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Rwanda Country Situational Analysis

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Introduction to the Assignment

Camco has awarded the contract to assist the East African community (EAC) in the development of a regional Climate Change Master Plan. The purpose of the EAC Climate change master Plan is to provide a comprehensive and cohesive framework for the effective coordinated response to climate change adaptation and mitigation issues affecting the region. In collaboration with EAC Secretariat and respective EAC countries, Camco works with close collaboration working groups of experts in addition to a group of National Experts from EAC countries contracted by CAMCO to complete the assignment.

This report focus on climate change and development issues in Rwanda. In particular, the report provide technical meteorological elements of climate change and their impacts on the region and particular climate change issues for Rwanda.

The report highlights followings:

- (i) Critical review and compilation of a situation analysis of Rwanda for the Master Plan. The situation analysis explicitly include a review and commentary of the all structures at national and sub-national levels including constitutional, policy and legislative structures concerning climate change and related issues in Rwanda.
- (ii) Identification of a comprehensive review of all climate change related issues and events in Rwanda to be included in the Master Plan.

List of Acronyms

AAP: African Adaptation Program
AfDB: African Development Bank
AR4: Fourth Assessment Report
BRALIRWA: Brasserie et Limonaderie du Rwanda
CFSVA: Comprehensive Food Security and Vulnerability Analysis
CIF: Cost, insurance, freight
DRC: Democratic Republic of Congo
EAC: East African Community
EACCCMP: EAC Climate Change Master Plan
EATTFP: East African Trade and Transport Facilitation Project
ECMWF: European Centre for Medium-range Weather Forecast
ENSO: El-Nino Southern Oscillation
FAO: Food and Agriculture Organization
FOB: Free on board
GDP: Growth Domestic Product
GFS: Global Forecasting System
GoR: Government of Rwanda
GTZ: Deutsche Gesellschaft für Technische Zusammenarbeit (German technical cooperation)
IBA: Important Bird Area
IDA: International Development Association
IMF: International Monetary Fund
IPCC: Intergovernmental Panel on Climate Change
IRST: Institut National de Recherche Scientifique et Technologique
IRWR: Internal Renewable Water Resource
ITCZ: Inter-tropical Convergence Zone
IUCN: International Union for Conservation of Nature
LPG: Liquefied petroleum Gas
MDGs: Millennium Development Goals
MESSIR: Message Switching and Meteorological Telecommunication
MINECOFIN: Ministry of Finance and Economic Planning
MINELA: Ministry of Environment and Lands
MININFRA: Ministry of Infrastructure
MINITERE: Ministère des Terres, de l'Environnement, de l'Eau et des Forêts (Currently
MNELA: Ministry of Environment and Lands)
MSG: Meteosat Second Generation
NBR: National Bank of Rwanda
NCEP: National Centre for Environment Prediction
NEPAD: New Economic Partnership for African Development
NISR: National Institute of Statistics in Rwanda
NWP: Numerical Weather Prediction
ROR: Republic of Rwanda
SAIC: Science Applications International Cooperation
SINELAC: Société Internationale d'Electrification des Pays des Grands Lacs
SNEL: Société Nationale d'Electricité
SSB: Single-sideband modulation
SST : Sea surface Temperature
TAR: Third Assessment Report
TOE: Ton Oil Equivalent
WG I: Working Group One

Contents

Introduction to the Assignment.....	2
List of Acronyms	3
Contents.....	4
List of Figures.....	6
List of tables.....	7
Summary.....	8
1 Country Background.....	13
1.1 Location and introduction	13
1.1.1 Location	13
1.1.2 Topographic features	14
1.1.3 Water resources and wetlands.....	15
1.1.4 Land use	17
1.1.5 Natural resources.....	18
1.1.6 Physical infrastructures	21
1.2 Population	23
1.3 Rwanda's Political Origins and Evolution	25
1.4 Economy	26
1.4.1 Macro-economic Indicators.....	27
1.4.2 Inflation	27
1.4.3 External Debt	28
1.4.4 Trade.....	28
1.4.5 Economic growth	30
1.5 Energy Sources and security	31
1.5.1 Biomass	31
1.5.2 Petroleum products.....	33
1.5.3 Electricity and hydropower	34
1.5.4 Methane gas.....	36
1.5.5 Peat, Geothermal, Wind	37
1.5.6 Solar energy.....	38
1.5.7 Other energy sources and perspectives	39
1.5.8 Energy balance	40
1.5.9 Cross-border and regional implication for Energy Security	42
2 Climatic Trends and Variability.....	45
2.1 Background and history on climate observing system in Rwanda.....	45
2.2 Summary of key climate features	46

2.3	Trends of Precipitation and Temperature	48
2.3.1	Observed rainfall trends	49
2.3.2	Observed trends of temperature	51
2.4	Climate modelling and future projection	52
2.4.1	Results from AR4 Global climate models	53
2.4.2	Results from Royal Netherland meteorological Institute	53
2.4.3	Future temperature projections	54
3	Climate Change Challenges, Risks and Impacts	56
3.1	Agriculture and Food Security	56
3.1.1	Presentation of agriculture, livestock and fishing	56
3.1.2	Vulnerability of climate change on agriculture and food security	57
3.1.3	Climate vulnerability in the area of livestock and fish farming	60
3.1.4	Cross-Border and regional Implication in Agriculture and Food Security	60
3.2	Water resources	61
3.3	Natural resources	62
3.4	Energy Security	64
3.5	Physical infrastructure	65
3.6	Social infrastructures	66
4	Country climate change Response Initiative	68
4.1	Compliance with multilateral environmental obligations	68
4.2	Policy framework	69
4.3	Organization framework	71
4.4	Rwanda's Economic Development and Poverty Reduction Strategy (EDPRS)	72
4.5	Environment and climate change sector strategic plan 2010 - 2015	76
4.6	Existing Financing mechanisms under UNFCCC and Kyoto Protocol	80
4.7	Existing Financing mechanisms under Bi and Multilateral Cooperation	80
	Reference	83

List of Figures

Figure 1 Location of Rwanda in the heart of Africa	13
Figure 2 Rwanda, neighbors and location in EAC.....	14
Figure 3 Rwanda topographic features	15
Figure 4 Rwanda water resource network.....	16
Figure 5 A family of Mountain Gorillas	19
Figure 6 Rwanda protected area 2009.....	21
Figure 7 Kigali International Airport and national flag Carrier	22
Figure 8 Population densities by district in 2009	24
Figure 9 Population trends in Rwanda	24
Figure 10 Domestic firewood (1) and Mulindi tea factory firewood (2)	32
Figure 11 An inefficient traditional kiln for burning charcoal.....	33
Figure 12 Location of principal potential energy sources.....	36
Figure 13 Methane gas power plants in Lake Kivu.....	37
Figure 14 Global Solar radiations in Rwanda (kWh/m ² /day)	38
Figure 15 Regional interconnections of electric power	43
Figure 16 : Map showing relief and climate elements	48
Figure 17 Annual Number of rain days (days) at Kigali station	51
Figure 18 Variation of the annual average temperature in °C at Kigali and Kamembe stations.....	52
Figure 19 Observed and projected rainfall for short rain (October-December).....	54
Figure 20 Erosion phenomena in cultivated lands.....	58
Figure 21 Crop failure in Eastern Province due to the 2005 prolonged drought	58
Figure 22 Food insecurity per district in 2009.....	59
Figure 23 Dried out river during the drought	62
Figure 24 The draw-down of water table led to the conversion of this part of Rugezi marsh in pastureland	63
Figure 25 Cattle graze in the forest in Akagera National Park, especially during periods of drought.....	63
Figure 26 Water level decline on Lake Burera which supplies Hydroelectric plants of Ntaruka and Mukungwa.....	64
Figure 27 Landslides on Gikongoro-Cyangugu road in Nyungwe National Park.....	65
Figure 28 Flooded roads in Nyabihu (12th Sep 2007) and Nyandungu (23 rd Jan 2010).....	65
Figure 29 Flooded farm and human settlement in Bigogwe, Nyabihu District, on 12th Septembre 2007	66
Figure 30 Destruction of unplanned urban (Kigali) settlement due to heavy rains and Floods in the Hotel La Palisse compound (Photo of 23 rd January 2010)	67

List of tables

Table 1 Estimated and Projected water demand.....	17
Table 2 Characteristics of Rwanda population in 2008-2009.....	23
Table 3 Import of Rwanda by country/region of origin (Millions of USD)	29
Table 4 Trade balance	30
Table 5 Wood consumption and projection (tones par year)	32
Table 6 Evolution in the importation of petroleum products 2002-2006 (tones)	34
Table 7 Electricity production, importation and exportation (Kwh) from 2005 to 2009.....	35
Table 8 Summary of Rwanda's energy balance in Ton Oil Equivalent (TOE), 2007	41
Table 9 National production, importation and exportation comparisons (in kWh).....	42
Table 10 Kigali Monthly and annual average number of rain days for 1971-1990 and 1991-2010 periods.....	50
Table 11 Monthly and annual average rainfall totals and standard deviation.....	50
Table 12: Observed climate related disasters from 1998 to 2002	56
Table 13 Targets of the EDPRS in 2012.....	75
Table 14 Budget estimate for Climate change strategic plan (2010/2015).....	78
Table 15 Existing financing mechanisms under UNFCCC and Kyoto Protocol	80
Table 16 Main Climate change projects in Rwanda.....	81

Summary

Rwanda is geographically located in Central Africa between 1°04' and 2°51' south latitude, and between 28°45' and 31°15' east longitude. It has an area of 26,338 km², with an average density of about 321 inhabitants per km² and 433 inhabitants per km² as regards physiological density. Rwanda is land located country bordering with Burundi in South, Tanzania in East, Uganda in North and Democratic Republic of Congo in West.

Rwanda is divided in compartments varying from 1,000 m to 4,500 m of altitude. The country is essentially mountainous with over 70% of the cultivated land surface presenting slopes superior to 10%. The processes of erosion generated hills of various shapes on the major part of it. Mountains are generally separated by a network of valleys. With mountains and valleys, Rwanda is commonly known as a "**Country of the one thousand hills**". 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.

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 860 marshlands, covering a total surface of 278 536 ha, which corresponds to 10.6% of the country surface, 101 lakes covering 149487 ha, and 861 rivers totaling 6462 km in length (REMA 2008). Figure 4 show the Rwanda hydrologic network including main rivers, main lakes and main swamps.

Rwanda is covered by diversified ecosystems: natural ecosystems comprising mountainous humid forests, gallery-forests, savannahs, wetlands, planted forests and agro-ecosystems. All these ecosystems host a rich variety of fauna and flora species. 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).

Rwanda is the most densely populated country in Africa with about 384 inhabitants/km². 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. Table below shows characteristics of Rwanda population according to Statistical Year Books 2010 (NISR, 2010).

Designation	2008	2009
Households	2,286,396	2,352,797
Mean Household size	4.3	4.3
Mid-year population in Millions	9.83	10.1
Density/km ²	373	384
Number of Birth	417,171	429,065
Number of Death	142,339	143,538
Rate of natural increase per 100	2.80	2.82

Characteristics of Rwanda population in 2008-2009 Source: NISR, 2010

The road network in Rwanda constitutes around 14000 km, of which 5400 km constitute the main road network. According to studies accomplished by MNINFRA in 2005-6, of the main network, only 1075 km are paved. The remaining 4325 km are earth roads.

Importation and Exportation to and from Rwanda are currently facilitated mainly with roads. Rwanda use Mombasa port through Kenya and Uganda and Dar-Es-Salaam port through Tanzania.

Rwanda's main air gateway is Kigali International Airport, located at Kanombe, approximately 10 km from Kigali City centre. In addition to Rwanda Air express, the Kigali International airport is used also by: Kenya Airways and Ethiopian with three flights a day, Brussels Airline (2 times a week) and recently by KLM once a week. This transport is mainly limited to business flights and importation of a certain category of goods.

Water transport is generally limited to commercial ships operating in Kivu Lake bordering with DRC. Rwanda has cross-border Rivers (Akagera, Akanyaru and Rusizi) but these rivers are not used for navigation. Plans are underway to conduct a feasibility and engineering study of the navigability of the Akagera River waterway, to permit multi-modal transport, ie rail/water/road, connections. Positive results of the study shall permit establishment of several multi-modal transport connections.

Rwanda doesn't have a railway. However, there is plans to construct the first part of a railway line system for Rwanda between Isaka (Tanzania) and Kigali. The rail line envisaged is about 450 km long, of which 175 km will be on the Rwandese territory and the rest on the Tanzanian soil.

Concerning Organizational framework, Rwanda has four Provinces (Northern, Southern, Eastern and Western Province) and City Kigali. The country is therefore subdivided into 30 Districts and 416 Sectors

From the political point of view, the Government Vision 2020 represents its leitmotif. Its main priorities are the environment protection and management, poverty reduction and investments promotion. To achieve these objectives, a number of sector based policies are implemented in various domains (environment, land, energy, agriculture, habitat, decentralization and good governance and management of natural disasters).

From the legal point of view, Article 49 of the Constitution of Rwanda (04/06/2003) and the organic law determining the environment protection, conservation and management, ensures a proper protection of its natural capital.

About 57 % 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 (REMA, 2009).

In Rwanda the real GDP at constant prices of 2001 grew by 6 % in 2007 against 5.5 % in 2006. GDP growth during the last 5 years has reflected a positive trend even if there was a decrease of 1.6 % 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 % respectively of the value added in 2007 compared to the previous year (NBR 2008)

The imports of the country are classified in four main categories that are the consumer goods, equipment goods, intermediate goods and energy and lubricants. In general, the consumer goods occupy the first place among the imports. In 2006, they represent 29% of the total value of imports CIF. The importance of equipment goods in overall imports recorded in these years is due to the increase of the imports of machines and equipments,

like automatic information processing machines, power generators, as well as the electric devices for telephone communication.

Concerning specifically importation of food commodities from and neighbouring countries, Rwanda imports palm oil from Burundi, rice, sugar and wheat flour from Tanzania, banana, milk and corn from Uganda and industrial food from Kenya.

The exports of Rwanda are dominated by coffee, tea and some minerals that constituted nearly 85% of the FOB value of the exports in 2004; 80% in 2005 and 2006. Although the exports revenues are increasing from 2005 to 2008, the imports costs are also drastically increased in the same period making increasing negative trade balance.

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. 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 % of the population and imported petroleum products consume more than 40 % of foreign exchange.

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 Rwanda potential of energy resources is estimated as follows:

- Hydropower: 350MW;
- Methane gas: 55 billion Nm³ with a rated capacity of 700MW;
- Geothermal power: 170-340MW;
- Solar power energy: 5.2 kWh/day/ m²;
- Peat reserves which are about 155 million tonnes of dry matter.

Domestic production of electricity is around 70%, import 29%, export, 1%, and that the cost of electricity in Rwanda is among the most expensive in the world. The regional electricity grid inter-connections are planned to allow Rwanda to share power with the rest of Africa. The report on collection of existing data from National Land Centre (NLC, 2009) the interconnection to import and export electricity as follow:

- 1000 MW from Ethiopia;
- Electricity from Zambia;
- Export from Lake Kivu

Recent testimony on climate change in Rwanda indicates that:

- Temperature increased with high frequency of warm days exceeding 30°C; this is likely to impact on increase of malaria and other diseases related to warm weather;
- The number of annual rain days decreased and this is likely to impact negatively on agricultural productivity as crops requires the quantity of water within the given number of days;

- At the same time the frequency of torrential rain increased with daily rainfall quantity sometimes exceeding the total monthly rainfall; this is natural disasters caused by floods including soil erosion;
- The number of dry spells during rainy season increased affecting poor performance of crops;
- In most cases we are observing late onset of rainfall and/or early rainfall cessation during rainy season and this also affect poor performance of agriculture productivity.

In Rwanda, there is high likelihood that rainfall quantity will increase by the end of 21st century. However model predictions are averages for long periods; daily, monthly and annual variability are uncertain. While this rainfall increase is predicted to be between 10 and 20% of observed mean rainfall in 1961-1990, there is no indication whether the temporal rainfall distribution will enough to meet future water requirements.

Concerning temperature, it is expected to increase gradually in Rwanda during the 21st century. The increase expected is from 0.75 to 3.25°C during the shorter dry season (December to February) and from 1 to 3.25°C during the longer dry season (June-August).

According to Participatory Evaluation of Poverty Report written in October 2001, climate hazards occupy the third place among 10 most important causes of poverty in Rwanda.

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 leading to drought

Disaster	Damages and consequences	Affected regions	Period (year)
Droughts	266,993 people threatened by famine	South-east and central valley	1998-2000
Floods accompanied with landslides	<ul style="list-style-type: none"> • death of 42 persons • collapsed houses: 1,244 • destructed houses: 4.605 • damaged crops: 1,645 ha • death to livestock: 159 • damaged infrastructure: 83 (50 bridges, 24 roads, 9 schools) 	The north-west and the west of the country	September to December 2001
Floods and associated erosion and landslides	<ul style="list-style-type: none"> • deaths: 66 people • collapsed houses: 1,929 • destructed houses: 1,213 • Damaged infrastructure: 116 (22 roads, 7 bridges, 16 small bridges, 2 water supply, 63 water sources, 6 schools • death of Livestock: 175 • Crops: 1,077.5 ha damaged 	North-west, south-west Kigali City	Only within May 2002

Observed climate related disasters from 1998 to 2002. Source: MININFRA, Department of Meteorology, 2004

Rwanda has ratified and signed more than 10 International Conventions and Protocols on or related to environment. Rwanda is an active participant in major international multilateral conventions relating to environmental governance, most notably the Convention on Biological Diversity (CBD), the United Nations Framework Convention on Climate Change (UNFCCC) and the Convention to Combat Desertification and Drought (UNCDD).

Sector policies have been prepared and implemented including environmental policy, agriculture policy, water policy, Energy policy, land policy, forestry policy and transport policy.

At the institutional level, the Ministry of Lands and Environment (MINELA) is the Ministry responsible for designing the state policy related to climate change management, environment protection, conservation and management, while REMA (Rwanda Environment Management Authority) is the official organ in charge of implementing this policy. From 2009, a Department of Climate Change and International Environmental Obligation (CCIO) was created and from 2010, it starts to be operational under REMA.

Under Rwanda's Economic Development and Poverty reduction Strategy (EDPRS) Environment, climate change and land priorities involve ecosystems, the rehabilitation of degraded areas and strengthening newly established central and decentralised institutions. Special attention will be paid to sustainable land tenure security through the planning and management of land registration and rational land use, soil and water conservation, reforestation, preservation of biological diversity and adaptation and mitigation against the impact of climate change.

Rwanda developed the Environment and Climate Change Strategic Plan. This strategic plan focus on design of the Climate Change comprehensive and budgeted programme with following national priorities:

- Generating spatial and thematic information on Rwanda's climate change vulnerability, including implications for poverty reduction and regional integration;
- Developing a policy and institutional framework for integrated climate change management;
- Capacity development for climate change management including disaster preparedness and response, climate change mitigation and adaptation, in a sustainable way;
- Public-private partnerships for sustainable financing and management of climate change issues, including international negotiations and communication.

Existing financing mechanisms under UNFCCC and Kyoto protocol are mainly limited to development of National communications related to UNFCCC and NAPA.

The source of funding from Bilateral and Multilateral Cooperation concerns mainly studies and ground projects. The main donors are: UNDP, UNEP, IISD, Japan, U.K. and Sweden. Following table shows the projects titles, sponsors, periods, budgets, implementing agency and area of implementation.

1 Country Background

1.1 Location and introduction

1.1.1 Location

Rwanda is geographically located in Central Africa between 1°04' and 2°51' south latitude, and between 28°45' and 31°15' east longitude. It has an area of 26,338 km², with an average density of about 321 inhabitants per km² and 433 inhabitants per km² as regards physiological density.

Rwanda is land located country bordering with Burundi in South, Tanzania in East, and Uganda in North and Democratic Republic of Congo in West. It is located in western centre of East African Community (EAC) and in the hearth of Africa on around 1,200 km from Indian Ocean, 2,200 km from Atlantic Ocean, 3,650 km from Mediterranean Sea and from 3,750 km from the South African Cap. Following maps shows Rwanda location in the hearth of Africa (Fig 1), Rwanda neighbors and location in EAC (Fig 2)



Figure 1 Location of Rwanda in the heart of Africa

Source: Google

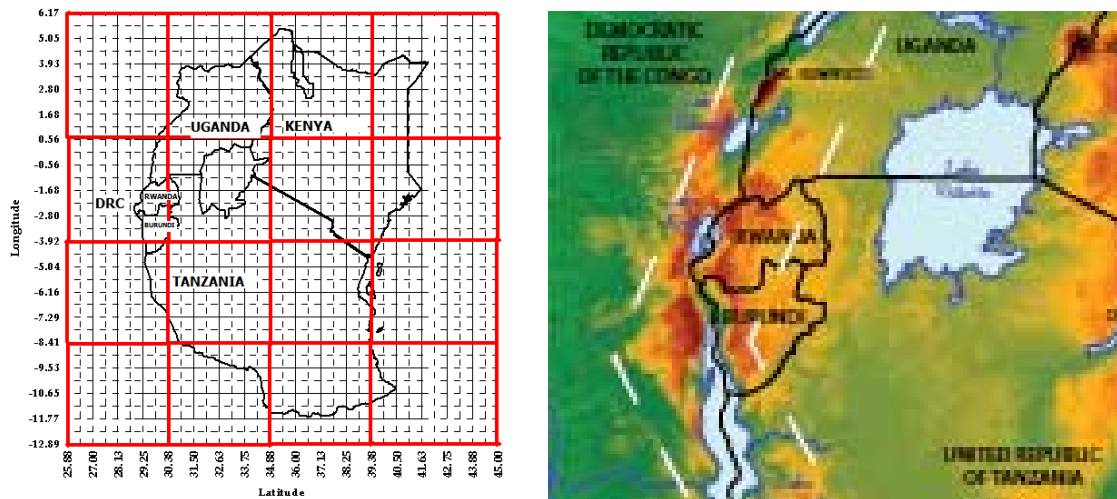


Figure 2 Rwanda, neighbors and location in EAC

1.1.2 Topographic features

Rwanda is divided in compartments varying from 1,000 m to 4,500 m of altitude. The country is essentially mountainous with over 70% of the cultivated land surface presenting slopes superior to 10%. The processes of erosion generated hills of various shapes on the major part of it. Mountains are generally separated by a network of valleys. With mountains and valleys, Rwanda is commonly known as a “**Country of the one thousand hills**”.

Rwanda relief can be divided into four following categories:

- (i) **The Congo-Nile Ridge.** This is a range of mountains, with an altitude ranging between 2500-3000 m. Overhanging Lake Kivu, it divides Rwanda's waters in two parts: those which flow into the Congo basin in the west; and, those which flow into the Nile in the east. The Congo-Nile Ridge is dominated in the north-west by the volcanoes range, which consists of five massifs, the highest of which is Kalisimbi with an altitude of 4507 m.
- (ii) **The Central Plateau.** With an altitude ranging between 2000-1500 m, the central plateau's relief is made of hills with tops that are sometimes stretched, sometimes round, separated by deep valleys of 50-15 m, often filled up with alluvial deposits.
- (iii) **The lowlands of the East.** The lowlands are dominated by a depression of the relief, generally undulating between 1500-1100 m of altitude.
- (iv) **The lowlands of the South West in the plain of Bugarama.** This is part of a tectonic depression of the African Rift, and it has an altitude of 900 m.

Figure 3 below shows Rwanda topographic features.

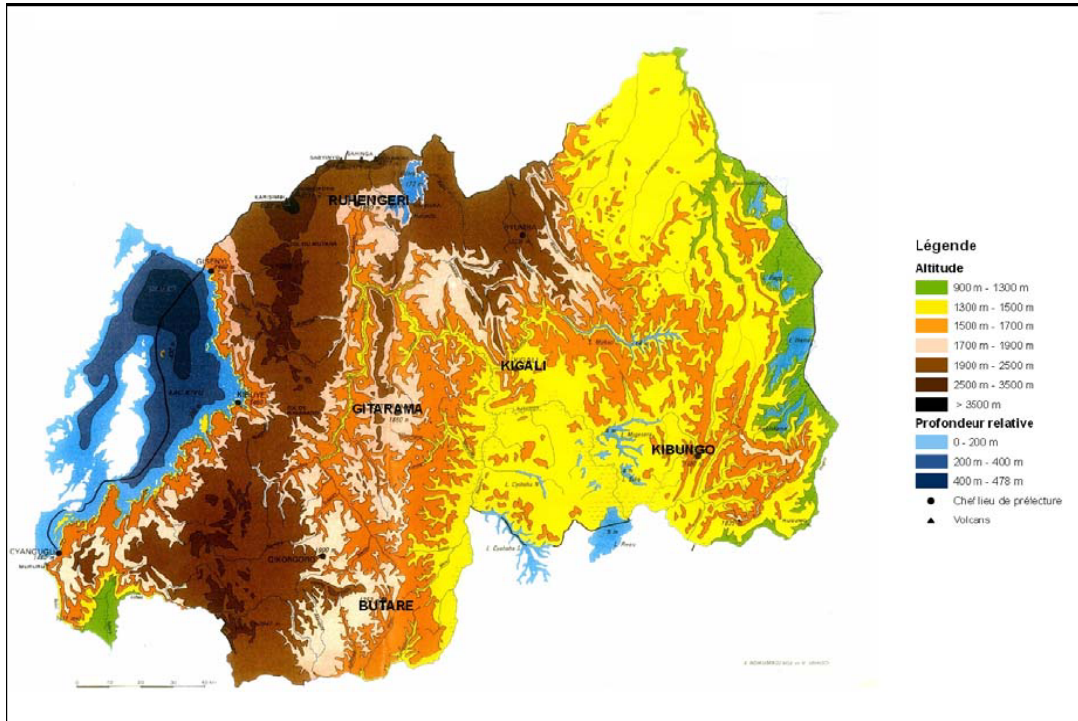


Figure 3 Rwanda topographic features

Source: Atlass du Rwanda, UNR, 1981

1.1.3 Water resources and wetlands

Rwanda has a dense hydrographic network with $\pm 2 \text{ km/km}^2$, generally well endowed with sources from discontinuous aquifers of Precambrian terrains.

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. The water resources are mainly influenced by rainfall and evaporation and hence climate information and preparedness are essential in the management of water 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.

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 860 marshlands, covering a total surface of 278 536 ha, which corresponds to 10.6% of the country surface, 101 lakes covering 149487 ha, and 861 rivers totaling 6462 km in length (REMA 2008). Figure 4 show the Rwanda hydrologic network including main rivers, main lakes and main swamps.

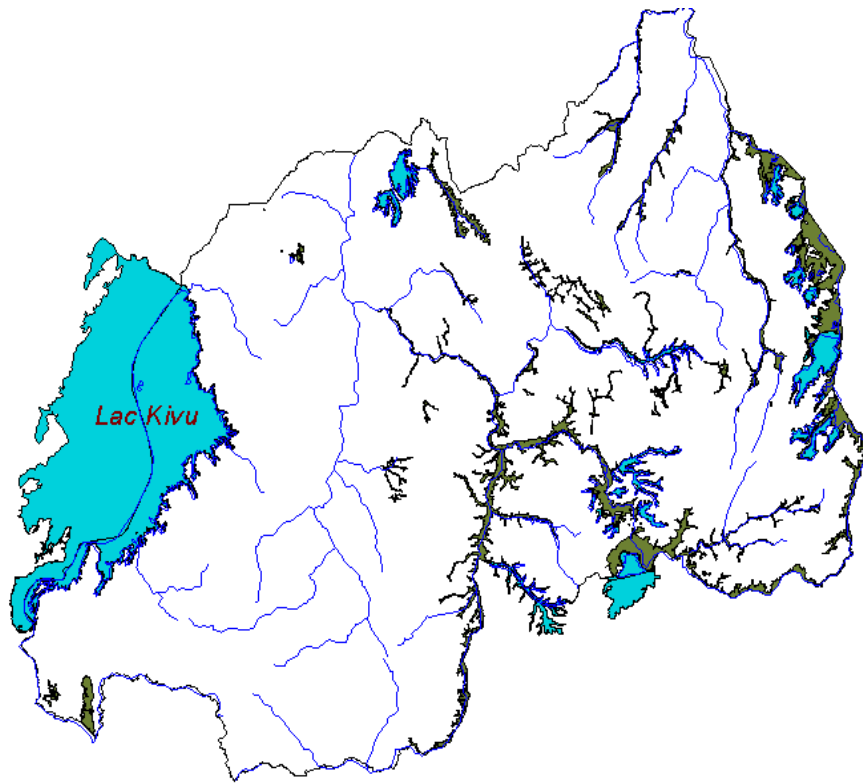


Figure 4 Rwanda water resource network

Source: Rwanda Meteorological Service, Generation and application of climate information, products and services for disaster preparedness and sustainable development in Rwanda; Kigali, June 2004

Water use and water demand

The total supply of drinking water in 2009 in Rwanda was estimated at 73.81% of the Rwandan population, while the average consumption per capita was estimated at 54.7 liters per capita per day.

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, estimated that industrial water consumption was 0.013 km³/yr

Estimated and projected water demand in 2005 and 2020 by different sectors are highlighted in table 1 below.

Table 1 Estimated and Projected water demand

Sector	Water demand (m ³ /year)	
	2005	2020
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

According to World Resources Institute, 2003c (1993 data), Rwanda has a relatively low withdrawal rate of 0.8 km³ per year or 141 m³ per capita per year. The low withdrawal¹ rate suggests that there is currently little pressure on Rwanda's water systems in meeting demands.

This does not imply, however, that the internal capacity of ecosystems to capture, store and release water is not being deteriorated - FAO data show a decrease in per capita IRWR from 833 m³/year in 1994 to 638 m³/year in 1999–2000 (Karyabwite 2000, p 11), implying that the present system cannot meet the demand for water if all individuals are given the minimum amount of 1000 m³ as recommended by the United Nations. Baechler (1999) using the Falkenmark indicator, estimates that Rwanda is among water scarce countries of the world, and Ehrlich *et al* (2000) states that countries with less than 1700 m³ of water available per capita cannot maintain food self sufficiency reliably. Rwanda, with 870 m³/year per capita water availability by mid 1990s, ranks as 18 from the bottom of countries with Per-Capita Water Availability Below 1,700 m³/p/year.

Cross-border and shared water resources and wetlands

The major cross-border lakes include Kivu (DRC), Cyohoha (Burundi), Rweru (Burundi). The major cross-border rivers include the Akagera (Tanzania), Akanyaru (Burundi), Kagitumba (Uganda), Muvumba (Uganda), Ruvubu (Burundi), Rusizi (Burundi and DRC).

According to official gazette N°44 of 01/11/2011, the major marshlands with international importance are: Akagera Aval, Cyizinga, Lac Ihema, Gahando, Bushenge-Ruhwa, Ruhwa, Ruhwa aval, Lac Rweru, Rweru-Mugesera-Nyabarongo, Akagera, Agkagera aval, Kabaya-Kirimbi, Kagitumba aval, Akanyaru, Mulindi, Muvumba, Ngenda, Rusizi, Rutigita, Urwanda and Rugezi.

1.1.4 Land use

Rwanda State of Environment and Outlook (REMA, 2009) and in Inventaire rapide des marais du Rwanda (REMA, 2009; module 3, pp iii) provide following information :

- Over 74% of national territory is used for agriculture (including cultivated lands, cultivated marshlands, pasture and fallow, agro-forestry, woodlots and others);
- Forests and protected areas are located on 10% of the total national area;
- Lakes occupy 6% of national territory;

¹ Refers to total water removed for human uses in a year, not counting evaporative losses from storage basins.

- Natural and protected marshlands are found on 4%;
- Remaining lands (less than 6%) are occupied by buildings, roads etc...

1.1.5 Natural resources

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)

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, agropastoral areas, grassland, grazing and fallow land

Flora

Rwanda harbors 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

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 afromontane 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 (Rwanda State of Environment and outlook, REMA, 2009).

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) (Rwanda State of Environment and outlook, REMA, 2009).

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), *Diaphananthe delepierreana* Lebel & Geerinck (Orchidaceae) and *Ypsilopus liae* Delpierre and Lebel (Orchidaceae) all endemic to Nyungwe National Park (Rwanda State of Environment and outlook, REMA, 2009). The

number of these newly discovered species shows that the number of plant species found in Rwanda is far from being totally known.

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 hamlyn*), the mountain monkey (*Cercopithecus hoesti*) in Nyungwe, the Chimpanzee (*Pan troglodytes*) in Nyungwe and Gishwati, and the Golden monkey (*Cercopithecus mitis kandti*) 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 rare species such as the giant pangolin.



Figure 5 A family of Mountain Gorillas

Rwanda is one of the top birding countries with 670 different birds having been recorded (Rwanda State of Environment and outlook, REMA, 2009).

Animal races bred in Rwanda are mixed with native and nonnative 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*) (Rwanda State of Environment and outlook, REMA, 2009).

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

Cross-border natural resources and biodiversity

Rwanda has biodiversity in Volcanoes national park bordering with Uganda, Akagera national park bordering with Tanzania and Nyungwe National Reserve bordering with Burundi.

The Volcanoes National Park is home to about 30 % of the global population of Mountain Gorilla (*Gorilla gorilla beringei*). It has other 115 mammals' species, including the golden monkey (*Cercopithecus mitis kandti*), elephants, buffaloes, 187 bird species, 27 species of reptiles and amphibians and 33 arthropod species. It has also 245 plants, 17 of which are threatened; and 13 species of orchids including *Disa starsii*, *Polystachyakermessia*, *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 hamlyni*) 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 (Plumptre *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 *Oriciarenieri*, *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: *Diaphanthe 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), *Syncerus caffer* (buffalo), *Panthera leo* (leopard) and *Tragelaphus spekii* (sitatunga). The flora of the Akagera National Park is diverse and 6 species of orchids are recorded. The grass savannah 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 .

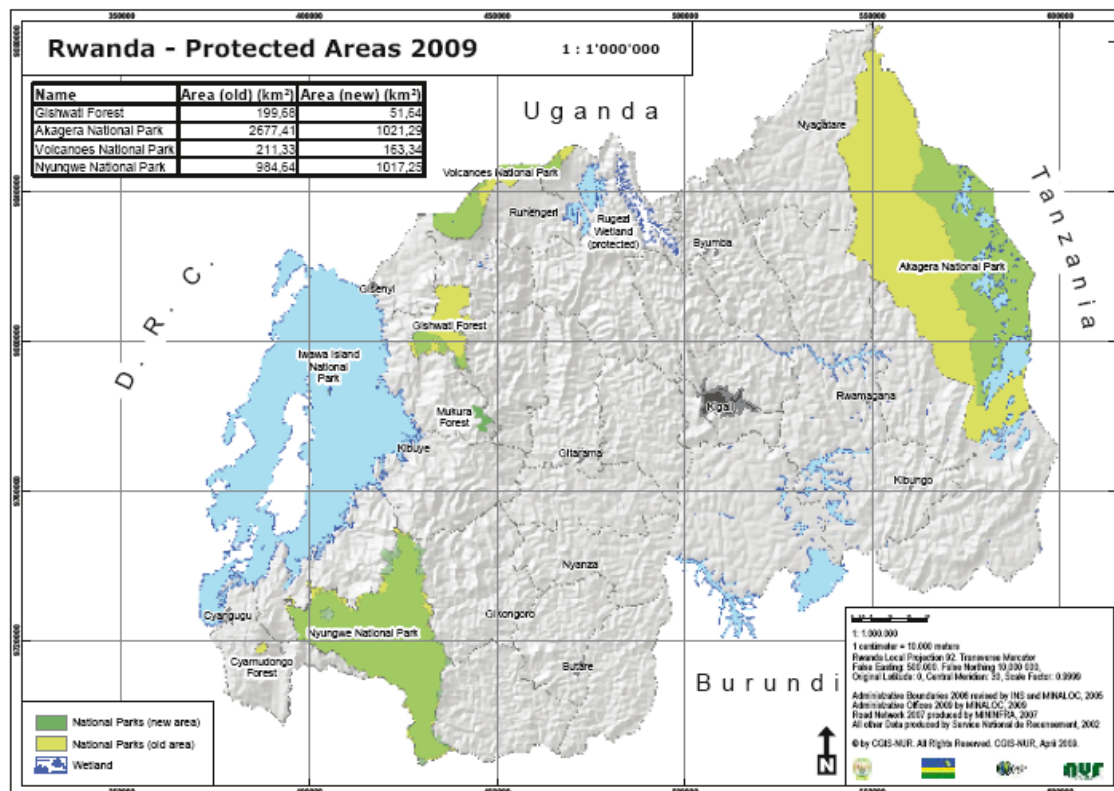


Figure 6 Rwanda protected area 2009

Source: REMA, 2009

1.1.6 Physical infrastructures

Roads

The road network in Rwanda constitutes around 14000 km, of which 5400 km constitute the main road network. According to studies accomplished by MNINFRA in 2005-6, of the main network, only 1075 km are paved. The remaining 4325 km are earth roads. The national and inter-urban main road network is placed under the jurisdiction of the Ministry of Infrastructure (MININFRA). This network connects the provinces among themselves and Rwanda to neighbouring countries. The secondary road network is under the responsibility of the districts.

Importation and Exportation to and from Rwanda are currently facilitated mainly with roads. Rwanda use Mombasa port through Kenya and Uganda and Dar-Es-Salaam port through Tanzania. All goods from or to these ports as well as goods from or to other EAC countries pass through cross-border roads. These roads are also used by Rwandans or EAC citizens travelling from Rwanda or to other EAC countries.

Air transport

Rwanda's main air gateway is Kigali International Airport, located at Kanombe, approximately 10 km from Kigali City centre. The airport has international flights to Nairobi, Entebbe, Addis Ababa, Bujumbura, Brazzaville, Johannesburg and Brussels, and

is the main airport for the national carrier Rwanda Air Express. Plans to construct a new airport at Bugesera, 40 km south-east of Kigali, are under way.

In addition to Rwanda Air express, The Kigali International airport is used also by: Kenya Airways and Ethiopian with three flights a day, Brussels Airline (2 times a week) and recently by KLM once a week. This transport is mainly limited to business flights and importation of a certain category of goods.



Figure 7 Kigali International Airport and national flag Carrier

Source: Report on collection of Existing data (NLC, 2009)

Water transport

Rwanda has cross-border Rivers (Akagera, Akanyaru and Rusizi) but these rivers are not used for navigation. According to the information obtained Ministry of Infrastructure (MININFRA), plans are underway to conduct a feasibility and engineering study of the navigability of the Akagera River waterway, to permit multi-modal transport, ie rail/water/road, connections.

The study is to be funded by the World Bank under the East African Trade and Transport Facilitation Project (EATTFP). Positive results of the study shall permit establishment of several multi-modal transport connections.

Railway

Rwanda doesn't have a railway. Being a landlocked country far from seaports; the nearest port of Dar-es-Salaam is about 1400 km away, the country's highly rolling terrain and its state pose a major obstacle in its socioeconomic development efforts. As solution to overcome this obstacle, Rwanda plans to construct the first part of a railway line system for Rwanda between Isaka (Tanzania) and Kigali. The rail line envisaged is about 450 km long, of which 175 km will be on the Rwandese territory and the rest on the Tanzanian soil. The project is at the stage of feasibility study, which has just been completed.

Specifically, the railway study under MININFRA aims at finding an optimal solution to the construction of the Isaka-Kigali railway line on a 'central corridor', to especially open up

Rwanda to the ports of the east African coast on the Indian Ocean. To this end, areas of high mining, industrial and agricultural production potential of Rwanda would be rail connected with the Kagera and Shinyanga Regions in Tanzania, Burundi and the Eastern Provinces of the Democratic Republic of Congo (DRC).

1.2 Population

Rwanda is the most densely populated country in Africa with about 384 inhabitants/km². 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. Table 2 shows characteristics of Rwanda population according to Statistical Year Books 2010 (NISR, 2010). Figure 5 provides an illustration of population density by district.

With an annual growth rate of 2.9%, the population of Rwanda is currently estimated at over 10 million with an urban population of up to 17 %. The population is expected to grow to around 16 million by 2020 unless family planning, education and outreach strategies are intensified (ROR 2000). The Government aims to reduce the population annual growth rate to 2.2 % by 2012 and to increase percentage of urban population to 30% by 2020. Figure 6 shows total and rural population and counts (left axis) and the share of urban population (right axis).

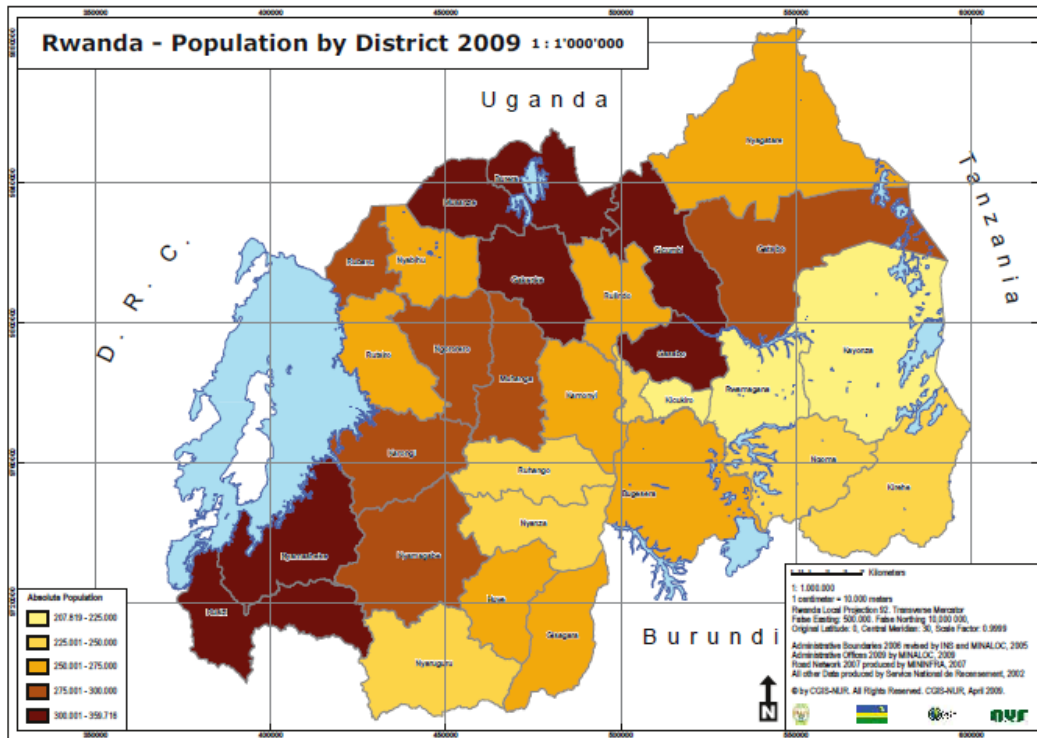
The population is relatively young with 67 % of the total population below the age of 25 most of whom are unemployed (MINECOFIN 2003). This situation has created a high dependency ratio amongst the population. Since the livelihoods of about 90 % of people are inextricably linked to land, population growth 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 migration has been largely experienced in the former Umutara province, now part of Eastern province.

Table 2 Characteristics of Rwanda population in 2008-2009

Designation	2008	2009
Households	2,286,396	2,352,797
Mean Household size	4.3	4.3
Mid-year population in Millions	9.83	10.1
Density/km ²	373	384
Number of Birth	417,171	429,065
Number of Death	142,339	143,538
Rate of natural increase per 100	2.80	2.82

Source: NISR, 2010



Map production: REMA

Figure 8 Population densities by district in 2009

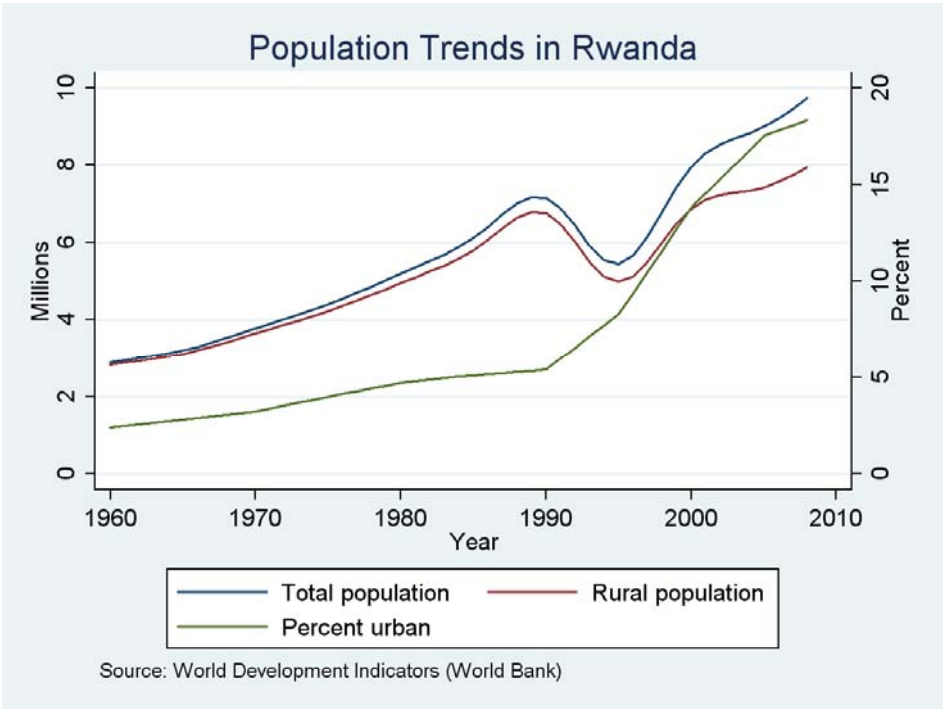


Figure 9 Population trends in Rwanda

1.3 Rwanda's Political Origins and Evolution

Kingdom with clan groups

The Republic of Rwanda traces its origins to one of the oldest kingdoms in the East and Central African sub-region. Due to absence of records, it is not clear when this kingdom was founded. However, it is generally agreed that somewhere between the 14th and 16th centuries, the kingdom of Rwanda existed as a fully-fledged well administered, highly centralised entity.

Other historical accounts, however, suggest that since the 11th century, Rwanda existed as a nation founded on a common history of its people, shared values and a single language and culture, extending well beyond the current borders of the country.

The unity of the Rwandan nation was also based on the clan groups and common rites with no discrimination based on ethnicity (MINECOFIN, 2000). Whereas the seat of the kingdom tended to move from one hill to another, these were invariably located in Nyanza near Butare. Kigali, the current capital of Rwanda bears no historic significance, having been created after the arrival of Europeans. It was in Kigali that the Germans established their headquarters, and built the residence of the colonial governor.

Belgian administration with League of Nations mandate

German control of Rwanda, however, did not last long as this came to an end following German's defeat in the First World War. Indeed, it was on May 6, 1916 that Belgian troops entered Kigali, signalling the defeat of the Germans. When the war ended three years later, Belgian administration of Rwanda was formalised but this was to be undertaken on behalf of the League of Nations following the declaration of Rwanda and Burundi as mandate territories of the League of Nations. Whereas the main administrative centre for the Rwanda-Urundi mandate was in Bujumbura - in today's Burundi - Kigali served as local seat of the colonial administration inside Rwanda.

Ethnic conflict supported by colonial administration

Like for most African countries, the road to independence was marred also by Rwanda by ethnic conflict. In the case of Rwanda it pitted the majority Hutu against minority Tutsi, all of which was fanned and supported by the Belgian colonial administration as well as the powerful Catholic Church. The results were the massacres of Tutsis, many of whom fled into exile in neighbouring countries. These conflicts also culminated into the overthrow of the centuries-old monarchy, and Rwanda became a republic.

Genocide

Rwanda's post-colonial history has also been marked by sporadic periods of upheavals and state-sponsored marginalisation of certain sections of the population within the country. The state also invested a lot of efforts in denying those Rwandans who had fled into exile the right to return to their country. Having sought all peaceful means to resolving issues, Rwandans, particularly those in exile resorted to waging a liberation war in the early 1990s. The civil upheavals of the 1990s culminated into the 1994 genocide, which claimed more than one million lives and created a similar number of refugees and displaced persons.

Post 1994 political reconstitution and governance reforms

The genocide had a devastating effect on the Rwanda's social, economic and political fabric, as well as on its human resource base and institutional capacity. The situation returned to normal with the restoration of peace, the return of refugees and the undertaking of prudent liberalised economic policies and programmes with the assistance of international donors. The disruptive legacy of the 1990s has now been largely corrected, and the country's economic and social recovery has been strong and steady. About a decade-and-a-half since the genocide, Rwanda has made tremendous strides in rebuilding its socio-political landscape, and significant achievements have been registered, including restoration of security for people and property across the country, putting in place and capacitating key state institutions. This was a National level governance reforms.

Among others, Rwanda several reforms including:

- Security and reforms;
- Democratisation and citizen participation;
- Participation in the planning process secured;
- Free political competition and the independence of the media and civil society;
- Gender address with highest 55 % female parliamentarians.

Organizational, Political, and legal framework

In addition to the City-Province of Kigali, Rwanda has four Provinces (Northern, Southern, Eastern and Western Province). It is subdivided into 30 Districts and 416 Sectors.

From the political point of view, the Government Vision 2020 represents its leitmotif. Its main priorities are the environment protection and management, poverty reduction and investments promotion. To achieve these objectives, a number of sector based policies are implemented in various domains (environment, land, energy, agriculture, habitat, decentralization and good governance and management of natural disasters).

From the legal point of view, Article 49 of the Constitution of Rwanda (04/06/2003) and the organic law determining the environment protection, conservation and management, ensures a proper protection of its natural capital.

1.4 Economy

About 57 % 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. 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. All economic activities including production, consumption and waste disposal subsist in the environment.

1.4.1 Macro-economic Indicators

In Rwanda the real GDP at constant prices of 2001 grew by 6 % in 2007 against 5.5 % in 2006. GDP growth during the last 5 years has reflected a positive trend even if there was a decrease of 1.6 % 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 % 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 % The tertiary sector maintained the first position in the structure of GDP with 48 % of the GDP at constant prices of 2001, followed by primary sector (31 %) and then secondary sector with 15 % of the GDP in 2007 (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%: rising from 181.3 to 199.9 thousand Rwanda Francs. In terms of US \$ there was an increase of 10.3 %: from US \$ 331 to 365 in 2006 and 2007 respectively.

1.4.2 Inflation

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 % against 8.9 % in 2006 (NBR 2008). In terms of import indices, the volume and the value indices increased by 43.84 and 47.04 %, in 2006 and 2007 respectively. Among imported goods, energy and lubricants registered the greatest rise of 99.46 % in value. Fuel led with a rise of 106.32 % in value against a rise of 5.33 % in volume (NBR 2008).

In general, 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 and cereals. 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.

1.4.3 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 programmes, among others. 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 % 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 \$449.8million 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 % with 86 % 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 % of total public external debt. The remaining 14.49 % 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.

1.4.4 Trade

The imports of the country are classified in four main categories that are the consumer goods, equipment goods, intermediate goods and energy and lubricants. In general, the consumer goods occupy the first place among the imports. In 2006, they represent 29% of the total value of imports CIF.

The importance of equipment goods in overall imports recorded in these years is due to the increase of the imports of machines and equipments, like automatic information processing machines, power generators, as well as the electric devices for telephone communication.

Concerning specifically importation of food commodities from and neighbouring counties, Rwanda imports palm oil from Burundi, rice, sugar and wheat flour from Tanzania, banana, milk and corn from Uganda and industrial food from Kenya.

Table 3 bellow shows the import of Rwanda by county/region of origin (2004-2009) in millions of USD. Import from EAC mainly from Kenya and Uganda are predominant.

Table 3 Import of Rwanda by country/region of origin (Millions of USD)

Country/Region	2004	2005	2006	2007	2008	2009
Burundi	0.5	0.26	0.37	2.05	3.56	4.31
Kenya	38.85	49.92	69.45	85.67	128.96	152.69
Tanzania	5.15	8.01	8.31	15.7	25.55	81.53
Uganda	23.36	39.01	61.64	98.52	145.26	151.83
Total EAC	67.35	96.94	139.4	199.89	299.77	390.36
COMESA	12.78	13.59	19.71	31.03	59.74	30.49
ECOWAS	0.75	0.78	2.23	0.3	1.96	2.09
SADC	17.8	26.21	22.44	35.47	15.47	41.17
Rest of Africa	0.35	1.31	0.48	0.63	0.13	5.46
EU	68.52	108.7	113.97	127.47	237.28	277.18
United Kingdom	6.34	10.75	8.37	11.84	26.55	25.02
USA	16.79	14.33	16.1	28.87	36.65	36.18
United Arab Emirates						
India	12.82	19.09	23.11	30.99	48.67	43.5
China	13.2	17.94	22.77	49.62	98.87	80.42
ROW	18.07	77.53	94.89	167.11	155.36	121.46

Source: NISR, 2010

Notes:

- (1) COMESA excludes Kenya and Uganda
- (2) SADC excludes Tanzania
- (3) COMESA and SADC have overlapping membership

The exports of Rwanda are dominated by coffee, tea and some minerals that constituted nearly 85% of the FOB value of the exports in 2004; 80% in 2005 and 2006. The weak diversification of the export products and the low level of the values exported continue to be a handicap of the country to generate its own foreign currencies. The prices of export products, fixed by the international market, are very volatile. The exports of our main cash crops (coffee and tea), depend on climatic conditions that are beyond the country's control.

However, some efforts are currently deployed to increase the level of exports by improving quality exported and diversification of export products. Between 2003 and 2004, the values of exports increased by 55.52%, going from 63.1 millions of USD to 98.1 million USD. They increased by 27.46% from 2004 to 2005, from 98.1 millions of USD to 125 million USD and

23% between 2005 and 2006, growing from 125 millions of USD to 154 million USD. The exports of coffee exceeded 15.01 million in 2003 to 32.2 million USD in 2004, 38.3 Millions in 2005 and 54.4 Million USD in 2006. The exports FOB of tea were estimated between 22 million and 24 millions USD over the period 2003-2005. They however registered good performance in 2006; reaching a value of 32 millions USD; indicating a growth rate of 31% from 2005.

The increase in value of exported coffee has been encouraged by the progressive improvement of the quality and prices. The exported fully-washed coffee amounted to 300 tons in 2003; 542 tons in 2004 and 739 tons in 2005. The average price of coffee increased, growing from 1.01\$/Kg in 2003 to 1.2\$/Kg in 2004 and 2.1\$/Kg in 2005. The price of 2005 remains more or less the same in 2006.

The quantity exported which totaled 14,700 tons in 2003 has almost doubled, reaching 27,085 tons in 2004 before dropping to 18,399 tons in 2005. In 2006, the export performance raised to 26,534 tons. Exports of minerals registered a drop of 1.8% between 2005 and 2006. Although still low, the trend of exports recorded for the period 2004-2006, after the drop in 2002 and 2003, deserves particular attention for the progressive improvement in the coming years.

In EAC countries, the main food commodities exported from Rwanda is potatoes to Burundi.

Although the exports revenues are increasing from 2005 to 2008, the imports costs are also drastically increased in the same period making increasing negative trade balance. Table 4 shows exports revenues (dominated by FOB of Coffee and Tea), imports costs and trade balance in Millions of USD from 2005 to 2008.

Table 4 Trade balance

Year	2 005	2 006	2 007	2 008
Trade balance	-228.70	-299.02	-404.39	-624.16
Exports, f.o.b.	125.00	147.38	176.77	256.56
Of which : coffe	38.30	54.04	35.67	46.91
tea	24.40	31.86	31.52	40.05
Imports, f.o.b	-353.60	-446.40	-581.16	-880.72
Services and income (net)	-193.70	-160.95	-14.38	-148.39
Services (net)	-166.50	-132.30	-113.33	-123.16

Source: NISR, 2010

1.4.5 Economic growth

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.

With two thirds of the population aged less than twenty five years old, 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 % by 2012. Exports growth is scheduled to increase at 15 % per annum compared to the current rate of 10 %. This accelerated pace of growth will be made possible through a large increase in the investment rate which will rise from 15 to 23 % of GDP by 2012 (ROR 2007).

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

1.5 Energy Sources and security

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 % of the population and imported petroleum products consume more than 40 % of foreign exchange.

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 Rwanda potential of energy resources is estimated as follows:

- Hydropower: 350MW;
- Methane gas: 55 billion Nm³ with a rated capacity of 700MW;
- Geothermal power: 170-340MW;
- Solar power energy: 5.2 kWh/day/ m²;
- Peat reserves which are about 155 million tonnes of dry matter.

1.5.1 Biomass

Biomass is used in the form of firewood (Table 5), 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 % 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.

Table 5 Wood consumption and projection (tones par year)

Year	2005	2006	2007	2008	2009	2010
Fuel wood (urban areas)	81,916	86,831	92,041	97,564	103,417	109,622
Fuel wood (rural areas)	2,805,431	2,871,907	2,939,317	3,007,623	3,076,787	3,146,761
Wood for charcoal (urban areas)	1,643,655	1,732,734	1,836,698	1,946,900	2,063,714	2,187,537
Wood for charcoal in rural area	123,409	126,333	129,298	132,303	135,346	138,424
Wood for industries / 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: MININFRA / Rwanda State of Environment, REMA, 2009

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.



Figure 10 Domestic firewood (1) and Mulindi tea factory firewood (2)

Source: (1) National Land centre, report on collection of existing data, 2009
 (2) Nzeyimana Isidore, 2010



Figure 11 An inefficient traditional kiln for burning charcoal

Source: Rwanda state of Environment and outlook, REMA, 2009

In 2003, the charcoal market had a turnover of US \$30 million (World Bank 2006). The current trend towards increased urbanisation 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.

1.5.2 Petroleum products

The consumption of petroleum products (all imported), is clearly increasing with the rising number of vehicles, particularly since 2005, the year when electricity began to be produced from thermal power plants. About 42 % of the electricity produced in Rwanda is produced by diesel generators. However, the transport sector remains the main fuel consumer (80% of all imported petroleum products). Table 6 below presents the progressive distribution of petroleum products import during the period 2002 to 2006.

Table 6 Evolution in the importation of petroleum products 2002-2006 (tones)

Year	2002	2003	2004	2005	2006
Gasoline for vehicles	39,506	41,114	42,818	43,441	50,342
Fuel for airplanes		2 .67	1,114	15,632	17,914,9
Diesel	26,145	28,357	43,701	57,818	79,394
Kerosene	13,543	16,818	16,698	25,327	19,259
Fuel oil	11,550	14,823	14,736	15,794	18,534
Liquefied Petroleum Gas	0.65	237	215	310	0
Total	90,745	101,349	118,168	142,690	167,528

Source: Rwanda Revenue Authority / Civil Aviation Authority

1.5.3 Electricity and hydropower

Since 2004 the production of hydroelectric power plants has declined and this power loss was compensated for by thermoelectric power to reach 44 MW of current demand. Electricity is used mainly in industries (40%), households (40%) and other services (20%) with an access rate of only 6%. Note that domestic production of electricity is around 70%, import 29%, export 1%, and that the cost of electricity in Rwanda is among the most expensive in the world.

Table 7 Electricity production, importation and exportation (Kwh) from 2005 to 2009

	2005	2006	2007	2008	2009
Total production (Kwh)	115,856,932	168,699,973	165,448,004	194,473,021	248,318,483
GIHIRA	5,908,750	6,029,050	7,196,241	6,430,650	5,666,000
GISENYI	4,380,560	3,814,850	5,590,620	6,425,190	1,219,631
JABANA	25,397,799	19,237,640	11,029,740	5,122,100	16,325,766
GATSATA	14,071,873	1,184,000	1,979,000	0	73,866,951
Rental POWER GIKONDO	10,653,130	82,256,473	79,214,470	78,203,264	73,866,951
Rental POWER II MUKUNGWA		27 594 260	30 726 706	38 733 648	42 820 811
NTARUKA	15 350 620	5 703 000	5 528 000	15 095 700	29 413 000
MUKUNGWA	40 094 200	22 880 700	24 058 944	44 153 377	62 599 700
SOLAR ENERGY JALI			124 283	309 092	362 917
GAZ METHANE	0	0	0	0	3 311 590
Exportation	1 822 661	2 033 200	2 146 300	2 154 950	2 914 851
CYANIKA-GISORO	1 806 552	2 033 200	2 144 300	2 108 950	2 622 837
MURURU II	0	0	0	20 000	94 220
GOMA(Elgz)	16 109	0	2 000	26 000	197 794
Importation	89 098 300	64 097 400	80 517 740	84 688 127	62 386 306
RUSIZI I (SNEL)	20 891 800	20 528 400	19 792 640	20 186 127	14 337 080
RUSIZI II(SNELAC)	64,564,000	40,784,000	60,051,600	64,258,000	47,488,000
KABALE(UEB)	3,594,337	2,785,000	673,500	244,000	475,500
GOMA(SNEL/RDC)	48,163	0	0	0	125,726

Source: Statistical Year Book, NISR, 2010

Summary of installed/available capacity of distributed electricity in Rwanda

In house Hydro-electricity:

- Ntaruka - installed capacity 11.75 MW, available capacity 6 MW;
- Mukungwa - installed capacity 12.50 MW, available capacity 11 MW;
- Gihira - installed capacity 1.8 MW, available capacity 1.8 MW;
- Gisenyi - installed capacity 1.2 MW, available capacity 1.2 MW;

Imported Hydroelectricity:

- Rusizi1 (SNEL) - Installed capacity 3.5 MW, available capacity 3.5 MW;
- Rusizi2 (SNELAC) - Installed capacity 12 MW, available capacity 8 MW.

In house Thermal Electricity:

- Jabana - 7.8 MW.

Rental Thermal Electricity:

- Aggreko 1 (Gikondo) - 10 MW; and,
- Aggreko 2 (Mukungwa) - 5 MW.

Others:

- Nyamyotsi 1 micro hydro power - 75 Kw,
- Kigali solar - 250 kW.

Figure 9 is the Rwanda map of principal potential energy sources

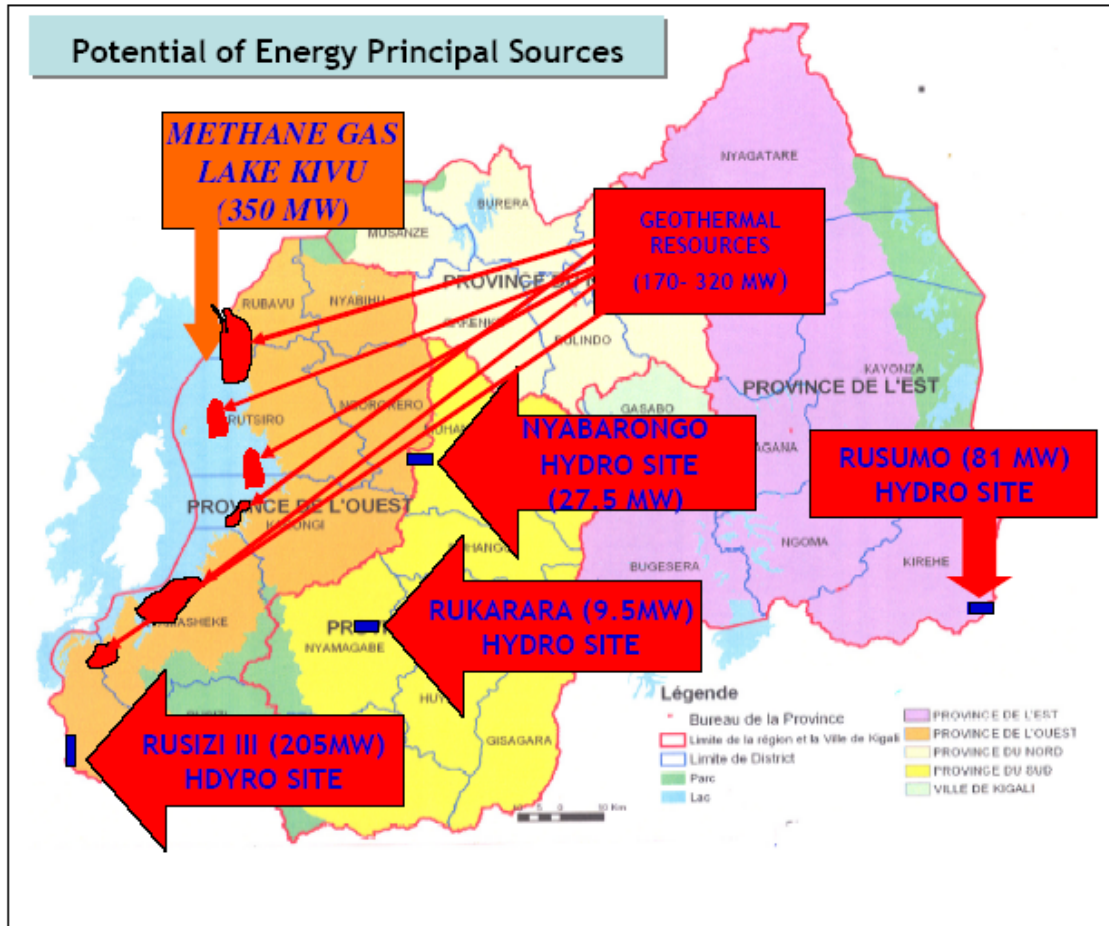


Figure 12 Location of principal potential energy sources

Source: National Land centre, report on collection of existing data, 2009

Micro-hydro electricity

In addition to principal hydro-electricity production, the ministry of Infrastructure (MININFRA) has developed a Micro Hydro Atlas that has identified all potential sites for small hydro power plants. 333 such sites are identified with a capacity between 2-10 KW each. Studies and construction works for some of these sites have been undertaken and are at different stages of implementation.

1.5.4 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 (Figure 13). 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.



Figure 13 Methane gas power plants in Lake Kivu

Source: Rwanda State of environment and outlook (REMA, 2009)

The first efforts to utilize the methane deposits were undertaken in the late 1950s with 1.5 million cubic meters of gas being supplied annually to the nearby BRALIRWA 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 tonnes 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.

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. In 2009, the methane gas power plant installed at Lake Kivu produced 3,331,590 Kwh (table 7)

1.5.5 Peat, Geothermal, Wind

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.

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.

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.

1.5.6 Solar energy

Using meteorological model and daily data covering 20 years, C. Museruka and A. Mutabazi in Assessment of Global solar radiation over Rwanda (C. Museruka and A. Mutabazi, 2007), found that, Rwanda possess solar energy estimated as follow:

- The minimum average value is 4.3 kWh/m² per/day;
- The maximum average value is 5.2kWh/m²/day;
- The annual mean values by sites are: Kigali (4.70 kWh/m²/day), Gabiro (4.60 kWh/m²/day), Karisoke/Ruhengeri (4.54 kWh/m²/day), Gikongoro/Nyamagabe (4.70 kWh/m²/day) and Karama/Bugesera (4.74 kWh/m²/day).

Based on these results, C. Museruka and A. Mutabazi estimated the solar energy on ground ranges from about 4 to 5 kWh/m²/day over the year

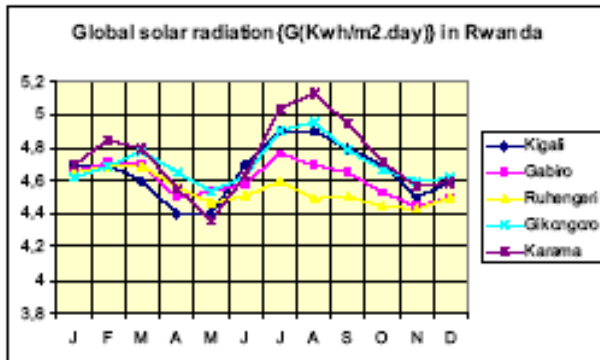


Figure 14 Global Solar radiations in Rwanda (kWh/m²/day)

Source: International Conference on Clean Electrical Power, 2007. ICCEP apos;07. Volume , Issue , 21-23 May 2007
Page(s): 670 – 676. DOI 10.1109/ ICCEP.2007.384312; Full paper : <http://esp.ictp.it/personnel/associates/alphonse-mutabazi>

The solar plant mounted at the peak of Mount Jali with installed capacity of 250 KW is rated the largest PV project in Africa. Power produced by the plant has been connected to the national grid. The solar system is jointly owned by a German utility company, Stadtwerke Mainz and the City of Kigali. The Ministry of infrastructure is looking into using solar system solutions for public institutions like schools, health centres and local administration offices in areas far from the electricity grid.

Solar water heaters have been introduced in the Rwanda, but on a very limited scale. They would enable the country to save electric energy to heat water. Moreover the return on investment for individual users is recovered only in about 4 year's time. Government is currently working on a cabinet paper to make solar water heating installations compulsory on all new urban constructions, and has removed import duties on solar energy products as an incentive for investors and consumers. The solar energy sector is open to investors for example in setting up an assembly plants for solar energy panels and related accessories.

1.5.7 Other energy sources and perspectives

Biogas

A National Domestic Biogas Program is in place, aiming at construction of 15, 000 biogas digesters by 2011, with support from the Netherlands Government through GTZ. The beneficiaries shall be households with at least two cows. Gas for cooking and lighting is to be produced. Two Pilot Projects - both meant to be implemented in the year 2008 - are in place, ie, construction of:

- 100 masonry digesters in Rulindo, Durango, Gasabo and Muhanga districts; and,
- 100 pre cast fiber glass digesters from China in different districts;
- Ministry of education (MINEDUC) in collaboration with Ministry of Infrastructure (MININFRA) is also looking into the viability of generating biogas from school toilets to be used for cooking and other purposes.

Prospects for oil exploration in Rwanda

Rwanda has recently registered an increased interest in oil exploration - especially in the western Rift Valley in the country. The motivation is the recent oil discovery in the northern part of the Rift Valley in Uganda.

The presence of methane gas dissolved in the deep waters of Kivu, which originates partly from the earth crust, is interpreted by some experts as an indication of probable oil presence below the Lake sediments. A area under preliminary survey is the western part of Rwanda along Lake Kivu, covering 1631 km² in area. After study of existing literature, the consultant Van Gold embarked on a satellite study of the lake that suggests that there are a number of oil seeps on the surface of Lake Kivu.

The indications were positive enough to embark further on an airborne magnetic and gravity survey of the exploration area, which was undertaken in September 2008. 2086 km of airborne survey were recorded, and the data was analysed to indicate the size and nature of the sediment base under and around Lake Kivu. The results of the survey to be availed soon. If all the indications for petroleum potential remain positive, Van Gold in co-operation with other partners will embark on a seismic survey.

Bio-fuels

There are basically two main bio-fuel avenues, which are currently pursued in other countries:

- Ethanol, which can be used as a substitute for petrol or as a means of 'extending', imported petrol - it may be derived from sugar or sugarrelated by products among other sources;
- Bio-diesel which is produced from waste oils or from oil-rich crops such as oil palm, jatropha and pongamia.

For landlocked Rwanda, the possibility of producing biofuels is worth exploring. However, the associated costs and benefits would also need to be scrupulously analysed. In countries where there is significant production of bio-fuels, it is normally supported with government subsidies or mandated production requirements that artificially enhance price. In a country

like Rwanda, which cannot afford such measures - and where population density is relatively high and agricultural land is already intensively cultivated for other essential needs - further research will be needed before bio-fuels can be embraced as a significant element of policy and strategy.

At this stage, therefore, the following rather cautious statement has been included in the Government's Energy Policy Document to capture the national bio-fuels policy: "Encourage careful research to be conducted into the potential of large-scale bio fuel production in Rwanda taking into account not just the direct costs and benefits, but indirect opportunity costs particularly in respect of potential reductions in food crops and import substitution or export cash crops, the implications for use of water resources and the environment, net employment implications and a detailed risk analysis.

The Institute of Scientific and Technological Research (IRST) has been taking the lead on bio-diesel research. The Government should continue to support and encourage both public and private sector entities to conduct research and process development work in the field of bio-fuels.

Currently IRST established a pumping biofuel station at Mulindi (Kicukiro District). This station is used by buses operating at Kigali-Bujumbura-Kigali (daily transport), by Rwandan high officials having car consuming biofuel and by some private peoples and companies.

Conversion of Methane Gas

In a bid to reduce dependency on conventional oil imports, new concepts to produce hydrocarbons locally are under discussion by MININFRA in partnership with the private sector. Proposals have been received from a number of investors. One promising endeavour is the conversion of methane gas from Lake Kivu into either liquid petroleum gas (LPG) or even diesel, which could be used to drive ordinary cars or other engines.

1.5.8 Energy balance

In terms of primary energy, biomass is by far the largest source, with firewood and wood for charcoal making constituting almost 80% of the energy used in Rwanda, and agricultural residues and peat accounting for another 6%. The remaining forms of energy are petroleum fuels (11%, including diesel needed for power generation) and hydroelectricity (4%). About 23% of the primary energy is lost in charcoal making, diesel power generation, and electricity transmission and distribution losses. The charcoal conversion losses amount to one-third of the total volume of wood used.

A summary of Rwanda's energy balance is summarised in Table 3 below.

Table 8 Summary of Rwanda's energy balance in Ton Oil Equivalent (TOE), 2007

	wood	Agri residues	wood for charcoal	peat	gasoline	diesel	Fuel oil	kerosene	LPG	methane	electricity	total	
Gross Supply (G&P)													
domestic production	850,936	99,878	420,542	301	-						47,073	1,418,729	
imports					53,499	88,682	14,802	20,715	202		15,308	193,208	
total	850,936	99,878	420,542	301	53,499	88,682	14,802	20,715	202	-	62,381	1,611,938	100%
G&P	53%	6%	26%	0%	3%	6%	1%	1%	0%	0%	4%	100%	
Conversion & losses (C&L)													
electricity conversion						42,364						42,364	
Elec T&D											17,810	17,810	
charcoal conversion			317,802									317,802	
total C&L	-	-	317,802	-	-	42,364	-	-	-	-	17,810	377,976	23%
Net supply	850,936	99,878	102,740	301	53,499	46,318	14,802	20,715	202	-	44,571	1,233,962	77%
Exports	-	-	-	-	-	-	-	-	-	-	-	-	
Demand													
households	765,842	79,902	97,603					20,715	202		33,428	997,693	81%
industries	85,094	19,979	5,137	301			14,802				8,914	134,223	11%
services											2,229	2,229	0%
transport					53,499	46,318					-	99,817	8%
total	850,936	99,878	102,740	301	53,499	46,318	14,802	20,715	202	-	44,571	1,233,962	100%
	69%	8%	8%	0%	4%	4%	1%	2%	0%	0%	4%	100%	

Source: adopted from SolaRwanda: Naceur Haman, 2010

1.5.9 Cross-border and regional implication for Energy Security

As indicated above, Rwanda imports electricity from SINELEC 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 9 below shows the trends in national hydropower production with comparisons between imports and exports for 2006-2008.

As indicated in above, domestic production of electricity is around 70%, import 29%, export, 1%, and that the cost of electricity in Rwanda is among the most expensive in the world

Table 9 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	2,145,950	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: Rwanda State of Environment and outlook (REMA, 2009)

The regional electricity grid inter-connections are planned to allow Rwanda to share power with the rest of Africa. The report on collection of existing data from National Land Centre (NLC, 2009) the interconnection to import and export electricity as follow:

- 1000 MW from Ethiopia;
- Electricity from Zambia;
- Export from Lake Kivu

Inter-connections to import and export electricity to and from Rwanda is illustrated on Figure 12 bellow

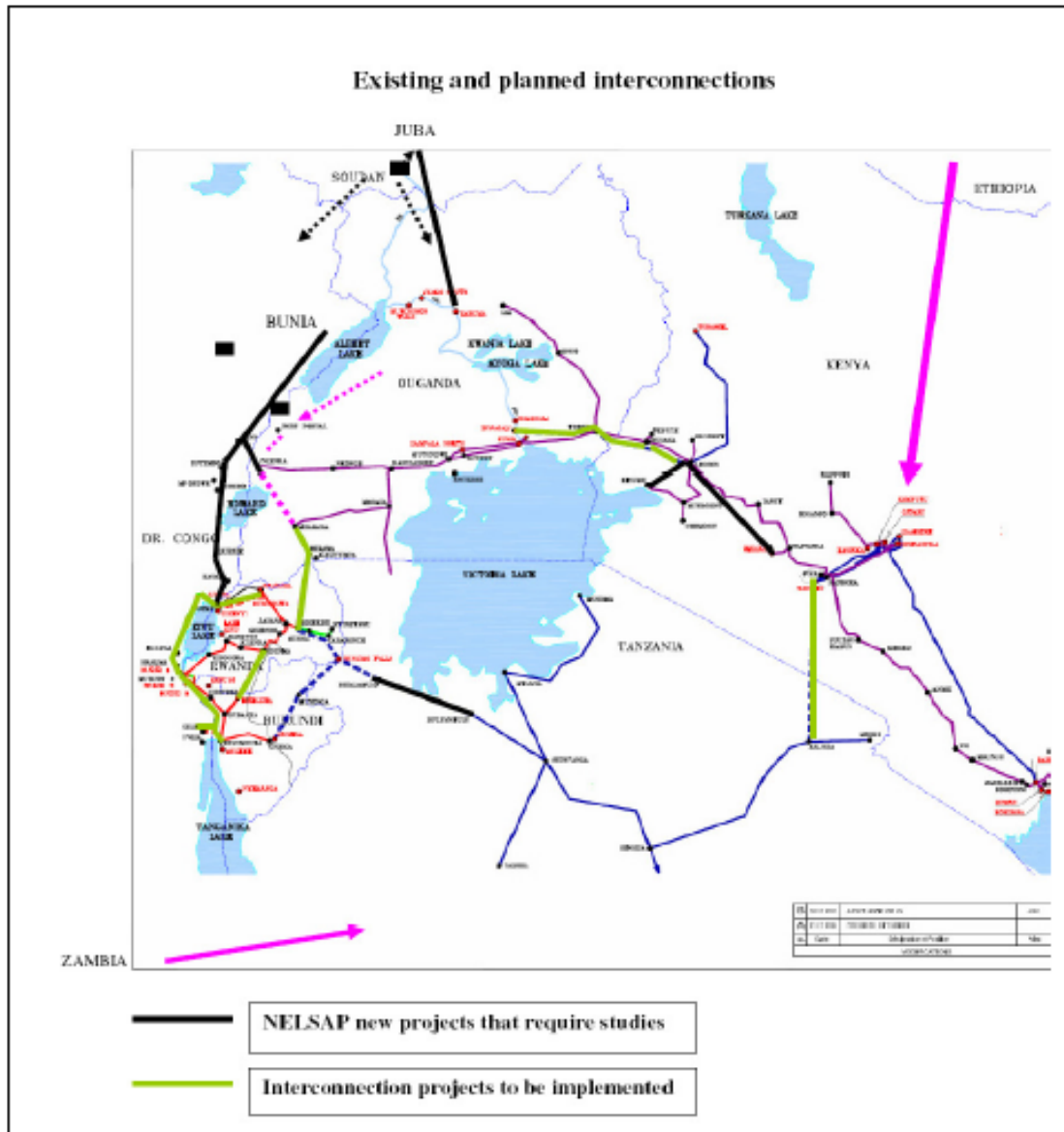


Figure 15 Regional interconnections of electric power

Source: NLC, 2009

The Kampala–Kigali oil pipeline project

Petroleum products for the Rwanda market are imported almost exclusively through the northern road corridor. From the Kenyan port of Mombassa the petroleum is transported in a pipeline that runs through Kenya’s mainland to Eldoret, from where it distributed by truck tankers to Uganda, Rwanda, Burundi and eastern parts of the DRC.

The long distance from Mombassa increases petroleum product costs, as well as vulnerability and dependence on Kenya. The latter was badly felt during the crisis in the last two months of 2008 when the only route was through Tanzania.

To increase supply reliability and minimize transport cost of imported petroleum, the Government of Rwanda has joined Kenya and Uganda in the East African oil pipeline project. Extension of the existing pipeline from Eldoret to Kampala was in March 2008, awarded to Tamoil Africa Holdings Ltd, through a concession contract, on a build-own and operate model.

Rwanda is expecting to benefit from further extension of the pipeline from Kampala to Kigali (about 600 km). Discussions to extend the pipeline to Bujumbura are ongoing. Tamoil Africa holdings Ltd shall also soon start a techno-feasibility study on a Kampala-Kigali pipeline. A market survey by Science Applications International Cooperation (SAIC), by financial support from the US Trade Development Agency, confirmed the project's commercial viability where the cost of current trucking shall be lowered from USD 56.89 to about USD 42.44 per cubic meter, hence easing the oil tariff structure. In the meantime a project to increase the current storage capacity of petroleum products in Rwanda of 175,500 m³ is under implementation.

2 Climatic Trends and Variability

2.1 Background and history on climate observing system in Rwanda

In Rwanda, the first rain gauge station was installed in 1907 at save catholic mission in the current southern province. The systematic observation of rainfall and temperature started in 1930s with around 30 climatological stations measuring rainfall (mainly) and some stations measuring rainfall and temperature (daily total rainfall and daily maximum and minimum temperature).

The Rwanda Meteorological Service was created in 1962 for aviation purposes. Therefore, between 1967 and 1975, a synoptic observing station network was established. This network included 5 stations installed on one international airport and four national aerodromes of Kigali, Butare, Kamebe, Ruhengeri and Gisenyi respectively.

In 1988, with World Meteorological Organization project, Rwanda established the station network of agro-meteorological observation. In addition to the already existing 5 synoptic stations, th network was extended to include 6 stations (Nyagatare, Kibungo, Rubengera, Gikongoro, Byumba and Kinigi). In other words, the whole network comprised 11 stations with 6 dedicated to agro-meteorological observation and 5 to synoptic observations including agro-meteorology.

Up to the end of 1992 (before the war of 1994), the total number systematic climate observation in Rwanda comprised 144 climatological stations distributed on national territory (among these, around 40 were equipped with thermometers and rain gauges and the rest with rain gauges only) and 11 main stations with 6 dedicated for agro-meteorological and 5 for synoptic observations making all together 155 stations.

However, it is to be mentioned that this observing station network was destroyed during the war of 1990-1994.

In summary, the historic meteorological/climatic data of Rwanda observed from three subsystems are: climatological, synoptic and agro-meteorological observing station networks. The measurement frequencies are hourly (synoptic stations), three-hourly (agro-meteorological station) and daily (climatological stations). From these data, decadal (ten days), monthly, seasonal and annual data are calculated.

These data comprise mainly: wind (speed and direction at 10 m height and 2 m height), temperature (maximum temperature, minimum temperature, temperature on glass, wet bulb temperature, soil temperature at 100cm, 50cm, 20cm and 10cm underground), number of sunshine hours, cloudiness (cloud cover and type of cloud), evaporation (in shelter and on evaporation pan), atmospheric pressure (measured on the site and reduced to sea level), relative humidity, vapour pressure, rainfall duration (diurnal, nocturne), rainfall quantity (diurnal, nocturne, total of the day), maximum hourly rainfall quantity.

Currently, the Rwanda Meteorological Service repaired 14 synoptic and agro meteorological stations and 34 climatological stations. By the end of 2011, it is planned to have 225 observing stations including four subsystems (synoptic, agro-meterology, climatology and

automatic) which means that, for the first time since the war in 1990-1994, Rwanda will have in 2011 the minimum meteorological network restored.

Rwanda Meteorological service have a data receiver for Meteosat Second Generation and a MESSIR processing system which allow it to receive continental climate data and satellite data on daily basis but these data are not archived for future needs.

Concerning organisational and structure point of view, Rwanda Meteorological Service has a 5 years meteorological strategic plan including rehabilitating the meteorological/ climatological observing network and recruiting staff. In addition, recent cabinet meeting approved autonomous status promoting Rwanda Meteorological Service.

2.2 Summary of key climate features

Rwanda coordinates indicate that this country is entirely situated in the equatorial zone. Yet its higher altitude between 900 and 4,500 m above sea level moderates its temperatures and accounts for its temperate climate in classification.

The classification of the climates according to Koppen is based on a combination of temperatures (takes into consideration the hottest coldest month) and rainfall (distribution during the year, depending on whether they are distributed throughout the year, centered on the winter or centred on the summer)

Considering temperatures, Rwanda is divided into two main parts:

- Regions where temperatures of the coldest month do never fall below 18°C. These are eastern regions of the country (Umutara, Bugesera Kibungo and some part of the central plateau) to which the Kivu lake sides and the plains of Bugarama are also added. These regions are connected to the category A of Koppen corresponding to the tropical climate;
- Regions where temperatures of the coldest month vary between -3°C and 18° C and where temperatures of the hottest month are always above 10°C. These regions are connected to the C category of Koppen corresponding to the hot moderate climate. These are regions where the altitude moderates temperatures.

Considering rainfall, Since Rwanda is located in the south of the Equator, the classification refers to the winter and the southern summer. During the southern winter (June, July, August) Rwanda experiences a dry season. We can therefore connect the Rwandan climate to the W category of Koppen i.e. the summer rains and the winter drought.

While combining rainfall and temperatures, we can conclude that:

- The eastern Rwanda experiences a tropical humid climate of AW type
- The western Rwanda experiences a hot moderate climate of CW type.

This second type corroborates the general idea that Rwanda is mainly characterized by a **tropical climate moderated by the altitude**.

Briefly, the above mentioned two climatic regions can be separated by the isotherm 18°C which crosses the country from Gicumbi to Huye.

In fact, the observed average of 1961 to 1990 show that rains like temperatures are moderate; this is in fact the result of a combination of a certain number of factors whose explanation is in the general and regional atmospheric circulation. These factors are among others: Inter-Tropical Convergence Zone (ITCZ), subtropical anticyclones, tropical cyclones, monsoons, east waves as well as the tile connections such as the temperatures of the surface of the oceans (SST) and the episodes El Nino/Southern Oscillation (ENSO⁴).

The principal factor that controls the rainy seasons in Rwanda is the ITCZ². Low pressures, the maximum of humidity and the convergence of winds characterize this one. It crosses Rwanda twice a year and determines two rainy periods:

- From mid-September to mid-December and from March to May. The ITCZ is at its turn controlled by the position and intensity of subtropical anticyclones such as the Mascarene Islands, Saint Helen, Azores and the Arabian ridge (Arabian high pressure). In this season, the dominating winds are from the Northeast and humidity comes from masses humidified by the Indian Ocean and Lake Victoria;
- The dry season that follows (mid-December to end February) is characterized by the penetration in East Africa by masses of dry and cold airs from the Arabian Dorsal. However, the moderating effect of Lake Victoria and the diversity of the Rwandans relief maintain some rainfalls in our country.
- During the season from March to May, Rwanda is influenced by a front situated between the dry winds from Southeast and from Southwest, which carry the humidity from the South Atlantic passing through the Congolese Basin
- Lastly, during the dry season from June to mid-September, the air masses of winds from South–East which arrive in Rwanda are dried of the continental air crossing of Tanzania and present a divergence in the low layers. These conditions are unfavourable to precipitations.

The annual mean rainfall totals varies westward from 700 mm to 1,600 mm following the topographic features. The annual mean temperature varies eastward from 15°C to 21° from western highland to eastern plains and hills respectively.

The annual mean maximum temperatures range from 13 ° C to 28 ° C according to the layering of relief. The low values of 13 ° C to 20 ° C are observed in Northwest in the volcanic region. The highest values above 25 ° C are located in the east and south east of the country and that the shores of Lake Kivu. Elsewhere in the country, the maximum temperatures are viable at 20 ° C to 25 ° C. The average annual minimum temperatures range from 5 ° C to 16 ° C by also the layering of relief. The lowest values of 5 ° C to 10 ° C are located in the North West in the volcanic region and the South West to the summits of the peak Congo Nile. Temperatures significantly colder ranging from 11 ° C to 13 ° C are observed in the high mountains of North, over much of South West and the extreme south east. The rest of the country enjoys the minimum temperatures significantly warmer ranging from 14 ° C to 16 ° C.

Latitude Sud

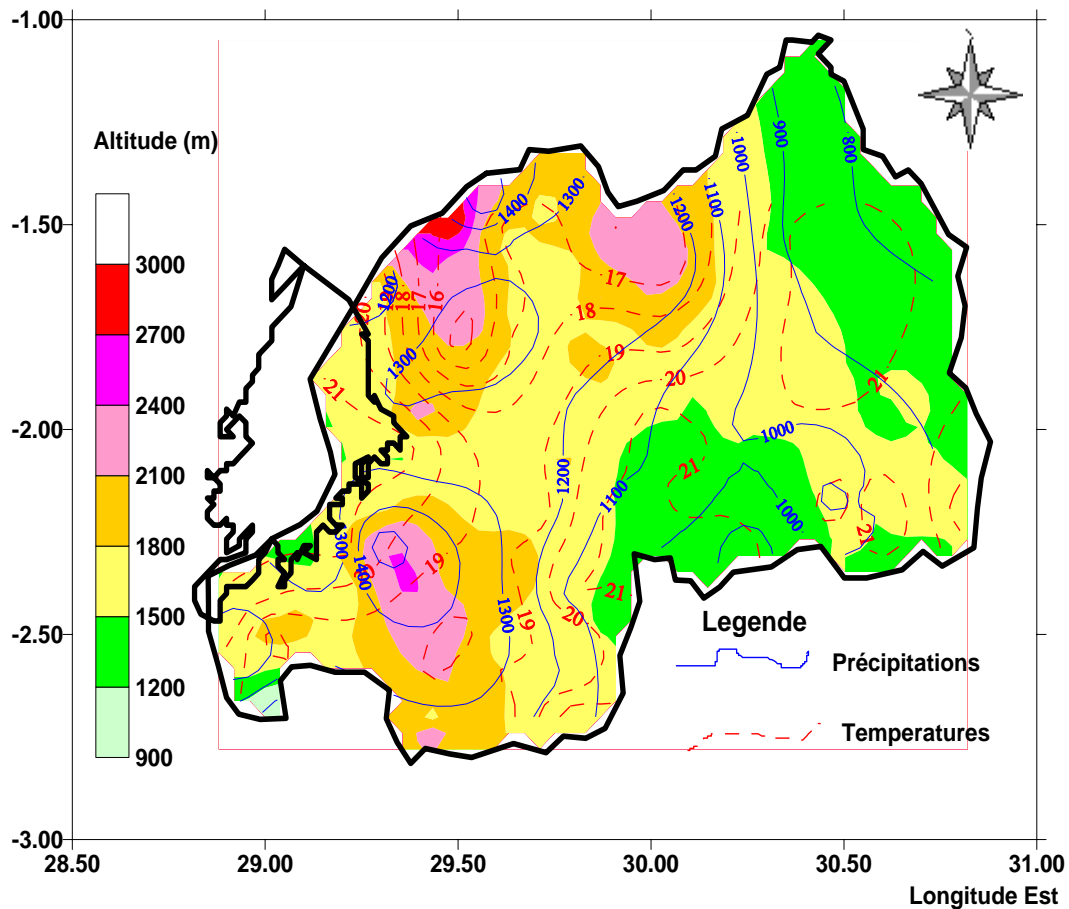


Figure 16 : Map showing relief and climate elements

Source: Data collected at National Meteorological Service

2.3 Trends of Precipitation and Temperature

Recent testimony on climate change in Rwanda indicates that:

- Temperature increased with high frequency of warm days exceeding 30°C; this is likely to impact on increase of malaria and other diseases related to warm weather;
- The number of annual rain days decreased and this is likely to impact negatively on agricultural productivity as crops requires the quantity of water within the given number of days;
- At the same time the frequency of torrential rain increased with daily rainfall quantity sometimes exceeding the total monthly rainfall; this is natural disasters caused by floods including soil erosion;
- The number of dry spells during rainy season increased affecting poor performance of crops;
- In most cases we are observing late onset of rainfall and/or early rainfall cessation during rainy season and this also affect poor performance of agriculture productivity.

2.3.1 Observed rainfall trends

According to the Second National Communication related to Climate Change (REMA, 2010) observed rainfall at Kigali meteorological station indicates that the monthly and annual total rainfalls recorded during the six years are generally lower than the average of 1961 to 1990. More particularly, April, the month with the highest rainfalls has been recorded as having the rainfall equivalent to 27%, 48%, 88%, 70% and 52% respectively in 2000, 2001, 2002, 2003 and 2005.

It should be mentioned, however, that the months of July, September, November and December have had higher rainfalls than normal with the percentages respectively of 1,441% (in 2001), 189% (in 2003), 165% (in 2006) and 153% (in 2006). In fact, the mean monthly total rainfall of July for the period 1961-1990 is 8.4 mm, however in 2001, it has been recorded 120.8 mm in this month making 1,441% of long-term average and most this rain, fall in one day on 22nd July 2001. This resulted floods which are not usually observed in dry month of July.

It can be noted that these excessive rainfalls are not equally distributed across months; they may take place in less than four days and sometimes in one day and are therefore followed by floods and landslides. This is the case of heavy rains which were observed on the 3rd of May 2002 in Kigali city, and which resulted in heavy flooding in the Nyabugogo valley. The Kanombe Airport meteorological station indicated 63,2mm of rainfall night of 2nd to 3rd May 2002. We can also mention the heavy rains in September 2007 which affected the Districts of Rubavu (Gisenyi station: 70.8mm) and Nyabihu (particularly Bigogwe Sector)

An analysis of the daily rainfall data for Kigali Airport station for the period 1971-2010 is provided in table 10 bellow. The comparison of 1971-1990 and 1991-2009 periods indicate that the monthly average number of rain days generally decreased for most of months including April and November, the most rainiest months of year. In fact the annual average total number of rain days was 146 days for the period 1971-1990 and become 131 days for the period 1991-2009. This indicates the poor rainfall performance in last years. However there is a slight improvement in March.

Table 10 Kigali Monthly and annual average number of rain days for 1971-1990 and 1991-2010 periods

Month	Number of Raindays	
	1971-1990	1991-2010
Jan	11	11
Feb	13	11
Mar	15	16
Apr	20	17
May	14	12
Jun	3	3
Jul	2	2
Aug	6	4
Sep	12	10
Oct	17	17
Nov	19	16
Dec	15	13
Annual totals	146	131

Source: Data from Rwanda Meteorological service, Analysis by A. Mutabazi (2010)

The monthly average rainfall totals, summarised in table 11 decreased in the last years (1991-2009 period) generally. This is also confirmed by the annual average rainfall totals which decreased from 1020 mm to 920 mm. In other words, during the 1991-2009 periods, there is a decrease of average rainfall of about 100 mm per year compared to 1971-1990 period. In addition, the standard deviation has generally increased, meaning that the rainfall becomes more instable. In other words, this indicates that in the last period (1991-2009), the rainfall maxima are very high in some years and the rainfall minima are very low in other years.

Table 11 Monthly and annual average rainfall totals and standard deviation

Month	Average 1971-1990	Standard deviation 1971-1990	Average 1991-2010	Standard deviation 1991-2010
Jan	64	31	77	37
Feb	100	38	82	50
Mar	106	35	120	51
Apr	182	60	131	38
May	103	66	88	54
Jun	20	26	21	24
Jul	9	17	15	30
Aug	34	34	31	26
Sep	86	44	62	34
Oct	98	33	108	48
Nov	128	44	112	43
Dec	99	34	72	36
Annual	1029.	128.	920.	175.

Source: Data from Rwanda Meteorological service, Analysis by A. Mutabazi (2010)

Figure 17 shows the trend of annual total number of rainfall days. On average, the annual total number of rainfall days decreased from 148 days to 124 days from 1971 to 2009.

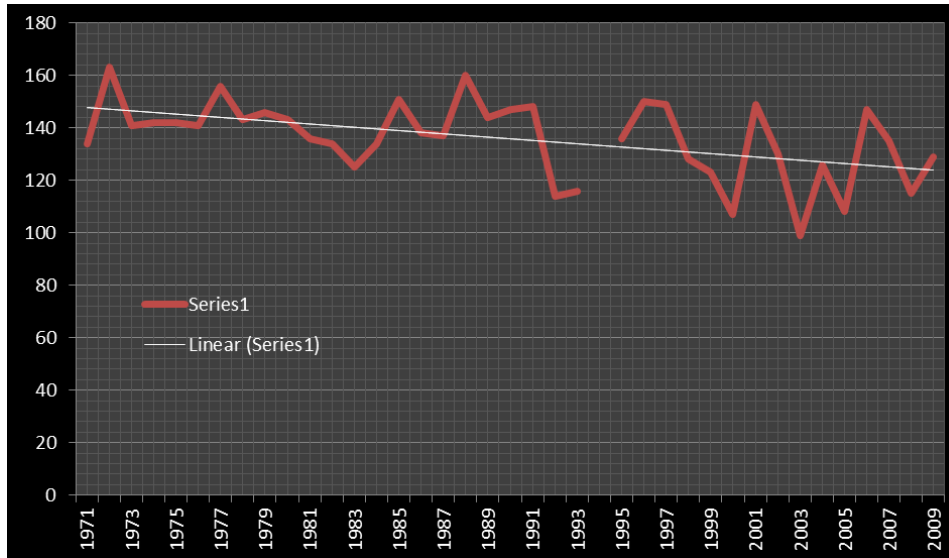


Figure 17 Annual Number of rain days (days) at Kigali station

Source: Data from Rwanda Meteorological service, Analysis by A. Mutabazi (2010)

2.3.2 Observed trends of temperature

The analysis of the average annual temperatures from the Kigali Airport Station (1971-2007) located in the centre of the country and of Kamembe station (south-West of Rwanda) shows a clear increasing tendency in rainfalls. Figure 3 bellow seems to confirm this. In fact, it can be observed in the case of Kigali Airport for instance that the average value was 19.8°C in 1971 and 21.0°C in 2009. This reveals an increase of 1.2°C in 39 years (Figure 18).

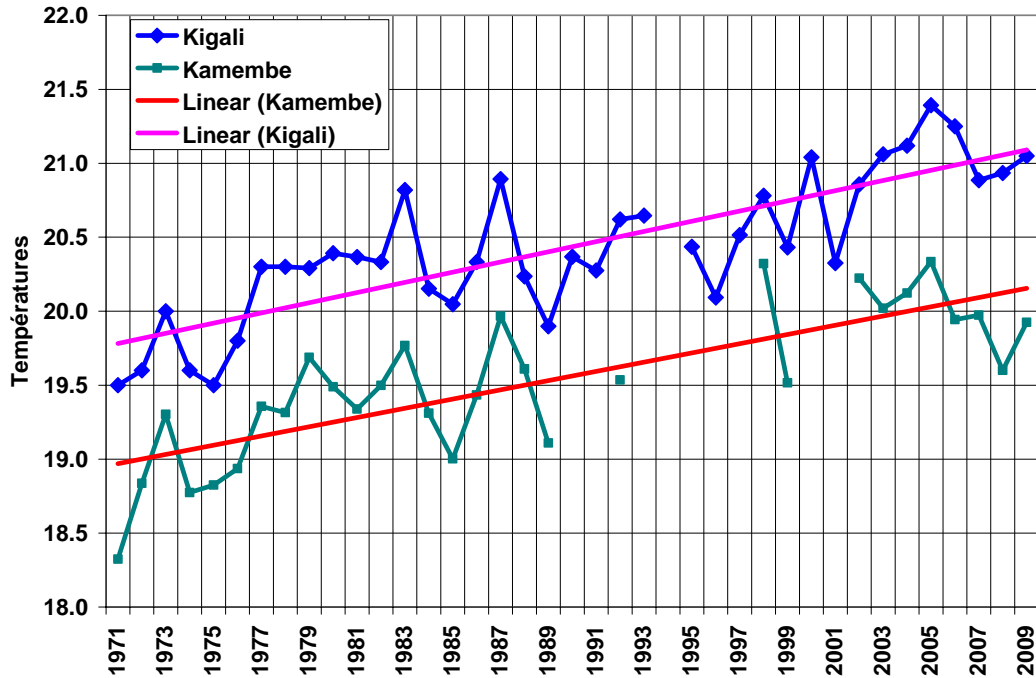


Figure 18 Variation of the annual average temperature in °C at Kigali and Kamembe stations

Source: Rwanda second National Communication related to Climate change (REMA, 2010)

This temperature increase of 1.2°C in 39 years is remarkable in as much as it exceeds the one caused by global warming estimated at 0.8°C in 150 years. A similar situation is equally noticed at Kamembe Airport station located in the south west of Rwanda.

2.4 Climate modelling and future projection

Data Processing Systems in Rwanda for real time forecasting operations is not automated. Local observed real time data is exchanged through SSB radio, telephone and internet. External data is exchanged through MSG receivers. Observed real time data such as pressure, temperature, relative humidity, rainfall, cloud cover and type are collected on hard copy. Data are controlled and validated before to be stored as soft and hard copy.

For weather forecasting, local observed data, regional synoptic data, satellite imageries and South African surface charts are used for analysis of air masses and to determine the prevailing local and regional weather. Therefore, Weather forecasting section uses the following products:

- Satellite products from MSG including, ECMWF models, etc...
- NCEP Global Forecasting System (GFS) model from internet
- Germany High Resolution Model from internet (run by Kenya Meteorological Department)
- South Africa Model products available through internet.

These parameters are used in weather discussion involving professionals charged with forecasting. A consensus is reached in the final forecast products for 1 to 3 days ahead of weather forecasting. Forecasting comprises mainly deterministic / probabilistic rainfall forecast of rainfall and temperature broadcasted every day on national radio and TV. In

addition, to 24-hour forecast, Rwanda Meteorological Service issues 7-day weather forecast, seasonal forecast and aviation forecast. However, there is a need to improve the quality and quantity of general public weather and climate forecast.

Currently, Rwanda does not run any High Resolution Numerical Weather Prediction nor Dynamical Climate Modelling. In order to enhance numerical weather prediction and climate modelling in Rwanda, two activities are planned:

- (i) An international consultant was hired by Rwanda Meteorological Service to build capacity in Numerical weather Prediction (NWP);
- (ii) The project of Africa Adaptation Program (AAP) currently running under Rwanda Environment Management Authority (REMA) is being to enhance capacity of research and mainstreaming future climate scenarios and projections by use of climate modelling.

2.4.1 Results from AR4 Global climate models

The fourth IPCC report (IPCC, 4th Assessment Report, WG I, Ch.11: Regional projections; J.H. Christensen et al.) according to which the warming of the African continent could exceed that of the global warming of the planet.

According to the same source, pre-equatorial East Africa including Rwanda is likely to be affected by an increase of rainfall ranging from 10 to 20%.

2.4.2 Results from Royal Netherland meteorological Institute

Future climate change projects for over Rwanda are available from the Royal Netherlands Meteorological Institute website: http://www.knmi.nl/africa_scenarios/East_Africa/region8/. The same information can be found in Mxolisi E. Shongwe (M. Shongwe, 2010)². Using 12 different Global Circulation models, Shongwe shows that in Rwanda and Burundi, there is high likelihood that rainfall quantity will increase by the end of 21st century. However model predictions are averages for long periods; daily, monthly and annual variability are uncertain.

While this rainfall increase is predicted to be between 10 and 20% of observed mean rainfall in 1961-1990, there is no indication whether the temporal rainfall distribution will enough to meet future water requirements.

According to what is observed in Rwanda since 1990s, there is a probability of having less rainfall days (impacting mostly on phonologic periods of crops) and more intense rainfall (daily) resulting in an increased amount of floods, landslides and associated impacts.

Figure 19 bellow shows the comparison of observed rainfall with model simulations during the preceding century (1990-2000) as well as anomalies projections in 21st century (2000-2100)

² Mxolisi E. Shongwe , Projected changes in mean and extreme precipitation in Africa under global warming, Part II: East Africa” (Journal of Climate, November 22, 2010)

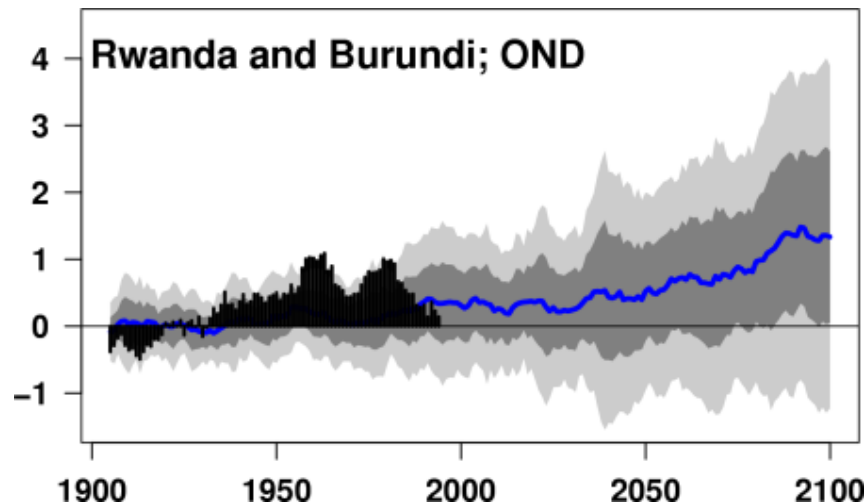


Figure 19 Observed and projected rainfall for short rain (October-December)

Source: http://www.knmi.nl/africa_scenarios/East_Africa/region8/

2.4.3 Future temperature projections

According to climate scenarios A1F1, A2, B1 and B2 the temperature is expected to increase gradually in Rwanda during the 21st century (Ruosteenoja et al., 2003) The increase expected is from 0.75 to 3.25°C during the shorter dry season (December to February) and from 1 to 3.25°C during the longer dry season (June-August).

Scenario families contain individual scenarios with common themes. The six families of scenarios discussed in the IPCC's [Third Assessment Report](#) (TAR) and [Fourth Assessment Report](#) (AR4) are A1FI, A1B, A1T, A2, B1, and B2.

Scenario descriptions are based on those in AR4, which are identical to those in TAR.

The A1 scenarios are of a more integrated world. The A1 family of scenarios is characterized by:

- Rapid economic growth.
- A global population that reaches 9 billion in 2050 and then gradually declines.
- The quick spread of new and efficient technologies.
- A convergent world - income and way of life converge between regions. Extensive social and cultural interactions worldwide.

There are subsets to the A1 family based on their technological emphasis:

- A1FI - An emphasis on fossil-fuels.
- A1B - A balanced emphasis on all energy sources.
- A1T - Emphasis on non-fossil energy sources.

The A2 scenarios are of a more divided world. The A2 family of scenarios is characterized by:

- A world of independently operating, self-reliant nations.
- Continuously increasing population.

- Regionally oriented economic development.
- Slower and more fragmented technological changes and improvements to per capita income.

The B1 scenarios are of a world more integrated, and more ecologically friendly. The B1 scenarios are characterized by:

- Rapid economic growth as in A1, but with rapid changes towards a service and information economy.
- Population rising to 9 billion in 2050 and then declining as in A1.
- Reductions in material intensity and the introduction of clean and resource efficient technologies.
- An emphasis on global solutions to economic, social and environmental stability.

The B2 scenarios are of a world more divided, but more ecologically friendly. The B2 scenarios are characterized by:

- Continuously increasing population, but at a slower rate than in A2.
- Emphasis on local rather than global solutions to economic, social and environmental stability.
- Intermediate levels of economic development.
- Less rapid and more fragmented technological change than in A1 and B1.

3 Climate Change Challenges, Risks and Impacts

According to Participatory Evaluation of Poverty Report written in October 2001, climate hazards occupy the third place among 10 most important causes of poverty in Rwanda.

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 leading to drought (Table 12)

Table 12: Observed climate related disasters from 1998 to 2002

Disaster	Damages and consequences	Affected regions	Period (year)
Droughts	266,993 people threatened by famine	South-east and central valley	1998-2000
Floods accompanied with landslides	<ul style="list-style-type: none"> • death of 42 persons • collapsed houses: 1,244 • destructed houses: 4.605 • damaged crops: 1,645 ha • death to livestock: 159 • damaged infrastructure: 83 (50 bridges, 24 roads, 9 schools) 	The north-west and the west of the country	September to December 2001
Floods and associated erosion and landslides	<ul style="list-style-type: none"> • deaths: 66 people • collapsed houses: 1,929 • destructed houses: 1,213 • Damaged infrastructure: 116 (22 roads, 7 bridges, 16 small bridges, 2 water supply, 63 water sources, 6 schools • death of Livestock: 175 • Crops: 1,077.5 ha damaged 	North-west, south-west Kigali City	Only within May 2002

Source: MININFRA, Department of Meteorology, 2004

3.1 Agriculture and Food Security

3.1.1 Presentation of agriculture, livestock and fishing

Rwanda has about 1.4 million hectares of arable land, of which 60-70% i.e. 840,000 ha. are cultivated during the two growing seasons September-October and march-May. In 2009, the population engaged in agriculture was 80%. Agriculture contributes 34% of GDP and 71%

of export revenues. In addition, it is the main source of revenues for 87% of the population. The Government considers agriculture to be the engine of economic growth in the country.

According to Rwandan habits, the breeding of cows is preferred but the number of cows does not seem to improve in proportion to the population growth; due to the small size of family land property; and consequently small ruminants, pigs and poultry are gaining more and more importance. Consequently only zero grazing type of farming is encouraged throughout the country (CFSVA).

While livestock proves to be important as a potential source of income, the number of stock breeders remains relatively low. In this context, the government has helped the deprived peasants who do not have enough land by introducing the project 'One Cow per Poor Family' and some small ruminants and pigs.

Fishing in Rwanda is practiced in Lake Kivu, Northern lakes, Lake Muhazi, depression lakes of Bugesera, Southeast lakes and lakes of Akagera National Park (ANP). It is also practiced in small hill dams constructed for various purposes, in ponds and rivers. Fishing is still at the embryonic stage and its demand is higher compared to the production. During the 1994 genocide, all of the fish ponds were 100% damaged, and their rehabilitation began only in 2008.

3.1.2 Vulnerability of climate change on agriculture and food security

Climate-related disasters like drought and flooding are becoming more regular. The poor are particularly vulnerable to these shocks. The eastern and south eastern regions are most affected by prolonged drought while the northern and western regions experience abundant rainfall that usually causes erosion, flooding and landslides. These extreme climate events have adverse environmental impacts on agricultural productivity.

- Erosion affects at least 50% of all farmers - 30% decline in farm productivity;
- Deterioration of soil is detrimental Rwanda's food security for over 90 % of the people who depend solely on agriculture in Rwanda.
- Rwanda's agriculture is highly dependent on climatic conditions and drought is cited an important vulnerability factor.
- Drought, irregular rains and dry spells were the most commonly reported shocks for households. The frequencies are reported as Bugesera (87.0%), in the south (Nyanza, 71.4%; Gisagara 60.4%; Huye 58.7%), and, in the east, Rusizi-Nyamasheke (58.8%).
-



Figure 20 Erosion phenomena in cultivated lands

Source: Rwanda, Initial National Communication related to Climate Change (MINITERE, 2005)



Figure 21 Crop failure in Eastern Province due to the 2005 prolonged drought

Source: REMA, Rwanda State of Environment and Outlook, 2009

In recent years it has been noticed that there is a shift in growing seasons A (September-November) and B (March-May). The short dry season (mid-December - mid-February) seems to disappear as indicates the continuity of rain until the first ten days of May. This causes the delay of Season B.

This disturbance confuses farmers on planting dates. As a result, they cultivate late with the risk of an early onset of the dry season, before the harvest. Thus, we observe lower yields, intensification of crop diseases, and reduction of irrigation water.

Floods recently observed in the Northwest of the country caused loss of food production and displacement of human lives, leaving people homeless and without food. The observed floods in the marshes of the Nyabarongo and Akanyaru rivers during the months of April-May destroy crops. The drought is the shock the mostly encountered in the Southeast of the country where it appears as the major factor of vulnerability. In this region, the decreases in annual rain-fall as well as prolonged and cyclical droughts lead to food insecurity and displacement of communities.

The National Institute of Statistics of Rwanda, often in collaboration with the Ministry of Agriculture and Livestock, conducts sample surveys to determine the nutritional status after a long period (5 years for EICV and 2 years for EDS).

According to the survey conducted in 2009 by CFSVA, 21.5% of Rwandan households, against 34.6% in 2006 were vulnerable to food insecurity due to lack of food crops and adequate proteins. Women in reproductive age (15-49 years) and children under five are most affected with respectively 7% and 4.6%, and the underweight representing 15.8%. Droughts and erratic rainfall affect 60-90% of households particularly in the districts of Bugesera, Nyanza, Gisagara, Huye, Rusizi-Nyamasheke, causing rising prices of staple foods. Among these vulnerable communities, geographic disparities exist in the light of changing conditions related to climate change. During the first survey on food security in 2006, the most frequent shocks severely affected two of the 13 natural regions of Rwanda namely:

- (i) The Eastern Plateau with 5% of the affected population and has experienced rainfall of approximately 53.3% of the average annual rainfall in normal times;
- (ii) The region of Bugesera with 4.8% of the affected population and which experienced 30% of the average annual rainfall in normal times.

The 2009 assessment, presents a different trend (extreme rainfall), with three regions namely the Congo-Nile crest, the eastern edge of Lake Kivu and the South East are the most vulnerable. This is explained by the fact that the western regions and the Congo-Nile Crest have experienced extreme rainfall causing soil erosion and floods that have had a negative impact more significant than in other regions. These regions are usually characterized by degraded soil due to constant erosion accentuated during abnormal rainy seasons.

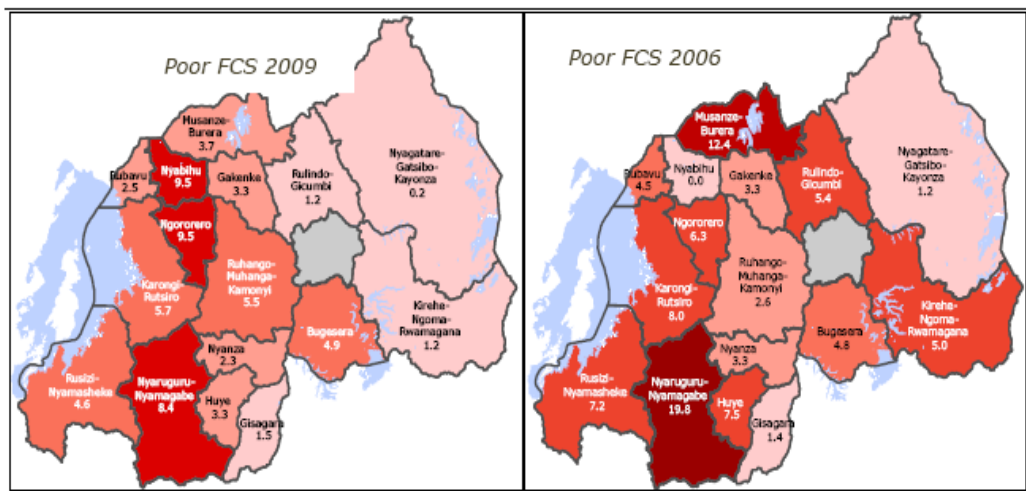


Figure 22 Food insecurity per district in 2009

Source: Rwanda, Second national communication related to climate change (REMA, 2010)

The map 21 above shows that in terms of food security, Rwanda has five regions, the most vulnerable is the region of the Congo-Nile Crest(8.4 -9.5%) in the Districts of Ngororero, Nyabihu, Nyaruguru and Nyamagabe representing 14% of the national population and 42% of the overall national population in terms of food insecurity.

3.1.3 Climate vulnerability in the area of livestock and fish farming

According to climate scenarios for Rwanda, air temperatures will increase by 1 to 3°C by the year 2100. This shall have several following implications:

- Displacement of wet and dry seasons and therefore displacement of livestock in the eastern region of the country in search of pasture and water; drought leads to dehydration causing the fatigue of livestock and the occurrence of respiratory diseases ;
- The occurrence of respiratory diseases and foot rot in the northwest of the country with higher rainfall.
- Decrease in milk production resulting in the decrease of sources of income for the population;
- Important overland runoff (resulting from drying out) on slopes under cultivation causing high sedimentation in lakes for fishing.

3.1.4 Cross-Border and regional Implication in Agriculture and Food Security

Rwanda participates in two regional research programs for agriculture and development namely AGRA and ASARECA. These are African programs where EAC research institutions are members and develop joint projects among them and/or with other Africa Countries.

AGRA is Alliance for a Green Revolution in Africa. It works to achieve a food secure and prosperous Africa through the promotion of rapid, sustainable agricultural growth based on smallholder farmers. Smallholders--the majority women--produce most of Africa's food, and do so with minimal resources and little government support. AGRA aims to ensure that smallholders have what they need to succeed: good seeds and healthy soils; access to markets, information, financing, storage and transport; and policies that provide them with comprehensive support. Through developing Africa's high-potential breadbasket areas, while also boosting farm productivity across more challenging environments, AGRA works to transform smallholder agriculture into a highly productive, efficient, sustainable and competitive system, and do so while protecting the environment.

ASARECA is Association for Strengthening Agricultural Research in Eastern and Central Africa. It is a non-political organization of the National Agricultural Research Systems (NARS) of ten countries: Burundi, D. R. Congo, Eritrea, Ethiopia, Kenya, Madagascar, Rwanda, Sudan, Tanzania and Uganda. It aims at increasing the efficiency of agricultural research in the region so as to facilitate economic growth, food security and export competitiveness through productive and sustainable agriculture.

3.2 Water resources

Enormous pressure on water resources, over the recent years, has been exerted on the water and wetlands resources through various emerging and increasing uses driven by the growing population and new activities demand. Some of these threats include agricultural intensification, pollution, invasive species, overuse and an inadequate institutional framework to manage the wetlands.

Some of these threats have affected both the quantity and quality of water available. With decreasing amounts of rainfall and increasing temperature (increasing evapotranspiration), the hydrological regime of wetlands is being threatened and water quantity being reduced. In addition, climate change is contributes to degradation of swamps.

Prolonged droughts coupled with high temperatures and a high evapotranspiration have caused additional pressure on water resources, causing: reduced river discharges, decline of base level for rivers and lakes, drying up of springs and loss of biodiversity of aquatic systems.

Such droughts occur frequently in bioclimatic regions of East, South-East and some areas of the country's central plateau (Umutara, Kibungo Bugesera Mayaga and Muhanga) where people suffer at times of famines especially in vulnerable families.

In 2004 - 2005, prolonged drought, coupled with human action of making a drain in the Rugezi marshland which feeds Burera and Ruhondo lakes, contributed significantly to the reduction of electricity generation by Ntaruka and Mujungwa hydropower plants, as the result of the reduction of water level in those lakes. Electricity production dropped from 12 MW to 3 MW for Ntaruka and from 11 MW to 2 MW for Mukungwa plant.

Similarly, in dry seasons, water treatment plants supplying the cities in the country face the problem of sensible decrease of water discharges in rivers which supply those stations, causing drinking water shortages in cities and rural areas served by these stations.

For example, Kimisagara water treatment plant faces shortage in dry seasons. It loses part of the water to be treated from river Yanze whose stream discharges drop significantly as a result of rising temperatures, but also because of the activities of watering vegetable crops carried out by farmers to save their crops during the dry season.

These climatic changes also affect the groundwater, causing the reduction of water tables and therefore reduce the flow of springs and wells that supply drinking water to the majority of the population in rural areas. On the other hand, torrential rainfall occasioning floods and landslides are being to affect water siltation and destruction of drinking water infrastructures.



Figure 23 Dried out river during the drought

Source: Rwanda State of Environment and Outlook (REMA, 2009)

3.3 Natural resources

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 % 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)

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.

Among these threats, climate change is most linked to the loss of habitat by conversion of natural habitats. There is an indirect linkage due human activity already impacted by climate change such as practices of agriculture activities in Marshland due to lack of rainfall. This is the case of Rugezi wetland degradation in 2000.



Figure 24 The draw-down of water table led to the conversion of this part of Rugezi marsh in pastureland

Source: Sylvère Hategekimana, Emmanuel Twarabamenye
http://www.irst.ac.rw/IMG/pdf/Paper_for_V_International_Symposium_on_En_Hydrology1.pdf

Other climate change related threats observed in Rwanda are pressure on ecosystems presented under different forms such as: reduction of protected areas, overexploitation of biological resources, non-regulated introduction of exotic species and bush fires.



Figure 25 Cattle graze in the forest in Akagera National Park, especially during periods of drought
Source: Rwanda State of Environment and Outlook (REMA, 2009)

In Rwanda, there no documented and no study linking with direct climate change impacts on changes in species composition, changes in ecosystems, increases in wildfires, nature and chemical composition of water sources and tourism linking to natural resources.

However, according to Rwanda State of Environment and Outlook (REMA, 2009), some areas of the country that are habitat to threatened species or rich with biodiversity that needs 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. 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.

3.4 Energy Security

Rwanda energy background is detailed in 1.5 above. Climate change impacts on energy infrastructures during heavy rains. With prolonged drought causing high evaporation, climate change impact on hydropower production potential. Also long drought would have impact on biomass production. On other hand, the temperature increase could enhance more solar energy production.



Figure 26 Water level decline on Lake Burera which supplies Hydroelectric plants of Ntaruka and Mukungwa

Source: Rwanda, Second national Communication related to Climate change (REMA, 2010)

3.5 Physical infrastructure

In Rwanda, the road transports covers 14,000 km of roads. The Air traffic is mainly dominated by 4 air companies. Maritime transport is mainly practised on Lake Kivu. The project of railway co-shared with Tanzania and Burundi is on final stage and very soon will be implemented.

Heavy rain falls observed in last times due to climate change bring about deadly landslides that damage road infrastructures. Following photos show (i) Landslides on Gikongoro-Cyangugu road in Nyungwe National Park and (ii) Flooded road in Bigogwe, Nyabihu District, on 12th Septembre 2007.



Figure 27 Landslides on Gikongoro-Cyangugu road in Nyungwe National Park

Source: Rwanda, Initial National Communication related to Climate Change (MINITERE, 2005)



Figure 28 Flooded roads in Nyabihu (12th Sep 2007) and Nyandungu (23rd Jan 2010)

Source: Rwanda Second National Communication related to Climate Change (REMA, 2010)

3.6 Social infrastructures

In Eastern Province effects of drought on food security and livestock constitute major risk elements and create favourable conditions to famines that cause displacements of the populations and transhumance of the livestock.

On the other hand, heavy rain falls observed in last times due to climate change bring about deadly landslides that damage road infrastructures or sweep away the population's houses in rural areas. In urban areas, flood risks are bigger for human settlements located in the valley-bottom areas on riverbanks / lakeshores or marshlands. The overpopulated districts in these zones are threatened by epidemics like malaria and diarrhoeic diseases.

Urban infrastructures are threatened due to runoff that sweep away land, gravel and other materials that obstruct gutters that collect rain water, hence the overflowing of waters and destruction of roadways and houses built with fragile materials. Most of the country's industries operate in Kigali city and the big majority of them are located in the Valley of Runganwa River as well as in the Valley of Nyabugogo River. These valleys are characterised by very high vulnerability to flooding which causes considerable damages during rainy.

The diseases or health problems relevant to the climatic extremes are malaria, cholera, meningitis and accidents related to flood damages due to heavy rains like dwellings or infrastructures destructions and landslides.



Figure 29 Flooded farm and human settlement in Bigogwe, Nyabihu District, on 12th Septembre 2007

Source: Rwanda State of Environment and Outlook (REMA, 2009)



Figure 30 Destruction of unplanned urban (Kigali) settlement due to heavy rains and Floods in the Hotel La Palisse compound (Photo of 23rd January 2010)

Source: REMA, Department of Environmental Impact Assessment, Compliance and Pollution Control

4 Country climate change Response Initiative

4.1 Compliance with multilateral environmental obligations

Rwanda has ratified and signed more than 10 International Conventions and Protocols on or related to environment. Rwanda is an active participant in major international multilateral conventions relating to environmental governance, most notably the Convention on Biological Diversity (CBD), the United Nations Framework Convention on Climate Change (UNFCCC) and the Convention to Combat Desertification and Drought (UNCCD).

The references of all International Environmental Convention (IEC) signed or ratified are the following:

- (i) International Convention on Biological Diversity and its Habitat signed in RIO DE JANEIRO in BRAZIL on 5 June 1992, as approved by Presidential Order n° 017/01 of 18 March 1995;
- (ii) United Nations Framework Convention on Climate Change, signed in RIO DE JANEIRO in BRAZIL on 5 June 1992, as approved by Presidential Order n° 021/01 of 30 May 1995;
- (iii) STOCKHOLM Convention on persistent organic pollutants, signed in STOCKHOLM on 22 May 2001, as approved by Presidential Order n° 78/01 of 8 July 2002;
- (iv) ROTTERDAM International Convention on the establishment of international procedures agreed by states on commercial transactions of agricultural pesticides and other poisonous products, signed in ROTTERDAM on 11 September 1998 and in New York from 12 November 1998 to 10 September 1999 as approved by Presidential Order n° 28/01 of 24 August 2003 approving the membership of Rwanda;
- (v) BASEL Convention on the Control of Transboundary Movements of Hazardous wastes and their disposal as adopted at BASEL on 22 March 1989, and approved by Presidential Order n° 29/01 of 24 August 2003 approving the membership of Rwanda;
- (vi) MONTREAL International Convention on Substances that Deplete the Ozone Layer, signed in LONDON (1990), COPENHAGEN (1992), MONTREAL (1997), BEIJING (1999), especially in its Article 2 of LONDON amendments, and Article 3 of COPENHAGEN, MONTREAL and BEIJING amendments as approved by Presidential Order n° 30/01 of 24 August 2003 related to the membership of Rwanda;
- (vii) CARTAGENA protocol on Biosafety to the Convention of Biological Biodiversity signed in NAIROBI from May 15, to 26, 2000 and in NEW YORK from June 5, 2000 to June 4, 2001 as authorised to be ratified by Law n° 38/2003 of 29 December 2003;
- (viii) KYOTO Protocol to the Framework Convention on Climate Change adopted at KYOTO on March 6, 1998 as authorised to be ratified by Law n° 36/ 2003 of 29 December 2003;
- (ix) RAMSAR International Convention of February 2, 1971 on Wetlands of International importance, especially as waterfowl habitats as authorised to be ratified by Law n° 37/2003 of 29 December 2003;
- (x) BONN Convention opened for signature on June 23, 1979 on conservation of migratory species of wild animals as authorised to be ratified by Law n° 35/2003 of 29 December 2003 ;

- (xi) Washington Agreement of March 3, 1973 on International Trade in endangered species of Wild Flora and Fauna as authorised to be ratified by Presidential Order n° 211 of 25 June 1980;

As part of the implementation of the 3 Rio Conventions, commonly referred to as Multilateral Environmental Agreements (MEAs), the GoR developed National Strategies and Action plans for each convention viz: the National Biodiversity Strategy and Action Plan (NBSAP) 2003, National Plan of Action (NAPA) for climate change adaptation (2006/7), and National Action Plan (NAP) for combating desertification. These strategies and action plans reflect national priorities for ENR sector that are online with the EDPRS priorities.

In addition, Rwanda participates in regional initiatives related to environment protection and management as the Nile Basin Initiative, the Lake Victoria Biodiversity Programme and the New Partnership for Africa's Development (NEPAD).

4.2 Policy framework

(i) Environment and Climate Change:

Rwanda has its Environment policy. The National Environment policy sets out overall and specific objectives as well as fundamental principles for improved management of environment, both at the central and local level, in accordance with the country's current policy of decentralisation and good governance.

It also lays a solid foundation for the establishment of a legal framework for improved management of the environment, as well as the right principles for the participation of the population in general, and women and youth in particular.

The environment policy has provisions on climate change. Natural disasters are those which are due to climatic or seismo-volcanic disturbances. Those representing a permanent threat to our country include drought, torrential rains, floods and landslides. Natural disasters resulting to the climate variations are mainly due to deforestation which causes the high vulnerability.

The overall objective of the environmental policy is the improvement of people's wellbeing, the judicious utilisation of natural resources and the protection and rational management of ecosystems for sustainable and fair development.

The policy specific objectives are as follow:

- To improve the health and the quality of life for every citizen and promote sustainable socio-economic development;
- To integrate environmental aspects into all the development policies, in planning and budgeting;
- To conserve , preserve and restore ecosystems and maintain ecological and systems functioning;
- Optimum utilisation of resources and attain a sustainable level of consumption of resources;
- To create awareness among the public to understand and appreciate the relationship between environment and development;

- To ensure the participation of individuals and the community in the environment activities with special attention to women and the youth;
- To ensure that the basic needs of today's population and those of future generations are met.

(ii) Agriculture policy

Agriculture Policy suggests a strategic plan for transformation of agriculture and indirect deals with climate changes. Most of the proposed actions aim at protection and conservation of the soils against erosion and restoration of their fertility.

(iii) Water Policy

The national water policy has a mission to create favourable conditions for fair and sustainable access for the population, men, women and children, to water and sanitation infrastructure and to the development of natural resources.

The overall objective of the sector policy is to improve the living conditions of the population through optimal use of water resources and access of all to water and sanitation services.

The specific objectives to address the sector concerns are:

- Rational and sustainable management of water resource;
- Increased rate of access to drinking water;
- Increased rate of access to water of agro – livestock;
- Development of sanitation and promotion of hygiene;
- Mastery of water for environmental protection;
- Increased use of water for energy production;
- Capacity building.

(iv) Energy policy

The aim of the energy sector policy is to effectively contribute to the growth of the national economy and thereby improve the standard of living for the entire nation in a sustainable and environmentally sound manner.

The mission of the energy sector is to create conditions for the provision of safe, reliable, efficient, cost-effective and environmentally appropriate energy services to all sectors on a sustainable basis.

By fulfilling its vision and mission, the energy sector will contribute to social economic development, and in the long-term framework, poverty reduction.

The national energy policy objectives are to ensure availability of reliable and affordable energy supplies and their use in a rational and sustainable manner in order to support national development goals. The national energy policy, therefore, aims to establish an efficient energy production, procurement, transportation, distribution and end-use systems in an environmentally sound and sustainable manner.

(v) Forestry policy

The forestry policy addresses all these issues and also, targets ecological and economic welfare of the existing woodlands/forests, forestry research, other types of forestry, institutional capacity building (number and quality of the personnel) and the ongoing desertification process in some parts of the country. Moreover, it is of paramount importance to link forestry with rural development by establishing relationship between forestry and actors, i.e. beneficiaries.

The overall goal of the forestry policy is to make forestry one of the bedrocks of economy and of national ecological balance. The forestry policy has the following specific objectives:

- Improvement of the management of forest resources;
- Improvement of forestry extension and education;
- Adding value on wood and non timber forest products;
- Development of forestry and agro-forestry research;
- Saving wood;
- Building the capacities of forestry institutions;
- Assessment of the contribution of goods and services of the forestry sector; to the national economy;
- Strengthening of sub-regional and international cooperation in forestry;
- Integration of gender-related challenges and roles with forestry management;

(vi) Transport policy

Rwanda landlocked status has a negative impact on the economic growth and development of the country. The exceptionally high cost of transport at national and international levels, coupled with insufficient affordable and accessible modes of transport for people in both urban and rural areas, constitute a major constraint which must be taken into account for the sector policy to achieve the short, medium and long-term development goals that Rwanda has mandated.

The Transport Sector Policy, approved in 2008, defines the vision of the Government for the sector as well as its strategic orientations which will guide its actions for the next five years. The Transport Sector Policy is informed by planning tools such as the Vision 2020, the Economic Development and Poverty Reduction Strategy (EDPRS), the National Investment Strategy, and the Medium Term Expenditure Framework. It also takes into account other tools of reference such as the Millennium Development Goals and the action plan of the Sub-Saharan Africa Transport Policy (SSATP). The Policy incorporates cross-cutting issues such as HIV/AIDS and environmental protection.

4.3 Organization framework

At the institutional level, the Ministry of Lands and Environment (MINELA) is the Ministry responsible for designing the state policy related to climate change management, environment protection, conservation and management, while REMA (Rwanda Environment Management Authority) is the official organ in charge of implementing this policy. A successful outcome of this policy requires the collaboration between REMA and all potential

stakeholders: departments in ministries, public institutions, schools and research institutions, international bodies and nongovernment organizations.

REMA is the Authority in Rwanda in charge of supervision, following up and ensuring that issues relating to environment and Climate change receive attention in all national plans. REMA has responsibility to implement the Environment and climate change policy within Economic Development and Poverty Reduction Strategy (EDPRS) framework.

From 2009, a Department of Climate Change and International Environmental Obligation (CCIO) was created and from 2010, it starts to be operational under REMA. The main functions of CCIO Department include:

- Developing the capacity of REMA in clean development mechanism;
- Assuring the secretariat of the National Designated Authority under the Kyoto Protocols Clean Development Mechanism;
- Coordinating the preparation and implementation of policy, strategy and regulatory frameworks and instruments towards mitigation and adaptation of the country on climate change;
- Advising on opportunities and emerging issues related to climate change and climate change responses measures;
- Coordinating implementation of Multilateral Environment Agreements (MEAs) and other Regional and international Agreements in the field of environment;
- Provide technical input in negotiating and implementing regional and international conventions, protocols and treaties relating to environmental management;
- Initiate and coordinate the drafting of the national reports and assess convention decisions and recommendation to update the plan by integrating those that are relevant;
- Coordinate the work of the Conventions Focal Points;
- Provide technical advices related to GEF endorsement of projects;
- Ensure national compliance with international and regional agreements related to environment.

The structure of the Climate Change and International Environmental Obligation is as follow:

- (i) Climate Change and Environmental International Obligations: the Acting Director is nominated;
- (ii) Climate and Greenhouse Gases Data Management: one staff hired;
- (iii) Vulnerability Adaptation Assessment and Project Management: one staff hired;
- (iv) Mitigation Assessment and Project Management: one staff hired;
- (v) International Environmental Agreements: One staff hired to combine with (iii)

4.4 Rwanda's Economic Development and Poverty Reduction Strategy (EDPRS)

Rwanda's Economic Development and Poverty Reduction Strategy (EDPRS) provides a medium term framework for achieving the country's long term development aspirations as embodied in Rwanda Vision 2020, the seven years Government of Rwanda (GoR) programme, and the Millennium Development goals.

The strategy builds on strong achievements in human capital development and promotes three flagship programmes. These flagships serve as a means to prioritise actions by the GoR, mobilise resources for development and improve policy implementation through more co-ordinated interventions across sectors.

Environment, climate change and land priorities involve ecosystems, the rehabilitation of degraded areas and strengthening newly established central and decentralised institutions. Special attention will be paid to sustainable land tenure security through the planning and management of land registration and rational land use, soil and water conservation, reforestation, preservation of biological diversity and adaptation and mitigation against the impact of climate change.

There are several environmental targets in the EDPRS. Five critically degraded ecosystems will be mapped, assessed and rehabilitated from the current 50% to 80% in 2012 as part of the Integrated Management of Critical Ecosystems (IMCE) project. Rehabilitated ecosystems will contribute to an increase in hydro-electric power generation as in the case of the *Ntaruka* station which is presently operating below capacity due to a drastic decline in water levels within the *Rugezi* wetland. Restored wetlands will provide water for irrigation, and both wetlands and protected forest areas, such as *Nyungwe*, will promote income generation from tourism. Moreover, a land use and management master plan will be developed.

It is planned to increase the proportion of protected areas for biodiversity preservation from 8% to 10% in 2012. Forest and agro-forest coverage is scheduled to increase from 20% to 23% of total surface land area, and annual wood consumption is due to be reduced by 30% from the 2002 figure. Soil erosion and soil fertility decline will be reduced by 24% over the EDPRS period. In mining, the targets are to increase mineral exports by 250% and increase employment from 25,000 to 37,000 of which 20-30% of those employed should be women. In climate change, it is intended to strengthen the national capacity of mitigation and adaptation by integrating the climate change in all sector policies and programmes. In order to address the climate change impact, awareness will be raised and adaptation projects will be implemented.

In agriculture, the main programmes include the intensification of sustainable production systems in crop cultivation and animal husbandry; building the technical and organizational capacity of farmers; promoting commodity chains and agribusiness, and strengthening the institutional framework of the sector at central and local level.

Agriculture accounts for over one-third of GDP, but its average annual growth rate of 4.8% in 2001-2006 was only half that registered in 1996-2000 (9.5%). Thus, it is essential to increase agricultural productivity to ensure that Rwanda meets its growth target. To this end, it is planned that the area to be protected against soil erosion will rise from 40% of the agricultural land area in 2006 to 100% in 2012. The area under irrigation will increase from 15,000 to 24,000 hectares, and of this, the hillside area irrigated will expand from 130 hectares to 1,100 hectares. The area of reclaimed marshland will increase from 11,105 to 31,105 hectares. Agricultural intensification will be promoted with regard to both crop and livestock production. It is intended that the proportion of rural households with livestock will rise from 71% to 85% and the main epidemic animal diseases will be eradicated or controlled. The application of inorganic mineral fertiliser will increase from 11% to 40%, and the use of improved seed will rise from 24% to 37%.

Infrastructure: Infrastructure consists of five sub-sectors: transport, energy, habitat, ICT and meteorology. In the transport sub-sector, the Ministry of Infrastructure (MININFRA) plans to have trained 100 staff and to have started at least five major projects by 2012.

The classified road network will be rehabilitated and maintained during the EDPRS, so that 31% of the network is in good condition by 2012 and 75% of district roads rehabilitated. In the energy sub-sector, 200,000 households will have access to electricity by 2012.

The total capacity will increase from the present 45MW to 130MW by 2012 mainly through the generation of 50MW more of hydro-electric power, while Lake Kivu methane gas reserves will come on stream and generate 25MW of energy.

The electricity coverage of institutions providing social and administrative services will rise from 50% to 80%. In the area of habitat and public assets management, emphasis will be put on the planning and development of improved rural and urban human settlements consistent with the contemplated sustainable land use and environment protection schemes.

Improve health status and slow down population growth

At the level of health outcomes, it is planned to reduce the total fertility rate from 6.1 to 4.5 children per woman, and to reduce HIV incidence among 15-24 year old men and women from 1% to 0.5%. The incidence of chronic malnutrition (stunting) among the under-fives is planned to fall from 45% to 35%, while the prevalence of anaemia among women aged 15-49 is scheduled to decrease from 33% to 20%.

It is planned that the percentage of the population living within one hour of a functioning health centre will rise from 58% to 70%, and the proportion of health centres and hospitals equipped to provide a comprehensive preventive and curative health care package covering family planning, nutrition and infectious diseases will increase from 45% to 70%. The proportion of children sleeping under insecticide treated bed nets (ITNs) is planned to rise from 16% to 90%, while the corresponding proportion for pregnant women will increase from 20% to 90%. *Chemoprophylaxis* coverage of pregnant women will rise from 6% to 94%.

Improve water resources management and access to safe drinking water and sanitation

A high priority of the EDPRS is to ensure sustainable and integrated water resources management and development (IWRM&D) for multipurpose use (energy production, irrigation, navigability). To this end, capacity will be developed and institutions will be built at national and trans-boundary levels, pilot sub-basin committees and Local Water Associations (LWAs) will be established in the *Nyaborongo* and *Muvumba* Basins, while IWRM&D governance and investment plans will be put in place for the entire country by 2012. Underground and surface water master plans will also be implemented.

Summary of EDPRS targets are in table 15 below.

Table 13 Targets of the EDPRS in 2012

Priority area	Indicator	Baseline 2006	Target 2012
Growth and poverty reduction	Real GDP growth (% annual)	6.5	8.1
	Export growth (% annual)	10	15
	National investment (% of GDP)	16.3	24.4
	Share of population living in poverty (%)	57	46
	Share of population living in extreme poverty(%)	37	24
	Poverty incidence among people living infemale-headed households (%)	60	48
	Employment in agriculture (% reporting asmain occupation)	80	70
Widen and strengthen the Finan-cial Sector	Private Sector credit (% of GDP)	10	15
	Financial depth (broad money/GDP)	20	22.5
Develop skills	Pupil/teacher ratio in primary schools	70:1	47:1
	Pupils/classroom in primary schools	70:1	52:1
	Gross secondary school enrolment	10	30
Raise agricultural productivityand ensure food security	% of agricultural land protected against soilerosion	40	100
	Area under irrigation (hectares)	15,000	24,000
	Use of mineral fertiliser (kgs/ha)	11	40
	Rural households with livestock (%)	71	85
Improve environmental manage-ment	Forestry coverage (%)	20	23.5
	Reduction in annual wood consumption (mil-lion cubic metres)	8.9	6.2
	Critically degraded ecosystems mapped, as-sessed and rehabilitated (%)	50	80
Build infrastructure	Households with access to electricity (numberof households)	70,000	200,000
	Electricity generation (off/on grid, MW)	45	130
	Classified Road road network in good condi-tion (%)	11	31
	ICT composite network coverage (%)	75	100
Improve health status and reduceslow down population growth	Infant mortality (deaths per 1,000 live births)	86	70
	Maternal mortality (deaths per 100,000 livebirths)	750	600
	Population covered by health insuranceschemes (%)	70	95
	Women aged 15-45 using modern contraccep-tive techniques (%)	10	70
	Incidence of HIV among 15-24 year olds (%)	1	0.5
	Total Fertility Rate (children per woman)	6.1	4.5

Increase access to safe drinking water and sanitation	Access to safe drinking water (% of population)	64	86
Strengthen governance, security and the rule of law	Share of population expressing satisfaction/confidence in decentralised governance (%)	85	100

Source: Economic development & poverty reduction strategy 2008 – 2012 (MINECOFIN, 2007)

4.5 Environment and climate change sector strategic plan 2010 - 2015

Environment and Climate Change intends to operationalize the eight-programme strategy of Environment and Natural resource Sector Strategic Plan. It was prepared in partnership with various stakeholders and will be implemented within Sector Wide approach frameworks which will facilitate the Government of Rwanda to mobilize donors wishing to contribute in Environment and climate change related projects and programs.

The Environment and Climate Change Strategic Plan specific objectives:

- (i) To ensure that the productive and regulatory functioning of ecosystems in Rwanda is restored, maintained or enhanced by rehabilitating, conserving and sustainably managing all critical ecosystems;
- (ii) To ensure that Rwanda is protected from the effects of climate change by putting in place and implementing appropriate mechanisms for mitigation and adaptation, through mobilization of and collaboration with stakeholders;
- (iii) To ensure that environmental sustainability principles are effectively mainstreamed into all national development policies, programmes, plans and budgets;
- (iv) To ensure that Rwanda has adequate and sustained capacity for effective environmental governance and decentralized service delivery
- (v) To ensure that Pollution is controlled and effectively managed

In this strategic plan, the Rationale, Strategic focus and National priorities for Climate Change are as follow:

Rationale

Although Rwanda is a low-carbon economy, it's among those most vulnerable to climate change. Recent events – prolonged droughts characterised by crop failures, erratic and destructive rains, floods, have demonstrated that climate change is real and will affect poor countries like Rwanda , natural resource dependent communities with limited safety nets like the most Rwandans. Presently, climate change management initiatives in Rwanda are limited to monitoring green house gases (GHG) emissions and a few projects for mitigation and adaptation, under the Rio Multilateral Environmental Agreements (MEAs).

Strategic focus

The Climate Change programme will design and implement a comprehensive national climate change policy and strategy, to integrate climate change into all development policies, programmes and budgets.

National priorities

- Generating spatial and thematic information on Rwanda's climate change vulnerability, including implications for poverty reduction and regional integration;
- Developing a policy and institutional framework for integrated climate change management;
- Capacity development for climate change management including disaster preparedness and response, climate change mitigation and adaptation, in a sustainable way;
- Public-private partnerships for sustainable financing and management of climate change issues, including international negotiations and communication.

Table 14 Budget estimate for Climate change strategic plan (2010/2015)

Programme Outcomes, Outputs and Major Activities	Total Estimates (RwF' million)	2010-2011	2011-2012	2012-2013	2013-2014	2014-2015
Outcome 2: National Capacity developed for cost-effective & sustainable Climate Change management	5,737,646,500	307,388,000	3,374,314,500	1,345,439,000	671,745,000	38,760,000
Output 2.1: Climate change related vulnerability of population monitored to support socio-economic development	1,172,374,000	238,475,000	292,410,000	641,489,000	0	0
<i>2.1.1: Conduct baseline study accros sectors to improve data and information relevant to climate change;</i>	76,950,000	38,475,000	38,475,000	0	0	0
<i>2.1.2: Assess recent climate change using historical climate data and downscaling with high resolution climate models</i>	87,210,000	0	87,210,000	0	0	0
<i>2.1.3.: Conduct climate change vulnerability assessment and mapping</i>	79,515,000	0	79,515,000	0	0	0
<i>2.1.4: Regular monitoring of climate change and its impacts</i>	29,070,000	0	0	29,070,000	0	0
<i>2.1.5: Develop technical capacity for GHGs inventory analysis and reporting</i>	282,150,000	0	0	282,150,000	0	0
<i>2.1.6: Develop technical capacity for GHGs mitigation assessment including carbon trade projects</i>	90,630,000	0	0	90,630,000	0	0
<i>2.1.7: Develop technical capacity for adaptation to climate change for various sectors</i>	90,630,000	0	0	90,630,000	0	0
<i>2.1.8: Conduct sector specific studies on resilience and coping mechanisms to improve adaptation to climate change</i>	90,630,000	0	0	90,630,000	0	0
<i>2.1.9: Carry out monitoring of mitigation and adaptation projects</i>	241,279,000	200,000,000	0	41,279,000	0	0
<i>2.1.10. Conduct a study on appropriate technology transfer in Rwanda for climate change management;</i>	17,100,000	0	0	17,100,000	0	0

Output 2.2: Integrated National Climate Change management policy and strategy developed and implemented	4,470,766,500	39,900,000	3,036,931,500	683,430,000	671,745,000	38,760,000
2.2.1: Develop national climate change policy	20,520,000	0	0	20,520,000	0	0
2.2.2: Facilitate national participation in regional and international negotiations and policy formulation on climate change adaptation and mitigation	82,080,000	10,260,000	10,260,000	20,520,000	20,520,000	20,520,000
2.2.3: Organise annual research-based policy dialogue on climate change;	20,520,000	0	0	20,520,000	0	0
2.2.4: Develop national climate change mitigation and adaptation strategies & plans of actions (NAMAs= National appropriate mitigation actions and NAPAs= National adaptation programmes of action)	65,521,500	0	65,521,500	0	63,555,000	0
2.2.5: Establish a climate change information and knowledge exchange system	84,360,000	29,640,000	18,240,000	18,240,000	18,240,000	18,240,000
2.2.6: Develop guidelines, methodologies & other support tools for integrating climate change issues for major sectors	2,065,680,000	0	2,065,680,000	0	0	0
2.2.7: In collaboration with the NDMU and meteorological services develop a climate-related disaster management system linking existing early warning systems	2,050,290,000	0	877,230,000	603,630,000	569,430,000	0
2.2.8: Professional development in climate modeling and climate change impact assessment with Support effective public awareness campaigns, publication and dissemination on climate change for policy makers	0	0	0	0	0	0
Output 2.3: Private sector involvement in climate change management promoted	94,506,000	29,013,000	44,973,000	20,520,000	0	0
2.3.1: In collaboration with NAFA and other sectors, Ensure integration of low-carbon growth mechanisms into the national competitiveness policy;	20,520,000	0	0	20,520,000	0	0
2.3.2: Mobilise & sensitise private sector to invest in carbon projects ; prepare & disseminate guidelines for low carbon investments	39,871,500	11,955,750	27,915,750	0	0	0
2.3.3: Identify, train & equip private sector focal points and change agents for GHGs/ODSs emission reduction;	34,114,500	17,057,250	17,057,250	0	0	0

Source: REMA, Environment sub-sector strategic plan 2010 – 2015, May 2010, Annexe 2

4.6 Existing Financing mechanisms under UNFCCC and Kyoto Protocol

Following are background and existing financing mechanisms under UNFCCC and Kyoto Protocol:

Table 15 Existing financing mechanisms under UNFCCC and Kyoto Protocol

Period	Action/Activity	Grant Source	Budget US\$
1992	Ratification of the UNFCCC by the GoR	-	
2003	Ratification of Kyoto Protocol		
2003-2005	Formulation of Initial national communication	GEF-UNEP	330,000
2005	Creation of the Designated National Authority (DNA) under Kyoto Protocol dealing with Clean Development Mechanism Projects (CDM)	-	
2005-2006	Formulation of the National Adaptation Programs of Actions (NAPA)	GEF-UNEP	195,000
2007-2010	Formulation of Second National Communication	GEF-UNEP	405,000

Source: EAC Secretariat, Report on the EAC climate change fund and modalities for its Operationalisation held in Burundi, Bujumbura, September 2010, Annexe III

4.7 Existing Financing mechanisms under Bi and Multilateral Cooperation

Overall projects

The source of funding from Bilateral and Multilateral Cooperation concerns mainly studies and ground projects. The main donors are: UNDP, UNEP, IISD, Japan, U.K. and Sweden. Following table shows the projects titles, sponsors, periods, budgets, implementing agency and area of implementation.

National Strategy on Climate Change and Low Carbon Development

In November 2010, it was launched a project to develop a National Strategy on Climate Change and Low Carbon Development. This 9-month project is funded by the Climate Development Knowledge Network (CDKN) and DFID- Rwanda and is being undertaken by the Smith School of Enterprise and the Environment (SSEE) at the University of Oxford. This project comes at the request of H.E. President Kagame and aims to build upon work that is already being done in Rwanda on climate change. There are a number of unique aspects to the project designed to

make it successful, namely the research team is embedded in government ministries, there is a large team of expert advisors from the preeminent University of Oxford supporting the researchers, and the Principal Investigator is experienced in UK Climate Change strategy development at the highest level. This project aims to look beyond Vision 2020 to the year 2050, and envisions Rwanda as a low carbon developed economy that is robust enough to withstand the challenges of climate change.

The Sida-supported Natural Resources and Environment Program in Rwanda

The governments of Rwanda and Sweden have agreed to implement a Natural Resources and Environmental Support Program. The program will support Rwanda in achieving its Economic Development and Poverty Reduction Strategy (EPDRS), Millennium Development Goals (MDGs) and Vision 2020.

The report of the Sida-supported Natural Resources and environment Program highlight six main activities for climate change preparedness:

- (i) Revise and update of relevant National Strategies and Plans for climate change preparedness, adaptation and mitigation with focus on technology development and transfer, and human capacity building;
- (ii) Engagement and support to the UNFCCC process, and any relevant follow up to international or regional initiatives;
- (iii) Investigate and target present or new opportunities for support and partnerships on climate change oriented mechanisms (technology transfer, the NAMA mechanism, CDM etc);
- (iv) Prepare information and database system;
- (v) Skills development at all levels on climate change related fields;
- (vi) Initiate and coordinate implementation of Multilateral Environmental Agreements (MEAs) and other development programs.

Table 16 Main Climate change projects in Rwanda

N°	Project title	Implementing agency	Area of implementation	Period	Budget (donor side) US\$	Donors/ Observation
1	Reducing Vulnerability to Climate Change by Establishing Early Warning and Disaster Preparedness Systems Support for Integrated Watershed Management in flood prone areas	REMA-UNDP REMA-UNEP	North and West of Rwanda	2010-2014	3,486,000	LDCF

2	Supporting Integrated and Comprehensive approaches to climate Change adaptation in africa-Building a national approach in Rwanda (AAP)	REMA-UNDP	Whole country but mainly in 6 districts most affected by CC	2010-2011	2,932,925	Japan;
3	Reducing Vulnerability of Rwanda s energy sector impacts of climate change	KIST Kigali Institute of Education	Bulera-Musanze Districts	Phase II: 2009-2010	248,333	IISD Note: The 2ndphase of this project (US\$10,713) failed
4	3. Building capacity and rising awareness for a sensitive community on climatechange adaptation in Rwanda a CC DARE Project (UNEP/UNDP).	NBDF (Nile Basin Discourse Forum) and RENGOF (Rwanda Environmental NGO Forum)	Countrywide	August-2009-January 2010	150,000	CC DARE/ UNDP-UNEP
5	Economic of Climate Change in Rwanda (Study)	Department for International Development (DFID)	Countrywide	2008-2009	£460,000 including Kenya, Burundi and a regional report	U.K.
6	Capacity Reinforcement of CDM projects in Rwanda	REMA	Countrywide	2009-2012	296,000	Japan
					300,000	UNDP
					150,000	UNEP

Source: EAC Secretariat, Report on the EAC climate change fund and modalities for its Operationalisation held in Burundi, Bujumbura, September 2010, Annexe III

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