REPUBLIC OF RWANDA

MINISTRY OF NATURAL RESOURCES



SECOND NATIONAL COMMUNICATION UNDER THE UNITED NATIONS FRAMEWORK CONVENTION ON CLIMATE CHANGE (U.N.F.C.C.C)

UNEP

UNFCCC

FOREWORD

As Party to the United Nations Framework Convention on Climate Change (UNFCCC), Rwanda is taking precautionary measures to predict, prevent or reduce the causes of climate change and to minimize their harmful effects on sustainable development. This report is the continuation of the Initial National Communication which has resulted in a number of Government actions, namely the following:

- National Adaptation Programmes of Action to climate change (NAPA) in 2006;
- Publication of a booklet entitled "Tumenye guhangana n'Imihindagurikire y'Ibihe", standing for "Adapting to Climate Change" in the Rwandan context, which is an education and a sensitization tool for the general public.

There is no denying that this report will further guide policy decision makers in the preparation and implementation of national development plans which will take into account both environment sustainability and climate change impacts, especially in the most vulnerable sectors, namely agriculture, water resources, energy and health.

The gaps observed in the quality assurance of hydrometeorological data needed for reliable seasonal forecasts as well as the lack of data in each sector of activities necessary for mitigation and adaptation strategies will require more efforts to improve the formulation of the Third National Communication, based on better background knowledge on climate change and its effects.

Implementation of the strategic options identified in this Second National Communication report will be possible owing to the established synergetic partnership involving the public and private sectors, NGOs and Development Organizations.

We are pleased to express our gratitude to those who, in one way or another, have contributed in the preparation and publication of this Second National Communication report. Our appreciation goes particularly to the following:

- The UNFCCC Secretariat, Global Environmental Facility (GEF) and UNEP, in its quality as GEF Implementing Agency, for their financial and technical support and training in different methodological tools;
- All international and national experts who have conducted sector studies;
- And last but not least, all those who took part in different validation workshops, which considered the thematic reports and the final report of the Rwanda Second National Communication under the UNFCCC.

As we submit this Second National Communication, Rwanda has adopted its "National Climate Change and Low carbon Development Strategy" of which the content and the perspectives will be reflected in the Third National Communication.

Stanislas KAMANZI
Minister of Natural Resources



ABBREVIATIONS AND ACRONYMS

ALICOMEC	Alimentation, Commerce général des produits Chimiques
APC Mashyuza	Action pour la Promotion de la Chaux de Mashyuza
Unité AST	Unité à Activité Scientifique et Technologique
BNR	Banque Nationale du Rwanda
$CaCO_3$	Carbonate de Calcium
CCNUCC	Convention Cadre des Nations Unies sur les Changements Climatiques
CDC	Comités de Développement Communautaire
CDM	Clean Development Mechanism
CFJ	Centres de Formation des Jeunes
CHUK	Centre Hospitalier Universitaire de Kigali
CIMERWA	Cimenterie du Rwanda
CNCC	Comité National sur les Changements Climatiques
CITES	Convention on International Trade of Endangered Species
CO	Monoxyde de Carbone
COCOCHAUMA	Coopérative de Production de la Chaux de Mashyuza
CO_2	Dioxyde de Carbone
CH_4	Méthane
COVNM	Composés Organiques Volatile Non-Méthaniques
CP.8	Huitième Conférence des Parties
DBO	Demande Biochimique par Oxygène
DSM	Déchets Solides Municipaux
DSSAT	Decision Support System for Agrotechnology Transfer
DSRP	Document de Stratégies de Réduction de la Pauvreté
EDPRS	Economic Development and Poverty Reduction Strategy
EICV	Enquête Intégrale sur les Conditions de Vie des ménages
CFSVA	Comprehensive Food Security and Vulnerability Assessment
EH	Equivalent Habitat
ELECTROGAZ	Etablissement de Production et de Distribution d'Electricité, d'Eau et de Gaz
FAO	Food Agriculture Organization
FCS	Food Consumption Security
FEM	Fonds pour l'Environnement Mondial
FEWS	Famine Early Warning System
FRW	Franc Rwandais
GCM	Global Circulation Model
Gg	Gigagramme
GBK	Gisenyi Butare Kibuye
GES	Gaz à Effet de Serre
GIEC	Groupe Intergouvernemental d'Experts sur l'évolution du Climat
GPL	Gaz pétrole lampant
HIMO	Haute Intensité de Main d'œuvre
IEC	Information, Education et Communication
INADES	Institut Africain pour le Développement Economique et Social
INSR	Institut National des Statistiques du Rwanda
IPCC	Intergovernmental Panel on Climate Change
IRST	Institut de Recherche Scientifique et Technologique
ISAE	Higher Institute of Agriculture and Animal Husbandry

ISAR	Institut des Sciences Agronomiques du Rwanda
IUCN	International Union for Conservation Nature
KHI	Kigali Health Institute
KIE	Kigali Institute of Education
KIST	Kigali Institute of Science, Technology and Management
MAM	Mars- Avril- Mai
MDP	Mécanisme de Développement Propre
MINAGRI	Ministère de l'Agriculture et des Ressources Animales
MINALOC	Ministère de l'Administration Locale, du Développement Communautaire et des Affaires Sociales
MINEDUC	Ministère de l'Education Nationale, de la Recherche Scientifique et de la Technologie
MINELA	Ministry of Environment and Lands
MINERENA	Ministère de l'Energie, de l'Eau et des Ressources Naturelles
MINICOM	Ministère du Commerce, de la Promotion des Investissements, du Tourisme et des Coopératives
MINECOFIN	Ministère des Finances et de la Planification Economique
MININFRA	Ministère des Infrastructures
MINISANTE	Ministère de la Santé
MINITERE	Ministère des Terres, de l'Environnement, de l'Eau, des Forêts et des Mines
NAFA	National Forestry Authority
NEPAD	New Partnership for Africa Development
NISR	National Institute of Statistics of Rwanda
NMVOC	Non-methane volatile organic compound
OMS	Organisation Mondiale de la Santé
OMM	Organisation Météorologique Mondiale
ONG	Organisations Non Gouvernementales
ORTPN	Office Rwandais du Tourisme et des Parcs Nationaux
PAFOR	Projet d'Appui à l'Aménagement des Forêts du Rwanda
PANA	Programmes d'Action Nationaux d'Adaptation aux changements climatiques
PGNRE	Projet de Gestion Nationale de Ressources en Eau
PIB	Produit Intérieur Brut
PNA	Parc National de l'Akagera
PNB	Produit National Brut
PNN	Parc National de Nyungwe
PNUE	Programme des Nations Unies pour l'Environnement
PNV	Parc National des Volcans
PRSP	Poverty Reduction Strategic Papers
PSS	Plan Stratégique Sectoriel
PVC	Projet pour la valorisation du calcaire
RHODA	Rwanda Horticulture Development Authority
RADA	Rwanda Agriculture Development Authority
RALDA	Rwanda Agriculture and Livestock Development Authority
RDB	Rwanda Development Board
REDD	Réduction des Emissions issues de la Déforestation et de la dégradation forestière
REDD+	Réduction des Emissions issues de la Déforestation et de la dégradation forestière et de la conservation
REMA	Rwanda Environment Management Authority

RRA	Rwanda Revenue Authority
SOND	Septembre-Octobre-Novembre-Décembre
SPUR	Simulating Production and Utilization of Range Land
SWAP	Sector Wilde Approach
TRAP	Center for Treatment and Research on Aids, Malaria, Tuberculosis and other Epidemics
UNESCO	Organisation des Nations Unies pour l'Education, la Science et la Culture
UAAC	Université Adventiste d'Afrique Centrale
ULK	Université Libre de Kigali
UNILAK	Université Laïque de Kigali
UNR	Université Nationale du Rwanda
UTCATF	Utilisation des Terres, Changement d'Affectation des Terres et Foresterie
WATBAL	Spatial lumped conceptual integrated catchment Water Balance model

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EXECUTIVE SUMMARY

INTRODUCTION

One of the current major concerns of mankind is climate change. These are attributed directly or indirectly to human activities which lead to the increased emission of greenhouse gases (CO_2, N_2O, CH_4, CO, NOx, NMVOC). It should be noted that these activities are directly related to economic development of different countries. This work constitutes the Second National Communication under the United Nations Framework Convention on Climate Change (UNFCCC)

Chapter I: National circumstances

The Rwandan relief is hilly and mountainous between 1,400 and 3,000 m(temperate climate, Köppen Cw)is geographically located in Central Africa between 1°04' and 2°51' of south latitude and between28°45' and 31°15' of east longitude.

Out of Rwanda's total area of 26,338 km^2, only 52% (~1,385,000 ha), plus 100,000 ha of marshland are used by about 80% of the population, with an average density of about 321 inhabitants per km^2 in 2002.

Rwanda's economy which is agriculture based is still substance in nature, which leads to serious environmental degradation due to overexploitation of the soil. An integrated management of this natural resource is necessary in order to achieve a sustainable development within the current framework of climate change. In fact, Agriculture contributes by 34% of Gross National Product and 71% of export earnings.

Animal husbandry in Rwanda is generally practiced in stalls at the household level, except in the North-Eastern region of the country where it is done extensively. Owing to the high population density of the country, ruminants, pigs and poultry become more and more important.
Fishing in Rwanda is practiced in various lakes of the country, small dams, constructed for different purposes, as well as in ponds and rivers.

Natural rain forests constitute the highest proportion of the Rwandan forest cover (33%), followed by Eucalyptus plantations (26%) and degraded forests (15.7%). Most rain forests are protected whereas the degraded forests are regularly used for various domestic purposes. Forest lands that have not been degraded since 2000 are mainly located in Nyungwe, Birunga and AKAGERA National Park.

From the policy point of view, Rwanda's Vision 2020 clearly defines the future of the country.. One of the pillars of the vision 2020 is to shift from subsistence to productive and market based agriculture with protection of environment and sustainable natural resource management as a cross cutting in all the sectors.

At the institutional level, the Ministry of Natural Resources (MINIRENA) is the ministry responsible for setting up the state policy related to the protection, conservation and environmental management.

Rwanda is divided into two major drainage basins: the nile to the west 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.

An analysis of the monthly and annual total rainfall at Kigali-Airport station for the period from 1961 to 1990 shows a clear downward trend as compared to previous years. However, the analysis of annual average temperatures (Kigali-Airport and Kamembe stations seem to indicate a clear upward trend (0,9°c within 27 years); this seems to conform to A1F1, A2, B1 and B2 the climate scenarios (Ruosteenoja and al., 2003).

The socio-economic indicators used here come from Rwanda National Institute of Statistics (2006), and the Ministry of Finance and Economic Planning (2003; 2006).

Several sectors of activities are herein studied in relation to climate change. They are:

- The current energy consumption in the country is subdivided in biomass consumption 86% (wood-energy and agricultural residues), represents 86% of the energy consumption;

  Petroleum products (11%) and electricity (3%) of which 56% come from the hydroelectric plants and 44% from thermal power plants.
- The transportation sector is dominated by road transport.. The number of small cars exceeds that of four-wheel vehicles (44.245) which are followed by pick-ups (8.113) and jeeps (6882).
- The industrial sector in Rwanda is mainly made up by mines and quarries and manufacturing companies (agro-industry and small & medium enterprises). The cement production company" CIMERWA" and the lime production cooperative "COCOCHAUMA" are the two main sources of greenhouse gas emissions.

- Dump sites in Rwandan towns are non sanitary , especially that of Kigali/Kicukiro (Nyanza landfill), of which the solid waste quantity is overflowing and clearly increasing. It has shifted from 21.000 tons in 2003 to 27.875 tons in 2005 and to 37.979 tons in 2007.

  Like with the case of solid wastes, sewage management remains a critical problem in unplanned settlements; they are discharged directly in nature without treatment

Chapter II: National Inventories of the GHG Emissions and Absorptions

Rwanda does not have its own methodology for estimating national GHG emissions and absorptions. The guidelines for the preparation of national communications of Parties not concerned in Annex I of the Convention (decision 17/CP.8) and the IPCC methodology have been used.

For the year 2005, chosen as the baseline, the results of the studies conducted on the GHG inventory show that Rwanda has contributed to the emissions of 530.88Gg of carbon dioxide (CO_2), 71.31Gg of methane (CH_4), 10Gg of nitrogen hemioxide(N_2O), 16Gg of oxides of nitrogen (NOx), 2,327Gg of carbon monoxide (CO), 42Gg of non methane volatile organic compounds (COVNM) and 18Gg of sulfuric oxides (Sox).

Taking into account the Global Warming Potential (PRG100) respectively below: 1 for CO_2, 21 for CH_4 and 310 for N_2O, total aggregate emissions rose up to 5,010.4Gg CO_2-eq-Gg.The **LULUCF** sector indicates emissions which are relatively weaker in CO (1957Gg) compared with the absorption of CO_2 (-8545Gg). The total GHG emissions, direct (CO_2, CH_4 and N_2O) and indirect (CO, NOx, NMVOC and SOx) have positively changed between 2003 and 2006 as indicated in the following table:

Table 23: Trends in GHG Emissions

Emissions (Gg)	**2003**	**2004**	**2005**	**2006**
DIRECT GHG				
Total Carbon Dioxide (CO_2)	452.37	483.89	530.88	601.05
Industrial Processes	145.18	148.47	150.52	153.91
Energy	307.19	335.42	380.36	447.14
Total land use land use change and forestry (CO_2 absorption)	-6620	-6964	-8545	-10126
Total biomass	6747.19	6983.35	7227.6	7493.68
Total Methane(CH_4)	64.27	68.75	71.31	74.1
Energy	18.54	19.19	19.86	20.6
Agriculture	43.5	47.1	48.9	50.7
Waste	2.23	2.46	2.55	2.8
Total Nitrous oxide (N_2O)	3.53	7.93	9.83	11.73
Energy	0.24	0.25	0.26	0.27
Agriculture	3.2	7.6	9.5	11.4
land use , land use change and forestry	0.09	0.08	0.07	0.06
INDIRECT GHG				
Carbon monoxide (CO)	1963.08	2006.76	2327	2652.482
Nitrogen oxides (NOx)	15.316	15.217	16.008	16.799
NMVOCs /COVNMs	38.96	40.37	41.78	43.57
Sulfur oxides (SOx)	16.6	16.94	18.07	18.48

In the present work, several indicators of GHG quality estimation have been used. These include: exhaustiveness, transparency, comparability, coherence, accuracy, and evaluation of uncertainties.

The category analysis of emission sources was made according to the "key category analysis" from IPCC software. Two key-sources came out: Agriculture, with respective values of N_2O and CH4 of 2,882.1Gg and 955.4Gg, Energy with respective values of CH_4 and CO_2 of 416.1Gg and 269.9Gg; that is, the total of 90.2%. LULUCF with its value of -8545Gg represents a sink.

To improve on the next inventories of GHG emissions, several general recommendations have been proposed in various sectors of activities, namely basic data collection by concerned services in charge of energy, agriculture, land use and forestry, industrial processes and waste management.

Chapter III: Mitigation of Green House Gas Emissions and Enhancement of Sinks

The Government vision expects that by 2020, Rwanda would have reduced the quantity of wood used as a source of energy from 90% to 40%. The hydraulic potential, in addition to that of methane gas, should meet the population needs in power energy in all development activities in the country, with a surplus of 125MW compared to 2002. Within the framework of 2020 vision, and especially in the government's recent Strategic Plan for Poverty Reduction (PRSP), some objectives have been adopted to ensure a growth rate of energy consumption of 9.6% per year, to ensure a rural electrification rate of 30% and to enable the population from 6% to 35% to have access to electricity.

All the data related to this point were analyzed according to both baseline (2020 Vision) and mitigation of greenhouse gas emissions scenarios. The baseline data includes the number of the population, the annual population growth rate, the gross domestic product, the number of households, the average size of the families, and the rate of urbanization.

On basis of energy demand estimates, both baseline and mitigation scenarios have been proposed for urban and rural households.

The hypotheses of GHG emissions mitigation in the industry sector are based on the following:

- the substitution of fuel by Kivu Lake methane gas,
- the substitution of one quarter firewood used in institutions through biogas, the use of furnaces of high energy performance in institutions, and
- afforestation to increase the quantity of firewood and the quantity of forests to sequestrate greenhouse gas emissions.

The users of this category are grouped into units called "Buildings" in the LEAP software.

As regards the transport, the number of engine vehicles in 2006, was 41,052 (NISR, 2006) with an annual increase of 10%. For the long period from 2005 to 2030, the latter has been estimated at 6%, corresponding to the annual growth of GDP.

The energy transformation requires two operations, namely transport and distribution which lead to losses estimated at 20% for electricity, 5% for charcoal and 1% for gas. Hydro-electricity contributes to 50%; the rest is produced through to fuel thermal generators.

As for agriculture, land use and land use change and forestry, the GHG emissions mitigation scenarios take into account the demand in wood in the forthcoming 40 years. However, species, whose exploitation provides the most important economic interests and with greater chance of carbon trading (Clean Development Mechanism) are privileged. In 2005, demand in energy-wood was 7,822,063 tons while the offer was 4,982,063 tons. To bridge this gap in wood energy, eucalyptus is proposed.

Several options for Green House Gas emissions mitigation in various areas of energy sector (household, industry, transport, and energy transformation) have been identified, selected and justified.

The following figures indicate the variation in energy total demand (in millions gigajoules) and the related variation of GHG emissions (CO_2equivalent). This energy variation from 2005 to 2030 is linked to GHG baseline and mitigation scenarios for the branch of energy demand and its three sub-branches (households, industry and transportation) as well as the energy transformation.

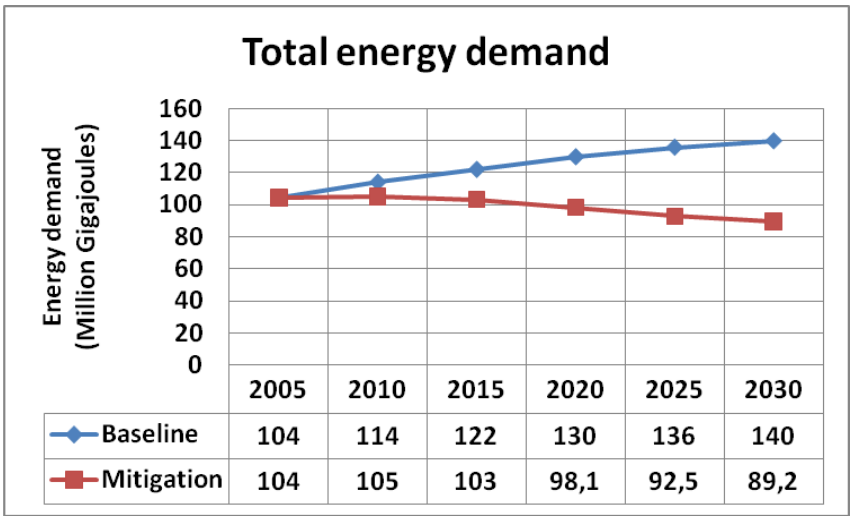


Figure 15a: Total Energy Demand

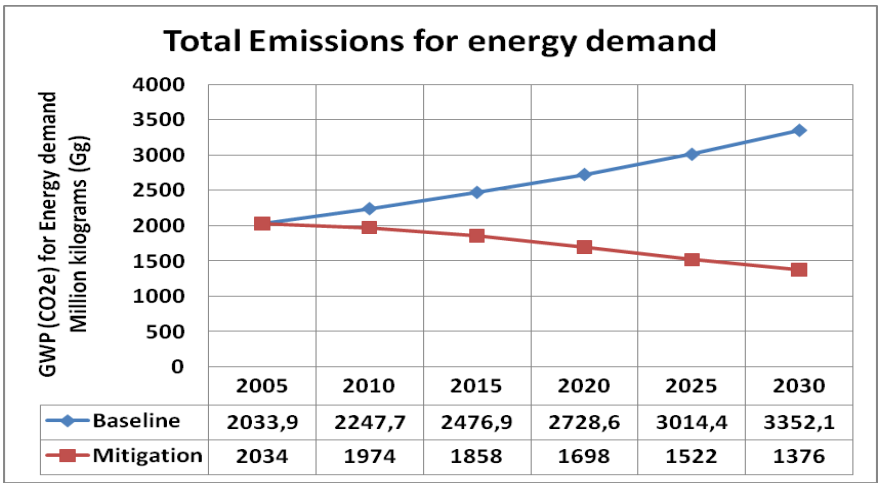


Figure16a: Total emissions for energy demand

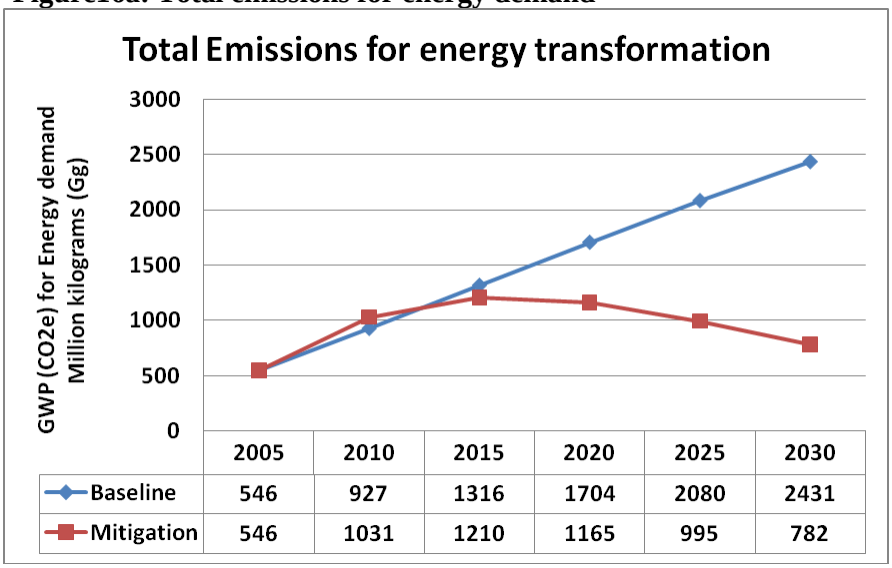


Figure 17a: Total emissions coming from energy transformation

With regard to reduced emissions, we distinguish the emissions linked to the use of the energy, and those linked to agriculture, land use, land use change and forestry. The following table indicates emissions in CO2equivalent reduced by the mitigation of GHG emissions options linked to the total use of energy (demand and energy transformation).

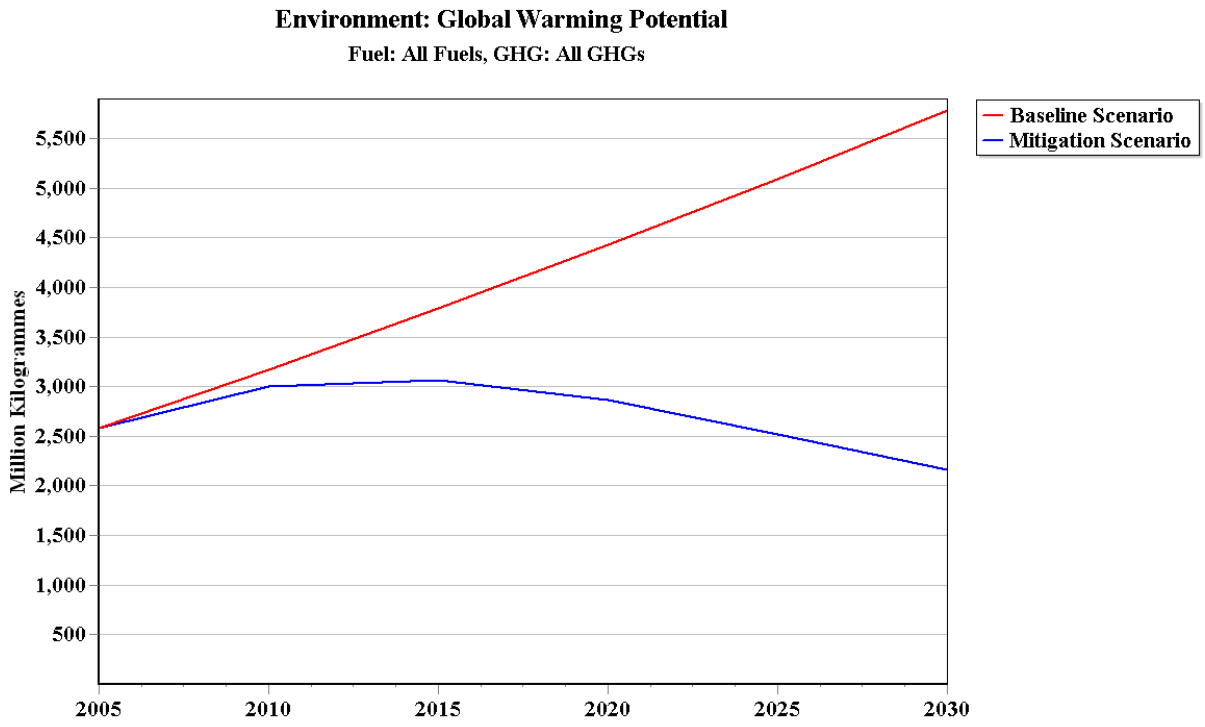


Figure 18: Evolution of reduced total emissions

Figure 19 above, shows the effect of the poposed options on environment taking into account the mitigation of GHG emissions

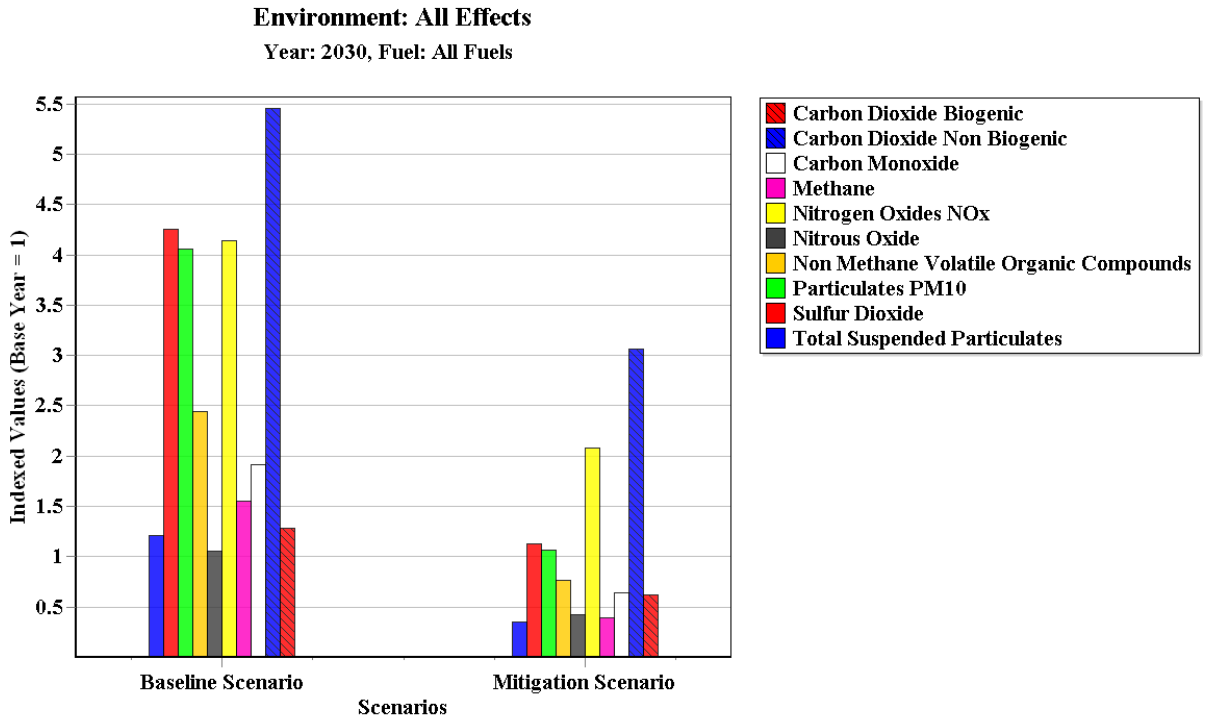


Figure 19: Effect of proposed options on the environment

As for the emissions related to agriculture, land use, land use change and forestry, the total reduced quantity of CO_2e in tons (sequestrated by forests) will be **-18,862,500 tCO_2e** considering the mitigation option proposed by 2030.

Chapter IV: Vulnerability and Adaptation to Climate Change

Climate Scenarios

Rwanda's geographical location, its relief, population density and socio-economic indicators make it vulnerable to natural and anthropogenic risks.

Climate projections for Rwanda were worked out for the period of 2010-2100 taking 1971-2007 as the base line period. The MAGICC model (model for the assessment of climate change caused by greenhouse gas emissions) was used to develop climate estimates of Rwanda in relation to the data of that baseline period. Three models (over 17) namely PCM_00, IAP_97 and LMD_98, were found to best represent the projections with the following results.

- All three models predict an average increase in minimum, average and maximum temperatures towards the years 2020-2100. The increase in the annual average maximum temperatures reaches 3.3 ° C.

- For rain, projections show that both models, IAP_97 and LMD_98, respect the variability of the two wet seasons during the months of March, April, May and September-October-November, but with a growing shift that reaches 50 mm in April and December for the models LMD_98 and IAP_97 respectively.
- For the average potential evapotranspiration, the outputs of the models IAP_97 and LMD_98 show that the annual potential evapotranspiration will increase each year. For IAP_97, it is expected that it will reach 1,351 mm towards 2020, 1,432mm towards 2050 and 1,682mm towards 2100.

WATER RESOURCES

Rwanda has a dense hydrographic network with ± 2 km/km^2, generally well endowed with sources from discontinuous aquifers of Precambrian terrains.

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 industrial sector is still less developed in Rwanda, water needs could rise from 1.3 to 6.1 million m^3.

Water demand in agriculture is limited to irrigation which is rarely practiced in Rwanda (mainly in rice growing). The current water needs, for intensive crop growing, are estimated at140 Mm^3. Water consumption for cattle remains low and represents about 10% of total needs. The water needs by the end of 2020, assessed on the basis of the methodology and the evolution of surface areas and livestock for 2020, are estimated at 840 Mm^3/year.

The WATBAL model (spatial lumped conceptual integrated catchment WATer BALance model) was applied to the Nyabarongo river hydrographic basin, in Kigali, with an area of 8,900 km^2

(monthly average temperatures and precipitations from 1971 to 2005 of Ruhengeri, Byimana, Gikongoro / Nyamagabe and Rwamagana stations). The LMD_98 model was used to get the evapotranspiration data corresponding to the projection years, 2010-2100.

For the projections 2010-2100, average discharges of Nyabarongo at Kigali may be slightly low compared to the average discharges of the baseline year 1988. This implies a reduction of water flow discharges in the years to come.

Vulnerability to climate change in the sector of water resources is evident, given a high frequency of prolonged droughts and heavy rainfalls causing runoff, which coupled with the natural fragility of soils and deforestation (Gishwati forest), erodes a significant amount of land into valleys and lowlands; this explains the important flooding causing losses, not only in human lives and material, but also in biodiversity. To remedy this, three fundamental adaptation measures are possible: increase water supply, reduce demand for water resources and manage, both the demand and the supply, differently.

AGRICULTURE

Since the 80s, the country's agricultural sector faces a series of unique constraints. Because of a high population density, land is still insufficient when most farmers mostly practice rain fed agriculture (the use of organic and non organic, is still very low).

Because of the lack of certain data needed to launch the DSSAT, SPUR and other models, this study on climate vulnerability on agriculture and food security collects only information on activities already carried out by the Ministry of Agriculture and Animal Resources (MINAGRI) since the publication of the initial national communication under the UNFCCC. It is about the displacement of growing seasons A (September-November) and B (March-May), which causes the perturbation of sowing dates, lower yields, intensification of crop diseases, and the reduction of irrigation water.

According to climate scenarios for Rwanda, the averages air temperatures will increase from 1 to 3^{o} C by the year 2100. This will have several implications on agriculture and livestock such as the outbreak of respiratory disease and foot rot in areas with heavy rainfall, and reduction of milk production resulting in the decline of incomes for the population.

The projection of agricultural production from 2000 to 2100, made using the coefficients proposed by the DSSAT Model, shows, among selected major crops, a sharp increase of cereals and a slight increase of groundnuts. If temperatures continue to rise, this could reduce expected production unless irrigation is maximized.

In terms of adaptation to climate change, the EDPRS 2008-2010 has incorporated the NAPA priorities and has developed several strategies for adaptation to climate change in different sectors, with particular emphasis on investment in early warning systems and seasonal weather forecasts.

FORESTS

Several types of vegetation are encountered in Rwanda and include: mountain rain forest (1500-3000 m) and degraded sub-mountain forest (1500-2000 m), the grassland savannah in the central plateau (1600-2000 m), lowland savanna, xerophile forest and forest (1300-1600 m), marsh vegetation of medium and high altitudes (1300-2500 m), and alpine and subalpine vegetation of volcanic terrains (3000-4500 m). The main dominant tree species and of socio-economic importance are the Eucalyptus and Pinus while Grevillea ranks first in Agroforestry.

Regarding vulnerability, the height and distribution of rainfall and high evapotranspiration during the vegetative period, will limit the availability of bio-climatic conditions of these three species of trees in lower areas (planar and hilly areas). On the contrary, in high lands areas, other factors such as extreme winds and floods will affect them.

Finally, several strategies for adaptation to climate change and mitigation of GHG emissions have been proposed; these include afforestation, reforestation, forest management, reduced deforestation, management of timber products, use of forest products to replace oil,(bio energy), improvement of tree species to increase biomass productivity and carbon sequestration, and improved technologies for remote sensing for the study of vegetation and soil, the potential for carbon sequestration and for mapping of land use and land use change.

HEALTH

Rwanda is not immune to shocks and natural disasters related to climate. One of the manifestations of these disasters is the impact they have on the health sector in causing transmissible diseases such as malaria, cholera, water borne diseases and non transmissible diseases such as meningitis.
Altogether, the main causes of mortality in the general population are AIDS with opportunistic infections, followed by severe malaria. The two diseases alone account for more than 35% of deaths. Erosion, landslides, floods and prolonged droughts are other disasters affecting human health.

In Rwanda, several measures of adaptation to climate change in the area of human health exist even if some are very expensive. Moreover, some are already incorporated into national strategies under implementation (EDPRS Sector Strategies of Health Sector), others are performed with little attention and others are to plan afresh.
Here, among others, are some strategies to strengthen according to disease categories: preparation of risk maps, and information system for hydro-agro-meteorological warning, professional capacity building in health sector, use of improved latrines, culture to wash hands after using the toilet, creation of non-farm job in areas vulnerable to climate change affecting agricultural production, increase irrigated agriculture on a large scale, revive storage, processing, and preservation techniques, of foodstuffs (food security stock in each administrative area), habitat planning in order to avoid flood areas and steep slopes with high risk for landslides (Musanze, Nyamasheke, Rusizi, Nyabihu ,and Rubavu).

Chapter V: Additional Information Considered Relevant to Achieve the Objective of the Convention

Like many developing countries,Rwanda has had to face a severe energy crisis in electricity. It nevertheless managed to largely resolve this problem through the use of bulbs with low energy consumption, methane gas and particularly through the use of supplementary thermal energy sources.

The above mentioned solutions have been accompanied by a sharp rise in the price of KWH of electricity. This means that the people resort to wood as a source of energy, which leads to deforestation and hence to the diminution of sinks of greenhouse gas emissions. To cope with this situation, the use of appropriate technologies for adaptation to climate change, including electric and non electric braziers as well as improved furnaces with low wood consumption, is required.

Regarding education, it is clear that neither single school nor academic programs make reference to climate change. It is therefore imperative to incorporate such courses in all programmes from Primary to Higher Education. This could be achieved through KIE by starting ECE combination (Environment-Climate Change with Education), mainly focusing on Environment and Climate Change.

In Rwanda, research activities are less developed due to limitation in infrastructure, highly skilled staff and funding. However, a number of desertations in related fields (geography, agriculture,biology, applied sciences etc) have been written by teachers, researchers and students from higher institutions of learning like, KIE,KHI,ISAR,NUR,KIST
Publications in Rwanda is still at a low scale and efforts to make publications from the higher institutions mentioned above as regular as possible are still needed.
Given current research difficulties in general, it would be helpful for REMA to get involved in this area in collaboration with other research and or higher learning.

Regarding the meteorological data in Rwanda, the meteorological service has a large historical databank (managed by the CLICOM climate software) that goes back to 1906 and from more than 50 operational stations before 1994. After that date, only a few stations were put back into service between 1998 and 2000 for civil aviation purpose. Unfortunately, much of this data is not yet computerized and is only available for consultation in technical documents (no updated climate directories and no single agro meteorological bulletin has ever been published)

Like in the meteorology, hydrological stations (47 in number) were shuttered in the 1994 genocide. 40 stations have however been rehabilitated both liquid and solid gauging is currently carried out.

To ensure the continuity of national communications of Rwanda, a national coordination office was established. It comprises Government Departments, Universities, Institutes and Research Institutions. Nevertheless, there is a need to enhance the operation of this team.

In terms of capacity, there is a need to organize training and in-service training sessions for researchers and lecturers of climate change, post graduate studies (certificates, diplomas, masters, and doctorates)

In order to communicate useful information on climate change to potential researchers, the following is recommended:

- To launch a specialized website (to be integrated into that of REMA) and a network of researchers in climate change;
- the establishment of a databank of diversified data and research works (conferences, seminars, theses) on different aspects of climate change and a national, provincial and inter-institutions coordination network;
- Strengthening cooperation between East African Community countries which meet regularly to develop and put in place a joint master plan for adaptation to climate change.
- use of cultural associations and media

Chapter VI: Difficulties , Gaps Financial Resources Technical Means Necessary Capacity to Remedy those Difficulties

Despite the existence of economic, legal and political stimulating conditions, Government still experiences hindrances regarding the limited appropriate technologies for energy saving as well as the scaling up of the already existing ones.

INTRODUCTION

One of the current major concerns of mankind is climate change. These are attributed directly or indirectly to human activities which lead to the increased emission of greenhouse gases (CO_2, N_2O, CH_4, CO, NOx, NMVOC). It should be noted that these activities are directly related to economic development of different countries.
These emissions affect the composition of the world atmosphere along the natural vulnerability of the climate. They are often accompanied with significant harmful effects (vulnerability) on the composition, resistance, productivity of natural and manmade ecosystems, functioning of the socio-economic systems, man's health and welfare.

It is therefore the responsibility of UNFCCC Parties and the Kyoto Protocol to take precautionary measures to predict, prevent or reduce the causes of climate change and limit their harmful effects in order to achieve sustainable development.

To date, parties to the UNFCCC and Kyoto Protocol are required to apply and disseminate practical technologies and processes which can enable to control, reduce or prevent anthropogenic GHG emissions (which are not regulated by the Montreal Protocol) in all relevant sectors, especially, those of energy, transport, industry, agriculture, forestry and wastes management.
This implies that on top of reducing the greenhouse gas emissions at the minimum level and strengthening of their sinks, the following actions need to be implemented:

- Systematic observation and the constitution of archive data on climate system which would facilitate, to better understand the causes, effects, magnitude and the sequences of climate change, and to reduce and get rid of any uncertainties that may subsist in this regard;
- Exchange of scientific, technological, technical, socio-economic and regulation data on the climate system and climate change, as well as the socio-economic consequences which might arise from anthropogenic reactions;
- Education, training and sensitization of the public in the field of climate change, as well as massive involvement of NGOs

In accordance with the above concerns, this report constitutes the second National Communication under the UNFCCC.

However, we recall that Rwanda developed its initial communication which considers 2002 as a year of reference instead of 1994. 2005 was chosen as reference year for the second national communication and its GHG inventories covers the period of 2003-2006. The choice of 2005 was motivated by the fact that this year was stable than 1994 which is considered as a year with many socio economic perturbations and Tutsi Genocide in Rwanda.
Rwanda has not its own methodology for estimation of national GHG emissions and sinks. However, the directives for establishment of national communications of non annex I parties of convention according to the decision 17/CP.8 and GIEC method were used.

Thus, this report is structured as follows:

- The first chapter presents the national circumstances. It focuses on the political, institutional, legal, physiographic (relief, climate, and natural resources) framework, and on the socio-economic indicators;

- The second chapter deals with national inventory of emissions and absorptions of GHG (CO_2, N_2O, CH_4, CO, NOx, COVNM), sector per sector (energy, transport, industry, wastes, agriculture, and animal husbandry);
- The third chapter deals with the mitigation of GHG emissions and the strengthening of sinks, in relation to the data on energy demand, energy transformation, agriculture and animal husbandry, land use, land use change and forestry;
- The fourth chapter is concerned with the vulnerability and adaptation to climate change in relation to climate change scenarios, water resources, agriculture, forest and health;
- The fifth chapter is related to additional information deemed useful to achieve the convention goal which is climate change integration, transfer of technologies, research and systematic observations, information on the research projects, education, development and capacity building in relation to climate change, information and information network for researchers, training and sensitization of the public
- The sixth and final chapter deals with difficulties, identified gaps, financial resources, technical means and capacity necessary for remediation; it focuses on obstacles and gaps, barriers identification, and the impact of the selected options at the macro-economic level.

CHAPTER I: NATIONAL CIRCUMSTANCES



Rwanda is a mountainous and overpopulated country. Its production, mainly agricultural, remains insufficient and leads to serious environment degradation due to overexploitation. An integrated management of this natural capital proves to be necessary in order to achieve a sustainable development under the current framework of Climate Change.

1.1. Political, Institutional 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.

The three Rio Conventions and other protocols relating to natural capital were signed and ratified by Rwandan Government. This country also 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).

At the institutional level, the Ministry of Lands and Environment (MINELA) is the Ministry responsible for designing the state policy related to 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.

1.2 Physiographic Settings

1.2.1. Relief and climate elements

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 km^2, with an average density of about 321 inhabitants per km^2 and 433 inhabitants per km^2 as regards physiological density. Its storey relief presents, from West to East, the following:

- The mountainous region of the Congo-Nile Crest overlooking Lake Kivu (1462 m) and showing peaks at 2,500 and 3,500 m. The temperature varies from 15 to 17°C; its annual average rainfall around 1,400mm with one dry month, July, and can reach or exceed 1600 mm;

- The central plateau, a dissected landscape with hills culminating around 1700-1800 m, and temperature ranging from 19 to 20°C. The dry season lasts there three months (June-August) and its annual rainfall varies around 1200 mm;

- The Eastern low plateau, also dissected but with a wider flat topography around 1500 m (1,400-1,600 m). The annual average temperature is in the range of 21 to 22°C, and less annual rainfall ,generally around 950 mm; the dry season lasts three to four months (June-September);

- Finally, a small north Tanganyika graben is found in Bugarama where annual average temperature may reach 24°C, and rainfall about 800 mm. Its dry season is more severe, lasting five to six months (May-October).

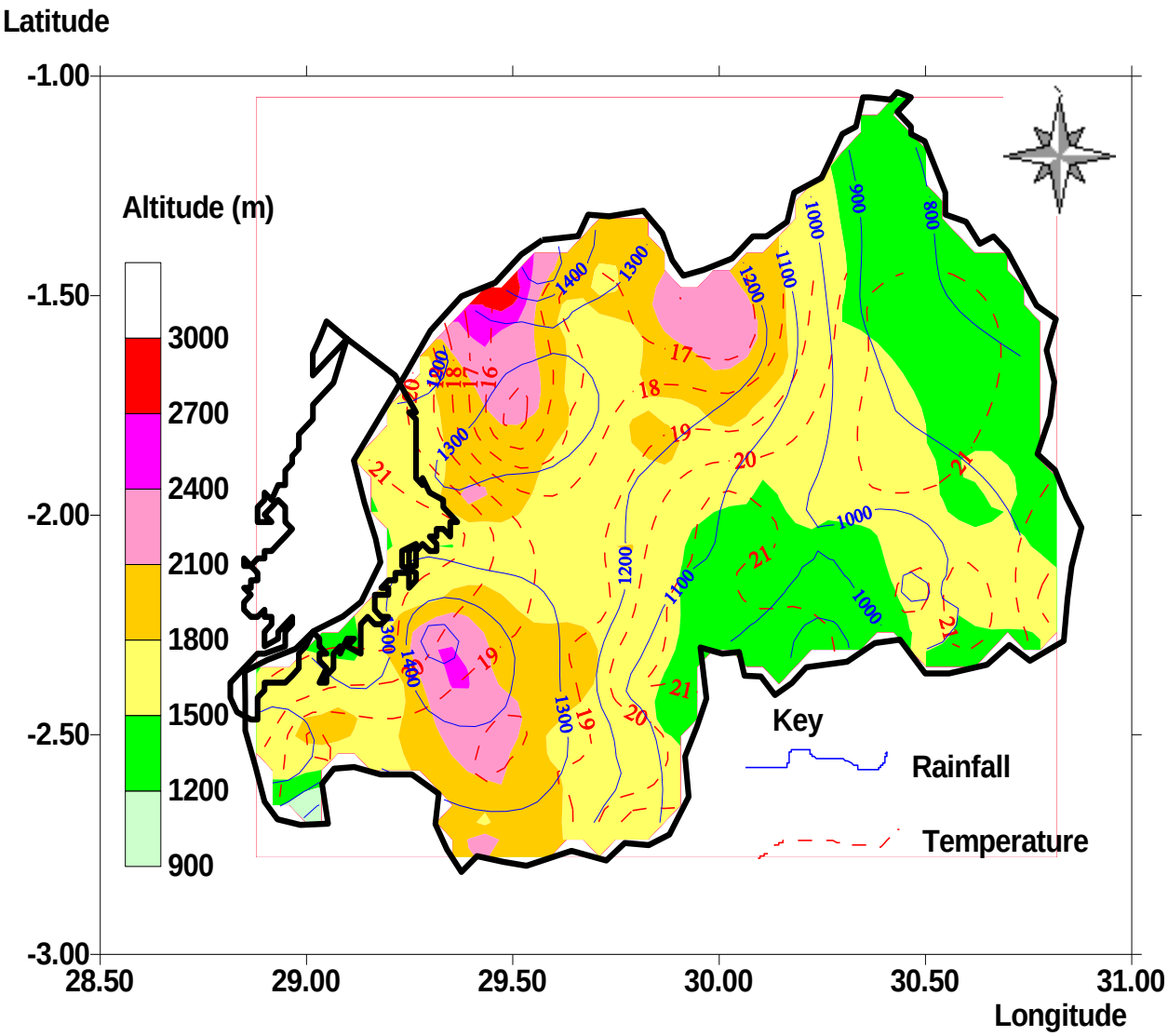


Figure 1: Map showing elevation and climate elements
Source: Data collected at National Meteorological Service

1.2.2. Natural Resources

The soil and subsoil

Out of Rwanda's total area of 26,338 km^2, only 52% (~1,385,000 ha), plus 100,000 ha of marshland are used by about 80% of the population, with an average density of about 321 inhabitants per km^2.

Given the very high population density (-321ha/km^2 in 2002) and the fact that about 92 % of the active population are farmers, there is a strong pressure on land (0.6 ha per household), water, flora, fauna, and other nonrenewable resources.

All this leads to consequences such as soil and wetlands degradation, soil erosion, fertility reduction, deforestation, loss of biodiversity and pollution (MINITERE, 2004).

The agricultural soil potential is very low. Apart from the very fertile volcanic region in the North-West, the rest of the country has infertile soils formed from poor magma rocks (granites) which are less metamorphic and which have been leached away (ferrugination and ferrallitisation).

Finally, the excessive mineral exploitation of the country has led to a strong environmental destruction and pollution by mining companies. More than 150 mining associations operate on this small territory. In fact, Rwandan substratum contains mineral deposits such as cassiterite, wolfram, Colombo -tantalite, gold and quarries representing 6%, 13% and 43% of export revenues of the country, in the respective years 1999, 2000 and 2001.

Surface water

Rwanda which covers an area of 26,338 km^2 has a very dense hydrologic network with more or less 2 km/km^2. Two hydrologic basins share these water resources. To the west, the Congo basin drains 33% of the territory and 10% of water resources (Sebeya, Koko, Rubyiro, Ruhwa, Rusizi rivers etc); the volcanic chain of Birunga are limited to the north.

To the East there is the Nile Basin, which drains 67% of the territory and 90% of water through Nyabarongo and Akagera . The latter is considered to be the source of the Nile and it is the main tributary of Lake Victoria with an average discharge of 256 m^3 / s.
The Nile Basin in Rwanda overflows many small lakes such as Burera, Ruhondo, Cyohoha, South, Mugesera, Muhazi, Rwampanga, Mihindi, Mirayi, etc ...). These lakes are shallow (5 to 7 meters deep), apart from Burera and Ruhondo lakes, which are 50 and 60 meters deep.
Average flows at the main hydrological stations have 78 m^3 /s (Nyabarongo-Kigali), 100m^3 / s (Nyabarongo-Kanzenze), 232 m^3 /s (Akagera-Rusumo), and 256 m^3 /s (Akagera-Kagitumba). Several cases of water flooding are known, namely in the alluvial plain of the Nyabarongo river with a weak slope of marshland (~ 1%).

The surface waters also comprise wetlands, which play a big role of large flooding plains during the long rainy season. Thus, they act as a sponge in reducing maximal flows in rainy seasons and keeping a relatively high flow in dry seasons.

Concerning the quality of water, surface waters are with mineral materials. In mining and volcanic regions, these waters contain arsenic, lead, mercury, iodine and other toxic metalloids and heavy metals.

Physico-chemical pollution of water is not common because of the low level of industrialization and the use of agricultural inputs. Microbiological pollution is often observed and comes from various wastes and household wastes. Therefore, once picked up for drinking, especially in urban areas, surface waters are subject to a purification and treatment with chlorine to eliminate pathogens.

Ground water

From hydrological point of view, Rwanda is generally endowed with sources arising from discontinuous aquifers of Precambrian rocks. Apart from the alluvial filling up of main valleys and volcanic deposits, in Rwanda there are only discontinuous aquifers, composed of banks and quartzitic beds, substratum altered areas and numerous cracks that affect the Precambrian terrains.

Many springs represent outlets of these aquifers with diffuse water supply, located on valley slopes of rivers and marshes. Localized outlets of these aquifers are made up of many sources, as well as valleys of rivers and wetlands which can drain aquifers that are formed on slopes (diffuse water supply). Therefore, the water - table is close to the surface and easy to be located in plains, valleys and depressions.
An analysis of the river low water level discharges estimates the total refill of the country's aquifers at $66m^3/s$. This total refill includes $9m^3/s$ of waters which come out as water resurgence of good quality with a pH of 6 to 7. These sources are estimated by UNICEF at 22,300 and are found in a big number in the West and the North of the Country.

1.2.3. Climate and Climate Change

Rwanda coordinates indicate that it's entirely situated in the equatorial zone. Yet its higher altitude between 1,400 and 3,000m moderates its temperatures and accounts for its temperate climate (Köppen Cw).

An analysis of the total monthly and annual rainfall at Kigali Airport station for the period from 1961 to 1990 shows a clear downward trend as compared to previous years. The annual total average of rainfall which was of 1040 mm in 1961 has decreased to 960 mm in 2006. This means a decrease of 80 mm during the past 46 years.

Indeed, the monthly and annual total rainfalls recorded during the last six years are generally lower than the average of 1961 to 1990. 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 1441% (in 2001), 189% (in 2003), 165% (in 2006) and 153% (in 2006).

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 can be exemplified by the rains which were received on the 3rd May 2002 which Kigali City which according to data from the Kanombe Airport meteorological stations were 63.2mm and resulted in heavy flooding. 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).

The analysis of the average annual temperatures of Kigali Airport Station (1971-2007) located in the center of the country and of Kamembe (south-West of Rwanda) shows a clear increasing tendency in rainfalls. Figure 2 below illustrates 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.

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 (figure 2) located in the south west of Rwanda. This seems to confirm the findings of 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.

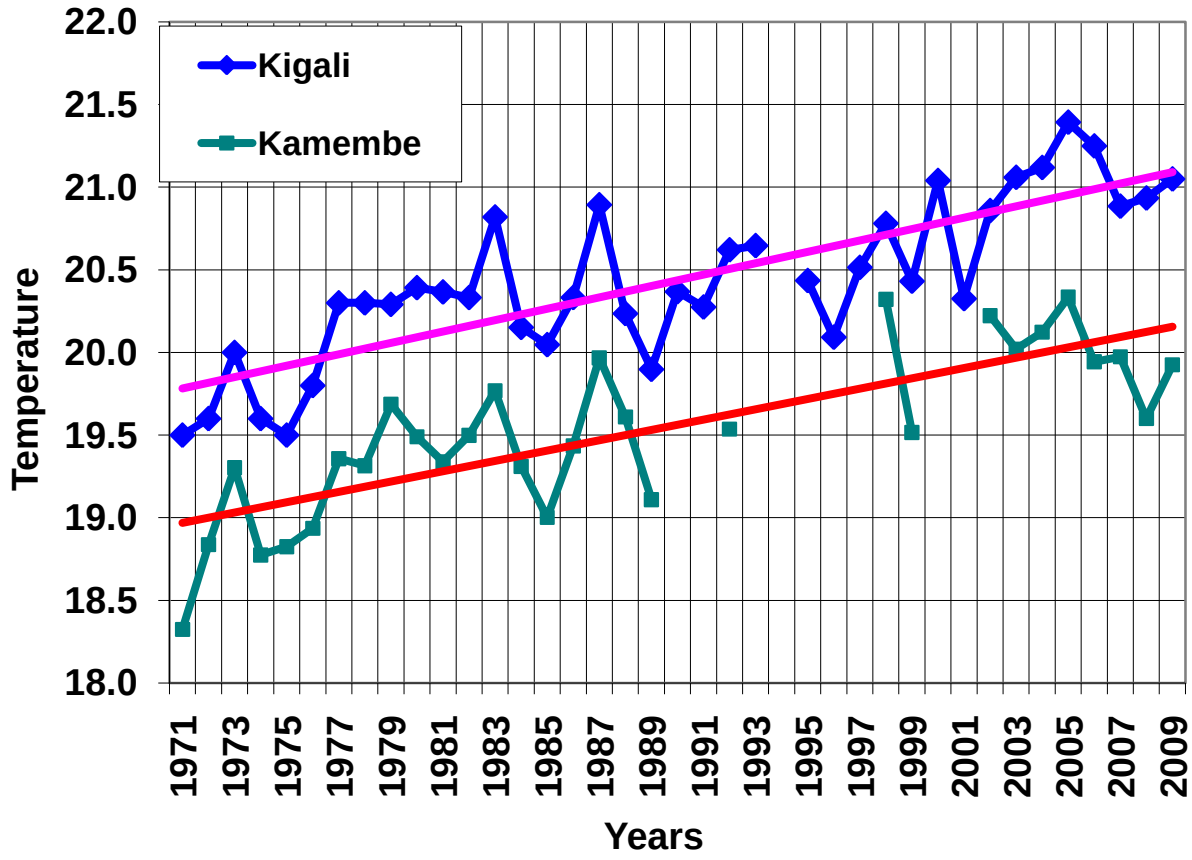


Figure 2: Variation of the annual average temperature in °C (1971-2009) at Station de Kigali Airport (centre of the country) and Kamembe Airport (South West of the country) station

(Source: Data analysis provided by the Rwanda meteorological service)

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)

1.3. Socio-economic indicators

The socio-economic indicators used are from the National Institute of Statistics of Rwanda (2006), the Ministry of Finance and Economic Planning (2003, 2006).
According to these studies, the following observations were made:

- The Rwandan population was estimated at 8,814,253 inhabitants in 2005, with 4,602,923 women and 4,211,330 men, i.e. approximately 52% for women and 48% for men. The GDP per capita was then Rwf 151,000 or U.S. $. 272.
- Agriculture, forestry and fishing activities contributed 39% of GDP, industry 14% and services 41%. Adjustments (mainly taxes raised on products) represented 7% of GDP.

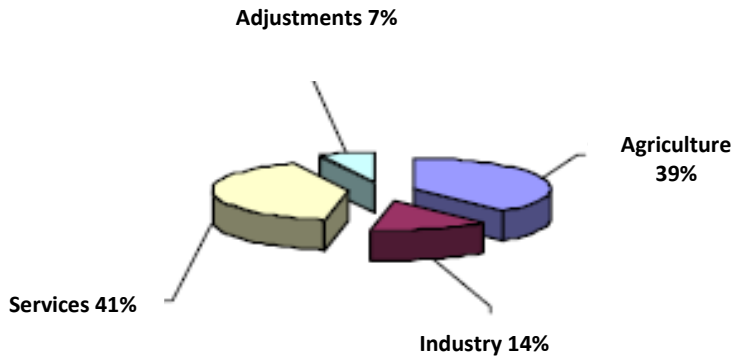


Figure 3: The Structure of nominal GDP, 2005
Source: Rwanda Development Indicators, 2005 RNIS

Tables 1, 2, 3 and 4 below show the socio-economic indicators of the sectors of finance, population, settlement, employment, health, education and literacy.

Table 1: Comparison of socio-economic indicators from 1980 to 2005

Socio-Economic Indicators	**1980**	**1990**	**2002**	**2005**
Population (million)	5 .163	6.879	8.162	**8.814**
% female	-	51.3	52.3	**52.2**
size and composition of household • Country average • Rural environment • Urban environment				 **4.6** **4.5** **4.8**
Fertility rate	8.3	6.9	5.6	**6.1**
Maternal mortality rate (for 100,000 births)	-	1300	1071	**750**
Annual growth rate (%)	3.1	3.1	1.2	**1.2**
Poverty Index (%)	40	53	60	**56.9**
Life expectancy	46	49.5	49	**49**
Infant mortality (per 1000 births)	128	85	107	**86**
Mortality for - 5 years (per 1000 births)	224	150	196	**152**
HIV / AIDS prevalence (ages 15-49)	-	-	13.7	**3**
Gross enrollment in primary	63	70	110.5	**140.2**
% Of girls in total enrollment %	48.0	49.6	73	**86.9**
Net enrollment in primary education	-	-	73,7	**85,9**
Gross enrollment in secondary education	3.0	8.0	13.9	**-**
Net enrollment in secondary education	-	-	6.9	**10.0**
% Of girls in total enrollment	33.3	39.9	74.9	**-**
% Of girls in total enrollment (Higher Education)	8.2	16.6	52.5	**-**
Inflation rate in%	-	-	-	9.12
Exchange rate (Rwanda francs for U.S. $ 1)	-	-	-	557.81
Taxes and customs revenues without CBT (in billion Rwandan francs)	-	-	-	161.4
Non-tax revenues (in billions of Rwandan francs)	-	-	-	17.8
Public expenditure (in billion Rwandan francs) • Regular budget • Development budget	-	-	-	365.9 228.2 137.7

Table 2: National Accounts and Public Finances

	Socio-Economic Indicators		**2005**
1	Gross Domestic Product	At current prices in billion Rwf	**1.332**
		Per head	**151,000 (272 USD)**
		Proportion of agriculture	**39%**
		Proportion of services	**14%**
		Proportion of industries	**41%**
		Adjustment (Taxes on products)	**7%**
		GDP growth	**6%**
2	GDP Distribution	Formal (including taxes)	**23%**
		Informal	**35%**
		Non-monetary production	**31%**
		Government	**11%**
3	Value of exports in USD		**125,000,000**
4	Money	in % GDP	**18.2**
		In billion of Rwf	**217.8**
		% Of the variation between 2001 and 2005	**26.4**
5	Credit to private sector	In billion of Rwf	**131**
		Proportion of agriculture	**4%**
		Proportion of agriculture with related activities (collection, processing , export)	**10%**
6	Investment level	Percentage of GDP (consisting mainly of building)	**16%**
		The rate of investment growth	**12%**
7	Revenue and Customs Tax	Collections in billions	**164.4**
		Proportion of GDP	**14%**
8	External public debt	in billion Rwf	**1,573.2**
		Proportion of GDP	**74.4%**
9	Domestic public debt	in billion Rwf	**216.3**
		Proportion of GDP	**9%**
10	Non-taxable receipts	in billion Rwf	**17.8**
11	public expenditure	Total in billion Rwf	**365.9**
		Regular budget in billion of Rwf	**228.9**
		Development budget in billion of Rwf	**137.7**
12	Exchange Rates	In Rwf	**557.81**
13	Inflation rate	In percentage	**9.12**

Table 3: Population and settlement

	Socio-Economic Indicators		**2005**
1	Number of population	Total	**8,814,253**
		Proportion of females	**52%**
		Proportion living in rural areas	**82%**
		Proportion under 25 years	**67%**
		Proportion aged over 65 years	**3%**
		Growth rate	**3%**
2	Size and composition of household	National Level	**4.6**
		Rural	**4.5**
		Urban	**4.8**
3	Proportion of population having electricity	National Level	**5%**
		Rural	**25%**
		Urban	**1%**
4	Urbanization rate	In percentage	**17.5**
5	Proportion of population having Radio receiver	National Level	**46%**
		Rural	**65%**
		Urban	**43%**
6	Proportion of population having televisions	National Level	**2%**
		Rural area	**14%**
		Urban area	**0.3%**

Table 4: Employment, health, education and literacy

	Socio-Economic Indicators		**2005**
1	Unemployment rate	Male, urban area	**29.6%**
		Female, urban area	**37.4%**
		Males, rural area	**45.3%**
		Female, rural area	**24.8%**
2	Occupation in farming activities	Males	**85.5**
		Female	**61.5**
3	Poverty Index		**56.9**
4	Fertility rate		**6.1**
5	Rates of maternal mortality	per 100,000 births	**750**
6	Infant mortality rate	per 100,000 births	**86**
7	Mortality for - 5 years	per 1,000 births	**152**
8	HIV / AIDS prevalence	between 15-49 years	**3%**
9	Life expectancy		**49 ans**
10	Percentage of girls in total enrollment		**50.9**
11	Attendance rates for children aged between 7 to 12 years	Girls	**86.9**
		Boys	**84.8**
12	Percentage of girls in secondary school	Ordinary level	**48**
		High level	**47**
13	Net Enrolment in secondary school	National level	**10.0**
14	Percentage of women in public higher Learning Institutions	Public	**25%**
		Private	**58%**
15	Literacy rate	Kigali City	**88.1%**
		Rural area	**75.1%**
		National level	**76.8%**

CHAPTER II: NATIONAL INVENTORY OF GHG EMISSIONS AND ABSORPTION



While drafting the first national communication for Rwanda, the base line year for the inventory of greenhouse gas emissions was 2002 instead of 1994, the year of major socio-economic perturbations and genocide in Rwanda. For this second communication, the base line year is 2005, belonging to the period 2003-2006.

Five of the six sectors for greenhouse gas emissions inventory recommended by the IPCC (1996.2000, 2003) will be the focus of this study: energy, industrial processes, agriculture, land use , land use change and forestry (LULUCF), and wastes (B.V Braatz and M. Doorn, 2002).

Only gases attributable to the sector of solvents and other products have not been inventoried, due to the data uncertainties in the field of beer and bread manufacturing and due to the negligible quantity of those gases. Similarly, hydrofluorocarbons (HCFs), perfluorcarbons (PFCs) and sulfur hexafluoride (SF6) have not been inventoried (Rwanda, a country not included in Annex 1 of the Convention) because of their low quantity.

2.1. Sector-Based Description

2.1.1. Energy sector

Rwanda has energy resources whose potential is estimated as follows:

- Hydropower: 350MW;
- Methane gas: 55 billion Nm^3 with a rated capacity of 700MW;
- Geothermal power: 170-340MW;
- Solar power energy: 5.5 kWh/day/ m^2;
- Peat reserves which are about 155 million tons of dry matter.

The country's current energy consumption is subdivided as follows:

- Biomass (fuel wood and agricultural residues), 86% of energy consumption;
- Petroleum products, 11% of energy consumption; and
- Electricity , 3% of energy consumption of which 56% comes from hydropower plants and 44% from thermal power plants

Biomass

Consumption of energy from biomass is estimated at 0.48 kg / person / day of wood charcoal, 1.45 kg / person / day of firewood, and 0.24 kg / person/ day of agricultural residues. It is used mainly in households, community institutions and industries (restaurants, schools, prisons, military barracks and tea factories).

This demand is however not satisfied. From this consumption, a deficit of about 7,000,000 m^3/year has been evaluated, which suggests an over-exploitation of timber resources leading to increasing deforestation and recourse to agricultural residues useful for soil fertility. The table below indicates the level of wood consumption from 2005 to 2010.

Table 5: Wood consumption and projection (ton per year)

Year	**2005**	**2006**
Fuel wood in urban area	81,916	86,831
Wood for charcoal in urban area	1,643,655	1,732,734
Fuel wood in rural area	2,805,431	2,871,907
Wood for charcoal in rural area	123,409	126,333
Wood for industries / institutions	336,652	344,629
Total	4,982,063	5,162,434

Source: MININFRA / Rwanda State of Environment, REMA, 2009

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. However, the transport sector remains the main fuel consumer. The table below presents the progressive distribution of petroleum products imported during the period 2002 to 2006.

Table 6: The evolution in the importation of petroleum products 2002-2006 (tons)

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

Source: Rwanda Revenue Authority / Civil Aviation Authority

Electricity

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 comparatively expensive. However, this MINECOFIN report (2005) does not talk about agriculture, yet it is one of the important sectors of the country

Table 7: Evolution of electricity consumption

Description	**2003**	**2004**	**2005**	**2006**
Domestic Production (GWh)	117.6	90.5	115.8	168,7
Exports (GWh)	3.3	2.2	1.8	2,0
Imports (GWh)	120.9	115.6	89.1	64,1
Available (GWh)	235.2	203.9	203.1	

Source: MINIFRA/ ELECTROGAZ

Table 8: Electricity supply/ per mode of production and prices from 2002 to 2006

Year	**2003**	**2004**	**2005**	**2006**
Hydro Electricity	100%	100%	70%	44%
Thermo Electricity	0%	0%	30%	56%
Total	100%	100%	100%	100%
Tarif (US cents)/KWh	7	7	14	22

Source: MININFRA / ELECTROGAZ

Table 9: Consumption of fuel/ diesel from thermal power plants in 2005 and 2006 (assuming that 1 liter = 0, 84 kg)

Year / Place	2005		2006	
	Liters	**tons**	**liters**	**tons**
Jabana	6,616,150		4,693,680	
Gatsata	4,576,821		338,308	
Mukungwa	2,789,873		7,219,033	
Gikondo	2,798,873		21,708,918	
Total	**16,781,717**	**14, 096, 6** (24%)	**33,959,939**	**28,526.3** (35%)

Source: MININFRA / ELECTROGAZ

2.1.2. Transport Sector

The transport sector is dominated by road transport. The table 10 below shows the evolution of the Rwandan fleet of vehicles, which has been increasing from 2002 to 2006. The number of saloon cars dominates among the four-wheel drive vehicles (44,245), followed by pick-ups (8,113) and jeeps (6,882).

After putting in place a computerized system by Rwanda Revenue Authority, only 18,281 vehicles were reregistered out of 22,023 which was registered before. Air transport is provided from the airports of Kanombe and Kamembe by a foreign fleet (Kenya Airways, Ethiopian Airlines, and SN Brussels) and Rwanda Air Express. This transport is limited to business flights and importation of a certain category of goods.

Table 10: The evolution of fleet of vehicles from 2002-2006

Description	**2003**	**2004**	**2005**	**2006**
Motorcycles	3879	7230	12124	15525
1. Private vehicles				
Cars	6261	8524	10323	11245
Microbus	52	63	70	72
Minibus	2057	2682	3407	3693
Pickup	4156	5729	7227	8113
Jeeps	3013	4372	6176	6882
Bus	47	70	85	104
Trucks	880	1363	1640	1816
Trailers	236	333	389	458
Semi-trailers	46	66	79	92
2. Public vehicles				1000

Source: Rwanda Revenue Authority (RRA) / MININFRA Observation

2.1.3. Industry sector

The industry sector in Rwanda is mainly comprised of mining, quarrying and manufacturing (agro-industry and small & medium enterprises). This sector is young (1964) and contributes to GDP for about 20%. The cement production company "CIMERWA" and the lime production cooperative "COCOCHAUMA" are the two main sources of greenhouse gas emissions through the calcinations of carbonates at 600-900°C and combustion of oil fuel at 1400°C. The tables 11 and 12 below indicate the cement and lime production from 2000-2006 and from 2003 to 2006 respectively.

Table 11: Production of cement at the national level (tons)

Year	2003	2004	2005	2006
Cement production in tons	105105	104288	101128	102588

Source: RNIS, CIMERWA

Table 12: Production of lime

Year	COCOCHAOMA lime (in T)	(lime in kg)	hydrated lime
2003	186389	113210	69609
2004	201558	119780	66054
2005	206917	127283	75 54
2006	398768	131181	83224

2.1.4. Wastes sector

The rubbish tips found in towns of Rwanda are wild and made up mainly of household wastes. Because of being densely populated (703,000 inhabitants in 2005) and numerous activities, the uncontrolled rubbish damp site in Kigali city, located at Kicukiro(Nyanza damp site), noted a neat increase in the amount of solid wastes. It virtually doubled from 21,000 tons in 2003 to 37 979 tons in 2007 through a transit of 27,875 tons in 2005.

Although Burning of waste in open air is prohibited by the law although some rare cases open incineration can be observed in Rwanda. General wastes incineration is usually done in the open, few institutions do it in the incinerators. This is the case of the *Lycée Notre Dame de Cîteaux* and Kigali Institute of Education (KIE).

As is the case of solid wastes, wastewater management in urban areas remains a crucial problem in spontaneous settlements as this wastewater flows directly into nature without any treatment. In the case of medium and high standing housing, septic tanks are used for wastewater treatment. However, efforts are being undertaken in this area. We can mention the case of wastewater treatment at the *Centre Hospitalier Universitaire de Kigali* (CHUK), the use of lagoons and rotordisk in Nyarutarama.

2.1.5. Agriculture and animal husbandry sector

Agriculture

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.(SOND and MAM).
In 2009, the population engaged in agriculture was 80%. Agriculture contributes 34% of GNP 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.

Since the 80s, the country's agricultural sector faces a series of unique constraints. Because of the high population density in Rwanda, land is still insufficient. Such a situation is aggravated by the fact that most farmers practice mainly rain-based agriculture. Soil fertility has been deteriorated due to the demographic pressure on lands while the use of organic and non organic inputs remains very low. In addition, a great number of lands in Rwanda run a high risk of erosion due to its mountainous relief with steep slopes. However, the inadequate management of this natural capital (overexploitation, erosion) and the use of traditional technologies have led to soil degradation.

To move to the phase of market based agriculture through modern farming techniques and the use of inputs, the country has embarked on a strategy of intensification of strategic food crops: rice, maize, beans, potato and wheat in addition to traditional cash and export crops (tea, coffee, and pyrethrum). This is possible owing to efficient use of land and water, food crops marketing as well as capacity building in research and dissemination services.

Furthermore, efforts are made to reduce the population dependency on agriculture as a unique revenue source, by consolidating other sectors, namely those of industry and services. Table 13 below indicates areas occupied by main crops.

Table 13: Area occupied by main crops

Crops	**1990**	**2000**	**2003**	**2005**	**2007**
Cereals	248072	277557	311484	344211	342009
Leguminous plants	344691	406204	444541	405945	467181
Roots and tubers	401853	425429	442869	426379	435874
Bananas	400570	360470	358418	361251	351958
Fruits and Vegetables	18374	41696	58225	81777	83959
Total	**1,413,560**	**1,511,352**	**1,615,538**	**1,619,563**	**1,680,981**
Coffee				33000	
Tea			9588	11750	12306
Pyrethrum			3191	3191	

Rice in Rwanda is normally cultivated in marshes. Data on areas for growing rice indicates that these areas have increased from 6,423 ha in 2002 to 30,000 ha in 2009. Other marshes are under preparation in an effort to meet the population needs.

Table 14: Rice irrigated lands in Rwanda 2002-2009

Rice Production	**2003**	**2004**	**2005**	**2006**
Production (MT)	28,191	46,191	62,193	60,446
Area (ha)	7,667	12,167	13,922	13,123
yield	2,945	3,244	3,885	3,856
Consumption	66,000	69,432	73,042	76,841
Consumption per capita	66,000	72600	79860	87846

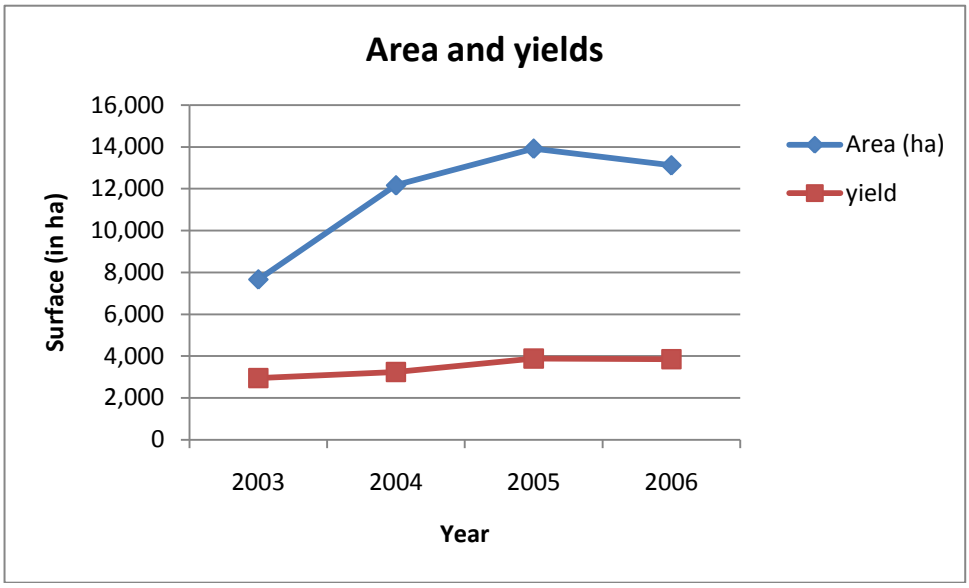


Figure 4: Rice cultivation lands and yields from 2002 to 2009
(Source MINAGRI, Evaluation of crops).

As it is indicated in figure 4, the periods 2002- 2003 and 2007 - 2008 were marked by a drop in rice production due to a decrease in rainfalls and rise in temperatures. Rice cultivated in marshes requires a large amount of water in its reproductive phase (from blossoming to grain formation).

Animal husbandry

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

According to the survey conducted on Food Security and Nutrition in 2009 by the WFP, a large number of household cow breeders has been observed in the District of Gakenke (80%), Bugesera (73%) and Ruhango-Muhanga- Kamonyi (72%), that is, respectively 52% for livestock

in Gakenke, and 43% in Kamonyi, Muhanga and Ruhango, while poultry is more common in Bugesera. Thus, small ruminants, pigs and poultry have become more important in the country as indicated in Table 15 below. The only problem remains: small sizes of arable lands for the expansion of livestock (lack of pasture in general).
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.

Table 15: Animal production (MINAGRI and MINECOFIN RARDA, 2006)

TYPE	2003	2004	2005	2006
Cattle	991697	1006572	1077206	1122179
Goats	1270903	1263962	1663551	1688279
Sheep	371766	686837	689556	695367
Pigs	211918	326652	456043	527531
Poultry	2482124	2482124	2109196	1776027
Rabbits	498401	520057	427444	418361

(Source: Joint Sector Review / EDPRS Self Evaluation)

Fishing

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 valley 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.

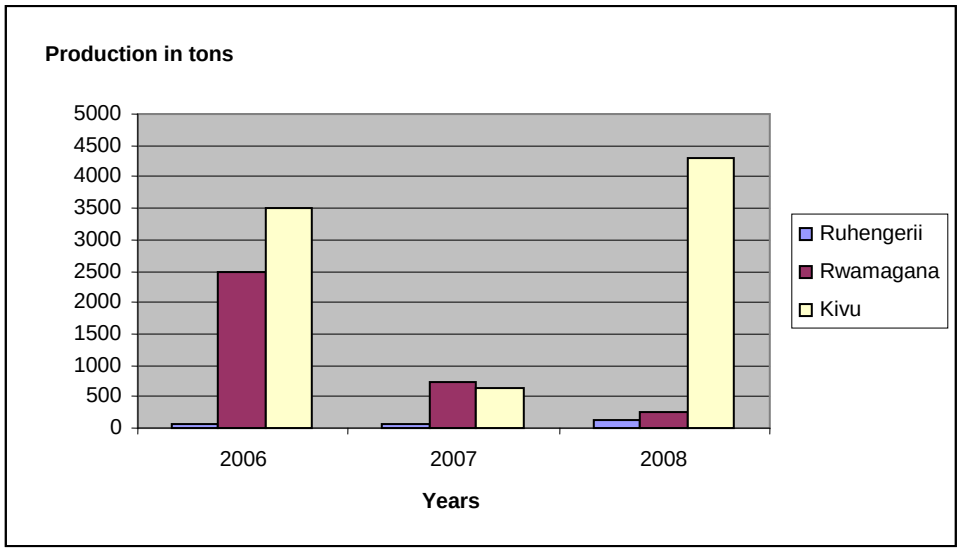


Figure 5: Fishing production from 2006 to 2008 (by the Project PAIGELAC)

As indicated on figure 5, the decrease in tons of fish in 2007 was due to the use of small fishing nets during the fishing that caught simultaneously small and big fish emptying completely the lakes. A quick intervention was therefore made to fishermen requesting them to exclusively use more appropriate equipment.

2.1.6. The sector of land use, land use change and forestry (LULUCF)

The natural vegetation of Rwanda, (where it still exists), comprises grass savannas, shrubs, bushes, and mountainous rain forest trees, gallery forests, and marsh and aquatic vegetation (MINITERE, 2007).

These types of forests and vegetation are grouped into four categories namely:

- natural forests on both sides of Congo Nile Crest and containing Nyungwe National Park, Gishwati and Mukura Forests, natural forest of Birunga volcanoe parks 2) gallery and savannas natural forests, galleries of Akagera National Park;

- Gallery Forest vestiges and the Savannahs of Bugesera, Gisaka and;

- Plantation trees forests and trees mainly dominated by exotic species (Eucalyptus spp, Pinus spp, Grevillea robusta, etc...), most of them scattered in fields (agroforestry) and along anti-erosive ditches and/ along the roads.

Humid natural forests represent the biggest part of Rwandan forest cover (33%), followed by Eucalyptus plantations (26%) and degraded forests (15.7%). Most humid forests are protected while plantations and degraded forests are regularly used for various domestic purposes.

Forest lands that have not been degraded since 2000 are mainly located in national parks namely: Nyungwe,Birunga and AKAGERA

Table 16: Area for parks from 2000 to 2006 in Ha (Source: ORTPN, 2007)

Parks	**2003**	**2004**	**2005**	**2006**
NYUNGWE	92400	92400	92400	92400
BIRUNGA	16000	12000	12000	12000
AKAGERA	90000	90000	90000	90000

Table 17: Area for natural reserves from 2000 to 2006 in hectares (MINIRENA)

Natural reserves	**2003**	**2004**	**2005**	**2006**
Gishwati	700	700	700	700
Mukura	1200	1200	1200	1200

Table 18: Area of managed forest plantations (ISAR, 2007)

Years	**2003**	**2004**	**2005**	**2006**
Forest Plantation	306653	321600	321600	398165

2.2. Methodologies

Rwanda does not have its own methodology for estimating national emissions and absorptions of greenhouse gases. Some guidelines for the establishment of national communications from Parties not targeted in Annex I of the Convention (decision 17/CP.8) and the IPCC methodology (1996, 2000, and 2003) have been used. The tables 19, 20, 21, and 22 below, provide their summary.

Table 19: Sources of data per sectors

Sector	**Sources**
Energy	MINIFRA, MINICOM, BNR, CAA, car dealers, carriers, including oil companies like KOBIL
Industrial processes	CIMERWA, COCOCHAUMA
Agriculture (numbers of cows, goats, sheep and poultry)	MINAGRI, RARDA, RDA, MINECOFIN
LULUCF	ISAR, MINIRENA, MINAGRI
Wastes	Kigali City Council
Population	MINECOFIN, INSR

Table 20: Methodologies for data analysis and evaluation per sector

Sectors		**Methodologies**
Energy	Biomass	Product of population (2002-2007) by individual average consumption of wood and charcoal
	Oil products	Level 1 reference and sector-based method Liters → volumic mass → tons
Industrial processes	Portland Cement	Level 1 method; the clinker content has been estimated at 95% by default
	Lime	No data. Using the value by default (85/15) for lime of high content of dolomatic Ca; Supposition hydrated lime is nil
Agriculture	Cows, goats, sheep, poultry	Number → emissions
	Rice	Cultivated areas → emissions
	Burning	Surfaces burnt for grazing
	Harvest residues	Tons of Crop → residue estimation
LULUCF	Solid lands	Forest Inventory (satellite image LANDSAT, July years?)?
	Marsh	Inventory (LANDSAT satellite image, July 2003)
Wastes	Solid	Quantity
	Liquid	No data

Table 21: Methodologies of the analysis and estimations of emission factors

Sector		**Methodologies**
Energy	four-stroke engines	IPCC (1996), emission factor = 20 kg / TJ
	Motorcycles (two-stroke)	IPCC (1996) emission factor is 3 times higher than that of four-stroke engines
Industrial Process		No data Use of the weight fraction equal to 0.65 by default Emission factor of 0.51 ton of CO2 per a clinker ton Emission factor of hydrated lime = 0.59
Agriculture	Cattle	No differentiation between dairy and non dairy Cattle, factors of emission of IPCC 1996 for regions of Africa and the Middle East
	manure	Emissions factors in temperate countries 15°<t°<25°C
	rice-growing	No organic fertilizers, emission factors = 1 Emission factor of Methane integrated by season (g / m) = arithmetic average
	Fertilizers	IPCC, 1996 Fsn = N fest * (1 - Frac gasp)
	Total nitrogen excretion	IPCC/ GIEC, 1996 The size of livestock
	Nitrogen contribution	IPCC/ GIEC 1996/2000 ? FBN T2 Culture BF - Frac NCRBF
LULUCF		IPCC/ GIEC 2003, Level 1, Values of the humid tropical zones (0.5 for the density of dry matter and 1.5 for net annual increase)
Waste	Discharge	OPD/ DPO according IPCC /2000, first level decomposition
	Wastewater	degradation in aerobic culture

Table 22: Quality Control / Quality Assurance per sectors

Sector		**Uncertainty**	**Guarantee**
ENERGY	Quality Assurance	IPCC 2000 ; statistics of petroleum products; Tolerance = ± 0.3% Gasoline ± 0.2% kerosene	RRA
	Quality control		RRA, Police, BNR, MINICOM
	Fuel density	Average density: Diesel = 0.840 ± 0.025	KOBIL, MINICOM, Rwanda Bureau of

		Petrol = 0.76 ± 0.05	Standards
	Volume of fuel	diesel: 0.2 Petrol: 0.3	
	Final uncertainty	Density - Diesel: 3% - Petrol: 5%	
Industrial processes	Cement production	15 % CIMERWA	Rwanda development indicators
	Lime production	25 % COCOCHAUMA	
Agriculture	Cows, goats, sheep, poultry	Uncertainty estimated at 20%	MINAGRI
	Flooded areas		
LULUCF	Secondary Data	Uncertainty estimated at 40%	MINAGRI
Waste	Solid	Uncertainty = 10% (tonnage of trucks)	
	Wastewater	Uncertainty = ± 10% population in 2005	

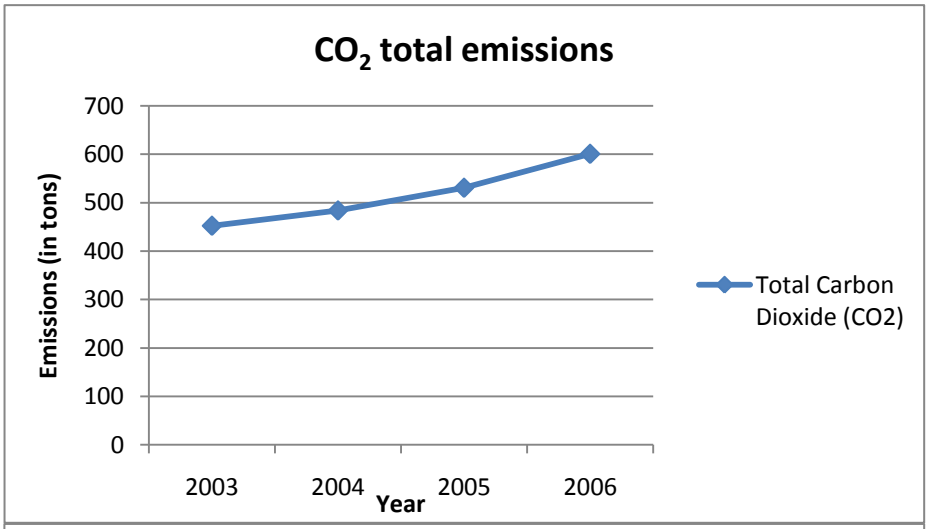
2.3. Trends in GHG Emissions

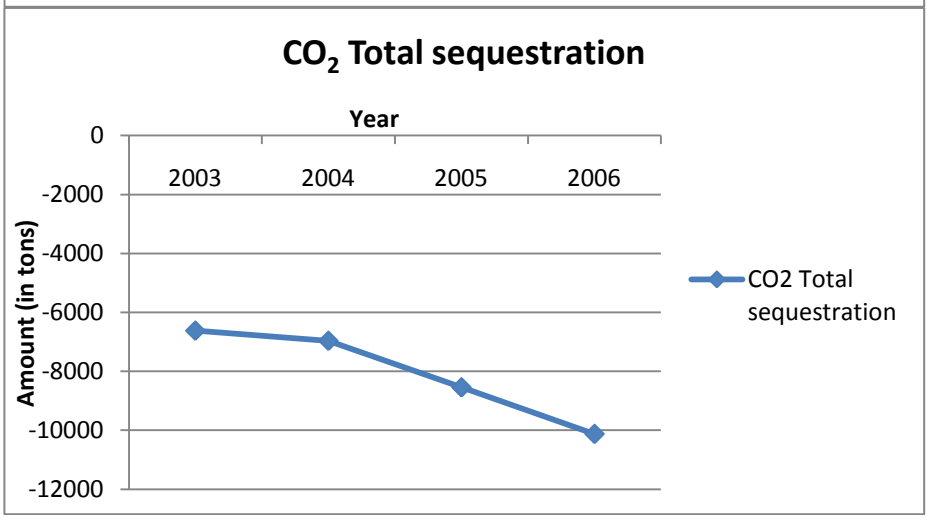
The total GHG emissions, direct (CO_2, CH_4 and N_2O) as well as indirect ones (CO, NOx, NMVOC and SOx) have had in general a positive evolution between 2003 and 2006 as indicated in the following table 23 and figure 6 below.

Table 23: Trends in GHG Emissions

Emissions (Gg)	**2003**	**2004**	**2005**	**2006**
DIRECT GHG				
Total Carbon Dioxide (CO2)	452.37	483.89	530.88	601.05
Industrial Processes	145.18	148.47	150.52	153.91
Energy	307.19	335.42	380.36	447.14
Total land use , land use change and forestry (absorbed CO_2)	-6620	-6964	-8545	-10126
Total biomass (for memory)	6747.19	6983.35	7227.6	7493.68
Total Methane(CH_4)	64.27	68.75	71.31	74.1
Energy	18.54	19.19	19.86	20.6
Agriculture	43.5	47.1	48.9	50.7
Wastes	2.23	2.46	2.55	2.8

Total Nitrogen oxide (N_2O)	3.53	7.93	9.83	11.73
Energy	0.24	0.25	0.26	0.27
Agriculture	3.2	7.6	9.5	11.4
Lands and Forestry settlements	0.09	0.08	0.07	0.06
INDIRECT GHG Emissions				
Carbon monoxide (CO)	1963.08	2006.76	2327	2652.482
Nitrogen oxides (NOx)	15.316	15.217	16.008	16.799
NMVOCs /COVNMs	38.96	40.37	41.78	43.57
Sulfur oxides (SOx)	16.6	16.94	18.07	18.48





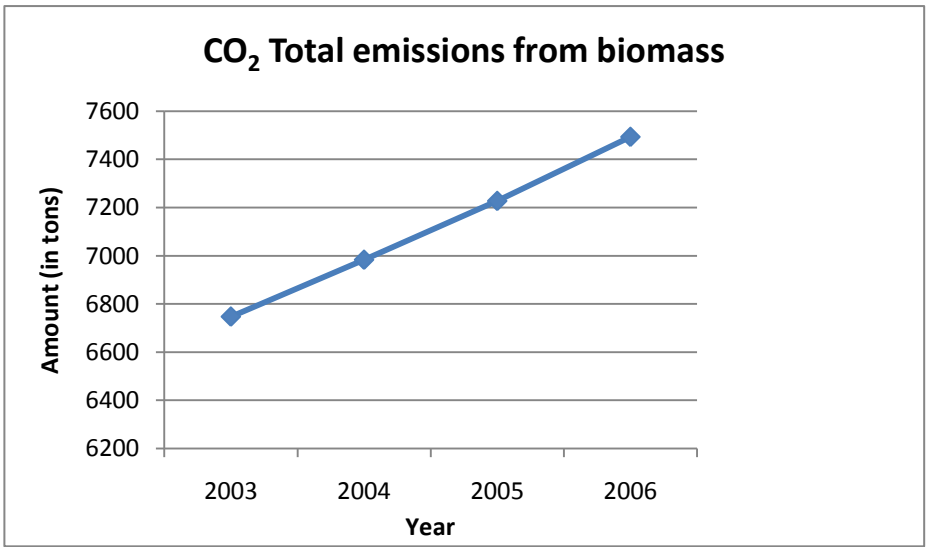


Figure 6: Trends of GHG emissions

2.4. Analysis of GHG Emissions, Gas per Gas

For the year 2005, chosen as the base line year, the results of surveys conducted on GHG emissions inventory show that Rwanda has contributed for direct gases with emissions of 530.88Gg of carbon dioxide ($CO_{2)}$, 71.31Gg of methane (CH_4), 10Gg of nitrogen mono oxide(N_2O), however for indirect gases, Rwanda contributed with 16Gg of nitrogen oxide (NOx), 2327Gg of carbon monoxide (CO), 42Gg of non methanic volatile organic compounds (COVNM), and with 18Gg of sulfur oxides (SOx).

According to the guidelines of Decision 17/CP.8 and of IPCC, the emissions from biomass combustion (fire wood, charcoal, agricultural residues) and those from international bunkers are reported separately from other CO2 emissions (table 24). The quantity of these emissions is 7,228Gg and 17Gg of CO z respectively for the biomass combustion and international bunkers.

Table 24: Recapitulation of national GHG Emissions estimates according to the decision 17/CP.8

Greenhouse gas source and sink categories	CO_2 emissions (Gg)	CO_2 removals (Gg)	CH_4 (Gg)	N_2O (Gg)	NO_x (Gg)	CO (Gg)	NMVOCs (Gg)	SO_x (Gg)
Total national emissions and absorption	**531**	**-8,545**	**71**	**10**	**14**	**2,327**	**42**	**18**
1. Energy	**380**	**NA**	**20**	**0**	**14**	**361**	**42**	**18**
A. Fuel combustion (sector based approach)	380		20	0	14	361	42	18
1. Energy Industries	45		NO	0	0	0	0	0
2. Manufacturing industries and construction	28		NO	0	0	0	0	1
3. Transport	274		NO	0	7	17	3	0
4. Other sectors	34		20	0	7	344	38	17
5. Other (please specify)	NE		NE	0	0	0	0	0
B. Fugitive emissions from fuels	NA		NE		0	0	0	0
1. Solid fuels			NE		0	0	0	0
2. Oil and natural gas			NE		0	0	0	0
2. Industrial processes	**151**	**NA**	**NO**	**NO**	**0**	**0**	**0**	**0**
A. Mineral products	151				0	0	0	0
B. Chemical industry	0		NO	NO	0	0	0	0
C. Metal production	0		NO	NO	0	0	0	0
D. Other production	0		NO	NO	0	0	0	0
E. Production of halocarbons and sulphur hexafluoride								
F. Consumption of halocarbons and sulphur hexafluoride								
G. Other (please specify)	NO		NO	NO	0	0	0	0
3. Solvent and other products use	**NE**			**NE**			**0**	
4. Agriculture			**49**	**10**	**0**	**9**	**0**	**0**
A. Enteric fermentation			45					
B. Manure management			2	0			0	
C. Rice cultivation			1				0	
D. Agricultural soils				9			0	
E. Prescribed burning of savannahs			0	0	0	0	0	
F. Field burning of agricultural residues			0	0	0	9	0	
G. Other (please specify)			0	0	0	0	0	
5. Land-use change and forestry [1]	**0**	**-8,545**	**0**	**0**	**0**	**1,957**	**0**	**0**
A. Changes in forest and other woody biomass stocks	0	0						
B. Forest and grassland transformation	455	0	0	0	0	1,957		
C. Abandonment of managed lands		-9,000						
D. CO_2 emissions and removals from soil	0	0						
E. Other (please specify)	NE	NE	NE	NE	0	0		
6. Waste			**3**	**NE**	**0**	**0**	**0**	**0**
A. Solid waste disposal on land			1		0		0	
B. Waste-water handling			2	NE	0	0	0	
C. Waste incineration					0	0	0	0
D. Other (please specify)			NE	NE	0	0	0	0
7. Other (please specify)	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Memo items								
International bunkers	**17**		**0**	**0**	**0**	**0**	**0**	**0**
Aviation	17		0	0	0	0	0	0
Marine	0		0	0	0	0	0	0
CO2 emissions from biomass	**7,228**							

2.5. Analysis of GHG Emissions, Sector per Sector, 2005

The study of GHG emissions per sector covers five sectors: energy, industrial processes, agriculture, land use, land use change and forestry (LULUCF) and wastes. The summary of GHG emissions for the base line year 2005 is given in Table 25 and in Figure 7.

Table 25: Overview of GHG emissions for the reference year 2005

Greenhouse gas source and sink categories	CO_2 emissions (Gg)	CO_2 Absorption (Gg)	CH_4 (Gg)	N_2O (Gg)	NO_x (Gg)	CO (Gg)	NMVOCs (Gg)	SO_x (Gg)
Total national emissions and absorption	**531**	**-8,545**	**71**	**10**	**14**	**2,327**	**42**	**18**
1. Energy	**380**	**0**	**20**	**0**	**14**	**361**	**42**	**18**
2. Industrial processes	**151**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
3. Agriculture			**49**	**10**	**0**	**9**	**0**	**0**
4. Land-use change and forestry	**0**	**-8,545**	**0**	**0**	**0**	**1,957**	**0**	**0**
5. Waste			**3**	**0**	**0**	**0**	**0**	**0**
Memo items								
International bunkers	**17**		**0**	**0**	**0**	**0**	**0**	**0**
CO_2 emissions from biomass	**7,228**							

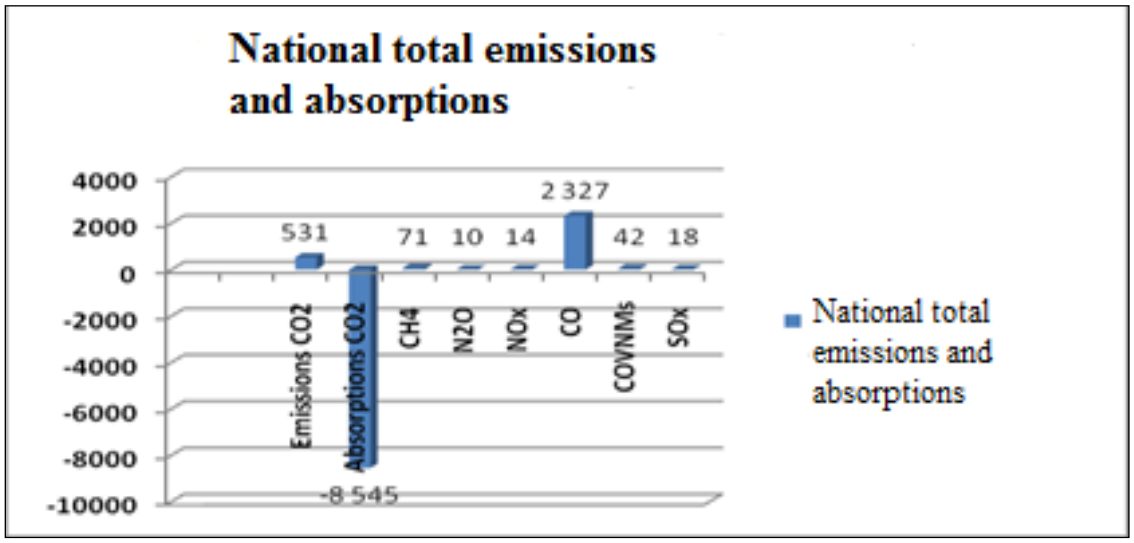


Figure 7: GHG emissions in 2005 in Gg

The analysis of this table 25 and figure 7 shows that, concerning the distribution of direct gas emissions, CO2 emissions hold the largest share with 87%; they are followed by those of methane gas with 11%, and nitrogen mono oxide with 2 %.

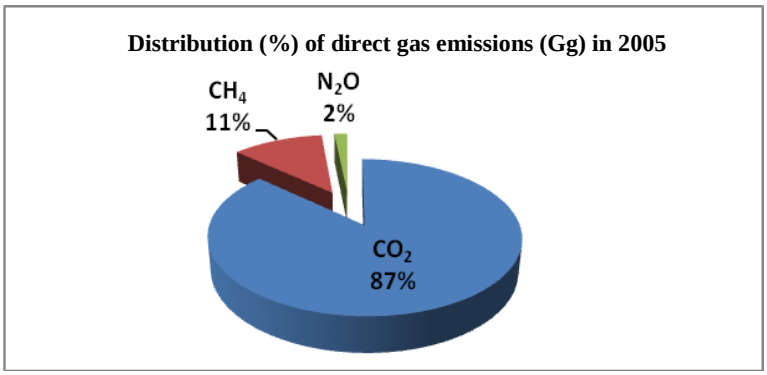


Figure 8: Distribution of the emissions of direct gases (%) in 2005

The energy sector is dominated by the emission of two gases: CO_2 (380.4Gg) and CO (361.2Gg), followed far by other four gases namely, COVNMs (41.8Gg), CH_4 (19.9Gg), SOx (18.1Gg) and NOx (13.8Gg).

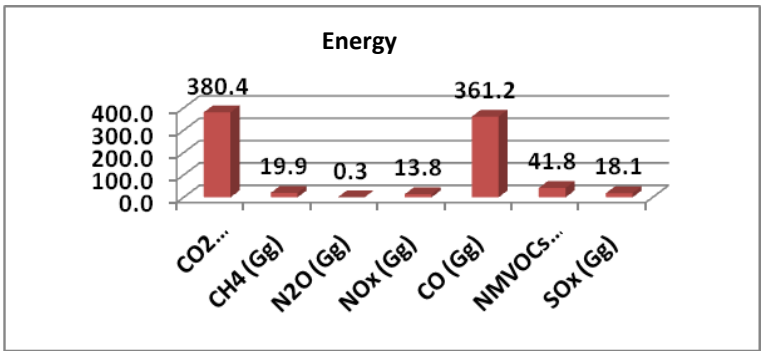


Figure 9: The total GHG emissions for the energy sector in 2005

The industrial processes sector is exclusively dominated by the emission of CO_2 (151Gg).

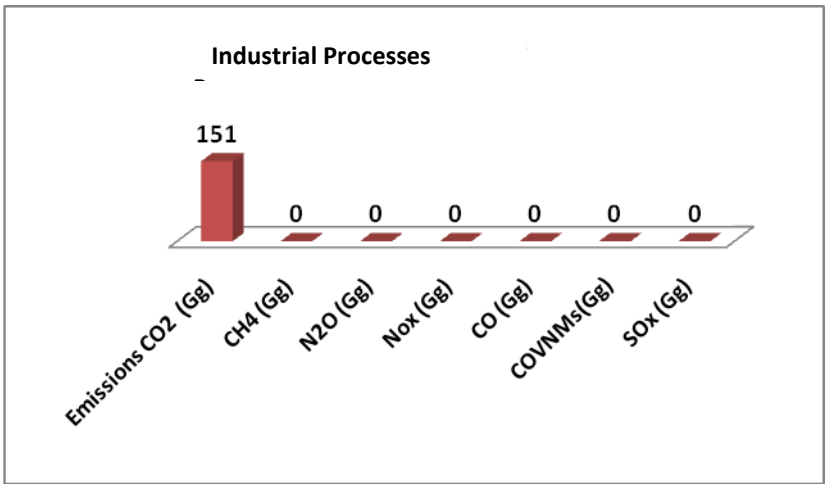


Figure 10: GHG emissions from the sector of industrial processing in 2005

As for agricultural sector (figure 11), the total emissions of methane (CH4), nitrogen hemioxide (N_2O), carbon monoxide (CO), are estimated at 49Gg, 10Gg, and 9Gg respectively.

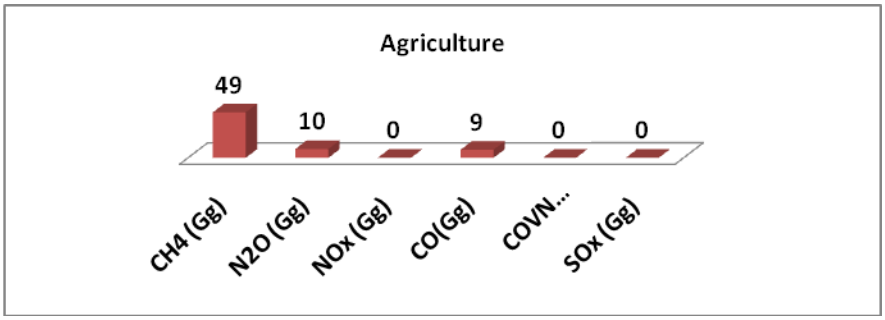


Figure 11: The total GHG emissions for the agricultural sector in 2005

The **LULUCF** sector has relatively lower emissions of CO (1957Gg) compared to the absorption of CO_2 (-8,545Gg). The subsector of wetlands (marshes) is characterized by the emissions of CH_4 (0.47Gg), N_2O (0.00352Gg) and NOx (0.05Gg)

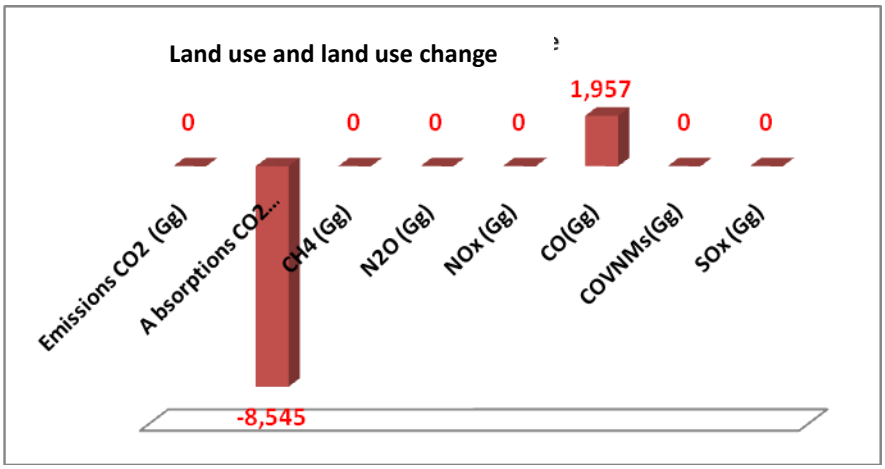


Figure 12: GHG Emissions for LULUCF sector in 2005

As for the wastes sector (figure 13), it is dominated by CH_4 (3Gg)

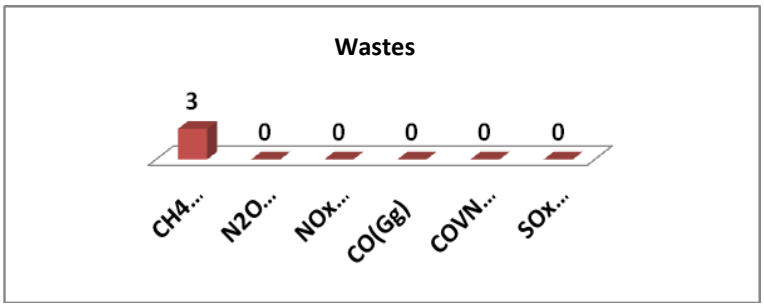


Figure 13: GHG Emissions for the wastes sector in 2005

Taking into account the Global Warming Potential (GWP G100) respectively as follows: 1 for CO_2, 21 for CH_4 and 310 for N_2O, total aggregate emissions rose up to 5,010.4 CO_2 eq-Gg. Hence the national balance of emission-absorption is negative in 2005 since, with the total emissions **of 5,010.4Gg CO2eq and the total absorption of -8545Gg CO2eq, the balance is -3,534.6Gg** CO_2 **that is an absorption of -3,534.6Gg** CO_2 **eq.**

Table 26: Total aggregate emissions/ CO_2 eq in 2005

Sector of emissions	**CO2eq in Gg**	**% of total**
Total National CO2eq emitted	5010,4	100
Energy	891,3	17,8
Industrial Processing	150,52	3,0
Agriculture	3909,9	78,0
LULUCF	10,9	0,2
Wastes	47,25	0,9

The distribution of aggregated emissions (figure 14&15) is as follows:

- Gas per gas: 61% of nitrogen hemioxide, 29% of methane, and 10% of carbon dioxide
- Sector per sector: agriculture (78%), energy (18%), industrial processes (3%), and wastes (1%).

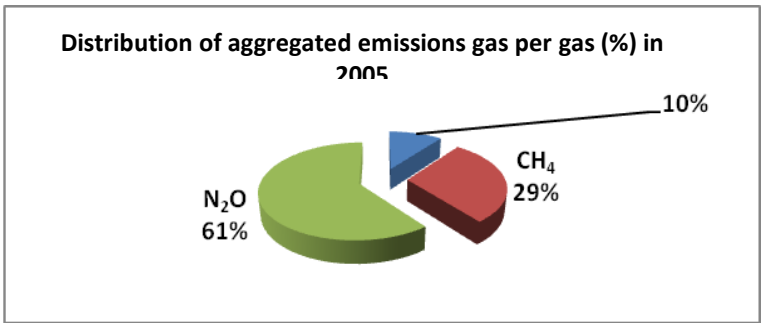


Figure 14: Distribution of aggregated emissions gas per gas (%) in 2005

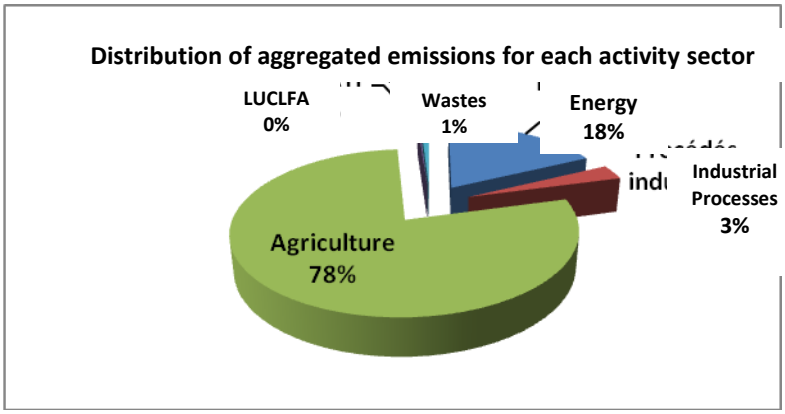


Figure 15: Distribution of aggregated emissions for each sector (%) in 2005

2.6. Quality indicators of GHG emissions estimation

Exhaustiveness

The sectors of activities related to GHG emissions and absorptions as covered in this survey are: energy, industrial Processes, agriculture, land use, land use change and forestry as well as wastes.

For the sector of energy, the inventory focused on biomass (fire wood, wood charcoal and agricultural residues) and oil products, the unique sources of GHG emissions in Rwanda;

For the sector of industrial Processes, the sources of GHG emissions today throughout the whole national territory are: cement and lime productions. However, the uncertainties about data related to beer and bread manufacturing are such that we preferred not to evaluate the emissions in these subsections;

For the sector of agriculture, the inventory has been conducted on the activity data of existing sources on the whole Rwandan territory. The only existing sources on the national territory are:

domestic livestock, rice plantations, controlled burning of savannas, combustions of the agricultural residues and the cultivated soils;

For the sector of land use , land use change and forestry, all the surface areas of existing forest categories in Rwanda have been considered;

For the sector of wastes, the solid wastes and sewage water wastes are the only potential source of methane emissions.

Transparency

The data has been collected from public and private institutions such as the National Institute of Statistics, the Ministry of Finances and the Economic Planning, the Ministry of Trade and Industry, the Ministry of Agriculture, the Ministry of Infrastructures, the National Bank of Rwanda, the Rwanda Bureau of Standards, the Rwanda Revenue Authority, Rwanda Institute of Agronomic Sciences , the Rwanda Environment Management Authority, Kigali City Council, Civil Aviation Authority, the cement production factory and the lime production cooperative,.

As priorities of the present scientific research do not aim at the quantification of the GHG emissions, Rwanda does not have its own emissions factors. Therefore, to estimate the GHG emissions , the emissions factors provided by IPCC have been used in consideration of the average values of tropical regions.

Comparability

Neighboring countries which have the same conditions as those in Rwanda have not yet published their second national communications for us to be able to make any comparison with them.

Other countries in our region which have availed their second national communication reports on the web site of the United Nations Convention on Climatic Change are: the Democratic Republic of Congo and Congo Brazzaville. However, in the inventory of the GHG emissions, these two countries did not use the table 17/CP.8. It is therefore impossible for us to make any comparison with our GHG emissions inventories.
Recently Niger published its second national communication. Even though the conditions of Niger are far from being comparable with those of Rwanda, we think that the energy needs per inhabitant of Niger and Rwanda can be comparable. We have therefore compared GHG emissions of Rwanda with those of Niger in the energy sector.

The energy sector is a key sector for Rwanda because, apart from the emissions related to biomass combustion (7,228 Gg) and the emissions of the international bunkers (17Gg), both of them inventoried for our memory, this sector is reported to have the following percentages in terms of emissions: 72% of CO_2 , 28% of CH_4 , 100% of NOx , 16% of CO , 100% of NMVOC and 100% of SOx .

However, there are considerable differences between Rwanda and Niger:

- The baseline year for GHG emissions survey is 2005 for Rwanda and 2000 for Niger;
- The population of Rwanda is estimated at 8,814,253 inhabitants in 2005 and that of Niger is 11,060,291 inhabitants in 2001
- The surface of Rwanda is 26,338 Km2 against 1,267,000 km² of Niger.

The following Table 27 presents a comparison of the emissions in the energy sector.

Table 27: Comparison of the GHG emissions of Rwanda and Niger in the energy sector

Gas emissions in Gg	**CO_2**	**CH_4**	**N_2O**	**NOx**	**CO**	**NMVOC**	**SOx**
Rwanda	**380**	**20**	**0**	**14**	**361**	**42**	**18**
Niger	**1.887**	**35**	**0**	**21**	**614**	**76**	**2140**

The analysis of this table gives us the following information:

- The CH_4, N_2O, NOx, CO and NMVOC emissions are comparable because, the population of Niger is estimated at 1.5 times in relation to that of Rwanda and the emissions are in the same proportions

- On the other hand, the CO_2 emissions of Niger are 5 times more than those of Rwanda. This can be explained through considerable differences as mentioned above. Besides, it should be noted that one part of the electricity production in Niger is based on coal

However, the remarkable difference to which we did not find an explanation is on SOx emissions since Rwanda has estimated them at 18Gg as opposed to 2140Gg for Niger.

Coherence

Procedures for data collection and estimating emission factors and the methodologies used follow the recommendations of good practices from IPCC (IPCC, 2000) as well as the decision 17/CP.8 (UNFCCC, 2003). The same procedures and methodologies have been used for the reference year and for other years

Accuracy

The IPCC (IPCC, 2000) good practices, the decision 17/CP.8 were used as the main documentation. The IPCC software was used to quantify the GHG emissions. The software results verification was done using calculators.

Assessment of uncertainties

Uncertainties in estimating GHG emissions come from two main sources:

• Lack and inadequate representation of data;
• Application of emission factors for conditions not completely similar.

In the GHG emissions inventory, three levels of trust / assurance were adopted in accordance with the IPCCC methodology. They are based on the judgments of experts who participated in the inventories. The protocol used for the expert's judgment lies in data availability and collection and data management methods used by the institution or organism which provided the data.

The criteria used to define high, medium and low confidence in the two sub-sectors reflect the quality of activity data generally available or collected in the sub-sector, the level of confidence with which the relationship between activity data and emissions was established.

Table 28: Confidence level

Level of trust	**Level of uncertainty**	**Energy**	**Industrial Processes**	**Agriculture**	**LULUCF**	**Wastes**
Top	Uncertainty	<5 %	< 20 %	< 20 %	< 20 %	< 15 %
Middle	Uncertainty	5-10 %	20-50 %	20-65 %	20-80 %	15-40 %
Lower	Uncertainty	> 15 %	>50%	> 65%	> 80%	> 40%

2.7. Key category and non-Key category Sources of GHG Emissions

The analysis per category of emissions sources was made according to the "key category analysis" from IPCC software. From Table 29 below, two key sources can be pinpointed: Agriculture, with respective values of N2O and CH4 2882.1Gg and 955.4Gg, and Energy with respective values of CH4 and CO2 and 416.1Gg and 269.9Gg; i.e. the total of 90.2%, of LULUCF with its value of –8545Gg, representing a sink.

However, with the exception of the sector of land affectation and forestry, we note that four key sources stand out: N2O and CH4 with respectively 2882.1Gg and 955.4Gg values in the agricultural sector, as well CH4 and CO2 of energy sector with 416.1Gg and 269.9Gg respective values, i.e. a total of 90.2%.

Table 29: Analysis of key-sources of GHG emissions

Country	Rwanda									
Invent. Year	2005									
IPCC Source Categ.	Sector	Source Categories to be Assessed in Key Source Category Analysis [1]	Applic. GHG	Emission Estimate (current year, non-LULUCF) (Gg CO2eq)	Estimate (current year, LULUCF) (Gg CO2eq)	Total absolute estimate incl. LULUCF (current year) (Gg CO2eq)	Lvl Ass. excl. LULUCF (%)	Cumul. level excl. LULUCF (%)	Lvl Ass. incl. LULUCF (%)	Cumul. lev incl LULUCF (%)
Sum	**Sum**	**Sum**		**5,012.9**	**-8,545.0**	**13,557.9**				
Enter number	LULUCF	Enter sub-category [2]	CO_2		-8,545.0	8545.0	n/a	0.0%	63.0%	**63.0%**
4.D	Agriculture	N2O (Direct and Indirect) Emissions from Agriculutural land	N_2O	2,882.1		2882.1	57.5%	57.5%	21.3%	**84.3%**
4.A	Agriculture	CH4 Emissions from Enteric Fermentation in Domestic Livestock	CH_4	955.4		955.4	19.1%	76.6%	7.0%	**91.3%**
1.A.4	Energy	Other Sectors: Residential CH4	CH_4	416.1		416.1	8.3%	84.9%	3.1%	**94.4%**
1.A.3	Energy	CO2 Mobile Combustion: Road Vehicles	CO_2	269.9		269.9	5.4%	90.2%	2.0%	96.4%

2.8. Improvements Expected for the Future National Inventories of GHG Emissions

The insufficiency and absence of statistical data remains a challenge in different activity sectors in Rwanda. This is partly due to the importance of the informal sector. In addition, statistical data have not been collected for the purposes of the inventory of GHG emissions.
In terms of institutional arrangements for the establishment of the present inventories, the project "Second National Communication "while according priority to those who had been able to participate to the First National Communication, was compelled to make recourse to short term training for qualified staff from the ministries responsible for energy, transport, agriculture, forests and industry as well to institutions of higher learning and research.

In order to improve future GHG emissions inventories, the following general recommendations were proposed:

- Regular creation and update of a databank for the inventory of GHG emissions within the Unit "Climate Change and Multilateral Agreements on the Environment" recently created within Rwanda Environment Management Authority (REMA);
- Collaboration between Rwanda Environment Management Authority and sector based institutions concerned with GHG emissions inventory in order to improve the quality and quantity of data;
- Additional supports to facilitate investigations or surveys capable of generating information necessary for the setting up of better quality inventories;
- Include the protocol of level of data reliability
- Develop emission factors specific to Rwanda based on scientific researches.

However, specific recommendations to different economic sectors are the following:

Energy Sector

- To systematically measure the densities of petroleum products entering Rwanda and save these values.
- To record more data on the vehicle fleet, ex.: Age, type of treatment of exhaust gases in case it exists on the vehicle...
- To systematically register, while differentiating, the consumption of jet kerosene used for domestic transport and international transport.

Agriculture Sector

- To reinforce agricultural research on the determination of emission factors for agricultural activities and agricultural practices currently used in Rwanda;
- To include activity data not normally taken into account by those public institutions such as dairy and non-dairy cows, histosols, mineral fertilizer etc..

Sector of Lands and Forestry Use

Improvements targeted in the sector of land use, land use change and forestry, are linked essentially to national policies of this sector. The following suggestions have been made:

- To update data of areas classified in categories which have not benefited yet from a regular inventory such as: forestry lands, cultivated lands which change from one season to another;
- To monitor changes and update data on wetlands, settlements (urban areas which can be obtained by remote sensing), and other lands (rocks and other unexploited lands).

Sector of Industrial Processes and Wastes

- To conduct a survey in order to know the composition of urban wastes;
- To conduct surveys for the purpose of availing the total quantity of soda used in the country;
- To obtain activity data on the consumption of halocarbons (HFCs and PFCs) and sulfur hexafluoride;
- To conduct surveys in order to obtain the small-scale production, of oil bread production through the number of bakeries shops and the total consumption at the national level.

CONCLUSION

For the year 2005, chosen as the base line year, the results of surveys conducted on GHG emissions inventory show that Rwanda has contributed to direct gases with emissions of 530.88Gg of carbon dioxide ($CO_{2)}$, 71.31Gg of methane (CH_4), 10Gg of nitrogen hemioxide(N_2O); however for indirect gases, Rwanda contributed with 16Gg of nitrogen oxide (NOx), 2327Gg of carbon monoxide (CO), 42Gg of non methanic volatile organic compounds (COVNM), and with 18Gg of sulfur oxides (SOx).

In terms of GHG emissions in carbon equivalent, the total emissions amount to 5,010.4Gg CO_2eq including agriculture with to 3909Gg CO2eq (78%), energy with 891.3Gg CO2eq (17, 8%), industrial processes with 150.52Gg CO_2eq (3%), wastes with 47.25Gg CO2eq (0.9%) and land use, land use change and forestry with 10.9Gg CO_2eq (0.2%).

The amount of emissions inventoried for our memory is 722Gg of CO_2 for biomass combustion and 17Gg of CO_2 for international bunkers

It should be noted that the national balance between emissions and absorption is negative in 2005 for, with the total emissions of 5010.4Gg CO_2eq and total absorption of -8545Ggr CO_2eq, the balance is -3534.6Ggr CO eq, i.**e. an absorption of -3534.6Gg CO_2 eq.**

From 2003 to 2006, the variation of direct gas was as follows: the most emitted gas is carbon dioxide (CO_2) ranging from 452Ggr to 601Gg. It is followed by methane (CH4), ranging from 64 to 74Gg and nitrogen hemioxide with the variation of 3.53Ggr to 11.73Gg.

In the same period, the total aggregate emissions ranges from 2896.34 to 5793.45Gg CO_2eq CO_2 eq with the largest contribution from agriculture (from 1905.05Gg to 4598.7Gg CO_2eq CO_2 eq) followed by the energy sector (from 770.93Gg to 823Gg CO_2eq CO_2 eq).

Moreover, the total CO_2 absorbed varies from -6620Gg in 2003 to -10,126Gg in 2006 and CO_2 emissions due to biomass (for memory) range from 6747 to 7494Gg.

CHAPTER III: MITIGATION OF GHG EMISSIONS AND REINFORCEMENT OF SINKS



Having ratified the UN Framework Convention on Climate Change, Rwanda has therefore an obligation to take precautionary measures to anticipate, prevent and mitigate the causes of climate change and limit their adverse effects. To attain this target, it is necessary that these policies and measures take into account the diversity of socio-economic contexts of the country.

In the case of Rwanda, policies and measures have been taken by the government to prevent and reduce the causes of climate change and mitigate their effects, for a sustainable socio-economic development.

While making sure that the environment is protected, these policies and measures should allow a rational utilization of energy resources, an increasing access by the population to more energy at a reasonable cost, satisfaction of energy needs in different sectors (industry, services, agriculture etc...), improvement of transport services and an increase and protection of forest cover.

The Government vision expects that by 2020, Rwanda shall have reduced the use of wood in the energy balance from 90% to 40%. The hydraulic potential associated with that of methane gas should meet the population needs in electric energy in all development activities in the country with a supplement of 125MW compared to 2002. As part of Vision 2020 and especially in its

recent Strategic Plan for Economic Development and Poverty Eradication (EDPRS), the Government set itself the objectives of maintaining a growth rate in electricity consumption at 9.6% per year, to ensure a rural electrification rate of 30% and to enable the population to have electricity from 6% to 35%.

The main objective of this study is to make an evaluation and national analysis of different technologies, measures and activities that are likely to reduce the sources of emissions of Greenhouse Gases or to promote their absorption as well as a regular update of a databank for the inventory of greenhouse gas emissions in Rwanda.

The evaluation includes a description and analysis of the measures of existing activities or those planned at the national levels which are capable of contributing to the reduction and / or absorption of greenhouse gas emissions.

This study includes the following three sections: (i).data collection; (ii). Choice of hypotheses, methods, models, tools, and development of scenarios, (iii) analysis of results of options of GHG emissions.

3.1 Data Collection

Data on key hypotheses, the demand and energy transformation, land use allocation were collected from government services. However specific data on the quantity of fuel consumed per day and per vehicle were estimated on basis of a survey carried out in private institutions such as ATRACO, ACETAMORWA, VOLCANO, RWANDA-MOTOR. Lastly, the data on future projections were estimated on basis of the vision 2020 of the government and from the experts' judgment based on the national conditions.

3.1.1. Key hypotheses

The key hypotheses comprised the number of the population, the annual growth rate of the population, the gross domestic product, the number of households, the average size of families, and the rate of urbanization. According the report on Development indicators (The National Institute of Statistics of Rwanda, 2006) in 2005, the Population in Rwanda was estimated at 8.81 millions, the growth rated of the population at 3%, the GDP per capita at 272USD, the number of households at 1.9 millions, the average size of families at 4.6 members and the rate of urbanization at 17%.

3.1.2. Data on energy demand

(i). Households

In rural areas, biomass provides 94% of energy needs, the rest being covered by other options such as kerosene, gasoline, dry batteries, electricity or other sources of renewable energy.

In 2005 Rwandan population comprised 1,830,000 households of which 17% were urban, 83% rural[1]; with an average energy consumption estimated at 30 kWh per year per person in all forms[2] of activities. Wood energy consumption was 4,982,063 tons while the total demand amounted to 7,822,063 tons.

The data on the use of energy for lighting and for cooking per household was obtained from the report of the National Institute of Statistics of Rwanda (NISR,2006) on an integral survey on life conditions of households (EICV1 for 2001 and EICV2 for 2005). The following tables 30 and 31 show the use of energy for different needs in 2001 (EICV) and in 2005 (EICV2).

Table 30: Energy use for lighting (%)

	EICV1	EICV2	EICV1	EICV2	EICV1	EICV2	EICV1	EICV2
	City of Kigali		Other towns		Rural area		National Level	
Public utility (Electrogaz)	41.9	37.2	8.1	12.0	0.7	0.7	4.5	4.3
Generator	0.1				0.1	0.0	0.1	0.0
Kerosene lantern	34.5	32.3	19.8	25.9	8.1	9.5	11.1	12.7
Gas Lamp	0.4	0.0		0.0	0.1	0.0	0.1	0.0
Firewood	0.8	0.1	11.4	5.7	25.7	17.6	22.6	15.2
Candle	3.9	7.8	0.7	2.4	0.6	1.0	0.9	1.6
Traditional lamp (Agatadowa)	18.5	22.3	59.6	51.4	62.9	69.5	59.1	64.4
Other		0.3	0.4	2.5	1.8	1.7	1.6	1.7
	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Source: EICV2, Rwanda National Institute of Statistics (RNIS, 2006)

[1] Rwanda Development Indicators, National Institute of Statistics,2005/2006
[2] MININFRA/world bank, Estimation of energy report, 2006

Table 31: Energy use for cooking (%)

	EICV1	EICV2	EICV1	EICV2	EICV1	EICV2	EICV1	EICV2
	City of Kigali		Other towns		Rural areas		National level	
Wood	21.4	23.1	81.7	73.7	97.7	95.5	90.4	88.2
Charcoal	75.8	72.4	16.3	19.6	0.8	1.1	8.0	7.9
Gas	0.5	0.2	0.2	0.1	0.0		0.1	0.0
Electricity	0.5	0.2	0.2	0.3	0.2	0.0	0.2	0.1
Kerosene	0.3	0.8	0.1	0.3	0.1	0.0	0.1	0.1
Miscellaneous burning	0.0	0.1	0.9	2.5	0.7	3.0	0.7	2.7
Other	1.5	3.3	0.6	3.4	0.5	0.4	0.6	0.9
	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Source: EICV2, Rwanda National Institute of Statistics (RNIS, 2006)
EICV: Integral Survey on life conditions of Households

(ii). Industry and transport

Small and medium Industries and community Institutions used 366.520 tons of wood for 2005 and this consumption grows in time with the economic development of the country.

For the sector of manufacturing, the consumption of energy is distributed in fuel oil with 9.225 tons for the year 2005. The table below shows the evolution of the demand per industry from 2002 to 2006

In 2005, the transport is assured mainly by road with a fleet estimated at 41.052 vehicles all categories included and for a total consumption of 87.162 tons of petrol and diesel.

Table 32: Evolution in demand by industry from 2002 to 2006

Year		2003	2004	2005	2006
Industries Fuel Oil	Fuel oil (tons)	14.823	14.736	15.794	18.534
Transport	Petrol	41.114	42.818	43.441	50.342
	Diesel	28.357	42.936	43.721	50.868

Source: MININFRA

3.1.3 Data on energy transformation

Energy transformation is divided into transmission and distribution of electricity, electricity generation, charcoal production, methane gas production, biogas production, and production of solar energy. The data related to these subdivisions read as follows:

- Transmission and distribution out-put of electricity: The contribution (%) and output (%) of electricity generation according to the mode of production. ;
- Output (%) and input (%) per mode of production of other energy sources (charcoal, methane gas, biogas, solar energy).

In 2005, hydroelectricity contributed to 50% of electricity generation and the remaining 50% were generated by fuel thermal plants.

According to the information provided by RECO-RWASCO, the loss of energy in 2005 due to transmission and distribution of electric energy including commercial[3] losses is estimated at 20 %. In other words, the transmission and the distribution output of electricity is 80%. The losses through charcoal and gas transport are respectively 5% according and 1% according to MININFRA reports;

Table 33**:** Evolution of the energy transformation from 2003 to 2006

Year	**2003**	**2004**	**2005**	**2006**
Domestic production	117 .6 GWh	90.5GWh	116Gwh	169GWh
Imports	120.8GWh	120.8GWh	89.09GWh	64.09GWh
Total	238.4GWh	211.3GWh	205.09GWh	233.09GWh

Source: MININFRA

3.1.4. Data on Agriculture

In the area of agriculture, land use, land use change and forestry, the data is about the distribution (in ha), of forest lands farmlands, wet lands, lakes and other lands. The population, mainly agriculturalist increases by more than one million per year. The total area of arable lands in Rwanda reaches 1.4 million hectares equivalent to 52% of the country's surface area. Nevertheless, in recent years, cultivated areas exceed 1.6 million hectares. If 0.47 million hectares for permanent pasturelands is added, the percentage of lands used for agriculture, exceeds 70% (REMA, 2009).

Recent inventory of marshes in Rwanda (REMA, 2009) indicated that Rwanda contains 860 marshes covering 278,536 ha of which 20% (38 marshes) are fully protected, 74% (475 marshes) are to be used under certain conditions, and 6% (347 marshes) are to be used without any limitation. As shown in the table 34 the forest area of Rwanda was estimated at 240,746 ha in 2007, which is more or less equivalent to 10.1% of the national surface area. The Government of Rwanda plans to increase the national forest cover from 10% to 30% by 2020.

[3] RECO-RWASCO 2010 , Electricity Generation, Import and Export (KWh) from 1998 to 2009 by Donath

Table 34: The category of forests and their surface areas in 2007

Category of forest	Surface area in hectares	% of the national territory
Wet natural forests	79,797.86	3.35
Degraded natural forests	38,003.51	1.59
Bamboo	4,381,47	0.18
Savannas	3,726.81	0.16
Eucalyptus plantations	63,560.75	2.67
New plantations of eucalyptus and scrub	39,204.82	1.64
Plantation of Pinus	12,071.31	0.51
Total	240,746.53	10.10

Source: Rwanda State of Environment, REMA, 2009

3.2 Choice of Hypotheses, Methods, Models, Tools and Development of Scenarios

All the data is analyzed according to the baseline and GHG emissions scenarios. Baseline scenarios represent the continuity of activities and the method of their implementation (business as usual). However, the scenarios of GHG mitigation consist of implementing measures proposed after the analysis and evaluation, in conformity with the possibilities of mitigation of GHG emissions as well as the economic, technological and cultural opportunities of Rwanda

3.2.1 Methodologies

Taking into account the current policy in Rwanda as well as its implementation, the base line scenarios are based on Government sector based policies, the national strategy for poverty reduction and the Vision 2020. The latter, for example, intends to achieve the following:

- An increased access to electricity energy from 2% in 2000 to 35% by 2020 and a reduction of fuel wood contribution from 94% in 2000 to 50% in 2020;
- Expansion of the use of improved cook stoves with high energetic performance of 40%;
- Increased use of fertilizers from 0.5% in 2000 to 15% in 2020;
- The reduction of the number of people engaged in agriculture from 90% in 2000 to 50% in 2020;
- Increase of the national forest cover from currently10% of the national territory to (30%) in 2020.

As for the mitigation scenarios, four documents (IPCC, 2007; REMA, 2009; CDM/JI 2008; and CDM in charts, 2007) have helped to develop the mitigation scenarios from the data of the baseline year.2005 LEAP software (Long-Range Energy Alternatives Planning system) and COMAP (Comprehensive Mitigation Assessment Process) were used to this effect.

3.2.2 Scenarios for key hypotheses

For baseline and GHG mitigation scenarios, we suggest the variations of key hypotheses from 2005 to 2030 as follows:

- Population annual growth: 2.5% for the mitigation scenarios instead of 3% for baseline scenarios;
- GDP annual growth: 8% for mitigation the scenarios instead of 6% for baseline scenarios.

Table 35: Projections of key hypothesizes

Variable	2005	**2030 Baseline**	**2030 Mitigation**
Population (millions)	8 ,81	18,5	**16,3**
Annual rate of population growth	3 %	3 %	**2,5**
GDP per head	272 USD	1167 USD	**1862 USD**
Number of households (millions)	1,9	3,978	**3,522**
Family average size	4,6	4,6	**4**
Urbanization rate	17%	30%	**40%**

Source: RNIS: Rwanda Development Indicators, 2006; MINECOFIN: Vision 2020; Expert Judgment

The following scenarios concern the demand and the energy transformation.

(i) Baseline and mitigation scenarios for households

For baseline scenarios, 25% of urban population had access to electricity in 2005. It is expected that the urban population will move from 17 to 30 % and shall fully have access to electricity. The main fuel utilized for cooking is fire wood in rural households and charcoal in urban households. For baseline scenarios (2005 to 2030) the number of rural households using fire wood shall drop from 98.9% to 50%. As for replacement of fire wood, the use of biogas shall rise from 0.5% to 50%. For urban households however, the use of wood charcoal shall go down from 72.4% to 50% from 2005 to 2030 and the remaining 50% shall use gas (25%), electricity (15% and wood (15%).

Between 2005 and 2030, lighting for urban households will rise from 25% to 100%, the refrigeration from 10% to 50%, the TV from 14% to 100% and ironing shall be 100% for urban population with access to electricity. The rural population with access to power energy was of 1% in 200. This proportion is expected to grow up to 35% in 2030.

For mitigation scenarios, it is suggested that in 2030, at least 40% of the population be urban residents and access to electricity. Concerning the rural population (60%) of the national

population), it is accepted that only 60% (i.e 36% of the national population) access to electricity.

For cooking en towns, it is proposed that 50% use gas, 20% electricity, 20% charcoal and only ten percent fire wood. On the contrary in rural areas, 40% of households without access to electricity shall use firewood while 60% of that population shall use biogas. Given the fact that the current national policy concerning the use of biogas, and possible improvements in future, 20% more of the population without access to electricity shall use fire wood and biogas; hence 80% of the population (without access to power) shall get biogas lighting. As for households with access to electricity, it is suggested that 70% use biogas, 15% charcoal and 10% wood and electricity.

Table 36: Baseline and Mitigation scenarios for urban households

Category	**Activity**	**Technology**	**User (%)**			**Energy intensities (annual consumption)**				**Cost ($ U.S./yr)**		
			2005	**2030 Ref**	**2030 Mitigation**	**Unit**	**2005**	**2030 Ref**	**2030 Mitigation**	**2005**	**2030 Ref**	**2030 Mitigation**
Electrified	Cooking	Gas	0.2	25	**50**	l	300	300	**300**	600	600	**600**
		Charcoal	72.4	50	**20**	kg	840	630	**420**	250	250	**250**
		Wood	23.1	15	**10**	kg	3200	2400	**1600**	150	150	**150**
		Kerosene	0.55	1	**1**	l	60	60	**60**	120	120	**120**
		Electricity	0.25	10	**20**	kWh	9125	9125	**9125**	2100	2100	**1050**
	Lighting	Electricity	100	100	**100**	kWh	365	365	**365**	84	84	**42**
	Refrigeration	Refrigeration	10	10	**50**	kWh	730	730	**730**	168	168	**84**
	Ironing	Ironing	100	100	**100**	kWh	104	104	**104**	24	24	**12**
	Televi-sion	Televi-sion	14	14	**100**	kWh	55	55	**55**	13	13	**7**
Non-Electrified	Cooking	Charcoal	45	0	**0**	kg	840	640	**420**	250	250	**250**
		Wood	55	0	**0**	kg	3200	2400	**1600**	150	150	**150**
	Lighting	Traditional lamp	36.1	0	**0**	l	6	6	**6**	12	12	**12**
		Kerosene	29.1	0	**0**	l	12	12	**12**	24	24	**24**

RNIS: EICV2, 2006; RNIS: Rwanda Development Indicators, 2006; MINECIFIN: Vision 2020; Experts' Judgment

Table 37**:**Baseline and Mitigation scenarios for rural households

Category	Activity	Technology	User (%)			Intensity Energy (annual consumption)				Cost ($ U.S./yr)		
			2005	2030 (1)	2030 (2)	Unit	2005	2030 (1)	2030 (2)	2005	2030 (1)	2030 (2)
Electrified	Cooking	Charcoal	100	25	**15**	kg	840	630	**420**	250	250	**250**
		Wood	100	25	**10**	kg	3200	240	**1600**	150	150	**150**
		Biogas	5	50	**70**	l	300	300	**300**	300	300	**300**
		Electricity	1	5	**10**	kWh	9125	9125	**9125**	2100	2100	**1050**
	Lighting	Electricity	100	100	**100**	kWh	365	365	**60**	84	84	**42**
	Refrige-ration	Refrige-ration	100	100	**100**	kWh	730	730	**730**	168	168	**84**
Non-Electrified **Non Electrified**	Cooking	Charcoal	1.1	5	**5**	kg	840	630	**420**	250	250	**250**
		Wood	98.9	50	**40**	kg	3200	2400	**1600**	150	150	**150**
		Biogas	0.5	50	**60**	l	300	300	**300**	300	300	**300**
	Lighting	Kerosene	9.5	9.5	**10**	l	12	12	**12**	24	24	**24**
		Traditional lamp	70	70	**10**	l	6	6	**6**	12	12	**12**
		Wood	18	18	**0**	kg	0	0	**0**	0	0	**0**
		Biogas	0.1	0.1	**80**	L	30	30	**30**	0	30	**30**

Source: RNIS: EICV2, 2006; RNIS: Rwanda Development Indicators, 2006; MINECIFIN: Vision 2020; of Judgment Experts
(1) Reference, (2) Mitigation

The analysis of the tables above shows that the scenarios for the mitigation of GHG focus on the following options:

- Recourse to other alternative energies for households: For urban households, the measures proposed concern the increase of gas users from 0.2% to 50% for cooking and an increase of electricity users from 0.25% to 20%. For rural households it is expected that there will be an increase of users of biogas from 5% to 70% (rural electrified households) and from 0.5% to 60% (rural no electrified households). In addition, 100% of urban population and 40% of the rural population are expected to access to electricity. Lastly for cooking needs for both rural and urban areas, the use of solar water heaters shall be supported and extended given the fact that the country has sufficient solar potentials.
- Replacement of incandescent bulbs by bulbs with low energy consumption, a CDM project in connection to this alternative is underway.

- Intensive electrification: Rwanda has got a considerable power potential estimated at 1 200 MW. The potential originates from hydraulic, geothermal, methane gas, peat and other sources of energy. The major part is yet to be exploited.

- Introduction of improved stoves and furnaces at a large scale: this alternative targets improved cook stoves at an affordable price, capable of reducing the quantity of fuel wood at 50% of the quantity currently used for cooking.

(ii) Baseline and mitigation scenarios for industries and institutions.

Since only the data on consumptions is available, the users of this category are grouped in units referred to as Buildings in the LEAP soft ware. The first building characterizes industries connected to the electrical network including mainly BRALIRWA, SULFO and the CIMERWA. The second building replaces Small and Medium Enterprises as well as institutions such as tea factories and Secondary schools.

The hypotheses for baseline scenarios are as follows: For the first building category, the evolution of the fuel oil consumption shall move from 9.225 tons in 2005 at 19.315 tons in 2030. For the category of the second building, fire wood is used 100% and shall remain 100% by 2030.

The hypotheses for the mitigation of GHG emissions for the industry sector are based on fuel substitution by lake Kivu gas methane and the substitution of a quarter of fire wood used in institutions by biogas, the use furnaces with higher energetic performance, and the afforestation in order to increase the quantity of fire wood as well as the quantity of forests which would help to sequestrate GHG emissions.

Table 38: Baseline and mitigation of GHG emissions scenarios for the sector of industry and institutions

		User (*)		**Energy Intensity Annual Consumption**				**Cost ($ U.S./yr)**		
category	**Techno logy**	**2005**	**2030**	**Unit**	**2005**	**2030 (1)**	**2030 (2)**	**2005**	**2030 (1)**	**2030 (2)**
Network	**Fuel**	*	*	ton	9.225	19.315	**19.315**	6.918.750	14.486.250	**14.486.250**
	Methane	*	*	m^3	0	0	**28742560**			
SME& institutio ns	**Woods**	*	*	ton	336.652	704.874	**528.655**	4.063.042	8.507.100	**8.507.100**
	Biogas	*	*	m^3	0	0	**121394967**			

Source: MININFRA / ELECTROGAZ; REMA: Rwanda State of Env: ironment, 2009; Expert Judgment
(1) Reference, (2) Mitigation
2. Energy transformation

The analysis of the table above shows that the scenarios for the mitigation of GHG emissions proposed in the sector of industry and institutions focuses on the following options:

- Replacement of fuel used in industries: This option intends to replace the fuel used by BRALIRWA, CIMERWA and UTEXRWA and other similar factories by Lake Kivu gas methane.

- Introduction of furnaces with a very low energy consumption and the replacement of combustibles in SME and institutions: This option intends to introduce thermal solar energy, furnaces with low wood energy consumption in some school institutions and the replacement of wood energy by biogas.

- Introduction of new industrial technologies: This option intends to introduce new technologies for the production of cement by CIMERWA. These consist of the reduction of clinker content and the introduction of chemicals of certain decarbonated materials before cooking.

(iii)Baseline and mitigation scenarios for transport

In 2006, the number of motorized vehicles was of 41052(NISR, 2006) and their annual increase was 10%. For the long period from 2005 to 2030, the latter was estimated at 6%, corresponding to the annual GDP growth. The vehicles in question are categorized in the following categories: motorbikes, saloon cars, trucks and buses. The data was provided by the following users: ATRACO, ACETAMORWA, VOLCANO, and RWANDA-MOTOR.

Table 39: Estimation of fuel consumption per vehicle

Vehicle	Quantity of fuel per day	Total number of days of service
Motorbikes	5l/d	360d
Pick-Up+ Jeeps	10L/d	360d
Minibuses	40L/d	360d
Trucks	60L/d	300d
Bus	60L/d	360d

For the GHG mitigation scenarios, we assume an annual growth of 3% instead of 6% (the case of baseline scenario), as result of quality vehicles importation, emission quota regulation, improvement of public transport and fuel substitution.

These estimations have led to the calculation of energy intensity consumed each year as shown in Table 40 below:

Table 40: Baseline situation, baseline and mitigation scenarios for the transports sub-sector

transport sector Category	% Vehicle			Energy intensity (consumption per year)				Cost		
	2005	2030 (1)	2030 (2)	Unit	2005	2030 (1)	2030 (2)	2005	2030 (1)	2030 (2)
Motorcycles (Petrol)	29,52	29,52	**10**	liter	1.800	1.800	**1080**	3600	3600	2160
Cars (Petrol :90% Diesel: 10%)	57,96	57,96	**75**	liter	3.000	3.000	**1800**	6000	6000	3600
				liter	3.000	3.000	**1800**	6000	6000	3600
Minibus (Petrol: 90%, Diesel: 10%)	8,3	8,3	**5**	liter	14.400	14.400	**8640**	28800	28800	17280
				liter	14.400	14.400	**8640**	28800	28800	17280
Trucks (Diesel)	3,9	3,9	**5**	liter	18.000	18.000	**10800**	36000	36000	21600
Bus (Diesel)	0,2	0,2	**5**	liter	21.600	21.600	**12960**	43200	43200	25920

Source: survey and of experts' judgment

The analysis of the table above shows that the mitigation of GHG emissions proposed in the sector of transport focuses on the following options:

- Regulation of vehicles emissions : this option comprises in itself several measures including:
- Enhance the improvement of technical check up including measuring direct GHG emissions from vehicles.
- The regulation of the quality of imported vehicles taking into account the year of manufacturing, the mileage and other technical characteristics required.
- Promotion of vehicles with the mode of injection compression (diesel engine with direct injection and turbo compressor);
- The promotion of vehicles using natural gas (Lake Kivu methane gas).

- Promotion of public transport: This option includes specific measures concerning the public transport based on buses which save fuel, with big capacity to board many passengers and driven on main roads. The big buses shall be linked to buses with lower capacity driven on secondary roads. The proposed system should be coordinated in order to ensure comfort, punctuality, regularity, representativeness, getting in and off facilities.
- Recourse to other energy sources and the improvement of energy transmission and distribution output: This option targets resorting to other sources of clean energy such as biogas, solar energy, the valorization of municipal solid wastes , the exploitation of Lake Kivu methane gas as well as the improvement of energy transmission and distribution output.

(iv) Baseline and mitigation scenarios for energy transformation

In 2030, for baseline scenarios, national power needs shall be met at 40% through hydroelectricity, 55% through gas thermal power plants (Lake Kivu methane gas), 4% through geothermal electricity generation and 1% through solar energy. The production outputs of electricity are 70% for hydropower and geothermal power generation, 45% for gas and fuel generators. The outputs for the production of charcoal are 11% for the traditional mode and 35% for improved mode.

The proposals of mitigation scenarios for the energy transformation are the following:

- The electricity transmission and distribution output shall be 90%;
- The contribution of the production of electricity is estimated at 50% for hydropower, 20% for lake Kivu methane gas , 4% for solar energy, 25% for geothermal and 1% for biogas and municipal solid wastes[4]

Table 41: Baseline and mitigation scenarios for electricity production

Electricity production	**Contribution (%)**			**Yield (%)**		
	2005	**2030 (1)**	**2030 (2)**	**2005**	**2030(1)**	**2030(2)**
Hydro power	50	40	50	70	70	90
Kivu Methane	0	55	20	45	45	90
Solar	0	1	4	80	80	99
Geothermal	0	4	25	70	70	70
DSM (3)	0	0	1	70	70	70
Diesel	50	0	0	45	45	45
Biogas	0	0	5	0	0	90

Source: MININFRA / RECO-RWASCO; Expert Judgment
(1) Baseline Scenarios (2), Scenarios of mitigation, (3) MSW: Municipal Solid Waste

[4] DSM: Municipal Solid Wastes

Table 42: Baseline and mitigation scenarios for the production of other sources of energy

Production of other energy sources	**Mode**	**Contribution (%)**			**Yield (%)**		
		2005	**2030 (1)**	**2030 (2)**	**2005**	**2030 (1)**	**2030 (2)**
Charcoal Production	Traditional	100	100	0	11	11	11
	Improved	0	0	100	35	35	50
methane production	Purification	100	100	100	80	80	100
biogas production	**Bio digester**	100	100	100	100	100	100
Production of Solar energy	**Heat**	100	100	100	80	80	100

Source: MININFRA / RECO-RWASCO, Experts' Judgment
(1) baseline Scenarios (2) Mitigation Scenarios

The analysis of the table above shows that the mitigation scenarios proposed in the sector of energy transformation are concerned with the following option: Improvement of production output through the use of clean energy. This alternative intends to get rid of thermal power energy generation and replace it by extending hydroelectricity and valorize methane gas as well as the replacement of the traditional production of charcoal by improved furnaces.
The figure 15 below shows the mitigation proposition for generation, transmission and distribution of energy to users according to their demand.

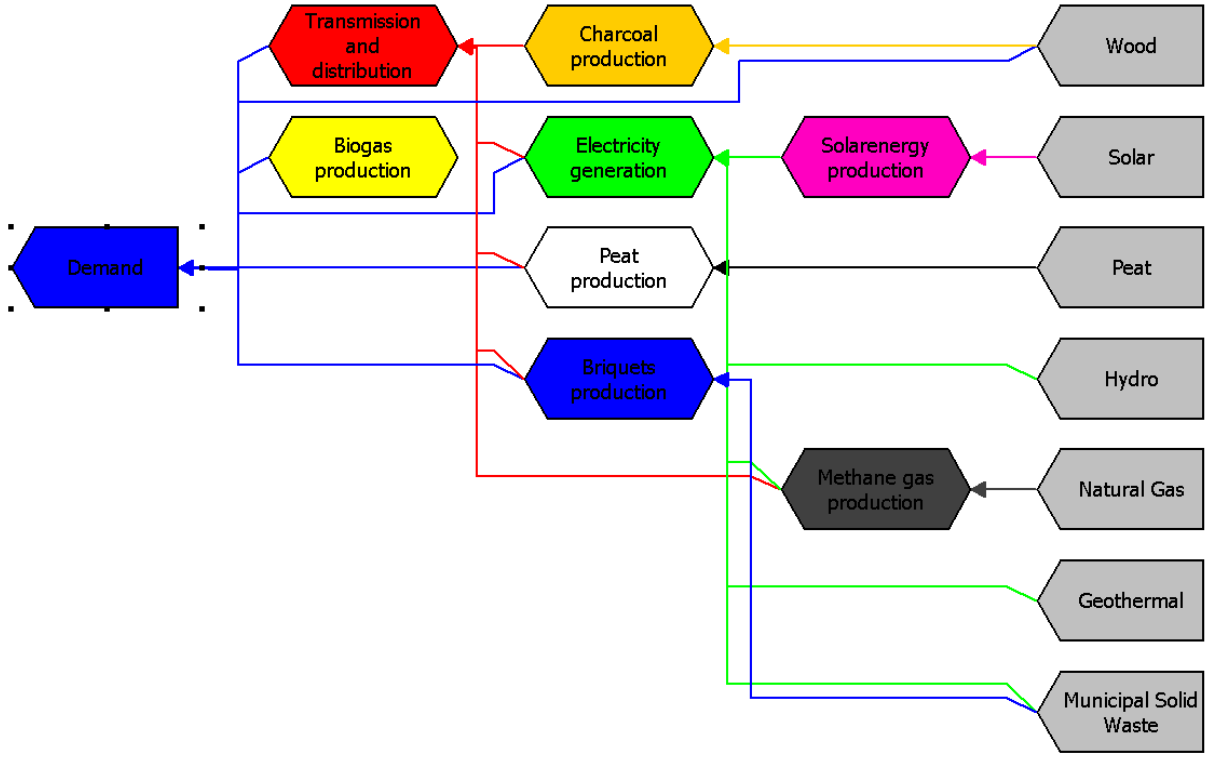


Figure 16: Diagram of production, transmission and distribution of energy according to the demand

3.2.3. Scenarios for agriculture, land use, land use change and forestry

Scenarios corresponding to this point are made taking into account the following parameters:

- Mechanized intensive agriculture;
- Modern animal husbandry in stalls;
- Increase small forest plantations (green parks) in the framework of regrouped habitat services;
- Use marginal lands (steep slopes, rocks) for forest plantations;
- Planting trees in cities along roadsides ,recreational spaces and wood parks
- Increase agricultural marshlands and for fallowing purpose, in the context of self sufficiency in food and market based agriculture.

The GHG mitigation scenarios take into account the demand for timber in the forthcoming 40 years. However, species whose exploitation provides the most important economic interests and with greater chance of carbon trade (Clean Development Mechanism) are preferred.

In 2005, the demand in fuel wood was 7,822,063 tons while the supply was 4,982,063 tons. This wood supply corresponds to an area of 63,560 ha wood trees. This entails that the current demand in wood corresponds to an area of 99,792 ha. Considering the population growth of 3% per year, it is evident that plantations on an area of 325,525 ha would meet the wood demand in 2045. But it is expected that the consumption of fuel wood by households would decrease from 94% to 50% by 2020. We could then predict that 200,000 ha will be sufficient to meet the demand in 2020 and 250,000 ha in 2045.

I order to fill this gap in fuel wood, eucalyptus is proposed. The criteria for selecting Eucalyptus species according to sites in Rwanda were studied by J.NDUWAMUNGU et alii (2007).

Criteria for the selection of appropriate species for indicated sites generally come under three categories: performance in terms of biophysical data (e.g. altitude, rainfall, soil, trimming, resistance against pests and diseases), the objectives of management (e.g. fire wood and timber production, etc...) and impact on the environment (e.g. soil erosion, conservation of biodiversity and water balance). The following Table 43 shows the distribution of lands for GHG mitigation scenario.

Table 43: Lands distribution in '000 ha for mitigation scenarios

MITIGATION SCENARIO	2005	2010	2020	2030	2040	2045
Forest lands						
Natural forest (rain and degraded)	118	118	118	118	118	118
Bamboos	4	14	34	54	74	84
Savannah	4	4	4	4	4	4
Eucalyptus plantation and copices	103	133	193	253	313	343
Pinus plantation	12	12	12	12	12	12
Recreation zones, parks and urban trees	86	86.125	86.375	86.625	86.875	87
Other forest plantations (Grevillea, Cedrela,etc.	0.5	20.5	60.5	100.5	140.5	160.5
Sub total forest land	**327**	**388**	**508**	**628**	**749**	**809**
Agricultural land						
Cultivated Marshlands	148	154	167	180	193	200
Fallow Marshlands	17	18	22	25	28	30
Cultivated arid areas	1370	1313	1199	1085	971	914
Permanent pastures	470	448.75	406.25	363.75	321.25	300
Agroforestery	200	262.5	387.5	512.5	637.5	700
Sub total Agricultural lands	**2,204**	**2,197**	**2,181**	**2,166**	**2,151**	**2,143**
Others						
Natural Marshlands	114	106	90	74	57	49
Lakes	149	149	149	149	149	149
Others lands	39	57	93	129	166	184
TOTAL	**2634**	**2634.1**	**2634.1**	**2634.1**	**2634.12**	**2634**

Source: REMA: State of Environment Rwanda, MINECOFIN: Vision 2020; REMA: Inventory of Marsh, 2009; Expert Judgment

The analysis of the table above shows that the mitigation of GHG emissions proposed in the sector of agriculture, land use, land use change and forestry focuses on the following options:

- Restoration and protection of natural forests. In 2005, the sequestration of CO2 by forests was 9 000Gg. The restoration and protection of forests shall contribute to the increase and stabilization of the sequestration of CO2;
- The intensification of agroforestry. Agroforestry species proposed are as follows:

✓ For high altitudes: Alnus acuminate, croton macrostackys;

✓ For medium and low altitudes : Caliandra colothyrsus, leuceana diversifolia, leuceana pollida, Leuceana diricandra, Gliricidia Sepium, Senna Spectabilis; plastic species such as Sesbania Sesban, Tephrosia Vogelii and Moringa loeifera,. The choice of the species depends on both its economic importance and its carbon trade.

✓ Bamboo plantations in humid protected areas. The bamboo offers especially economic advantages, particularly in making wood charcoal, furniture, fences, construction of houses, water collection.

- Plantations of eucalyptus on mountains which cannot be used for cultivation. To fill the gap in fire wood demand, there should be 200 000ha of eucalyptus in 2020 and 250 000 ha in 2045.
- Plantation of Grevillea robusta, cedrela Serata and other species which can provide timber.

3.2.4 Justification of selected mitigation options

Table 44 below gives the options selected to reduce GHG emissions, their justifications and their impacts.

Table 44: Justification of selected mitigation options of GHG

Options	Justification	Impacts/Evaluation
1. The use of other alternative energy for households	For domestic cooking in cities, the proposed measures are about the increase of gas users from 0,2% to 50% and the increase in number of electricity users from 0,25 % to 20% for 100% the urban population without electricity. For rural households, the increase in biogas users from 5% to 70% (rural households with electricity) and from 0.5% to 60% (rural households without electricity) provided 40% of the rural population ends up by having access to electricity. This option will be facilitated by an efficient exploitation and a high awareness of the value of methane gas from Lake Kivu and the reduction electricity cost. As regards heating needs in urban and rural areas , the use solar water heaters will be supported and thereafter extended since the country has sufficient solar potentials	This option may allow the reduction of firewood (city) from 94.6% to 35%
2. Replacement incandescent bulbs with low- energy consumption bulbs	One project relating to this option is being implemented. The initiators of this project are RECO-RWASCO; other partners include World Bank and Ministry of Infrastructures.	This option enables to save power energy which can be used for other purposes requiring other energy sources emitting greenhouse gases such as firewood
3. Promotion of the use of biogas	The policy of promoting biogas is being implemented. However, to attain the proposed number (60% of the rural household without electricity and 70 % with electricity), more efforts should be made including the improvement of biogas technology, the creation and construction of biogas digesters maintenance companies	Population will be able to use biogas for cooking and lighting purposes instead of using wood, charcoal, kerosene and diesel.

Options	Justification	Impacts/Evaluation
4. The introduction of improved stoves and furnaces on a large scale	This option aims at securing improved furnaces at an affordable price, which could reduce the quantity of firewood from 75% to 50% of the quantity currently for cooking. 30% of urban population without electricity, 25% of rural households with electricity and 40% of rural households without electricity are all targeted by this program.	In addition to reducing greenhouse gases, this option will help in reducing the number of trees to be cut and to guarantee the wood and firewood for other purposes
5. The replacement of fuel in industries	This option is intended to substitute the fuel used by BRALIRWA, CIMERWA and Utexrwa for the lake Kivu methane gas. The transformation unit of fuel with gas methane is: 1 liter of fuel = 1.25 Nm3 (N m3 is 0 ° C and 1013 hPa)	This option is economically viable with an efficient operation and enhancement in value of gas methane from Lake Kivu, which emits less greenhouse gases compared to fuel
6. The introduction of low energy-consumption furnaces and substitution for fuels for SME and institutions	This option aims at introducing furnaces with low firewood- consumption furnishes in certain schools institutions and the substitution of firewood for biogas in others institutions, as well as thermal solar energy for firewood for heating in needs .	By 2030, ¼ of wood energy will be replaced by biogas and ½ of wood energy will be reduced to half though the use of low consumption energy furnishes in school institutions Wood energy used in tea factories will be reduced to ¼ by new technologies for heat recovery.
7. The introduction of new industrial technologies	This option aims at introducing new technologies of cement manufacturing by CIMERWA. These technologies consist in : (I) Reducing the clinker content; (Ii) The introduction of chemicals before cooking certain decarbonated materials	This option may be accompanied by additional costs which may affect the cement price on the market. A prior study with the help of carbon credits is required to determine the viability of this option
8. The regulation of emissions	This option includes a large number of measures including : - The reinforcement and the improvement of the technical automobile control including the evaluation of GHG emitted by vehicles - Quality regulation of imported vehicles with due consideration to the manufacture year, mileage and other technical requirements; -Fostering the use of vehicles with compression injection system (diesel engines with direct injection and turbo compressor) - The promotion of vehicles using natural gas (methane from Lake Kivu) This option includes specific measures for the public transport network based on fuel- economy buses, high capacity passenger transport and operating on main roads. These big buses are connected to low-capacity buses driving on small roads.	The implementation of a large number of these measures, especially the first six ones, can contribute to the reduction of 20% to 30% of GHG emissions. The combination of fuel storage measurement with that of "depollution" technology may also contribute to improving air quality in cities. This system will be facilitated with infrastructure projects in "Kigali Master Plan". A similar transport

9. The promotion of public transport by vehicles	This measure aims at developing a system of public transportation in Kigali city, also linking therefore transportation between the city and districts in the countryside. The proposed system should be coordinated to ensure the comfort, punctuality, regularity, representativeness and ease of boarding and arrivals.	system exists in Colombia (Bogota) under the name "TransMilenio CDM " in collaboration Holland and Switzerland Together with the option of regulating vehicle emissions as proposed above, this option will significantly influence the population on preferring public transportation or only use private vehicles in emergency cases. With few exceptions, both options can contribute to the reduction of 40% to 60% of GHG emissions compared to baseline scenarios. We apply the low value (40%) for our GHG mitigation scenario.
10. The use of other energy sources and the improvement of transport and energy distribution	This option is about the use of other suitable energy sources such as biogas, solar, municipal solid waste recovery, the exploitation of methane gas from Lake Kivu as well as improving the efficiency of transportation and distribution of energy.	board supply will help save the forests, reduce dependence on petroleum products
11. Improvement of production efficiency through the use of proper energy	This option aims to suppress the production of energy by thermal power and replace it by hydropower and the use of methane gas, replacing the traditional production of charcoal by better furnaces, General improvement of energy production.	This option will help in saving forests and can also reduce energy costs by reducing the loss during the production of energy the cost of energy
12. Restoration and protection of natural forests	The restoration of natural forests targets national parks of Birunga and Nyungwe as well as natural forest of Gishwati. Such protections concerns also Akagera National Park	In 2005, the CO_2 sequestration by forests of 9,000 Gg. Restoration and protection of forests is contributing to the increase and stabilization of CO_2 sequestration

13. Intensification of agro forestry	Agroforestry species proposed are: (I) for high altitudes: Alnus acuminata, croton macrostackys; (Ii) for medium and low altitude: Calliandra Colothyrsus, Leuceana diversifolia, Leuceana Pollida, Leuceana diricandra, Gliricidia sepium, Senna spectabilis; (Iii) The plastic species such as Sesbania sesban, Tephrosia vogelii and Moringa oleifera. The choice of species depends on both its economic importance and carbon trading.	Agro forestry species are always combined with crops on tropical soils that are often overexploited and degraded. .
14. The plantation of bamboo on protected humid zones	Bamboo essentially offers economic benefits, particularly in making charcoal, furniture, fencing, house construction, water harvesting, handicrafts and especially in the production of matches, baskets, toothpicks, and various other handicrafts and horticulture industry. Bamboo is used by more than half the world's population for purposes as diverse as food, fuel and clothing.	Bamboo grows faster and therefore effective for the restoring vegetation cover of degraded lands. In addition, it releases 35% more oxygen than equivalenttimber stands. On absorption of greenhouse gases, a hectare of bamboo has the ability to absorb 12 tons of carbon dioxide from the atmosphere.
15. The plantation of eucalyptus trees on the arable mountains	To meet the demand for wood energy would require 200,000 hectares of eucalyptus in 2020 and 250,000 ha in 2045.	The selection of Eucalyptus species by sites in Rwanda has been studied in the scientific paper entitled: Eucalyptus in Rwanda: The Blame Are True or false? According to this article, species
16. The plantation of Grevillea robusta, Cedrela Serata and other species	Timber production	CO2 sequestration

3.3. Analysis of Results from GHG Emissions Options

3.3.1 Assessment and analysis of energy variation and related GHG emissions

The assessment and analysis in the tables 45, 46 and 47 below, focuses on the energy variation (in millions of gigajoules) and the variation of related greenhouse gas emissions (in CO_2 equivalents). This energy variation from 2005 to 2030 is linked to the baseline and mitigation of GHG emissions scenarios for the branch of energy demand and its sub branches (households, industry and transportation) as well as for energy transformation.

Table 45: Baseline and mitigation scenarios of energy demand in various domains

Scenario: Baseline and Mitigation Scenarios, Fuel: All Fuels								
Branch: Demand								
Units: Million Gigajoules								
Sub-Branch	**Scenarios**	**2005**	**2010**	**2015**	**2020**	**2025**	**2030**	**Total**
Households	Baseline	87	92.1	95.5	96.9	95.5	90.7	**558**
	Mitigation	87	84.9	79.4	71.3	62.6	56.3	**442**
Industry	Baseline	11.2	13.6	16.1	18.5	21	23.4	**104**
	Mitigation	11.2	13.7	16.2	18.8	21.3	23.8	**105**
Transport	Baseline	5.9	7.9	10.6	14.2	19	25.4	**83**
	Mitigation	5.9	6.6	7.3	7.9	8.6	9.1	**45.4**
Total	**Baseline**	104	114	122	130	136	140	**745**
	Mitigation	**104**	**105**	**103**	**98.1**	**92.5**	**89.2**	**592**

Figure 17: Energy demand

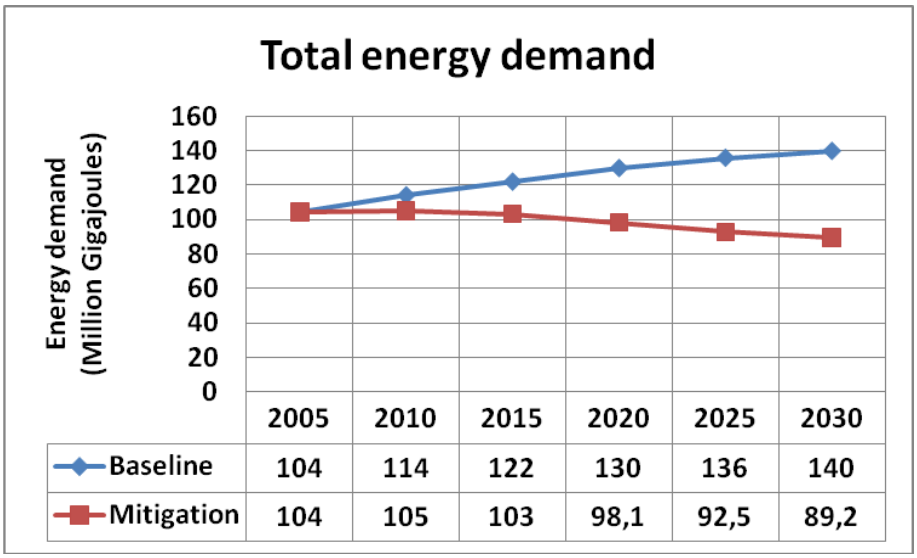


Figure 17a: Total Energy Demand

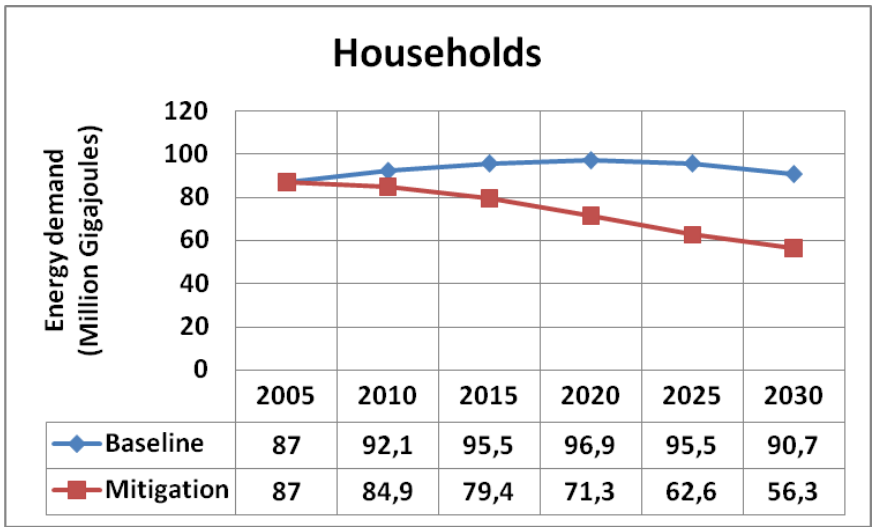


Figure 17b: Energy Demand for Household

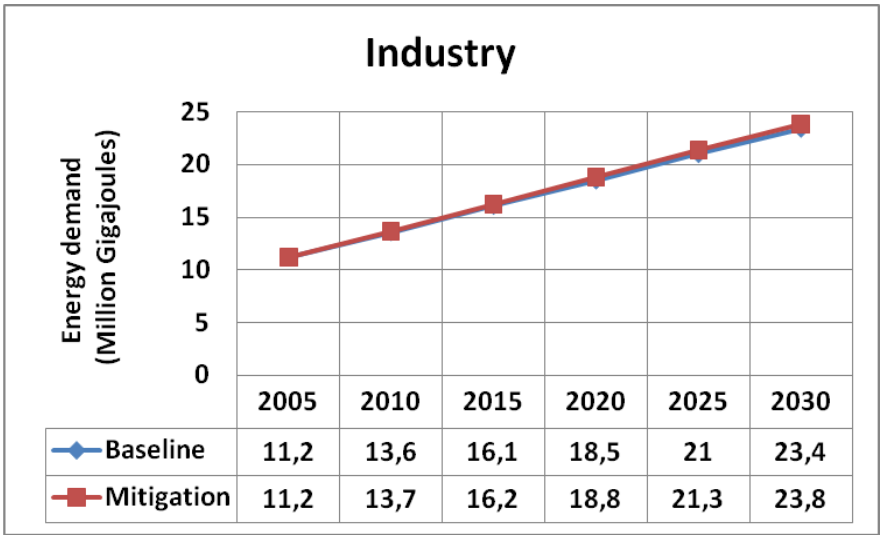


Figure 17c: Energy Demand for Industry

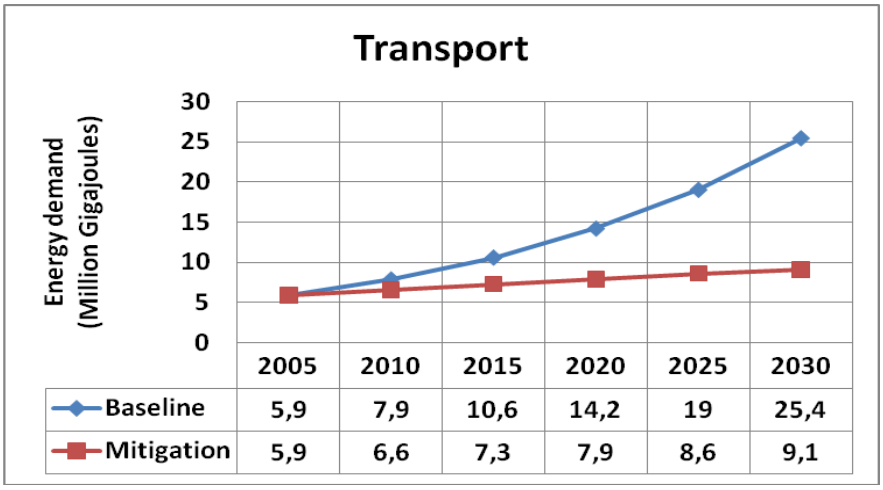


Figure 17d: Total Energy Demand for Transportation

Table 46**:** Emissions from energy demand (baseline and mitigation data)

Environment: Global Warming Potential (CO2e)								
Scenario: Baseline and Mitigation Scenario, Fuel: All Fuels, GHG: All GHGs								
Branch: Demand								
Units: Million Kilograms (Gg)								
Sub-Branch	**Scenarios**	**2005**	**2010**	**2015**	**2020**	**2025**	**2030**	**Total**
Households	Baseline	1528.1	1580	1598.1	1573	1494	1349.3	**9122**
	Mitigation	1528	1403	1220	995.4	757.7	556.1	**6460**
Industry	Baseline	76.5	93.2	109.9	126.6	143.4	160.1	**710**
	Mitigation	76.5	92.5	108.5	124.5	140.5	156.5	**699**

Transport	Baseline	429.3	574.6	768.9	1028.9	1376.9	1842.7	**6021**
	Mitigation	429.3	479	529.2	578.5	624.3	663.3	**3304**
Total	**Baseline**	2033.9	2247.7	2476.9	2728.6	3014.4	3352.1	**15853**
	Mitigation	2034	1974	1858	1698	1522	1376	**10463**

Figure 18: Emissions from energy demand (baseline and mitigation data)

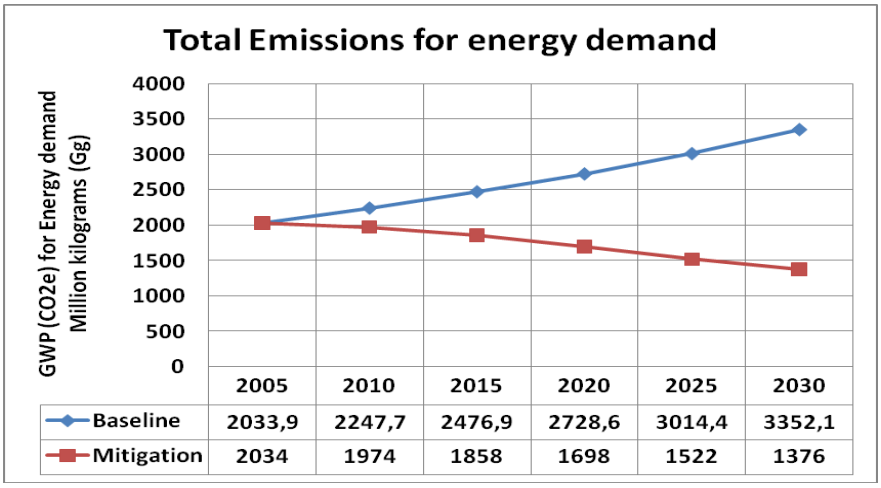


Figure18a: Total emissions from energy demand

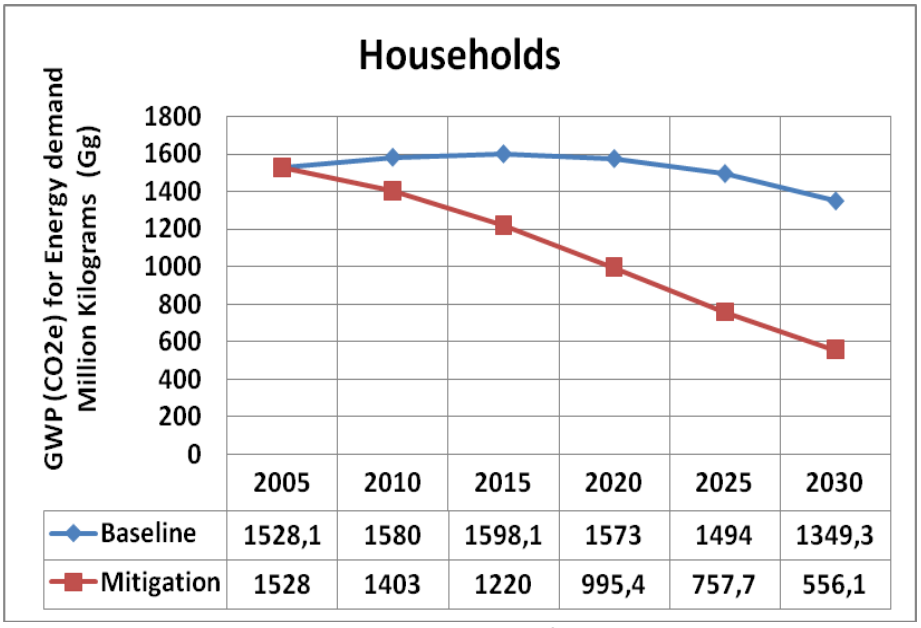


Figure18b: Emissions from energy demand /household

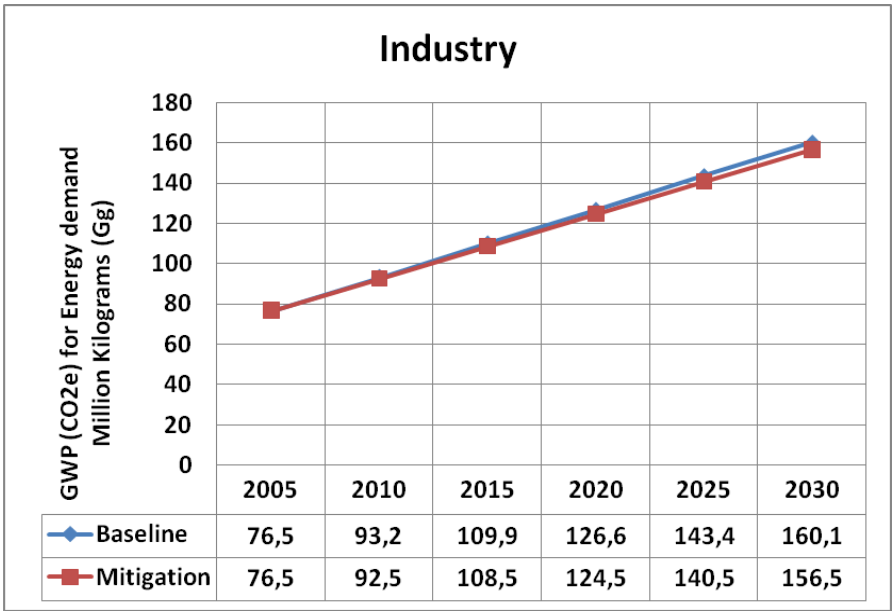


Figure18c: Emissions from energy demand /Industry

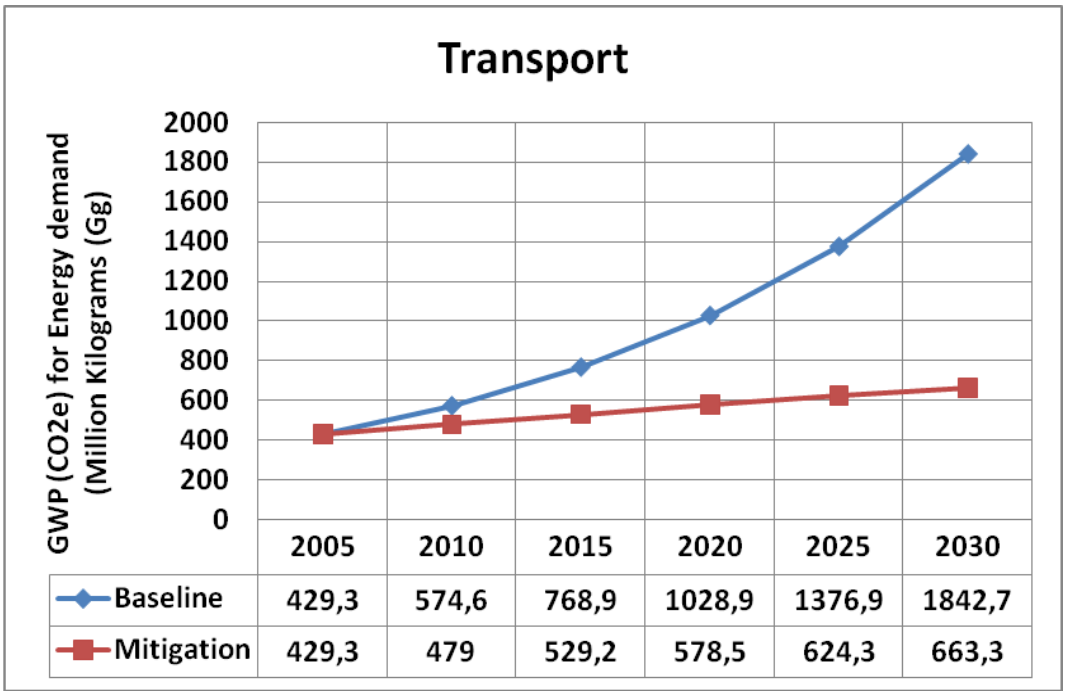


Figure18d: Emissions from energy demand /Transport

Table 47: Emissions from energy transformation (Results provided by LEAP software)

Environment: Global Warming Potential (CO_2e)								
Scenario: Baseline and Mitigation Scenario, Fuel: All Fuels, GHG: All GHGs								
Branch: Transformation								
Units: Million Kilograms (Gg)								
Sub-Branch	**Scenarios**	**2005**	**2010**	**2015**	**2020**	**2025**	**2030**	**Total**
Electricity generation	Baseline	18.2	58.7	113.1	182.6	266.3	360.5	**999.4**
	Mitigation	18.2	106.8	205.3	293.8	332.9	252.8	**6460**
Charcoal production	Baseline	527.8	860.8	1172.6	1439.6	1631.2	1709.4	**7342**
	Mitigation	527.8	897.9	939.4	746.3	444.2	166.7	**3722**
Methane gas production	Baseline	0	7	30	81.9	182.3	360.5	**661.7**
	Mitigation	0	26.7	65.6	125.1	218	362.6	**798**
Total	**Baseline**	**546**	**927**	**1316**	**1704**	**2080**	**2431**	**9003**
	Mitigation	**546**	**1031**	**1210**	**1165**	**995**	**782**	**5730**

Figure 19: Emissions from energy transformation

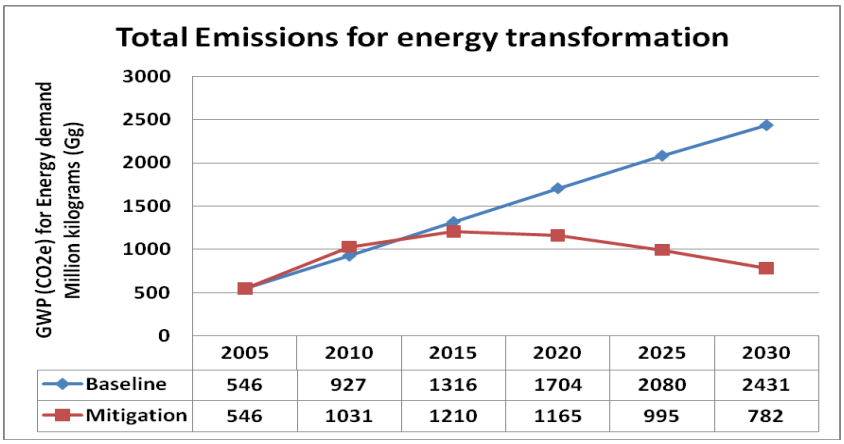


Figure 19a: Total emissions coming from energy transformation

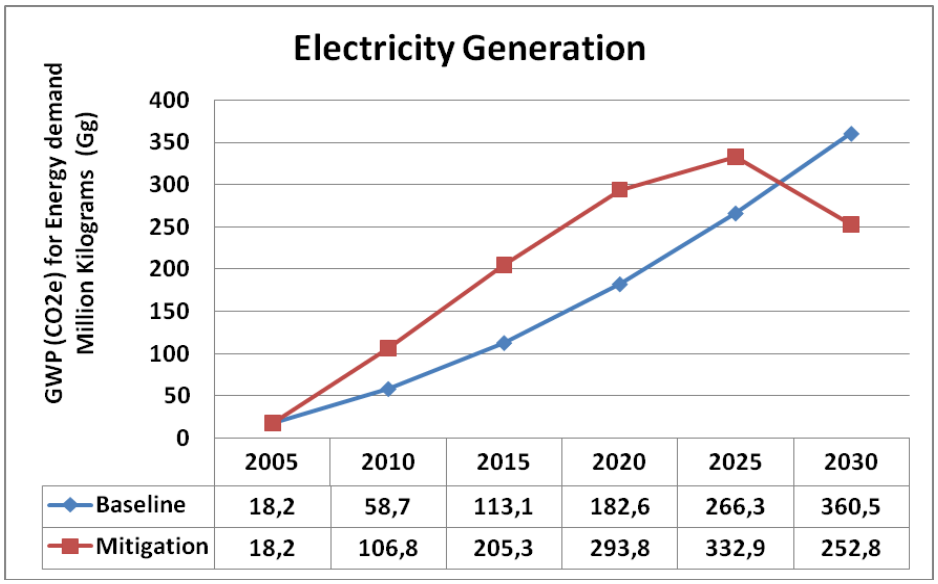


Figure 19b: Emissions from electricity generation

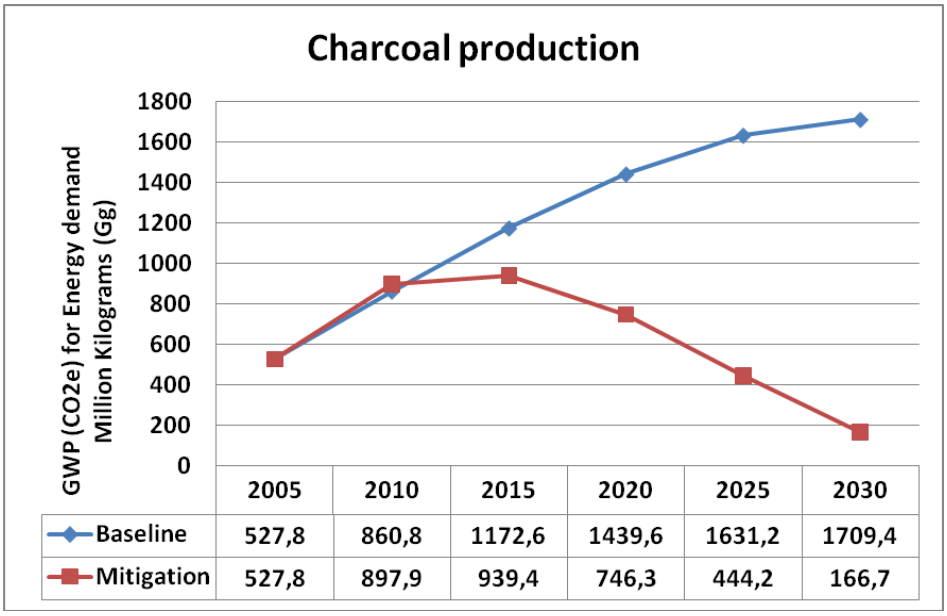


Figure 19c: Emissions coming from charcoal production

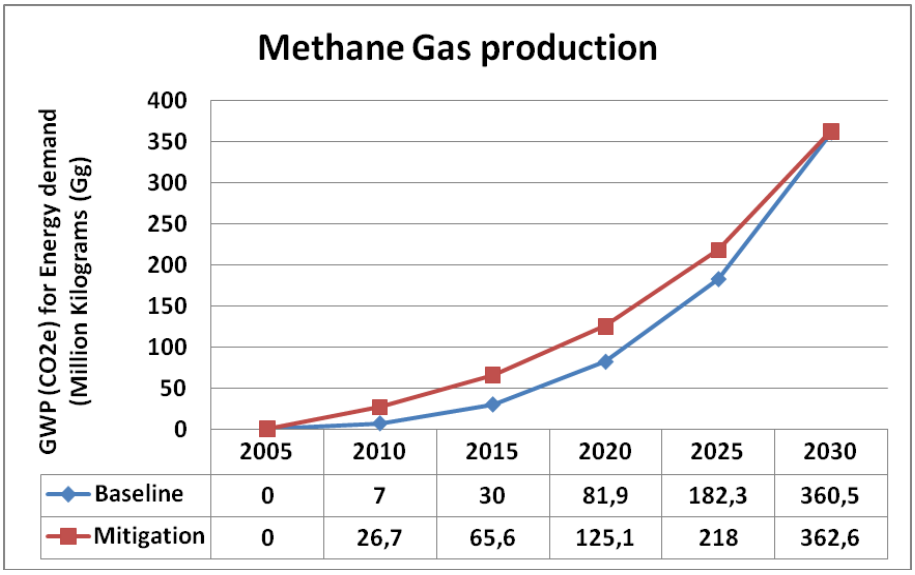


Figure 19d: Emissions coming from methane gas production

3.3.4. Reduced emissions

With regard to reduced emissions, it is important to distinguish the emissions linked to the use of the energy, the reduction effect of these emissions on environment as well as those linked to agriculture in terms of land use, land use change and forestry

(i) Emissions linked to the use of energy

The following table indicates emissions in CO_2 equivalent reduced by the mitigation of GHG emissions options linked to the total use of energy (demand and energy transformation). An important reduction in the use fuel wood and charcoal shall lead to a clear decline of aggregated totals of emissions of GHG from 2015. By 2030, the proposed mitigation options will contribute to the total reduction of the GHG emissions of 1569Gg of CO_2 equivalent in 2020 and 3625Gg of CO2 equivalent in 2030. The total reduction of the GHG emissions for the period 2005-2030 is of 8.663Gg of CO_2 equivalent i.e. 8.663.000 tons of CO_2 equivalents.

Table 48: Total emissions reduced

Environment: Global Warming Potential (CO2e)
Fuel-oil: All Fuel-oils, GHG,: All GHGs
Branch: Rwanda_Mitigation_Final_May_2010
Units: Million Kilograms (Gg)

	2005	2010	2015	2020	2025	2030	Total
Baseline Scenario	2579.9	3174.2	3792.7	4432.6	5094.1	5782.5	**24856**
Mitigation Scenario	2579.9	3005.7	3068.1	2863.5	2517.5	2158	**16193**
Reduced emissions	**0**	**168.5**	**724.6**	**1569**	**2577**	**3625**	**8663**

Source : LEAP Analysis

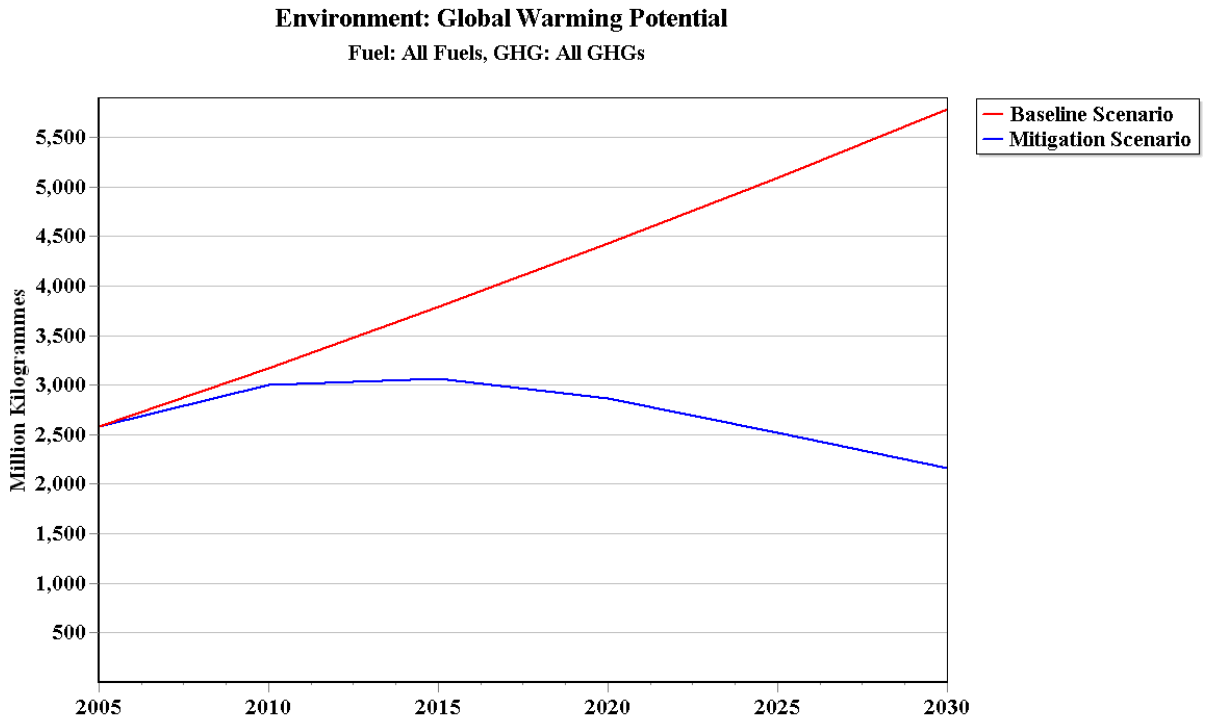


Figure 20: Evolution of the total reduced emissions

Table 49 and figure 21 below indicate the effect of the proposed options (in relation to energy) on the environment considering the reduction of all gas emissions. In fact, if the emissions in 2005, considered as the baseline year, are subject to the index of value 1, the emissions of sulfur dioxide, PM10 particles, dioxide of non biogenic carbon and nitrogen oxide could increase 4.3 times, 4.1 times, 4 times, and 3.6 times respectively by 2030 if Rwanda opts for baseline scenarios or 'Business as usual scenarios' containing the Government programs and plans.

On the other hand, if Rwanda prefers to opt for mitigation measures proposed here, the same gases could increase in 2030, 1.1 times, 1.1 times, 1.8 times, and 1.7 times in comparison to 2005.

It should be noted that among GHG emissions, the carbon dioxide (CO_2), methane (CH4) and the nitrogen hemioxide (N_2O) are direct gases for which we calculate the aggregated emissions of CO_2equivalent through their values of world global warming of the planet.

Table 49: Effect of the proposed options on the environment
Environment: All Effects
Year: 2030, Fuel: All Fuels
Branch: Demand
Units: Indexed Values (2005: Base Year = 1)

	Baseline Scenario	**Mitigation Scenario**
Biogenic Dioxide Carbon	1.1	0.6
Non Biogenic Carbon Dioxide	4	1.8
Carbon Monoxide	1.4	0.5
Methane	0.8	0.3
Nitrogen Oxides NOx	3.6	1.7
Nitrous Oxide	1	0.4
Non Methane Volatile Organic Compounds	1.6	0.4
Particulates PM10	4.1	1.1
Sulfur Dioxide	4.3	1.1
Total Suspended Particulates	0.9	0.3

Source: LEAP analysis

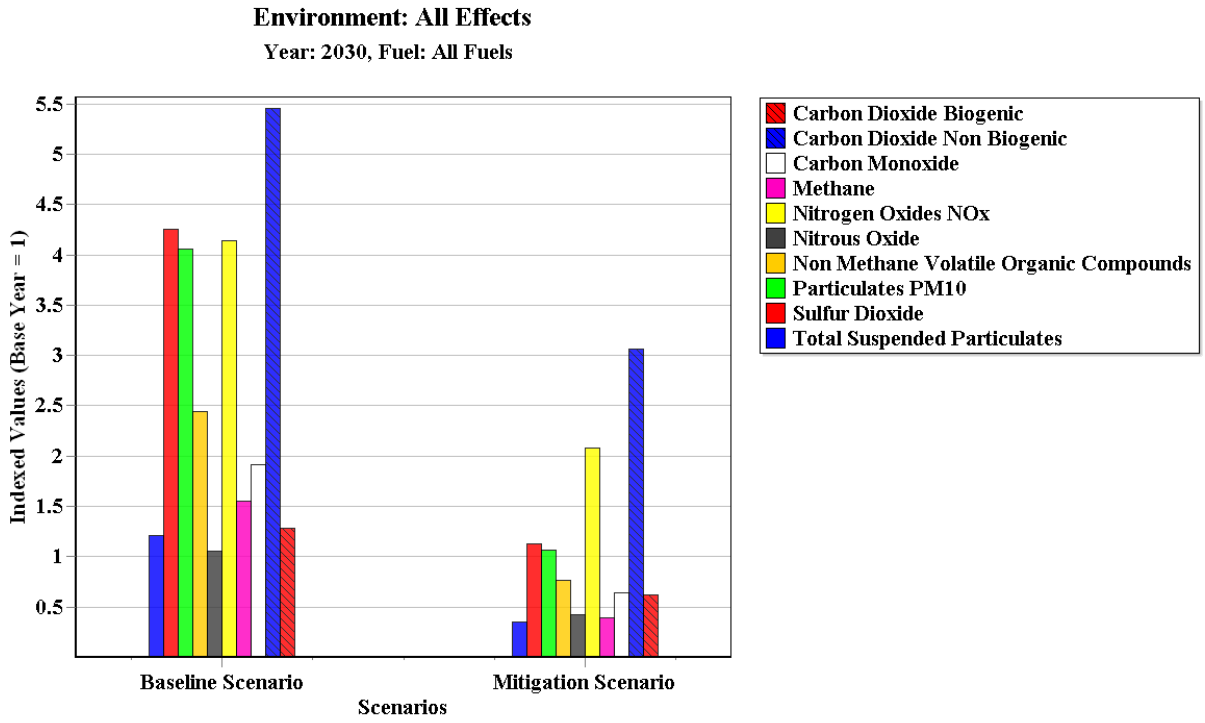


Figure 21: Effect of proposed options on environment

(iii)Emissions linked to agriculture, land use, land use change and forestry

Basing on the proposed mitigation options, Table 50 below indicates that by the end of 2030, the reduced total quantity in tons of CO2 equivalent (sequestrated by forests) will be 18,862,500 tCO2e. The values of the sequestrated emissions per hectare and per year (tCO2e/ha/year) have been adopted according to the GHG emissions inventory report (MINITERE, 2005 and the document found on the web site: http://www.bamboocentral.org/shareinrepair/faq.htm)

Table 50: The total quantity of CO_2 reduced by GHG mitigation related to agriculture, land use, land use change and forestry

	Base year (2005) area (ha)	Sequestrated emission per ha and per year tCO_2e/ha/year	Planted Area (ha) 2005-2020	Total 2005-2020 Sequestered emission (tCO_2e)	2020-2030 Planted Area (ha)	Total 2020-2030 Sequestered emission (tCO_2e)	Total 2005-2030 Sequestered emission (tCO_2e)
MITIGATION SCENARIO							
Bamboos	4000	60	30000	1800000	20000	1200000	3000000
Eucalyptus plantation and coppices	103000	37	90000	3330000	60000	2220000	5550000
Other forest plantations (Grevillea, Cedrela, etc...)	500	25	60000	1500000	40000	1000000	2500000
Agroforestery	200000	25	187500	4687500	125000	3125000	7812500
Total 2005-2030 sequestered emissions in CO_2 equivalent							**18.862.500**

Source: Comap software results

CHAPTER IV: VULNERABILITY AND ADAPTATION TO CLIMATE CHANGES



The geographical location of Rwanda, its relief, population density as well as its socio-economic indicators -, make this country vulnerable to natural and anthropogenic risks.

In Rwanda, observed climate change is linked to the general circulation of winds and the variation of temperatures in the region of Central Africa where Rwanda is located. During the past 30 years, Rwanda has experienced climate change in terms of frequency, intensity and persistence of extreme changes such as heavy rain-falls, heat waves, drought and climate events such as El Nino and La Nina. The frequency of rainfalls deficits reached 16%. The occurrence of rainfall deficits and excess has significantly increased in recent years.

Climate changes during this same period have had an impact on the environment, economy and human lives.

4.1. Scenarios of climate change in Rwanda

4.1.1. Projection of climate changes in Rwanda

The Fourth Assessment Report of Intergovernmental Panel on Climate Changes (IPCC AR4) has found that the observed changes in average surface temperature in Africa are an increase between 0.2 and 2.0 °C within the period 1970 - 2004. According to the same estimation, the annual temperatures in Rwanda may be 1.0° C to 2.0° C higher.

Climate projections for Rwanda were done for the period of 2010 -2100 using the period 1971-2007 as the baseline. These projections are based on the outputs of Global Circulation Models (GCM). The nearest GCM output coordinates for Rwanda are found in two grid boxes. The first one is between 0 ° and 5 ° south latitudes and between 25 ° and 30 ° east longitude, while the second one is between 0 ° and 5 ° South latitude and between 30 ° and 35 ° East longitude. Rwandan data appears to be unique in the sense that average data from different stations do not represent the real climatology of the country, due to a net variation in relief altitudes between different stations.

The MAGICC Model (Model for the Assessment of Greenhouse-gas induced climate change) was used to work out climate estimates for Rwanda in relation to the data from 1971 to 2007. Where the data were not available (1990 to 2007), data were generated from statistical correlation analysis method between Kigali Airport station and other climatological stations, selected for this purpose.

4.1.2 Methodologies for Developing Climate Scenarios

In order to develop scenarios for climate change, the following steps were followed in the selection of the three GCMs most suitable to Rwandan conditions:

Calculate the average temperatures of the country from monthly average temperatures observed at all the meteorological stations.

- Consider that one output obtained from 1 * CO_2 equals one concentration of GHG emissions from all the 17 GCMs;
- Compare the regional output 1* CO_2 with climate data observed through the use of statistical correlation analysis; and
- Select the three GCMs models that best reflect the current climate.

Baseline Scenarios

Table 50 shows data on various meteorological elements from the data bank archives of Rwanda meteorological Service. According to this data, the annual average temperature of Rwanda is about 18°C, the maximum temperature being around 25°C and the minimum being about 13°C.

There are two rainy seasons, March-May (MAM) and September-December (SOND) with an annual average rainfall of about 1,295 mm. The highest monthly average rainfall observed in April is about 157mm.

Climate change scenarios

From 17 GCMs models, the three GCMs most suitable for Rwanda are illustrated in table 51. Thus PCM_ 00, IAP_97 and LMD_98 were found to best represent the meteorological data projections from 2010 to 2100.i.e the average temperature, maximum temperature, average rainfall, and average evapotranspiration. Projections made for temperatures show that all three models predict an average increase in minimum, average and maximum temperatures towards the years 2020-2100. The increase in the annual maximum temperatures reaches 3.3 °C.

For rainfalls, projections made show that two GCMs, IAP_97 and LMD_98, respect the variability of 2 wet seasons during March-April-May months and September-October-November, but with a rising change which reaches 50 mm in April and December for LMD_98 and IAP_97 models. Concerning the projections made for the average potential evapotranspiration, it rises during the dry seasons in December-January and June-August, while it rises sharply from June to August for PCM_00 model scenarios, which does not correspond to the real climate conditions of Rwanda. Therefore, the outputs of IAP_97 and LMD_98 models show that the annual potential evapotranspiration is likely to increase every year. For IAP_97, it is predicted that it will reach 1351 mm by 2020, 1432 mm by 2050 and 1682 by 2100.

Table 51: Baseline Scenario

Baseline scenario	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEPT	OCT	NOV	DEC	ANNUAL
AVERAGE TEMPERATURE (oC)													
1971 - 2007	18.9	19.1	19.2	19.0	18.7	18.0	17.7	17.8	17.8	18.1	18.4	18.8	18.4
MINIMUM TEMPERATURE(oC)													
1971 - 2007	12.6	12.9	13.4	13.7	13.6	12.6	12.4	12.8	12.5	12.7	12.8	12.7	12.9
MAXIMUM TEMPERATURE(oC)													
1971 - 2007	25.5	25.7	25.5	24.8	24.2	23.8	23.5	23.4	23.6	23.9	24.4	25.3	24.5
RAINFALL													
1971 - 2007 (MM)	68.76	75.00	120.07	157.19	132.17	78.57	77.68	116.59	125.77	133.96	126.37	82.53	1294.7
NCAR RAINFALL (MM/DAY)	*0.39*	*0.43*	*0.41*	*0.38*	*1.44*	*3.69*	*6.88*	*9.93*	*6.6*	*3.37*	*1.34*	*0.55*	3.0
SOLAR RADIATION(W/M-2)													
1971 - 2007	4.35	3.96	3.75	3.75	3.78	5.04	5.05	4.34	4.12	3.91	3.80	3.48	4.1
RELATIVE HUMIDITY(%)													
1971 - 2007	73	78	80	80	80	70	60	62	69	75	78	80	73.8
WINDS (m/s)													
1971 - 2000	2.09	2.01	2.04	1.84	1.99	2.13	2.41	2.67	2.52	2.51	2.23	2.13	2.2
POTENTIAL EVAPOTRANSPIRATION ON GRASS(ETP in mm)													
1971 - 2000	109.16	106.40	107.51	105.85	101.98	119.94	129.06	124.92	121.32	112.48	106.68	96.17	1341.5

Table 52: Comparison of model performance

Table 51: COMPARISON OF MODEL PERFORMANCE

MODELS	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEPT	OCT	NOV	DEC	Correlation	
1971-2007	18.9	19.1	19.2	19.0	18.7	18.0	17.7	17.8	17.8	18.1	18.4	18.8		
BRCM98	23.1	23.2	22.9	23.4	26.8	28.7	28.0	28.9	29.1	27.4	23.9	22.6	-0.91	
CCC199	19.9	20.2	21.1	21.2	20.0	18.4	18.5	20.2	22.0	22.1	20.9	20.2	0.16	
CCSR96	25.4	25.2	25.2	23.8	24.4	25.5	25.0	27.2	29.5	31.4	26.5	26.0	-0.54	
CERF98	21.7	21.7	21.8	21.8	21.6	21.9	24.2	25.5	26.0	24.1	22.3	21.8	-0.80	
CSI296	20.9	21.3	21.6	21.5	21.0	19.8	19.6	20.4	21.7	21.9	21.4	21.0	0.44	
CSM_98	20.6	21.9	22.2	21.7	21.1	20.4	20.6	21.4	21.5	21.4	21.0	20.5	0.41	
ECH395	22.1	23.6	23.4	23.2	25.5	28.1	27.9	28.6	29.5	25.5	22.5	22.2	-0.85	
ECH498	22.3	23.2	23.5	23.0	23.8	24.7	25.7	26.6	26.2	24.0	22.7	22.0	0.26	
GFDL90	21.0	22.5	21.5	19.7	17.3	16.4	19.1	20.0	22.0	21.7	20.6	20.0	0.26	
GISS95	22.8	23.4	24.4	24.5	24.0	24.0	25.4	25.9	25.6	24.8	23.8	23.1	-0.68	
HAD295	21.5	22.0	22.5	23.1	23.5	23.3	22.8	22.7	22.7	22.6	22.3	21.8	-0.35	
HAD300	22.7	23.8	24.1	23.7	23.5	23.4	22.8	23.0	23.7	23.9	23.2	22.8	0.28	
IAP_97	22.5	24.1	24.8	23.1	21.0	19.7	19.9	21.7	23.1	24.2	23.5	22.6	0.55	2
LMD_98	25.3	25.7	24.8	23.3	22.3	21.9	22.9	24.3	23.3	21.7	21.2	22.7	0.48	3
MRI_95	24.0	24.7	25.4	24.5	23.2	23.7	25.3	25.9	25.6	25.8	25.3	24.1	-0.37	
PCM_00	21.2	22.0	22.1	21.2	20.0	20.0	19.8	20.5	21.1	21.1	20.7	20.8	0.67	1
WM_95	26.5	27.6	27.9	26.8	25.5	25.4	26.9	27.8	28.8	29.4	27.2	25.9	-0.21	

For the projected minimum temperature (table 53 and figure 22), the three GCMs show the same increasing trend every year and the annual change related to the historical mean varies from 0.44 to 0.6 for 2020, 1.2 to 1.9 for 2050, and 2.3 to 3.3 for 2100.

Table 53: Min t°C change projections

Min t °C change projections	2020	2050	2100
PCM_00	0.44	1.2	2.5
IAP_97	0.5	1.3	2.3
LMD_98	0.6	1.9	3.3

Figure 22: Temperature projections

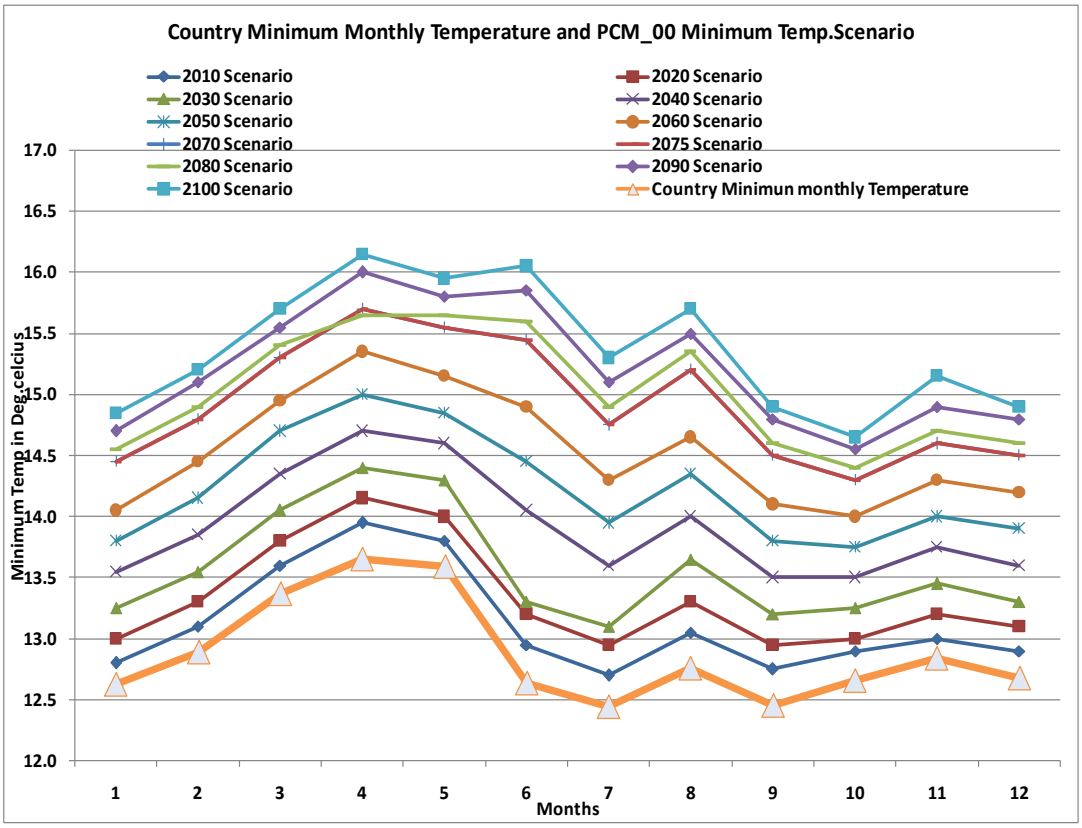


Figure 22a: PCM_00 projected min. temperature

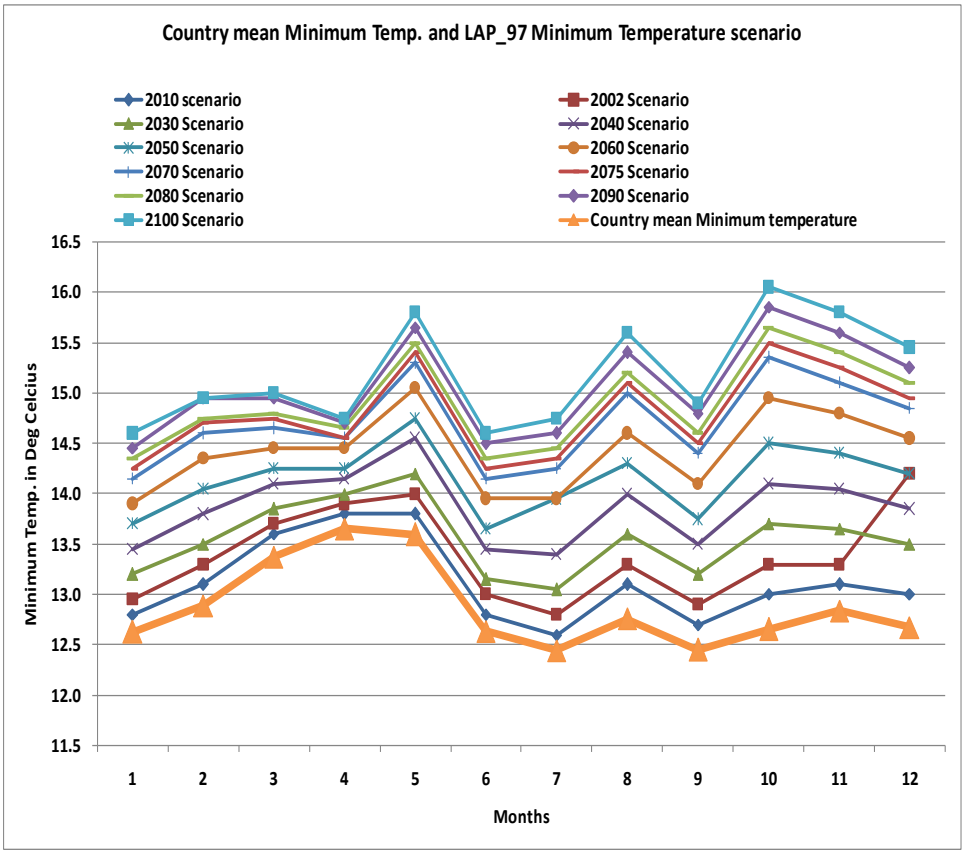


Figure 22b: IAP_97 projected min. temperature

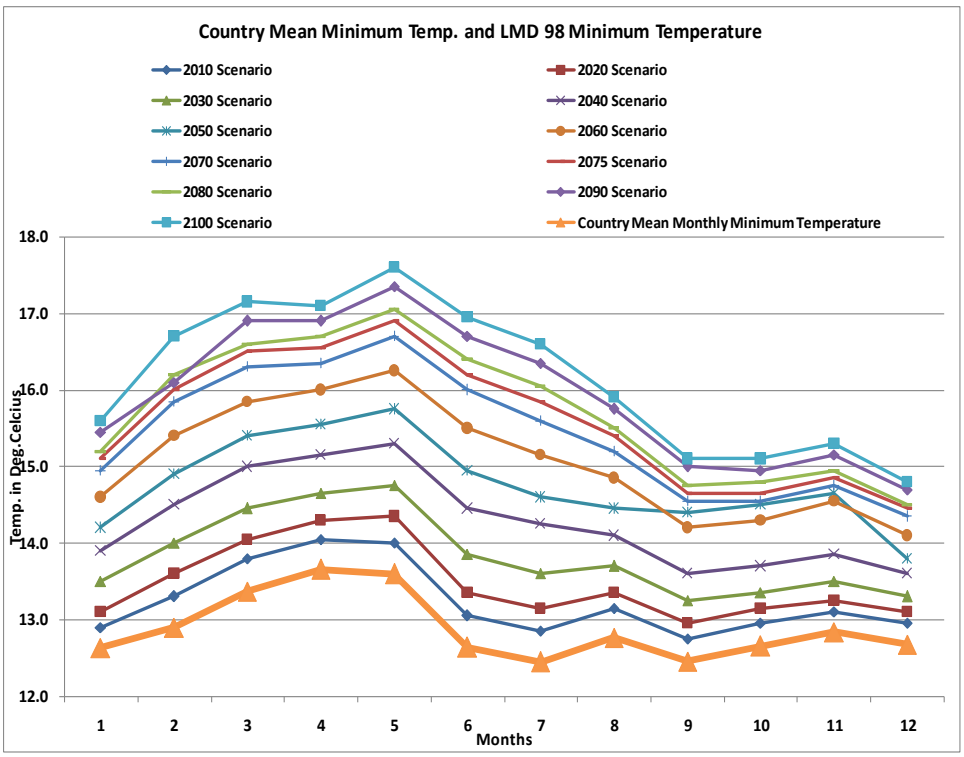


Figure 22c : LMD_98 projected min. temperature

Mean temperatures (table 54 and figure 23) are expected to increase for all three models, approximately of about 1.3°C to 1.9°C in 2050 and of 2.3°C to 3.3°C in 2100 above the baseline mean.

Table 54**:** Mean t°C change projections

Changes in aver.T °C	2020	2050	2100
PCM_00	0.44	1.3	2.5
IAP_97	0.5	1.3	2.3
LMD_98	0.6	1.9	3.3

Figure 23: Projected mean temperature

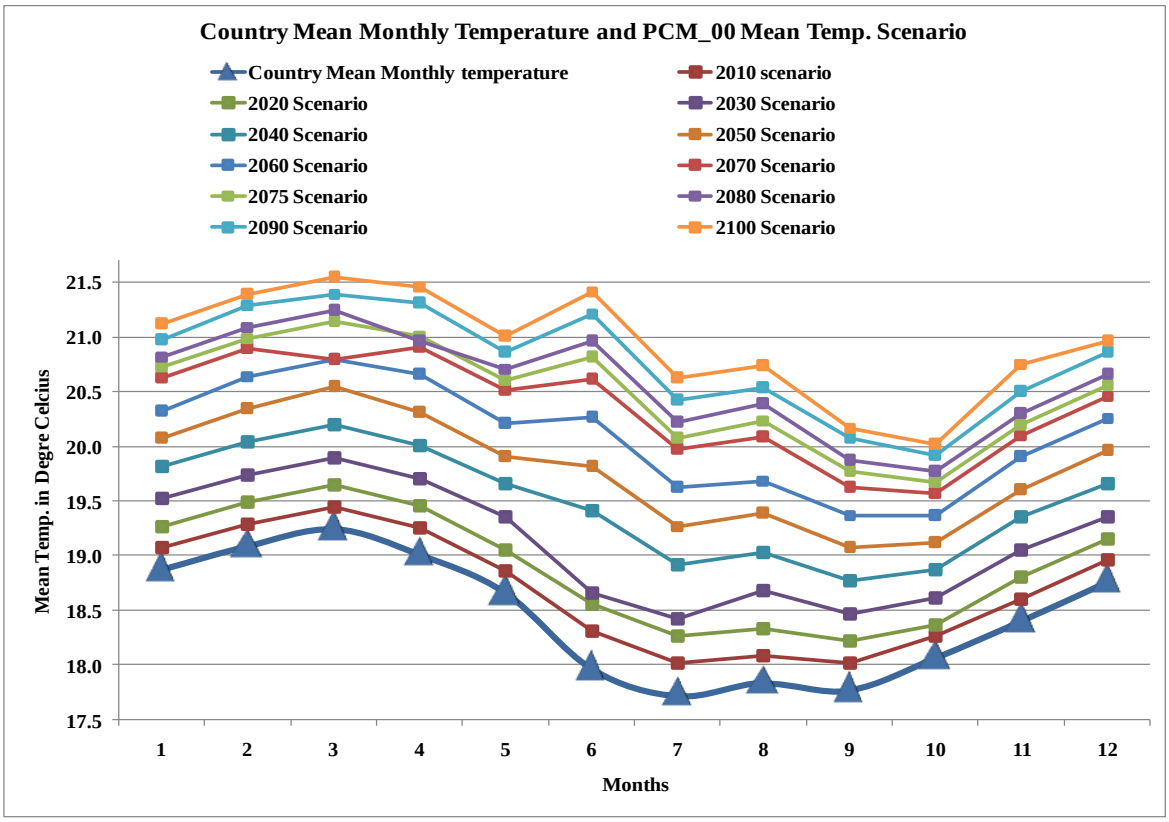


Figure 23a: Projected mean temperature, PCM_00

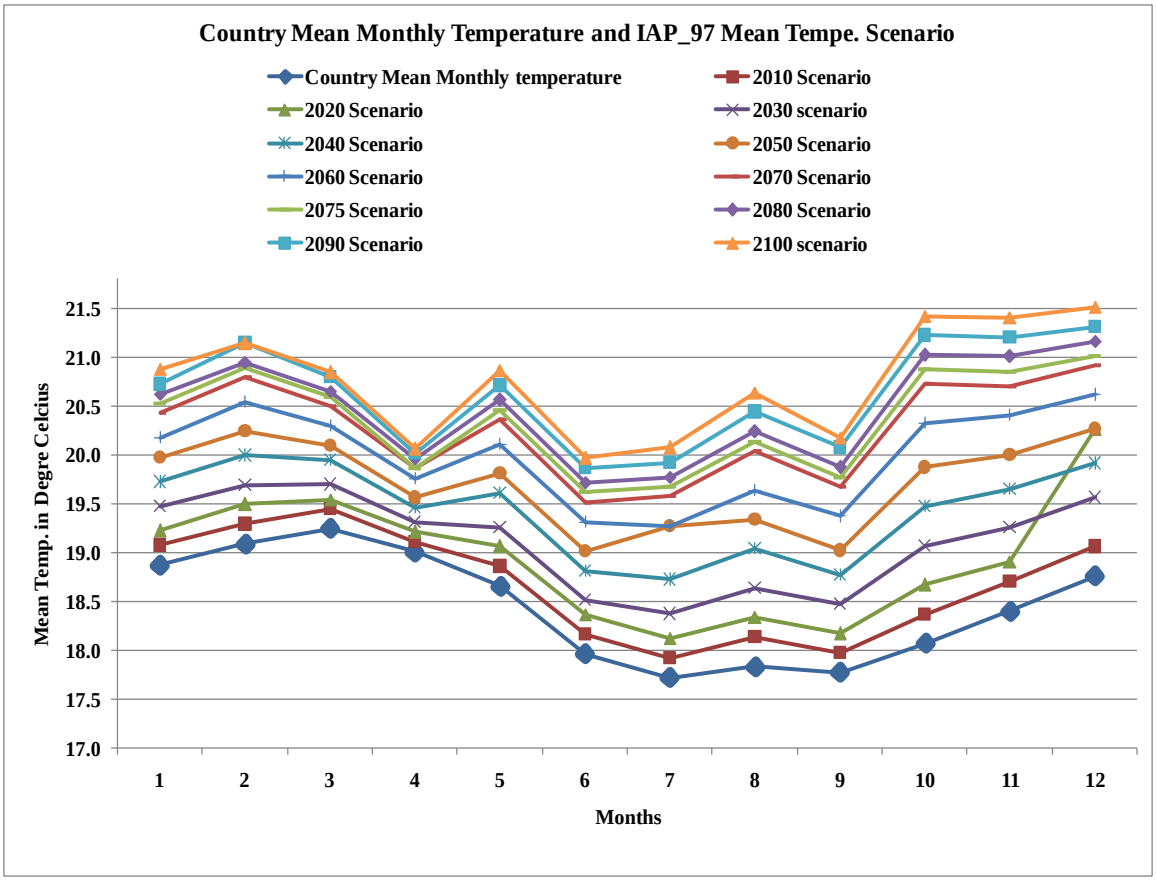


Figure 23b: Pprojected mean temperature, IAP_97

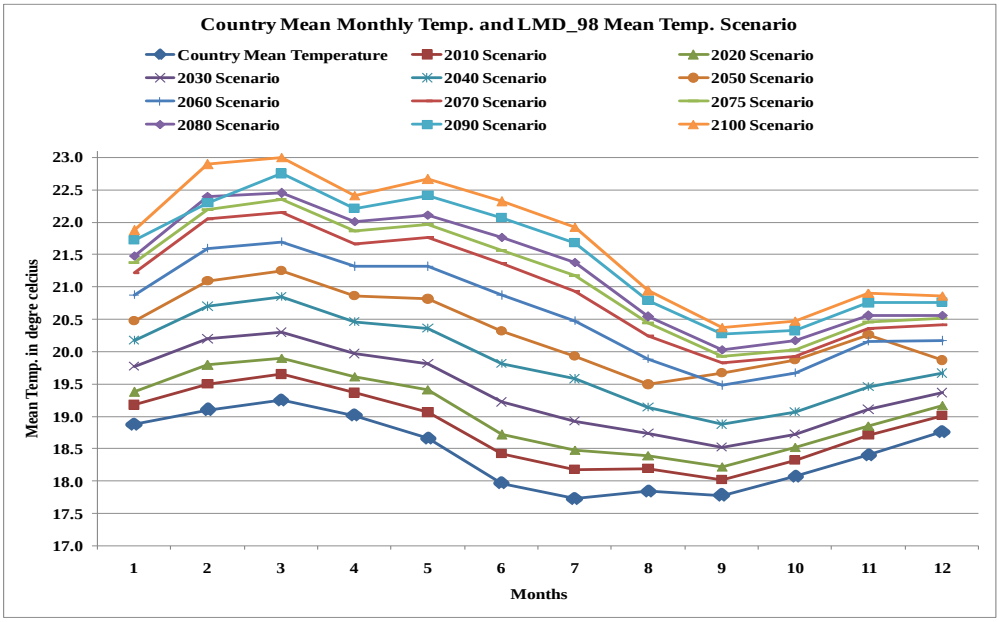


Figure 23c: LMD_98 projected mean temperature

For the projected maximum temperature, the 3 GCMs have a similar trend in annual increase in the historical average maximum temperature. The increase in maximum temperature varies from 0.44 to 0.6 in 2020, from 1.3 to 1.9 in 2050, and from 2.5 to 3.3 in 2100, for the three models.

Table 55: Max t°C change projections

Max t°C change projections	2020	2050	2100
PCM_00	0.44	1.3	2.5
IAP_97	0.5	1.3	2.3
LMD_98	0.6	1.9	3.3

Figure 24: Projected max Temperature

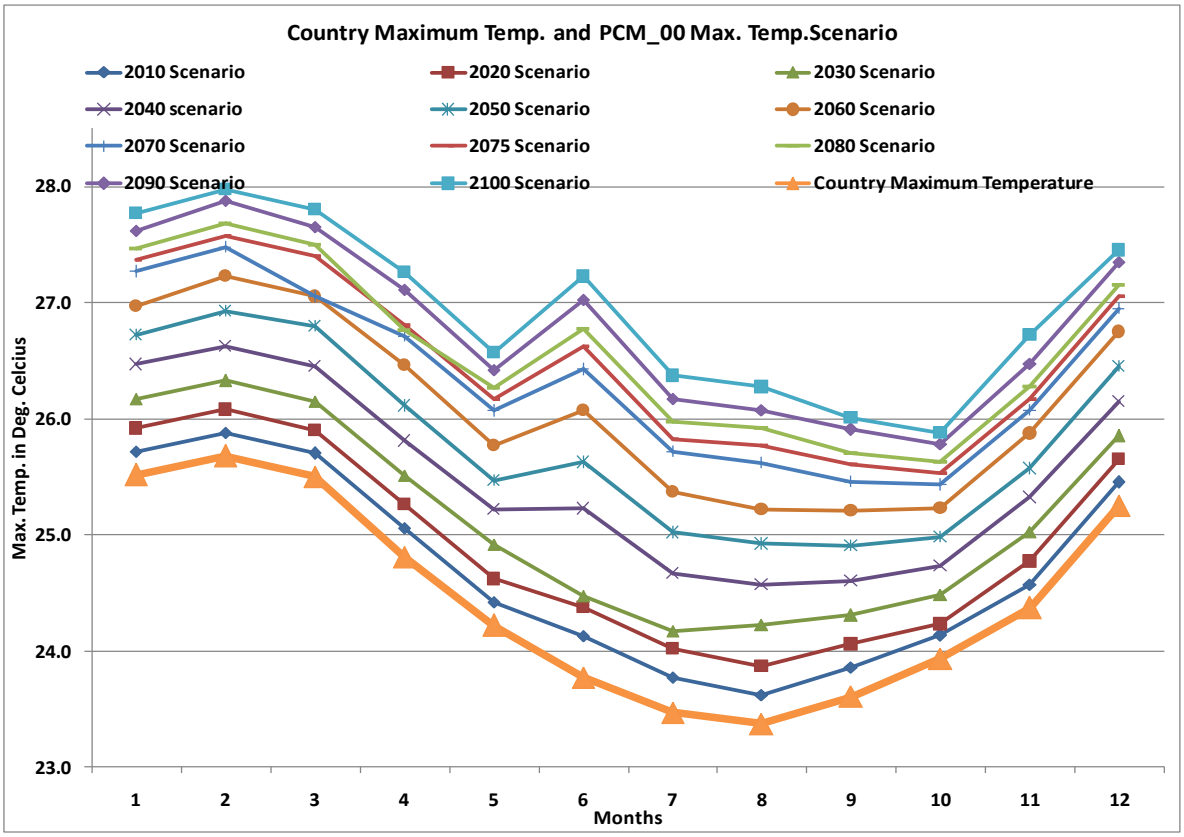


Figure24a: Projected max Temperature, PCM_00

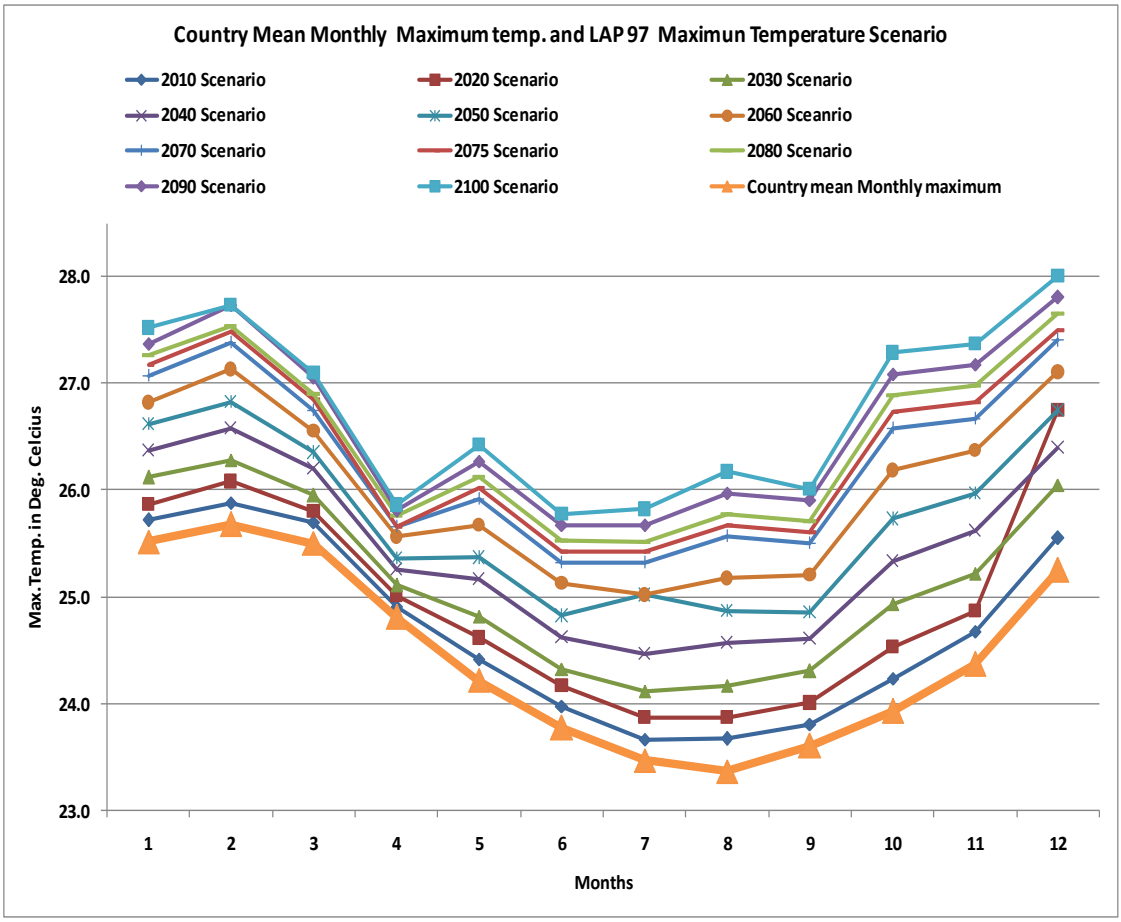


Figure 24b: Projected max Temperature, IAP_97

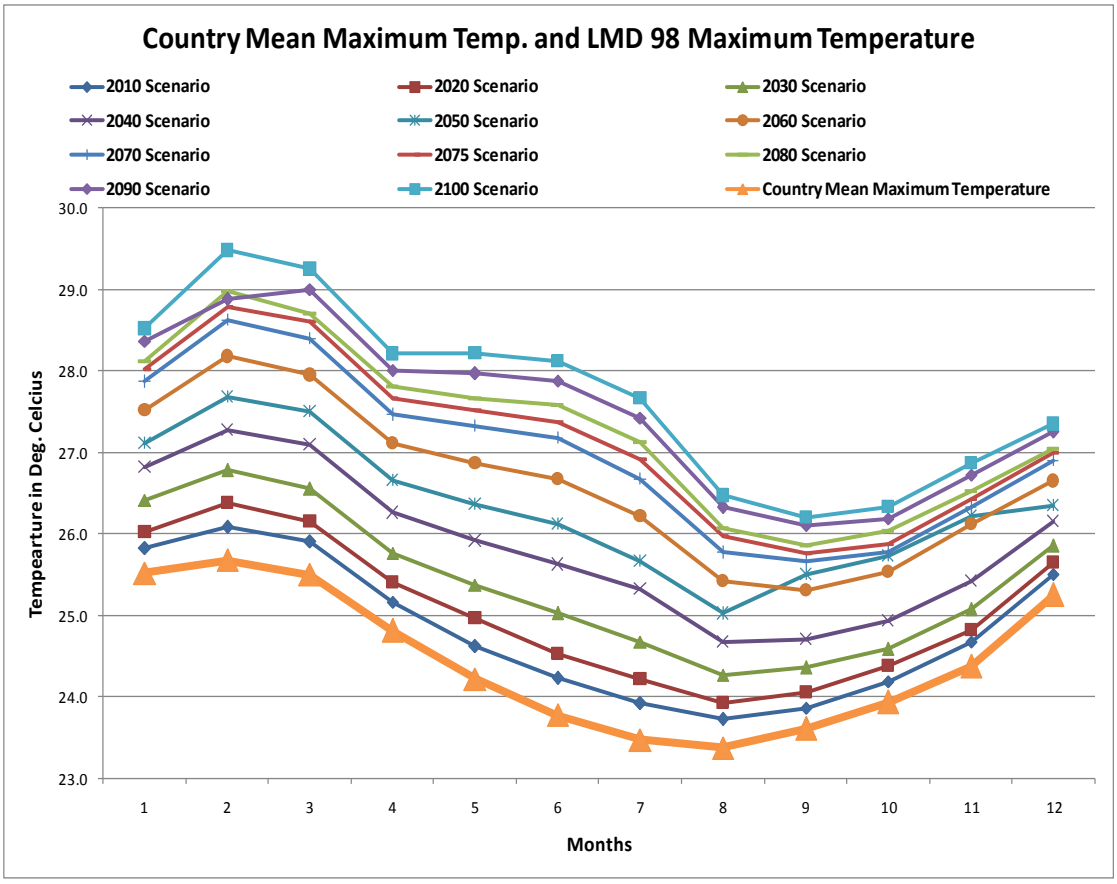


Figure 24c: Projected max Temperature, LMD_98

Lastly, concerning the projected mean monthly rainfall (figure 25) we notice that for IAP_97 and LMD_98 models **,** peaks of monthly average rainfalls are recorded during the rainy seasons of March- May and September-December; while for PCM_00 model scenarios, the same peaks appear during the dry season (June-August).Therefore, the model outputs in the case of IAP_97 and LMD_98 indicate that, compared to observed data, they perform better. However, the LMD_98 model displays a better image of the dry seasons (Dec-Jan and June-August) and the rainy seasons (MAM and SOND).

Figure 25: Projected mean monthly rainfall

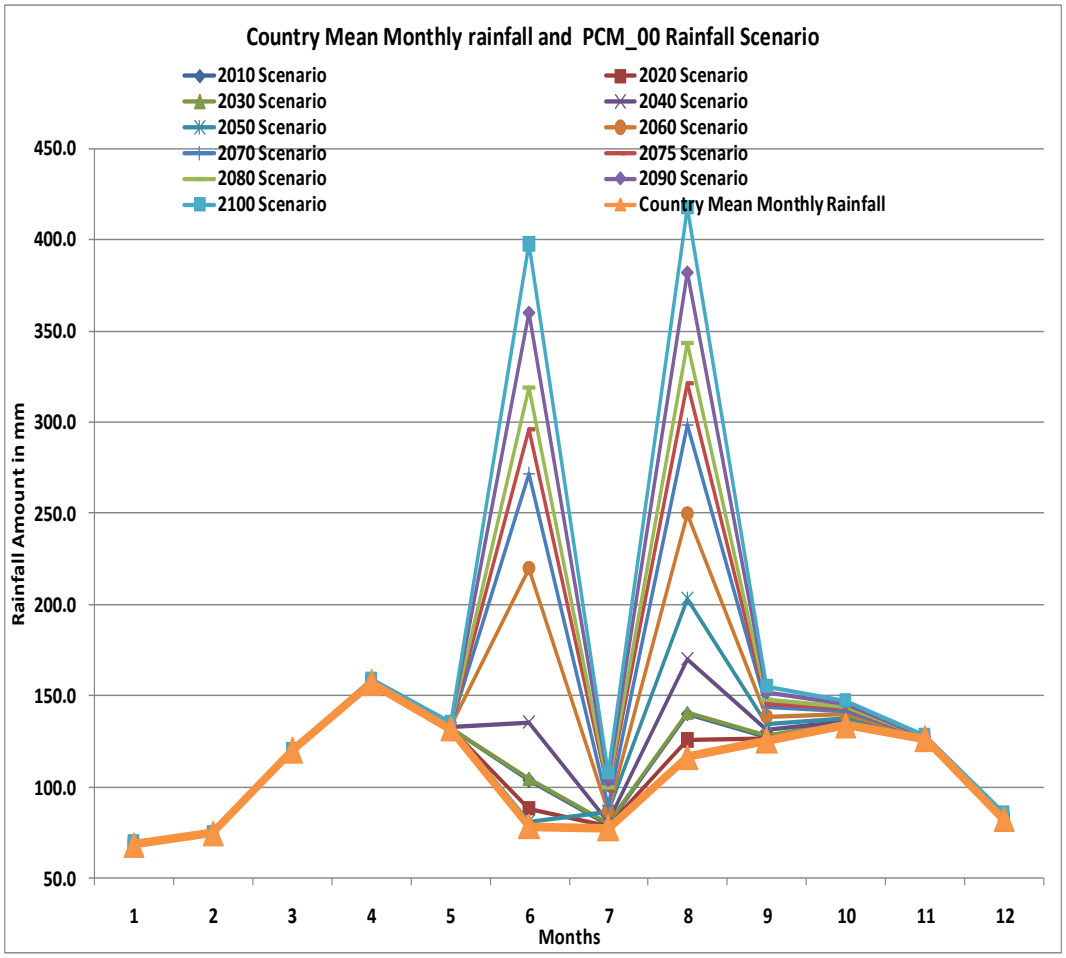


Figure 25a: Projected mean monthly rainfall, PCM_00

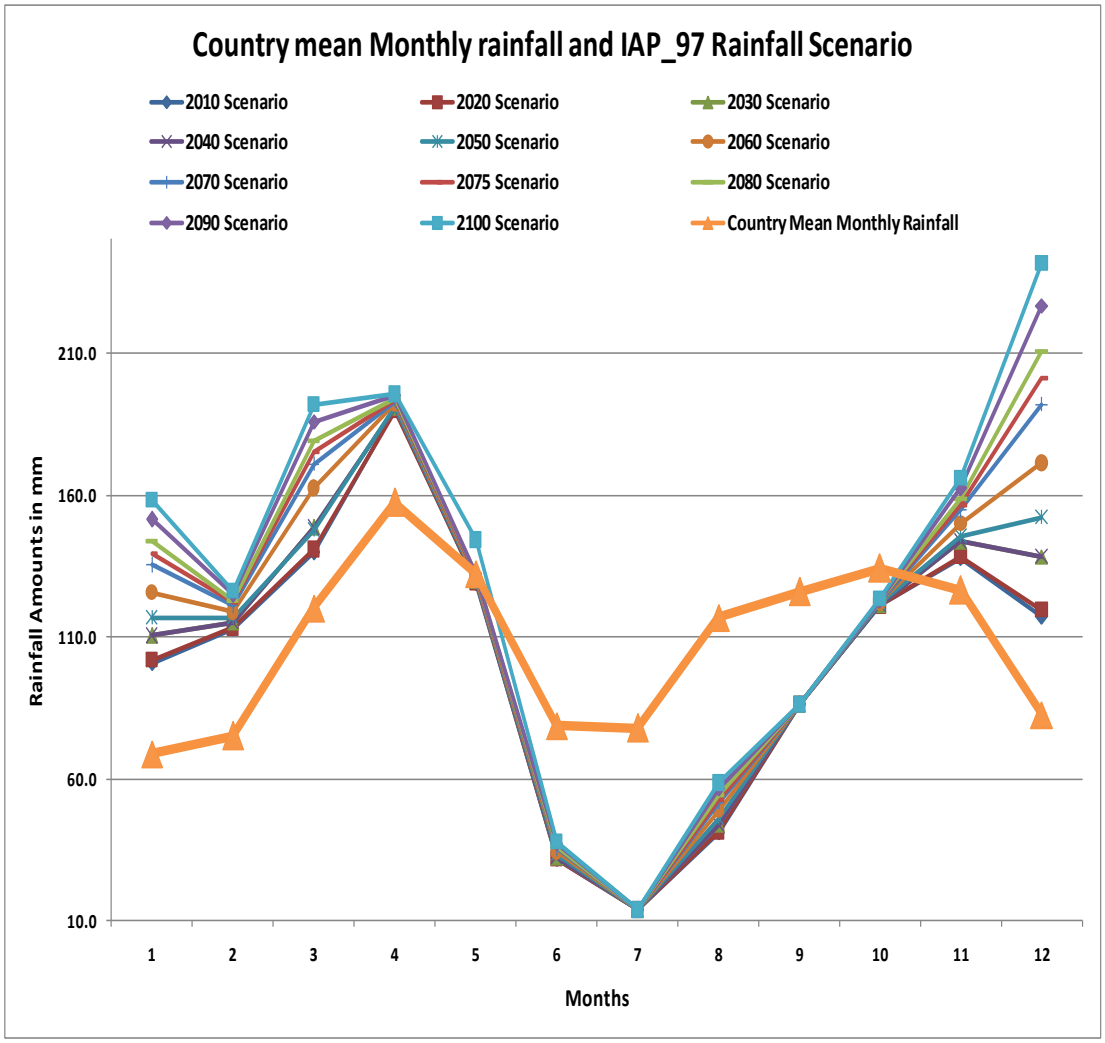


Figure 25b: Projected mean monthly rainfall, IAP_97

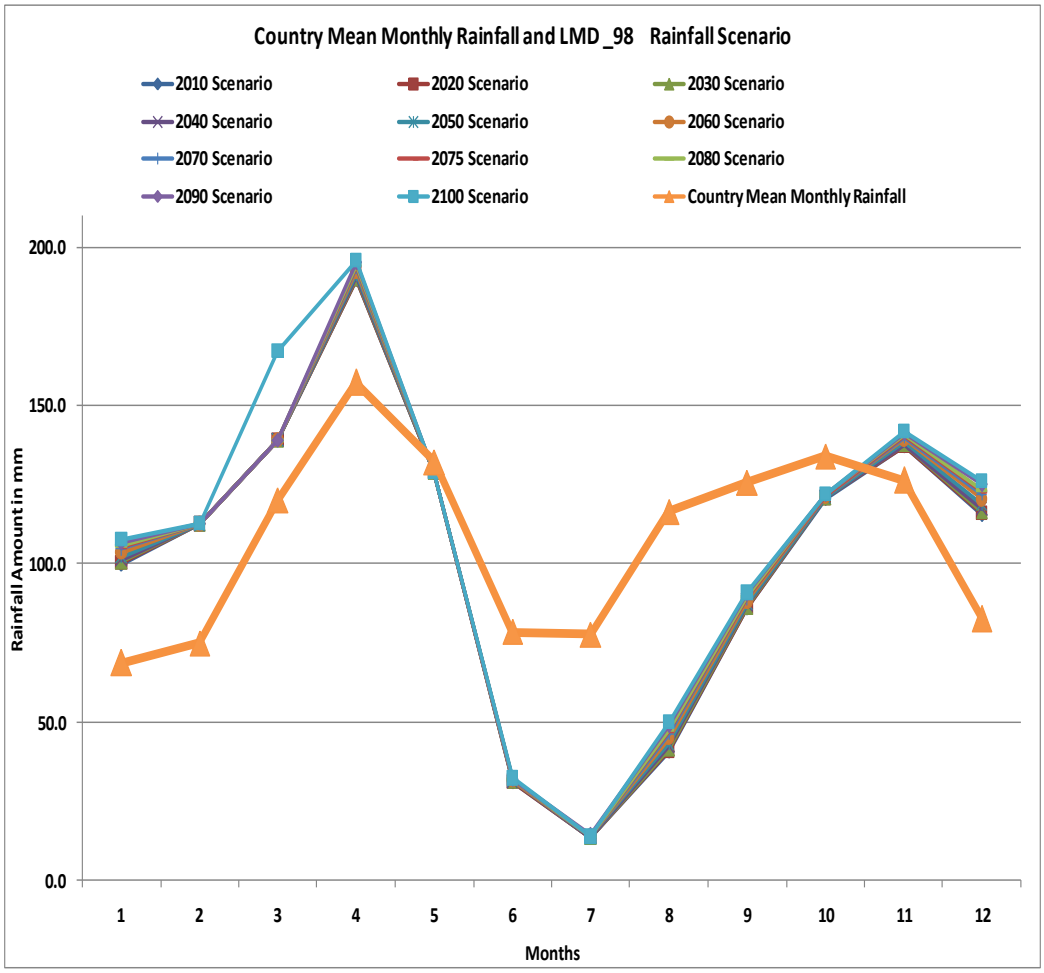


Figure 25c: Projected mean monthly rainfall, LMD_98

4.2. Water Resources

It is well known that water resources have a direct influence on the quality of people's lives, their health and productivity. Water is essential not only for human life but also for animal husbandry, agriculture, industrial development, hydroelectric power generation, socio-economic development and poverty eradication. As one can imagine, the negative impact of climate change on surface and underground water resources can be catastrophic for the country.

Surface and underground waters were discussed in the chapter on national circumstances.

4.2.1 Current situation on water use and demand

Demand and access to potable water

According to a recent report on the national inventory of drinking water supply and sanitation in Rwanda published in 2009 and using two main parameters namely availability of potable water per liter and per capita, as well as the accessibility in terms of the distance it takes to access water for a household, it appears that regions with rainfall deficit are the less advantaged in drinking water supply. As shown in the following table, the total supply in potable water supply in 2009 in Rwanda was estimated at 73.81% of Rwandese population while the average consumption per capita was estimated at 54.7 liters /capita/day.

Table 56: Total drinking water supply per province in 2009, in Rwanda

Indicators	**Kigali City**	**Southern Province**	**Western Province**	**Northern Province**	**Eastern Province**	**Rwanda**
Total Population	892,036	2,266,110	2, Promote integrated fish farming 086	1,610,831	2.380.107	9,057,170
Total drinking water Production (m^3)	72,632	145,478	114,312	99,984	63,034	495,441
Average accessibility to potable water (%)	96.68	67.44	75.4	68.91	73.01	73.81
Consumption per capita per day (in litres)	81.42	64.2	50.8	62.07	30.9	54.70

Source: MINIRENA (2009)

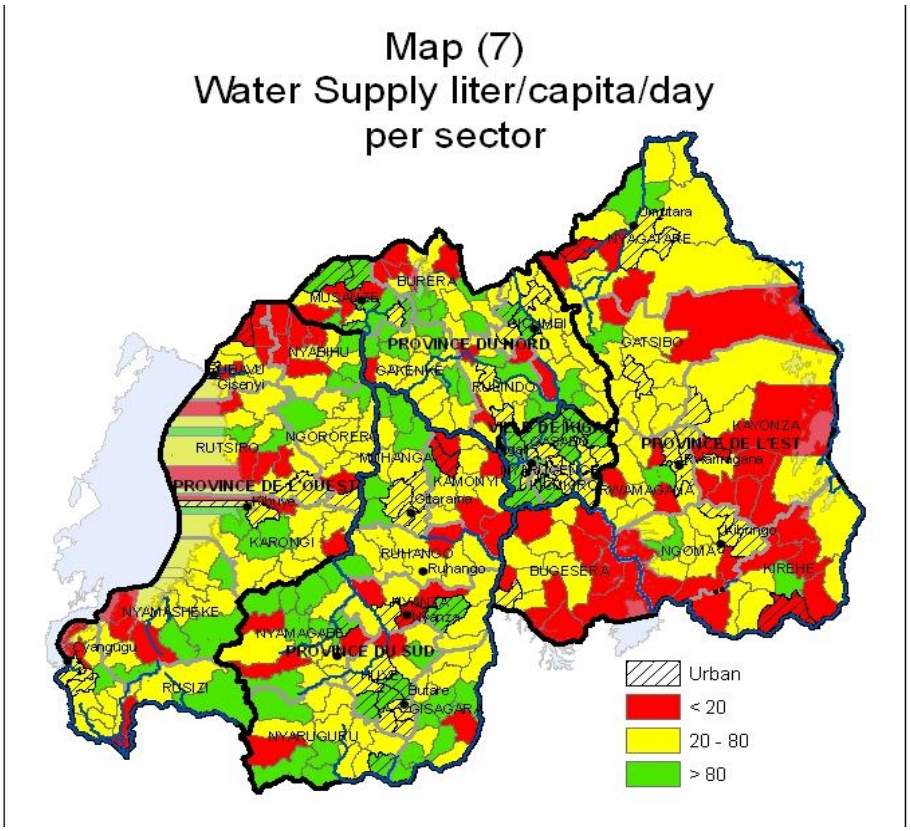


Figure 26: Supply in potable water per sector and per capita (l/p/j)
Source: MINIRENA (2009)

According to this map, South –Eastern regions (Bugesera, Eastern plateau) usually with rainfall deficit have low quantities of drinking water per household per day. Most of the sectors of that region receive quantities of drinking water less than national average of 5.47 l/p/j and lower to international norms of 20 l/p/j.

Two other regions which experience deficit in drinking water supply are those of volcanic soils in the North Western part of the country and the areas surrounding Lake Kivu in the west of Rwanda. In these regions, there are limited modern infrastructures for water supply where by more than 60% of the households have to travel for more than 500 m to access portable water.

Future needs in water supply by 2020 amount to 470, 000 m^3/day or 170Mm^3/an. This implies double of the 2005 needs.

Concerning the quality of the water As far as water quality is concerned, only occasional analyses without follow up (with no proper monitoring system) in the course of the year,

are carried out. It is therefore difficult to have a precise idea on the quality of water and the intensity of environmental pollution.

The industrial demand

The industrial sector remains generally weak in Rwanda. The majority of existing companies are engaged in the domains of agri-food processing, chemical or para chemical, as well as the extraction of raw materials and minerals. These companies are mostly based in the capital, Kigali. Basing on the studies surveys conducted by MINITERE (2005; PGNRE), the growth rate of industries was estimated at 8% in 2010, 15% in 2015 and 10% in 2020. The needs (needs in what) would rise from 1.3 to 6.1 million m^3 per year.
The growth rate is expected to rise higher between 2010 and 2015 as a result of inciting measures taken by the Government and extension plans for the different industries.

Water demand in agriculture

Water demand in agriculture is limited to irrigation which is less practiced in Rwanda (especially in rice growing plantations).

Current needs have been evaluated on the basis of existing irrigated lands totaling 5,000 ha and essentially devoted to rice growing. These needs have been estimated at 140 Mm^3 for intensive crop growing.

Livestock water consumption remains low and represents about 10% of the total needs.
Water demand needs by 2020, evaluated on the basis of the methodology and evolution of surface areas and the number of heads of cattle for 2020, are estimated at 840 Mm^3/ year.

Water demand for irrigated hillsides crop growing remains relatively low compared to the needs of wetlands crop growing with respectively the needs of 48 Mm^3 per year for the former against 78 Mm^3 per year for the latter.
The livestock water consumption remains low: 14Mm^3 per year.

Water demands in energy generation

Rwanda experiences a shortage in hydro power energy. On one hand In fact, only 6% of the population is connected to the power grid: 20% in urban areas and 2.5% in rural areas.

However, Rwanda has a great potential to increase its hydroelectrical energy production due to its dense hydrographical network and a high relief.

4.2.2. Future projections of Nyabarongo discharges

In order to evaluate the impact of climate change on water resources in Rwanda and identify possible adaptation measures, the watershed of Nyabarongo river has been selected in order to apply simulation techniques of the hydrological balance of rivers in Rwanda and determine the total quantity of runoff and infiltration water, as well as the estimation of water resources available for domestic, industrial, farming, and for ecosystems use.

The simulation technique applied to this study is the WATBAL model (Spatial lumped conceptual integrated catchment WATer BALance model). This model has two components: a hydrologic balance, representing the flow of water at the entrance and at the exit of the watershed and an estimation of the potential evapotranspitration.

Calibration of the model and baseline scenarios

To apply this model, an area of 8,900 km^2 from Nyabarongo river basin was chosen. For this study, average temperatures and rainfalls of Ruhengeri, Byimana, Gikongoro (Nyamagabe) and Rwamagana stations were used for the period from 1971 to 2005.

For the assessment of evapotranspiration at the level of the selected watershed, it was necessary to proceed with the use of results from the climate scenarios of LMD_98 model in order to have data on evapotranspiration over the projection years from 2010 to 2100.

As for hydrological data, monthly mean discharges of Nyabarongo at Kigali Station from 1961 to 2005 have been used. The model was also calibrated in function of years with normal, high and low discharges. Thus, the years 1997, 1998 and 2001 were identified as years of high discharges, 1988 and 2002 as years of normal discharges and 1981 and 1984 as years of low discharges. The following graphic shows the years of high, medium and low discharges in the hydrological regime of Nyabarongo, 1971-2003.

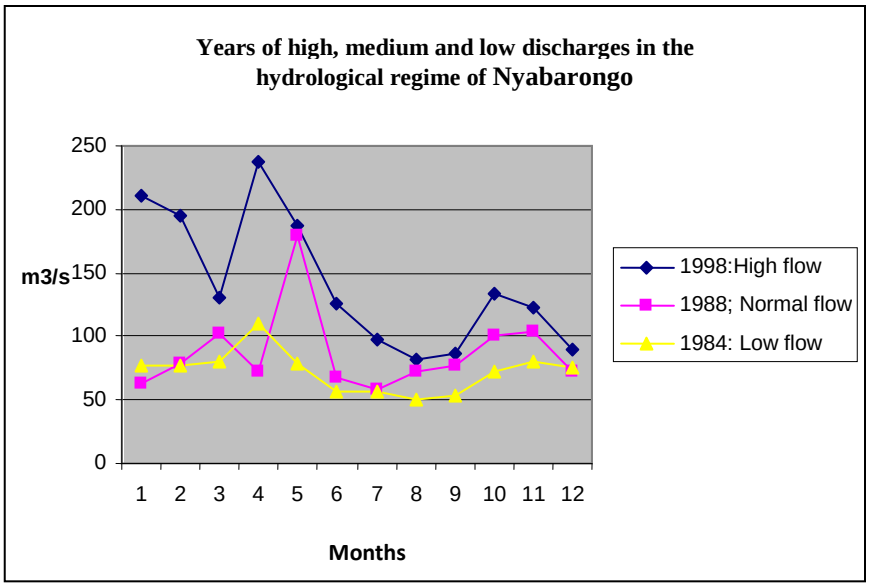


Figure 27: Years of high, medium and low discharges in the hydrological regime of Nyabarongo, 1971-2003

(i) For 1998, the year of high hydrological discharges, high discharges of Nyabarongo begin from January, with a decline in March followed by an increase in Nyabarongo flow in April. Low discharges occur in July and continue up to September during which a new rise in discharges was observed until October.

The year 1988, the year of mean discharges is also characterized by a flow with two peaks: a high increase in discharges in May and a low one in November.

The year 1984, year of low discharges, presents a low peak in April and another lower peak in November.

Future projections for Nyabarongo discharges /Kigali, 2010 to 2100

The graph below shows the projected monthly mean discharges of Nyabarongo in Kigali from 2010 to 2100.

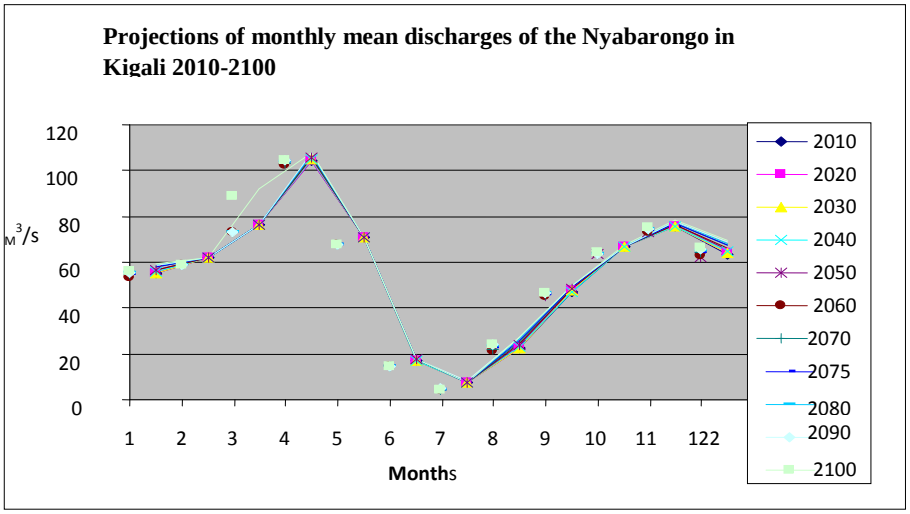


Figure 28: Projections of monthly mean discharges of Nyabarongo in Kigali (2010-2100)

According to these projections from 2010 to 2100 mean discharges of Nyabarongo would be slightly low compared to mean discharges of the baseline year 1988. This implies a decrease in river flows in the years to come. Nevertheless, as shown in the above figure, the differences in flow rates between years remain very low.

For the period 2010 to 2100, there would be a significant decrease (from 240 m 3 / s to 120 m 3 / s) in maximum discharges in comparison with the baseline year of 1998 (year of maximum discharges). However, the configuration of discharges in the course of the year would remain the same, with high discharges in March-April and the low water period in June-September.
For the minima, discharges might be also low, not exceeding 90 m3/s in April, while in 1984, the baseline year with low discharges, they reached 110 m3/s in the same month.

4.2.3. Vulnerability assessment of climate change in the sector of water resources

Climate changes that Rwanda has been facing during the last three years have had an impact on water resources by causing floods as well as droughts leading to reduction of river discharges, the decline of water levels in lakes and rivers, the drying up of springs, loss of aquatic biodiversity and the reduction of power energy generation.

Erosion, landslides and floods

Frequent heavy rainfalls causing runoff on steep slopes, which, coupled with the natural fragility of the soils and other anthropogenically induced factors in land use management issues such as deforestation of forests (Gishwati) take away a significant amount of soil into valleys and lowlands.

Unexpected floods caused by abnormal high rains have caused losses not only in human lives and material, but also in biodiversity.

Thus, September 12, 2007, 15 people died and two others were reported missing following torrential rains that devastated the sectors of Bigogwe (Nyabihu district) and Kanzenze (Rubavu district) respectively in the Northern and Western Provinces. A total of 456 houses and hundreds of hectares of plantations of potatoes were also destroyed. 2403 people from 438 families were displaced.

Between 2006-2008, the Rwandan Red Cross helped assisted (came to the rescue of) more than 5,820 people affected by floods in different parts of the country in the following districts: Nyabihu, Rubavu, Musanze, Kayonza, Kirehe, Ngoma and Rwamagana.

In September 2008 heavy rains and winds affected eight of the 12 sectors of Rubavu District: Gisenyi, Rubavu, Rugerero, Nyamyumba, Nyundo, Cyanzarwe, Nyakiriba and Kanama. Floods submerged more than 500 homes and destroyed about 2,000 hectares of crops. bridges, roads and pylons, as well as schools were severely damaged too. Up to 1982 homes, 72 primary schools and 34 secondary schools were completely or partially destroyed.



Figure 29: Flash floods with serious damage to human lives and Infrastructures in Bigogwe: Nyabihu District, Northern Province

Areas at risk of flooding and landslides are located in the northern, western and southern provinces, where there is uneven topography, as shown in the map below.

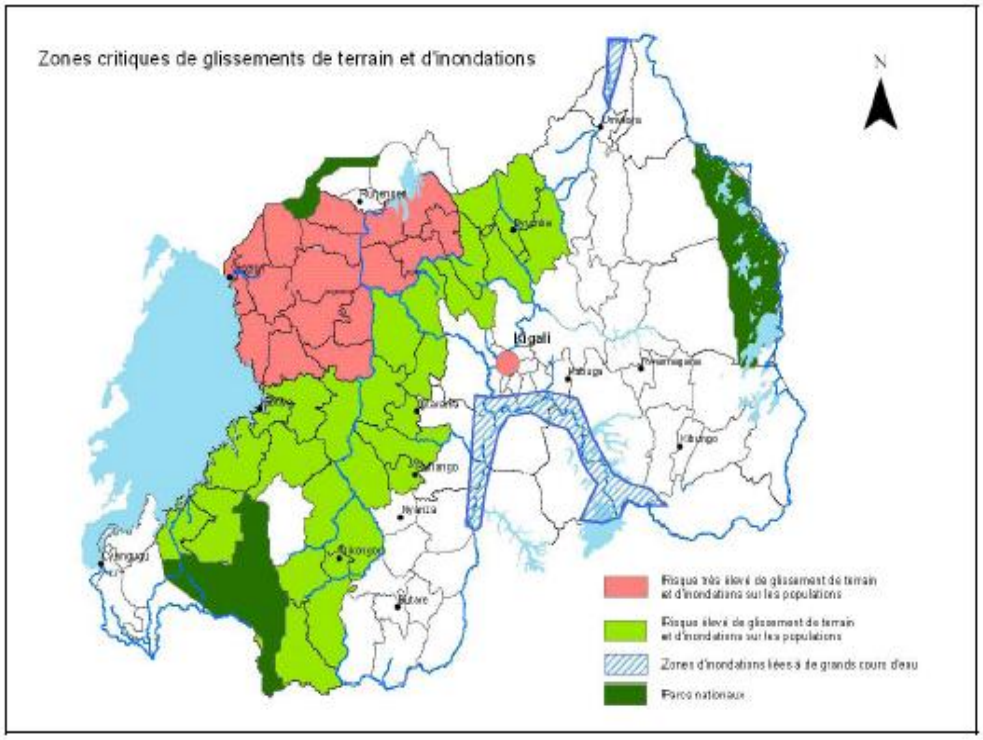


Figure 30: Areas which are likely to have floods and landslides

Droughts

Prolonged droughts coupled with high temperatures and high evapotranspiration rates have caused induced additional pressure on water resources, causing:
• reduced river discharges;
• decline of baseflow for rivers and lakes;
• drying up of springs;
• loss of biodiversity of aquatic systems

Such droughts are frequently observed in bioclimatic regions of East, South-East and some areas of Rwanda's central plateau (Umutara, Kibungo, Bugesera, Mayaga and Muhanga) where people suffer at times of famines resulting in hunger crisis especially in vulnerable families.

In 2004 - 2005, prolonged drought, coupled with anthropogenic activity namely the drainage of Rugezi marshland,which feeds Burera and Ruhondo lakes, contributed significantly to the reduction of electricity generation by Ntaruka and Mukungwa

hydropower plants, as the result of the reduction of water level in those lakes. Indeed, Electricity production dropped from 12 MW to 3 MW for Ntaruka plant and from 11 MW to 2 MW for Mukungwa plant.

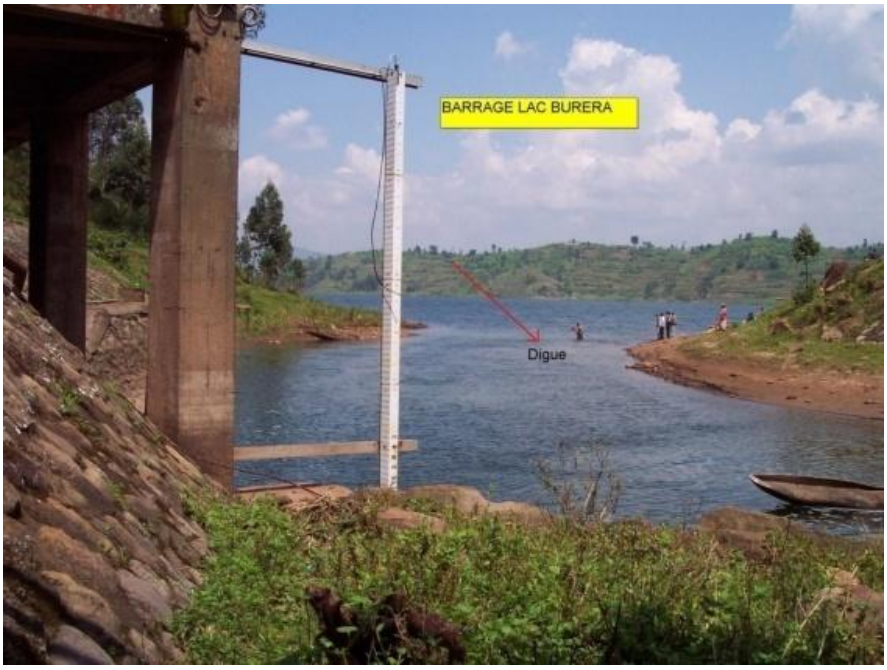


Figure 31: Water level decline in Lake Burera which supplies Hydropower plants of Ntaruka and Mukungwa

Similarly, in dry seasons, water treatment plants supplying the city and towns of Rwanda face a problem of considerable baseflow decrease in rivers which supply those stations plants hence causing drinking water shortages in cities and rural areas served by these stations.

Kimisagara water treatment plant, for example, frequently faces shortage in dry seasons. Such shortages result from considerable decrease of the quantity of water to be treated from river Yanze whose baseflow significantly drops as a result of rising temperatures. This situation is aggravated by activities of watering vegetable crops carried out upstream by farmers to save their crops during the dry season.

These climatic changes also affect the groundwater, decreasing/lowering ground water tables and therefore reducing the flow of springs and wells that supply drinking water to the majority of the population in rural areas.

In addition, rain water deficiency during periods of drought have severely affected agricultural production, causing food shortage in the regions of East and South - East of the country, especially in the Bugesera region where migration of some families fleeing the disaster has been observed.

4.2.4. ADAPTATION MEASURES TO CLIMATE CHANGE IN THE WATER RESOURCES SECTOR IN RWANDA

In the area of water resources, three fundamental measures of adaptation are possible: increase the water supply, reduce the demand for water resources and manage the demand and supply differently. However, in this report, adaptation measures have been identified on the basis of national, cultural, geographical criteria and climate change risks.

Given the fact that the list of adaptation measures is long, the following selection criteria were used to identify 2 to 5 adaptation measures that are potentially most effective. Those which answered with more "yes" to different criteria selected for their analysis, were retained for the next stage of evaluation.

Table 57: Selection of technical adaptation measures

adaptation	**Of high priority**	**Priority objective**	**Efficiency**	**Other Benefits**	**Low cost**	**low Barriers**
1. Plan and coordinate the development of watershed	Yes	Yes	Yes	Yes	Yes	Yes
2. To adopt an emergency plan for fighting against drought	Yes	Yes	Yes	Yes	Yes	No
3. Pollution Control	Yes	Yes	Yes	Yes	No	No
4. Water Conservation	Yes	Yes	Yes	Yes	No	No
5. Promote the use of groundwater resources	Yes	Yes	Yes	Yes	No	No
6. Behavioral changes in the use of water	No	No	Yes	Yes	Yes	No
7. Reuse and recycle water	No	No	Yes	Yes	No	No
8. Construction of Dams	No	No	Yes	Yes	No	No
9. Transfer of water between watersheds	No	No	Yes	Yes	No	No
10. Water supply system based on market prices	No	No	Yes	Yes	No	No
11. Minor changes on the infrastructure construction	No	No	Yes	Yes	No	No
12. Water conservation by reducing the demand	No	No	Yes	No	No	No

4.2.5. ACTION PLAN FOR THE IMPLEMENTATION OF ADAPTATION MEASURES IN THE SECTOR OF WATER RESOURCES

The following table illustrates the action plan for the implementation of adaptation measures to climate change in the sector of water resources in Rwanda

Table 58: Action plan for the implementation of adaptation measures to climate change in the sector of water resources in Rwanda

Area of intervention 1: Strengthening a friendly political, legislative and institutional framework in the management and protection of water resources

No	Objectives	Expected results	Indicators	Activities	Intervening parties	Period
1	Empower local authorities and other partners in the rational and participatory management of water resources.	Responsibilities of local authorities in the management of water resources are defined and widely known.	Guidelines and brochures developed and distributed. Number of sensitization seminars and workshops organized. Number of participants involved Clear tasks and responsibilities for a% of actors.	Development of guidelines defining the responsibilities of local actors.	MINIRENA MININFRA MINALOC REMA DISTRICTS	2011-2012
			Number of distributed copies of policies and laws; Number of targeted beneficiaries	Popularization Outreach/ dissemination of policies and laws on decentralization and rational management of water resources.	MINIRENA MININFRA MINALOC REMA DISTRICTS	2011-2012
		Laws and regulations on management of water resources are applied and reinforced constantly	Number of updated laws; Number of application texts adopted and implemented	the amendment of laws and elaboration of application texts	MINIRENA MININFRA DISTRICTS REMA	2011-2015
			Number of distributed copies of policies and laws; Number of beneficiaries	dissemination of amended laws and application texts	MINIRENA MININFRA REMA DISTRICTS	2011-2015

Area of intervention 2: Sustainable management of water resources

No	Objectives	Expected results	Indicators	Activities	intervening parties	Period	Estimated cost
1	Strengthen the basic knowledge and develop information systems on water resources.	People in vulnerable areas are regularly informed and alerted about extreme weather conditions manifestations.	The quantity of water supplies are numbered and distributed on the basis of different user needs	Improvement of knowledge on water resources.	MINIRENA MININFRA REMA Water Agency	2011-2015	
			Number of Climate bulletins published per year .	Rehabilitate and equip 120 meteorogical stations evenly distributed across climate regions of Rwanda.	MININFRA	2011-2015	
			Number of hydrological directories published annually	Rehabilitate 100 damaged hydrological and limnological stations.	MINIRENA	2011-2015	
			Number of monthly publications of hydrometeorological data in the media per month.	Involve the media in the publication of hydrometeorological newsletters in the region	MININFRA MINIRENA	2011-2012	
2	Develop and strengthen programs for integrated management of water resources.	Water resource is well managed and efficiently exploited.	Number of lakes and rivers whose shores and banks are respectively protected	Anti-erosion planning, including landslides and protection of riverbanks and lakeshores.	MINIRENA REMA	2011-2016	
			Proportion of protected area of river banks and lake shores	Planning of anti-erosion, including landslides and riverbank protection of rivers and lakeshores.	MINIRENA REMA		
			% of degraded ecosystems rehabilitated	Restore degraded aquatic ecosystems	MINIRENA REMA	2011-2020	

Area of intervention 3: Establishing an emergency plan to the fight against drought

No	Objectives	Expected results	Indicators	Activities	intervening parties	Period
1	Empower local authorities and other partners in the establishment and operationalization of an emergency plan against droughts.	The policy against drought is known and responsibilities of local authorities in the management of droughts are defined and widely known	Number of distributed copies of policy and laws; Number of beneficiaries targeted.	Extension / dissemination of policies and laws on decentralization and management of drought.	Ministry of Disaster Management and Refugees, MINALOC DISTRICTS	2011-2012
			Guidelines and brochures developed and distributed; Number of sensitization seminars and workshops organized; Number of partners involved; Tasks and responsibilities clear to % of actors	Development of a guide defining the responsibilities of local actors.	MINALOC DISTRICTS	2011-2012
2	Strengthening the information system and early hydro-agro-meteorological warning mechanisms	People in vulnerable regions are regularly alerted on climaticphenomena	Number of climate bulletins published annually	Rehabilitate and equip 150 meteorological stations spread across the climatic regions of the country.	MINIRENA MININFRA	2011-2014
			Number of hydrological directories published annually	Rehabilitate 120 hydrological and limnological stations damaged	MINIRENA	2011-2014
			Number of publications of hydrometeorological data in the media per month..	Involve the media in the publication of hydrometeorological data across the country and the region.	MININFRA MINIRENA	2011-2012
3	Provide the population of vulnerable regions with new techniques of fighting against drought	Life conditions for people in vulnerable areas are improved.	Number of techniques for collecting water.	Promotion and extension of new techniques for collecting rain and irrigation water..	MINAGRI MINIRENA	2011-2015
			Number of crop varieties resistant to climatic unexpected events.	Vulgarization of new crop varieties early and resistant	MINAGRI ISAR	2011-2020

				to unexpected climatic events		
			Number and types of conservation technologies for agricultural products adopted and valued	Identification and extention of conservation technologies for agricultural products.	MINAGRI ISAR	2011-2020

Area of intervention 4: Water Conservation

Nº	Objectives	Expected results	Indicators	Activities	Intervening parties	Period
1	Ensure better use of water resources	People are sensitized on the use of new techniques of harvesting rainwater	Number of new techniques for rainwater harvesting adopted by the population; Number of seminars and workshops of sensitization organized about new techniques; Number of beneficiaries targeted	Promotion and vulgarization of new techniques for rainwater harvesting	MINIRENA MINAGRI RADA	2011-2014
		Natural water reservoirs of the country (Natural forests of National Park of Nyungwe, and Volcanos National Park) are rehabilitated and protected	Number of Ha of Forests of NPN and VNP rehabilitated; Laws protecting such parks are established	Reforestation of all degraded areas in the Parks of Nyungwe and Volcanoes.	MINIRENA RDB NAFA ISAR	2011-2015
		Water erosion is controlled.	% of land protected against erosion. Hectares of radical terraces are valued.	Planning and valuation of an area of 400,000 Ha in radical terraces at national level.	MINAGRI RADA DISTRICTS NGOs Cooperative	2010-2012

Area of intervention 5: Integrated watershed management

Nº	Objectives	Expected results	Indicators	Activities	intervening parties	Period
1	Ensure better watershed management	master plan for watershed management is operational (four pilot watersheds)	established master plan for watershed management; established guidelines for the development and use of watersheds at national, district and local levels.	Developing the Master Plan watershed management and the cost evaluation of its implementation; Determined 4 four pilot watersheds to be developed;	MINAGRI MINIRENA DISTRICT	2011-2013
2	Empower local authorities, population and other partners in	responsibilities of local authorities , population and partners in the	Brochures and guidelines on techniques and erosion control in watersheds are developed and distributed.	Elaboration of a guidelines defining the responsibilities of actors	MINAGRI MINIRENA DISTRICT REMA	2011-2012

	the integrated management and planning of watershed	integrated management of watersheds are defined and known	Number of participants targeted. Clear tasks and responsibilities for % of actors			
3	Ensure the conservation of land and increasing agricultural production in 4 pilot watersheds	Water erosion is under control at 100%	Percentage of land protected against erosion; Number of hectares terraced radically valued on the pilot watersheds	planning and valorization of an area of 500,000 ha of radical terracing on all 4 pilot watersheds.	MINAGRI RADA DISTRICT NGO Cooperative	2011-2013

Area of intervention 6: International, regional and sub-regional cooperation

No	Objectives	Results	Indicators	Activities	intervening parties	Period
1	Reinforce regional and international cooperation	the participation in international forums is assured.	% of forums which Rwanda has participated to. Funds mobilized and projects financed.	Preparing projects for submission in international, regional and sub-regional forums, on management of water resources and adaptation measures in this sector.	MINIRENA MININFRA MINAGRI Ministry of Disaster Management and Refugee.	2011-2015
2	Mobilize for the implementation of national action plan for adaptation to climate change in the sector of water resources.	Roundtables of donors are organized to reach a larger number of donors.	Number of organized roundtables.	Organization of roundtables of donors.	MINIRENA MINAGRI MININFRA	2011-2015

Area of intervention 7: Research and monitoring-evaluation system

No	Objectives	Results	Indicators	Activities	Intervening parties	Period
1	Strengthen a basic knowledge and develop information and monitoring systems for vulnerable aquatic ecosystems	A network of observation and supervising is established for monitoring the fragile aquatic ecosystems	Observation network in place ; Monitoring and evaluation reports of the development of fragile ecosystems; Databases on the status of water resources.	Reinforcing basic knowledge on water resources and their degradation.	MINIRENA UNR/ NUR ORINFOR MEDIA	2011-2015
2	Ensure monitoring of the phenomenon of the degradation of water resources	System for collecting and disseminating data on the degradation of water resources exists and is functional	information system in place. Data collected and disseminated.	Development of a monitoring-evaluation and communication strategy of national action plan for adaptation to climate change in the sector of water resources.	MINIRENA MININFRA MINAGRI REMA	2011-2015

3	To orient, plan and monitor the implementation of national action plan for adaptation to climate change in the sector of water resources.	Indicators for monitoring and evaluation of the implementation and the impact of the national action plan for adaptation to climate change in the sector of water resources have been developed and applied.	Regular reports on the implementation of National Action Plan for Adaptation to Climate Change in the sector of water; Orientation / well defined frameworks and distributed to actors; Monitoring and evaluation functions well defined at all levels.	Establishing a system of monitoring-evaluation and communication strategy of the National Action Plan for Adaptation to Climate Change in the water sector.	MINIRENA MININFRA MINAGRI RNIS MEDIA	2011-2015
		A communication strategy is implemented and the information flows between all actors involved in the management of water resources.	Existence of a communication strategy; Flow of information between actors; Dissemination of messages			

4.2.6. Mechanisms and means for the implementation of adaptation measures to climate change in the management of water resources

Sectors related to water use are numerous and actions, techniques or adaptation measures to climate change vary depending on the vulnerability of water resources in each sector. Thus, measures are needed to ensure better coordination of all actions aimed at efficient use of water resources for sustainable development of the country.

(i) **The different levels involved in the implementation of adaptation measures to climate change in the water resources management**

At the local level

Adaptation measures to climate change in the management of water resources go through performance contracts which determine annual actions to which Districts authorities commit themselves, in front of the President of the Republic of Rwanda, to achieve in a period of one year. Such actions are determined through consultations with local communities, stakeholders and local authorities at the village level (imidugudu) cells, and administrative sectors.. The exercise of performance contracts has been proved efficient and will be used as part of the implementation framework of the national action plan for adaptation to climate change in the sector of water resources. Main actions selected in each district include:

• Protection of rivers and lakes against erosion;
• Collection of rainwaterfrom roofs of homes and institutions;
• Development of 100 ha of radical terraces per year;
• Development of anti-erosion ditches and plantation of agro-forestry trees;
• Reforestation of degraded areas (60 ha per administrative Sector, 12 ha per administrative cell, 2 ha per "umudugudu");
• Protection of wetlands;
• Construction of hydropower microplants;
• Development of infrastructure for water supply and sanitation;
• Development of groundwater sources.

At the national level

At the national level, the Ministry in charge of natural resources will be responsible for monitoring and regular evaluation of achievements of the actions vowed for in the performance contracts for the implementation of this action plan. All actors intervening in policy making and Government programs development, namely departments in ministries and parastatal institutions should be involved, and more particularly the following:

• The Ministry in charge of natural resources;
• The Ministry of Infrastructure, which is in charge of water and sanitation, energy, transportation and housing;
• The Ministry of Agriculture;
• The Ministry of Finance and Economic Planning;
• The Ministry of Foreign Affairs which is in charge of international cooperation and mobilization of donors;
• The Ministry of Disaster Management and Refugee Affairs.
• Projects, Commissions, National institutions such as REMA, NAFA, RADA, RHODA, RDB and RARDA.

(ii) Mechanisms for consultation and coordination of actions

Consultation between projects and programs of the national action plan for adaptation to climate change is a necessity; but it will only be viable if all stakeholders (Government, development partners, civil society, beneficiaries) give it credibility as a forum for information exchanges/sharing and joint research on the harmonization of interventions. This harmonization should take place both at the rural community level and at the level of district, province and country.

To ensure the smooth functioning of the consultation frameworks, it is necessary to

clarify the statutes, objectives, membership, organization and operation which will govern them.

(iii) Financial mechanisms

In the context of financial resources mobilization for the implementation of national action plan for adaptation to climate change in the sector of water resources, Rwanda can opt for:

• The use of the National Fund for the Environment in Rwanda and the National Forest Fund;

• The exploitation of traditional sources of funding (budget development, NGOs).

CONCLUSION

Under the effect of global warming, we should expect to face an increasing number of effects of the impact of climate change in Rwanda, namely, those related to the fall of water level of rivers and lakes, floods, landslides , erosion, droughts, ... making community life conditions more precarious and unstable in vulnerable areas.
It is thus in this context that a national action plan of adaptation to these various natural and human disasters is indispensable, to ensure better living conditions for people in vulnerable areas and contribute to the overall development of the country.

For this plan to be successful there will be a need to put in place an efficient monitoring and evaluation system in order to correct and orient actions undertaken in the context of the national action plan for the adaptation to climate change in the sector of water resources.

4.3. Agriculture

4.3.1 Current situation of agricultural sector

Since the 80s, Rwanda's agricultural sector faces a unique set of constraints. Because of its high population density, land is still insufficient, while most farmers practice mostly rain fed agriculture. Soil fertility has deteriorated with the demographic pressure on land while the use of organic and non organic inputs remains very low. In addition, much of the land in Rwanda is at high risk of erosion due to its mountainous terrain with steep slopes. These physical and socio-economic characteristics of the country are compounded by variability, seasonal as well as inter-annual climate changes.

In order to remedy this situation, the agricultural policy encourages changes in production techniques for agriculture to move from subsistence to market based agriculture, through more

promising modern agricultural techniques. The country has undertaken an intensification strategy in which the emphasis is put on a number of strategic food crops of high value such as rice, maize, beans, potatoes and wheat as well as fruits and vegetables.

The current focus is to accelerate and promote increased use of inputs and modern techniques for crop and livestock production**;** efficient use of land and water including rainwater harvesting and irrigation on hills; marketing of agricultural products, and capacity building in the areas of research and extension services.

With Vision 2020, the Government of Rwanda intends to develop and adopt agricultural policies based on watering projects in villages and intensive agroforestry projects in irrigation for cereal crops that consume a small amount of water and managed by traditional socio-political structures. These policies have the dual purpose of restoring the biomass protection cover, in desertified and degraded soils and reduce drought that causes migration to urban areas. Thus, the activities planned are as follows**:**

- 60,650 ha of marsh shall be developed and used for rice and other crops;
- 156 ponds and 22 underground storage reservoirs shall be built in the country for a small-scale irrigation;
- 45,360 ha of land on hills shall be developed for irrigation.

The table below shows the projected activities in the area of rain water collection and irrigation on hills (2009-2020).

Table 59**:** Intended activities in case of rainwater collection and irrigation on hills (2009-2020)

STRATEGY	**ACTIVITIES INTENDED**	**COMPLETION PERIOD**
INVESTMENT IN ACTIVITIES ON HILLS	**120 Ha** on hills shall be under irrigation system	End of 2009
	240 Ha on hills shall be under irrigation system in Bugesera District	End of 2009
	According to EDPRS objectives**, 3000 Ha** on hills shall be under irrigation system	End of 2012
	According to the objectives of vision 2020**, 10000 Ha** on hills shall be under irrigation system	End of 2020
	Development of irrigation Master Plan	The Irrigation Master Plan shall be developed for the country in 2010

In the area of rainwater collection and irrigation, constraints and weaknesses met are as follows:

- Some farmers seem to neglect the integration of agriculture and livestock while waiting for RADA to continue providing them with non refundable modern inputs;
- Some associations of water users are not working properly because of lack of cooperation of involved parties. Others do not timely and regularly maximize the use of water in the valley-dams;
- Lack of qualified technical personnel in managing water resources in some areas and financial resources in particular;
- Insufficient knowledge in planning irrigation projects at the national level;
- Lack of meteorological and hydrological data and reliable data on water in general;
- Insufficient operational practices and maintenance;
- The weight of traditional agriculture (without sufficient inputs and irrigation practices and measures for adequate conservation and soil fertilization) can not alone generate enough income to justify the installation of irrigation infrastructure and the investment in operation and maintenance;
- Issues of land ownership (land conflicts and the very small scale land production do not encourage farmers to invest in water and land management);
- Scarcity of plains suitable for irrigation in the country except the plains along the rivers Nyabarongo-Akagera and Muvumba in the East Province.

Given these constraints, the following solutions are proposed by the Government**:**

- Educate local authorities to encourage farmers on the importance of using harvested rainwater and modern inputs (improved seeds, pesticides and fungicides) to increase production;
- Regularly train farmers and District agronomists on the use of collected rainwater, and modern inputs, etc

4.3.2. Climate vulnerability on agriculture and food security

Methodology

Due to lack of certain necessary data to launch pilot programmes such as DSSAT and SPUR, this study gathers only the information on activities already accomplished by the Ministry of Agriculture and Animal Resources (MINAGRI) since the publication of the initial national

communication under the UNFCCC.

Climate vulnerability in agriculture

In recent years it has been noticed that there is a shift in growing seasons A (September-November) and B (March-May); however the climate vulnerabilities observed remain almost unchanged in the same regions identified in both the Initial National Communication and the NAPA Report (National Action Programmes for Adaptation to Climate Change). 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.
Drought is the mostly encountered shock in the South-Eastern part of the country where it appears as the major factor of vulnerability. In this region, the decrease in annual rainfall from 1000 mm to 700 mm as well as prolonged and cyclical droughts lead to food insecurity and displacement of communities.
The National Institute of Statistics of Rwanda, in collaboration with the Ministry of Agriculture and Livestock, often 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 by 7% and 4.6% respectively, and the underweight representing 15.8%. Droughts and erratic rainfalls affect 60-90% of households particularly in the districts of Bugesera, Nyanza, Gisagara, Huye, Rusizi-Nyamasheke, which caused a rise in 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:

- The Eastern Plateau with 5**%** of the affected population has experienced rainfall of approximately 53.3**%** of the average annual rainfall in normal times;
- The region of Bugesera with 4.8**%** of the affected population experienced 30% of the average annual rainfall in normal times.

The 2009 assessment**,** presents a different trend (extreme rainfalls**)**, with three regions namely the Congo-Nile crest, the eastern edge of Lake Kivu and the South East being the most vulnerable
(map**,** Figure 29**).** Such trend is explained by the fact that western regions and the Congo-Nile Crest have experienced extreme rainfall causing soil erosion and floods that have had more significant impacts than in other regions. These regions are usually characterized by degraded soils due to constant erosion accentuated during abnormal rainy seasons**.**

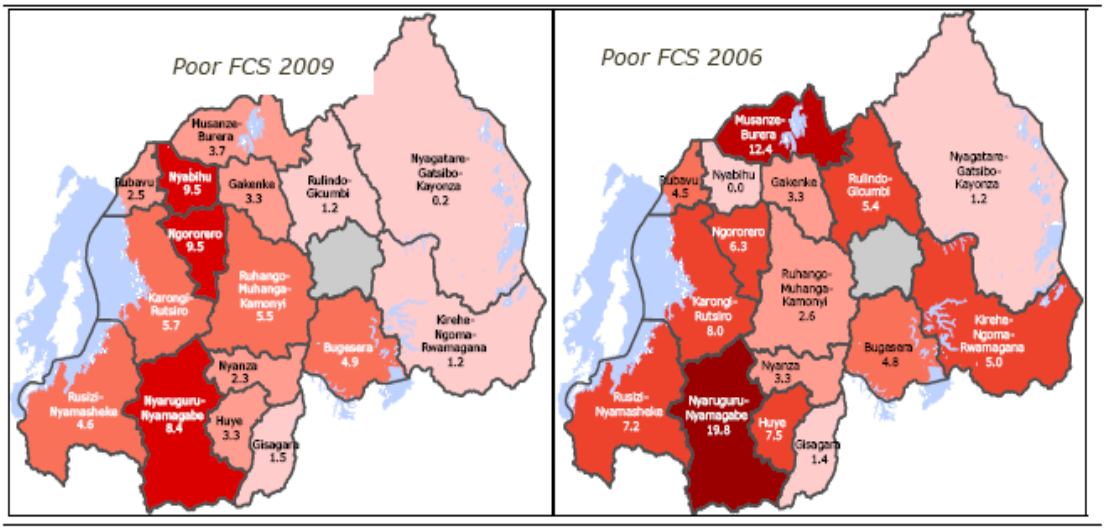


Figure 32: Food insecurity per district in 2009

Source: CFSVA, 2009.

This map shows that in terms of food insecurity**,** Rwanda has five regions, the most vulnerable being 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.

Climate vulnerability in the area of livestock and fish farming

According to climate scenarios for Rwanda**,** air temperatures are expected to increase by 1 to 3^{o}C by the year 2100**.** This shall have several following implications:

- Shift of wet and dry seasons leading to 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 exploited for fishing.

4.3.3. Projection of agricultural production from 2000 to 2100

Although we did not use the DSSAT model**,** we used its coefficients in an attempt to make the projection of agricultural production. The latter seems to show**,** among the major selected crops**,** a large increase in acreage for grain and a slight increase in the acreage for groundnuts. However**,** if temperatures continue to rise, the expected production may decline unless irrigation is maximized**.** The results provided in the table 59 below are somewhat questionable because they do not indicate a simultaneous growth and reduction of cultivated land, agricultural land assumed being constant**.**

Table 60: Annual growth rate estimates for acreage under cultivation

TYPE OF CROPS	2000	2001-2010	2011-2025	2026-2050	2051-2075	2076-2100
CEREALS						
ANNUAL GROWTH RATE (%)		0.9	0.7	0.4	0.3	0.3
SCENARIO OF CULTIVATED ACREAGE (000 ha)	263,248.000	289,309.552	319,687.055	351,655.760	378,029.942	406,382.188
RICE						
ANNUAL GROWTH RATE (%)		0.9	0.7	0.4	0.3	0.3
ACREAGE OF CULTIVATED LAND SCENARIO (000 ha)	4,266.000	4,688.334	5,180.609	5,698.670	6,126.070	6,585.525
GROUNDNUTS						
ANNUAL GROWTH RATE (%)		0.9	0.7	0.4	0.3	0.3
SCENARIO OF CULTIVATED ACREAGE (000 ha)	333,205.000	366,192.295	404,642.486	445,106.735	478,489.740	514,376.470
NB: Annual growth rate FAO (1993) according to lecture notes of Joel Smith, 1994.						

Table 61: Database on crops (1971-2000)

TYPE OF CROP	**CULTIVATED ACREAGE (000 ha)**	**HARVESTED ACREAGE (000 ha)**	**YIELD Kg/ha**	**PRODUCTION (000 Tons)**
CEREALS				
SORGHUM	174,195.0		890.0	155,106.0
MAIZE	89,053.0		702.0	62,502.0
TOTAL CEREALS	**263,248.0**	**0.0**	**1,592.0**	**217,608.0**
RICE				
MARSH	4,266.0			11,564.0
IRRIGUATED	**30,000.0**	**20,000.0**	**4,265.0**	**127,953.0**
TOTAL RICE	**34,266.0**	**20,000.0**	**4,265.0**	**139,517.0**
VOLUBLE	**333,205.0**		**646.0**	**215,347.0**
TOTAL CROPS	**630,719.0**	**20,000.0**	**5,707.0**	**572,472.0**

Table 62: Projections of production in MT (Scenario from 2000 to 2100)

Crop	**2000**	**2001-2010**	**2011-2025**	**2026-2050**	**2051-2075**	**2076-2100**
Maize	217608	256385.746	322533.268	386233.588	467342.642	565484.597
Rice	11564	15252.916	20400.775	27898.060	33198.691	39506.443
Groundnuts	215347.000	279068.177	374090.892	534949.975	617867.221	713636.641

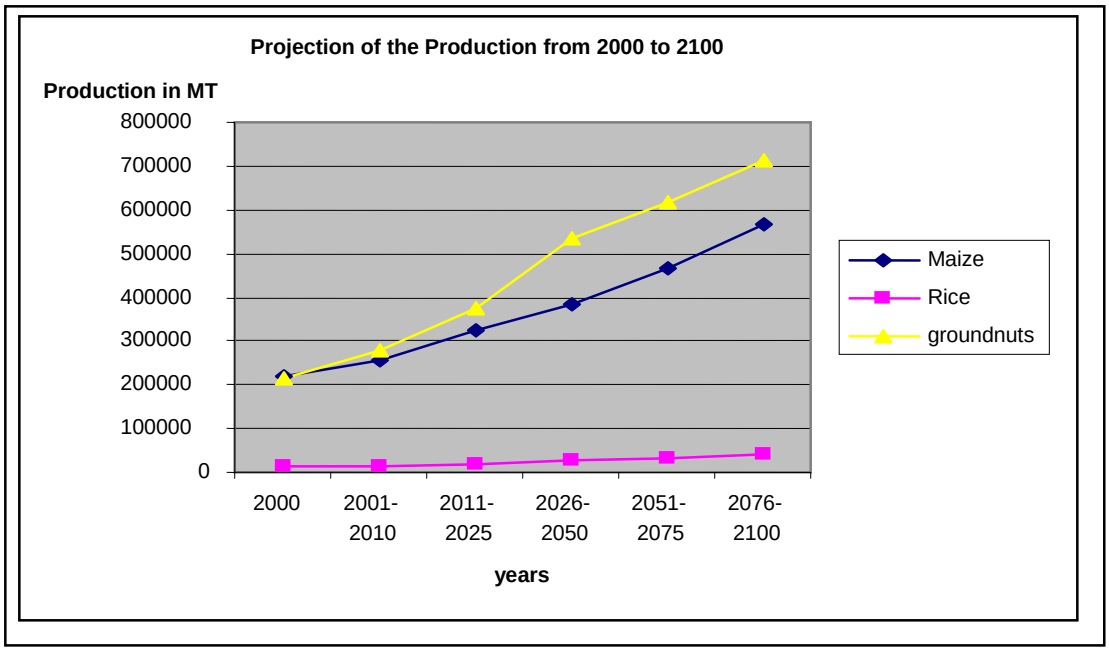


Figure 33: Evolution of the Production from 2000 to 2100

4.3.4. Adaptation to climate change adopted by the Government of Rwanda in the areas of agriculture, livestock and fish-farming

NAPA (2004) suggests immediate and urgent actions to be undertaken in different socio-economic sectors of the country**.**

In agriculture**,** the following priorities were identified**:**

- Integrated management of water resources ;
- Establishment of information systems, for hydro-agro-meteorological warning and rapid intervention;
- Promotion of income generating activities other than agricultural ones;
- Promotion of intensive agriculture;
- Introduction of crop varieties resistant to environmental conditions;
- Development of alternative energy resources to replace fuel wood.

The EDPRS 2008-2010 incorporated NAPA priorities and the following strategies and actions were developed:

- Diversification and intensification of crop production, livestock and fisheries;
- Organization, mobilization and capacity building for farmers and professional organizations;
- Promotion of gender approach and reduction of vulnerability of disadvantaged groups;
- Diversification of sources of incomes and employment for rural communities;
- Linkage of production with the market and integration of the agricultural economy in the national and regional economy;
- Capacity building for service providers, privatization and promotion of private sector;
- Sustainable water and land management as well as natural resources;

- Creation of an enabling environment for productive investment, entrepreneurship and employment development in agribusiness.

As part of this study, below are strategies for adaptation to climate change that might be explored by the Government in different sectors

Agriculture

- Investment in early warning systems and seasonal forecasts;
- Development of early varieties (maize, beans, cassava, soybeans and potatoes) that give high yield and are resistant to drought, diseases and harmful insects;
- Introduction of technologies and improved methods in agriculture such as irrigation on the hills and use of non organic and organic fertilizers and change in sowing dates following the displacement of current growing seasons;
- The Crop Intensification Program (CIP) intends to cultivate 150,000 ha during the growing season 2010 B east and north of the country;
- Introduction of vegetable gardens at the household level.

Animal husbandry

- Adopt stall feeding and provide a cow per family to produce organic manure;
- Develop small livestock (goats, sheep, rabbits and poultry) for the production of meat;
- Apply modern agriculture by introducing animal traction.

Fish-Farming

- Protection of the aquatic areas and wetlands by prohibiting farmers from growing crops within 50 m from the lake shores and within 10 m from the banks of rivers in order to avoid sedimentation due to crop growing on hill slopes.
- Introduction of adapted species of fish in lakes, ponds and rivers.

Soil Conservation

- Planting of trees;
- Practice of agroforestry;
- Practice progressive and radical terracing according to the nature of the ground.

Up to 2020, the Government has set a target program to make radical terraces on 80% of arable land. Currently 6.2% are already developed (Source: RADA). All progressive terracing must be transformed into radical terraces where it is practicable to fight against erosion, landslides and floods. One hectare of radical terraces can easily produce 25 tons of potatoes.
The table 62 below gives in details the list of measures and adaptation strategies underway recommended

Table 63: Examples of adaptation measures to climate change in the sector of Agriculture

Sector	Adaptation strategies
Agriculture	-Improved soil conservation techniques especially in highlands (North-West Rwanda and in areas of Congo-Nile Crest) and introduction of agroforestry; -Introduction of new crop varieties, especially early, resistant and adapted to climate; -Use of improved technology in agriculture (e.g: crop irrigation) and intensification of the dissemination of information and techniques serving as a link between the researcher and the farmer; -Promotion of income generating and mutual development activities; -Training of farmers grouped in associations and cooperatives.
Animal husbandry	-Promotion of animal husbandry in stalls; -Development and exploitation of modern pastures; -Improvement of conditions for feeding and watering; -Fight against contagious animal diseases and development of health surveillance; -Promotion of dairies; -Support to veterinary research and animal husbandry; -Revival of the livestock –beef line; -Support to organization of professionals in the livestock sector; -Support to privatization of the zoo-veterinary profession. -One cow per household
Fish Farming	- Protection of water resources and aquatic ecosystems; - Promote integrated fish farming through the development and implementation of integrated development plans of watersheds and the use of fish –farming techniques with high yield,; - Restoration of fish stocks; - Protection and Biodiversity;-Development of private initiative and professionalization of the sector fish.
Soil conservation	-Integrating efficient methods of erosion control, restoration and improvement of soil fertility adapted to the environment and socio-economic conditions of beneficiaries; - Collection of rainwater to keep it on the farm and concentrate it on the root zone to meet the highest crop water needs; -Work out an integrated management plan at the watershed scale that takes into account the peculiarities of family farms; - Put in place land-flow zones that will limit the speed of water flow, facilitate derivation when the water is abundant and stabilize works located downstream.

Table 64: National action plan for adaptation and implementation in agriculture

Objectives	**Expected results**	**Indicators**	**Activities**	**Period**	**Institutions responsible**	**Estimates in RWF**
1. Develop irrigation techniques	Irrigation on hills is practiced in vulnerable regions.	Number of hectares with irrigation on hills	-Increase irrigation practices on hills in vulnerable zones -Develop marshlands	2011-2013	MINAGRI	BD MINAGRI
2. Improve soil conservation techniques	Erosion control is practiced in highlands	Erosion control is carried out at 70%	-Sensitize the population on practices of soil conservation -Build big holes on hills to retain water for agropastoral activities -Create and exploit radical terraces	2011-2014	MINAGRI/ RADA	BD MINAGRI
3. Help poor population	A rapid warning system is put in place	Food security is improved	-Distribute early and resistant seeds (beans, maize, soybeans cassava cuttings) –Distribute small livestock (goats, poultry) -Educate communities on irrigation in marshlands.	Indeterminate	MINAGRI, MINALOC, FAO	BD MINAGRI, MINALOC, MINICOM
5. Strengthen the hydro-agrometeorological information system.	Regular warnings on climate manifestations	Number of climatological bulletins published per year.	Rehabilitate and equip equitably 150 stations meteorological stations in climatic regions	2011-2013	MININFRA	BD MINAGRI
		Number of hydrological directories published per year	Rehabilitate 80 hydrological and limnimetric damaged stations	2011-2013		
		Number of publications of hydrometeorological	Involve media in the publication of hydrometeorological data especially in vulnerable	2011-2013		

		data in the media each month.	regions.			
		Number of experts working at the national meteorolog ical service	Recruit and train qualified personnel for the National meteorological Service	2011-2013		
		5 thematic maps showing vulnerable regions are developed and updated each year.	To make maps of climate phenomena in regions with high climate risks	2011-2013		

Conclusion and Recommendations

Since the 80s, the country's agricultural sector faces a series of unique constraints. Because of a very high population density, the land remains insufficient, while most farmers mostly practice rain fed agriculture. Soil fertility has deteriorated with the population pressure on land while the use of organic and non organic inputs remains very low. In addition, lots of land in Rwanda is at high risk of erosion due to its mountainous relief with steep slopes. These physical and socio-economic characteristics of the country are accentuated by the variability of seasonal and interannual climate change.

In order to remedy this situation, agricultural policy encourages changes in production techniques for agriculture to move from subsistence to market oriented agriculture through the use of modern agricultural techniques that are promising. The country has then undertaken a strategy for the intensification in which the emphasis is placed on a certain number of strategic food crops with high value such as rice, maize, beans, potatoes, wheat, fruits and vegetables.

Because of unpredicted climate conditions, positive projections made on the production from 2000 to 2100 are likely not to be achieved. With the current phenomena of climate change in Rwanda especially during the growing seasons, sometimes production is declining or increasing. In fact, in terms of climate vulnerability in the agricultural sector, it has been noticed in recent years, that there is a shift of growing seasons A (September-December) and B (March-May). The short dry season (mid-December - mid-February) seems to disappear as demonstrated by the

continuity of rain until the first ten days of May. This presently causes the delay of Season B.

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

A rapid intervention which could be done would be to review the beginnings of seasons**,** determine water needs for crops per growing season and agrobioclimatic region**.** A sensitization of farmers by advisory extension services is a priority for improving production and livestock systems

In the terms and conditions, it had been recommended to use the DSSAT program to make projections on production until the year 2100**.** Unfortunately this did not happen due to lack of data to launch the program and ignorance of alternative solutions**.**

To improve this situation, the following recommendations are proposed:

- Put in place a database on production jointly with the Ministry of Agriculture, the Ministry of Environment and Lands and the Institute of National Statistics of Rwanda;
- Continue the rehabilitation of all meteorological, climate and hydrometeorological stations and make systematic observations in accordance with the WMO standards;
- Recruitment and training of qualified personnel;
- Training of national experts on the use of programs such as the DSSAT Model;
- Finalize the soil map of the country and avail the necessary soil data.

4.4. Forests

The vegetation cover, which was important in the 1960's:658500 ha (MINAGRI, Direction des Forêts, 2001), has been reduced over the years and reached 240746 ha in 2007(National forest Inventory by NUR- CGIS & MINITERE).Such loss is estimated to 63% of the 1960's forest cover. If nothing is done to stop this situation, this will lead to the total extinction of the Rwandan forest cover leading to negative consequences. We are therefore obliged to take corrective and preventive measures to fight against this blight due to deforestation and climate change.

For the development of this work, the use of the WINGAP MODEL and HOLDRIDGE MODEL is recommended to predict future trends . Unfortunately, due to lack of required data it was not possible to apply simulation models and estimate uncertainty as recommended by IPCC guidance.

4.4.1. Vegetation types of Rwanda

Rwanda is characterized by 17 vegetation types of which the main six are the following:

- Montane rain forests in the western Province (Cyamudongo, Gishwati, Mukura and Nyungwe) found at 1500-3000 m,
- Degraded montane forest around Cyamudongo, Gishwati, Mukura and Nyungwe forests found in Western Province at 1500-2000 m;

- Grass savannas with *Brachiaria platynota* and different types of crops in the Central plateau found at 1600-2000 m;
- Low altitude savannas with *Themeda triandra* and *Hyparrhenia filipendula* with zones of *Loudetia simplex* and xerophyllous forest on hill slopes and mesophyllous forest in the valleys of East and South Provinces (Akagera, Amayaga, Bugesera and Umutara) at an altitude of 1300-1600 m ;
- Medium and high swamps found at 1300-2500 m and ;
- Alpine and sub-alpine volcanic vegetation found at 3000-4500 m.

4.4.2. Major dominant tree species

In Rwanda, forests provide many wood and non-wood products and other services of direct benefit to people. Rwandans use wood for diverse purposes: source of firewood, charcoal, timber, and furniture among others.

Trees and shrubs are also a valuable resource because of their remarkable role in the improvement of our well being: living environment, soil productivity, climate amelioration, water source protection and carbon dioxide sequestration …

In Rwanda it has been revealed that *Eucalyptus spp.* and *pinus spp.* are two major socio economic tree species while in agroforestry, *Grevillea spp.* comes on top.

In order to assess vulnerability to climate change of forests and forestry, we chose these 3 tree species to predict the future trends. It is evident that the mismanagement of these species with multiple purposes may cause remarkable negative effects on human beings and especially affect forests.
On the other hand, vulnerability to climate change can be observed if these species do not grow, or if they shift from one zone to another, due to climate variability and change.

4.4.3. Vulnerability Assessment to Climate Change of Forests and Forestry

Forests are subject to many pressures resulting in changes to their structure and composition, as well as their function which are not only driven by climate, but also by socio-economic factors. On the other side, political factors have an impact on land use and land use change.

Under the conditions of future climate change, the precipitation depth and distribution as well as the high evapotranspiration during the vegetation period will limit the existence of bioclimatic conditions of these three tree species in the lower zones (planar and collinear zones). Opposite to that situation, in the high altitude zones, other factors such as extreme winds and floodswill affect forests. Forests are influenced by climate and influence climate in return. The effect of forests on the climate occurs directly at both local and regional scale, through their characteristic pattern of absorption of solar radiation, evaporation of water, and surface roughness, and also indirectly at the global scale through the carbon which they store or release(UNEP/IVM Handbook of forest).

In Rwanda, factors deteriorating the forests and forestry vulnerability to climate change are the following:

- A shift in the geographical area which favors forests' growth: This factor is only driven by climate. According to the scenario, we observe that Pinus will disappear in the highlands (in 2100).
- Inadaptation: the change in climate will be of high magnitude and forests will not cope with it. For instance there will be some seeds which will fail to germinate in some regions.
- Forest diseases: unfavorable climatic conditions will become the cause of weakening and diseases of forests. For instance, in low lands high temperatures will decrease the air entry potential in the soil, a cause of root diseases.
- Anthropogenic stress: due to the disturbance in climatic conditions, population will be exposed thus take refuge in forests, exploiting their products and services, reducing the area covered with forests, degrading species composition, decreasing forest reserves and productive capacity, and modifying the forest age composition.
- Fires: Drier conditions will result in increased fires and losses in biomass and soil carbon. As the temperature will increase along the years, we expect fires as it has been the case of Akagera National Park, Nyungwe National Park (because of Bee keeping farmers) and recently in 2010 the Volcano National Park.

- Actions of abiotic noxious agents (Extreme winds, floods and drought ...): In Rwanda, supramontane forest areas in the North and West provinces constitute the most threatened areas. Ecosystems bordering the region in question are averagely endangered (plantations).
- Actions of biotic noxious agents – insects: Among biotic noxious agents, Folivoracious and subcortical insects prevail in the planar and collinear areas. This was the case of Bugesera in the years 1998 -2002, due to the increasing temperature and low humidity of soil, favourable for the growth of noxious insects in this region.
- Forest cover disappearance: the change in climate will lead, to the rise of air temperatures, soil desiccation and drop in rainfall on one hand, while on the other hand it will threaten forests and lead to land degradation, soil erosion and landslides.

These changes will have effects on the economic and social systems which depend on forestry: loss or gain of the sector turnover, export earnings, jobs, and access to fuel wood, construction materials, and forest products. They will also have consequences on the species dependent on forests and ecosystem services such as the maintenance of steady and clean water supplies. These changed bioclimatic conditions will threaten the structure of the existing communities and the occurrence of tree species, especially *Grevillea*, Pine tree and *Eucalyptus.*

The tables below show savannah trees behavior in low and high altitudes. The three species in question can be favorable in the high lands because their growing temperatures (*Pinus* 19 – 21^{o}C, *E. maidenii*: 18 – 22 ^{o}C, *E. globulus*: 12 – 18 ^{o}C) are within the range of growing temperatures. Thus *Grevilea* (14 – 30 ^{o}C) will not be affected even in medium and high altitudes.

According to the temperature variations over the years (2010 - 2100), there will be no significant shift in forest distribution because many species will remain in the range of their growing temperature. However, other factors such as inadaptation, forest diseases, fires, forest cover disappearance, actions of abiotic noxious agents**,** which lead to forest vulnerability must be monitored and controlled.

Table 65: Low altitude savannah (Akagera, amayaga, Bugesera and Umutara)

Years	2010	2030	2050	2075	2100
Max. Temp in °C	26.7	27.4	28	28.7	29.2
E. camaldulensis Growth range 22 – 41°C	Favorable	Favorable	Favorable	Favorable	Favorable
Grevilea Growth range 14-30 °C	Favorable	Favorable	Favorable	Favorable	Favorable
Pinus Growth range 14-22 °C	Not favorable (Forest shift)	Not favorable (Forest shift)	Not favorable (Forest shift)	Not favorable (Forest shift)	Not favorable (Forest shift)

Table 66: High altitude (Buberuka, lava zone, congo nile crest)

Years	2010	2030	2050	2075	2100
Max. Temp	20.2	20.7	21.3	22	22.5
E. maidenii Growth range 18 -22 °C	Favorable	Favorable	Favorable	Favorable	Favorable
Grevilea Growth range 14-30 °C	Favorable	Favorable	Favorable	Favorable	Favorable
Pinus Growth range 14-22 °C	Favorable	Favorable	Favorable	Favorable	Not favorable

4.4.4. Strategies and national action plan for adaptation and GHG mitigation in the sector of forest

It is evident that neither adaptation nor mitigation alone can avoid all climate change impacts. Adaptation and mitigation can complement each other and together can significantly reduce the risks of climate change.

This includes the following strategies: forestation; reforestation; forest management; reduced deforestation; harvested wood product management; use of forestry products for bioenergy to replace fossil fuel use; tree species improvement to increase biomass productivity and carbon

sequestration; improved remote sensing technologies for the study of vegetation/soil, carbon sequestration potential and the mapping of land use , land use change.

The table below shows the proposed action plan to implement the adaptation and mitigation options in forestry sector. It is important to know that many of these actions are ongoing and will succeed because of the high political will. Indeed, they are embodied in different development programs (Vision 2020, EDPRS, VUP,) and the strategic plans of all involved institutions (MINIRENA, MININFRA, MINAGRI).

Table 67: Action plan for adaptation and GHG mitigation in forestry sector

Name of the measure/policy	**Objective and / or activity affected**	**Time horizon**	**Type of instrument**	**Implementing entity / entities**	**Possible barriers / Risks**
Soil stock protection	Increase of soil carbon stock (100% radical terraces)	2017	Regulatory	Environment Agriculture Administration	Decrease in forest plantations
Regulation and valorization of timber extraction	Reduction of permanently deforested area	2017	Regulatory	Forestry Administration	Low commitment of all partners
Afforestation of non forest area	Increase of GHG sinks	2017	Regulatory	Forestry Environment Agriculture Administration	-Budget -Natural disasters
Tree species composition change	Carbon sequestration in forest trees biomass (increase of carbon units stock) And enhancement of forest adaptability to climate change	2015	Technical	Forestry	Critical policies
Enhancement of alternative energy sources utilization other than the use of forest tree biomass	Replacement of fossil fuels based on renewable energy sources	2013	Regulatory and economic	Forestry Energy Administration	-Budget -No alternative sources of energy -infrastructure failure
Strengthening genetic and species diversity of forests	Enhancement of adaptability of forest ecosystems to climate change.	2015	Technical	Agriculture Forestry Education Environment ISAR IRST	-Budget -execution capacity -complex design (technical complexity)
Adaptation of extraction and production technologies to environmental requirements.	Reduction of permanently deforested areas	2015	Technical	Forestry Environment Education	-budget -infrastructure failure

Name of the measure/policy	Objective and / or activity affected	Time horizon	Type of instrument	Implementing entity / entities	Possible barriers / Risks
Changes of hydric influence of forests.	Regular control and evaluation of hydrological and climatic elements.	2017	Technical	Water Forestry RURA	-Government commitment/Political will
Enforcement of the existing laws	Raising public awareness	2013	Regulatory	Forestry Environment Administration	-Partnership failing to deliver
Research strategies and priorities, extension strategies and packages	Harmonize and strengthen agroforestry research and programs development	2013	Regulatory	Forestry, Environment, Education ISAR IRST	-Budget, -Strategic vision, planning and communication -Coordination failure

CONCLUSION AND RECOMMENDATIONS

The vegetation cover, which was significant in the 1960's (658,500 ha; MINAGRI, Direction des Forêts 2001), has been reduced over the years and reached 24,0746 ha in 2007(National forest Inventory by NUR- CGIS & MINITERE). This led to the loss of about 63% of this forest cover. If nothing is done to stop this situation, this will lead to the total extinction of the Rwandan forest cover leading to negative consequences. We are therefore obliged to take corrective and preventive measures to fight against this blight due to deforestation and climate change.

In Rwanda, Eucalyptus and Pinus and Grevillea are the main tree species recommended in agroforestry for their socio-economic impact. Thus, in order to assess vulnerability to climate change of forests and forestry, the three tree species were chosen to make projections.

Unfortunately, the recommended WINGAP and HOLDRIDGE models could not be used due to lack of sufficient data. However, under future climate change conditions, the height and the distribution of rains as well as the high evapotranspiration during the growing period will limit the existence of bio-climatic conditions of these three species of trees in lower areas (valleys and hills). On the contrary, in higher zones, other factors such as violent winds and floods will affect the forests.

In Rwanda, factors that worsen the vulnerability of forests and forestry to climate change are: a shift in the geographical area in favor of the forest, inadaptation, forest diseases, anthropogenic stress, fires, the activities of biotic (insects) and abiotic harmful agents (violent winds, floods and droughts), and loss of forest cover.

These changes will affect socio-economic systems that depend on forestry: loss or gain of turnover, export revenue, employment, access to fuel wood, building materials and other forest products. They will also have implications on species that depend on forests and on the role of the ecosystem in maintaining a regular supply of potable water. The change of these bioclimatic conditions will threaten the structure of existing communities and especially tree species, such as Grevillea, Pinus and Eucalyptus.

The biggest recommendation concerning the organizational framework is the creation of a national coordinating committee in agroforestry by the Central Government for policy design.

4.5. Health

4.5.1. Impact of climate change on human health

Rwanda is not immune to shocks and natural disasters related to climate since the beginning of the last century as noted by the IPCC experts and due to the increase in temperature on the surface of the earth.

One of the manifestations of these disasters is the impact they have on the health sector by causing transmissible diseases such as malaria, cholera and waterborne diseases as well as non transmissible diseases such as meningitis.

In 2008 there were over five million new cases of patient visits in Rwanda. From these consultations it was revealed that the main causes of patient visits were lung infections (34.1%), malaria (11.3%) and diseases related to poor hygiene (10.5%), which can largely be prevented by improving hygiene and behavior change (reference).

However, the main causes of mortality in the entire population are AIDS and its opportunistic diseases as well as severe malaria. The two diseases alone account for more than 35% of deaths. Among children under 5 years, lung infections, diarrhea, malnutrition and prematurity related also to malaria are major causes of mortality (reference).

The occurrence of these disasters increases with the prevalence of malnutrition among individuals usually victims of other shocks such as extreme poverty, chronic diseases, lack of arable land and lack of other sources of income (reference).

Malaria

Malaria continues to affect the health and the national development. Despite a significant reduction in malaria mortality and morbidity in 2007, malaria remains the second leading cause of mortality and is responsible for 23.27% of all deaths registered in the country, of which 11.5% were due to severe malaria (reference). While this disease is preventable and treatable, it particularly affects pregnant women and children under 5 years.

Given the fact that different scenarios developed by the IPCC Experts (projections up to 2080) predict a future rise of temperature and consequently the rise of malaria in the whole region (East Africa), it is therefore necessary to put in place an efficient preventive system in order to keep on benefiting from the current situation which is altogether positive. This implies that at the level of Rwanda and of the whole of East Africa, investments in the whole sector of health should increase in order to prevent the increase of malaria prevalence.

Material and human damages caused by erosion, floods and landslides

Erosion, landslides and floods are other disasters affecting human health due to climate change in Rwanda. Areas at high risk for floods and landslides are those with higher frequency of daily precipitations of more than 50 mm. These regions characterized by excessive rains are located in the mountainous provinces of North, West and South.

Such disasters have never ceased to cause loss of materials and human lives together with other negative consequences on agriculture production and the national economy in general.



Figure 34: Floods at Bigogwe, Nyabihu District, on 12th September 2007

As said before (**4.2. Water resources**), unexpected floods due to abnormal high rainfall caused important losses in Bigogwe, not only in human lives and infrastructures, but also in biodiversity.

Neglected tropical diseases

Infections of neglected tropical bacterial and parasitic diseases represent one of the largest economic and health burdens experienced by Rwandans. The mapping of these diseases indicated that 65% of Rwandans suffer from intestinal worms (soil-transmitted helminths, schistosomiasis, and filaria) (reference).This mapping has three layers:

- West: High prevalence: > 70%;
- East: moderate prevalence: between 70-50%;
- Center: Low prevalence: <50%

The Western Region has the highest prevalence because it is characterized by heavy rainfall, and more permeable soil which allows infiltration of water contaminated by pathogens that may survive given the conducive environment. A more detailed study

could analyze the quality of spring water in the region to assess its biochemical parameters and its level of potability.

Cholera

Cholera is a devastating disease and sometimes fatal caused by *Vibrio cholerae* bacterium which is usually transmitted through contaminated water. It causes an acute gastrointestinal infection with an incubation period of 2 to 6 days.

Experts in environmental health and climate change agree on the real causes of this disease The latter are related to the contamination of drinking water caused by harsh weathers (water deficits or excess rainfall), wars which lead to displacements and refugee camps without adequate sanitation, as well as poverty. That is why this epidemic continues to spread in Asia, the Middle East, Latin America and Sub-Saharan Africa including Rwanda.

While the first vulnerability assessment of the health sector (2004) pointed out the prevalence of cholera in the South-West and North of Rwanda following the contamination of drinking water by extreme rainfall, a recent evaluation (2006-2008) reports it also in other regions including the driest region in the East. An exceptional case was reported in the city of Kigali (reference).

According to the report from TRAC (2008) and WHO, cases of cholera in Rwanda are sporadic and have increased from 338 in 2006 to 894 in 2007 falling to 425 in 2008. If in 2006 there were no deaths, however, there have been 17 cases of deaths in 2007 and 20 deaths in 2008. The climate analysis shows that these cases correspond to dry seasons for Eastern Region with poor rainfall and to periods of flooding for Northwest parts whose precipitation is often higher than the national average.

Table 17: Synthesis on the types of diseases related to climate change

Diseases Categories	Diseases	Manifestation of climate phenomenon	Predilection region	The most affected Social categories	Current trend
Waterborne diseases	Malaria	Floods, heatwaves or high temperatures	The whole country especially: - East (1000-1500m of altitude) ;- Central plateau around wetlands (between 1675-1862 m of altitude).	- Children under five ; - Pregnant women	Decreasing
	Intestinal Parasites (Diarrhea)	Water contamination during floods, Lack of hygiene due to moisturedeficit following drought	The entire country but more specifically Eastern, Western and Northern regions (lava)	- Children under five years ; - Pregnant women	Stable
	Cholera	Floods ;water deficit	- Lake Kivu shore ; Lava Region; - Outskirts of Kigali City ; -Eastern Plateau .	All categories	Sporadic
Diseases related to heat	Celebro-spinal meningitis	heatwaves; high temperatures; Drought	Central Plateau and Eastern Plateau	All categories	Sporadic
	Cardio-vascular and cerebro-vascular diseases	heatwaves; high temperatures; drought	Eastern savannahs	Old people	Sporadic
Respiratory diseases	Acute bronchitis, Bronchiolitis	heat waves, drought	Entire country	All categories	Stable
Pneumonias		heatwaves, drought	Entire country	Children and Old people	Decreasing
Asthma		Heat, drought		Children , old people	Decreasing
Food insecurity	Malnutrition	Drought ; Floods ; Landslide	-Bugesera ; - Congo= Nile Crest ; - South of the	Children under five years	Stable

			Country ; - Eastern savannahs		
	Anemia	Drought ; Floods ; Landslides	Entire country : especially Kigali City and the Eastern Region	-Children below one year ; - Women	Progressive
Victims of floods and landslides.	Natural disasters	Floods; Landslides	North, West and South regions,	All categories of people living in houses perched on high fragile hills and valleys.	Sporadic

4.5.2. Public investment in the health sector and the impact of climate change on the national economy

Public Investment in Health Sector

The overall objective of public investment in the health sector is to improve financial access to health services. This helps to protect the community against financial risk and medical poverty trap. The proportion of the total budget allocated to MINISANTE (Ministry of Health)in relation to the national total budget has remained below 10% from 2002 to 2007 except in 2006 when it was estimated to 13%. The average growth rate turns around 5%.
As for individual expenditures, targets for public annual expenditure per capita allocated to health were estimated at $ 16 in 2009 ($14.1 in 2006 and $11.3 in 2008).

Impact of climate change on the national economy

The projections of the socio-economic scenario show a positive impact on GDP growth if one considers the GDP growth rate as well as the growth rate of its key sectors including: agriculture, livestock, forestry, fishing, electricity, water and sanitation, trade, services and transport.

If the natural population growth rate drops as expected from 2.7% in 2010 to 1.4% in 2100, the GDP growth rate remaining higher above 8% with more than 5.9% in agriculture and over 15% in the sector of services and industries, the evolution of GDP shall also remain positive. Nevertheless, the overall budget for adaptation will have to continuously increase to cope with the vulnerability of these sectors as a result of climate change.

4.5.3 Identification of the most appropriate adaptation options for health sector in Rwanda

It is possible to find adaptation measures against the phenomena of climate change that affect human health even if some of them are very expensive.

Moreover, some are already incorporated into national strategies currently under implementation (EDPRS Sector Strategies of Health Sector) others are carried out with little attention, while others are to plan afresh.

Table 68: Most appropriate adaptation options in the sector of health

Categories of diseases	Strategies underway	Strategies to enhance	New strategies or options	Observations
All categories of diseases	Increase the capacity of the community to subscribe to the systems of health insurance.	The hydro-agro-meteorological information warning system needs to be strengthened by: -The rehabilitation and the creation of new hydrometeorological stations, - Recruitment of sufficient staff in both quantity and quality for national meteorological service, - The preparation of risk maps that would allow mapping the areas most exposed to bad weather and advise in time people for not settling or undertake risky investments in such areas		At the end of 2008, 91% of the population were subscribed to health insurance systems at national level (including RAMA, MMI, and other private programmes). The National Meteorological Centre remains poorly equipped and less staffed in terms of human resources for collection, monitoring and publication of weather forecasting data.
	Institutionalization of an educational system, training and sensitization.			- Community health workers exist in all cells throughout the country and help the community to prevent the population against preventable diseases. - PHAST [5]and HAMS[6] programmes have been institutionalized in all health facilities and in all schools.
	Increase geographical accessibility to health			At the end of the year 2008, about 77% of the population

[5] Participatory Hygiene and Sanitation
[6] Hygiene and Sanitation in School Environment

Categories of diseases	Strategies underway	Strategies to enhance	New strategies or options	Observations
	services			would walk less than 5 km to reach a health centre (World Bank Rwanda Country Status Report, 2009).
		Capacity building for professionals in the health sector		The health sector does not have sufficient professionals specialized in environmental health.
Water borne diseases	The accomplishment of the MDG[7] No. 6: has been incorporated into the EDPRS, and is particularly implemented by institutions in charge of health sector, both national and decentralized institutions. - The use of impregnated mosquito nets, - The eradication of mosquito breeding sites, - Nationwide Mosquito control			-The first national strategy for malaria treatment is preventive, followed by the curative one to completely eliminate new infections caused by the *falciparum* parasite by 2013. However, the country will face the problem of proximity to neighbouring countries with high endemicity of the parasite. In 2009, 58% and 64% of children and pregnant women respectively were sleeping under impregnated mosquito nets.
		The use of improved latrines and culture of hand washing after using the toilet in households and all institutions.		Currently the majority of Rwandan households do not use improved latrines (55%) and hand washing after the toilet is also practiced at a very low rate: 34%.

[7] Millenium Development Goal

Categories of diseases	Strategies underway	Strategies to enhance	New strategies or options	Observations
Food insecurity	The accomplishment of MDG 1: Eradicate extreme poverty and hunger has been integrated in the EDPRS and will be implemented by all concerned institutions: agriculture, health, trade and business.	-Enroll all children in Childhood Development Centers (CDC) which integrate nutrition, health and education. - Disseminate vegetable gardens for every household in rural and urban communities. - Create non-farming employment in areas vulnerable to climate change affecting agricultural production. - Increase large scale irrigated agriculture. - Resume techniques for food storage, processing and preservation (food security stocks in each administrative sector).	- Launch an information system on agricultural markets and help farmers to join the circuit: production, processing, marketing. - Make regular monitoring of the state of malnutrition in each district and curb migration from the countryside to cities by creating new jobs in the most vulnerable regions	- Currently, the rate of enrollment in Childhood Development Centers is estimated at 3% and these centers are predominantly run by private organizations, the new policy commits the government to invest a lot to promote child development . - Currently the % of the workforce employed in the non-farming sector is 13%. This reflects a great pressure on agricultural land and the vulnerability experienced by people living on this profession in case of weather disturbances. - EDPRS is considering to increase the irrigated area from 15,000 ha in 2008 to 24,000 ha in 2012, but this should go hand in hand with the collection, preservation and use of rainwater collected on the roofs of houses or in the valleys-dams. - Currently, there are small units processing some food products such as cassava, maize, soybeans, and sorghum. As much as this is needed in the processing of most consumed foods like potato, sweet potato and beans.
Victims of floods and landslides		Encourage planned housing in urban areas that avoid floodplain areas and steep slopes at high risk of landslides. (Musanze, Nyamasheke, Rusizi,		Currently habitat in rural villages (Imidugudu) is 17% while urban housing in well planned areas is 15%. These rates, still very low, reflect the danger faced by people still vulnerable to disasters of

Categories of diseases	Strategies underway	Strategies to enhance	New strategies or options	Observations
		Nyabihu and Rubavu)		landslides, especially in the North West where the habitat remains perched on high fragile hills.

4.5.4 Conclusion and recommendations

Some vector-transmissible diseases are expected to be more frequent and more geographically widespread as a result of global warming.

According to a study on the effects of climate on infectious diseases in areas currently at risk (IPCC, 1997), a study based on a range of GCM scenarios, one must fear an epidemic potential increase of 12 to 27% for malaria and from 31 to 47% for dengue and lower rise of 11 to 17% for schistosomiasis.

The incidence of infectious waterborne diseases or related to water, already responsible for most epidemics in the region, should also increase as rising temperatures and humidity shall be added to the current conditions: population growth, urbanization, deterioration of water quality and other trends.

If the natural growth rate of population moves as expected from 2.7% in 2010 to 1.4% in 2100, the GDP growth rate remaining above 8% with more than 5.9% in agriculture and over 15% in the service sector and industries, the evolution of GDP will remain also positive. But the overall budget for adaptation will have to continuously increase to cope with the vulnerability of these sectors due to climate change.

CHAPTER V: OTHER INFORMATION CONSIDERED RELEVANT TO THE OBJECTIVE OF THE CONVENTION

5.1 Integration of Climate Change

In order to integrate climate change into national development plans, the NAPA (The National Programmes for the Adptation to Climate Change) report identified urgent and immediate priorities for adaptation, and is a guide document for policy orientation towards different economic sectors. It is within this framework that the sector strategic plans (SSP 2008 - 2012) incorporated the NAPA priorities in their respective domains. It is hoped that similar efforts are also made in the context of mitigating greenhouse gas emissions.

In November 2010, the Government, in collaboration with the Climate and Development Knowledge Network (CDKN) and Smith School of Enterprise and Environment at Oxford University, proposed a national strategy on climate change and development of low carbon emission. From this collaboration, support is expected in the four following areas: research, technical assistance, knowledge transfer and partnership. The aim of this project is threefold:

- Produce a report proposing a national strategy on climate change and development in low carbon emission.
- Build the capacity for Rwandans in terms of techniques for modeling the climate impact, aspects of data production, and the establishment of a climate observatory in Rwanda;
- Provide a framework enabling detailed sector based studies and put in place relevant plans.

5.2 Transfer of Technology

Although there are several causes of increased greenhouse gas emissions, some of them are altogether avoidable. This is the case of ignorance of the community in the field of technologies adapted to climate change. It is therefore necessary for the Rwandan government to train and educate the community about this type of technology and invest in it.

Among the means to reduce the negative impact, the government could prohibit the use

of outdated technologies and equipment, inefficient use of fuel and energy resources.

In addition the Government should not only put in place policies but also it should ensure proper implementation aiming at mitigating greenhouse gas emissions. It should also facilitate financial and technological opportunities for promoting the process of transfer of these appropriate technologies for the mitigation of greenhouse gas emissions and adaptation to climate change.

In Rwanda there exist already several priority areas in which it is possible to implement these measures. These include the sectors of energy, human settlements, agriculture and food security, waste management and water sanitation (Health), hydrology and water resources and industry.
Currently, the Government is trying to establish a special policy for energy saving based on existing appropriate technologies and at a low cost. It is in this context that it encourages making non electric braziers and improved furnaces with a low fuel wood consumption and that the technology of using electric braziers with charcoal waste was encouraged; and manufacturers of those braziers have been sheltered at the Don Bosco Kicukiro Technical School.

It is therefore important for the government to propose projects for adaptation to climate change and mitigation of greenhouse gas emissions in various sectors. However, the government is facing several obstacles including lack and insufficient local and foreign investments, inability to have modern facilities and insufficient technical know how for the implementation, maintenance and development of these new technologies.

Information on technologies for adaptation to climate change

As it is the case with many developing countries, Rwanda has had to face a severe energy crisis in the area of electricity. However, it is clear that with an efficient policy, Rwanda has managed to solve to a great extent this problem through the use of methane gas, low energy consumption light bulbs and especially the use of additional sources of thermal energy.

The latter solution was accompanied by a sharp rise in the price of KW/hr of electricity which does not allow the majority of the community to access it. This resulted in the community using wood as an energy source which contributes to deforestation and hence to the reduction of sinks of greenhouse gases. To cope with such a situation, the use of appropriate technologies for adaptation to climate change is necessary. These are technologies adapted to the socio-economic and environmental context of Rwanda, as the ones mentioned above.

These technologies affect the sectors of industry, energy, human settlements, transport, agriculture and food security, forestry, waste management and wastewater processing,

hydrology and water resources, terrestrial ecosystems and freshwater and finally health.

Other technologies are associated with behavior change in the consumption of imported products. These technologies are either currently in place in the country or they are proposed for initial use.

For most of these technologies, the main information available indicates cost estimates, the target group and eventually the means necessary for manufacturing some tools for adaptation or for the reduction of the impact of climate change. For each technology, there is a need to conduct surveys on environmental and socio-economic impact before it can be promoted in the community for use.

5.3. Research and Systematic Observation

Research as any systematic observation of data requires the existence of a highly qualified staff. Such personnel is found particularly in research and higher learning institutions be they public or private.

The oldest among them is the National Institute of Scientific and Technological Research (IRST/NISTR), the "Institut des Sciences Agronomiques du Rwanda" (ISAR) and the National University of Rwanda (NUR). It was only recently that other research units and / or Higher Learning Institutions both public and private were put in place (KIST, KIE, ISAE, UMUTARA / POLYTECHNIC, ULK, UAAC, UNILAK, INADES, etc..).

Although there are about 28 Higher Learning Institutions in Rwanda and 2 Research Centers (IRST and ISAR) no specific training is provided in the field of climate change. However, some lecturers and students close to that field (geography, agriculture, biology, applied sciences, etc.) write works (mémoires) and publish some articles in that field. This is the case of institutions such as UNR, KIE, KIST, ISAE UNATEK, etc.).As it can be observed, a need for higher specialized training is required.
Regarding publications, it is clear that there is a severe shortage of organs for publication. For the whole of Rwanda, only a few institutions of higher learning have scientific journals whose regularity in publication is problematic. These are: UNR, KIST, ISAE and the ULK.

Given such difficulties in research activities in general, it would be beneficial for REMA to get involved in this activity and seek collaboration form other Research and /or Higher Learning institutions. Such research activity could focus on the following points:

- Creation of a website specializing in climate change to be integrated into REMA website and moderated by trained personnel;
- Organization of systematic observations in order to provide a reliable database in different areas (meteorology, greenhouse gas emissions mitigation, vulnerability, adaptation and other information);

- Establishment of groups or teams of technical experts in various fields related to climate change and creation of a network of experts in climate change;
- Creation of Cultural Associations with interest in climate change and for research purpose in areas such as emission and reduction of GHG, vulnerability and adaptation, technology transfer etc .
- Creation of publication organs for the flow of scientific information such as newsletters, scientific papers (Professional papers) and scientific journals for articles;
- Establishment of national and provincial committees on climate change and a structure for coordination incorporating Government Departments, Institutions of Higher Learning, Research Centers, rural community leaders, teachers in secondary and primary schools as well as cultural associations etc . These national committees include the following national sub-committees:

✓ ▪ The sub-committee in charge of constituting the database. It would be responsible for coordinating data sources, including data on climate (temperature, precipitation, winds ...) and hydrological (liquid and solid discharges, staget-discharge relationship, water balance of rivers). In this context, it would be beneficial and less costly to make of schools parallel centers for collecting such data using teachers of geography and science on the spot (additional information). This measure would be in the same direction as that of the 2010 program of meteorology which consists of rehabilitating several climatologic and agrometeorologic stations. It should be the same for hydrological services;

✓ The Sub-Committee in charge of Research in Higher Learning Institutions would, inter alia, be responsible for establishing:

- -lists of dissertations, theses, publications and scientific papers produced in various Institutions,
- -documented list of dissertation topics as well as the list of potential supervisors; -coordination of research activities;
- -schedule of public lectures and seminars to be held during the year;
- -the list of trainings on methods and techniques for research on climate change;
- -the list of potential donors for research in climate change;

✓ The Sub-Committee for the Coordination and publication will be responsible for:

- establishing the list of researchers and publications;
- organizing annual national and provincial conferences;
- report on the research status on climate change;
- Promoting research on climate change through dissertation research funding, scholarships and awards (best dissertations, theses, conferences,to be published in ad hoc journals);

- list Cultural Associations per research interest (GHG reduction, Vulnerability, Adaptation, Technology Transfer).

Collection systems and meteorological databank in Rwanda

Meteorological service has a large historical databank (managed by CLICOM climate software) dated as back as 1906 and from more than 50 stations which were operational before 1994. After that date, only a few stations were put back into service between 1998 and 2000 for civil aviation purposes. Unfortunately, much of this data is not yet computerized and is still consulted from technical documents.

Indeed, the meteorological service currently operates very slowly due to lack of sufficient staff and facilities needed for collecting, entering and processing data.

Since it resumed operations after the 1994 war, the service has not yet updated climatologic and agrometeorologicl directories and no single newsletter was published. Thus, updated data, necessary for different users in their routine activities is lacking. Currently, there is a plan for rehabilitating the climatologic network system and recruiting staff.

Collection systems and hydrological databases

As in the case of meteorology since 1994, hydrological stations, which numbered 47 have almost all disappeared. This means that gauging liquids and solids is no longer carried out at the hydrological centre. The latter is currently a component of the department of "Strategic Planning and Policy in the Ministry of Environment and Lands.

5.4. Information on Research Programmes

In Rwanda, as it is the case in many developing countries, research activities are less developed due to lack of adequate infrastructures, highly qualified staff and funding. Nevertheless, some Research and / or Higher Learning Institutions manage to carry out some research activities. Find below those which have in their programmes research projects on climate change:

- KIE: Research Project on Prevention of hydrogeologic risks in Rwanda;
- KHI: Research project on the collection of rainwater in the N-W zone of the country;
- ISAR / UNR: Research Project on Capacity Building of ISAR on adapting agriculture to climate change and policy recommendations;

- KIST: Research project on adaptation to climate change in the sector of energy in 2009 (UNEP & IIED).

5.5. Education

Education plays a very important role in the development process especially in the dissemination and assimilation of information including information on climate change.
Unfortunately, it is clear that school as well as academic programmes make no direct reference to issues of climate change. It is therefore imperative to incorporate these courses in all curricula right from Primary to Higher Education. The following is a proposal of educational programmes to provide.

Content for Primary Schools

The goal of primary education is to lead pupils to learn about the existence of certain elements of the physical and human environment.

This is generally a simple listing and brief description of the facts. Education on climate change should therefore be taken into account and present the following progression:

- At the lower Primary school stage, education on climate change should be carried out in the form of vocabulary using pictures of isolated facts such as biomes, climate, aerosols and atmosphere, water base levels (general and local), erosion and erosion control, towns and villages, technological change, natural disasters, energy sources, technologies in relation to climate change, water-borne diseases, etc.
- In Upper Primary School, as the curriculum should consist of an introduction to earth space exploration, using ground observation, manuals, plans, maps and photos, etc… It would be good to move to practical aspects such as: field observation, and reading them on maps showing diverse climatic zones.

Content for secondary schools

In ordinary level, the program introduces aspects of the environment conservation, environmental degradation (deforestation, poaching, land degradation, overgrazing, industrial waste, etc.), at this occasion pupils will be taught the relationship of cause and effect in relation to climate change as well as the importance of protected areas on climate (national parks, natural forests and galleries). At this level, it would be good to introduce:

- the concepts of equilibrium and disequilibrium of the environment;

- causes, consequences and manifestations of climate change in the environment; and
- finally the measures for adaptation.

At upper secondary level, as the emphasis is put on human activities, it would be good not only to link those activities to the causes, consequences and manifestations of climate change in the environment but also study:

- the composition and the general atmospheric circulation with emphasis on the unicity of between the air at the surface on earth;
- the EN SO-La Nina events;
- greenhouse gas emissions, their sources and sinks as well as the ozone hole;
- changes in baseline levels of snow and ice covers;
- energy sources together with their advantages, disadvantages and risks associated with their transportation;
- various types of pollution (air, water, soil), etc.

Finally, it would be good to insist on the use of vocabulary related to climate change in various language classes (e.g. structure, composition, dictation, and in speaking activities etc.)

Content for higher education

The structure of educational programmes in higher education makes no reference to climate change. In addition, the current shift from "course" to "modular" system comes to mask several courses under globalizing names. For example, in KIE, geography courses of ecology and biogeography are merged into a single module known as physical geography which teaches at the same time the geomorphology, climatology, ecology and biogeography.

To emphasize on the necessity of knowledge about climate change, it would be nice to propose to the Ministry of Education to introduce in compulsory modules of level 1 of higher education a module entitled "Environment and Climate Change" in all combinations of higher education.

Such a module would comprise the following 6 chapters:

- Materials and methods of work related to climate change;

- Emission and calculation of greenhouse gas emissions per sector (energy, Industrial processes, agriculture, land use, land use change and forestry, waste, etc.).
- Measures and strategies for mitigating greenhouse gas emissions;
- Vulnerability and adaptation to climate change;
- Systematic observations, research and public sensitization.

Finally, it would be good to start in KIE, a combination entitled "Environment and Climate Change with Education" which would train teachers specializing in this field and who could teach courses in science and geography.
Once on field, in the whole country, these teachers could serve as a qualified scientific personnel for collecting and processing data on climate change on the entire territory of Rwanda against a small encouragement.

5.6. Capacity Building in Relation to Climate Change

To ensure the continuity of national communications in Rwanda, a National Coordination Office has been established. It includes focal points of Government departments, Universities, Institutes and Research Institutions. Several meetings have been held based on required studies such as the preparation of National Communications and National Plans for Adaptation to Climate Change (NAPA).

However, it would be a better thing to enhance the action of this team by the following actions: establish provincial coordination offices; form groups or teams of technical experts specialised in various areas of climate change; promote the involvement and participation of other actors (Consultancy firms, Cultural associations, etc.)

In terms of education, organize on top of the combination Environment –Climate Change with Education (ECE), post graduate trainings (certificates, diplomas, masters, and doctorates in climate change), training and in-service training sessions for researchers and lecturers or teachers of climate change by highly qualified staff.

5.7. Information and Information Network for Researchers

To date, nothing is done to provide useful information on climate change to potential researchers. Also there is not yet any information network. This is a real handicap for the development of research in the field of climate change.

To remedy this, some of the recommendations mentioned earlier are proposed again here;

- Establish a specialized website and a network of experts specialized in climate change;

- Build up a database and research publications on aspects of climate change (conferences, seminars, dissertations, thesis) and a network for national and provincial as well as inter-institutional coordination;
- Strengthen cooperation among the East African Community member countries, which regularly meet, in order to develop a joint master plan for adaptation to climate change.

5.8 Training and Sensitization of the Public

To cope with the problems of environmental degradation, the eradication of poverty and the effects of climate change for sustainable development (Vision 2020 and National Strategy for Poverty Reduction), the Government of Rwanda relied, inter alia, on training and public sensitization.

In fact, the latter constitutes a key factor in the implementation of the UN Convention on Climate Change. The level of public understanding of climate change issues will allow it to play its full role in the establishment of policies and decision making in this regard. Here are some recommendations that can help achieve this goal:

- Enhancement of national and international environment, water, meteorology, tree, biodiversity weeks, days etc.;
- Sensitization campaign tours organized in vulnerable areas;
- Introduction of emissions on climate change in the ordinary programs of State & private TV and Radio stations (games, competitions, organization of radio TV sketches on Climate change);
- Creation of audio-visual stations (TV & radio) specialized in Climate Change and run by qualified staff;
- Organization of culture weeks on Climate Change (fairs, festivals);
- Training of rural community leaders;
- Dissemination, throughout the country and in institutions of primary, secondary and tertiary education, of stands and exhibition and information centres on issues related to climate change (posters, booklets, films, documentaries, chronicles, brochures, political speeches, newspapers and banners).

It is within this framework that the Initial National Communication presents the Project " Enabling Activities for the Preparation of the Initial National Communication under the UNFCCC", which required the translation in to Kinyarwanda the national language, some texts and documents related to environment. These are texts and other documents of Conventions and their Protocols on environment showing a synergy related to climate change, biodiversity, the fight against desertification and the protection of the ozone layer. The goal of this translation is to for use as a primary tool for public sensitization on

aspects relating to environment in general and climate change in particular. A similar situation is envisaged for the second communication, but its implementation still depends on the availability of funds.

CHAPTER VI: DIFFICULTIES IDENTIFIED GAPS, FINANCIAL RESOURCES, TECHNICAL MEANS AND CAPABILITIES NEEDED FOR REMEDY

6.1. Obstacles and Gaps

Despite the existence of stimulating economic, political and legal conditions in Rwanda, implementation on a large scale as well as the transfer of appropriate technologies for adaptation to climate changes in different sectors meets several potential obstacles. These include:

- Limited knowledge and awareness of the population in the field of climate ;
- Lack of sufficient local and foreign investments;
- Lack of knowledge about local needs for technology resulting from a low level of scientific and technological research; and
- A context with a less developed local market, appropriate technologies for energy saving, characterized by lack of government financial intervention especially in investment, training workshops, experience sharing and pilot demonstration projects.

In fact, the government faces several obstacles such as the inability to avail modern facilities and insufficient technical ability to implement these new technologies. Consequently, the government should establish a special policy for saving energy based on existing appropriate technologies and at a low cost.

The high cost of electricity price resulting from the introduction of thermal plants compels the population to switch to a cheaper source of energy which is fuel wood.

6.2. Identification of Barriers

In the sector of energy, the first barrier is the need for investment in structures for the production and distribution of electricity.

The second minor barrier is represented by dietary and cooking habits in the area of dissemination of improved stoves. In fact, households use traditional stoves for heating and grilling corn during the rainy season and use improved stoves during the dry season and display them when there is a visit by local authorities. But this barrier can be easily overcome through education and sensitization of households on issues of energy and environment.

In the sector of agriculture, land use, land use change and forestry, three barriers can affect proposed measures to reduce greenhouse gas emissions. These are:

- Limited understanding of the mechanisms for clean development by decision makers;
- Lack of investment;
- Climate perturbations.

These barriers may prevent the implementation of some projects and the choice of some at the expense of the others. To overcome these barriers, the Project for Capacity building for Designated National Authority and CDM project within REMA should increase efforts to raise awareness of policy makers and clarify the procedures for access to carbon credits by REED+.

6.3. Impact on the Options Selected at the Macro level

The saving on energy consumption can be used for other activities that improve the living conditions of households and at the same time, and especially for transport. This can contribute to the reduction of foreign exchange spent on imports of petroleum products which take more than 80% of our foreign exchange. .

Mitigation measures in the sector of agriculture, land use, land use change and forestry may facilitate the creation of new jobs; improve on the industrial sector and exports.

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ANNEXES

Annex 1: Table of the data to be used for calculations in the energy sector

Imports/Consumptions (1000 tons; TJ)

Fuel	Year & Ref. / Fact / Convers	2003 MINICOM	2004 Kerozen, Diesel, LPG & et Jet Kerosen	2005 Kerozen & Diesel	2006 MINICOM	2007 MINICOM
1 Petrol	44,8TJ/ 1000t	30,24231/39,87962 Δ= -9,63731 1354,855/1786,607	38,163344/41,510209 Δ= -3,34687 1709,718/1859,657	44,409935/43,258093 Δ= 1,151842 1989,565/1937,963	49,827436/48,082198 Δ= 1,745238 2232,269/2154,082	49,97787/50,92147 Δ= -0,9436 2239,009/2281,282
2 Gasoil R= Road EI = Energy Industries	43,33	23,98753/38,74596 Δ= -14,7584 1063,367/1717,608	43,402604/43,386125 Δ= 0,016479 1924,037/1923,307	55,79709/56,45385 Δ= -0,65676 2473,485/2502,599 R=42,35725= 1835,338 TJ EI =	78,330908/76,086146 Δ= 2,244762 3472,409/3372,899 R=47,559796=2060,76596068TJ EI =28,52635=1236,04675 TJ	83,30406/82,61766 Δ= 0,6864 3692,869/3662,441

				14,09664=610,8074112TJ		
3' Jet Kerosen BNR	**44,59**	**0,00267/**	**1,11410/** **49,677719**			
3 Kerosen	**44,75**	**13,37048/11,89765** **Δ=1,47283** **598,329/532,4198**	**12,690837/12,979586** **Δ= -0,288749** **567,915/580,8365**	**10,61913/10,36358** **Δ= 0,25555** **475,2061/463,7702**	**10,841599/10,694699** **Δ=0,1469** **485,1616/478,5878**	**11,89222/12,03038** **Δ= -0,13816** **532,1768/538,3595**
4 Fuel Oil	**40,19**	**14,40791/6,98758** **Δ= 7,42033** **579,0539/280,8308**	**5,808653/7,297785** **Δ= -1,48913** **233,4498/293,298**	**9,543916/9,016033** **Δ=0,527883** **383,57/362,3544**	**5,551083/5,319232** **Δ= 0,231851** **223,098/213,7799**	**3,36123/4,33870** **Δ= -0,97747** **135,0878/174,3724**
5 GPL	**47,31**	**0,237/** **11,21247**	**0,215/** **10,17165**	**0,31/** **14,6661/**	**0,336/** **15,89616**	
6 Lubrifiants	**40,19**	**0,96047/** **38,6012893**	**1,39088/** **55,8994672**	**1,604/** **64,46476**	**1,178/** **47,34382**	

Data Jet Kerosen (Silas) in liters (density = 807,5 average between 775 and 840 KOBIL) :

7.826.205 in 2003, 7.245.511 in 2004, 8.253.931 in 2005, 9.211.244 in 2006

Unilaterally classified in International Bunkers (IB) after substraction of BNR data (Internal alleged consumptions /internal thefts).
For years without BNR data,generated by rule of three referring to the data of 2004 : VI=1,11410/5,8507501325= 19% ; BI = 81 %

(1000 tons= … TJ)

3' Jet Kerosen	**44,59**	**6,3196605375= 281,793663367125 TJ ; (-0,00267= BI =6,3169905375)**	**5,8507501325 = 260,884948408175 TJ (-1,11410=BI= 4,7366501325)**	**6,6650492825 = 297,194547506675 TJ (-1,266359363675=BI= 5,398689918825)**	**7,43807953 = 331,6639662427 TJ (-1,4132351107 = BI= 6,0248444193)**	
Values TJ		**0,1190553 281,674608067125**	**49,677719 211,207229408175**	**56,46696402626825 240,72758348040675**	**63,016153586113 268,647812656587**	

NB. : The data of the year 2003 was provided by MINICOM, at the raw form and with kg or ton as unit (and not litre !)

Imports of petroleum products (tons)

	Fuel oïl	**Petrol**	**Kérosène**	**Diesel**	**LPG**	**Jet Kerosene**
2003	14407,91	30242,31	13370,48	23987,53	237	2,67
2004	5943,17	37905,48	12690,84	43402,6	215	1114,10
2005	9764,93	44109,87	10619,13	55797,09	310	
2006	5740,02	50436,43	10841,60	79668,77	336	

Consumption of petroleum products (tons)

	Fuel lourd	Essence	Kérosène	Diesel
2003	6987,58	39879,62	11897,65	38745,96
2004	7466,79	41229,73	12979,59	43386,13
2005	9224,83	42965,81	10363,58	56453,85
2006	5153,87	49273,36	10694,70	77696,88
2007	3906,28	36973,72	8874,71	61366,11

Imports without data on consumptions

Product (t)\Year	2003
Petrol	**41.114**
Gasoil	**28.357**
Kerosen	**16.818**
Fuel Oil	**14.823**
GPL	**237**

- For the petrol density (ρ) people systematically take the value of 0,740 provided by a slip sample from MINICOM. Such value is within standards of various types of petrol imported from Kenya ($\rho \leq 0.780$; KOBIL documents)
- For diesel we keep $\rho = 0.840$ comprised between 0.820 and 0.870 (KOBI documents)
- For kerosene we keep $\rho = 0.795$
- For Fuel Oïl we take $\rho = 0.950$ instead of $\rho = 0.972$ taken into account earlier
- The petroleum products supplied to Rwanda and Burundi come from Kenya. Kenya itself buys its products mainly from BAHREIN. They import 30 % of refined products and 70 raw that it refines itself before distribution to Kenya, Rwanda and Burundi.
- Uncertainties on on fuels:
  - Petrol : 0,3 %
  - Diesel : 0,2 %
- The sole value available for petroleum products from BAHREIN is that of « Crude Oil » PCI : 42.71 MJ/kg (cfr Revised 1996 ; IPCC, Guidelines for National Greenhouse Gases Inventories : Reference Manual pp1.16)

Annex 2. Information on data processing

1) **Processing of raw material intended for the use of software**
   - ⊗ MINICOM data on fuel 2004, 2005 and 2006 in liters, i twas necessary to convert them in kg (tons, kilotons). To this effect there was a need to use the volumic masses :
     - Petrol : 0, 740 (MINICOM value)
     - Diesel : 0,840 (cfr. Value …)
     - Fuel-oil : 0,950 (cfr. Value …)
     - Kerosene (petrol) : 0, 795 (value KOBIL)
     - Jet Kerosene : 807,5 (average between 775 and 840, KOBIL limit values)
   - ⊗ Data processing on jet Kerosene

     Since there BNR data were available only for 2003 and 2004, it was assumed that they concerned Jet Kerosene for domestic consumption (CI) and the balance for International Bunkers (BI). For years without BNR data the rule of three was used to generate the ventilation by refering to the year 2004, for domestic flights (1,11410/5,8507501325= 19%) and the balance for internationalBunkers i.e BI= 81%

2) **Estimates of uncertainties**
   - ⊗ Uncertainties on fuel volumes (KOBIL values) :
     - Petrol: 0,3 %
     - Diesel : 0,2 %
   - ⊗ Uncertainties on fuel densities :
     - Diesel : between 0,815 (0,820) and 0,865 (0,870) : (KOBIL values) ; taht is +/- 3 % (0,025/0,840)
     - Petrol: density max 0,780 (KOBIL) ; that is (0,780-0,740)/ 0,740 = 5 %
   - ⊗ Combination of uncertainties on the quantity of fuels (Reminder : Multiplication)

     Final uncerainty = Square root of the total of squares of uncertainties

     - Diesel : ≈ 3 %
     - Petrol : ≈ 5 %
   - ⊗ Uncertainties over certain emission factors
     - Petrol: For CH4 and N2O emissions for two stroke engines (motocyclettes) emission factors by default to be used according to IPCC are three times higher than for the four stroke engines. Since the quantity of petrol used by motocycles was not known,

emission factors for four stroke engines were used ! CH_4 and N_2O emission factors were therefore under estmated !.

-

For 2005, if we approximate the number of motobikes to a quarter of all the vehicles using petrol and the quantity of petrol comsumed by motorbike (taxi moto) to half of the quantity of petrol consumed by vehicles with four stroke engines in average, there will be a need to add to the emissions mentioned above, the value of 200 % x ¼ x ½, that is 25 % or consider an emission factor 1.25 more higher than the one used. The uncertainty of CH_4 and N_2O emissions is therefore is therefore 25%

Annex 3. Table recapitulating resultants of the software by correcting the mistake in the grid box K25

This table corresponds to sheet 1-3s1 (Other biomas and Waste); *it is not concerned with CO2*

GHG (en Gg)

Method/gas		Activité	Combustible	2003	2004	2005	2006
Method of reference ; CO2							
			Gasoline	**122,57**	**127,59**	**132,96**	**147,79**
			Jet kerosene	**0,01**	**3,52**	**4,00**	**4,46**
		(1-1s4-5)	**J. K. Memo (Int.Bunkers)**	**19,94**	**14,95**	**17,04**	**19,02**
			Other kerosene	**37,88**	**41,33**	**33,00**	**34,05**
			Diesel	**123,10**	**137,85**	**179,37**	**241,74**
			Fuel Oil	**21,51**	**22,46**	**27,71**	**16,37**
			LPG	**0,70**	**0,64**	**0,92**	**1,00**
			Lubricants	**1,42**	**2,05**	**2,36**	**1,74**
			Total	***307,20***	***335,43***	***380,36***	***447,15***
Sector based Method (Tier 1)							
a) CO2	**1. Combustibles Minerals**	**Energy Industries**	**Diesel**	***0***	***0***	***44,79***	***90,63***
		Man. Ind & Constr. ; Heat Process	**Fuel oil (1-2s4-4B)**	***21,51***	***22,46***	***27,75***	***16,37***
		Transport(1-2s5-6)	**petrol**	**122,57**	**127,59**	**132,96**	**147,79**

			Diesel	**123,10**	**137,85**	**134,58**	**151,11**
			Lubrifiants	**1,42**	**2,5**	**2,36**	**1,74**
			Jet kerosene	**0,01**	**3,52**	**4,00**	**4,46**
		(1-2s7-8)	**JK, Internat. Aviat (Memo)**	***19,94***	***14,95***	***17,00***	***19,20***
			Total Transport	***247,10***	***271,00***	***273,90***	***305,09***
		Residential	**Other kerosene**	**37,88**	**41,33**	**33,00**	**34,05**
			LPG	**0,70**	**0,64**	**0,92**	**1,00**
			Total Residential	***38,58***	***41,96***	***33,92***	***35,05***
		Total Comb. Minéraux		***307,19***	***335,42***	***380,36***	***447,14***

	2. Memo (biomas)	**Residential**	**wood**	**6329,11**	**6550,63**	**6779,90**	**7029,76**
			charcoal	**375,32**	**388,46**	**402,05**	**416,43**
			Plant residues	**42,76**	**44,25**	**45,80**	**47,49**
			Total Biomasse	***6747,19***	***6983,35***	***7227,6***	**7493,68**

Method/gas		**Activity**	**Combustible**	**2003**	**2004**	**2005**	**2006**
b) CH4 (PRP=21)	**1. Mineral Combustibles**	**Energy Industries**	**Diesel**	***≈0***	***≈0***	***≈0***	***≈0***
		Man. Ind & Constr. ; Heat Process	**Fuel oil**	***≈0***	***≈0***	***≈0***	***≈0***
		Transport	**petrol**				
			Diesel				

			JK, Dom. Aviation	***≈0***	***≈0***	***≈0***	***≈0***
			JK, Internat. Aviat	***≈0***	***≈0***	***≈0***	***≈0***
			Total Transport ***Equiv CO2***	***0,04*** ***0,84***	***0,05*** ***1,05***	***0,05*** ***1,05***	***0,05*** ***1,05***
		Residential	**Other kerosene**				
			LPG				
	2. Biomas		**Biomas**				
			Total Residential ***Equiv CO2***	***18,50*** ***388,5***	***19,14*** ***401,94***	***19,81*** ***416,01***	***20,54*** ***431,34***
	Total CH4		***Equiv CO2***	***18,54*** ***389,34***	***19,19*** ***402,99***	***19,86*** ***417,06***	***20,60*** ***432,6***

c) N2O (PRP=310)	**1. Mineral Combustibles**	**Energy Industries**	**Diesel**	***≈0***	***≈0***	***≈0***	***≈0***
		Man. Ind & Constr. ; Heat Process	**Fuel oil**	***≈0***	***≈0***	***≈0***	***≈0***
		Transport	**Petrol**				
			Diesel				
			JK, Dom. Aviation	***≈0***	***≈0***	***≈0***	***≈0***
			JK, Internat. Aviat	***≈0***	***≈0***	***≈0***	***≈0***
			Total Transport	***≈0***	***≈0***	***≈0***	***≈0***
		Residential	**Other**				

			kerosene				
			LPG				
	2. Biomas		**Biomas**				
			Total Residential	***0,24***	***0,25***	***0,26***	***0,27***
			Equiv CO2	***74,4***	***77,5***	***80,6***	***83,7***
	Total N2O			***0,24***	***0,25***	***0,26***	***0,27***
			Equiv CO2	***74,4***	***77,5***	***80,6***	***83,7***

Methode/gas		**Activity**	**Combustible**	**2003**	**2004**	**2005**	**2006**
d) NOx	**1. Combustibles Minéraux**	**Energy Industries**	**Diesel**	***0***	***0***	***0,07***	***0,25***
		Man. Ind & Constr. ; Heat Process	**Fuel oil**	***0,06***	***0,06***	***0,07***	***0,04***
		Transport	**Petrol**				
			Diesel				
			JK, Dom. Aviation	***≈0***	**0,01**	**0,02**	**0,02**
			JK, Internat. Aviat	**0,08**	**0,06**	**0,07**	**0,08**
			Total Transport R	***6,31***	***6,81***	***6,79***	***7,59***
		Residential	**Other kerosene**				
			LPG				
	2. Biomas		**Biomas**				
			Total Residential	***6,33***	***6,56***	***6,77***	**7,02**
	Total NOx			***12,7***	***13,44***	***13,78***	***14,92***

Method/gas		Activity	Combustible	2003	2004	2005	2006
d) CO	**1. Mineral MineralCombustibles**	**Energy Industries**	**Diesel**	***0***	***0***	***0,01***	***0,02***
		Man. Ind & Constr. ; Heat Process	**Fuel oil**	***≈0***	***≈0***	***≈0***	***0,01***
		Transport	**petrol**				
			Diesel				
			JK, Dom.Aviation	**0**	**0**	**0,01**	**0,01**
			JK, Internat. Aviat	**0,03**	**0,02**	**0,02**	**0,03**
			Total Transport R	***16,01***	***16,80***	***17,34***	***19,29***
		Residential	**Other kerosene**				
			LPG				
	2. Biomas		**charcoal**	**24,45**	**25,309**	**26,195**	**27,131**
			wood	**294,54**	**304,849**	**315,52**	**327,146**
			residues	**1, 99**	**2,060**	**2,132**	**2,210**
			Total Residential	***320,99***	***332,23***	***343,85***	***356,50***
	Total CO			***333,24***	***349,30***	***362,12***	***375,82***

Method/gas		Activity	Combustible	2003	2004	2005	2006
d) NMVOC	**1. Mineral Combustibles**	**Energy Industries**	**Diesel**	***0***	***0***	***0***	***0,01***
		Man. Ind & Constr. ; Heat Process	**Fuel oil**	***≈0***	***≈0***	***≈0***	***≈0***
		Transport	**Petrol**				
			Diesel				
			JK, Dom. Aviation	***≈0***	***≈0***	***≈0***	***≈0***
			JK, Internat. Aviat	**0,01**	**0,01**	**0,01**	**0,01**
			Total Transport R	***3,02***	***3,17***	***3,27***	***3,64***
		Residential	**Other kerosene**				
			LPG				
	2. Biomas		**Biomas**				**39,91**
			Total Residential	***35,94***	***37,19***	***38,49***	***39,91***
	Total NMVOC			***38,96***	***40,37***	***41,78***	***43,57***

Method/gas		Activity	Combustible	2003	2004	2005	2006
d) SO2	**1. Mineral Combustibles**	**Energy Industries (1-4s1)**	**Diesel**	***0***	***0***	***0,08***	***0,17***

		Man. Ind & Constr. ; Heat Process (1-4s2)	**Fuel oil**	***0,56***	***0,58***	***0,72***	***0,43***
		Transport	**Petrol**	**0,06**	**0,08**	**0,09**	**0,10**
			Diesel	***0,17***	**0,27**	**0,25**	**0,29**
			JK, Dom. Aviation	***≈0***	***≈0***	***≈0***	***≈0***
		(1-4s3)	**JK, Internat. Aviat**	**0,06**	**0,0**	**0,01**	**0,01**
			Total Transport	***0,23***		***0,34***	***0,38***
	(1-4s4)	**Commercial +Residential +**	**Other kerosene**	**0,01**	**0,01**	**0,01**	**0,01**
			LPG	-	-	-	-
	2. Biomas	**(1-4s4)**	**Charcoal**	**0,07**	**0,07**	**0,07**	**0,08**
			wood	**15,71**	**16,26**	**16,83**	**17,45**
			Résid	**0,02**	**0,02**	**0,02**	**0,02**
			Total Com & Res	***15,81***	***16,36***	***16,93***	***17,55***
	Total SO2						

Annexe 4. IPCC Calculations Sheet

1. HEAD

Country	Rwanda
Inventory Year	2005
Title of Inventory	GREENHOUSE GAS INVENTORY
Contact Name	Alphonse MUTABAZI
Title	Consultant
Organisation	Rwanda Environment Management Authority
Address	P.O Box 7436 Kigali
	Rwanda
Phone	(+250) 722192752
Fax	
E-Mail	mutalpho@hotmail.com
Is uncertainty addressed?	
Related documents filed with UNFCCC	Decision 17/CP.8

2. TABLE 1 SECTORAL REPORT FOR ENERGY (Sheet 1 of 3)

SECTORAL REPORT FOR NATIONAL GREENHOUSE GAS INVENTORIES (Gg)							
GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2	CH_4	N_2O	NO_x	CO	NMVOC	SO_2
Total Energy	**380**	**20**	**0**	**14**	**361**	**42**	**18**
A Fuel Combustion Activities (Sectoral Approach)	**380**	**20**	**0**	**14**	**361**	**42**	**18**
1 Energy Industries	**45**	**0**	**0**	**0**	**0**	**0**	**0**
a Public Electricity and Heat Production							
b Petroleum Refining							
c Manufacture of Solid Fuels and Other Energy Industries							
2 Manufacturing Industries and Construction	**28**	**0**	**0**	**0**	**0**	**0**	**1**
a Iron and Steel							
b Non-Ferrous Metals							
c Chemicals							
d Pulp, Paper and Print							
e Food Processing, Beverages and Tobacco							
f Other (please specify)							

3. TABLE 1 SECTORAL REPORT FOR ENERGY (Sheet 2 of 3)

SECTORAL REPORT FOR NATIONAL GREENHOUSE GAS INVENTORIES (Gg)							
GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2	CH_4	N_2O	NO_x	CO	NMVOC	SO_2
3 Transport	**274**	**0**	**0**	**7**	**17**	**3**	**0**
a Civil Aviation	4	0	0	0	0	0	
b Road Transportation	270	0	0	7	17	3	
c Railways	0	0	0	0	0	0	
d Navigation	0	0	0	0	0	0	
e Other (please specify)	0						
Pipeline Transport	0						
4 Other Sectors	**34**	**20**	**0**	**7**	**344**	**38**	**17**
a Commercial/Institutional	0	0	0	0	0	0	
b Residential	34	20	0	7	344	38	
c Agriculture/Forestry/Fishing	0	0	0	0	0	0	
5 Other (please specify)	**0**	**0**	**0**	**0**	**0**	**0**	**0**
B Fugitive Emissions from Fuels	**0**	**0**	**0**	**0**	**0**	**0**	**0**

1 Solid Fuels	**0**	**0**	**0**	**0**	**0**	**0**	**0**
a Coal Mining		0					
b Solid Fuel Transformation							
c Other (please specify)							
2 Oil and Natural Gas	**0**	**0**	**0**	**0**	**0**	**0**	**0**
a Oil		0		0	0	0	0
b Natural Gas		0					
c Venting and Flaring		0					

4. TABLE 1 SECTORAL REPORT FOR ENERGY (Sheet 3 of 3)

SECTORAL REPORT FOR NATIONAL GREENHOUSE GAS INVENTORIES (Gg)							
GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2	CH_4	N_2O	NO_x	CO	NMVOC	SO_2
Memo Items (1)							
International Bunkers	**17**	**0**	**0**	**0**	**0**	**0**	**0**
Aviation	17	0	0	0	0	0	0
Marine	0	0	0	0	0	0	0
CO_2 Emissions from Biomass	**7,228**						

(1) Please do not include in energy totals.

5. TABLE 2 SECTORAL REPORT FOR INDUSTRIAL PROCESSES (Sheet 1 of 2)

SECTORAL REPORT FOR NATIONAL GREENHOUSE GAS INVENTORIES (Gg)													
GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2	CH_4	N_2O	NO_x	CO	NMVOC	SO_2	HFCs		PFCs		SF_6	
								P	A	P	A	P	A
Total Industrial Processes	**151**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
A Mineral Products	**151**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
1 Cement Production	75						0						
2 Lime Production	75												
3 Limestone and Dolomite Use	0												
4 Soda Ash Production and Use	0												
5 Asphalt Roofing					0	0							
6 Road Paving with Asphalt						0							
7 Other (please specify)	0	0	0	0	0	0	0	0	0	0	0	0	0
Glass Production						0							
Concrete Pumice Stone							0						
B Chemical Industry	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**

1 Ammonia Production	0				0	0	0						
2 Nitric Acid Production			0	0									
3 Adipic Acid Production			0	0	0	0							
4 Carbide Production	0	0											
5 Other (please specify)		0		0	0	0	0						
C Metal Production	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
1 Iron and Steel Production	0			0	0	0	0						
2 Ferroalloys Production	0												
3 Aluminium Production	0			0	0		0				0		
4 SF_6 Used in Aluminium and Magnesium Foundries													0
5 Other (please specify)	0												

P = Potential emissions based on Tier 1 Approach. A = Actual emissions based on Tier 2 Approach. This only applies in sectors where methods exist for both tiers.

6. TABLE 2 SECTORAL REPORT FOR INDUSTRIAL PROCESSES (Sheet 2 of 2)

SECTORAL REPORT FOR NATIONAL GREENHOUSE GAS INVENTORIES (Gg)													
GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2	CH_4	N_2O	NO_x	CO	NMVOC	SO_2	HFCs		PFCs		SF_6	
								P	A	P	A	P	A
D Other Production	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
1 Pulp and Paper				0	0	0	0						
2 Food and Drink						0							
E Production of Halocarbons and Sulphur Hexafluoride	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
1 By-product Emissions									0		0		
2 Fugitive Emissions									0		0		
3 Other (please specify)													
F Consumption of Halocarbons and Sulphur Hexafluoride	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
1 Refrigeration and Air Conditioning Equipment									0		0		
2 Foam Blowing									0		0		
3 Fire Extinguishers									0		0		0

4 Aerosols									0		0		
5 Solvents									0		0		
6 Other (please specify)									0		0		0
G Other (please specify)													

P = Potential emissions based on Tier 1 Approach. A= Actual emissions based on Tier 2 Approach. This only applies in sectors where methods exist for both tiers.

7. TABLE 3 SECTORAL REPORT FOR SOLVENT AND OTHER PRODUCT USE (Sheet 1 of 1)

SECTORAL REPORT FOR NATIONAL GREENHOUSE GAS INVENTORIES (Gg)			
GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2	N_2O	NMVOC
Total Solvent and Other Product Use	**0**	**0**	**0**
A Paint Application			
B Degreasing and Dry Cleaning			
C Chemical Products, Manufacture and Processing			
D Other (please specify)			

Please account for the quantity of carbon released in the form of NMVOC in both the NMVOC and the CO_2 columns.

No: The Revised 1996 IPCC Guidelines do not provide methodologies for the calculation of emissions of N_2O from solvent and other product use. If you have reported such data, you should provide additional information (activity data and emission factors) used to make these estimates.

8. TABLE 4 SECTORAL REPORT FOR AGRICULTURE (Sheet 1 of 2)

SECTORAL REPORT FOR NATIONAL GREENHOUSE GAS INVENTORIES (Gg)					
GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CH_4	N_2O	NO_x	CO	NMVOC
Total Agriculture	**48.814**	**10**	**0**	**9**	**0**
A Enteric Fermentation	**45.494**				
1 Cattle	35.398				
2 Buffalo	0.000				
3 Sheep	3.434				
4 Goats	6.320				
5 Camels and Llamas	0.000				
6 Horses	0.000				
7 Mules and Asses	0.000				
8 Swine	0.342				
9 Poultry	0.000				
10 Other (please specify)					
B Manure Management	**1.799**	**0**			
1 Cattle	1.079				
2 Buffalo	0.000				
3 Sheep	0.110				

4 Goats	0.215				
5 Camels and Llamas	0.000				
6 Horses	0.000				
7 Mules and Asses	0.000				
8 Swine	0.342				
9 Poultry	0.053				

9. TABLE 4 SECTORAL REPORT FOR AGRICULTURE (Sheet 2 of 2)

SECTORAL REPORT FOR NATIONAL GREENHOUSE GAS INVENTORIES (Gg)					
GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CH_4	N_2O	NO_x	CO	NMVOC
B Manure Management (cont...)					
10 Anaerobic		0.505585			
11 Liquid Systems		0.505585			
12 Solid Storage and Dry Lot		1.011170			
13 Other (please specify)		2.022339			
C Rice Cultivation	**1.110**				
1 Irrigated	1.110				

2 Rainfed	0.000				
3 Deep Water	0.000				
4 Other (please specify)					
D Agricultural Soils		9.30			
E Prescribed Burning of Savannas	**0.00130**	**0.00002**	**0.00102**	**0.03410**	
F Field Burning of Agricultural Residues [(1)]	**0.410**	**0.010**	**0.200**	**8.530**	
1 Cereals					
2 Pulse					
3 Tuber and Root					
4 Sugar Cane					
5 Other (please specify)					
G Other (please specify)					

10. TABLE 5 SECTORAL REPORT FOR LAND-USE CHANGE AND FORESTRY (Sheet 1 of 1)

SECTORAL REPORT FOR NATIONAL GREENHOUSE GAS INVENTORIES (Gg)						
GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 Emissions	CO_2 Removals	CH_4	N_2O	NO_x	CO
Total Land-Use Change and Forestry	(1) **0**	(1) **-8,545**	**0.47000**	**0**	**0.093350**	**1,957**
A Changes in Forest and Other Woody Biomass Stocks	(1)	(1)	**0.47000**	**0.00**	**0.093350**	
1 Tropical Forests						
2 Temperate Forests						
3 Boreal Forests						
4 Grasslands/Tundra						
5 Other (please specify)						
B Forest and Grassland Conversion	**455**		**0.00000**	**0**	**0.000000**	**1,957**
1 Tropical Forests	455					
2 Temperate Forests	0					
3 Boreal Forests	0					
4 Grasslands/Tundra	0					

5 Other (please specify)	0					
C Abandonment of Managed Lands		**-9,000**				
1 Tropical Forests		-9,000				
2 Temperate Forests		0				
3 Boreal Forests		0				
4 Grasslands/Tundra		0				
5 Other (please specify)		0				
D CO2 Emissions and Removals from Soil	(1) **0**	(1) **0**				
E Other (please specify)						

11. TABLE 5B (OPTIONAL) SECTORAL REPORT FOR LAND USE, LAND-USE CHANGE AND FORESTRY (Using the categories of the IPCC Good Practice Guidance on Land Use, Land-Use Change and Forestry) (Sheet 1 of 1)

SECTORAL REPORT FOR NATIONAL GREENHOUSE GAS INVENTORIES (Gg)							
GREENHOUSE GAS SOURCE AND SINK CATEGORIES		CO_2 Emissions	CO_2 Removals	CH_4	N_2O	NO_x	CO
Total Land Use, Land-Use Change and Forestry		**454.8**	**9,000.0**	**0.1470**	**0.0035**	**0.050000**	**1,957.0**
A. Forest Land		**260.0**	**8,750.0**	**0.0743**	**0.0000**	**0.000000**	**1,957.0**
	1. Forest Land Remaining Forest Land	260.0	8,750.0	0.0723	0.0000	0.000000	1,957.0
	2. Land Converted to Forest Land	0.0	0.0	0.0020	0.0000	0.000000	0.0
B. Cropland		**64.8**	**0.0**	**0.0000**	**0.0000**	**0.000000**	**0.0**
	1. Cropland Remaining Cropland	64.8	0.0	0.0000	0.0000	0.000000	0.0
	2. Land Converted to Cropland	0.0	0.0	0.0000	0.0000	0.000000	0.0
C. Grassland		**0.0**	**0.0**	**0.0000**	**0.0000**	**0.000000**	**0.0**
	1. Grassland Remaining Grassland	0.0	0.0	0.0000	0.0000	0.000000	0.0
	2. Land Converted to Grassland	0.0	0.0	0.0000	0.0000	0.000000	0.0
D. Wetlands		**130.0**	**0.0**	**0.0728**	**0.0035**	**0.050000**	**0.0**
	1. Wetlands Remaing Wetlands	130.0	0.0	0.0728	0.0035	0.050000	0.0
	2. Land Converted to Wetlands	0.0	0.0	0.0000	0.0000	0.000000	0.0
E. Settlements		**0.0**	**250.0**	**0.0000**	**0.0000**	**0.000000**	**0.0**
	1. Settlements Remaining Settlements	0.0	250.0	0.0000	0.0000	0.000000	0.0

	2. Land Converted to Settlements	0.0	0.0	0.0000	0.0000	0.000000	0.0
F. Other Land		**0.0**	**0.0**	**0.0000**	**0.0000**	**0.000000**	**0.0**
	1. Other Land Remaining Other Land			0.0000	0.0000	0.000000	0.0
	2. Land Converted to Other Land ---			0.0000	0.0000	0.000000	0.0
G. Other (Please specify)		**0.0**	**0.0**	**0.0000**	**0.0000**	**0.000000**	**0.0**
	Harvested Woord Products						
Information items							
Forest Land converted to Other Land-Use Categories							
Grassland converted to Other Land-Use Categories							

12. TABLE 6 SECTORAL REPORT FOR WASTE (Sheet 1 of 1)

TABLE 6 SECTORAL REPORT FOR WASTE

(Sheet 1 of 1)

SECTORAL REPORT FOR NATIONAL GREENHOUSE GAS INVENTORIES (Gg)						
GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 (1)	CH_4	N_2O	NO_x	CO	NMVOC
Total Waste	**0**	**3**	**0**			
A Solid Waste Disposal on Land	**0**	**1**	**0**			
1 Managed Waste Disposal on Land						
2 Unmanaged Waste Disposal Sites						
3 Other (please specify)						
B Wastewater Handling	**0**	**2**	**0**			
1 Industrial Wastewater		0				
2 Domestic and Commercial Wastewater		2	0			
3 Other (please specify)						
C Waste Incineration						
D Other (please specify)						

Annex 5. LIST OF PEOPLE AND EXPERTS INVOLVED

MINIRENA

- Stanislas KAMANZI, Minister of Natural Resources
- Caroline KAYONGA, Permanent Secretary

MINETERE

- Christophe BAZIVAMO, Minister of Lands, Environment, Forests and Mining
- Patricia HAJABAKIGA, Minister of State in charge of Lands and Environment
- MUNYANGANIZI BIKORO, Minister of state in charge of Environment , Water and Mining
- Vincent KAREGA, Minister of state in charge of Environment and Mining
- Emmanuel NSANZUMUGANWA

REMA

- Dr. Rose MUKANKOMEJE, Director General
- Godfrey MULIGO, Director : Administration and Finance

PROJECT COORDINATION UNIT « RWANDA: PREPARATION OF THE SECOND NATIONAL COMMUNICATION RELATED TO UNFCCC »

- Charles URAMUTSE, National Coordinator
- Josélyne MUTESI, Administrative Secretary/Accountant of the Project

RESPONSABLES/UNEP/GEF DES PROGRAMMES DE COMMUNICATIONS NATIONALES

- Dr.George MANFUL, Senior Task Manager, UNEP, Nairobi/Kenya
- Martin OKUN, Administration and Finance, UNEP/GEF, Nairobi/Kenya

INTERNATIONAL CONSULTANTS FOR THE TRAINING IN METHODOLOGIES OF:

- **GHG inventories**: -Prof. Ayite-Lo AJAVO, Togo

- **Mitigation of GHG**: -Audace NDAYIZEYE, Burundi

- **Vulnerability and adaptation to climate change** : -Bubu Pateh JALLOW, Gambie

NATIONAL EXPERTS:

Work group I: National Circumstances and GHG inventories

Coordination : - Alphonse MUTABAZI, REMA, Consultant,

- **Energy sector :** -Silas RUZIGANA, MININFRA,
  - Fidèle RURIHOSE, IRS
  - Cyprien HAKIZIMANA, IRST

-Sectors of industry and wastes management

-Aloys KAMATARI, UNR

-Egide NKURANGA, UNR

-Sectors of agriculture in the use of lands, change in allocation of lands and forestry:

-Désiré KAGABO, ISAR
-Gislain NGOGA TENGE, ISAR
-Didace KAYIRANGA, ISAR
-Emmanuel TWAGIRAYEZU, MINAGRI

Work group II: MITIGATION of GHG

- Alphonse MUTABAZI, REMA, Consultant,
-Silas RUZIGANA, MININFRA,
-Désiré KAGABO, ISAR
-Gislain NGOGA TENGE, ISAR

Work group III: Vulnerability and Adaptation to climate changes

-Climate scenarios : -John SEMAFARA NTAGANDA, Service Météorologique National/MININFRA

-Water ressources : -Sylvère MUNYANEZA, PRIMATURE

-Forests : -Jacques Moussango

-**Agriculture and food security** : -J.B UWIZEYIMANA., MINAGRI

-**Health :** -Maximilien USENGUMUREMYI

Work group IV:

-Other information considered relevant to the objective of the convention

- Pierre Lutumba ILUNGA, Professeur à KIE

- Difficulties, identified gaps, financial resources, technical means and capabilities needed for remedy

-Pierre Lutumba ILUNGA, Professeur à KIE

Compilation : -Pierre Lutumba ILUNGA, Professeur à KIE

NATIONAL COMMITTEE OF CLIMATE CHANGE

1	MUNYANEZA	SYLVERE	PRIMATURE
4	UWIMANA	SUZANNE	MINITERE, Point Focal CDB
5	DUSABEYEZU	SEBASTIEN	MINITERE/REMA/RDB, Point Focal CCNCC
6	RUZIGANA	SILAS	MININFRA
7	URAMUTSE	CHARLES	MINITERE/MINELA/REMA, Coordinateur National du Projet
8	SEMAFARA N.	JOHN	MININFRA
9	UWIZEYIMANA	J.BAPTISTE	MINAGRI
10	MUSABE	JULES SIMON	MINEDUC
11	USENGUMUREMYI	MAXIMILIEN	MINECOFIN
12	KALISA	NYIRIMBIBI	UNR
13	Dr.SEBASHONGORE	DIEUDONNE	KIST
14	HAKIZIMANA	CYPRIEN	IRST
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16	RUTAGENGWA	ANTOINE	ELECTROGAZ

17	KABERA	JULIET	REMA, Point Focal Projet Ozone
18	KALIWABO B.	DESIRE	RWANDA RURAL REHABILITATION INITIATIVE (RWARRI)
19	KAREMERA G.	PROTAIS	CARE INTERNATIONAL AU RWANDA
20	HABIMANA	CLAUDIEN	MINAGRI, Point Focal CCD
21	KAYITARE	ANECTO	PROG. INTERN. DE CONSERVATION DES GORILLES (PICG)
22	MUKAKAMARI	DANCILLA	ASSOCIATION RWANDAISE DES ECOLOGISTES (ARECO)
23	RUTEMBESA	G.EMILE	OFFICE RWANDAIS DE NORMALISATION (ORN)
24	KARAMBI	DAVID	ACAPE
25	RUTAGENGWA	SHEMA	ARPET