 6.1 and 5.0 and subsequent aftershocks occurred on 3rd and 14th February 2008 respectively. The epicentre of these earthquakes was located close to the Kivu lakeside city of Bukavu in the Democratic Republic of Congo (see figure 5). These earthquakes affected seriously Rusizi and Nyamasheke Districts where 37 people died and 643 were injured. In addition 1,201 families lost their homes and 20 primary and 4 secondary schools were damaged. According to the Government, 212 classrooms require reconstruction and an additional 113 need to be repaired. The hospital of Bushenge was also badly affected (OCHA 2008).

Volcanic eruptions

The volcanic chain in the northwest, including the Nyiragongo located in Democratic Republic of Congo, is still active and frequently erupts. This volcanic activity is a hazard for the inhabitants of the Goma and Gisenyi regions in the Democratic Republic of Congo and Rwanda, respectively.

The most recent eruption in August 2005 caused infrastructure damage in Goma city in Democratic Republic of Congo which borders Gisenyi city in Rubavu District. A major eruption began at Nyiragongo volcano on 17th January 2002 with lava flows reaching Goma. About 15 per cent of the town especially the commercial area and much of the water and electricity supply was destroyed by the lava flows and resulting fires. The lava flows triggered a massive exodus of the population from Goma, some going southwards inside DRC towards Saké, but the majority - perhaps up to 400,000 people - fled across the adjacent border into Rwanda in the vicinity of Gisenyi (IFRC 2002).

Responses

Adaptation to climate change

The majority of the Rwandan population relies on rain fed agriculture for their livelihoods, and the impacts of variability in climate patterns are already being felt. There are thus

opportunities for improved food security, water availability and livelihoods if programmes to assist with adapting to climate change are implemented. Rwanda is a signatory to the United Nations Framework Convention on Climate Change (UNFCCC) and to the Kyoto Protocol. In the framework of implementation of the convention but also in order to reduce the damage from disasters arising from the impacts of climate change, Rwanda has identified the following six priority areas for adaptation to climate change:

- Integrated Water Resource Management (IWRM);
- Setting up an information system for early warning of hydrological and agro-meteorological systems and rapid intervention mechanisms;
- Promotion of intensive agro-pastoral activities;
- Promotion of non agricultural income generating activities;
- Introduction of species resistant to extreme conditions;
- Development of alternative sources of energy to firewood.

Mechanisms to reduce vulnerability to disasters

Mechanisms to address disasters have mainly focused on mobilization and distribution of relief to populations affected by specific disaster events. The key elements of disaster management namely prevention, preparedness, assessment, mitigation and disaster reduction are now being given due attention. In this regard, a Disaster Management Coordination Unit (DMC) was established by the Cabinet Meeting of 27th October 2004 and Disaster Teams at district and sector levels were put in place in 2007. The Disaster Management Coordination Unit is under the national police and has the following mandate:

- Assess and evaluate disasters frequently observed in districts or sectors,
- Prepare disaster management programmes including disaster mitigation,
- Assess and evaluate disaster socio-economic cost,
- Report to Disaster Management Coordination (Prime Minister's office)

The Disaster Management Coordination Unit has carried out disasters risk assessments studies in the sensitive parts of the country, especially in the northern, western and southern parts of the country. There is an ongoing monitoring of volcanic activity by a team of volcanologists of the Goma Volcano Observatory together with the National University of Rwanda. However, this activity needs more human and

financial means to be able to monitor the Nyiragongo volcano and to disseminate or diffuse the research results and to have sufficient early warning systems.

Monitoring of meteorological parameters is also currently being given prominence. The few existing meteorological monitoring stations are run down due to a lack of maintenance and expertise to track changing climatic conditions. The country also does not have an operational observatory network to facilitate adequate understanding of the national climate conditions and lacks the ability to predict local climate change. Therefore the Government plans to gradually strengthen its meteorological service by adopting and implementing a meteorological policy and strategy, establishing an upper air observatory and establishing an atlas on the spatial and temporal distribution of rainfall, temperature and humidity over Rwanda by 2012 (ROR 2007).

Conclusions and recommendations

Climate plays a central role in agriculture which is the main stay of the Rwandan economy and community livelihood. However, due to anthropological activities, climate change is becoming a reality. Climate-related events like heavy rainfall or too little rainfall are becoming more frequent and are impacting on human wellbeing. These culminate into disasters like torrential rains drought, floods, landslides, earthquakes, volcanic eruptions and epidemics.

Prediction and early warning information and products are vital to the management, risk reduction and mitigation of disasters. Awareness-raising is important so that people know how to reduce risk and harm caused by the various disasters or other precautionary and mitigation measures.

The Rwanda Meteorological Service does not have enough capacity to deliver sufficient data, information and advisories due to the lack of sufficient qualified personnel, inadequate observing station network and sufficient data processing equipment. The Government is working on programmes to enable adaptation to some of the impacts of climate change. At the same time it has set up mechanisms to reduce vulnerability to disasters. It should soon be in position to monitor and issue forecasts well in advance for adequate preparation and handling of disasters.

In order to improve on prediction and early detection of extreme meteorological and hydrological events, and of climate variability and change, proper understanding of the processes that control global weather and climate systems is required. These processes include weather prediction research at all time scales, modelling and downscaling capacity, especially the potential to improve the prediction of climate variability or change at local level to be factored into disaster management and disaster risk reduction.

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ENVIRONMENTAL GOVERNANCE: NOW AND IN THE FUTURE



Chapter 10: Exploring the future of Rwanda's Environment using Scenarios

Introduction

In an increasingly uncertain world, effective environmental stewardship must assume, acknowledge and address the likelihood of future uncertainty. But a host of variables including climate change, uncertain socio-economic and political dispensation, consumer behavior, the national and global economy, demography and culture often obscure a clear road to a sustainable future. Further frustrating is that traditional environmental policy planning methods fail to unmask what could befall our society, environment and economy under competing and interlinked natural resource uses. Seeking more relevant solutions to current and future environmental challenges, the REO has deliberately opted for an outlook approach in order for proactive and innovative policies and strategies to be crafted or explored to ensure the country remains prepared to embrace future volatility - not run from it. This is with the realization that today's and tomorrow's challenges can result in multiple outcomes, and that policy formulation and implementation strategies must take them all into account. Environmental scenario planning is a tried and tested method that prepares us for numerous desirable and undesirable outcomes. A number of scenario exercises have been reported in relation to environment and natural resources (Easterling *et al.* 2007; Odada *et al.* 2009, Detlef, Ochola & Riha 2008, Sall, & Mureithi 1999, UNEP 2006, UNEP 2007).

In many ways the world in general and Rwanda in particular is vastly different than it was a decade ago and unexpected future changes can have a dramatic impact. Will changing socio-economic conditions threaten or sustain environmental goods and services? Is our country prepared to cope with catastrophic events? What effect could major policy shifts and socio-economic developments have on environment?

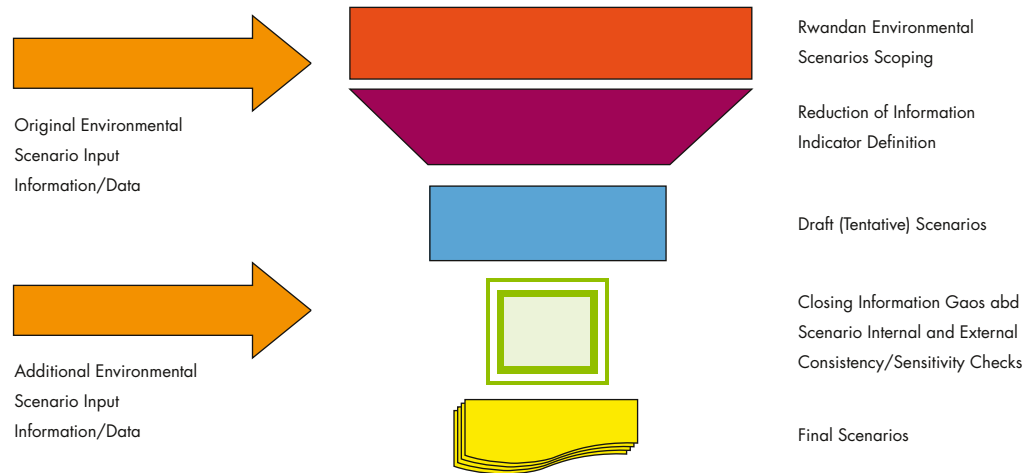
Environmental scenario planning helps envision a future very different from the present and develop concrete strategies that ensure success in a number of different plausible futures (Alcamo 2001). It takes a broader and realistic approach that assesses today's states and trends, explores tomorrow's

eventualities, and prepares us for both. Through scenario planning we are also able to develop specific, measurable indicators that provide an early warning of what the future may bring and the opportunity to start preparing today (Detlef, Ochola & Riha 2008, Easterling *et al.* 2007, UNEP 2007). The goal of the present Rwandan environmental scenario building process was to present insights into the national outlook, including short-term (up to 2025) scenarios for the major environmental issues addressed in this outlook report and possible policy responses. More specifically, the scenario building process for this outlook report was meant to achieve the following:

- Combine qualitative and quantitative information about the future evolution of environmental challenges and opportunities in Rwanda.
- Help REMA, other stakeholders, policy makers and experts 'think big' about various environmental issues;
- Identify the robustness of environmental policies under different future conditions;
- Illustrate how alternative policy pathways can achieve the environmental targets contained in the MDGs and the country's Vision 2020;
- Provide a picture of future alternative states of the environment in the absence/presence of policies and thus illustrate impacts of society on the country's natural environment and point out the need for environmental policies to address the impacts; and
- Raise awareness about the future connection between different environmental challenges such as climate change and threats to biodiversity and human well-being.

The Scenario Building Process

To complete this outlook report, REMA in collaboration with other stakeholders with the technical support of UNEP initiated an environmental scenario development process, based on the past models established for the Africa Environment Outlook (UNEP 2006) and the Global Environment Outlook (UNEP

Figure 1: Schematic representation of the process of REO scenario building

2007) processes. The purpose was to 'see' beyond typical assumptions and biases about the future and to promote a 'longer view.' The meetings held adopted a participatory scenario building approach to explore the future of the environment and the role of REMA and other stakeholders' in environmental protection. The teams considered the issues that were assessed in the earlier chapters and how they may be altered into the future through a selected set of interlinked drivers. These are explored in the scenarios presented in this chapter. The scenario building process is reflected in Figure 1.

Developing the scenarios

To frame the scenarios, the Scenario Development Team selected as axes two critical, uncertain driving forces that affect environmental quality and Rwanda's ability to meet its environmental targets in the Vision 2020 (ROR 2000) - economic growth and social cohesion. The economic growth axis was defined in terms of growth or decline in the total production and consumption of goods and services, as measured by the GDP in the national economy and the contribution of various sectors to it. At one end of the economic growth axis is high growth in GDP and growth rate. At the other end of the axis, growth rates slow or become negative.

The social change axis was defined in terms of the extent of shared values, mutual trust, inclusiveness and participation, and willingness to face common challenges and cooperate in meeting them. For purposes of the scenarios, alignment around shared environmental values is one of the main aspects of social cohesion. At one end of the social cohesion

axis, most individuals, communities, and organizations are committed to environmental protection. Different actors within society are willing to cooperate with one another and to support Government action in order to meet widely recognized environmental challenges. Toward the other end, society is increasingly fractionalized. Many people are indifferent or hostile to environmental values or refuse to recognize the seriousness of environmental challenges. Economic inequities, social conflicts, and practices that exclude people from participation create distrust and limit society's ability to cooperate in meeting challenges. This is shown in Figure 2.

These two 'drivers' or axes described as critical uncertainties, intersect to create four quadrants representing four possible scenario worlds: *Market Forces*, *Policy Reform*, *Fortress World* and *Great Transitions* (UNEP 2006). While they may at times appear exaggerated or unrealistic, each of the worlds represents the plausible extremes defined by the axes. The scenarios are intended to illustrate differing, potential impacts on human vulnerability and the environment presented by these possible worlds. They were constructed for the express purpose of promoting and facilitating strategic discussions among policy makers and environmental custodians.

Scenarios are not predictions. They are stories of how the future might unfold - plausible stories that reflect information about trends and potential future developments. These four scenarios were designed to span a range of potential future conditions. The actual future is not likely to match any one of these four worlds, but it will probably fall somewhere within the range of possibilities that the scenarios explore.

Figure 2: Using economic growth and social cohesion to develop the scenarios

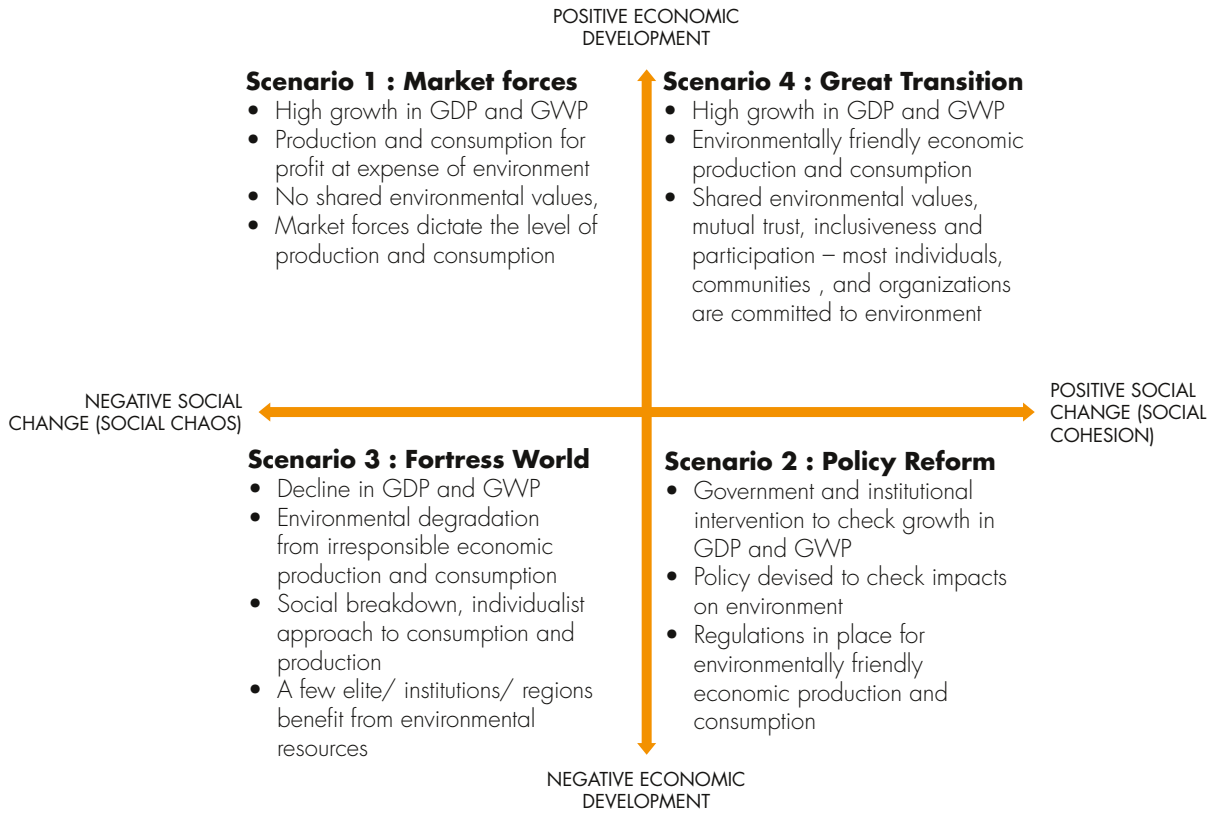
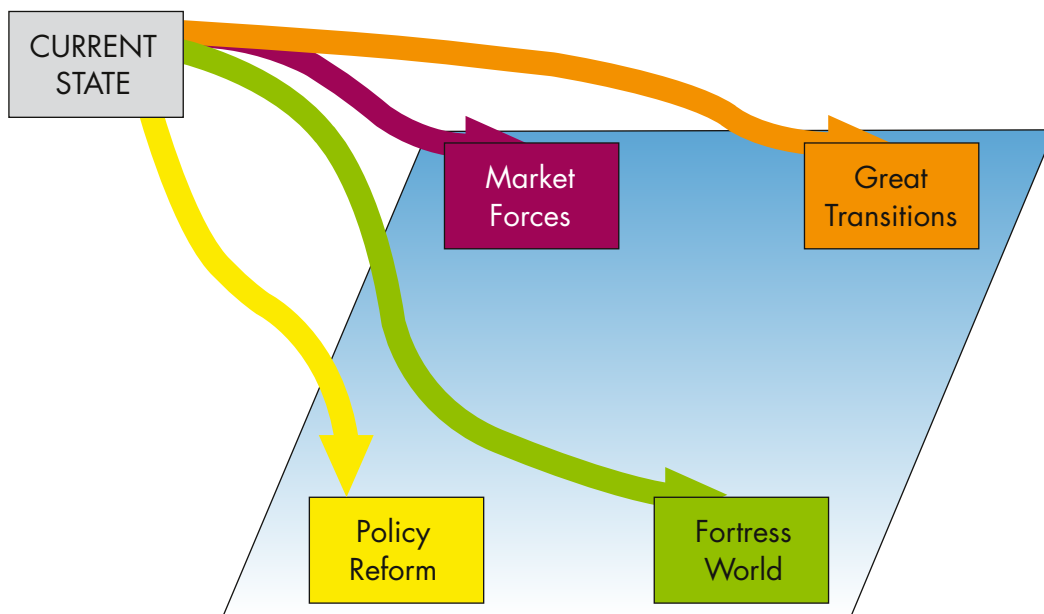


Figure 3: Scenario framework used for Rwanda Environment Outlook Scoping



The scenarios

The common aspect of all the explored futures as depicted in the scenario framework in Figure 3 comes down to an attempt to answer the question: how can we achieve sustainable socio-economic development in the most environment-friendly and least costly way possible? In this framework, the projection by policy makers into the suggested four basic scenarios (quadrants) shows different possible mechanisms depicting plausible pathways.

In the *Market Forces Scenario*, the environmental dimension is hardly perceivable, because it is bound to the effects of scale and product system reorganisation which do not come into the user's everyday experience. Exploitation of environmental goods and services are dictated by profit objectives and market forces. Solutions to environmental problems are consequently perceived as 'complete solutions' in an economic sense: is the offer right for me? If so how much does it cost?

In the *Policy Reform Scenario*, the environmental dimension is an integral part of the search for sustainable development. Government and institutions attempt to regulate through policies, the impacts of market forces on environment. The responses are however reactive and are barely accompanied by requisite social and behavioural changes.

In the *Fortress World Scenario*, a few select elite benefit from environmental goods and services at the expense of the vulnerable masses or regions. They, due to security concerns, enclose themselves in enclaves. The majority of the population however lives in degraded ecosystems while the elite institute protective measures to maintain status quo. Environmental conservation is only an integral part of sustainable development among the elite.

Finally, in the *Great Transitions Scenario*, social regeneration and complete paradigm shift leads to sustainable development and equity. Environmental conservation finds special echo in the theme of sustainable development and social change. Proactive policies and behaviour change characterize natural resources management with popular participation of all stakeholders. The solutions associated with this model are therefore perceived above all as opportunities for integrating social, economic and environmental goals.

The drivers

The drivers summarized in Box 1 are the set of direct and indirect factors that may singly or collectively dictate the future direction of the country's environment. These will influence the state and trends in environmental resources by dictating the level of production (supply) and consumption (demand) of environmental goods and services.



Urban development and settlement are among the drivers of Rwanda future environment

Box 1: Set of drivers for Rwanda Environmental Scenarios and their elements

<ul style="list-style-type: none"> • <i>Demography</i> <ul style="list-style-type: none"> - Population density - Migration/immigration - Population distribution (regional, rural/urban) - Population growth rate - Age structure and gender - Birth/death rate - Fertility/fecundity rate 	<ul style="list-style-type: none"> • <i>Economy</i> <ul style="list-style-type: none"> - Economic growth rate - GDP - Sector contribution to GDP - Commodity prices - Level of industrialization - Access to credit facilities - Inflation - Poverty levels
<ul style="list-style-type: none"> • <i>Social Change</i> <ul style="list-style-type: none"> - Gender balance - Consumption patterns/ behaviour - Imidugudu (social harmony) - Religion - Umuganda (community work) - Security and conflict - Literacy/illiteracy - Health issues (e.g. HIV/AIDS) - Media influence - Land distribution/tenure systems 	<ul style="list-style-type: none"> • <i>Culture and Tradition</i> <ul style="list-style-type: none"> - Ceremonies (wedding, ...etc) - Gacaca (traditional courts) - Traditional dancers (communication) - Traditional handicrafts - Indigenous knowledge • <i>Environment</i> <ul style="list-style-type: none"> - Climate change/variability - Environment legislation - Disasters (floods, landslides, temp extremes, earthquakes, volcanicity, mountainous landscapeetc) - Erosion, Land degradation - Deforestation - Fertility loss - Agricultural expansion
<ul style="list-style-type: none"> • <i>Technology</i> <ul style="list-style-type: none"> - Development of CDMs - Dissemination for new technologies for agriculture, land use, and environmental conservation. - ICT development - Improved technologies for mining, transport, etc) 	<ul style="list-style-type: none"> • <i>Governance</i> <ul style="list-style-type: none"> - Imihigo (district performance contracts) - Decentralization/decentralization - Political will - One family-one cow - TIG (prisoners working outside prison) - Civil society involvement - PPP - Transboundary issues - Conflicts and conflict management - Corruption

The drivers are interlinked in ways that may define how the pillars of Rwanda's Vision 2020 have been crafted and will be achieved. The Vision 2020 identifies six interwoven pillars, including good governance and efficient state, skilled human capital, vibrant private sector, world-class physical infrastructure and modern agriculture and livestock, all geared

towards national, regional and global markets in ways that will be directed by these drivers (ROR 2000). The analyses of the environmental issues presented in this outlook are based on qualitative and quantitative assumptions about the trends in each driver by scenario as illustrated in Figure 4.

Figure 4: Relative qualitative and quantitative assumptions of the trends of the drivers in each scenario

Driver/ Scenario Issue	Qualitative/Quantitative Assumption on Future Trends			
	Market Forces	Policy Reform	Fortress World	Great Transitions
Demography				
Social Change				
Technology				
Economy				
Culture and Tradition				
Governance				
Environment				

Exploring Rwanda’s Environmental Futures

Scenario 1: Market Forces

High Economic Growth, Low Social Cohesion & Environmental Irresponsibility

The global economic expansion that began in the new millennium thanks to successive waves of new technology emerging in a context of rapid economic globalization and profit goals was still going strong towards 2025. Profit making, even at the expense of the environment was the critical catalyst. Information technology was finally generating enormous productivity gains, and enabling local and multinational corporations to join in the plunder of Rwanda’s natural resources. Equity and environmental conservation took a back seat in development planning. The creation of regional and global economic blocks and preferential trade partnerships only helped to worsen the social and environmental concerns. The result was an acceleration of economic growth beyond all past experiences with the global consumer culture quickly permeating the Rwandan

society, with limited Government intervention. Many national companies, as well as ‘multinationals’ that were really loose confederations of national companies, evolved rapidly into integrated transnational corporations. Mergers and takeovers on a global scale created a handful of economic giants that dominated the country’s globalised economy.

Income distribution became more skewed within the country by social class, sector and region. Tensions increased sharply between rich and poor because being rich offered growing benefits such as access to market information and knowledge, social services and power. Population growth and large increases in the use of energy, materials, water, and other resources were having impacts on the environment. But these impacts attracted little attention – or investment – from a society preoccupied with growth and short-term profits. The climate was clearly changing, but Rwanda failed to adjust to these changes easily. The belief, that all the social and environmental stresses arising from population and economic growth could be resolved primarily by widespread ingenuity and the self-correcting action of competitive markets, was predominant.



Industries built near wetlands such as Gikondo Industrial Park are a threat to their integrity

Specifically, the scenario saw far-reaching health, environmental and social impacts some of which are listed below.

Water

- Rapid urbanization leading to rapid aquifer depletion
- Endangered freshwater ecosystems and fish stocks
- Huge expenses associated with water infrastructure (new and rehabilitated)
- Increased public health risks from lack of access to uncontaminated drinking water and adequate sanitation facilities; food shortages and malnutrition as reduced irrigation limits agricultural production
- Rich people and regions, few corporations, control access to most fresh, quality water
- Water becomes a growing source of division, with access to the best water sources restricted to those who can pay the highest prices; conflicts over water rights in parts of Kigali and other cities and in rural areas

Chemicals

- Rapidly increasing production causes increased chemical loadings in environment
- New chemical compounds are introduced with little concern about their impacts; too many are introduced too fast for adequate testing; unknown effects of interactions between chemicals
- Changes in mortality, growth rates, abundance, and age distributions of plant and animal species; changes in animal behavior patterns and migration
- Impacts of increased chemical production fall primarily on poorer populations
- New pharmaceuticals proliferate; drugs appear in water supply as waste products

Urban sprawl

- Escalating costs for maintaining far-flung low-density infrastructures while under-utilizing existing infrastructure
- Fragmentation of ecosystems, reducing biodiversity
- Increased non-point source pollution; increased air pollution from mobile sources
- Increased storm flow rates and downstream flooding because paved areas impair the landscape's ability to absorb run-off; erosion and water quality degradation
- Increased stress from worsening traffic congestion
- Loss of prime agricultural land
- Loss of wetlands, which are filled or disrupted to accommodate development
- Low income people are concentrated in the cheapest, most deteriorating housing in city slums and old suburbs; isolation from jobs exacerbates unemployment, crime, school breakdown, health and other social problems
- Sprawl continues unabated; the affluent move further out into ex-urban areas, isolate desirable resources like lakes and woodlands in gated communities
- Sprawl, auto-oriented development and high mobility weaken community life and cause a loss of human scale in the built environment

Biotechnology and nanotechnology

- Biotechnology brings developments such as genetically customized medical treatments and foods with higher nutrient value, but most benefits go to the affluent
- Little effort to develop potential of biotechnology or nanotechnology for environmental remediation, clean energy and manufacturing
- Nanotechnology emerges faster than the societal conversation on how to utilize it safely and poses novel risks

- Regulatory processes fail to keep up with rapid introduction of new biotechnology products
- Reliance on a few bioengineered crops leads to extinction of other crop varieties especially traditional crops
- Some biotechnology products cause significant problems such as gene transfer (competitively advantageous traits convey from genetically engineered crops to weeds) and phenotypic surprises (bioengineered organisms exhibit unexpected harmful traits)
- Transnational pharmaceutical firms capture genetic resources of Rwanda, but the country receives no financial benefits

Climate Change

- Rapid growth in energy use and endless debate over the reality and seriousness of climate change leads to a rapid rise in CO₂ concentrations
- More intense precipitation events, heavy rainfall days and flooding in some areas; more frequent and severe droughts in other areas
- Increases in accidents and disease associated with extreme weather events
- First measurable shifts of agricultural zones; first losses of wetlands, forests, grasslands due to inability to adapt to rate and magnitude of climate change
- Increases in insect- and animal-borne diseases, both endemic and imported
- First measurable loss of selected fisheries

Scenario 2: Policy Reform

Low Economic Growth, High Social Cohesion & Policy Interventions

Global civilization witnessed in the first decades of the 21st century are coupled to judicious measures, regulatory efforts by Government to correct the negative impacts of economic growth on environment and society. This continued through 2015 with efforts towards the MDGs and Vision 2020 targets heightened. The efforts were however not enough to bring real change and widespread and equitable prosperity to the people. Government interventions included addressing the demographic structure, environment and other sectors, using new policies, formulation reviews and other instruments. The population was increasing so rapidly many people still struggled to meet basic human needs. Explosive urban growth posed massive challenges of housing construction, infrastructure development, sanitation and public health.

During the 2010s, there was a dawning realization that there was actually a positive side to the economic slowdown witnessed with the country making reforms that were succeeding in attracting investment because of the lower labour costs and ease of setting businesses in Rwanda relative to neighbouring countries. ICT policies also helped the country in the competition for global investments.

There also were environmental benefits associated with this reform-oriented scenario. Exponential growth in resource



Effects of floods in Rulindo District Northern Province in 2006

use and energy consumption had been at the root of worsening environmental problems. Slowing growth eased many environmental impacts. Rising energy prices made it economically practical – indeed necessary – to invest in improving the efficiency of energy and resource use. Funds for investing in efficiency were limited compared to times of faster growth, but the economic pressures to invest in efficiency were unrelenting. The social benefits included strengthening of family and community life as people supported each other in hard times, and enjoyed spending more time together. A religious revival filled churches as religious leaders stressed the value of ‘relationship-based lives’ instead of ‘consumption-based lives’ and called for personal commitments to higher purposes than consumption. A movement emerged in all the country’s major religions stressing the unity of country and inter-ethnic cohesion.

Key goals of the reforms in this scenario included national, regional and global cooperation to help populations most in need of assistance, protection of the natural environment, and democratization of emergent local and regional institutions such as the East African Community (EAC). Governments and Internet-enabled social movements cooperated to organize new kinds of environmental monitoring networks and civic accountability networks to monitor industry practices. By 2025, the country had to come to terms with modest economic growth closer to aspirations for a sustainable future. The specific health, environmental and social impacts likely to be associated with this scenario are listed below.

Water

- Access to fresh water is recognized as a basic human right
- Careful communal decisions about water resources are made - how to share water rights, build water infrastructure, investing in appropriate water exploration and management technologies
- People learn to be much more efficient in their use of water
- Huge increases in human and animal waste as population increases

Chemicals

- Chemical production declines; pollution declines, but cleanup also regresses. Big debate over whether the shift leaves the country in better environmental shape than during period of high growth, but little data are generated

- Continued and abundant use of chemicals banned in commerce in developed countries
- Eventual greening of domestic manufacturers serves as a model for the region

Urban Sprawl

- Communities find new kinds of social structures to design ways to live and work that make sense for diverse families and an aging population
- Greater demand for mass transit and affordable modes of ‘clean’ transportation
- Modest housing becomes unaffordable and more, newer but low income neighborhoods are built
- Sprawl abates, people downsize
- Traditional jurisdictional fragmentation gives way to new forms of regional governance that are cheaper to administer and are based on social cohesion

Biotechnology and nanotechnology

- Incidence of inadvertent biotechnology side effects will increase
- Organic agricultural principles and community agriculture replace globalised and high tech agricultural techniques
- Public investment in biotechnology and nanotechnologies is geared toward direct developments to serve the greatest good
- The promise of genetically engineered crops remains unfulfilled, either because of technological difficulties or commercial problems

Climate change

- At domestic level, smaller vehicles, reduced energy consumption and greenhouse gas emissions
- Greenhouse gas emissions continue to rise but have partially abated with lower growth
- Higher altitude ecosystems decline
- Reduced demand for wood products leads to public interest in reforestation in anticipation of an eventual return to high demand with an improving economy

Scenario 3: Fortress World

Low Economic Growth & Low Social Cohesion

By 2025, it’s not too hard to see how Rwanda reverted to such a dark period. From the turn of the millennium, irrational exuberant economic optimism prevailed. Despite a few early trouble signals, the policies remained reactive from 2010 with a few people growing richer and richer at the expense of the environment and the poor masses. Energy demand

increased unabated. Farm prices rose steadily. Spot food shortages were occurring in unexpected food economic zones of the country. This unfolding food security situation across the different scenarios is shown in figure 5. Effects of the global financial crisis of the first decade of the scenario period lasted longer than expected beyond 2015. Prosperity in Rwanda was not as guaranteed as many thought. Collapse of stock markets globally and protectionist policies set off a chain reaction of negative economic and social events with the old barriers to trade making a comeback as countries circled their wagons in isolationism. Contribution of sectors to Rwandan economy declined. Internationally and domestically the gap between rich and poor was growing. Other social consequences of the Fortress World were considerable after 2015. The poor began to rage at the rich, creating a general atmosphere of blame and intolerance. People's sense of community and environmental protection narrowed greatly to focus only on their own survival within their tribes, clubs, zones, churches or neighbourhoods. Gated communities for those who remained wealthy multiplied. Urban sprawl worsened with the multiplicity of poorly serviced estates in towns. Rural urban migration further exacerbated the situation with crime rates soaring to all time highs between 2020 and 2025. Even noble assistance from the western world for

HIV/AIDS was withdrawn exposing the very poor to further suffering.

The environment did not fare too well during these 'dark days'. Population growth in the poorest parts of the cities and the country led to increased deforestation and soil erosion, escalation of problems that had once been on the verge of being solved. People lost any will to deal with climate change. Many of the alternative and energy efficient technologies that were nearing implementation were delayed or abandoned altogether. By 2015, climate change related disasters became more recognizable and common. Disasters like volcanoes, drought and flash floods increased in frequency with environmental refugees increasing and ability of communities and Government to deal with them eroded. Extended droughts affected more areas than the normally prone areas of Bugesera, Umutara, Kigali and Ngali. Flash floods were felt beyond Kigali, Ngali and Byumba. Between 2015 and 2025 hard-won progress towards MDGs and the country's 2020 Vision on basic environmental improvements as air and water quality was lost. Limited funding was available to repair the dilapidated water infrastructure of the nation's settlements. Specifically the following environmental challenges were experienced.



Demand for wood products such as charcoal and timber leads to deforestation leaving large tracts of land bare and exposed to erosion

Water

- Absence of economically achievable and innovative technologies for waste treatment and disposal
- Drugs people use appear in water supply as waste products
- Further degradation in water quality due to uncontrolled non-point source pollution
- Huge increases in human and animal waste as population increases
- Waterborne diseases, pathogens increase
- Significant financial needs associated with maintenance and improvements to water infrastructure are ignored
- Water shortages lead to conflict

Chemicals

- The country makes abundant use of chemicals banned in commerce in developed countries
- Increased invasions of alien organisms require use of more pesticides
- Indoor exposures worsen without progress or innovation in materials
- Industry continues to produce a significant number of new chemicals about which little is known
- Unexpected synergistic effects between chemicals occur

Urban sprawl

- Developments lead to reservoir contamination
- Decent housing becomes unaffordable and more new slums, and less modest neighbourhoods are built
- Localized flooding increases as absorption capacity of landscape decreases
- No comprehensive transportation solutions are developed
- Significant cycle of deterioration in larger cities

Biotechnology and nanotechnology

- Adverse gene flow and ecological effects from existing agricultural biotechnologies are left uncontrolled
- Loss of agro-biodiversity worsens
- Minimal progress made in transforming technologies

Climate change

- Emergent and old diseases and disease vectors advance in previously safe parts of the country
- Greenhouse gas emissions continue to rise, but partially abate with lower growth

- Higher altitude ecosystems start being impacted by climate change with attendant decline in productivity and deteriorating human well being
- No transitions are made to more energy efficient technologies

Scenario 4: Great Transitions

High Economic Growth & High Social Cohesion

By 2025, both the Rwandan and world economies had experienced two back-to-back decades of continuous, vigorous growth. The several crises points experienced along the way about economic stability were turning points changing the character of growth and catalyzing a sweeping shift toward more eco-efficient technologies and sustainable development.

Successive and successful policy responses to address water, land use, climate change, air pollution, urban sprawl and other environmental crises drove home the idea of 'eco-efficiency' and collective responsible production and consumption. The popular concept of 'using advanced technology' was changed to include the idea of doing more with less by using energy, water and materials more efficiently. Pollution and waste were increasingly viewed as design failures of any development project. During the 2010s, an eco-efficiency design revolution swept through the nation's economy, affecting agriculture, energy production and use, transportation, manufacturing, and construction. Energy-efficient buildings with healthy indoor environments became the new ideal in architecture and construction. New industrial systems were increasingly designed to work like ecosystems, recycling the 'wastes' of each process into 'food' for other processes.

All of these technological developments reduced the environmental impacts of growth, but they occurred largely for other reasons. They resulted in better goods and services preferred by consumers. They supported successful businesses and good green jobs. The benefits led to what came to be called 'the greening of the private sector' - a growing alignment between private sector, environmentalists and Government around shared aspirations for developing superior technologies in every sector.

Environmental protection was increasingly viewed as an integral part of a larger strategy of sustainable development that aimed at improving the economy, protecting and restoring the environment, and achieving greater equity and

other social goals - all at the same time. The most important aspect of this strategy was steering research and development into areas of technology that would do the most to reduce environmental impacts per unit of GNP. The strategy also emphasized improved science to deepen understanding of impacts on health and the environment, coordination across agencies and levels of Government, partnerships with the private sector, and innovative new approaches to open information access and public dialogue.

Rwanda had increasingly played a strong international and regional leadership role promoting strategies to make a rapid transition to eco-efficient technologies including the use of ICT and cooperation between nations in technology transfer. In this scenario, an abrupt paradigm shift towards more inclusive policies has reversed the negative trend in environmental integrity and natural resource productivity. More specifically agricultural productivity in terms of food and cash crop production has increased due mainly to proactive policies targeting expansion of arable land coupled with adoption of soil fertility management; restoration of degraded landscapes to approach the potential through fertilizer and other input subsidies; enhanced extension and research services for increased use of appropriate agricultural practices and modern inputs; and mitigation against the impacts of adverse climatic shocks.

The overall trends in productivity of food crops have been positive between 2010 and 2020. This has increased beyond the 2020 vision targets toward favorable productivity for key food security crops. The strong impetus from Government support has boosted cereals productivity (in particular wheat and rice) and fruits. Even the crops that had earlier stagnated like legumes, bananas and roots and tubers have seen improvements in total area cultivated as well as productivity. Increased production in major export crops was realized between 2015 and 2020 with significant increases seen in black tea by over 25 per cent and a corresponding 30 per cent increase in the value of exports. Privatization of the tea sector which was intensified between 2010 and 2020 was responsible for this upsurge.

In environmental terms, despite the high demographic pressure on land resources agriculture kept pace with environmental conservation spear-headed mainly by land consolidation, reduced human agricultural activities on wetlands and other vulnerable lands. Soil erosion from riverbanks and nutrient loading in water bodies such as the Nyabarongo river system and associated wetlands had been adequately addressed through education and popular participation of land users. There is marked reduction in the proportion of the country's lands prone to erosion, from the 39.1 per cent in 2009 to less than 10 per cent in 2025.



Human activities such as mining and quarries can have irreversible impacts to the environment

Water

- Water crises in Rwanda and in neighboring countries lead to extensive adoption of water-efficiency technologies
- Water emerges as a catalytic crisis that accelerates efforts to respond to climate change and to shift to new patterns of sustainable development
- Water shortages and domestic tensions and international conflicts lessened

Chemicals

- Chemical production increases, but a shift occurs towards 'green chemistry'
- Scientific progress makes possible major improvements in understanding the health and environmental impact of chemicals in the environment

Urban Sprawl

- Development of green transportation and manufacturing systems slashes air pollution from mobile sources, but encourages continuation of auto-oriented, low-density development

- Nearly all problems associated with sprawl are checked - from loss of wetlands and fragmentation of ecosystems to escalating infrastructure costs and weakening of community life

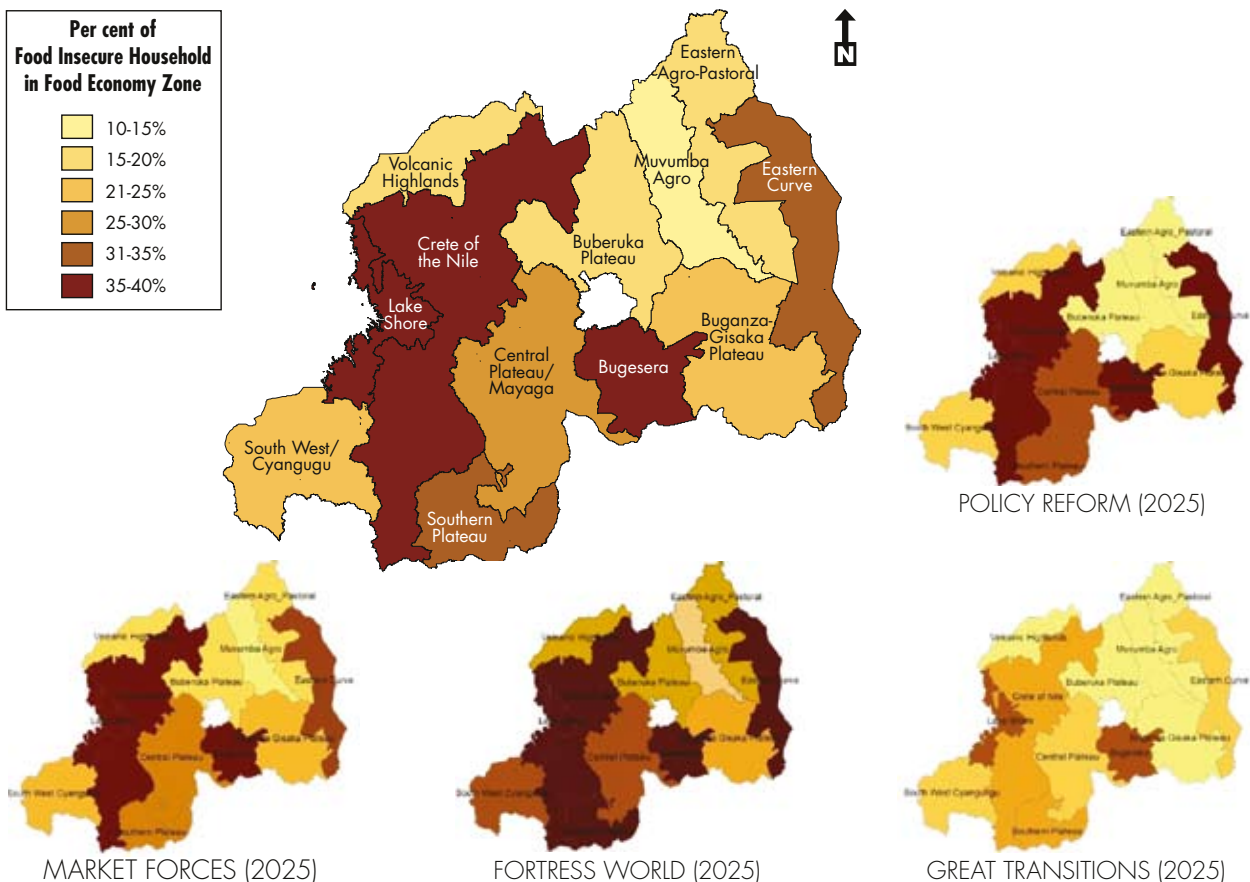
Biotechnology and nanotechnology

- Rwanda adopts biotechnology with shifts from 'for or against' biotechnology to new concepts of alternative 'biotechnology development paths,' some of which are highly problematic while others are promising in terms of health and environmental impacts
- Nanotechnology is still on the horizon, but there is extensive discussion of potential uses for environmental remediation, clean energy, and zero-waste manufacturing

Climate change

- Shift toward higher energy efficiency, fuel cells, renewables, and wellhead reforming of natural gas with CO₂ re-injection, begins to reduce CO₂ emissions
- Rwanda joins affluent nations in serious efforts to minimize climate change

Figure 5: Proportion of food insecure households in Rwanda's Food Economy Zones by 2025 under the four scenarios





Rwanda natural environment constitute an asset for tourism



Handcrafts items can be used as alternative to plastic shopping bags which cause environmental pollution

Conclusion: The Interlinkages and Policy Lessons

The scenarios explored in this chapter are presented as alternatives which aim to equip us with knowledge to reduce environmental impact and regenerate social environment. It is evident that there lie environmental impacts ahead in every pathway into 2025. More specifically, there are a variety of socio-economic changes that could be required if we are to reduce any environmental impacts and optimize economic gain under each scenario.

The Rwanda Environment Outlook scenarios work distinguishes four possible trajectories into the future: *Market Forces* - free markets, private enterprise, technological innovation and regional integration that bring growing prosperity and social progress, but with inequities and environmental stress; *Policy Reform* - reactive institutional and policy reforms enacted, no commensurate social and any particular behavioral changes; *Fortress World* - conflict between rich and poor, widespread environmental degradation, rising social instability, potential for violence and chaos create a country

with islands of prosperity surrounded by an ocean of poverty and despair; and *Great Transitions* - rising literacy, innovation and technological change, rise of civil society and greening of jobs and corporations lead to dramatically improved human development, environmental productivity, industrial efficiency.

An integrated assessment of these futures and an understanding of the interlinkages between the drivers of environmental change including climate change reveal a road map with challenges and opportunities similar to those highlighted in the country's Vision 2020 (ROR 2000). Rwanda will have to face these challenges and use the opportunities in realizing the targets set out in Vision 2020. Box 2 illustrates the current state, challenges and possibility of meeting some selected targets of the Vision 2020 and MDGs. More specifically, the country will have to streamline her planning processes to implement these 'lessons from the future'. All in all, to realize a robust Rwandan society towards 2025 a number of future lessons abound: policy shift towards deepening decentralization; institutional and legislative reforms and capacity building; genuine political will at the highest level of Government; robust traditional and formal community institutions; relevant ICT; regional integration; and support from international agencies.

Box 2: Rwanda: A futuristic strategic economy developed from a scenario perspective

The main features of Rwanda's recent socio-economic performance are contained in Republic of Rwanda (2007) and provide a context for elaborating development policy in the medium term. A futuristic view of socio-economic development strategies can be formulated from the fore-running scenario analysis.

Where is Rwanda?

- Economic growth has slowed, population growth continues to be rapid and the environment is under stress.
- Poverty has fallen, but needs to fall faster to meet the MDG and Vision 2020 targets
- Key indicators show that health has improved substantially, but inequalities in health outcomes persist.
- Access to secondary education lags behind primary, but tackling quality aspects of primary education are also a high priority
- Governance reforms are well advanced, but much remains to be done
- Improvements have been seen in a number of important areas:
- Increase economic growth through infrastructure, promotion of skills development and the Services Sector; Private Sector development and modernisation of agriculture.
- Slow down in population growth through reducing infant mortality; family planning and education outreach programmes, quality health care and schooling.
- Tackling extreme poverty through improved food security and targeted schemes of job creation and social protection.
- Efficiency in poverty reduction through better policy implementation, cross-sector coordination; sharper prioritisation of activities; better targeting of services for the poor; widespread mobilisation of the Private Sector; and the more effective use of monitoring and evaluation mechanisms.

Where does Rwanda desire to be?

Goals which reflect where Rwanda wants to be are well captured by the short, medium and long term targets in the Millennium Development Goals (MDGs) which have targets set for 2015, and the objectives of Rwanda Vision 2020 which have targets set for 2020 as well as the EDPRS with implicit targets for 2012.

Where could Rwanda be?

Given the drivers described in this chapter and the four explicit and mutually exclusive pathways leading to the worlds of Market Forces, Policy Reforms, Fortress World and Great Transitions, the country may or may not achieve its socio-economic development aspirations. Using selected MDG and Vision 2020 targets, the illustration below shows how progress might be achieved under each scenario by 2025.

MDG Vision 2020 Target	2006/7	Scenarios - 2025			
		Market Forces	Policy Reform	Fortress World	Great Transitions
Access to safe/clear water (%)	64	Orange	Light Green	Red	Dark Green
Land protection against soil erosion (%)	20	Dark Orange	Red	Red	Dark Green
Land tenure security (% of land parcels with land titles)	1	Orange	Dark Green	Red	Dark Green
Land area covered by forest	20	Dark Orange	Light Green	Orange	Dark Green
Wood energy in energy consumption (%)		Pink	Light Green	Pink	Dark Green
Rwandan population (million)	9.1	Yellow	Light Green	Orange	Light Green
Population growth rate (per cent)	2.6	Light Green	Light Green	Dark Orange	Light Green
Total fertility rate (children per woman)	6.1	Light Green	Light Green	Red	Light Green



Building in heights allow an effective land utilization



Protection of water resources



Erosion control contribute to the restoration of Rwanda's ecosystems and to the increase of agriculture productivity



Public ecological toilets in Kigali city center

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Chapter 11: Policy Analysis and Options for Action

Our lives on this planet depend on nature's provision of stability and resources. Current rates of human engendered environmental destruction threaten these resources and leave death and misery in their wakes. But we can avoid this.

But to do so we must act in concert and with a sense of urgency to make the structural and policy changes needed to maintain ecosystems and their services, control water and air pollution and reverse the trend leading to global warming

United Nations Millennium Project, 2005

Introduction

The message of the UN Millennium Project cited above is relevant to Rwanda's current poverty-environment situation. The analyses in the previous chapters indicate that human engendered environmental changes in Rwanda continue to threaten the livelihoods of the poor and the viability of the ecosystems to provide life-support services. If left unabated, the degradation of the environment and natural resources in Rwanda will undermine the country's ability to sustain economic growth that is vital to the goals of the EDPRS, including improvements in people's livelihoods. In light of the identified challenges and the opportunities, further structural and policy changes are needed in order to enable the country meet its sustainable development goals.

This chapter builds upon the results of the thematic assessments in the previous chapters, highlighting the main issues, the outlooks and the requisite structural and policy changes. It is assumed that the country will stay the course in pursuing the goals of Vision 2020, which to a large extent represents a progression from the current Rwandan situation that approximates the 'policy reform' scenario to that which approximates the 'great transition' scenario. It is further assumed that the structural and policy changes already undertaken and those underway, which benefit both the economy and the environment, will not be diluted.

Despite the documented degradation of Rwanda's environment and ecosystems, it is recognized that judicious and innovative use of the remaining environment asset can enable the country to make substantial contributions to the attainment of the

EDPRS goals, the MDGs and the New Partnership for Africa's Development (NEPAD) objectives. The imperative is that immediate actions are needed to curb ongoing degradation and innovative measures undertaken to seize the opportunities offered by the remaining stock of the environment asset. Given Rwanda's strong poverty-environment degradation spiral, the country's planners and policy makers cannot afford to ignore the price of environmental degradation in terms of declines in economic performance and people's standards of living. Postponing policy actions now in the hope of taking them later when Rwanda is wealthier seems not to be a wise option. Given the heavy dependence of the economy on the natural resource base, the continued degradation of the environment and natural resources is most likely to foreclose the prospects of future growth and further reduction in poverty.

In the sections that follow, the issues, outlooks, and possible policy actions for fostering sustainable development are provided for the various thematic areas that are assessed in the preceding chapters. The policy actions consist of both policy and structural changes, which if instituted to complement those in place, would enable Rwanda to stay the course towards its sustainable development objective. It would also enable the country to realize the national aspiration that by 2020 the Rwandan nation will be one in which the pressure on natural resources, particularly on land, water, biomass and biodiversity are reduced, the process of environmental pollution and degradation are reversed and the management and protection of these resources and the environment is more rational for the country to bequeath to future generations of Rwandese the basic wealth necessary for sustainable development.

Policy options for action

Environment and economic development

Issues

As already highlighted in Chapter 1: Environment and Development, Rwanda's economy is linked to the environment in many ways. All economic activities, including production, consumption and waste disposal, subsist on the environment. The intricate links between the country's natural resources, such as water, land, air, plants and animals requires that Rwanda

institutes policy and structural changes for more effective resolution of the challenges to sustainable development.

However, effective resolution of those challenges will depend partly on adequate public investment in the protection of environment and natural resources. To date, the budget allocation to sectors with mandates on the environment is rather minuscule given the magnitude of the challenges in ensuring environmental sustainability. Environmental stakeholders seem not to have sufficiently convinced the treasury that further investments in environment are good for both the economy and environment. From 2003 to 2007, however, the budget allocated to environment increased from 0.06 per cent to 1.15 per cent (MINITERE 2006).

Outlook

Despite the challenges posed by the global depression, Rwanda's economic performance in the medium term exhibits some degree of resilience, as the country maintains its strong record on sound macro-economic management, adequately implements its ICT policy, and effectively implements the EDPRS. These help to attract additional investments, thereby expanding employment, which in turn contributes to reducing the number of people directly dependent on agriculture with positive outcomes on the environment.

Growing civic competence within civil society enables active monitoring of economic and environmental performance. Civil society and other stakeholders make further use of the results of the ecosystem assessments and economic analysis under the Poverty-Environment (PEI) programme to engage in evidence-based advocacy for environment mainstreaming and enhanced investments in the environment and natural resources. The attendant pro-poor and pro-environment stance in policy-making, planning and budgeting yields improvements in the quality of growth and by extension promotes employment and environmental sustainability.

Possible policy actions

Notable progress has already been made in integrating environment into the EDPRS and some of the District Development Plans. Through the cleaner production programme, as already highlighted in the report, a number of industries are appreciating the mutual benefits of cleaner production to both the environment and the business bottom line (profit). There is need to appraise top executives in the ministries and parastatals as well as the country's legislators on the successes already made and what further actions

are required in sustaining the integration of environment and development. Towards this end and the overall promotion of the environment integration agenda, the following actions are proposed to complement those already underway.

- Institutionalize the integration of environment into policies, plans and programmes as provided for in the Environment Management Policy. Towards this end, appraise top executives of the various ministries and parastatals on the merits and challenges of environment mainstreaming; strengthen the capacity of sector and district planners and environmentalists for environmental assessment, poverty-environment mapping, policy analysis, economic analysis of various aspects of environmental degradation and environmental public expenditure review; and ensure the adequacy of environmental data, including its capture in future household surveys
- Apart from providing the skills mentioned above, draw upon the good practices and lessons learned from the Decentralized Environment Management Project (DEMP) and similar initiatives in the East African region to develop a strategy for effective mainstreaming of environment at the decentralized level. Supplement this with well-packaged education and information material on why environment matters and what actions the various stakeholders at the district and lower levels could take to promote environmental sustainability.
- Market failures and market distortions partly account for the ineffectiveness of environmental policies and laws despite increased efforts in applying the command and control approach in enforcement. Invest, therefore, in strengthening the capacity to assess the costs of environmental degradation (preferably via satellite account, for instance tourism) and how the various taxes and subsidies affect the achievement of environmental sustainability, with the view to developing suitable economic instruments to complement the command-and-control management regime.

Land use and agriculture

Issues

Agriculture will continue to be the mainstay of the Rwandan economy for the foreseeable future despite the documented progressive decline in its contribution to the GDP. Despite this, Rwanda's land resources are utilized in an inefficient and unsustainable manner (ROR 2000). A number of land use practices hurt both agricultural performance and environmental sustainability. These include conversion of wetlands into farms and pastures, cultivation of river banks and conversion of

forest land into farms. Some husbandry practices may also harm the environment. Excessive application of both fertilizers and pesticide is a case in point. Unless the extension service is effective, the target of increased use of fertilizers from 0.5 per cent in 2000 to 8 per cent in 2010 and 15 per cent by 2020 (ROR 2000) could adversely affect the environment, especially soil and water quality. Inappropriate management of irrigated agriculture can also have deleterious effects on soil productivity.

As revealed in Chapter 3: Land Use and Agriculture, the negative effects of changing land use and agriculture on environmental sustainability are partly linked to the piecemeal implementation of both the land policy and the land law. The limited coverage of formal land registration and its focus on urban areas and rural commercial farms and church land is affecting sustainable land management. It has been estimated that between 1.5 and 2 million land holdings would need to be registered over the next few decades, if all land in Rwanda is to be registered (DFID and MINITERE 2003). The very limited coverage of formal land registration in the rural areas is partly attributable to inability of land owners to meet the costs of land registration.

Overall, two basic constraints undermine enhanced agricultural performance: a) demographic pressures, which complicate the improvement of soil and water management, often leading to rapid decline in farm size and the disappearance of fallow period from the farming systems, over cultivation, lack of replenishment of organic matter, and cultivation of excessively steep slopes that have no erosion control measures; and b) very poor soils with low organic matter, except in lowlands and volcanic soils (ROR 2004a).



Gully erosion in Gishwati

Outlook

Unabated population growth continues to pose a formidable challenge to the loss in land productivity: as population pressure on land intensifies. The incidence of HIV and AIDS does not drastically affect population growth rate in the medium term. But the attendant morbidity adversely affects agricultural productivity, with implications for household incomes and food security.

Annual losses of 1.4 million tonnes of soil translate into a rather persistent decline in the country's capacity to feed 40,000 (Musahara 2006). Such losses adversely affect both the economy and the environment. The non-agricultural jobs in industry and services increase, thereby becoming a fetter to continued land fragmentation. In the spirit of the movement towards the great transition to sustainable development, the Government aggressively pursues the following Vision 2020 targets: a) reducing agricultural population from 90 per cent in 2000 to 75 per cent in 2010 and 50 per cent by 2020; and b) increasing non-agricultural jobs from 200,000 in 2000 to 500,000 in 2010 to 1,400,000 by 2020. An increase in the number of jobs in the industrial and services sector helps to reduce the number of people dependent on agriculture for their livelihoods. A positive environment gain is made.

In the short to medium term, the internal migration of the population from land scarce areas to those that seem to have land does not effectively solve the problem of land scarcity in Rwanda. Land scarcity, therefore, drives the needy population to encroach on the wetlands and forests. Government's capacity to enforce environment policies and laws on forests and wetlands does not improve sufficiently, resulting in unabated degradation of the wetlands and forests. Government institutes ways and means of ensuring that the land rights of people in the rural areas are secure; and this helps to avert land use conflicts. Those farmers with land titles use them as collateral to seek commercial loans for farm improvements. Sustainable land management is therefore enhanced.

The conflicts in jurisdiction and interest between the ministry responsible for agriculture and that for environment regarding the utilization of the land resource are adequately resolved in the medium term. In the short term, REMA takes statutory actions to ensure that there is sufficient compliance with the EIA requirements by those developing the wetlands.

The vulnerability of Rwanda's agriculture to climate change and the interest of Government in ensuring food security compel Government to pursue adaptive measures in mitigating the impacts of climate variability and climate change. In the same vein, Government enhances the capacity of its delegations to the international negotiations on a new global regime for managing climate change. It also seeks to access available trust and non-trust funds for mitigation and adaptation to climate change.



Population pressure is leading to encroachment on the Gishwati Natural Forest

Possible policy action

The Strategic Plan for Agricultural Transformation in Rwanda (ROR 2004a), if properly implemented, is likely to contribute to economic growth, poverty reduction and the protection of the environment and natural resources. The principle that the protection of the land heritage is the responsibility of those using it is endeared by a growing segment of the population. The communities should therefore be sufficiently sensitized in order to understand the need for and apply erosion control measures. Among the programme's 10 strategic axes, the one on sustainable management of natural resources, particularly water and soils, aims at stopping the destruction of soil and water resources. It provides for specific actions for the development of marshlands and irrigated agriculture.

Critical to the sustainable use of the land resource for improved agricultural performance and environmental

sustainability are the needs to strengthen the land resource rights of the poor and to enhance the ability of the poor to manage the environment. It is in this context that the following policy actions are recommended to complement those that MINAGRI, MINERA and REMA are already implementing.

- Given the issues of affordability of land registration and titling in rural areas, effectively implement the suggestion by DFID and MINITERE (2003) that a programme be instituted in the short-to-medium term to develop appropriate procedures for extending land registration to villagers and small land owners in rural areas. This will ensure that these categories of people have legally enforceable land rights
- Strengthen the capacity of community-based organizations in providing legal literacy to the poor regarding land rights in accordance with the current land policy and law. That capacity enhancement should also enable the organizations to monitor the implementation of both the land policy and land law
- In deepening decentralization, provide sufficient capacity development support and funds to the environment and other relevant committees at district and lower levels so that they can effectively execute their mandates on land and agriculture and also meet the environmental sustainability objective

Climate change and natural disasters

Issues

Having an economy that is heavily dependent on rain-fed agriculture, Rwanda's economy and people's livelihoods are vulnerable to climate variability and climate change. Agriculture, biodiversity, water resources are more likely to be affected by climate variability and climate change. Floods, droughts, landslides and increased incidences of malaria and cholera have been the main outcomes so far. Droughts, especially in the Bugesera region, have often translated into food insecurity in an area that previously was food secure. Besides the disasters associated with floods and droughts, Rwanda also is periodically affected by volcanic eruptions especially north-western part of the country.

Outlook

In the short to medium term, the reality of climate change in Rwanda evokes strategic actions in dealing with it. The dominant position of indifference to climate change alters considerably as the country experiences persistent ravages of floods, droughts and land slides. Many are now convinced by President Paul Kagame's affirmation that 'it does not help

us a great deal to keep citing the fact that climate change is expected to worsen our continental and national situation'. They, therefore, overwhelmingly endorse his advice that 'our preoccupation should be about implementing corrective measures' (ROR 2008).

Crucially, Government encourages investments in the careful understanding of the nature and impacts of climate variability and climate change on the economy and people's livelihoods. In trying to move from the policy reform to a great transitions agenda, Government and its development partners deliberately use the locally generated knowledge to support the mainstreaming of climate change into national and sector policies, plans and programmes. Similarly, Government and other funding agencies require climate proofing of investments in climate-sensitive sectors such as agriculture, water, infrastructure and health.

In the spirit of regional and global cooperation on the problem posed by climate change, Rwanda strengthens the capacity of its functionaries with mandates on this subject in order to ensure adequate information sharing with regional and global partners, effective participation in regional and global climate change fora, and collective action in terms of regional and global actions on mitigation of and adaptation to climate change. Its environment agencies, especially REMA aggressively seeks to access the available trust and non-trust funds to support Rwanda's activities in response to climate change.



Property destroyed in Bigogwe (Nyabihu District) in former Gishwati Natural Forest area

Possible policy actions

As a party to the United Nations Framework Convention on Climate Change and the Kyoto Protocol, Rwanda has taken actions in responding to the effects of climate change. These are already highlighted in the chapter on climate change and natural disasters. For purposes of reinforcing actions already underway, it is hereby proposed that the following actions that are also relevant for the Eastern Africa region (Orindi and Murray 2005) be considered.

- Document the nature and impacts of climate change, especially in the very sensitive sectors such as agriculture, infrastructure, water and health.
- Understand, document and strengthen existing livelihood coping strategies rather than imposing new, high-tech solutions.
- Coordinate efforts within and between Governments, private sector and civil society in promoting adaptation to climate change and sustainable development through sharing ideas. This will encourage innovation and maximize the efficiency with which limited resources are used.
- Integrate climate change adaptation into the development agenda across all sectors and levels of Government.
- Strengthen national capacity for effective engagement in the regional and global negotiations and collective actions to mitigate and adapt to climate change.

Biodiversity and genetic resources

Issues

Rwanda is a small country but with a wealth of biodiversity as is documented in Chapter 5: Biodiversity and Genetic Resources. However, having the highest population density in Africa and being heavily dependent on agriculture and natural resources, biodiversity, including genetic resources, face major threats from population pressure. Additional threats come from the conversion of natural habitats by human activities (mining and changes in land use) and the introduction of alien species. Some biodiversity and genetic resources are trans-boundary in nature and are therefore liable to population pressure and other threats from neighbouring countries. The insecurity in the Great Lakes region and the reported plunder of natural resources has also degraded the biodiversity and genetic resources to some extent. Rwanda-specific insecurity that culminated in the genocide also contributed to the erosion of the country's biodiversity and genetic resources.



A waterfall in Nyungwe national park

However, there are a number of opportunities that Rwanda could seize in promoting conservation and sustainable use of its biodiversity and genetic resources. These include the promotion of nature-based tourism, using the genetic resources in developing pharmaceutical and cosmetic industries, and using relevant components of the biodiversity to participate in global trade in carbon. Of concern are the lack of a biodiversity policy and law; weak enforcement of existing policies and laws and the lack of protection of biodiversity outside the protected areas as well as the endangered species and important bird species.

Outlook

Rwanda's biodiversity, especially its mountain gorillas continues to attract tourists, thereby enhancing revenue

generation from the tourism sector. The efforts of governments in the Great Lakes region to restore stability should ease the threats posed to Rwanda's biodiversity, especially the mountain gorillas. The weak slowdown in population growth and the continuing scarcity of land sustains the pressure that communities, especially those neighbouring the protected areas, exert on the biodiversity in protected areas. In aiming to transit from the policy reform to the great transitions agenda, Government provides sufficient incentives through co-management schemes to enable communities living around protected areas to commit to compliance with policies and laws governing protected areas.

Biodiversity outside protected areas continues to be vulnerable to erosion. Although actions by REMA succeed in

reducing water pollution by industrialists and developers of wetlands, the recovery of aquatic biodiversity is negligible. And as the country becomes more open to biotechnology and opens up to regional and international cooperation on developing biotechnology, there is initial vulnerability to the erosion of genetic resources due to the clandestine actions of gene hunters who pose as tourists in Rwanda. However, in the interest of reaping the financial benefits associated with the Convention on Biological Diversity, Rwanda builds national capacity to develop and implement national and regional projects supported by the Global Environment Facility (GEF).

Possible policy actions

Given the benefits that accrue from the biodiversity resources to the country, especially through tourism, Rwanda will continue to invest in better management of protected areas. The biodiversity and genetic resources outside protected areas are however equally important to Rwanda's development. Use of biotechnology by pharmaceutical and cosmetic industries accords growing importance to soil, aquatic and other forms of biodiversity that are currently unprotected. There is also local indigenous knowledge and technology that Rwandese use in reaping benefits from these biodiversity and genetic resources. This also deserves some protection.

Those who are the repository of such knowledge but are poor can very easily be lured into providing the information to gene hunters at negligible fees. For purposes of complementing existing policy and legal regimes that relate to the use and management of biodiversity and genetic resources, the following additional policy actions are proposed.

- Develop and promulgate biodiversity policy and law taking account of the existing biodiversity strategy and action plan developed under GEF. The biodiversity policy and law should adequately cover wildlife and other important genetic resources outside protected areas. They should also regulate research on biological resources, bio-prospecting and the patent rights of those who are repository of indigenous knowledge and technology.
- Once the new policy and law on biodiversity is in force, harmonize other existing policies and laws that relate to the protection of biodiversity and genetic resources with the new policy and law. Build capacity for effective enforcement of these policies and laws, including the development and application of appropriate economic instruments.

- For adequate biodiversity profiling that is central to effective management, strengthen national capacity for taxonomy, ethno-biology and ecology.

Forests and protected areas

Issues

The role of forests in preserving ecological balance is particularly important. Forests contribute greatly to watershed protection against erosion, thus making agriculture viable and also covering the daily basic wood needs for most of the country's population. Additionally, forests generate direct monetary incomes, thereby contributing to poverty reduction (ROR 2004b). In 1993 forests covered 26 per cent of the land area but by 2004 it covered only 19 per cent (ROR 2004b). Due to the genocide experienced by the country and inadequate investment in the training of foresters, currently there are few forest technicians.

The main threat to forests is the rapid increase in population, which is leading to forest encroachment and deforestation. Thus there is increasing wood shortage in the country. Factors accounting for this include: a) heavy (96 per cent) dependence of the population on wood as a source of domestic energy (ROR 2004b); b) weak afforestation efforts, especially between 1994 and 2001; c) dwindling population enthusiasm in afforestation; and d) weak institutional capacity that has rendered forest management ineffective.

Government efforts in increasing the forest coverage have been up against the following threats. Because of the increasing population pressure on land, the available land for reforestation is very limited. Only marginal land is usually available for reforestation. There is also shortage of forestry extension staff, which has weakened the support provided by the extension service. The population is no longer enthusiastic in tree planting. The profitability of reforestation remains uncertain and farfetched.

Outlook

In the medium term, the Rwandan population continues to depend on wood as a major source of its energy. However, given the problem of land scarcity that is yet to be resolved, the demand for wood outstrips supply. Resort to crop residues and animal wastes (dung) as sources of biomass energy becomes deleterious to soil structure and soil fertility. Extensive efforts by the NGOs and CBOs to promote energy-saving cook stoves help to avert the domestic energy crisis and the

adverse nutritional outcomes that are usually associated with preferences for foods that do not require too much energy for cooking.

The revitalization of the forestry extension service, however, enables the promotion of agro-forestry and the propagation and diffusion of locally adapted fast growing tree species. Government and the NGOs support communities and local governments into using woodlots and forests outside the protected areas to earn carbon funds. Similar efforts are made in using payment for environmental services to protect watersheds, thereby yielding benefits for the watershed forests as well as upstream and downstream communities.

As Government makes a strategic shift from a policy reform agenda to that of promoting sustainable development, it effectively uses the policy inter-linkages approach inherent in the forest policy, and performance contracts associated with results-based management, to achieve the Vision 2020 target of increasing access to electric energy from 2 per cent in 2000 to 35 per cent in 2020; and reduce the contribution of wood energy in the national energy consumption from 94 per cent in 2000 to 50 per cent in 2020. The decentralization policy is applied fully to devolve

authority and resource control to local governments. The capacity of local governments is sufficiently strengthened to avoid a negative backlash of devolution on environmental sustainability. The country's anticorruption measures are taken to eliminate practices in the forest sector that work against the interest of the poor. Government makes efforts to ensure that continued access to forests by nearby communities in order to harvest non-timber forest products to meet their livelihoods needs does not compromise the ecological integrity of the forest ecosystem.

Possible policy actions

Although the contributions of forests to the economy and people's livelihood appear to be substantial, an empirical documentation of those contributions is yet to be done. That empirical documental should, for instance, reveal the extent to which timber and non-timber products, carbon trade, and so on, contribute to Rwanda's economic growth. In addition to the ongoing efforts to improve the governance of the forest sector and to ensure effective compliance with the forest policy and law, the following additional actions are proposed:

Strengthen further the National Forest Authority to ensure improved governance and stewardship of the forest resources.



A sample of energy saving cook stoves ready for sale



© REMA

Building and cultivation close to river banks such as along the Nyabugogo River is a threat to the wetlands and water quality

- Strengthen the human resource capacity of the forest sector to ensure effective provision of technical and extension services.
- Promote agro-forestry that is well adapted to the land availability situation in Rwanda, taking special account of the needs of the land holders.
- Invest in the quantification of the contribution of forests to economic growth and poverty reduction.
- Sensitize the local communities and local governments on the opportunities for earning incomes through payment for environmental services and the earning of carbon funds. Build the capacities of relevant Government agencies and local NGOs to support the communities and local governments in seizing these opportunities.

and unchecked pollution as a result of untreated wastes (both domestic and industrial) being dumped into water courses. In urban areas, non-treated effluents are also dumped in rivers and marshlands. In urban and peri-urban areas, where sewerage pits are constructed in areas with high water table, like those close to marshlands or streams, water contamination is usually high. Also most of the industries in the country lack waste treatment facilities and discharge their effluents directly into water courses near them. Inappropriate application of fertilizers and pesticides also is also contributing to the contamination of water sources. When tests were conducted to establish water quality, the results revealed that some rivers contained high levels of the elements under investigation, well beyond those recommendation by WHO for drinking water (NUR 2002).

Water resources and wetlands

Issues

Although Rwanda possesses abundant water resources, the distribution of drinkable water is still inadequate and the rate of access in the country is estimated at 54 per cent, and does not exceed 44 per cent in rural areas (ROR 2004c). Some of the water sources have been subjected to heavy

Sediment loads from erosion water from deforested areas tends to contaminate lakes and rivers and interfere with the smooth flow of water that feeds into hydro-electric power stations. The degradation of wetlands by human activities is disrupting the provision of ecosystem services and impacting on the livelihoods of people who depend on wetland

resources. In situations where industries located in the wetlands fail to institute and implement adequate environment management plans, such wetlands are degraded. Where wetlands are drained for agricultural production, there tends to be a reduction in the water recharge capacity of and the overall water availability from such wetlands.

Outlook

Despite the apparent abundant availability of the water resources, unabated population growth rates in the medium term and the slow progress made by industries and developers of wetlands to ensure that their activities do not unduly contaminate the water courses; the per capita availability of clean and safe drinking water is reduced. Despite the tradition of a strong policy reform agenda in the last decade, there is considerable resistance to the introduction of demand management in the water sector. Political pressure has been exerted on the water utility to defer the revision of the water tariffs to reflect the economic value of water.

In the short to medium term, the competition for water for the various end uses intensifies. In response, the Government together with the civil society and the private sector invoke the country's decentralization, democratization and anticorruption principles to demand and institute a drastic reform of the water, agricultural and the industrial sectors. The upshot of this is an Integrated Water Resources Management regime, which becomes the norm for Rwanda. The anxiety to avoid the water and water-related energy crises compels Government to intensify inter-ministerial collaboration in the critical sectors such as water, energy, agriculture and industry.

At the same time, the economic pressures from the global recession impacts on the local economy, compelling industrialists to aggressively search for technologies that are more energy efficient. In the short run, the industrialists also join environmentalists and civil society in demanding that actions be taken to prevent a repeat of the recent energy crisis that resulted from reduced water flow from degraded wetlands into the hydro-electric power stations. REMA takes advantage of this movement and mobilizes sufficient resources to strengthen the capacity to guide on sustainable use and management of the wetland. It also strengthens the capacity for EIA, SEA, environmental audits and the monitoring of water quality.

Possible policy actions

In addition to the actions that are underway such as the establishment of the water resources management units in various ministries and piloting cleaner production approaches, additional actions are needed to ensure improved per capita availability of clean and safe water. Protection of the wetlands is also required to ensure that the ecosystem services they provide are not disrupted. The following are some of the proposed actions.

- Ensure that the integrated water resources management regime is in force and scaled up.
- Expand the cleaner production programme to cover more industries, while producing an empirical documentation of the benefits of the programme to the environment, industry and the economy.
- Intensify water quality monitoring and where practical train and engage the environment committees at the district level to support this effort.
- Encourage the water utilities and other relevant Government agencies to explore the feasibility and viability of water demand management, taking sufficient account of the rights of both the environment and the poor to water for sustaining ecological functions and human livelihoods, respectively.
- Finalize the classification and inventorying of wetlands in order to institute adequate wetlands management regimes.
- Harmonize and rationalize the function and mandates of the ministries responsible for both agriculture and the environment so as not to compromise the availability of wetland ecosystem services.

Energy resources

Issues

In Rwanda biomass based fuels dominate the energy scenario, with an estimated 96 per cent of the total energy supply made up of firewood, charcoal and agricultural residues (ROR 2004d). Energy consumption is intricately linked to environment and natural resources. Increased firewood and charcoal usage in the country contributes to deforestation. The use of agricultural residues as fuel in rural areas results in the loss of soil nutrients, thereby undermining agricultural productivity.

Energy use in most manufacturing industries in Rwanda is inefficient, largely because the equipment is old and the technologies in use are outdated. In the transport sector the energy challenge is to ensure efficient and safe use of

petroleum products. The standard of vehicles is a problem, given that many of them are reconditioned.

The increasing demand for energy in the modern sector has necessitated searching for alternative sources of energy. While expanding hydro-electricity remains an option, the Government is also keenly prospecting on the methane gas in Lake Kivu. Micro-hydro, geo-thermal, wind solar and peat are the renewable energy options under consideration.

Outlook

In an attempt to increase non-agricultural jobs from the base level of 200,000 in 2000 up to 1,400,000 by 2020, Rwanda pursues a vigorous programme of restructuring the economy so that the manufacturing and service sectors can contribute to growth in employment. The economic pressures arising from the ripple effects of the economic depression in the industrialized countries, however, makes energy efficiency in the transport and manufacturing sectors a critical issue in the medium term. Manufacturers voluntarily seek to replace some of their rather archaic equipment and technologies with minimal need for staff layoff.

In the short to medium term, there is more focus on the energy supply side. Prospecting for methane in Lake Kivu is accelerated and the piloting of production is fast-tracked in order to provide an alternative source of energy. Similar efforts are made in the renewable energy sub-sector. Scientific data collection on different sources of renewable energy becomes a priority. Furthermore, civil society organizations join other lobbyists in naming and shaming industries that are bent on frustrating the up scaling of the cleaner production programme. This is in addition to aggressive efforts to expand the use of energy efficient cook stoves and energy-efficient kilns for brick making, especially in areas already experiencing deficits in the availability of woody biomass.

In the medium term, rather than just sticking to the command and control approach to ensure that there is a positive link between energy consumption and environment sustainability; REMA partners with the private sector and the Ministry of Finance to develop and apply economic instruments to motivate the manufacturers to comply with environmental policy and law. It also strengthens its EIA unit in order to ensure timely community-level hearings on the EIA reports and rapid turn around in vetting the EIA reports.

Possible policy actions

While the current efforts by Government to develop an appropriate biomass strategy are commendable, a number of actions are needed to ensure improved energy supply, energy use efficiency and a positive energy-environmental sustainability nexus. In that regard, the following actions are proposed.

- Expeditiously develop the Lake Kivu methane and bring on-line additional hydro-power stations.
- Foster collaboration between the ministries responsible for agriculture, environment and energy to ensure that the development of wetlands does not interrupt the availability of water from the wetlands that feed hydro-power stations.
- Implement a wood and charcoal efficiency and a substitution strategy that can help curb deforestation.
- Make rural energy and electrification an integral part of the country's rural transformation and poverty reduction strategy with the view to achieving the Vision 2020 targets on percentage of the population with access to electricity.
- Enforce the SEA and EIA requirement in the development of new energy supply systems

Industry and mining

Issues

The majority of the industrial processing operations in Rwanda use fuel wood as a source of energy, thereby accelerating deforestation. This poses a threat of land degradation through accelerated soil erosion with adverse consequences for the environment and agriculture. In the Kigali city area, a significant number of factories are located in a low lying area – the Gikondo wetland. These factories have no proper liquid-waste disposal systems, and consequently pollute soils, ground and surface water. Generally, it is rare to find industrial enterprises that have efficient systems of liquid or effluent water processing and elimination. The waste water is discharged to environment without any preliminary treatment (ROR 2006).

The unplanned location of industries, petroleum depots and garages contribute to the environmental pollution problems. Almost all industries, garages and workshops are located in valleys or marshes and are bordered by heavily populated areas. The chemical discharges from the industries pollute water and in some instances the soils. These pollutants are for the most part toxic to humans and animals. The industrial effluents and other pollutants created in the

Gikondo-Nyabugogo wetland system pose trans-boundary environmental challenges. The polluted waters from the industrial park in the Gikondo-Nyabugogo wetland system are discharged into the Nyabarongo River and its tributaries. The Nyabarongo, in turn, feeds the polluted waters into the Akagera River that flows into Lake Victoria.

Although mining occupies a small area of the land, it can have significant and often irreversible environmental impacts. Sand harvesting and quarrying, if done inappropriately, can result in some significant environmental impacts. The dangers that are associated with mining include the displacement of people, land use changes, dust and noise pollution. The preparation of ores which use a lot of water constitutes a major pollutant of streams. A specific case in point is the water draining the mining sectors of Rutongo and Gatumba, which pollute the rivers of Nyabarongo and Nyabugogo with clay and sand sediment. The significant environmental challenges resulting from mining operations calls for a supportive institutional coordination framework that will see successful operationalisation of existing national policies in general and environmental and mining policies in particular.

Outlook

In pursuing the transformation of the economy to achieve both a reduction in the agricultural population and an increase in the non-agricultural jobs, Rwanda, in the medium term, boosts its industrial and mining sectors. In spite of its stand on economic liberalization, the Government intervenes by insisting that industrialists and miners must respect the country's environmental policy and law. This is a clear demonstration of the country's commitment to sustainable development.

Spurred by Government's desired shift from the policy reform agenda to one of a great transition to sustainable development, REMA negotiates effectively with the development partners and obtains adequate support to strengthen its institutional capacity to ensure environmentally friendly mining and industrial production in the country. In the interest of stimulating grassroots support for effective enforcement of the laws governing mining and industry, REMA works very closely with the ministries responsible for industry, mining and local Government and civil society organizations to legally empower the local communities in areas with industrial and mining operations in using existing laws to protect their constitutional rights to a clean and productive environment.

Efforts by miners and industrialists to corrupt the poor population into turning a blind eye to pollution hit a snag as the anti-corruption agency helps the poor communities to resist corruption. The few advocates who had benefited from the training provided under REMA's auspices on environmental law volunteer to provide legal service to communities interested in instituting litigation against miners and industrialists who pollute the environment on a pro bono basis. Even baits through community social responsibility projects fail to slow down the pro-environment movement at the grassroots. Fortunately communities had been assisted by development partners in ensuring that corporate social responsibility projects had clear contracts and clearly spelt out roles and responsibilities of contracting parties, and a mutually acceptable third party to mediate corporate social responsibility conflicts.

Possible policy action

Already REMA is instituting environmental regulatory instruments such as guidelines and standards intended to ensure that the desirable speedy transformation of the economy does not undermine environmental sustainability. The piloting of the cleaner production programme has provided a basis for ensuring that industrial expansion is done in ways that are consistent with the environmental sustainability objective of the country. The following additional actions are proposed as a means of reinforcing the aforementioned ones.

- REMA should undertake its statutory obligation under the Mines and Geology Policy to study the impacts of mining and quarries on the environment so as to ensure better compliance with the existing laws and regulations on mining.
- The Cleaner Production programme should be expanded in order to ensure that expanded industrial production brings benefits to both the economy and the environment.
- In deepening decentralization, REMA should work closely with the ministries responsible for industry, mining, environment and local Government to develop the capacity of district environment committees to enable them contribute to the monitoring and enforcement of the laws and regulations governing industrial and mining operations.

Population, health and human settlement

Issues

Rwanda has a young but fast growing population. The population was 9.2 million in 2006 and is expected to reach 16 million by 2020 unless family planning education and outreach strategies are intensified. With a population density of 397 inhabitants per square kilometer, Rwanda is the most densely populated country in Africa (ROR 2000).

Like other developing countries, Rwanda is experiencing increasing rural-urban migration. Perceived availability of and convenient access to service, infrastructure, amenities and employment encourages this form of migration.

Although Government has been trying to address population access to basic services in the urban areas, there is still a significant lack of adequate water, electricity supply, sanitation systems, and garbage collection systems. Housing is in short supply and the public transport network is inadequate. Human settlements are not adequately planned and this complicates the delivery of basic social services, including education, water and sanitation. The inability of fixed-income urban employees to use modern energy services compels them to rely heavily on biomass fuels with negative environmental and health implications.

Waste management remains poor. Drainage in the cities is generally inappropriate and is contaminated with refuse. The situation isn't any better in the rural areas. Although it is estimated that 86 per cent of the Rwandan rural population have latrines, few of the latrines meet the conditions for safe hygiene and sanitation. Urban air pollution, resulting from dust particles and vehicular emissions, is growing. So are air-borne diseases caused by dust particles and vehicular emission, particularly during the dry season?

Outlook

In spite of the family planning campaigns, there is no substantial slow down in population growth in the medium term; and despite effective HIV and AIDS campaigns the incidence of the epidemic does not subside in the short and medium term. However, this does not help to reduce population growth rate substantially. Although productivity gains are made in agriculture through the implementation of the Strategic Plan for Agricultural Transformation, it does not impact substantially on the pace of rural-urban migration. Scarcity of land becomes a push factor in rural-urban migration. So does the perceived increase in urban

employment, as new industries open up and the service sector expands.

In the medium term, however, water demand management becomes a reality. The difficulties that fixed-income dwellers experience in adapting to new water tariffs force them to resort to unclean sources of water. The upshot of this is increased morbidity of this category of urban workers. Those of them with insecure contracts are laid off for frequent absenteeism from work. Consequently, their remittances to family members in rural homes are interrupted, exposing them to income and food insecurity. To make ends meet those family members are extensively engaged in making bricks, mining sand and selling fire wood for which there is growing demand. These activities, however, do contribute to localized but serious degradation of the community woodlots and the wetlands.

Possible policy actions

The implementation of the human settlement policy is commendable action by Government, which is enabling some of the communities to have better access to basic services. With adequate funding of the National Water and Sanitation Authority, access to water and sanitation is likely to improve. Sanitation, too, should improve with the scaling up of the Ecosan programme by the Ministry of Natural Resources. The following actions are proposed to complement the ongoing ones for purposes of improving human welfare, human settlements and the provision of water and sanitation services.

- Evolve a rural growth centre strategy for purposes of increasing the opportunities for self employment and the employment in services, both of which can contribute to reducing rural-urban migration.
- Intensify the family planning programme and ensure that the family development message is powerful enough to counter the traditional, cultural and religious messages that tend to run counter to objectives of family planning.
- Make sufficient investment in the *imidugudu* programme to improve on human settlement, use the same opportunity to promote the uptake of energy-saving cook stoves, replanting of degraded hill tops in the neighbourhood and better provision of education, water, sanitation and health services.
- Encourage the districts that will be developing new DDPs to include targets on promoting environmental health in addition to the targets on environment protection.

- Seek to build and strengthen synergy between the programmes of the Ministry of Natural Resources on water and sanitation and those of the National Water and Sanitation Authority for purposes of enabling the country to meet its EDPRS and MDG targets on water and sanitation.

Environmental policies, legislation and institutional arrangements

Issues

Rwanda has made a remarkable progress in the development and implementation of environmental policies and legislation. A number of new policies and laws were promulgated in 2004. Many of these policies in sectors such as energy and industry make provision for issues of environmental sustainability. The country's institutional architecture for promoting environmental sustainability has also improved. The establishment of REMA in 2006 provided the country with the institutional machinery for supporting the implementation of the environmental policies and laws. The post genocide political dispensation, especially the principles associated with decentralization and democratization, has helped to ensure the engagement of the population in development of Rwanda's environmental policies and laws. Globally, poor people who are largely dependent on natural resources continue to have precarious livelihoods. Thus the question of their participation in policies that determine the security of their livelihood and the state of livelihood resources is important (IIED and IDS 2004).

There is growing consciousness in the country on the need to always examine the inter-linkages of policies and laws, especially when developing new and reviewing old policies and laws. The development of the Forest Policy attests to this. However, the capacity for policy implementation is weak at both the central and local Government levels. There is also heavy reliance on the command and control regime in the enforcement of environmental policies and laws. Efforts at domesticating the international environmental policies and laws that Rwanda has ratified remain weak. Although action plans for the implementation of these policies and laws have been developed, the tendency of not mainstreaming their key interventions into national and sector plans and programmes has tended to leave the plans with insufficient or no funding.

Outlook

In the short to medium term, environmental stakeholders, through REMA, succeed in sustaining the momentum on

environment mainstreaming that began with the integration of environment in the EDPRS. With continued funding from the development partners, REMA uses the second phase of the PEI and DEMP to rally more environment champions at both the national and district level. New and credible evidence continues to emerge from national and district levels on the costs the country is incurring by not investing sufficiently in environment management. On the plus side, there are some success stories on the benefits of additional investments in environment protection. The industrialists also are happy with the well-targeted second phase of the cleaner production programme. They now talk openly of how the programme has clearly demonstrated to them the benefits of environment protection to both industry and the economy. 'Win-win' is now a common slogan among industrialists.

Also in the short to medium term, a movement within civil society for the harmonization and rationalization of environmental and other related policies and laws gains momentum. The first annual review of the EDPRS sparked this movement and there is now growing demand for careful examination of the inter-linkages among policies and laws with the view to strengthening synergies, minimizing overlaps and eliminating policy conflicts. At that EDPRS review, a serious concern was also raised on the growing incapacity to implement environmental policies and laws. It was also observed at the EDPRS review that while the civil service reform helped to streamline the roles and responsibilities of the sector ministries and districts on this matter, it left the ministry too lean to provide adequate capacity development support to the districts. There was also anxiety on the capacity of REMA. Concerns were raised by the developers in the agricultural and industrial sectors that the vetting of their EIA reports by REMA has been unduly delayed. REMA's capacity in social marketing was also questioned.

Stunned by the increasing levels of water pollution in areas where mining and manufacturing occur, the coalition of advocates for environment protection, through the Parliamentary Committee on Environment and Natural Resources, convinces Cabinet to sanction annual budget allocation for the training of advocates on the country's environment law as a means of enhancing enforcement capacity. They also renew, to Cabinet, their commitment to provide *pro bono* legal services in helping community litigations against polluters so that the polluter pays principle is adequately applied.

Proposed policy actions

In addition to the ongoing implementation of environmental laws and policies and the strengthening of institutional capacity, the following actions are proposed.

- Increase the knowledge and awareness of the general public on environment laws and policies in order to facilitate public participation in the EIA public hearings in particular and in public decision making in general.
- Strengthen the human resource capacity of environmental and related institutions at national and district levels for environment assessment, policy analysis, monitoring and enforcement.
- Invest adequately in the training of advocates in environment law.
- Fill the critical gaps in environment policies and laws, ensuring that the inter-linkages approach is adhered to in the development of new policies and laws.
- Determine the actual institutional deficits and areas of overlap and conflict in order to strengthen the implementation capacities of the various agencies with mandates on natural resources and environment. Correct the deficits through a combination of staff training, adequate funding and governmental reform.

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