REPUBLIC OF RWANDA

Rwanda's First Biennial Update Report Under the United Nations Framework Convention on Climate Change (UNFCCC)

December, 2021

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Rwanda's First Biennial Update Report 2021

Under the United Nations Framework Convention on Climate Change

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Foreword

On behalf of the Republic of Rwanda, it is with great honour and privilege to present Rwanda's First Biennial Update Report (BUR1) accompanied by its stand-alone National GHG Inventory Report (NIR) covering the period from 2006 to 2018 as a fulfilment of the obligations for non-Annex I Parties to the United Nations Framework Convention on Climate Change (UNFCCC).

The Government of Rwanda (GoR) is among the countries, which ratified the United Nations Framework Convention on Climate Change (UNFCCC), and its Kyoto Protocol. It was also among the first countries to sign and ratify the Paris Agreement in 2016. This shows the willingness of being a responsible member of the global community, to seek and achieve global solutions on climate change.

As a signatory to the Convention and Paris Agreement, Rwanda has so far submitted its Initial (NC1), Second (NC2), and Third National Communication (TNC), in 2005, 2012 and 2018 respectively, its updated Nationally Determined Contribution (NDC) in 2020. Furthermore, Rwanda has kick-started the preparation process for its Fourth National Communication (NC4).

The process of developing the BUR1 was as important as the report itself. It involved all key national stakeholders and experts supported by Global Environment Facility (GEF) and UN Environment and used the best available guidelines. The BUR1 was produced using national expertise, with international support to ensure quality assurance of the National Greenhouse Gases Inventory and chapters of the report. The capacity-building components of the BUR1 have helped to increase national capacity in data analysis for estimation of Greenhouse Gases (GHG) emissions and sinks and GHG Inventory and mitigation assessment reports in line with 2006 IPCC Guidelines and strengthened awareness-raising on climate change in the country. These achievements are crucial for laying the foundation of having a strong and effective domestic monitoring and verification system needed for the future climate regime.

The knowledge created and generated within the BUR1 process will further guide policy decision makers to understand and feel confident in using the output data in climate mitigation planning because it presents the key achievements and challenges in the implementation of climate change actions. BUR is also valuable for evaluating the progress of climate actions and indicate areas that require special attention. Rwanda remains committed to help combat climate change, as demonstrated in its highly ambitious NDC.

The BUR1 findings reveal the main drivers of GHG emissions and sectoral priority areas in need of specific mitigation actions as well as training and capacity building, data acquisition, and storage gaps. In this context, the standalone National Inventory Report represents the most recent comprehensive analysis of GHG emissions and removals in Rwanda. It embodies an important milestone in our commitments under the UN-FCCC and the Enhanced Transparency Framework of the Paris Agreement as well as our efforts in raising climate change awareness to influence domestic policy.

As we submit this First Biennial Update report, Rwanda has adopted and started the path to fulfil its commitment presented in the "revised NDC", of which the content and the perspectives are reflected in this BUR1 where the Business As Usual (BAU) emissions projection was conducted based on the latest GHG inventory. Rwanda intends to deepen efforts to sharpen existing capacities and most of all, make sure that the preparation of climate reports ultimately becomes routine for the institutions involved.

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Acknowledgment

We are pleased to express the gratitude to those who contributed to the preparation and publication of Rwanda's first Biennial Update Report (BUR1). Our gratitude particularly goes to the Global Environment Facility (GEF) for providing financial support throughUN Environment as well as its technical and capacity building support in different methodological toolsutilized during the preparation of the Rwanda BUR1.

We would also like to take this opportunity to thank all sectoral experts drawn from key Ministries, Government institutions, Academia, Civil Society Organizations, Non-governmental organizations, and the Private Sector who actively participated in the review process by providing their valuable inputs as well as validating all compiled chapters of the BUR1.

Rwanda first Biennial Update Report would not have been possible without the hard work and dedication of national experts who conducted all sectoral studies and international experts, who provided their technical assistance to the national experts and reviewed the draft BUR1 to ensure that climate change-related reporting guidelines were respected and a robust and qualitative report is submitted to UN Environment and UNFCCC.

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Juliet KABERA
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List of symbols and acronyms

AC	Alternating Current
AD	Activity Data
AfDB	African Development Bank
AFOLU	Agriculture, Forestry and Other Land Use
ANP	Akagera National Park
AWGLCA	Ad Hoc Working Group for Long-Term Cooperative Action
BAU	Business As Usual
BEST	Biomass energy Strategy
BNR	National Bank of Rwanda
BOD	Biochemical Oxygen Demand
Btu	British Thermal Unit
BUR	Biennial Update Report
CAPEX	Capital Expenditure
CBIT	Capacity-building Initiative for Transparency
CBO	Community Based Environmental Organizations
CDKN	Climate and Development Knowledge Network
CDM	Clean Development Mechanism
CFS	Carbon Fix Standard
CFL	Compact Fluorescent Lamp
CH_4	Methane
CER	Certified Emission Reductions
CIF	Climate Investment Fund
CIMERWA	Ciments du Rwanda
CIP	Crop Intensification Program
CITEPA	Centre Interprofessionnel Technique d'étude de la Pollution Atmosphérique
CO_2	Carbon dioxide
CO_2eq	Carbon dioxide Equivalent
CoK	City of Kigali
CTCN	Climate Technology Centre and Network
COP	Conference of Parties
CP	Conference of the Parties
DC	Direct Current
DFID	Department for International Development

DEEM	Department of Environmental Education and Mainstreaming
EA	East Africa
EARP	Electricity Access Roll-out Program
EDCL	Energy Development Corporation Limited
EF	Emission Factor
EESD	Environmental Education for Sustainable Development
EDPRS	Economic Development and Poverty Reduction Strategy
EICV	Integrated Household Living Conditions Survey
ESSP	Energy Sector Strategic Plan
ETF	Enhanced Transparency Framework
EUCL	Energy Utility Corporation Limited
EV	Electric Vehicle
FAO	Food and Agriculture Organization
FAH	Forest of Hope Association
FCCC	Framework Convention on Climate Change
FIP	Forest Investment Plan
FOLU	Forestry and Other Land Use
FONERWA	Rwanda Green Fund for Environment
GCF	Green Climate Fund
GDP	Gross Domestic Product
GEF	Global Environment Facility
Gg	Gigagram
GGCRS	Green Growth and Climate Resilient Strategy
GHG	Greenhouse gas
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit
GoR	Government of Rwanda
GTS	Global Telecommunication System
GWP	Global Warming Potential
HFC	Hydrofluorocarbons
HFO	Heavy Fuels Oil
ICSEA	Improved Cook Stoves for East Africa
ICA	International Consultation and Analysis
ICT	Information and Communication Technology
IFAD	International Fund for Agricultural Development
IEA	International Energy Agency
IET	International Emissions Trading

INDC	Intended Nationally Determined Contributions
IITA	International Institute of Tropical Agriculture
IPCC	Intergovernmental Panel on Climate Change
IPPs	Independent Power Producers
IPPU	Industrial Processes and Product Use
IT	Information Technology
JI	Joint Implementation
JICA	Japanese International Cooperation Agency
KCC	Kigali City Council
LD	Latest data
LDCF	Least Developed Country Fund
LFG	Landfill Gas
LCDP	Least Cost Development Plan
LIP	Livestock Intensification Program
MAC	Mobile air-conditioning
MCF	Methane Correction Factor
MIDMAR	Ministry of Disaster Management and Refugee Affairs
MINAGRI	Ministry of Agriculture and Animal Resources
MINECOFIN	Ministry of Finance and Economic Planning
MINICOM	Ministry of Trade and Industry
MINALOC	Ministry of Local Government
MINEDUC	Ministry of Education
MININFRA	Ministry of Infrastructure
MINIRENA	Ministry of Natural Resources
MSW	Municipal Solid Waste
MINITERE	Ministère des Terres, de l'Environnement, des Forêts, de l'Eau et des Mines
MoE	Ministry of Environment
MoH	Ministry of Health
MRV	Measurement, Reporting and Verification
N_2O	Nitrous Oxide
NAMA	Nationally Appropriate Mitigation Action(s)
NAPA	National Adaptation Program of Action
NATCOM	National Communication Report
NC	National Communication
NDC	Nationally Determined Contributions
NEP	National Electrification Plan

NISR	National Institute of Statistics of Rwanda
NST	National Strategy of Transformation
NWP	Numerical Weather Prediction
ODS	Ozone Depleting Substances
ODU	Oxidized During Use
PCA	Project Coordination Agreement
PD	Previous Data
PIP	Project Implementation Plan
PSTA	Strategic Plan for Agriculture Transformation
QA/QC	Quality Assurance/Quality Control
RAB	Rwanda Agriculture and Animal Resources Development Board
RAC	Refrigeration and air-conditioning
RCMRD	Regional Centre for Mapping of Resources for Development
RDB	Rwanda Development Board
REG	Rwanda Energy Group
REMA	Rwanda Environment Management Authority
RFA	Rwanda Forest Authority
RHA	Rwanda Housing Authority
RLMUA	Rwanda Land Management and Use Authority
RISQ	Resources for Inventory Safety and Quality
RoR	Republic of Rwanda
RRA	Rwanda Revenue Authority
RPHC	Rwanda Population and Housing Census
RURA	Rwanda Utility Regulatory Agency
SACR	Send A Cow Rwanda
SAR	Second Assessment Report
SDGs	Sustainable Development Goals
SIDA	Swedish International Development Cooperation Agency
SNC	Second National Communication to the UNFCCC
SPCR	Strategic Programme for Climate Resilience
SSPs	Sector Strategic Plans
SWDS	Solid Waste Disposal Sites
SWH	Solar Water Heater
TAP	Technology Action Plans
TNA	Technology Needs Assessment
TNC	Third National Communication

TVET	Technical and Vocational Education and Training
UNCCD	United Nations Convention to Combat Desertification
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
UNICEF	United Nations Children's Fund
UNIDO	United Nations Industrial Development Organization
VER	Voluntary Emissions Reductions
VNP	Volcano National Park
VUP	Vision 2020 Umurenge Programme
WASAC	Water and Sanitation Corporation Ltd.
WAVES	Wealth Accounting and Valuation of Ecosystem Services
WtE	Waste to Energy
WMO	World Meteorological Organization
WWF	World Wildlife Fund
WWTP	Wastewater Treatment Plant

Executive summary

ES 1 National Circumstances

Rwanda is a landlocked country located in the east of central Africa. It lies between 1°4´ and 2°51´South latitude, and 28°53´ and 30°53´ East longitude and it covers an area of 26,338 km^2. Rwanda's administrative structure comprises 4 provinces (Eastern, Western, Northern and Southern Provinces) and the City of Kigali; all subdivided into 30 districts, 416 sectors, 2,148 cells, and 14,816 villages. The topography of Rwanda is ascending western ward from 1000 m to 4507 m above sea level.

The mean annual temperature oscillates between 20°C and 22°C. The central plateau region enjoys rainfall of between 1,100 mm and 1,300 mm with an annual mean temperature of between 18°C and 20°C. The highlands, including the Congo-Nile Ridge and volcanic chains of Birunga, benefit from an annual rainfall of between 1,300 mm and 1,650 mm with annual mean temperatures ranging between 10°C and 18°C. The region of Lake Kivu received 1,200-1,500mm rainfall with an annual mean temperature between 18 and 21°C, while Bugarama plain receives around 1000-1079 mm rain per year and a mean annual temperature of +24°C (Gaidashova et al. 2009).

The Fourth Rwanda Population and Housing Census (RPHC 4) conducted in 2012 indicated that the total population has increased from 8,128,553 people in 2002 to 10,515,973 people in 2012. The Integrated Household Living Conditions Survey 5 (EICV 5) (2016/2017) indicates that the total population of Rwanda is estimated to be 11.8 million in 2016/17 with an increase of 0.4 million people since the EICV4 (11.4 million) in 2013/14. The National Accounts in Statistical Yearbook 2019 indicates that the population was expected to increase up to 12,089,721 people in 2018 and to raise to 12,663,116 people in 2019 with 2,630,904 people (23.4%) living in urban areas.

The National Economic report published by MINECOFIN in 2019 indicates that during the fiscal year 2018/19, the economy of Rwanda recorded the highest growth in GDP of 9.5 % in the last 10 years, which marks almost 3 % higher than the 10-years' average. The growth was mainly driven by the industry sector, which saw its growth double from 8 % in 2017/18 to 16 % in 2018/19 due to construction and manufacturing boost, which saw 25 % and 12 % growth, respectively, in 2018/19. Although Rwanda had impressive economic growth, the country is still highly dominated by rain-fed agriculture. About 53 % of the working population was engaged in farming, which yields about 33 % of Rwandan GDP in 2018. The secondary sector, which includes industrial and mining activities, contributed up to 16 % of GDP and provided jobs to around 4 % of the national workforce in 2018. To ensure economic transformation, the Economic Development and Poverty Reduction Strategy II (EDPRS II) targeted the industrial (manufacturing, construction, and mining) sector to contribute 20 % to GDP by 2018 and to grow at an annual rate of 11.5%. However, this target was not yet achieved. The tertiary sector including services and tourism has

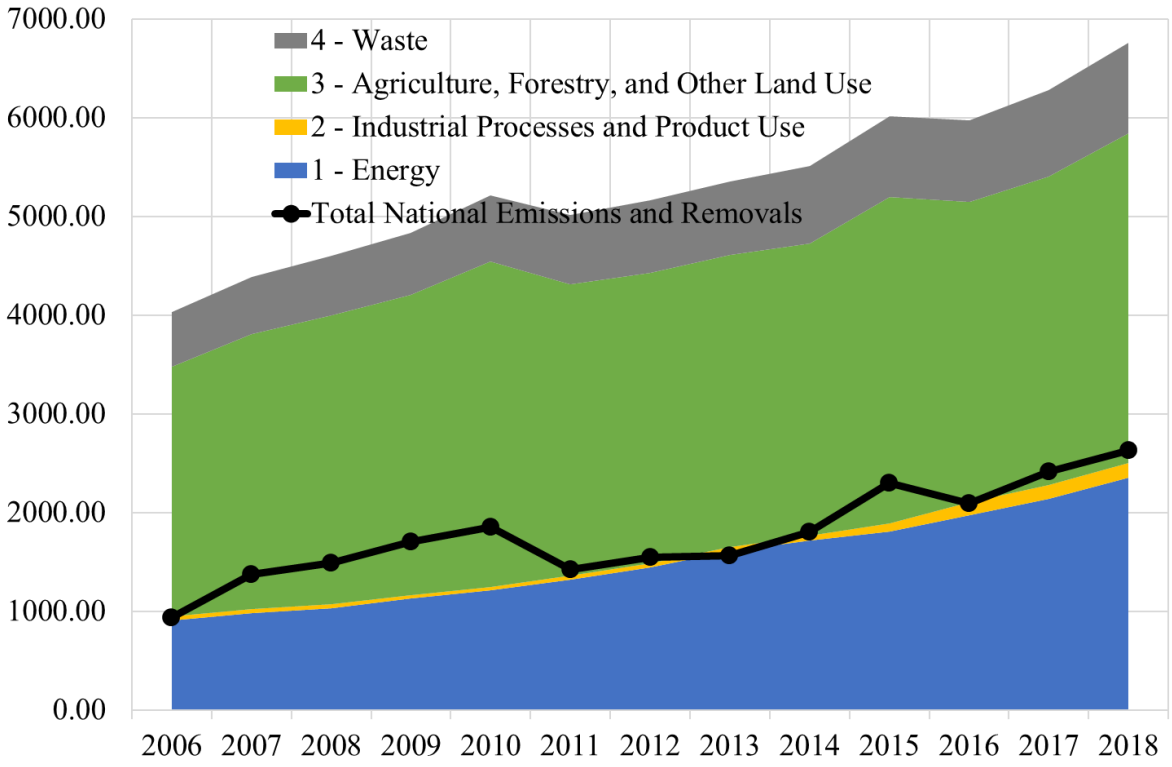
registered remarkable growth since 2010. It is the country's largest sector that contributed up to 46 % of Rwanda's GDP in 2018. The registered economic growth could be reflected in the improvement of the country's living standards. The EICV 5 reported that the proportion of people who were poor in 2016/17 was 38.2%, compared to 39.1 % in 2013/14. The extreme poverty rate fell from 16.3 % in 2014 to 16.0 % in 2017. Biomass (mostly wood fuel), is the most used fuel in households for cooking (83 % of households in 2019) and as a source of energy (86.3 % in 2016/2017), followed by petroleum at 9.7 %, electricity at 1.3 %, and others at about less than 0.5 %.

ES 2 National Greenhouse Gas Inventory

The greenhouse gases inventory reported in Rwanda's First Biennial Update Report (BUR 1) covers the period 2006-2018. Recalculations of the GHG emissions and removals were conducted to update the GHG emissions inventory submitted in the Third National Communication (TNC) and the 2016-2018 period was added to increase the coverage of the inventory. The reported GHG emissions and removals estimates were calculated using the 2006 IPCC Guidelines through version 2.691 of the 2006 IPCC (release January 2020). The sectoral activity data were gathered from various sector reports, the official national statistics from the National Institute of Statistics of Rwanda, and from recent surveys conducted by the Rwanda Environment Management Authority (REMA) to fill the data gaps reported in the previous national GHG inventory. All the data appearing in these official documents were further cross-checked with relevant institutions working in their respective sectors. Specific and relevant data were also obtained from research work published locally and in international journals as well as annual and technical reports from the different research institutions. In this GHG inventory, an effort was made to use the Tier 2 IPCC approach in various categories of the Agriculture, Forest and Other Land Use (AFOLU) and Waste sectors, whereas a combination of the Tier 1 methodology with country-specific data was used in Energy and Industrial Processes and Product Use (IPPU) sectors.

The GHG inventory covered the four greenhouse gases, viz., carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O) and hydrofluorocarbons (HFCs). The estimates of the latter direct GHG were estimated in all the four sectors (i.e., Energy, IPPU, AFOLU and Waste) and converted into CO_2 eq. using the Global Warming Potential (GWP) values provided by the IPCC in its Second Assessment Report (SAR) based on the effects of greenhouse gases over a 100-year time horizon.

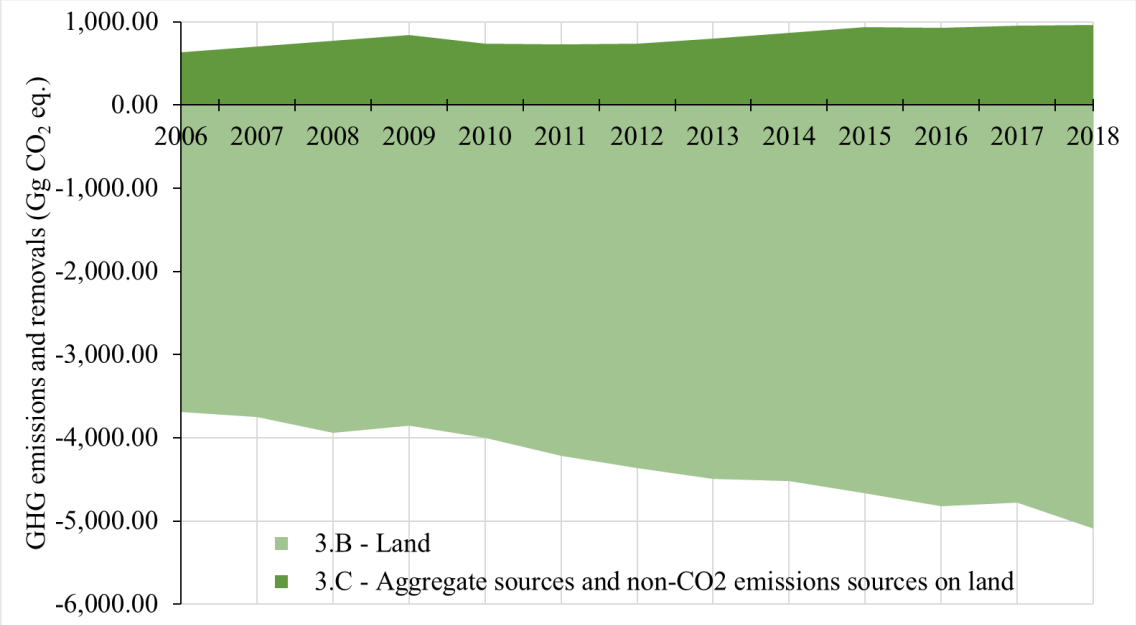
The shares and trends in GHG emissions excluding Forests and Land Use (FOLU) are presented in **ES Figure 1**. Over the period 2006 through 2018, the GHG emissions excluding FOLU had a steady increase with peaks in 2010, 2015 and 2018. The latter peaks, which stem from the livestock category, reflect the high populations of cattle in these years. It is clear from the figure that the livestock category was the main source of the GHG emissions followed by the transportation category while the IPPU sector had the least contribution.



ES Figure 1 Shares and trends in GHG emissions excluding FOLU (2006-2018), Gg CO_2 eq.

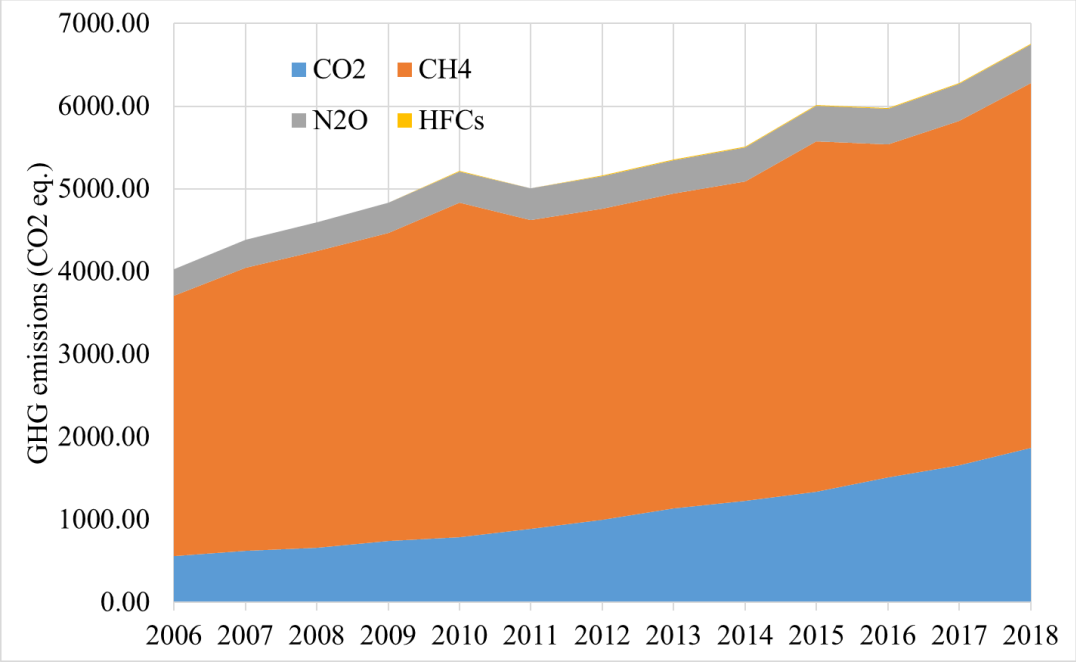
The GHG emissions by sources dominated over the removals by sinks, resulting in total net emissions each year during the whole period 2006-2018. It is interesting to note that in the previous GHG inventory, reported in the Third National Communication (TNC), GHG removals from FOLU (Forest and Other Land Use) had a dominant contribution to net emissions, resulting in net carbon sequestration. This difference in GHG emissions and removals is the result of improvement in GHG emissions calculation methodology and the discovery of new datasets, especially in agriculture and land use sub-categories, which are the dominant contributors to total GHG emissions and removals.

ES Figure 2 shows the shares and trends of GHG emissions and removals from FOLU. The time series shows that the GHG removals from forests dominated over the GHG emissions from Land Use, resulting in the total net sink. However, the removals were offset by the emissions from the other sources. The GHG removals had a consistently increasing trend (larger sink) over the whole period 2006-2018, while the emissions from the land use activities showed a steady trend.



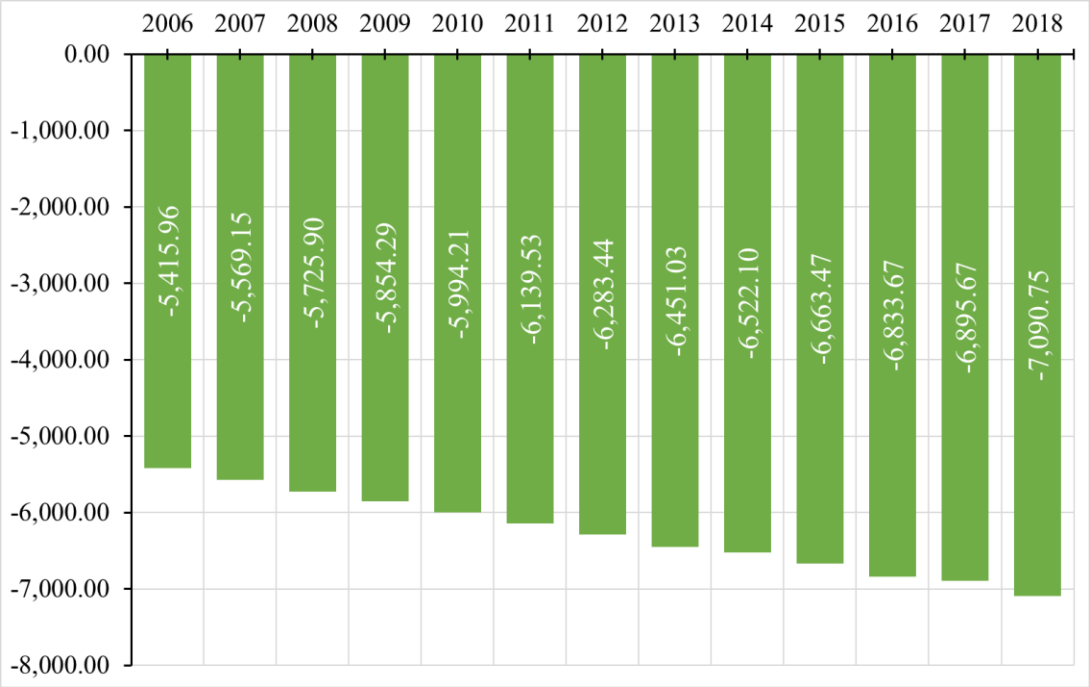
ES Figure 2 Shares and trends of GHG emissions and removals in FOLU (2006-2018)

The direct GHG (i.e., CO_2, CH_4, N_2O, and HFCs) were mainly considered in this inventory, and indirect gases such as carbon monoxide (CO) and Nitrogen oxide (NO_X) were estimated in AFOLU sector. Shares of the direct GHG emissions excluding FOLU in 2006 - 2018 are presented in **ES Figure 3**.



ES Figure 3 Trends in GHG emissions (excluding FOLU) by gas (2006-2018)

The analysis of GHG emissions and removals shows that CH_4 had the highest share, followed by CO_2 and N_2O, whereas HFCs had a negligible share. Most of the CH_4 and N_2O emissions were generated from the AFOLU sector and to a lesser extent by the Waste and Energy sectors. While the most CO_2 emissions were generated by the energy sector.



ES Figure 4 Trends in carbon dioxide removals, Gg CO_2 eq.

ES Figure 4 shows the carbon dioxide (CO_2) removals by sinks in Rwanda for the period 2006 through 2018. The time series shows that during the period 2006-2018, the country was characterized by a relative increase in CO_2 removals, which contributed to the reduction of the total GHG emissions. However, the GHG emissions remained higher than the removals in each year throughout the period 2006-2018.

ES 3 Mitigation Actions and their Effects

Over the years, it has been proven that climate change is a global challenge requiring an integrated global response along with the principle of common but differentiated responsibilities and respective capabilities. Rwanda is committed to taking urgent action to mitigate and adapt to the effects of climate change. As part of UNFCCC, Rwanda has joined the Paris agreement with a goal of limiting temperature rise to 2^{o}C with an effort to reach 1.5^{o}C compared to pre-industrial levels. Recently, Rwanda has submitted its revised NDC, in which the country has committed a GHG emissions reduction target of 38 % from the BAU levels projected from 2015. In this BUR, the BAU emissions were updated based on the latest GHG inventory and the projections were conducted from 2019 through 2030, taking 2018 as a base year. The assessment was conducted

based on the mitigation actions proposed in the recent NDC for all the sectors (i.e., Energy, IPPU, AFOLU and Waste) and for the direct gases. Alternative scenarios for GHG emission projections were further developed for mitigation options for the period 2020-2030 to quantify emissions reduction potential, associated cost and financial needs. These alternative scenarios included an increase in removals as well as projects leading to reduced emissions. The focus was made on the options which have shown high mitigation potential. The progress of the mitigation actions and the mitigation achieved were assessed. In addition, targets for 2030 were provided for all the mitigation actions.

ES 4 Measurement, Reporting, and Verification (MRV)

The Measurement, Reporting and Verification (MRV) system helps non-Annex I parties under UNFCCC to ensure a coordinated approach to the implementation of mitigation actions and adaptation measures, effectively fulfil reporting requirements under the Convention and link their national Greenhouse Gas (GHG) inventory with policy development tracking. The Government of Rwanda (GoR) tasked the Ministry of Environment (MoE) in collaboration with REMA, as governmental institutions, to coordinate and monitor all activities related to the domestic MRV. The MoE has a role and responsibility for the implementation of the domestic MRV system in close collaboration with various entities and institutions responsible for the collection and management of relevant data. Furthermore, it oversees the schedule, work plans for the inventory of GHG emissions by sources and removals by sinks, mitigation assessments, and performance metrics of Nationally Appropriate Mitigation Actions (NAMA), and ensure sufficient time and resources received from various entities can follow best practice.

ES 5 Support Received and Needs

Though the Rwanda Green Fund (FONERWA) was put in place to act as a public-private partnership vehicle that uses public financing mechanisms such as grants, lines of credit, loan guarantees, public venture capital, and equity capital for environmental and climate change activities, it needs more financial support to deal with environmental issues and adverse effects of climate change. FONERWA has managed to support 37 projects valuing Rwf 37,921,316,736 using funds from bilateral development partners and the Government of Rwanda (Rwf 127,763,110,124).

Furthermore, the Global Environment Facility (GEF) as a mechanism for international cooperation to provide new, and additional grant and concessional funding to meet the agreed incremental costs of measure to achieve agreed global environmental benefits, has capitalized USD 2,743,532,279 to the Government of Rwanda through its agencies. On top of the 37 projects mentioned above supported financially by FONERWA, 11 projects were financed through bilateral and multilateral grants awarded to the Government of Rwanda from 2014 through 2020. However, these financial supports from various sources are not yet enough to cope efficiently and effectively with the

adverse impacts of climate change in Rwanda. Thus, more involvement of private, bilateral and multilateral partners is welcome to reduce the adverse effects of climate change and other environmental issues in Rwanda.

Chapter 1. National circumstances

1.1 Geographical characteristics

1.1.1 Geographical location

Rwanda is a landlocked country located in the east of central Africa. It lies between 1°4´ to 2°51´south latitude, and 28°53´ to 30°53´ east longitude and it covers an area of 26,338 km^2. It lies approximately 120 kilometers south of the Equator, at 1,100 kilometers from the Indian Ocean, at 1,920 kilometers from the Atlantic Ocean, at 3,750 kilometers from the Mediterranean Sea, and 3,980 km from South Africa Cape. It is bordered by Uganda at the North, Tanzania at the East, Burundi at the South, and the Democratic Republic of Congo at the West (**Figure 1.1**).

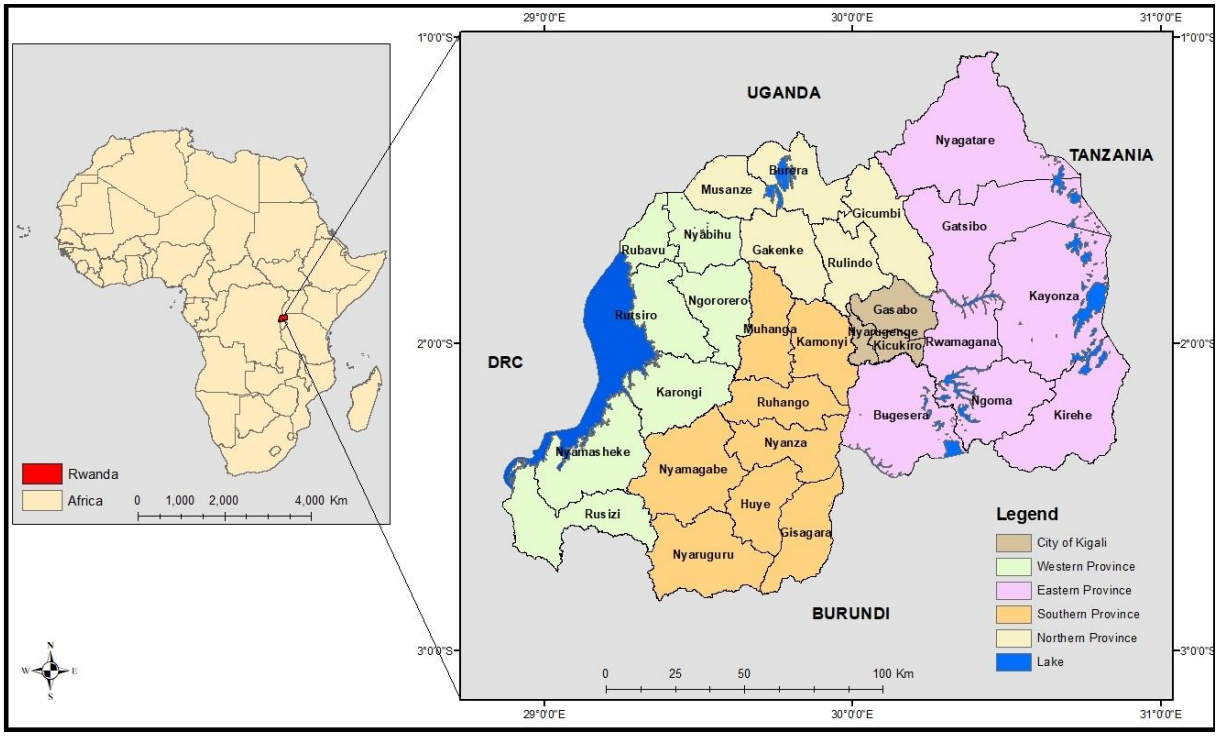


Figure 1.1 Administrative map of Rwanda

Rwanda's administrative structure comprises four Provinces (Eastern, Western, Northern, and Southern Provinces) and the City of Kigali (CoK). The four provinces and the City of Kigali are subdivided into 30 districts, 416 sectors, 2, 148 cells, and 14, 816 villages.

1.1.2 Topography

The topography of Rwanda is ascending western ward from 1000 m to 4507 m where eastern plains are lying on 1,300 m to 1,500 m and the central plateau region extended between 1,500 m and 2,000 m (**Figure 1.2**).

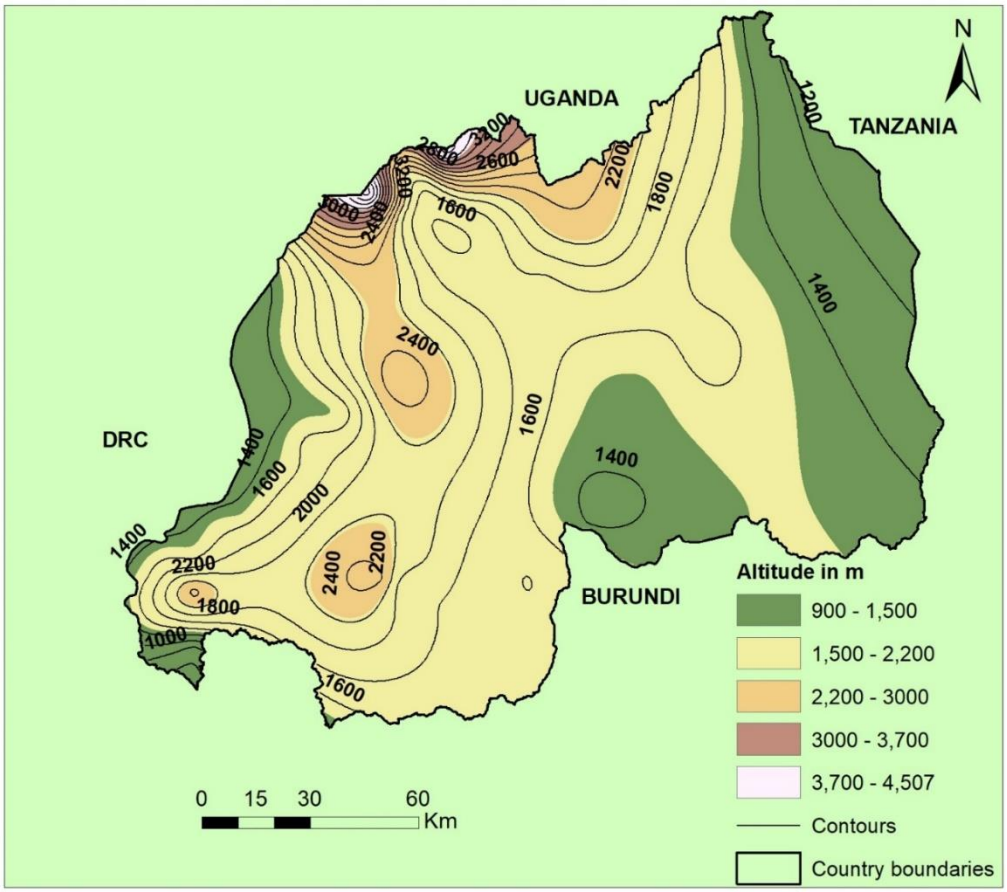


Figure 1.2 Topographic map of Rwanda

The Congo-Nile Ridge and volcanic chains of Birunga have heights varying between 1,800 m, 4,507 m (on the top of Kalisimbi Volcano) while the regions around Kivu Lake and Bugarama plains are sitting on 900 m to 1800 m (MINIRENA, 2010; Sirven & P., 1976).

1.1.3 Climate of Rwanda

Despite its proximity to the Equator, Rwanda enjoys a tropical climate moderated by hilly topography stretching from East to West. The country is divided into four main climatic regions, viz., eastern plains, central plateau, highlands, and regions around Lake Kivu. The eastern plains receive an annual rainfall of 700-1,100 mm, which falls in 57 to 100 days, with mean annual temperature oscillating between 20 °C and 22 °C (Ilunga et al., 2004; MINIRENA, 2010).

The central plateau region enjoys rainfall of 1,100-1,300 mm, received in 90 to 150 days, with an annual mean temperature of 18 °C-20 °C. The highlands, including the Congo-Nile Ridge and volcanic chains of Birunga, benefit from an annual rainfall of 1,300-1,650 mm, received in 140 to 210 days, with an annual mean temperature of 10 °C-18 °C. The region of Lake Kivu receives an annual rainfall of between 1,200 mm and 1,500 mm, received in 150 to 210 days, and annual mean temperature oscillating between 18 °C and 21 °C (Ilunga et al., 2004; MINIRENA, 2010; Muhire

& Ahmed, 2015). Bugarama plain is drier and hotter with 1000-1079 mm annual rainfall and 24°C mean annual temperature (Gaidashova et al., 2009).

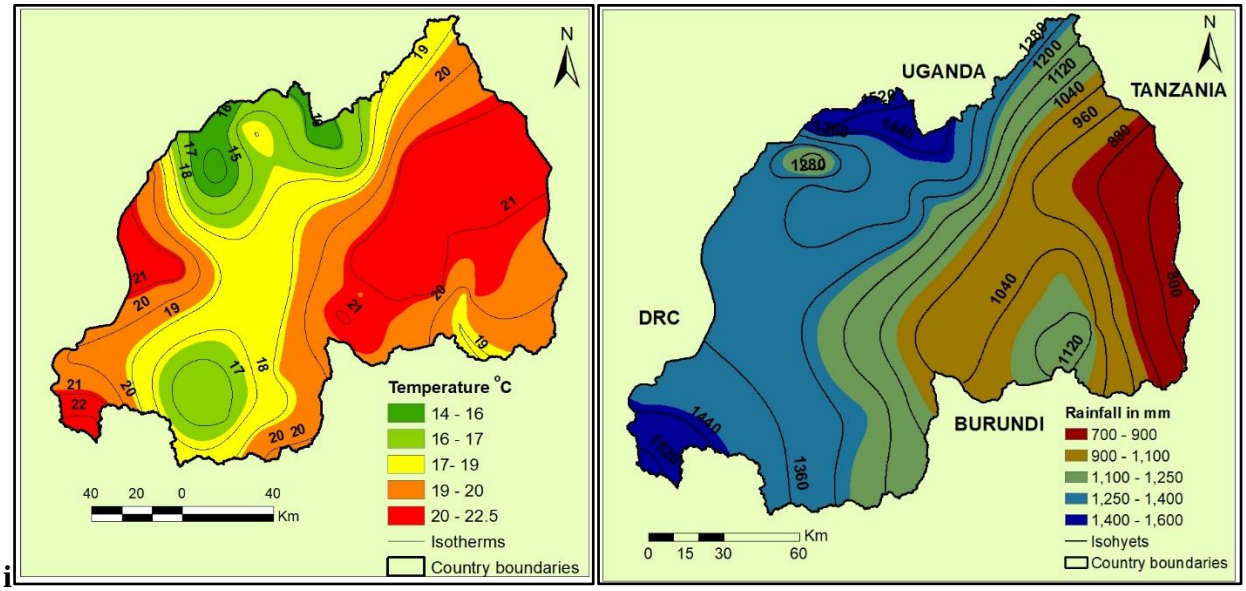


Figure 1.3 Spatial variation of temperature and rainfall in Rwanda

Data Source: Meteo Rwanda, 2019

Rwanda experiences four climatic seasons in which the long rainy (March-April-May) and short rainy (September-October-November) seasons alternate with long dry (June-July-August) and short dry seasons (December-January-February) throughout the year. The four seasons are largely controlled by the position and intensity of anticyclones such as Mascarenes, Saint Helena, Açores, and Siberian (Anyah & Semazzi, 2007; Ilunga et al., 2004; Kizza et al., 2009).

Rwanda gets the influence of Mascarene anticyclones from the coast of Mozambique in the Indian Ocean, which converge with wet winds (Saint Helena anticyclones) from the South Atlantic Ocean that pass over the Congo basin and Lake Kivu to form the Inter-tropical Convergence Zone over Rwanda. These anticyclones become responsible for the heavy rainfall yielded between March and May. Between June and August, the country comes under the influence of the dry Saint Helena and Azores anticyclones, which cause the dry conditions mainly in the eastern lowlands (Anyah & Semazzi, 2007; Clark, Webster, & Cole, 2003; Mutai & Ward, 2000).

At the beginning of September, the Inter-Tropical Convergence Zone (ITCZ) begins at the coast of Somalia and passes over Lake Victoria where it gathers humidity and brings rain to Rwanda, before heading southwards by the end of November. Dry and cold air masses (Siberian anticyclones) from the Arabian Sea are pushed by winter monsoon over Lake Victoria to yield some humidity, which gives a little rainfall in the highlands from December to February (Clark et al., 2003; Ilunga et al., 2004; Mutai & Ward, 2000).

1.2 Socio-economic characteristics

1.2.1 Population

The Fourth Rwanda Population and Housing Census (RPHC 4) conducted in 2012 indicated that the total population has increased from 8,128,553 people in 2002 to 10,515,973 people in 2012. The Integrated Household Living Conditions Survey 5 (EICV 5) indicates that the total population of Rwanda is estimated to be 11.8 million in 2016/17 with an increase of 0.4 million people since the EICV 4 (11.4 million) in 2013/14 (NISR, 2018c). The National Accounts in Statistical Year Book 2019 indicates that the population is expected to rise to 12,089,721 and 12,663,116 in 2018 and 2019, respectively with 2,630,904 (23.4 %) living in urban areas (NISR, 2019a). Therefore, there are additional 2,147,143 people from 2012 up to 2019. The time-series analysis shows that the population of Rwanda has increased throughout the years when it was almost doubled from 4,831,527 people in 1978 to 8,128,553 people in 2002 and is expected to double again in 2032.

1.2.2 Economy

The Vision 2020 adopted in 2000 and revised in 2012 had the main objectives to transform Rwanda into a middle-income country by 2020 based on a thriving private sector and a knowledge-based economy (MINECOFIN, 2000). It indicated that transforming Rwanda's economy would require increasing investments in industries and services. The industries should address basic needs according to the available market, firstly to satisfy local demand and even move towards export. The service sector becomes the most important engine of Rwanda's economy since Rwanda is landlocked and has limited natural resources.

Under the Economic Development and Poverty Reduction Strategy I (EDPRS I), priority was given to accelerating growth, creating employment and generating exports (MINECOFIN, 2007). The EDPRS II (2013-2018) focused on accelerating progress to middle-income status and better quality of life for all Rwandans, through sustained average GDP growth of 11.5 % and accelerated reduction of poverty to less than 30 % of the population (MINECOFIN, 2013). The first National Strategy of Transformation (NST 1) picked up from where the Economic Development and Poverty Reduction Strategy (EDPRS 2) left off and continues to accelerate the transformation and economic growth with the private sector at the helm (GoR, 2017).

The Annual economic reports indicated that in 2015/2016, the Rwandan economy grew by 6.5 % and during the fiscal year 2016/17, it grew by 3.4 %. During 2017/18, the Rwandan economy grew by 8.9 %, which was 5.5 % higher than 2016/17.
The National Economic report published by MINECOFIN indicates that during the fiscal year 2018/19 the economy of Rwanda recorded the highest growth in the last 10 years with 9.5 % which marks almost 3 % higher than the 10-years' average. MINECOFIN said that the growth was mainly driven by the industry sector, which saw its growth double from 8 % in 2017/18 to 16 % in 2018/19

due to construction and manufacturing boost, which saw 25 % and 12 % growth in 2018/19, respectively.

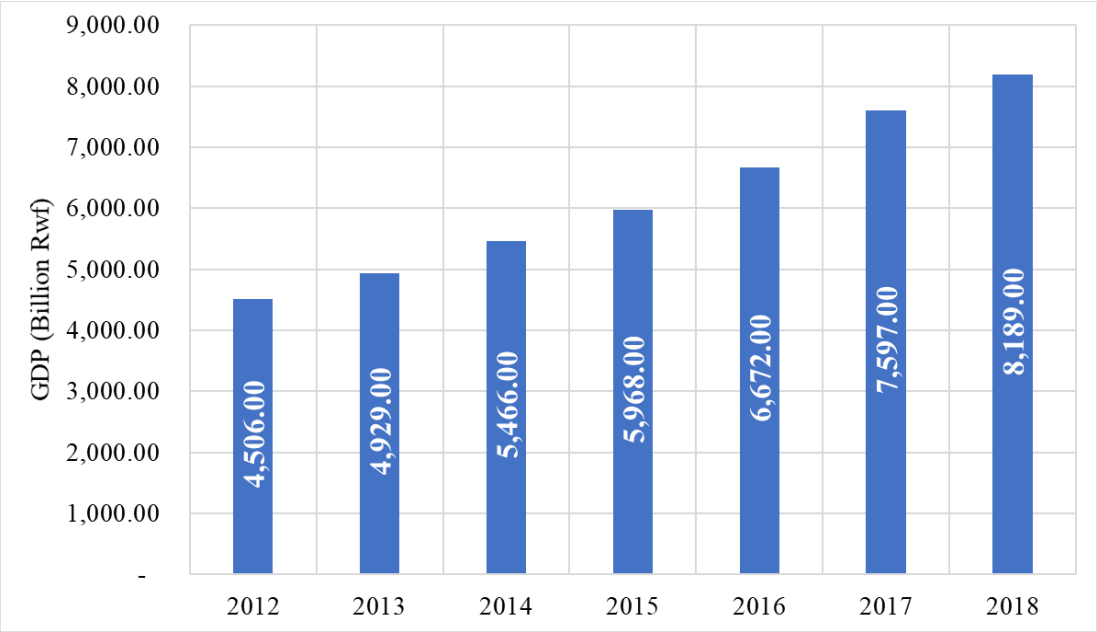


Figure 1.4 Evolution of Rwanda's Gross Domestic (GDP), 2012-2018

Source: (NISR, 2019a)

The Gross Domestic Product increased from Rwf 4,506 billion in 2012 to Rwf 7597 billion in 2017 and Rwf 8,189 billion in 2018 at the current price (NISR, 2019). This shows that Rwanda had exceptional economic growth in all sectors of activities in recent years.

1.3 Sectors of activity

1.3.1 Energy

The current national energy balance shows that biomass (mostly wood fuel) accounts for about 83 % in 2019, from 86.3 % in 2016/2017, of the total energy consumption, followed by petroleum at 9.7%, electricity at 1.3 %, and others at about less than 0.5% (MININFRA, 2018). In rural areas, the reliance on biomass is over 90%. Most Rwandans live in rural areas where traditional biomass, mainly wood fuel has remained the leading source of energy for cooking. The average household uses around 1.8 tonnes of firewood each year to satisfy its cooking needs with a traditional stove. At the national level, the use of electricity for lighting changed from 11 % in 2010/11 to 27.1 % in 2016/17; while the oil lamp and candle as the main source of lighting were used by 1.4 % and 6.1 % of households respectively as reported in EICV 5 (NISR, 2018c).

The use of charcoal has slightly increased across Provinces other than Kigali City and Eastern Province since the EICV 4. Electrification has been a priority policy area and the EICV 5 results

reflect this. Electricity use for lighting has significantly increased at the national level since the last survey in 2013/14 (from 20 % to 27 %). Provincial differences remain large, with 78 % of households in Kigali City using electricity.

As of December 2019, the cumulative connectivity rate was 52.8 % of Rwandan households including 38.5 % connected to the national grid and 14.3 % accessing through off-grid systems (mainly solar). During the elaboration of the EDPRS II, the Government of Rwanda took a clear policy decision to diversify the sources of electricity from the traditional dominant grid to include even off-grid connections. Subsequently, households far away from the planned national grid coverage have been encouraged to use alternatively cheaper connections such as Mini-grids and Solar Photovoltaics (PVs) to reduce the cost of access to electricity whilst relieving constraints on historical government subsidies.

The petroleum products consumed in the Energy sector in Rwanda include diesel/gas oil, heavy fuels oil, kerosene, motor gasoline, liquid petroleum gas, etc. The latter fuels are mainly used in transportation, electricity generation, manufacturing industries, and buildings. The use of these petroleum products in various activities contributes heavily to GHG emissions and constitutes an economic constraint since the total of liquid fuels is imported. Gas/diesel oil and motor gasoline are the most used in Rwanda as they increased from 142,281 in 2015 to 151,477 tonnes and from 87,838 in 2015 to 102,959 tonnes in 2018, respectively.

1.3.2 Industry

The secondary sector in Rwanda refers to industrial and mining activities. It contributed up to 16 % of GDP and it provides jobs to around 4 % of the national workforce in 2018. To ensure economic transformation, the EDPRS II targeted the industrial (manufacturing, construction, and mining) sector to contribute 20 % to GDP by 2018 and to grow at an annual rate of 11.5 %. However, this was not yet achieved. **Figure 1.5** shows the contributions of various industrial sub-sectors to national GDP for six years from 2012 through 2018. The industrial sector is dominated by the construction sector, followed by the food, beverages, and tobacco industries. Since 2017, food-processing activities overtook beverages in contributing to Rwandan GDP. Manufacturing sub-sectors showed a progressive improvement in production from 2012 up to 2018.

Table 1.1 Gross Domestic Product by kind of mining activities (in USD)

MINERAL	2012	2013	2014	2015	2016	2017	2018
Cassiterite	52,896,906	61,074,480	71,945,617	34,263,244	34,807,904	50,154,998	49,350,249
Coltan	56,911,604	134,571,614	104,780,331	66,200,323	39,742,507	62,209,186	71,461,829
Wolfram	26,262,461	30,053,783	26,592,318	17,343,125	11,873,683	12,604,563	21,352,433
Other	274,239	489,438	8,043,448	31,275,751	80,057,528	248,492,668	204,482,384
TOTAL	**136,345,210**	**226,189,315**	**211,361,714**	**149,082,443**	**166,481,621**	**373,461,416**	**346,646,895**

Source of data: EICV 5 (NISR, 2018a); Statistical yearbook 2019 (NISR, 2019a)

The mining sector provides income and employment to approximately 50,000 people (16 % of them are women); 14,000 people are employed in quarries; 773 sites are under exploration and/or exploitation. There are 369 active mining sites, operated by 259 companies; 36 companies are dealing with mineral processing and exporting (NISR, 2018c). The mining production by mineral types for the period 2012-2018 is summarized in **Table 1.1**.

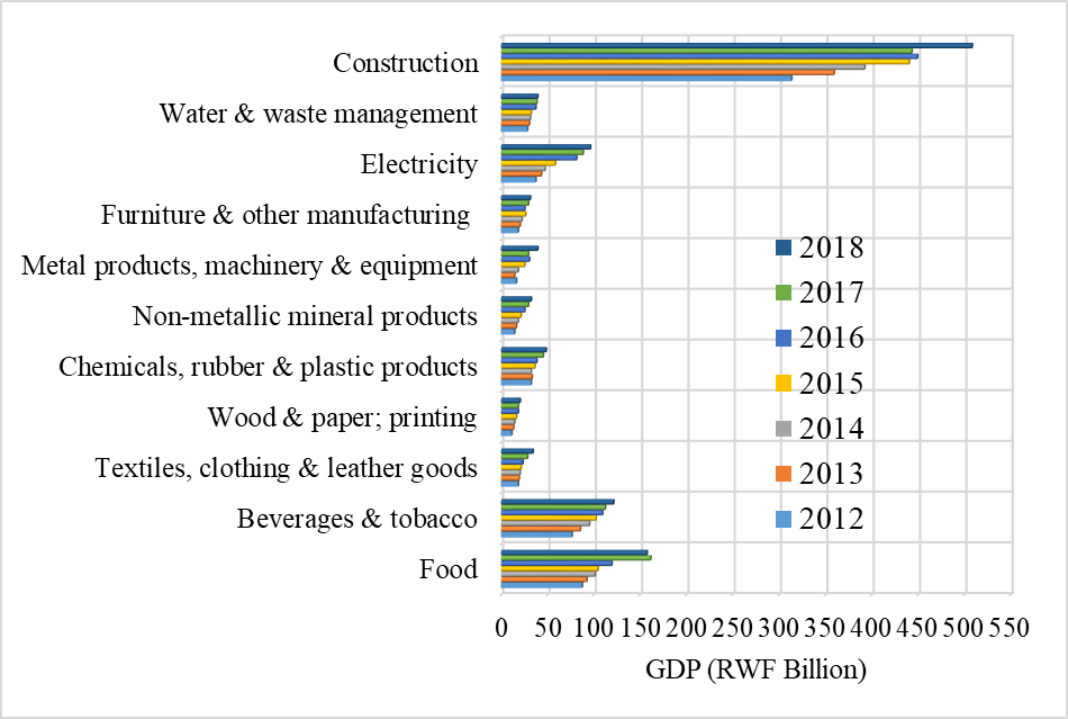


Figure 1.5 Gross Domestic Product by secondary activities

Source: (NISR, 2018c, 2019b, 2019a)

The production of cassiterite, coltan, wolfram and other minerals was estimated at 1,240.9 tonnes, 1,725.2 tonnes, 1,523.7 tonnes and 742.9 tonnes respectively to totalize annual production of 8,751.4 tonnes to contribute up to USD 373,461,416 to the National GDP in 2017 from USD 166,481,621 in the previous year (NISR, 2018). However, the income minerals were reduced to 346,646,895 USD in 2018 even though the production rose to 9,644.3 tonnes. This reduction might be attributed to the fall of their unit price at international markets in 2018.

1.3.3 Transport

The Government of Rwanda recognizes the transport sector as one of the key economic drivers of growth. The quality and reliability of Transport Infrastructure and Services are cornerstones for reduced transport costs, domestic and foreign investment attraction, and enhanced access to economic opportunities. The efficiency of the Transport Sector is thus critical to achieving the overarching objective of Rwanda's National Strategy for Transformation (NST 1) Economic

Transformation pillar of accelerating inclusive growth and development founded on the private sector, knowledge, and Rwanda's natural resources. Over the years, the Government of Rwanda and Development Partners increased investment in developing transport infrastructure, services as well as human resource development, to deliver diligently on the institutional mandate. The support has catalysed the development of modern infrastructure and services, generally contributing to a reduction in transaction costs, aiding mobility of goods and services thus, increasing the country's competitiveness. Under NST 1, the transport sector is pivotal in increasing domestic and international connectivity. The interventions made in the Transport sector focused on the key areas of land transport, inland transport, and trans-border infrastructure development. Subsequent sections provide an overview of the achievements recorded during the Fiscal Year 2018/2019.

Unpaved and paved national and urban roads were upgraded and rehabilitated to improve internal mobility and international connectivity. The total paved road network was extended to 1,973 km in 2019 from 1,930 km reached by the end of June 2018. As a result, the riding quality for the national paved roads network was sustained at 96.5 % of roads in good conditions; national unpaved roads recorded 73 % of roads in good conditions (NISR, 2019a). Furthermore, the number of vehicles increased from 183,703 in 2016 to 198,518 in 2017 and 216,204 vehicles in 2018. To reduce technical default-related accidents on Rwanda's roads, the Motor Vehicle Inspection centre was created as an integral part of the department of traffic and road safety at Rwanda National Police. The use of mobile machines with the engine gas emissions tester for vehicle inspection has improved the efficiency and effectiveness of the above-mentioned exercise. Furthermore, in 2016, the Government of Rwanda committed to reducing the number of imported old cars emitting toxic gases by increasing taxes. In the same line, the Government of Rwanda has introduced a long-term initiative on use of electric vehicles and motorbikes to reduce GHG emissions and the first trials were made in 2019.

1.3.4 Buildings

It is necessary to note that the urbanization policy was published in 2015 as a separate document to land policy. It provides a framework, which combines land, land use, urban planning and housing policy directions to achieve the efficient use of land and resources when developing housing. The urbanization policy of 2015 stands as a strategic driver of urban development and panacea for demographic pressures and sustainable land use, especially in urban areas. Rwanda's Vision 2020 targets at least 70 % of households living in rural areas to settle in integrated viable settlements. The targeted 35 % of the population by Vision 2020 to live in urban areas in 2020 was not achieved, as only 2,630,904 people (23.4 % of Rwandan population) were projected to be living in urban areas in 2019.

The current annual growth rate of the urban population is 4.1 % and the capital City of Kigali accommodated about half of the urban population. Through EDPRS 2, urbanization, and the rural

settlement sector strategic plan, six secondary cities were selected for the promotion of urban development outside of Kigali. The latter cities include Muhanga, Rubavu, Huye, Rusizi, Nyagatare and Musanze.

The EICV 5 results in 2018 showed an increase in the share of households living in planned villages commonly known as "umudugudu" (59%, compared to 49 % three years before), among the lower quintiles of the consumption distribution. The use of metal sheets as a roofing material has become more common across the country, with 67 % of households using this type of roofing on a national level in 2016/17, compared to 61 % in EICV 4 (2013/14). Slightly higher percentages of female-headed households than male-headed households live in isolated rural housing (18 % versus 16%), in dwellings provided free of charge (9 % vs 5%), dwellings with beaten earth as the main flooring material (72 % versus 67%), and tree trunks with mud as the main wall material (28 % versus 21%).

1.3.5 Agriculture and Forestry

Although Rwanda has realised rapid economic growth of around 8 % per year for five past years, agriculture growth was slower, on average 5.3 % per year. About 53 % of the working population was engaged in farming, which yielded about 33 % of Rwandan GDP in 2018 (EICV 5, 2018). It is at second position after services with 46 % and before industry sector with 16%, to contribute to the Rwandan's GDP. The total Rwandan agricultural land was 14,110 km^2 (53.57 % of the total territory) in 2016 and 14,147 km^2 (53.71%) in 2019 of the country's total surface area (NISR, 2019b).

Table 1.2 Agricultural land use in 2019

SN	Description	Total (Ha)	% to total land area
1	Intensive agricultural land (seasonal A and B)	1,414,781.4	53.7
2	Area under seasonal crops	1,024,508.2	38.89
3	Area under permanent crops	499,500	18.9
4	Area under permanent pasture	151,100	5.73
5	Temporary fallow land	114,600	4.35
6	Rangeland	133,848.5	5.08
7	Irrigated agricultural land	21,400	0.8
8	Temporarily midow and pasture	8,100	0.3

Source: (NISR, 2019b)

It is necessary to mention that apart from fertile volcanic soils in the north-western part of the country the remaining areas are less fertile and often have weathered soils. Furthermore, most Rwandan soils are shallow in depth especially in mountainous regions, which expose them to frequent fluvial erosion and landslides leading not only to their degradation and crop failure but also to the losses of human lives (Muhire & Ahmed, 2015). It was revealed that more than 62 % of households own less than 0.5 ha of the land farm. These small plots are overexploited for non-

stop growing of subsistence crops and farmers use traditional agricultural techniques and most of them depend on rain-fed agriculture. This leads to insufficient restoration of soil carbon, loss of soil organic matter and nutrients, thus soil degradation and a decrease in soil fertility, culminating in low crop productivity. The areas occupied by the key crops in Rwanda are shown in **Figure 1.6**.

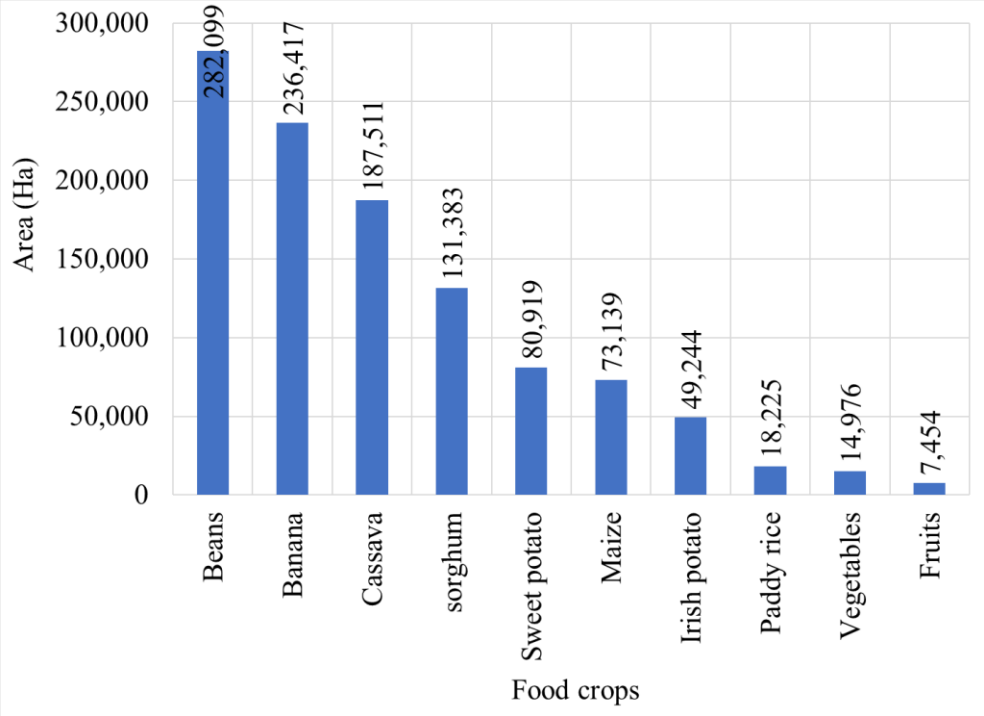


Figure 1.6 Areas occupied by the key food crops in 2019

The food crops grown in 2019 occupied 1,204,057 ha. The area occupied by various crops is presented in

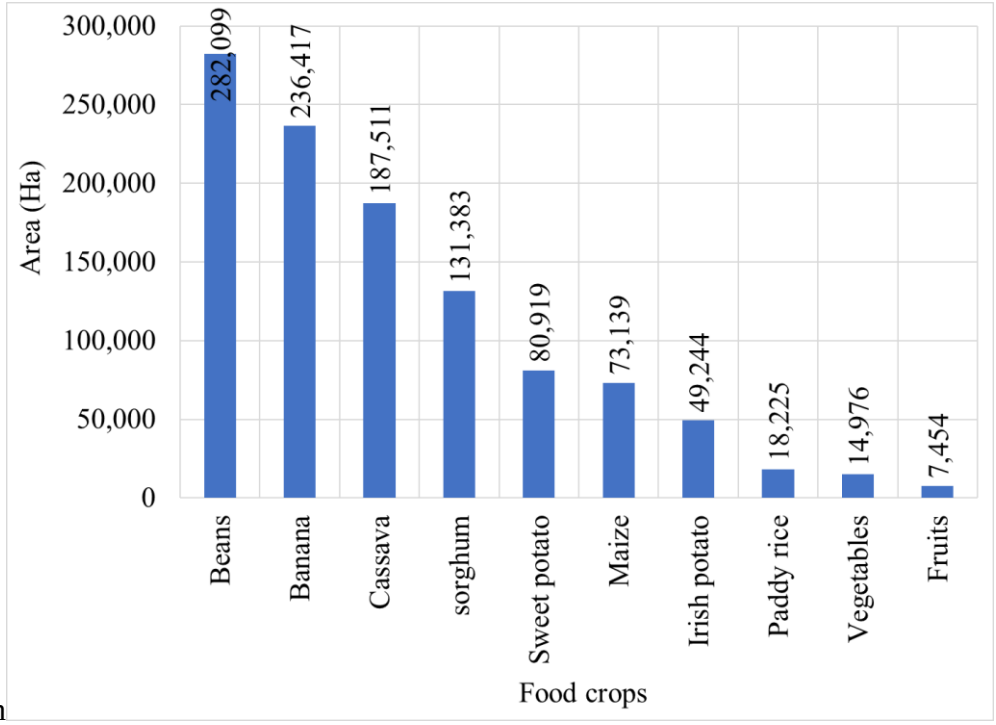


Figure 1.6. Beans occupied the highest area of 282,099 ha representing 23.42 %of the total cultivated area of the total area occupied by crops in 2019, while the fruits occupied the smallest area of 7,054 ha. Fallow land represented 15 % of the total arable land of Rwanda (NISR, 2019b).

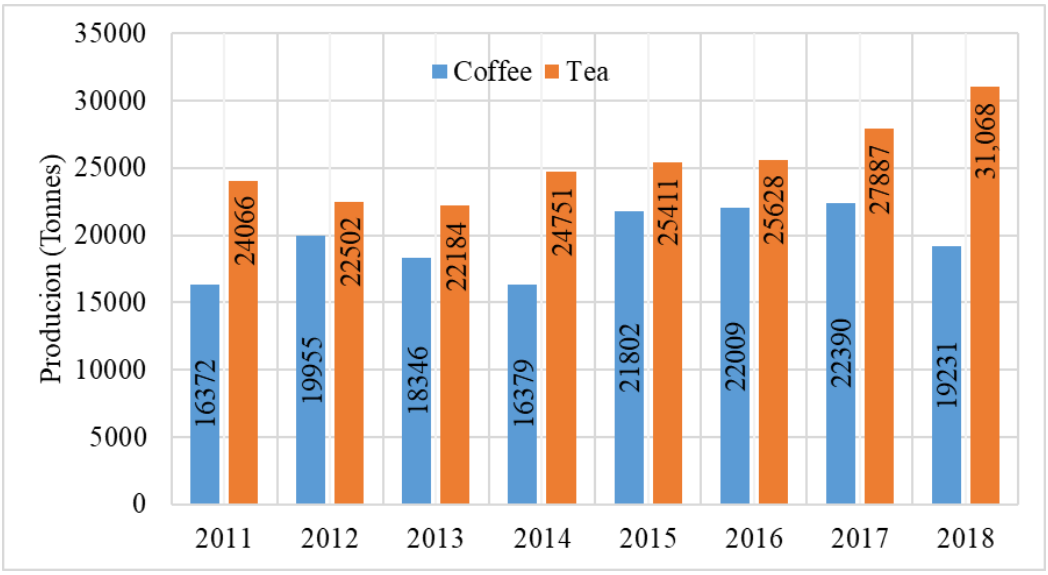


Figure 1.7 Evolution of tea and coffee production in Rwanda

Source data: EICV5, 2018; NIRS, 2018

Agricultural exports increased from 19.2 ('000 tonnes) in 2016-17 to 20.6 ('000 tonnes) in 2017-18, generating an additional 1.4 million USD in revenue. These were especially dominated by tea and coffee, which are the key cash crops grown in Rwanda. **Figure 1.7** shows the tea and coffee production in Rwanda. The coffee production increased from 16,372 tonnes in 2011 to 22,390 tonnes in 2017 and decreased to 19,231 tonnes in 2018. In the same years, tea production rose from 24,066 tonnes to 27,887 tonnes and 31,068 tonnes. This increase in food and cash crops production observed in Rwanda might be attributed to the agricultural reforms adopted since 2007. The latter reforms include the use of agricultural inputs like improved seeds and fertilizers, land use consolidation policy, marshland irrigation; erosion control programs by constructing progressive and/or radical terraces, one cow per family program, which sets out to integrate livestock keeping in agriculture by increasing the use of manure to improve soil fertility, among others.

1.3.6 Livestock and fishery

The promotion of livestock was not left out in process of socio-economic development of the country. **Figure 1.8** shows the changes that took place in the livestock population by type 2015 through 2018.

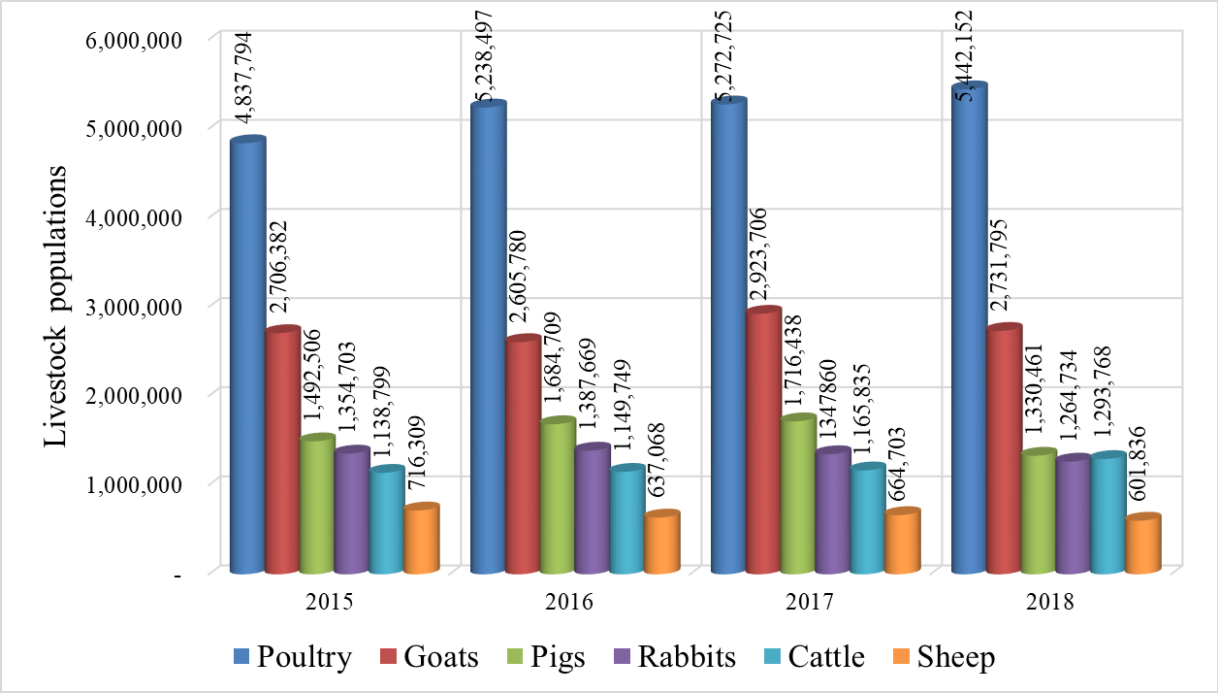


Figure 1.8 Livestock population by type and head

Source: RAB, 2019

The figure depicts an increasing pattern in total number of cattle and poultry from 1,138,799 and 4,837,794 in 2015 to 1,293,768 and 5,442,152 in 2018, respectively. However, a decreasing trend was seen in the remaining key animals kept in Rwanda (e.g., goats, sheep, pigs, rabbits). Goats

stood at 2,731,795 heads in 2018 compared to 2,706,382 and sheep were 601,836 in 2018 compared to 716,309 in 2015. Pigs and rabbits reduced from 1,492,506 and 1,354,703 in 2015 to 1,330,461 and 1,264,734 in 2018, respectively. Though these animals are not equally distributed among the Rwandan population, the figures reveal that a household keeps at least one of the above-mentioned animals. The largest livestock population is concentrated in the eastern and southern parts of the country. Poultry, goats, cattle remain the commonly owned domestic animals. Cattle predominate on the larger farms in the east and central regions (REMA, 2019d).

Increases in the volume of animal product exports like milk and meat were particularly significant. The production of milk and meat rose from 700,267 and 103,281 tonnes in 2015 to 815,074 and 162,470 tonnes in 2018, respectively. The same increasing trend was seen in eggs where they rose from 6,973 tonnes in 2015 to 7,936 tonnes in 2018. Furthermore, the production of honey was not left out as the production moved from 4,585 tonnes in 2015 to 5,200 tonnes in 2018 while the hides and skin production increased from 5,305 tonnes in 2015 to 6,567 tonnes. The figure below shows the evolution of fish production from 2015 to 2018.

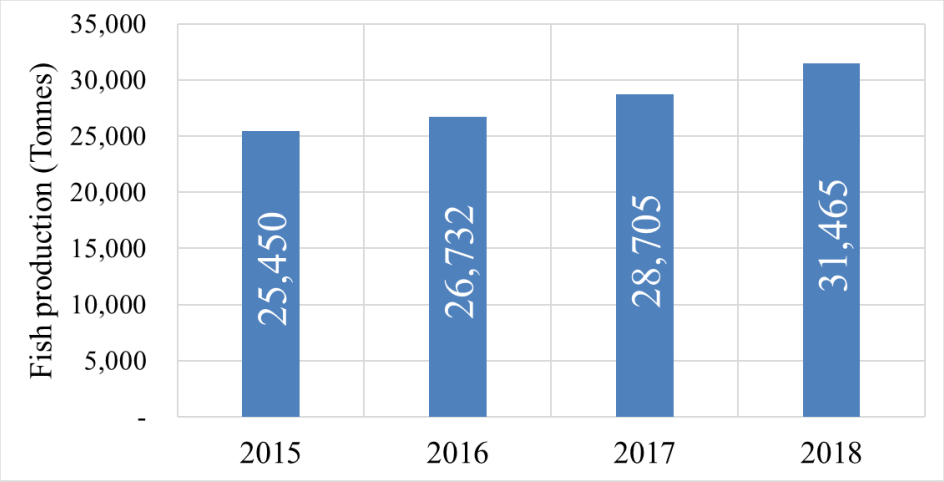


Figure 1.9 Fish production (2015-2018)

The figure above reveals a rise in fish production from 25,450 tonnes in 2015 to 31,465 tonnes in 2018. The production of 2015 was less than 24,550 tonnes registered in 2013 as reported in TNC (National Institute of Statistics of Rwanda, 2011). The fishing activities have been improved in all the country's lakes through the intervention of the Inland Lakes Integrated Development and Management Support Project (PAIGELAC). It is important highlighting that agricultural and livestock activities cannot be proliferous if the forest and vegetation cover are not well maintained to reduce soil erosion, landslides, and runoff that cause soil degradation to culminate by poor crops and animals productivity.

1.3.7 Forestry and vegetation cover

In 2019, forests of Rwanda occupy about 724,695 hectares of the total country land (30.4 %) of

which 387,425 ha (53.5 %) are plantations and 130,850 ha (18.1 %) are natural mountain rainforests, 161,843 ha are wooded savannah (22.3%) and 43,963 ha are shrubs (6.1%). The bamboo stand occupies only 613 hectares. In terms of density, about 318,434 ha are very dense forests (44%), 234,004 ha are moderately dense (32%), 146,222 ha are sparse (20%) and only 26,035 ha are much degraded (4%). In terms of regional leverage, South and Western Province take a big share (50 % of total forests) with 174,199 ha in the West and 177,537 ha in the South. Eastern province takes up to 38 % of the total forestland (274,630 ha). Northern Province contains only 85,688 ha and Kigali city remains only with 12,641 ha (MoE, 2019b). The top afforested district in 2019 is Nyaruguru with 55 % of its land occupied by forests (55,759 ha), followed by Rusizi district with 53 % of its land being forests (48,255 ha), Nyamagabe with 54,018 ha i.e., 50 % of its land, and Nyamasheke with 45,935 ha (48 % of its land). Savannah woodland of East makes Gatsibo and Kayonza districts be mostly covered by vegetation with 66,985 ha for Gatsibo (43 % of its land) and 80,645 ha for Kayonza with 45 % of land occupied by savannah. It is necessary to mention that the most covered districts by forests and savannah woodland are those occupied by national parks and forest reserves.

Table 1.3 National parks and forest reserves of Rwanda in 2019

Forest management status	Forest name/ Province	Forest area (ha)	Vegetation Characteristics	Biodiversity
National parks	Nyungwe NP	111,561	Montane tropical rainforest	More than 1,200 species of flora, 275 species of birds
	Volcanoes NP	16,000	Montane tropical rainforest	Mountain gorillas, a variety of plants and animal species
	Akagera NP	113,160	Shrubland/Savannah	More than 900 species of plants, 90 mammals, 5 giant wild animals
	Gishwati-Mukura NP	4,520	Montane tropical rainforest	Eastern chimpanzees, golden and mountain monkeys, shelters bushbabies, squirrels, and more than 200 and 250 species of birds and plant species
Forest reserves	Busaga, Buhanga, Sanza, Iwawa, Rubirizi, Makera, etc.	37,886	Montane tropical rainforest/ shrubland /savannah woodlands	Variety of plant species, mammals, and birds

Sub-total area	283,127 ha

Source: MoE, 2019.

Rwanda is also covered by public and private planted forests scattered across the country. Planted forests consist of exotic tree species like Eucalyptus, Pinus, and Grevillea, etc. Planted forests supply almost all fuelwood, with charcoal accounting for about 15.2 % of households' primary energy sources (Nyirambangutse et al., 2017).

Table 1.4 Unprotected woodlands and planted forests

Forest management status	Forest owner/ Province	Forest area(ha)	Vegetation Characteristics
Unprotected shrubland/savannah woodlands	Public and Private lands	116,210	Mostly arid species, e.g., *Acacia spp., Combretum spp.*
Public and Private Plantation forests	West Province	103,924	Mainly *Eucalyptus spp., Pinus sp., Grevillea robusta, Acacia melanoxylon*, and *Callitris spp.*
	South Province	132,683	
	East Province	64,649	
	North Province	73,791	
	Kigali city	12,379	
	Country (National)	387,425	

Except for city districts and towns where forests occupy less than 10 % of their lands, the less afforested are mainly Ngoma districts with 12 %, Gisagara, and Nyanza with 13 %, Kamonyi and Ruhango are afforested at 14 % of land under forest use. Afforestation efforts are needed in Mayaga, Bugesera, and eastern lowlands to mitigate consequences related to the lack of forests in these regions. In fact, not only the coverage is not satisfactory but also the density generally still needs improvement.

There is also vegetation found in wetlands and around lakes, rivers, and streams. Total wetlands cover 276,477 ha where 74 % of wetlands are of conditional exploitation, 6 % are of unconditional exploitation and 20 % of them are fully protected. They are dominated by *Papyrus spp.* especially in Kamiranzovu, Gishoma, Rugezi marshlands, and around lakes such as Muhazi, Burera, and Ruhondo (Nyirambangutse et al., 2017). Recently, the progress was not only registered in increasing forest and vegetation cover across the country but it was also seen in industrial development as was explained in the following section.

1.3.8 Waste management

Rwanda is recording a rapid urbanization process associated with rapid population growth in cities.

This increase is resulting in huge waste generation and high demand in public services including solid waste management services. However, there is no accurate study applied in Rwanda, which clarifies the amount and management of the household, agricultural, industrial, and commercial solid waste. Furthermore, the waste management policy and strategies are not yet fully implemented; the collection is properly done in the capital city of Kigali and a few towns located in the countryside. For secondary cities, licensed private companies sign the contract with Districts and the latter pays companies using hygiene tax collected from different commercial activities. Only households in city centres and mainly commercial activities benefit from the waste collection services that explains the low service coverage in these cities. Currently, landfills have been constructed in different parts of the country. This includes Nduba, Nyanza, Nyagatare, Ruhango, Huye, Kamonyi, Rwamagana, Nyamagabe, Musanze, Rubavu, Rusizi and Karongi. Though these landfills are used to receive solid wastes, there is no current comprehensive system of sorting solid waste at the source for collection, nor centralized sorting except for a couple of minor efforts for recycling and composting, such as efforts by COCEN company. Hence, a system of sorting waste at the source for collection should be developed to be able to treat wastes according to their types and compositions.

Compost heaps on the household's property and disposal in the household's fields and bushes are the main methods of rubbish disposal with 43 % and 47 % respectively. Very few households dispose most of their rubbish in rivers, lakes, or ditches, or burn it. The use of rubbish collection services in urban areas between EICV 4 and EICV 5 has increased from 36 % to 42%. On the other hand, in the rural areas, the percentage of households disposing of their rubbish directly in bushes or fields has increased from 42 % to 50 % between EICV 4 and EICV 5. This change has been most pronounced in Eastern Province (NISR, 2018a).

The estimation of wastewater remains a crucial challenge especially in spontaneous settlements and industrial areas because it is dumped directly into the physical environment, constructed sewage, pits, or water channels, which complicate its estimation. If this wastewater is channelled and treated at commonplace should facilitate its quantification.

Although the burning of waste in open areas is prohibited by the law in Rwanda, it is still done at a small scale; however, it is not easily estimated if it is unofficially done. Furthermore, data from incineration activities that are done at some hospitals, institutions, etc. are not available for inventory. Therefore, regular surveys are recommended to quantify the incinerated wastes. However, the institutions in charge of incineration activities should be requested to develop a recording system allowing quantifying the incinerated wastes.

There is a challenge to estimate the mass of waste deposited at managed landfills. Thus, Continual weighing (Weigh Bridge) of deposited waste at the Nduba landfill should be instituted via a weighbridge to gain accurate average daily and annual disposal mass. As well portable truck weights can be used to gain daily spot values of disposed of waste at the six secondary cities (Rubavu, Musanze, Nyagatare, Muhanga, Huye, and Rusizi).

1.3.9 Urban settlement

It is necessary to note that the urbanization policy was published in 2015 as a separate document to land policy. It provides a framework, which combines land, Land use, urban planning and housing policy directions to achieve the efficient use of land and resources when developing housing. The urbanization policy of 2015 stands as a strategic driver of urban development and panacea for demographic pressures and sustainable land use, especially in urban areas. Rwanda's Vision 2020 targets at least 70 % of households living in rural areas to settle in integrated viable settlements. The targeted 35 % of the population by vision 2020 to live in urban areas in 2020 was not achieved as only 2,630,904 (23.4 % of Rwandan population) was projected to be living in urban areas in 2019.

The current annual growth rate of the urban population is 4.1 % and the capital City of Kigali accommodated about half of the urban population. Through EDPRS 2, urbanization, and the rural settlement sector strategic plan, six secondary cities were selected for the promotion of urban development outside of Kigali. The cities are Muhanga, Rubavu, Huye, Rusizi, Nyagatare and Musanze.

The EICV 5 results in 2018 showed an increase in the share of households living in planned villages commonly known as "umudugudu" (59 %, compared to 49 % three years before), among the lower quintiles of the consumption distribution. The use of metal sheets as a roofing material has become more common across the country, with 67 % of households using this type of roofing on a national level in 2016/17 compared to 61 % in EICV4. Slightly higher percentages of female-headed households than male-headed households live in isolated rural housing (18 % versus 16 %), in dwellings provided free of charge (9 % vs 5%), dwellings with beaten earth as the main flooring material (72 % versus 67 %), and tree trunks with mud as the main wall material (28 % versus 21%).

1.3.10 Services

The tertiary sector including services and tourism has registered remarkable growth since 2010. It is the country's largest sector to contribute up to 46 %of Rwanda's GDP in 2018. The GDP from services at current prices increased from 3,156 billion RWF in 2016 to 3,524 billion in 2018, which translated to an increase of 10.44%. These services are provided from various categories like banking, insurance, transport, finance, wholesale and retail trade, hotels and restaurants, storage, communication, real estate, business services, public administration, education, and health services (NISR, 2019a). The real estate activities contributed much more (RWF 670 billion) in 2018 followed by wholesale and retail trade (RWF 566 billion). Cultural, domestic and other services along with public administration and defence also demonstrated a satisfactory contribution with 837 and Rwf 396 billion to GDP in 2018. The remaining service activities have shown also an increasing trend as seen in **Figure 1.5** (NISR, 2019a). Furthermore, tourism

continued to be prolific in Rwanda as it can be seen in the table below (**Table 1.5**) that the number of visitors to Rwanda's national parks increased from 24,120 in 2005 to 45,307 in 2010 and 94 036 in 2017 (NISR, 2018b).

Table 1.5 Statistics of national parks visits from 2005 to 2017

Year	Volcanoes National Park	Akagera National Park	Nyungwe National Park	Total
2005	10 495	11 476	2 386	24 120
2006	14 008	13 720	3 088	30 816
2007	18 001	16 323	3 981	38 305
2008	19 783	18 490	4 810	43 083
2009	18 865	14 890	4 695	38 450
2010	23 372	16 180	5 755	45 307
2011	26 821	22 457	8 274	58 153
2012	28 483	25 200	7 621	61 301
2013	25 199	29 687	6 902	61 788
2014	27 885	30 846	9 140	67 871
2015	27 111	36 862	8 817	72 790
2016	32 743	41 797	13 644	88 184
2017	35 567	44 054	14 415	94 036

Source of data: (NISR, 2018b)

The table above depicts that the total number of Rwandan national parks visitors was increased have increased from 2005 to 2017. This shows that tourism is increasingly contributing to the economy of the country.

1.4 Institutional arrangements

1.4.1 Institutional arrangements for preparation of the first BUR

The Ministry of Environment (MoE) is the key institution in charge of making policies, strategies, and programmes related to the environment and climate change. REMA has the legal mandate for national environmental protection, conservation, promotion, and overall management, including advisory to the government on all matters of the environment and climate change. REMA is also the national focal point institution of the UNFCCC and is, therefore, the central body responsible for the preparation of national communication and Biennial Update Reports (BURs) in fulfilment of reporting requirements under the convention.

The figure below **(Figure 1.10**) summarizes the Institutional Arrangements for the preparation of BUR 1. The preparation of the first Biennial Update Report (BUR 1) is under the responsibility of the Ministry of Environment through REMA. The project is implemented through three Thematic

Working Groups (i.e., National circumstances and crosscutting issues, Greenhouse gas inventory, and climate change mitigation) of technical experts supported by REMA staff.

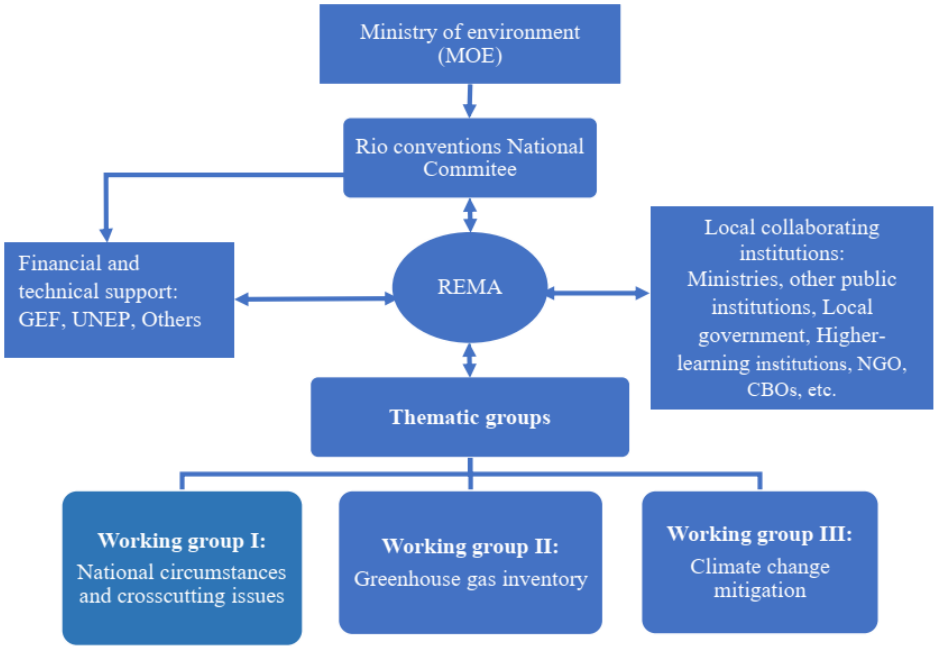


Figure 1.10 Institutional Arrangement for BUR1 preparation

It is important to mention that various governmental and non-governmental institutions contribute to providing key information and data used in the preparation of BUR1 and participated in validation processes of thematic reports for quality assurance concerning UNFCCC guidelines. The institutions that participated in the BUR development and their interventions are summarized in **Table 1.6**.

Table 1.6 Institutions involved in BUR preparation

SN	Institutions	Field of intervention	Key intervention in the BUR1 preparation
1	Ministry of Environment	Policies and laws on the environment	Endorsement and submission of the final report.
2	Rwanda Environment Management Authority (REMA)	Implementation of environmental policies and laws.	Responsible for compiling and producing thematic reports and final reports.
3	Rwanda Development Board (RDB)	Tourism and environmental conservation	Providing data on tourism and environmental conservation.
4	Rwanda Land Management and Use Authority (RLMUA).	Land use and management	Providing and validating data on land management and use.

SN	Institutions	Field of intervention	Key intervention in the BUR1 preparation
5	National Institute of Statistics (NISR)	Statistical data of Rwanda	Providing and validating key data to be used in the preparation of thematic reports.
6	Rwanda Agriculture Board (RAB)	Agricultural activities	Providing and validating data on agriculture.
7	Ministry of Agriculture and Animal Resources (MINAGRI)	Agricultural, livestock and fisheries sectors.	Providing and validating data on agriculture.
8	Ministry of Infrastructure	Infrastructure/Environment	Providing and validating data on energy, transport, housing and settlement, waste management.
9	Rwanda Forestry Authority	Forest management and use	Providing and validating data on forestry.
	Rwanda Water Resources Board	Water management and use	Providing and validating data on water
10	Rwanda Green Fund (FONERWA)	Environment and climate change	Providing and validating data on environment, climate change available funds in environment and climate change sector.
11	Ministry in charge of emergency Management (MINEMA)	Disaster and refugees' management/cross-cutting issues on the environment	Providing and validating data on occurred disasters.
12	Rwanda Meteorology Agency (Meteo Rwanda)	Data on weather, climate and climate change	Providing and validating data meteorological data.
13	University of Rwanda - College of Science and Technology	Research in some subfields of environmental science (especially in natural Sciences)	Validating draft and final thematic reports.
14	University of Rwanda - College of Education	Environmental and climate change education and research	Validating draft and final thematic reports.
15	United Nations Development Programme (UNDP)	Planning and implementation of some environmental cross-cutting projects	Providing data on available funds in the environmental sector. Validating draft and final thematic reports.

SN	Institutions	Field of intervention	Key intervention in the BUR1 preparation
16	Food Agriculture Organization (FAO)	Planning and implementation of some environmental projects in natural resources management (forestry, land, protected areas, etc.).	Data on environmental strategies and projects in natural resources management (forestry, land, protected areas. Validating draft and final thematic reports.
17	United States Agency International Development (USAID)	Planning and implementation of some environmental cross-cutting projects	Data on environmental strategies and projects in natural resources management (forestry, land, protected areas. Validating draft and final thematic reports.
18	Rwanda Mines, Petroleum and Gas Board (RMB)	Mining, quarries, petroleum and gas activities	Providing and validating data on mining, petroleum and gas.
19	Rwanda Housing Authority	Housing activities/environment	Providing and validating data on housing and settlement.
20	Rwanda Transport Development Agency (RTDA)	Transport/environment	Providing and validating data on transport.
21	Water and Sanitation Corporation (WASAC)	Provision of water	Providing and validating data on water and sanitation.
22	University of Rwanda - College of Agriculture, Animal Sciences and Veterinary Medicine (CAVM)	Research on agriculture and livestock	Validating draft and final thematic reports.
23	REG: Rwanda Energy Group Limited	Energy/environment	Providing and validating data on energy and electricity.
24	National Agriculture Export Board (NAEB)	Agricultural activities/environment	Providing and validating data on agricultural exports.
25	Swedish International Development Agency (SIDA)	Environmental sector	Data on environmental strategies and projects in natural resources management (forestry, land, protected areas Validating draft and final thematic reports.

1.4.2 Preparedness for the Enhanced Transparency Framework (ETF)

Rwanda has received funds from the Global Environment Facility (GEF) to strengthen the capacity of institutions in preparation to implement the ETF under Paris Agreement. The Rwanda Capacity Building Initiative for Transparency project was approved in August 2019 to strengthen the National GHG Inventory system. It offers targeted capacity building of key stakeholders to collect; process and feed data into the GHG Inventory system and it develops a data integration platform for data sharing and policy/decision making.

Through this project, the baseline institutional arrangement where REMA coordinates the GHG Inventory will be strengthened to work closely with the other Ministries, Agencies, and Departments at the national and District level. This will be reinforced with training to improve skills and capacity and equip REMA and the institutions that contribute to data provision and validation.

1.5 Legislations, policies, and strategies related to climate change

Rwanda has put in place a legal, policy, and strategic framework dealing with climate change, limiting the losses caused by climate change and variability effects to increase climate change adaptive capacity. Rwanda Environment Management Authority (REMA) oversees, follow-ups and mainstreams the environment in all development planning at the central and decentralized levels of governance while Rwanda Green Fund (FONERWA) has the mandate to mobilize and manage resources to support institutions and individuals to protect the environment and natural resources and respond to climate change and its impacts. The National Environment and Climate Change Policy was revised in June 2019 to provide strategic direction and responses to the issues in environmental management and climate change adaptation and mitigation. The policy was designed within the context of national, regional, and global development commitments (e.g., Vision 2050 aspirations, National Strategy for Transformation (NST 1), Green Growth and Climate Resilience Strategy (GGCRS), Nationally Determined Contributions (NDCs), Sustainable Development Goals (SDGs), Agenda 2063, East African Community-EAC Vision 2050, etc.).

To fulfil the country's obligations in implementing the international conventions related to environment and climate change, Rwanda has submitted the reports and actions plans. The latter include *inter alia* the Initial, Second and Third National Communication to the UNFCCC; the National Action Plan on the United Nations Convention to Combat Desertification (UNCCD); the National Adaptation Program of Action (NAPA) to climate change; Technology Needs Assessment, Nationally Appropriate Mitigation Actions (NAMA) and Nationally Determined Contributions (NDCs).

1.5.1 Vision 2050 aspirations (2020-2050)

Vision 2050 aspires to take Rwanda beyond high income to high living standards. Its income targets are to attain upper-middle-income country status by 2035 and high-income status by 2050 to provide high-quality livelihoods and living standards.

Environment and climate change was taken into consideration in key priority areas including the standards of life, developing modern infrastructure and livelihoods, and transformation for prosperity (developing high value and competitive off-farm green jobs and sectors).

1.5.2 Vision 2020 (2000-2020)

Vision 2020 is a long-term National Development Agenda adopted in 2000, and revised in 2012, with a vision to transform the country into a middle-income country by 2020. Vision 2020 recognizes that Rwanda's natural resources, environment, and climate change are connected to the country's development and that Rwanda is facing increasing climate change consequences including flooding, natural disasters, droughts, depletion of biodiversity, and degradation of its wetlands and waterways.

Vision 2020's focus on climate change and the environment in land use management, urban development, transport, energy, water, and waste management places the environment and climate change as a pivotal cross-cutting position in Rwanda's economic development and transformation.

1.5.3 National Strategy for Transformation (2017-2024)

National Strategy for Transformation (NST1) also called Seven Years Government Program (2017/2024) is a medium-term instrument introduced for the remainder of Vision 2020 and the first four years of Vision 2050.

It provides therefore foundation and vehicle towards vision 2050. Environment and climate change are highlighted, in the NST1, as cross-cutting areas of policy concerns, which can be positively impacted, by a range of development activities with priority given to agriculture, urbanization, industries, and energy.

1.5.4 EDPRS II (2013-2018)

The Economic Development and Poverty Reduction Strategy (EDPRS) was the Government's 5-year strategy for economic growth, poverty reduction, and human development for achieving the goals of Vision 2020. EDPRS II highlights the pursuit of a "green economy" as Priority 5 in economic transformation by placing a priority on the development of green urbanization and the promotion of green innovation in the industrial and private sectors. It further calls for the

establishment of a Centre of Excellence for research and skills development on green urbanization and a pilot "green" city (MINECOFIN, 2013).

EDPRS II goes on to note the importance of the environment and climate change as a cross-cutting issue, noting that Rwanda's economy is heavily dependent on the environment and natural resources which must be protected through mainstreaming environmental sustainability, reducing vulnerability to climate change, and preventing and controlling pollution. It notes the true cross-cutting nature of climate change across multiple policies and sectors including agriculture, energy, national resources, infrastructure, health, and the private and financial sectors (MINECOFIN, 2013).

1.5.5 Green Growth and Climate Change Resilience Strategy (2013-2050)

The Strategy provides a framework to select national priorities in line with ambitions set out in Vision 2020 and its stated objective of becoming a middle-income country and tackling issues of high population growth rates and density, limited availability of land, and dependence on imported fossil fuel for its electricity generation. This strategy looks at the period beyond 2020 until 2050 and recommends actions that Rwanda can take in the short to medium term to ensure its future stability and prosperity in a changing climate and uncertain energy future.

The purpose of this strategy is threefold, including guiding national policy and planning in an integrated way, to mainstream climate change into all sectors of the economy and position Rwanda in accessing access to international funding to achieve climate resilience and low carbon development. The strategy has 14 Programmes of Action that include mitigation and adaptation to climate change (**Table 1.7**).

Table 1.7 Programmes of actions reported in the Green Growth Strategy

Mitigation programmes of action	Adaptation programmes of action
Low carbon mix of power generation for the national grid	Sustainable intensification of agriculture
Sustainable small-scale energy installation in rural areas	Agriculture diversity in local and export markets
Green industry and private sector investment	Integrated Water Resources Management (IWRM) and planning
Climate compatible Mining	Integrated Land Use and Management
Low carbon urban settlements	Efficient resilient transport systems
	Ecotourism, Conservation, and Payment of Ecosystem Services
	Sustainable Forest and Agroforestry
	Disaster and Diseases prevention
	Climate data and projections

1.5.6 Nationally Determined Contribution (NDC), 2015-2030

Rwanda's updated NDC is built on the Green Growth and Climate Resilience Strategy (GGCRS) and focuses on adaptation and mitigation. The key sectors identified and prioritized under NDC include agriculture, forestry, tourism, water, land use, disaster management, climate data and projections, energy, transport, industry, and waste. The NDC for Rwanda reflects the national ambition by 2030 to join global efforts toward curbing global temperature rise below 2°C by 2100, with an aspirational target of 1.5°C. **Figure 1.11** provides a summary of the interlinks of the national development agendas.

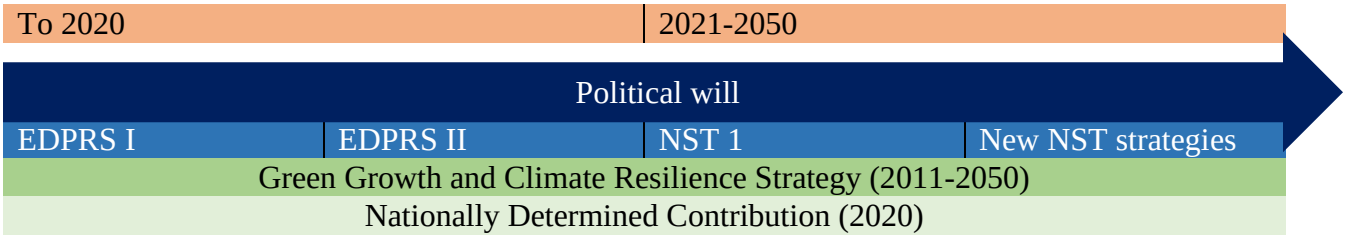


Figure 1.11 Strategic frameworks links

Chapter 2. National greenhouse gas inventory

2.1 Introduction

This chapter presents a summary of the updated national GHG inventory report for the period 2006 through 2018. Details regarding the methodologies and the results are reported in a standalone National GHG inventory Report. In this inventory, recalculations of the GHG emissions by sources and removals by the sink were conducted to update the Greenhouse Gas emissions inventory submitted in Third National Communication (TNC) and the 2016-2018 period was added to increase the coverage of the inventory to 2018. The reported GHG emissions and removals estimates were calculated and reported in consistence with the decision 2CP.17 and based on the guidelines for preparing the national communications from Parties not included in Annex I to the convention as contained in the annex to decision 17/CP.8. The calculations were performed using the 2006 IPCC guidelines through the latest 2006 IPCC software. Activity data were gathered from various sector reports, the official national statistics from the National Institute of Statistics of Rwanda, and from recent surveys conducted by REMA to fill the data gaps reported in the TNC. All the data appearing in these official documents were further cross-checked with relevant institutions working in their respective sectors. Specific and relevant data were also obtained from research work published locally and in international journals as well as annual and technical reports from the different research institutions.

In this inventory, an effort was made to use Tier 2 in various categories of the Agriculture, Forestry, and Land Use (AFOLU) and Waste sectors whereas a combination of the Tier 1 methodology with country-specific data was used in energy and Industrial Process and Product Use (IPPU) sectors. Direct greenhouse gases, i.e., CO_2, CH_4, N_2O, and HFCs were estimated in all four sectors (i.e., Energy, IPPU, AFOLU, and Waste) and converted in CO_2 equivalent (CO_2 eq.) using the Global Warming Potentials (GWPs) values provided by the IPCC in its Second Assessment Report (SAR) based on the effects of greenhouse gases over a 100-year time horizon.

2.2 Brief description of the GHG inventory steps

The national GHG inventory involved various steps, which were developed based on the challenges encountered in the previous inventories and the 2006 IPCC guidelines (IPCC 2006, 2006). **Figure 2.1** depicts the followed steps and their sequence in the NIR preparation.

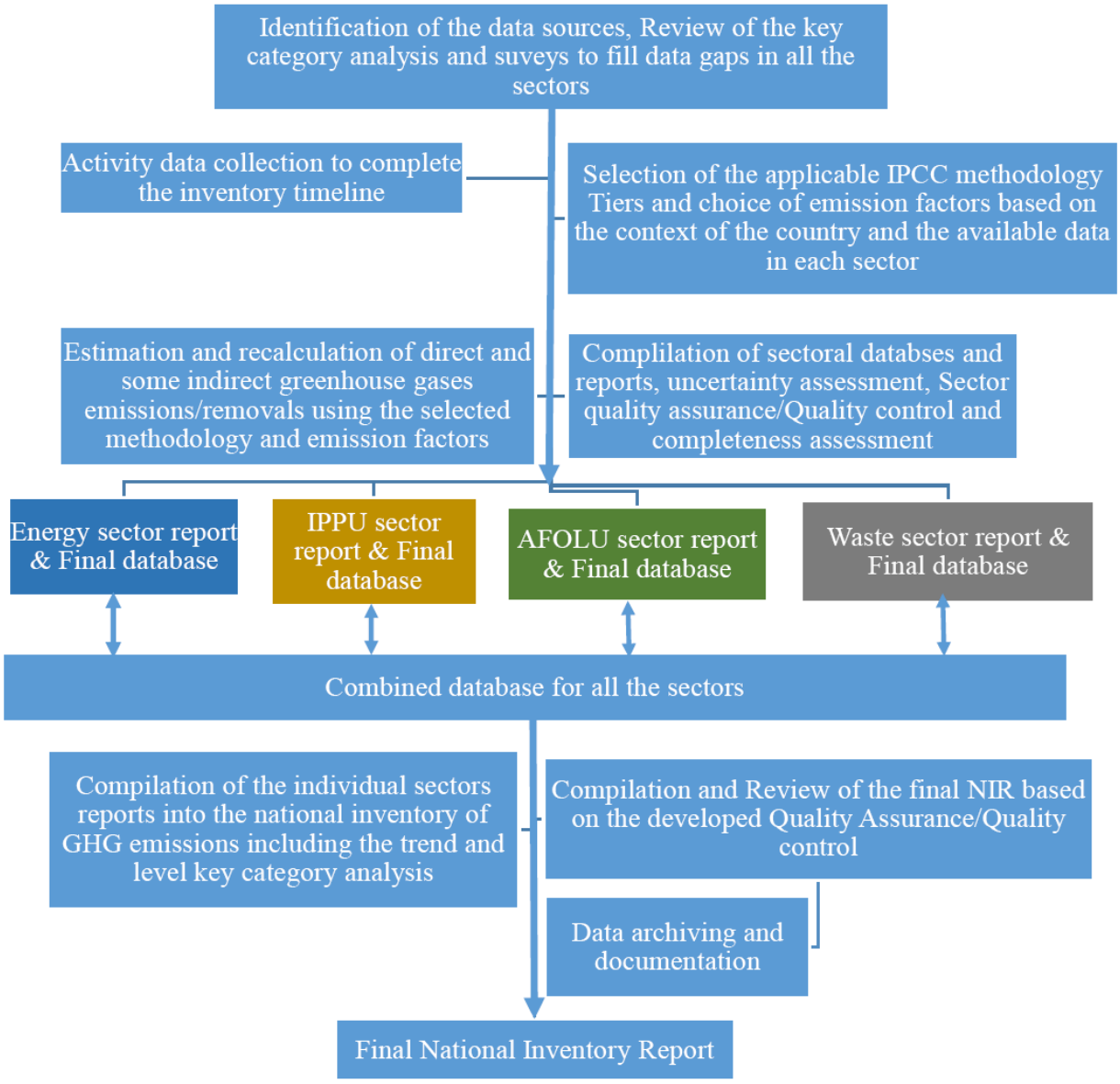


Figure 2.1 Steps in the development of the National GHG Inventory Report

Identification of the data sources, surveys to fill the activity data gaps identified in the previous GHG inventory with emphasis on the key categories:

- Activity data collection to complete the inventory timeline.
- Selection of the applicable IPCC methodology Tiers and choice of emission factors based on the context of the country and the available data in each sector.
- Estimation and recalculation of direct and some indirect greenhouse gases emissions/removals using the selected methodology and emission factors.
- Development of individual sectors reports on the GHG emissions/removals including the summary of total GHG emissions/removal by subcategory and by gas, sectors key

category analysis, uncertainty assessment, Sector quality assurance/Quality control, and completeness assessment.

- Compilation of the individual sectors emissions/removals reports into the national inventory of GHG emissions by sources and removal by sinks including the trend and level key category analysis.
- Review of the final NIR based on the developed Quality Assurance/Quality control.
- Data archiving and improved documentation.

2.3 Brief description of the institutional arrangement

The GHG inventory for Rwanda was developed by the GHG working group, under the sole responsibility of the Rwanda Environment Management Authority (REMA) through its division of Environment Analytics and Lake Kivu Monitoring (EALKM) and the Single Project Implementation Unit (SPIU). REMA's Technical staff coordinates activities of the GHG working groups, as well as their quality control and assurance. The Rio Convention National Committee, which comprises various stakeholders representing national institutions is responsible for supervising the inventory report development including the evaluation of key outputs to ensure the GHG inventory activities are being carried out on time. The National institutions are responsible for providing and ensuring the quality of the sectoral data.

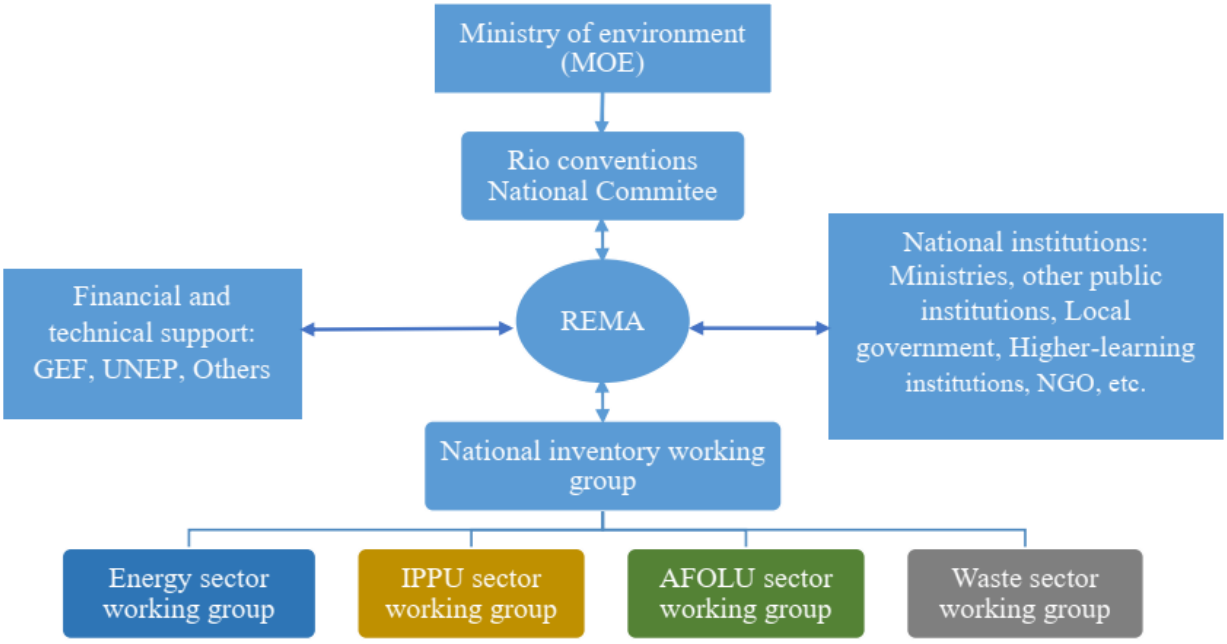


Figure 2.2 Institutional arrangements for GHG inventory development

The GHG working group is responsible for estimating GHG emissions and sinks in the republic of Rwanda, key sources analysis, quality assurance and quality control activities, uncertainty

assessment, documentation, and archiving of information related to the GHG inventory preparation process.

2.4 Brief description of the methodology and data collection

2.4.1 Guidelines

Rwanda's national inventory of greenhouse gases emissions and removals was prepared according to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories. Version 2.691 of the 2006 IPCC software (released on 23 January 2020), developed for these Guidelines, was used for data entry, emission calculation, and analysis of results.

2.4.2 Global Warming Potentials

The global warming potential values (GWPs) used to convert the estimated CH_4, N_2O, HFCs emissions in CO_2 equivalent (CO_2eq.) are presented in **Table 2.1**. They consist of the GWPs values provided by the IPCC in its Second Assessment Report (SAR) based on the effects of greenhouse gases over a 100-year time horizon.

Table 2.1 Global Warming Potential values

GHG	CO_2	CH_4	N_2O	HFC-32	HFC-125	HFC-134a	HFC-143a
GWP	1	21	310	650	2800	1300	3800

2.4.3 Methods

Rwanda's GHG inventory report was developed and structured according to the UNFCCC guidelines and in compliance with the 2006 IPCC guidelines. The GHG emissions and their uncertainties were estimated for the period 2006 and 2018 for the energy, IPPU, AFOLU, and Waste sectors and their respective categories. Tier 1 and Tier 2 methodologies were applied to estimate emissions of direct greenhouse gases (CO_2, CH_4, N_2O, and HFCs) for all sectors and country-specific data were considered where available. Activity data used for Rwanda's GHG inventory were mainly sourced from various stakeholders as detailed in subsequent sections. While the methodologies used for uncertainty assessment, quality assurance key category analysis, and completeness are provided in subsequent sections, a summary of the specific methodologies used in various categories and gases are provided in **Table 2.2**.

Table 2.2 Summary of the methods used in GHG emissions and removal calculations

IPCC categories	CO_2	CH_4	N_2O	HFCs
1.A.1 - Energy Industries				
1.A.1.a.i - Electricity Generation	Tier 1&2	Tier 1	Tier 1	NA
1.A.1.c.ii - Other Energy Industries	Tier 1	Tier 1	Tier 1	NA
1.A.1 - Energy Industries				

IPCC categories	CO_2	CH_4	N_2O	HFCs
1.A.2.e - Food Processing, Beverages and Tobacco	Tier 1	Tier 1	Tier 1	NA
1.A.2.f - Non-Metallic Minerals	Tier 1	Tier 1	Tier 1	NA
1.A.2.i - Mining (excluding fuels) and Quarrying	Tier 1	Tier 1	Tier 1	NA
1.A.2.k - Construction	Tier 1	Tier 1	Tier 1	NA
1.A.3 - Transport				
1.A.3.a.ii - Domestic Aviation	Tier 1	Tier 1	Tier 1	NA
1.A.3.b.i.1 - Passenger cars with 3-way catalysts	Tier 1&2	Tier 1	Tier 1	NA
1.A.3.b.ii.1 - Light-duty trucks with 3-way catalysts	Tier 1&2	Tier 1	Tier 1	NA
1.A.3.b.iii - Heavy-duty trucks and buses	Tier 1&2	Tier 1	Tier 1	NA
1.A.3.b.iv - Motorcycles	Tier 1&2	Tier 1	Tier 1	NA
1.A.3.d.ii - Domestic Water-borne Navigation	Tier 1	Tier 1	Tier 1	NA
1.A.3.e - Other Transportation	Tier 1	Tier 1	Tier 1	NA
1.A.3.e.ii - Off-road	Tier 1	Tier 1	Tier 1	NA
1.A.4 - Other Sectors				
1.A.4.a - Commercial/Institutional	Tier 1	Tier 1	Tier 1	NA
1.A.4.b - Residential	Tier 1	Tier 1	Tier 1	NA
1.A.4.c-Agriculture/Forestry/Fishing/Fish Farms	Tier 1	Tier 1	Tier 1	NA
2.A - Mineral Industry				
2.A.1 - Cement Production	Tier 1	NA	NA	NA
2.A.2 - Lime Production	Tier 1	NA	NA	NA
2.C - Metal Industry				
2.C.1 - Iron and Steel Production	Tier 1	Tier 1	NA	NA
2.C.2 - Ferroalloys Production	Tier 1	NO	NA	NA
2.D - Non-Energy Products from Fuels and Solvent Use				
2.D.1 - Lubricant Use	Tier 2	NA	NA	NA
2.D.2 - Paraffin Wax Use	Tier 1	NA	NA	NA
2.F Product Uses as Substitutes for Ozone Depleting Substances				
2.F.1.a - Refrigeration and Stationary Air Conditioning	NA	NA	NA	Tier 2
2.F.1.b - Mobile Air Conditioning	NA	NA	NA	Tier 2
3.A - Livestock				
3.A.1 Enteric Fermentation	NA	Tier 1&2	NA	NA
3.A.2 Manure Management	NA	Tier 1	Tier 1	NA
3.B - Land				
3.B.1 - Forest Land	Tier 1	NA	NE	NA
3.B.2 - Cropland	Tier 1	Tier 1	Tier 1	NA
3.B.3 - Grassland	Tier 1	NA	NA	NA
3.B.4 - Wetlands	Tier 1	NA	Tier 1	NA
3.B.5 - Settlements	Tier 1	NA	NA	NA
3.B.6 - Other Land	Tier 1	NA	NA	NA
3.C - Aggregate sources and non-CO_2 emissions sources on land				
3.C.1 - Emissions from biomass burning	Tier 1	Tier 1	Tier 1	NA
3.C.2 - Liming	Tier 1	NA	NA	NA
3.C.3 - Urea application	Tier 1	NA	NA	NA

IPCC categories	CO_2	CH_4	N_2O	HFCs
3.C.4 - Direct N_2O emissions from soils	NO	NA	Tier 1	NA
3.C.5 - Indirect N_2O emissions from soils	NO	NO	Tier 1	NA
3.C.6 - Indirect N_2O emissions from manure management	NO	NO	Tier 1	NA
3.C.7 - Rice cultivation	NO	Tier 1	NO	NA
4.A - Solid waste disposal				
4.A - Solid waste disposal	Tier 1	NO	NO	NA
4.B - Biological Treatment of Solid waste				
4.B - Biological Treatment of Solid waste	Tier 1	Tier 1	NO	NA
4.C - Incineration and Open Burning				
4.C.1 - Incineration	Tier 1	Tier 1	Tier 1	NA
4.C.2 - Open Burning	Tier 1	Tier 1	Tier 1	NA
4.D - Wastewater Treatment and discharge				
4.D.1- Domestic wastewater	Tier 1	Tier 1	NO	NA
4.D.1- Industrial wastewater	Tier 1	Tier 1	NA	NA

NO: Not Occurring, NA: Not Applicable, NE: Not Estimated

2.4.4 Activity data

The activity data were gathered from the official statistics, published national documents including the national reports from various institutions, the national statistical yearbooks (NISR, 2015, 2016, 2018b, 2019a), and from recent surveys conducted by REMA to fill the data gaps identified in the previous inventories (REMA, 2019b, 2019c, 2019d). All the data appearing in these official documents were further cross-checked with relevant institutions working in their respective sectors. Specific and relevant data were also obtained from research work published locally and in international journals as well as annual and technical reports from the different research institutions.

2.5 Trends in aggregated GHG emissions and removals

The summary of total GHG emissions and removals was estimated for the period 2006-2018 (**Table 2.3**). The estimates of GHG emissions reported here show some changes on those reported in the previous inventory as reported in the Third National Communication. These changes in GHG emissions reflect the recalculations due to improvements in GHG emission calculation methodology, the discovery of new datasets, and the correction of calculation errors in the previous data, especially in AFOLU, which is the dominant contributor to total GHG emissions and removals.

The summary of national total direct emissions reported as CO_2 equivalents within the four IPCC sectors is shown in **Table 2.3**. The national emissions (excluding FOLU) increased from 4,034.54 Gg CO_2 eq. in 2006 to 6,755.68 Gg CO_2 eq. in 2018 with an increase of 40.28 % compared to the 2006 level. However, a part of these emissions was offset by the removals from the forests. The national total emissions and removals reduced to 981.71 Gg in 2006 while those in 2018 reduced

to 2,630.11 Gg CO_2 eq. The increase in net emissions was estimated at 62.67 % of the 2006 level. It is clear from **Table 2.3** that the AFOLU and Energy sectors are the main sources of GHG emissions followed by the Waste sector, while the IPPU sector had the least contribution. Though IPPU had the least contribution to total emissions, it recorded the fastest growth of 73.41 % with the respect to 2006 level while the AFOLU recorded the slowest growth of 34.08%. The highest growth in IPPU sector emissions reflects the growth in clinker production in the cement industries and the growth in the ODS imports. Energy and Waste sector emissions grew by 61.39 and 39.47%, respectively. The high growth in Energy sector emissions reflects the growth in fleet population in the transport category.

Table 2.3 Summary of national total emissions and removals (2006-2018), Gg CO_2 eq.

Categories	2006	2007	2008	2009	2010	2011	2012
National Total Emissions and Removals	**981.71**	**1,334.7**	**1,427.4**	**1,820.7**	**1,946.7**	**1,525.1**	**1,532.64**
National Total Emissions (excluding FOLU)	**4,034.5**	**4,383.0**	**4,598.5**	**4,832.5**	**5,213.0**	**5,009.7**	**5,159.92**
1 - Energy	909.21	982.24	1,033.2	1,129.3	1,210.9	1,322.4	1,448.62
1.A - Fuel Combustion Activities	909.21	982.24	1,033.2	1,129.3	1,210.9	1,322.4	1,448.62
1.A.1 - Energy Industries	115.65	120.31	82.89	131.97	135.86	159.85	179.96
1.A.2 - Manufacturing Industries and Construction	75.46	84.62	82.74	82.03	81.46	85.52	84.15
1.A.3 - Transport	359.52	414.79	501.11	545.64	597.71	679.21	778.96
1.A.4 - Other Sectors	358.57	362.53	366.48	369.71	395.94	397.91	405.55
2 - Industrial Processes and Product Use	**40.26**	**39.60**	**39.76**	**34.94**	**36.54**	**38.29**	**39.47**
2.A - Mineral Industry	38.88	37.44	37.49	31.70	32.21	32.79	31.51
2.A.1 - Cement production	38.10	36.84	36.84	30.88	31.38	31.47	29.63
2.A.2 - Lime production	0.79	0.60	0.65	0.81	0.83	1.32	1.88
2.D - Non-Energy Products from Fuels and Solvent Use	0.96	1.32	0.99	1.47	2.06	2.09	2.81
2.D.1 - Lubricant Use	0.78	1.28	0.99	1.11	1.42	1.52	1.98
2.D.2 - Paraffin Wax Use	0.18	0.04	0.00	0.36	0.64	0.57	0.84
2.F - Product Uses as Substitutes for Ozone Depleting	0.42	0.84	1.27	1.72	2.20	2.71	3.26
2.F.1 - Refrigeration and Air Conditioning	0.42	0.84	1.27	1.72	2.20	2.71	3.26
3 - Agriculture, Forestry, and Other Land Use	-522.92	-263.30	-249.25	26.81	31.55	-535.95	-688.66
3.A - Livestock	2,529.9	2,786.4	2,923.4	3,040.6	3,299.9	2,950.8	2,941.34
3.A.1 - Enteric Fermentation	2,450.5	2,695.3	2,827.7	2,939.9	3,191.2	2,848.8	2,832.72
3.A.2 - Manure Management	79.34	91.08	95.74	100.71	108.63	101.98	108.62
3.B - Land	-	-	-	-	-	-	-4,367.37
3.B.1 - Forest land	-	-	-	-	-	-	-6,283.44
3.B.2 - Cropland	1,296.0	1,367.3	1,339.3	1,552.0	1,575.4	1,520.3	1,508.10

Categories	2006	2007	2008	2009	2010	2011	2012
National Total Emissions and Removals	**981.71**	**1,334.7**	**1,427.4**	**1,820.7**	**1,946.7**	**1,525.1**	**1,532.64**
National Total Emissions without FOLU	**4,034.5**	**4,383.0**	**4,598.5**	**4,832.5**	**5,213.0**	**5,009.7**	**5,159.92**
3.B.3 - Grassland	197.19	228.79	224.12	228.97	199.61	189.99	200.34
3.B.4 - Wetlands	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.B.5 - Settlements	232.10	222.23	219.17	219.68	216.72	213.94	206.80
3.B.6 - Other Land	2.05	2.05	0.84	2.06	0.97	2.06	0.84
3.C - Aggregate sources and non-CO_2 emissions sources on	635.78	700.53	771.22	839.77	735.21	728.53	740.09
3.C.1 - Emissions from biomass burning	NE	NE	NE	NE	NE	NE	NE
3.C.2 - Liming	NE	NE	NE	NE	NE	NE	NE
3.C.3 - Urea application	1.55	2.17	1.86	3.98	2.40	3.64	5.96
3.C.4 - Direct N_2O Emissions from managed soils	293.85	314.00	322.94	356.02	355.54	342.14	381.47
3.C.5 - Indirect N_2O Emissions from managed soils	78.89	87.09	90.65	101.64	102.25	96.71	119.97
3.C.6 - Indirect N_2O Emissions from manure management	49.07	54.35	56.99	59.71	64.96	58.97	60.96
3.C.7 - Rice cultivation	212.42	242.92	298.77	318.42	210.07	227.07	171.74
4 - Waste	555.16	576.23	603.69	629.66	667.70	700.31	733.22
4.A - Solid Waste Disposal	175.36	189.71	204.09	219.92	235.69	257.13	278.25
4.B - Biological Treatment of Solid Waste	140.02	143.66	147.39	151.23	163.41	167.66	172.16
4.C - Incineration and Open Burning of Waste	15.31	15.70	16.12	16.53	16.96	17.40	17.86
4.D - Wastewater Treatment and Discharge	224.48	227.16	236.09	241.98	251.64	258.12	264.94
Memo Items (5)							
International Bunkers	5.19	5.05	2.06	0.55	1.53	4.53	4.67
1.A.3.a.i - International Aviation (International Bunkers)	5.19	5.05	2.06	0.55	1.53	4.53	4.67
1 - Energy	**1,610.3**	**1,719.1**	**1,808.3**	**1,977.3**	**2,136.5**	**2,354.8**	**61.39**
1.A - Fuel Combustion Activities	1,610.3	1,719.1	1,808.3	1,977.3	2,136.5	2,354.8	61.39
1.A.1 - Energy Industries	221.36	229.95	193.32	171.29	212.00	277.44	58.31
1.A.2 - Manufacturing Industries and Construction	91.10	113.67	134.00	183.03	184.75	220.87	65.83

Categories	2013	2014	2015	2016	2017	2018	Change
National Total Emissions and Removals	**1,652.5**	**1,854.2**	**2,278.7**	**2,078.5**	**2,449.8**	**2,630.1**	**62.67**
National Total Emissions excluding FOLU	**5,353.2**	**5,509.1**	**6,009.7**	**5,971.3**	**6,275.9**	**6,755.6**	**40.28**
1.A.3 - Transport	879.95	942.53	1,031.6	1,137.5	1,226.0	1,344.5	73.26
1.A.4 - Other Sectors	417.89	433.03	449.35	485.47	513.72	512.00	29.97
2 - Industrial Processes and Product Use	**43.32**	**49.15**	**81.68**	**125.26**	**147.09**	**151.41**	**73.41**
2.A - Mineral Industry	34.63	38.13	69.11	109.85	131.73	134.90	71.17
2.A.1 - Cement production	31.39	35.97	65.44	106.68	129.15	132.81	71.31
2.A.2 - Lime production	3.24	2.16	3.67	3.17	2.58	2.09	62.23
2.D - Non-Energy Products from Fuels and Solvent Use	2.81	3.20	3.88	5.67	3.40	3.17	69.78
2.D.1 - Lubricant Use	1.93	2.05	2.47	4.46	2.05	2.03	61.54
2.D.2 - Paraffin Wax Use	0.88	1.15	1.40	1.21	1.35	1.14	84.46
2.F - Product Uses as Substitutes for Ozone Depleting	4.29	5.63	7.18	8.16	9.12	9.57	95.61
2.F.1 - Refrigeration and Air Conditioning	4.29	5.63	7.18	8.16	9.12	9.57	95.61
3 - Agriculture, Forestry, and Other Land Use	**-746.07**	**-695.86**	**-428.55**	**-849.58**	**-706.30**	**-793.30**	**34.08**
3.A - Livestock	2,957.3	2,961.9	3,306.3	3,047.2	3,123.9	3,332.2	24.08
3.A.1 - Enteric Fermentation	2,847.8	2,852.9	3,197.0	2,917.9	2,991.3	3,196.9	23.35
3.A.2 - Manure Management	109.56	109.02	109.25	129.29	132.61	135.30	41.36
3.B - Land	-	-	-	-	-	-	27.57
3.B.1 - Forest land	-	-	-	-	-	-	23.62
3.B.2 - Cropland	1,567.0	1,596.5	1,568.7	1,595.9	1,674.3	1,609.5	19.48
3.B.3 - Grassland	182.14	197.14	224.97	199.52	223.10	170.98	-15.33
3.B.4 - Wetlands	NE	NE	NE	11.06	13.70	14.32	100.00
3.B.5 - Settlements	203.10	204.06	202.45	203.68	204.72	201.45	-15.21
3.B.6 - Other Land	2.06	2.06	2.06	2.03	0.75	2.06	0.89
3.C - Aggregate sources and non-CO_2 emissions sources on	795.98	867.35	934.26	928.69	952.99	966.79	34.24
3.C.1 - Emissions from biomass burning	76.41	150.06	153.50	80.77	94.50	75.98	-0.57

Categories	2013	2014	2015	2016	2017	2018	Change
National Total Emissions and Removals	**1,652.5**	**1,854.2**	**2,278.7**	**2,078.5**	**2,449.8**	**2,630.1**	**62.67**
National Total Emissions excluding FOLU	**5,353.2**	**5,509.1**	**6,009.7**	**5,971.3**	**6,275.9**	**6,755.6**	**40.28**
3.C.2 - Liming	NE	NE	NE	8.37	10.72	8.66	3.36
3.C.3 - Urea application	8.49	2.21	7.74	4.75	2.78	7.02	77.94
3.C.4 - Direct N_2O Emissions from managed soils	368.36	354.23	377.33	377.27	378.59	405.92	27.61
3.C.5 - Indirect N_2O Emissions from managed soils	105.42	101.02	109.77	110.76	111.93	119.68	34.08
3.C.6 - Indirect N_2O Emissions from manure management	61.38	61.68	65.84	68.07	69.32	68.79	28.66
3.C.7 - Rice cultivation	175.91	198.16	220.10	278.70	285.15	280.74	24.34
4 - Waste	**745.03**	**781.74**	**817.33**	**825.55**	**872.58**	**917.16**	**39.47**
4.A - Solid Waste Disposal	300.02	326.41	351.18	376.58	413.02	446.39	60.72
4.B - Biological Treatment of Solid Waste	152.54	156.06	159.64	135.10	138.33	141.61	1.13
4.C - Incineration and Open Burning of Waste	18.23	18.65	19.08	19.73	20.20	20.69	26.01
4.D - Wastewater Treatment and Discharge	274.25	280.63	287.43	294.15	301.02	308.46	27.23
Memo Items (5)							
International Bunkers	2.37	23.11	60.04	94.68	113.28	133.06	95.42
1.A.3.a.i - International Aviation (International Bunkers)	2.37	23.11	60.04	94.68	113.28	133.06	95.42

NO: Not Occurring, NA: Not Applicable, NE: Not Estimated

Change: % change in emissions between 2006 – 2018.

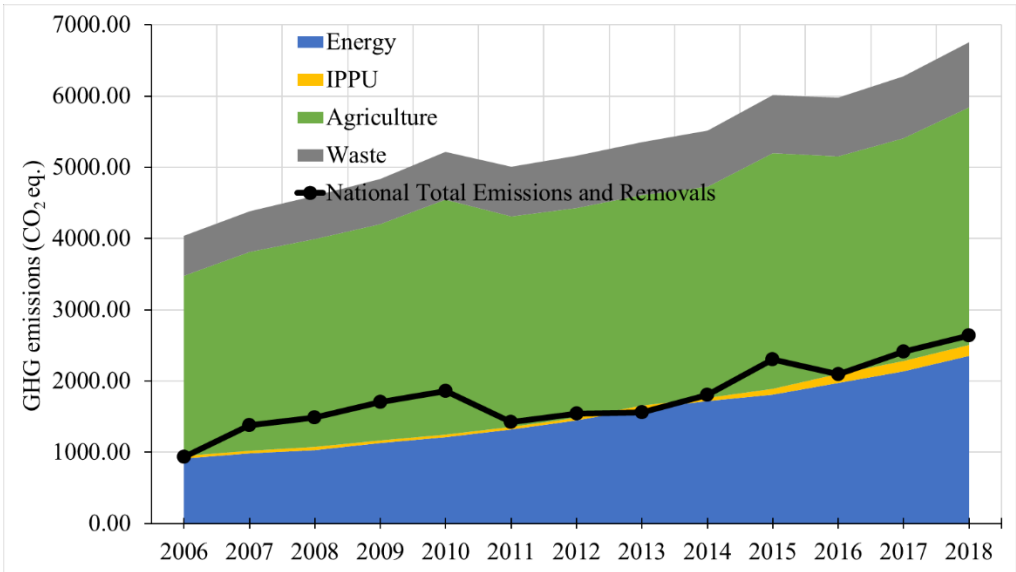


Figure 2.3 Shares and trends in GHG emissions excluding Forestry and Land Use (2006-2018), Gg CO_2 eq.

Figure 2.3 shows the trends and shares in net GHG emissions and removals (excluding FOLU). The dynamics of Rwanda's net GHG emissions had an increasing trend in total net emissions with some peaks in 2010, 2015, and 2018. These peaks, which stem from the AFOLU sector, reflect the high cattle population numbers in these years.

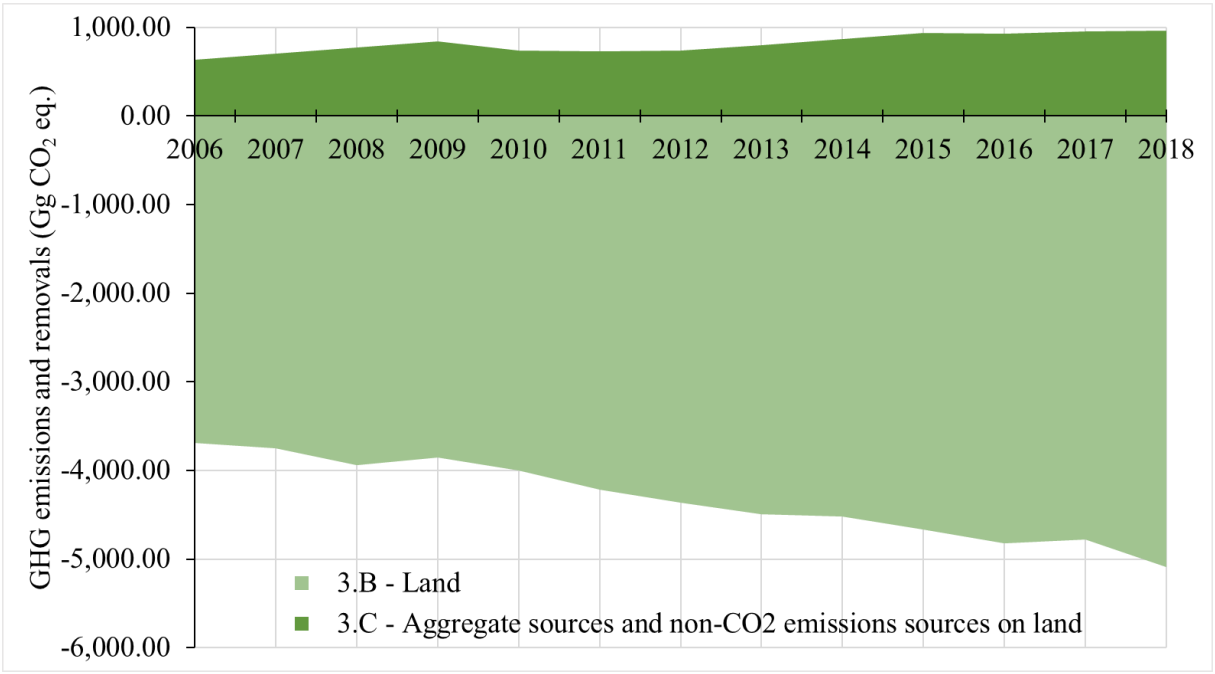


Figure 2.4 Trends and shares in total GHG emissions and removals from FOLU (2006-2018)

Figure 2.4 shows the GHG emissions and removals from the FOLU subsector. The time series shows that throughout the whole period of the inventory (2006-2018), the FOLU subsector acted as a CO_2 sink because the total emissions from the land use category were far smaller than the total removals.

2.6 Trends in GHG Emissions by sector

The shares of various sectors to total GHG emissions excluding FOLU are shown in Figure 2.5. In 2018, Rwanda's total GHG emissions were dominated by the emissions from Agriculture with 49.33 % of the total GHG emissions of 6,755.68 CO_2 eq., followed by the Energy sector with 34.86 % and Waste sector with 34.86 %, while the IPPU sector had the least share of 2.24 %. Though the IPPU sector had the least contribution to total GHG emissions (excluding FOLU) throughout the three years, it recorded the fastest growth since 2006. As seen from the figure, the IPPU share grew from 0.9 % in 2006 to 1.36 % and 2.24 % in 2015 and 2018, respectively. This rapid growth reflects the growth in the use of the clinker in the cement manufacturing industries and the use of HFCs in cooling systems.

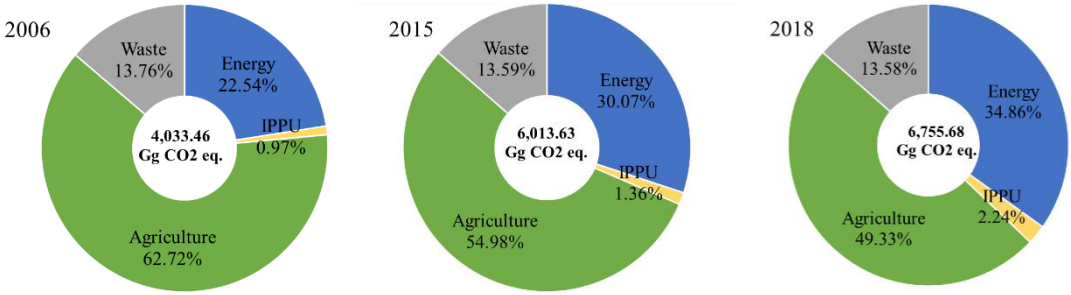


Figure 2.5 Shares of various sectors to total GHG emissions excluding FOLU in 2006, 2015 and 2018

The Agriculture sector was also the largest producer of GHG emissions in 2006 and 2015 with contributions of 62.72 % and 54.98%, respectively. It is worth noting the drop in the shares to total GHG emissions over the period 2006-2018, which reflects the rapid growth recorded by the Energy and IPPU sectors. The second-largest producer of GHG emissions is the Energy sector with shares of 22.54 %, 30.07 %, and 34.86 % to total GHG emissions in 2006, 2015, and 2018, respectively. The observed increase in the shares of the Energy sector to total GHG emissions reflect the rapid increase in the fleet population and the transportation emissions, the increase in biomass consumption in the brick manufacturing industries, the coal consumption in cement industries, and the use of methane gas and peat in electric power generation. The Waste sector is ranked third in the contribution to total GHG emissions with steady growth through the three years. Its shares to total GHG emissions were estimated at 13.76 %, 13.59 %, and 13.58 %, respectively.

2.6.1 Energy sector

According to the key category analysis, the Energy sector is the second contributor to Rwanda's total GHG emissions excluding FOLU. The general key category analysis revealed in 2018, four categories from the Energy sector had a key contribution to total GHG emissions from the Energy sector, viz., Road Transportation (1.A.3.b), Other Sectors - Biomass (1.A.4), Energy Industries - Gaseous Fuels (1.A.1) and Energy Industries - Liquid Fuels (1.A.1). **Figure 2.6** shows the trends in GHG emissions from the energy sector. The series shows a steadily increasing trend throughout the period 2006-2015 followed by a sharp increase in GHG emissions from 2015 through 2018. The latter sharp increase reflects the introduction of new peat to power, methane, and oil-powered power plants in the energy generation mix and the introduction of coal in the cement industry.

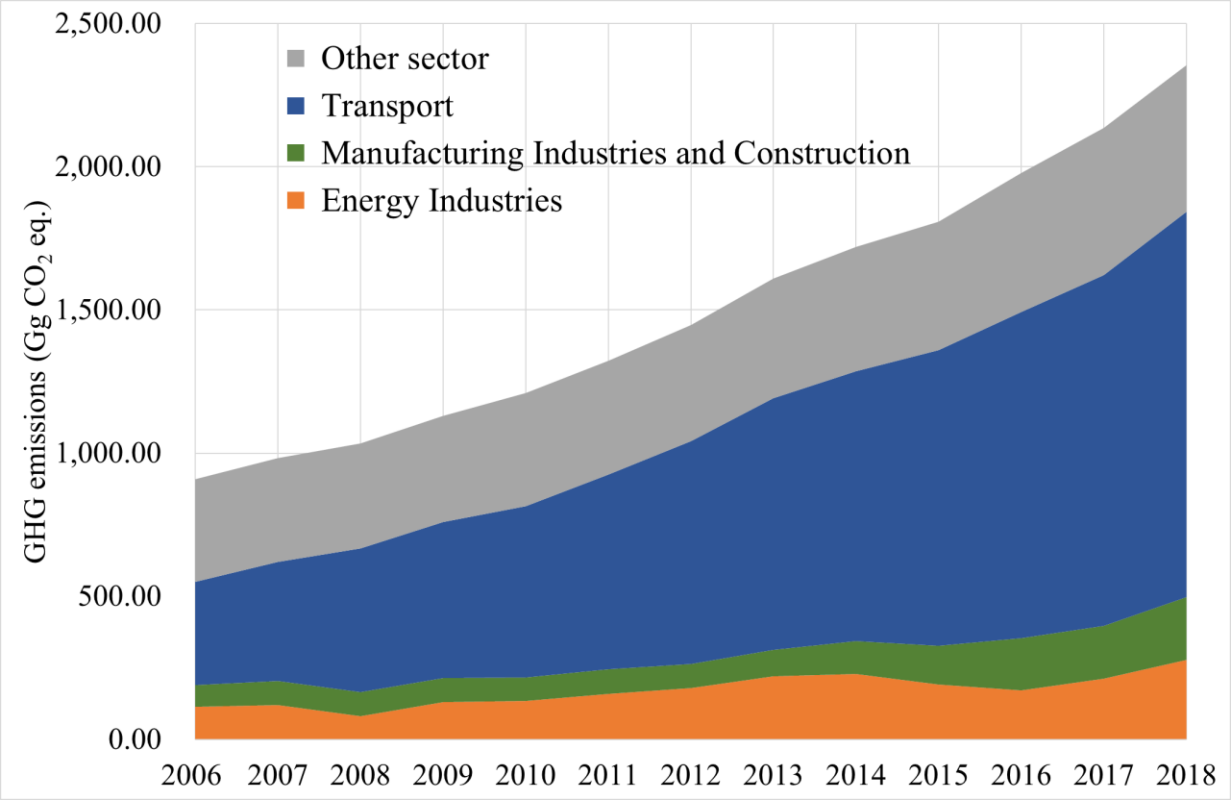


Figure 2.6 Trends in total energy GHG emissions (2006-2018)

2.6.2 IPPU sector

The GHG emissions from the IPPU sector are generated from (i) 2A Mineral industry, (ii) 2.C Metal industry, (iii) 2D Non-Energy Products from Fuels and Solvent Use, and (iv) 2F Product Use as Substitutes of Ozone-depleting substances are reported in this inventory. The total GHG emissions from the IPPU sector were dominated by the emissions from the mineral industries category (2.A) including cement production, followed by the Product Uses as Substitutes for Ozone Depleting Substances category (2.F) and the Non-Energy Products from Fuels and Solvent

Use (2.D) including lubricant use, while the Metal Industry (2.C) category had the least contribution. **Figure 2.7** shows the trends and shares of GHG emissions from the IPPU sector. The total GHG emissions from the IPPU sector show a steady trend from 2006 through 2014 followed by a tremendous increase over the 2014-2018 period. It is estimated that the total GHG emissions tripled from 2006 to 2018, with an annual growth rate of 12.8%. This increase is mainly due to the use of cement for the construction sector in Rwanda, which is experiencing a huge boost from needed infrastructures, and it is a key driver of the national economy. In addition, the growth in IPPU emissions can be explained by the increasing consumption of lubricants at the national level, which shifted from 1.31 to 3.35 Gg CO_2eq. from 2006 to 2018, respectively. The consumption of lubricants reflects the increase in motor vehicles registered over this period.

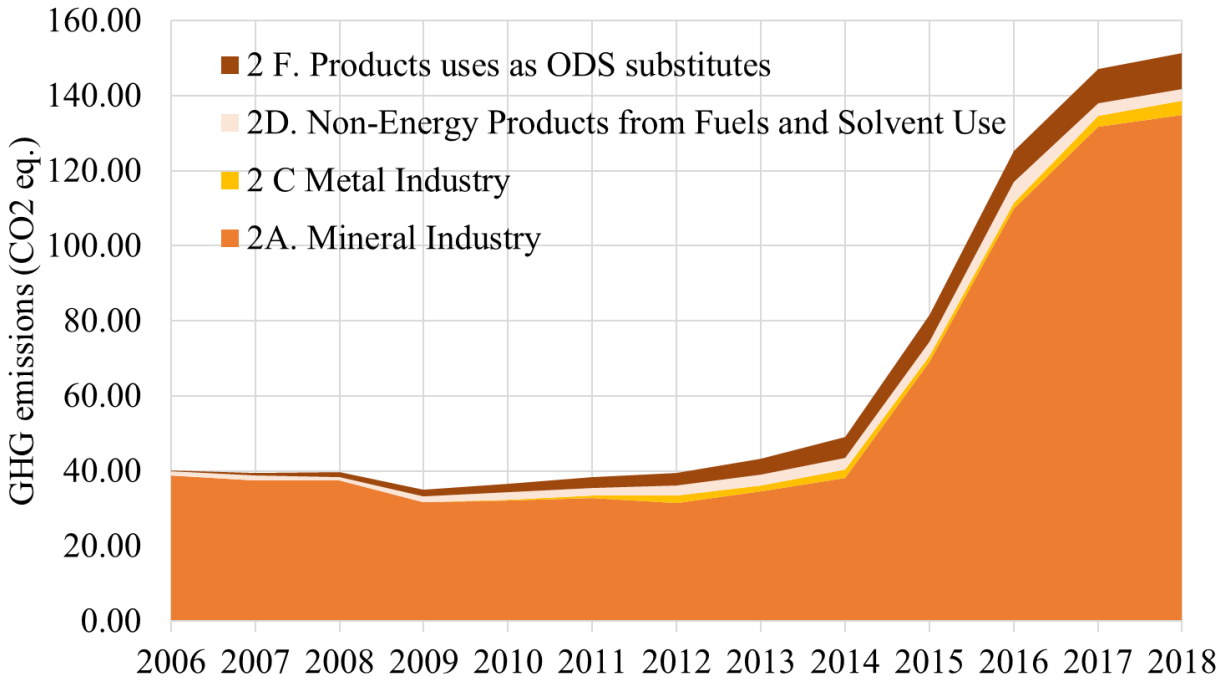


Figure 2.7 Trends and shares in GHG emissions from the IPPU sector

The huge import of lubricants in 2016 and the corresponding increase in Non-Energy Products use from Fuels and Solvent Category emissions, compared to the previous and following years, can be explained by the decline in crude oil price experienced in 2016 as mentioned in historical annual data of oil prices[1]. Similarly, the rise in emissions from product uses as substitutes for ODS is due to the increase of imported quantities of HFCs for refrigeration and stationary air-conditioning.

[1] https://www.macrotrends.net/1369/crude-oil-price-history-chart

2.6.3 AFOLU sector

The AFOLU sector, which is divided in this reporting into Agriculture and FOLU (i.e., Forestry and Other Land Use) subsectors, is the main source of GHG emissions and removals throughout the period 2006-2018. The general key category analysis revealed that eight of the identified sixteen key categories in 2018 were from the AFOLU sector. They include the Enteric Fermentation (3.A.1), Land Converted to Cropland (3.B.2.b), Cropland Remaining Cropland (3.B.2.a), Direct N_2O Emissions from managed soils (3.C.4), Rice cultivation (3.C.7), Land Converted to Settlements (3.B.5.b), Land Converted to Grassland (3.B.3.b), and Manure Management (3.A.2).

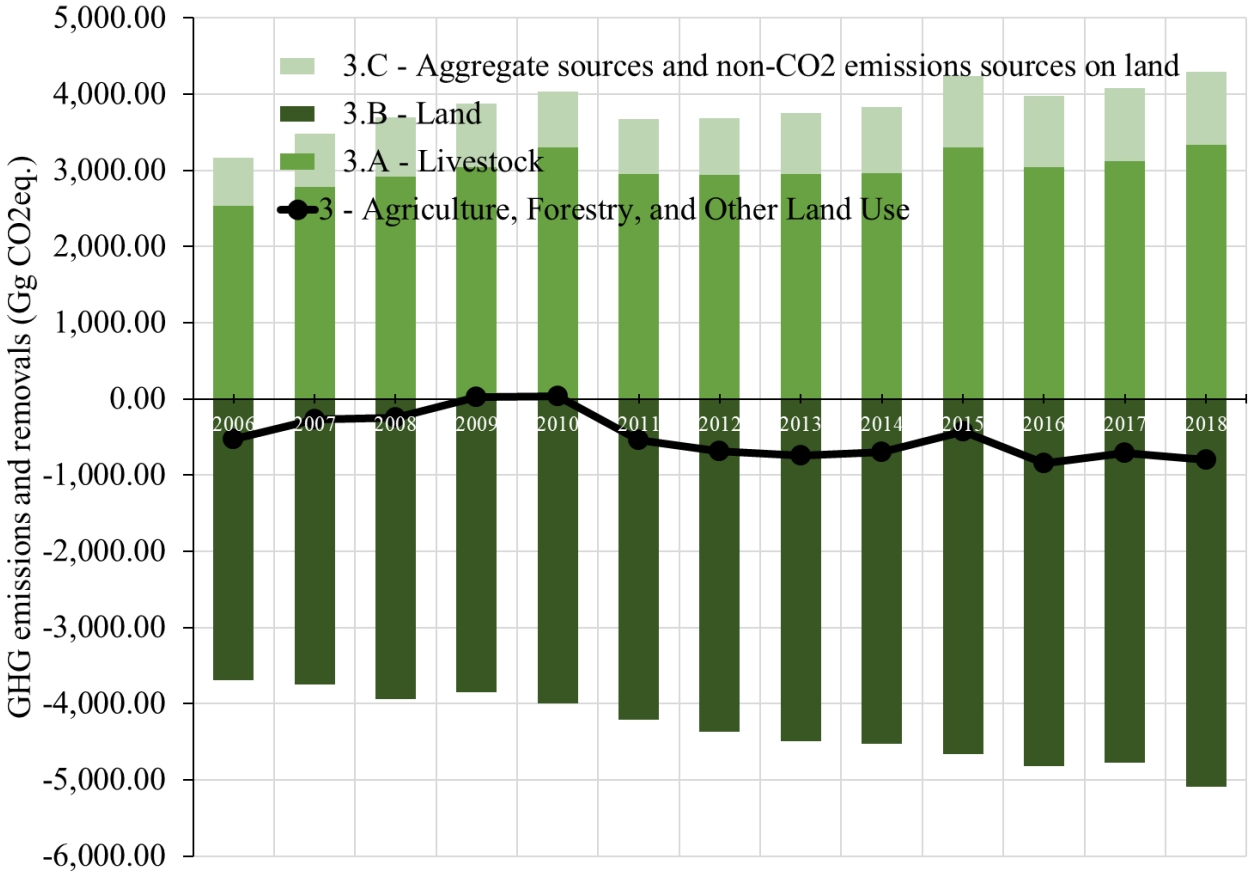


Figure 2.8 Trend in GHG emissions from AFOLU sector

Figure 2.8 shows the trends in GHG emissions and removals from the AFOLU sector. It is clear from the figure that the AFOLU sector was a net sink throughout the period 2006-2018 thanks to removals from Forests, except for 2009 and 2010. It is also important to note the high difference in the current emissions and removals and those reported in the TNC. There were much higher removals reported in the TNC; however, this was recalculated due to the use of more disaggregated/updated activity data, especially disturbances and wood harvest in forests data, and correction of the mistakes in GHG estimate in the urea application category. In addition, the

recalculations for 2006-2015 included the emissions from Land Use and Land Use change, livestock (with use of Tier 2 for Dairy cows), manure management systems, biomass burning, direct and indirect N_2O emissions from agriculture land and indirect N_2O emissions from manure management. The part of land and land use change was not captured in the TNC due to a lack of data at the time of the TNC inventory.

2.6.4 Waste sector

Based on the country context and the data availability, 4.A - Solid Waste Disposal, 4.B - Biological Treatment of Solid Waste, 4.C - Incineration and Open Burning of Waste, 4.D – Wastewater and Treatment and Discharge categories are reported under the waste sector. The GHG emissions were estimated using either available data from various literature or by using default values provided in the 2006 IPCC guidelines. The current results show a slight growth of emissions in all sub-categories mainly due to the increasing population in the same period and changes in the main mode of waste management.

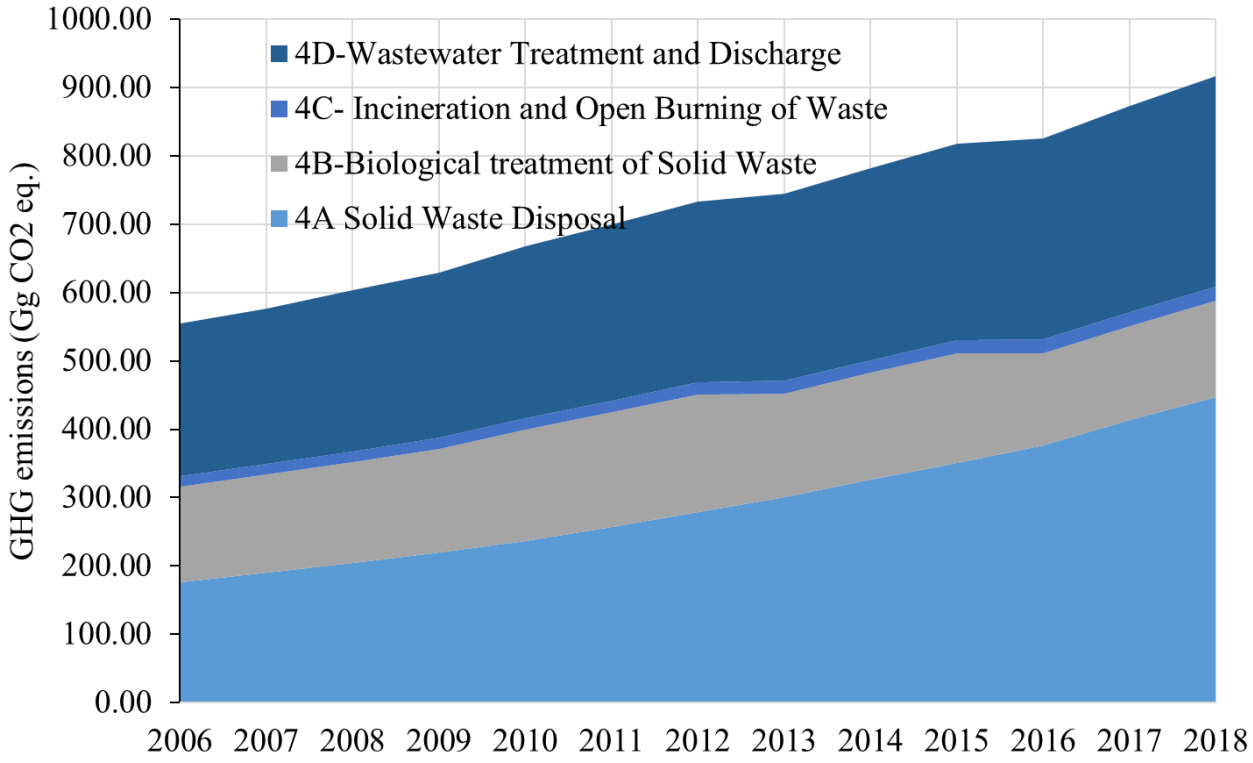


Figure 2.9 Trends in GHG emissions from the Waste sector

In general, the emissions in the Waste sector were growing at an annual rate of 4 % from 2006 to 2018 (**Figure 2.9**). In 2018, the total GHG emissions from Waste sector were predominantly from the Solid Waste Disposal with the highest emissions (48.67 %) followed by Wastewater Treatment and Discharge (33.63 %), Biological treatment of and Solid Waste (15.44 %) categories, while the and the Incineration and Open Burning of Waste category had a minor contribution of 2.26 %.

2.7 Trends in GHG emissions and removals per gas

As aforementioned, direct GHG (i.e., CO_2, CH_4, N_2O, and HFCs) were mainly considered in this inventory and indirect gases such as carbon monoxide (CO) and Nitrogen oxide (NO_X) were estimated in AFOLU. The summary of total GHG emissions and removals in 2018 are shown in **Table 2.4.** As evidenced from the table, CH_4 emissions had a dominant contribution to total GHG emissions (excluding FOLU) followed by the CO_2, whereas the HFCs emissions had a negligible contribution. Most of the CH_4 and N_2O were mainly generated from the AFOLU activities and to a lesser extent by the Waste and Energy sectors while most CO_2 emissions were generated by the Energy sector.

Table 2.4 Summary of GHG emissions and removals by gas in 2018, Gg CO_2 eq.

	CO_2	CH_4	N_2O	HFCs	SF_6	Total
Total National Emissions and Removals	**-3,209.21**	**4,727.26**	**1,102.49**	**9.57**	**NA**	**2,630.11**
Total National Emissions excluding FOLU	**1,867.83**	**4,414.16**	**464.12**	**9.57**	**NA**	**6,755.68**
1 - Energy	1,722.94	455.00	176.90	NA	NA	2,354.85
1.A - Fuel Combustion Activities	1,722.94	455.00	176.90	NA	NA	2,354.85
1.A.1 - Energy Industries	229.12	16.21	32.11	NA	NA	277.44
1.A.2 - Manufacturing Industries and Construction	145.42	25.39	50.06	NA	NA	220.87
1.A.3 - Transport	1,310.68	11.80	22.05	NA	NA	1,344.53
1.A.4 - Other Sectors	37.72	401.60	72.68	NA	NA	512.00
1.A.5 - non-Specified	NO	NO	NO	NA	NA	NO
1.B - Fugitive emissions from fuels	NO	NO	NO	NA	NA	NO
1.B.1 - Solid Fuels	NO	NO	NO	NA	NA	NO
1.B.2 - Oil and Natural Gas	NO	NO	NO	NA	NA	NO
1.B.3 - Other emissions from Energy Production	NO	NO	NO	NA	NA	NO
1.C - Carbon dioxide Transport and Storage	NO	NO	NO	NA	NA	NO
1.C.1 - Transport of CO_2	NO	NO	NO	NA	NA	NO
1.C.2 - Injection and Storage	NO	NO	NO	NA	NA	NO
1.C.3 - Other	NO	NO	NO	NA	NA	NO
2 - Industrial Processes and Product Use	141.84	NA	NA	9.57	NA	151.41
2.A - Mineral Industry	134.90	NA	NA	NA	NA	134.90
2.A.1 - Cement production	132.81	NA	NA	NA	NA	132.81
2.A.2 - Lime production	2.09	NA	NA	NA	NA	2.09
2.A.3 - Glass Production	NO	NA	NA	NA	NA	NA
2.A.4 - Other Process Uses of Carbonates	NO	NA	NA	NA	NA	NA
2.B - Chemical Industry	NO	NO	NO	NA	NA	NA
2.B.1 - Ammonia Production	NO	NA	NA	NA	NA	NA
2.B.2 - Nitric Acid Production	NA	NA	NO	NA	NA	NA

	CO_2	CH_4	N_2O	HFCs	SF_6	Total
Total National Emissions and Removals	**-3,209.21**	**4,727.26**	**1,102.49**	**9.57**	**NA**	**2,630.11**
Total National Emissions excluding FOLU	**1,867.83**	**4,414.16**	**464.12**	**9.57**	**NA**	**6,755.68**
2.B.3 - Adipic Acid Production	NA	NA	NO	NA	NA	NA
2.B.4 - Caprolactam, Glyoxal and Glyoxylic Acid Production	NA	NA	NO	NA	NA	NA
2.B.5 - Carbide Production	NO	NO	NA	NA	NA	NA
2.B.6 - Titanium Dioxide Production	NO	NA	NA	NA	NA	NA
2.B.7 - Soda Ash Production	NO	NA	NA	NA	NA	NA
2.B.8 - Petrochemical and Carbon Black Production	NO	NO	NA	NA	NA	NA
2.B.9 - Fluorochemical Production	NA	NA	NA	NA	NA	NA
2.C - Metal Industry	3.77	0.00	NA	NA	NA	3.77
2.C.1 - Iron and Steel Production	3.65	0.00	NA	NA	NA	3.65
2.C.2 - Ferroalloys Production	0.12	0.00	NA	NA	NA	0.12
2.C.3 - Aluminium production	NO	NA	NA	NA	NA	NO
2.C.4 - Magnesium production	NO	NA	NA	NA	NA	NA
2.C.5 - Lead Production	NO	NA	NA	NA	NA	NA
2.C.6 - Zinc Production	NO	NA	NA	NA	NA	NA
2.D - Non-Energy Products from Fuels and Solvent Use	3.17	NA	NA	NA	NA	3.17
2.D.1 - Lubricant Use	2.03	NA	NA	NA	NA	2.03
2.D.2 - Paraffin Wax Use	1.14	NA	NA	NA	NA	1.14
2.D.3 - Solvent Use	NA	NA	NA	NA	NA	NA
2.E - Electronics Industry	NA	NA	NA	NO	NA	NO
2.E.1 - Integrated Circuit or Semiconductor	NA	NA	NA	NO	NA	NO
2.E.2 - TFT Flat Panel Display	NA	NA	NA	NA	NA	NO
2.E.3 - Photovoltaics	NA	NA	NA	NA	NA	NO
2.E.4 - Heat Transfer Fluid	NA	NA	NA	NA	NA	NO
2.F - Product Uses as Substitutes for Ozone Depleting Substances	NA	NA	NA	9.57	NA	9.57
2.F.1 - Refrigeration and Air Conditioning	NA	NA	NA	9.57	NA	9.57
2.F.2 - Foam Blowing Agents	NA	NA	NA	NE	NA	NE

	CO_2	CH_4	N_2O	HFCs	SF_6	Total
Total National Emissions and Removals	**-3,209.21**	**4,727.26**	**1,102.49**	**9.57**	**NA**	**2,630.11**
Total National Emissions excluding FOLU	**1,867.83**	**4,414.16**	**464.12**	**9.57**	**NA**	**6,755.68**
2.F.3 - Fire Protection	NA	NA	NA	NE	NA	NE
2.F.4 - Aerosols	NA	NA	NA	NE	NA	NE
2.F.5 - Solvents	NA	NA	NA	NE	NA	NE
2.F.6 - Other Applications (please specify)	NA	NA	NA	NE	NA	NE
2.G - Other Product Manufacture and Use	NA	NA	NA	NO	NA	NO
2.G.1 - Electrical Equipment	NA	NA	NA	NO	NO	NO
2.G.2 - SF_6 and PFCs from Other Product Uses	NA	NA	NA	NO	NE	NO
2.G.3 - N_2O from Product Uses	NA	NA	NE	NA	NA	NE
2.H - Other	NO	NO	NO	NA	NA	NO
2.H.1 - Pulp and Paper Industry	NA	NA	NA	NA	NA	NA
2.H.2 - Food and Beverages Industry	NA	NA	NA	NA	NA	NA
2.H.3 - Other (please specify)	NA	NA	NA	NA	NA	NA
3 - Agriculture, Forestry, and Other Land Use	-5,077.04	3,590.77	692.97	NA	NA	-788.01
3.A - Livestock	NA	3,277.66	54.61	NA	NA	3,332.27
3.A.1 - Enteric Fermentation	NA	3,196.97	NA	NA	NA	3,196.97
3.A.2 - Manure Management	NA	80.69	54.61	NA	NA	135.30
3.B - Land	-5,092.71	NA	0.35	NA	NA	-5,030.22
3.B.1 - Forest land	-7,090.75	NA	NA	NA	NA	-7,090.75
3.B.2 - Cropland	1,609.57	NA	NA	NA	NA	1,609.57
3.B.3 - Grassland	170.98	NA	NA	NA	NA	170.98
3.B.4 - Wetlands	13.97	NA	0.35	NA	NA	11.65
3.B.5 - Settlements	201.45	NA	NA	NA	NA	266.27
3.B.6 - Other Land	2.06	NA	NA	NA	NA	2.06
3.C - Aggregate sources and non-CO_2 emissions sources on land	15.68	313.11	638.01	NA	NA	909.94
3.C.1 - Emissions from biomass burning	0.00	32.36	43.62	NA	NA	74.43
3.C.2 - Liming	8.66	NA	NA	NA	NA	8.66

	CO_2	CH_4	N_2O	HFCs	SF_6	Total
Total National Emissions and Removals	**-3,209.21**	**4,727.26**	**1,102.49**	**9.57**	**NA**	**2,630.11**
Total National Emissions excluding FOLU	**1,867.83**	**4,414.16**	**464.12**	**9.57**	**NA**	**6,755.68**
3.C.3 - Urea application	7.02	NA	NA	NA	NA	7.02
3.C.4 - Direct N_2O Emissions from managed soils	NA	NA	405.92	NA	NA	405.92
3.C.5 - Indirect N_2O Emissions from managed soils	NA	NA	119.68	NA	NA	64.38
3.C.6 - Indirect N_2O Emissions from manure management	NA	NA	68.79	NA	NA	68.79
3.C.7 - Rice cultivation	NA	280.74	NA	NA	NA	280.74
3.D - Other	NA	NA	NA	NA	NA	NA
3.D.1 - Harvested Wood Products	NE	NA	NA	NA	NA	NA
4 - Waste	3.04	681.49	232.62	NA	NA	917.16
4.A - Solid Waste Disposal	NA	446.39	NA	NA	NA	446.39
4.B - Biological Treatment of Solid Waste	NA	75.10	66.52	NA	NA	141.61
4.C - Incineration and Open Burning of Waste	3.04	14.80	2.85	NA	NA	20.69
4.D - Wastewater Treatment and Discharge	NA	145.21	163.25	NA	NA	308.46
Memo Items (5)	NO	NO	NO	NA	NA	NO
International Bunkers	131.89	0.02	1.14	NA	NA	133.06
1.A.3.a.i - International Aviation (International Bunkers)	131.89	0.02	1.14	NA	NA	133.06
1.A.3.d.i - International water-borne navigation (International bunkers)	NO	NO	NO	NA	NA	NO
1.A.5.c - Multilateral Operations	NO	NO	NO	NA	NA	NO

NO: Not Occurring, NE: Not Estimated, NA: Not Applicable.

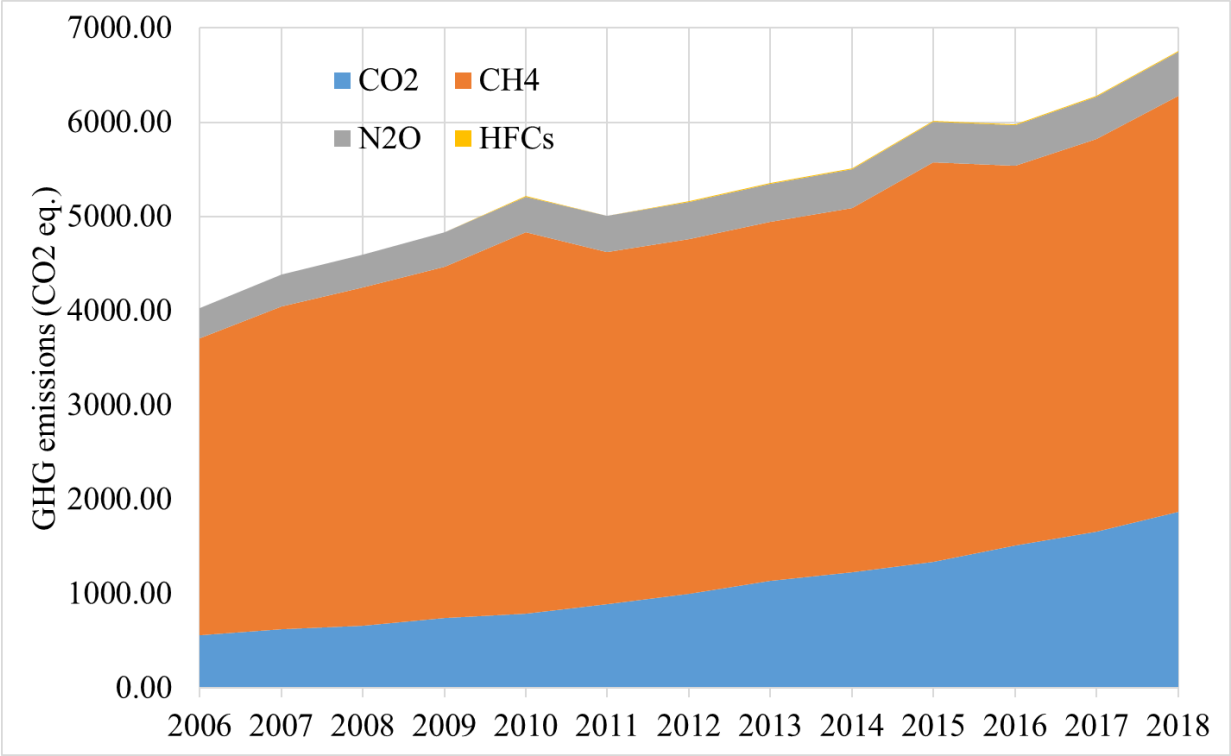


Figure 2.10 Trends in GHG emissions (excluding FOLU) by gas (2006-2018)

Figure 2.10 shows the trends in national GHG emissions (excluding FOLU) by gas for the period 2006 through 2018. The series shows that emissions increased significantly over the whole period with slight fluctuations in the methane emissions. As explained in the previous sections, the observed peaks in 2010, 2015 and 2018 are related to CH_4 emissions from the enteric fermentation, reflecting the fluctuation in cattle populations over this period.

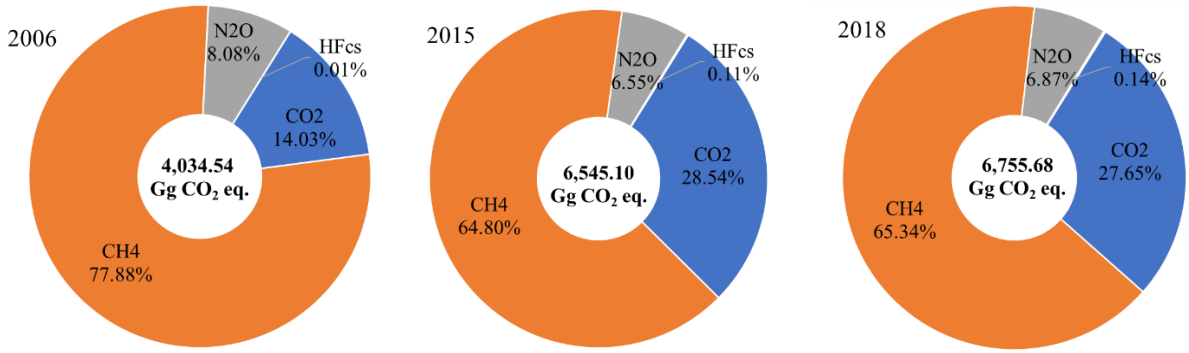


Figure 2.11 Shares of greenhouse gases to total GHG emissions (excluding FOLU) in 2006, 2015 and 2018

Figure 2.11 shows the shares of the direct GHG emissions (excluding FOLU) in 2006, 2015 and 2018. Methane (CH_4) emissions accounted for the largest share throughout these three years, followed by carbon dioxide (CO_2) emissions and nitrous oxide (N_2O) emissions. Hydrofluorocarbon (HFCs) represented the lowest share. Emissions of CH_4 accounted for 65.34

% of the total GHG emissions (excluding FOLU) of 6,755.68 Gg CO_2 eq. in 2018, whereas CO_2, N_2O and HFCs accounted for 27.65, 6.87 and 0.14%, respectively. In 2006, emissions of CH_4, CO_2, N_2O and HFCs accounted for 77.88, 14.03, 8.08 and 0.01%, respectively, of total emissions of 4,034.54 Gg CO_2 eq. The year 2015 was characterized by declines in the shares of CH_4, N_2O compared to those of 2006 and an increase in the shares of the CO_2 and HFCs emissions. Emissions of CH_4, CO_2, N_2O and HFCs accounted for 64.80, 28.54, 6.55 and 0.11 %, respectively of total emissions of 6.545.10 Gg CO_2 eq. The observed drops in the shares of CH_4 to GHG emissions (excluding FOLU) could be explained by the slight fluctuations in the cattle populations and the high increase in other gases emissions.

2.7.1 Carbon dioxide (CO_2) emissions

The period from 2006 through 2018 was characterized by a steady increase in CO_2 emissions, which were mainly generated by the combustion activities in the Energy sector, IPPU, and Land Use. **Figure 2.12** shows the trends in CO_2 emissions compared to the total GHG emissions (excluding FOLU). Carbon dioxide is the second most significant contributor to greenhouse gas emissions in Rwanda with the Energy sector responsible for more than 90 %of total CO_2 emissions (excluding FOLU) in 2018.

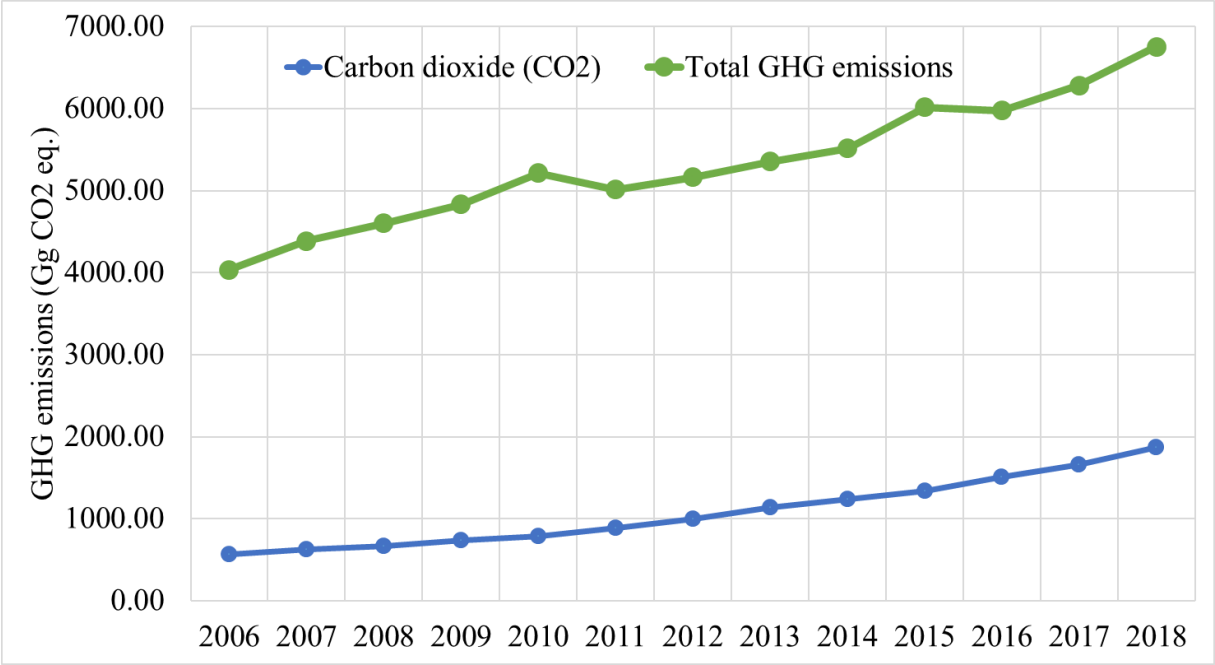


Figure 2.12 Trends in CO_2 emissions/Removals (2006-2018)

Carbon dioxide emissions increased steadily from 655.95 Gg. in 2006 to 1,867.83 Gg in 2018, indicating increases of 69.7 % from the 2006 level. The Energy sector remained the key source of CO_2 emissions throughout the three years followed by IPPU, while the Waste sector had the least contribution. However, as will be discussed in subsequent sections, these emissions were offset by the removals from forests, which showed a steady increase over the inventory period.

Figure 2.13 shows the carbon dioxide emissions (excluding Forestry and Other Land Use) by sectors in 2006, 2015 and 2018. In 2018, the Energy sector accounted for 92.24 % of the total emissions of CO_2 (excluding FOLU) of 1,867.83 Gg, while IPPU and Waste sectors accounted for 7.59 % and 0.16%, respectively.

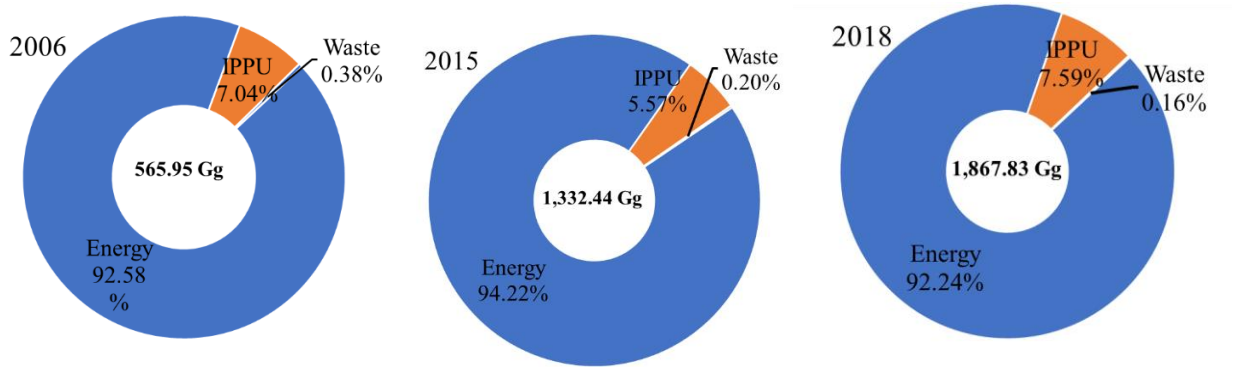


Figure 2.13 CO_2 emissions by sectors in 2006, 2015 and 2018 (excluding FOLU)

The shares of the CO_2 emissions (excluding FOLU) were 92.58, 7.04 and 0.38 % for energy, IPPU and waste, respectively. While the share of the Energy sector had a peak in 2015 with 94.22 %of 1,332.44, the IPPU and waste had slight drops with 5.57 and 0.20%, respectively.

2.7.2 Carbon dioxide removals

Carbon dioxide removal refers to the process of removing carbon dioxide from the atmosphere by carbon sinks and locking it away in decades, centuries, or millennia. This could slow, limit, or even reverse climate change. However, it is not a substitute for cutting greenhouse gas emissions. This is because carbon removal is generally slow-acting and may not be able to be deployed at scales commensurate with society's current greenhouse emissions. In this inventory, both the GHG removals by Forest Land and emissions generated by land use activities were estimated. **Figure 2.14** shows the carbon dioxide (CO_2) removals by forests in Rwanda for the period 2006 through 2018. The time series shows that during the period 2006-2018, the country was characterized by a relative increase in CO_2 removals with an increase of 23.62 % compared to the 2006 level at an annual growth rate of 0.6 %. However, as aforementioned, it is worth mentioning that these removals were completely offset by the GHG emissions.

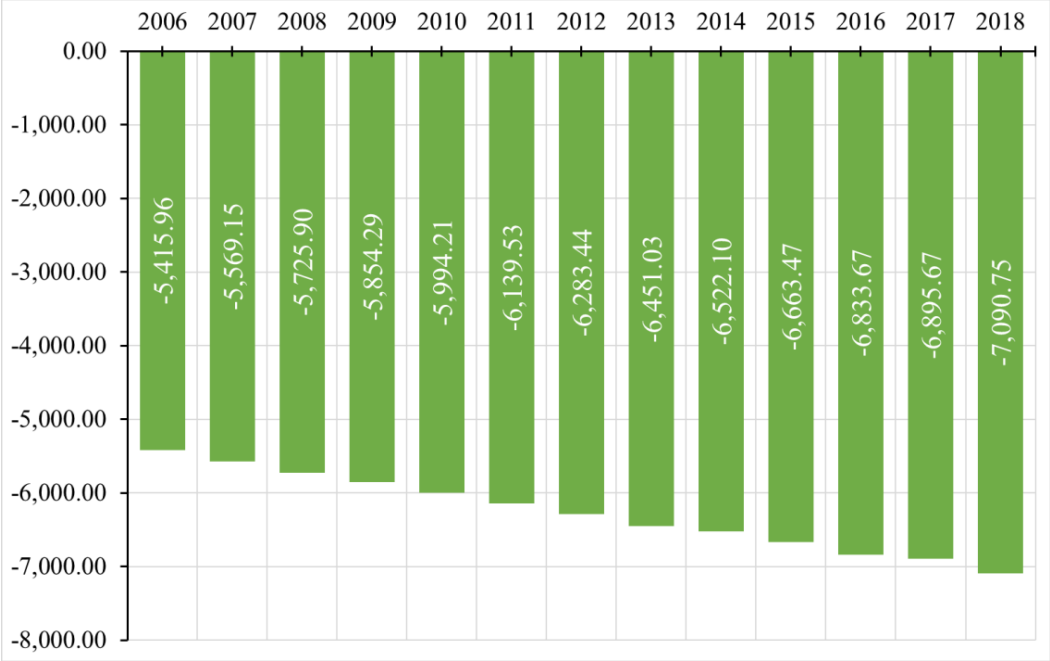


Figure 2.14 Trends in carbon dioxide removals, Gg CO_2 eq.

2.7.3 Methane (CH_4) emissions

Methane is the most significant contributor to greenhouse gas emissions (excluding FOLU) in Rwanda, which is mainly due to the large population of cattle.

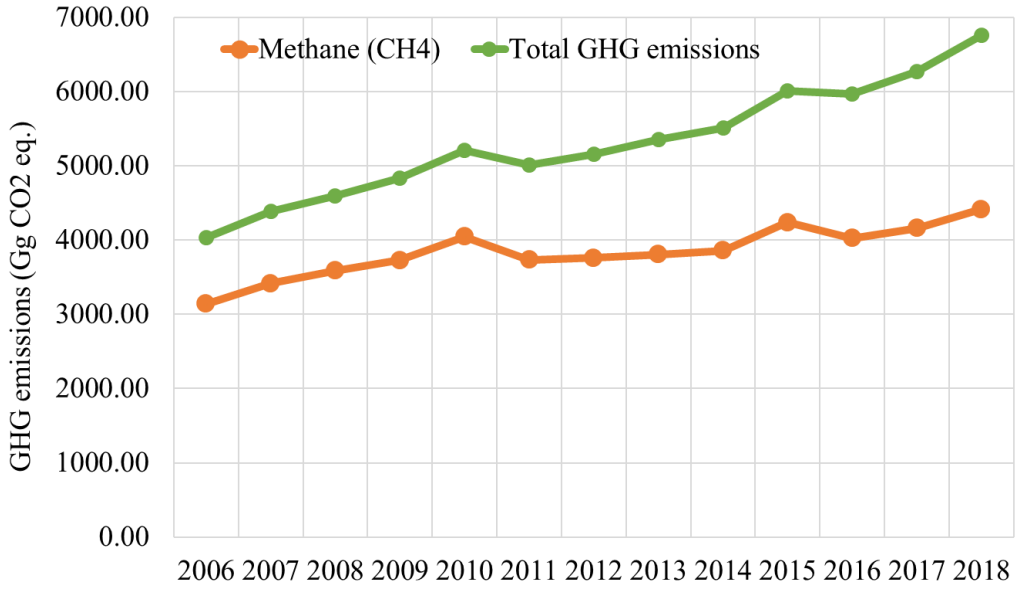


Figure 2.15 Trends in methane gas emissions (2006-2018)

In 2018, the CH_4 gas emissions appeared as a key gas in Enteric Fermentation (3.A.1), Solid Waste Disposal (4.A), Energy Other Sectors - Biomass (1.A.4), Rice cultivation (3.C.7), Wastewater

Treatment and Discharge (4.D), and Manure Management (3.A.2) key categories. **Figure 2.15** shows the trends in CH_4 gas emissions from 2006-2018. It is interesting to note that the CH_4 gas emissions had the same trend as the total emissions, confirming their notable contribution to the country's total emissions. Methane emissions increased from 3,354.43 Gg CO_2 eq. in 2006 reaching a peak of 4,179.06 Gg CO_2 eq. in 2018, representing an increase of 19.735 on the 2006 level. The series of total methane emissions (excluding FOLU) showed three peaks in 2010, 2015 and 2018, which reflects an increase in livestock numbers and therefore increased emissions from source categories 3.A-Enteric Fermentation and 3.B Manure Management.

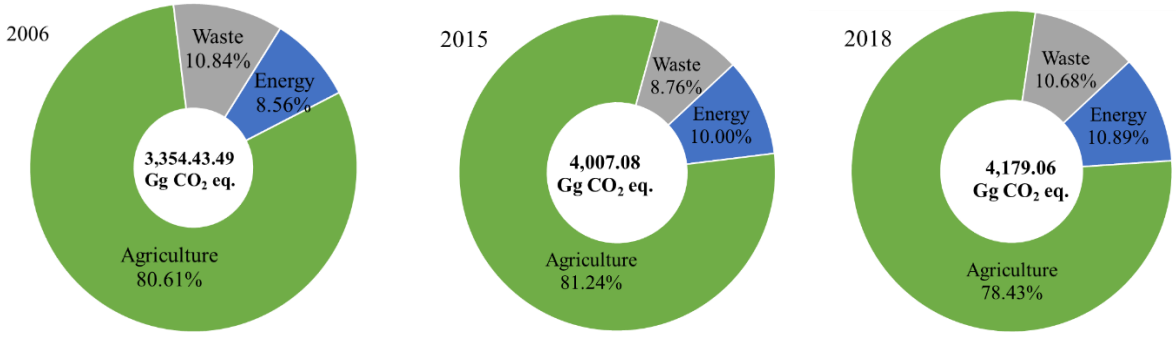


Figure 2.16 CH_4 emissions by sector in 2006, 2015 and 2018 (excluding FOLU)

In 2018, the agriculture sector (i.e., source categories 3.A Enteric Fermentation and 3.B Manure Management.) accounted for 78.43 % share of the total methane emissions (excluding FOLU) of 4,179.06 CO_2 eq. indicating a slight decline from 80.61 % of the total methane emissions (excluding FOLU) of 3,354.43 CO_2 eq. in 2006. The highest share of the agriculture sector to total methane emissions (excluding FOLU) of 81.24 % was recorded in 2015 (**Figure 2.16**). The energy and Waste sectors had comparable contributions to total methane emissions (excluding FOLU) with 10.89 and 10.68 % shares, respectively in 2018. The shares of the Energy sector increased from 8.56 % in 2006 to 10.00 % in 2015, while those of the waste sector decreased from 10.84% in 2006 to 8.76 % in 2015.

2.7.4 Nitrous oxide (N_2O) emission

As aforementioned, nitrous oxide (N_2O) emissions, which are mainly generated by Livestock, enteric fermentation sub-categories and the (direct and indirect) N_2O from managed soils of the AFOLU sector in Rwanda, have a relatively low contribution to total GHG emissions (excluding FOLU) (**Figure 2.17**). Other sources of N_2O include Biological Treatment of Solid Waste Wastewater Treatment and Discharge categories of the Waste sector and to a lesser extent, the biomass combustion activities of the Energy sector. During the period 2006 through 2018, the nitrous oxide emissions in Rwanda showed a steady increase from 876.82 Gg CO_2 eq. reaching a peak of 1046.12 CO_2 eq. in 2018 representing an increase of 16.18 % compared to the 2016 level (**Figure 2.17**). **Figure 2.17** shows the nitrous oxide emissions (excluding FOLU) by sector in the years 2006, 2015 and 2018. Agriculture accounted for 62.85 % of the total N_2O emissions

(excluding FOLU) in 2018 followed by the Waste sector with 21.10%, while the Energy sector had the lowest contribution of 16.05%.

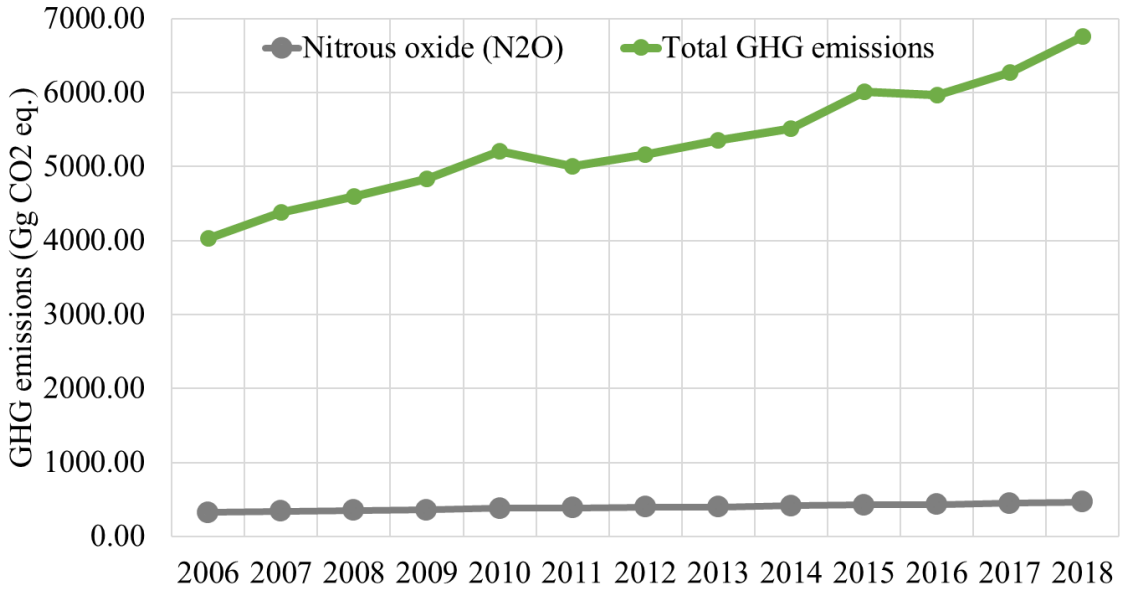


Figure 2.17 Trends in nitrous oxide (N_2O) emissions

The highest contributions of the agriculture sector of 49.91 % and 64.69 % to total N_2O emissions (excluding FOLU) were also observed in 2006 and 2015, respectively. It is also important to note the significant contributions of the agriculture sector to total nitrous oxide (excluding FOLU) in these three years, reflecting increased use of synthetic fertilizers and increased amounts of animal manures associated with increasing animal numbers over that period.

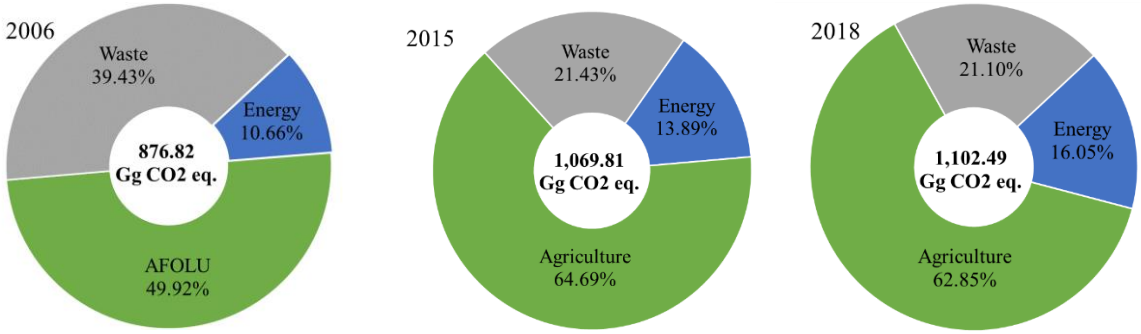


Figure 2.18 N_2O emissions by sector in 2006, 2015 and 2018 (excluding FOLU)

Another significant source of N_2O emissions is the Waste sector, especially for N_2O Biological Treatment of Solid Waste Wastewater Treatment and Discharge categories. Shares of the Waste sector to total N_2O emissions (excluding FOLU) decreased from 39.43 % in 2006 to 21.10 % in 2018 through 21.43 % in 2015. The low share of N_2O emissions in 2015 and 2018 reflect an improvement in manure waste management compared to 2006. The least contributor to total N_2O emissions is the Energy sector representing 10.66%, 13.89 % and 16.05 % in 2006, 2015 and 2018,

respectively. This observed increase reflects the increase in the use of biomass combustion activities, especially in brick manufacturing and tea estates.

2.7.5 Hydrofluorocarbons (HFCs) emissions

Hydrofluorocarbons (HFCs) and, to a very limited extent, perfluorocarbons (PFCs), have high global warming potentials and are being used as alternatives to different classes of ozone-depleting substances (ODS) that are being phased out under the Montreal Protocol. According to the IPCC 2006 guidelines, HFCs and PFCs are being used in a variety of applications that includes refrigeration and air conditioning, fire suppression and explosion protection, aerosols, solvent cleaning, foam blowing, and other applications such as equipment's sterilization.

Rwanda neither produces nor export substitutes for ozone-depleting substances but they are being imported mainly for refrigeration and stationary air conditioning and for Mobile air conditioning. Other applications, such as aerosols, solvent cleaning, and foam blowing are also used in Rwanda, however, there is a lack of data to include these sources of emissions for inventory. At the end of 2016, Rwanda initiated a survey on the use of alternatives to ODS as an activity under the Montreal Protocol. The survey covered the period from 2012 to 2015 and the major aim was to determine the trend of consumption of ODS alternatives in Rwanda from the year 2012 and beyond. The results show that the most used ODS alternative for that period was R134a while the least used was R290 (REMA, 2016). Among the ODS alternatives surveyed in Rwanda, the following HFCs were categorized as GHGs: HFC-134a, which is known as 1,1,1,2-tetrafluoroethane, HFC-125 known as 1,1,1,2,2-pentafluoroethane, HFC-143a, known as 1,1,1-Trifluoroethane, and HFC-32 known as difluoromethane. In addition, another survey on ODS and its alternatives was conducted by REMA in 2020 and covered the period from 2016 to 2019 and the results were used to complete this inventory. According to the above-mentioned inventories conducted by REMA in 2016 and 2020 (REMA, 2016, 2020), the blends imported in Rwanda do not contain PFCs and thus were not considered in this inventory.

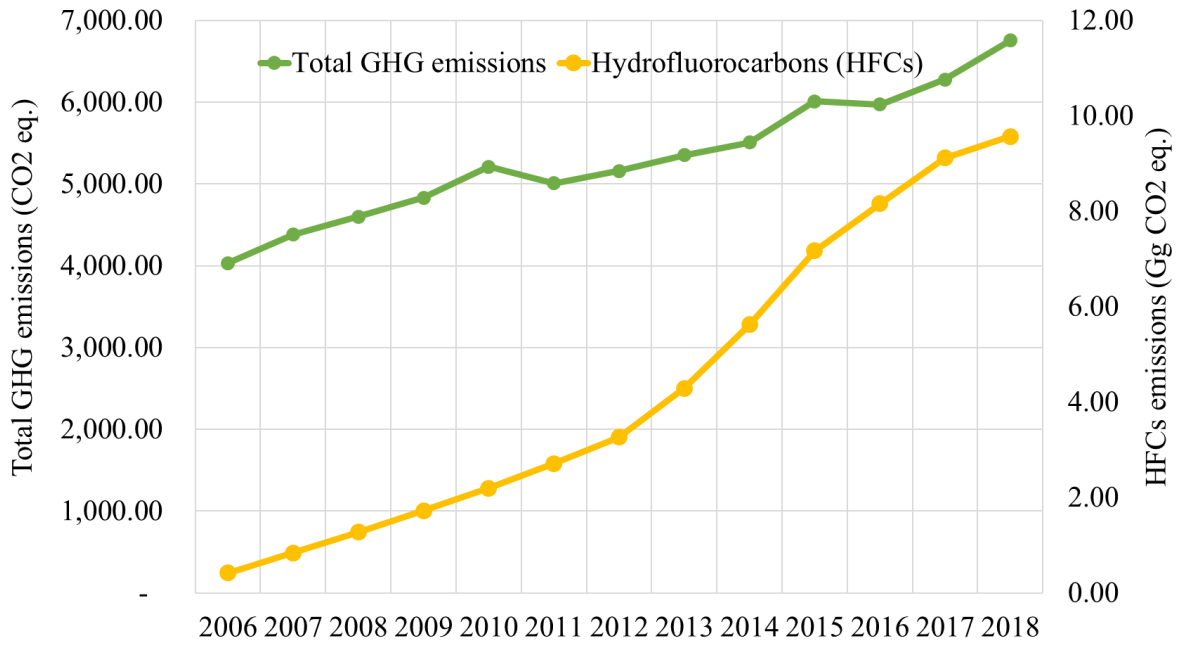


Figure 2.19 Trends in hydrofluorocarbons (HFCs) emissions

The trends in hydrofluorocarbons (HFCs) emissions are shown in **Figure 2.19**. It is evident from the figure that HFCs had an increasing trend with a sharp increase from 2012 to 2018. Over the latter period, which was covered by the previous two surveys on the use of ODS alternatives (REMA, 2016, 2020), the emissions have increased at an annual growth rate of 24%. In general, from 2012, HFC-134a as the major imported chemical is the principal contributor of the total emissions with an average contribution of 44.90 % followed by HFC-143a contributing 28.89 % and HFC-125 with 24.67 % and lastly HFC-32 with 1.54 % of the total HFCs emissions. It should be noted that the HFCs emissions have an annual growth of 10 % from 2015 to 2018.

2.7.6 Indirect gases

Though reporting on precursors and indirect emissions is not mandatory for Non-Annex I countries, there is a need to consider these gases since they are linked with national air pollution management which is a priority for the GoR. However due to time constraints, much effort was devoted to the estimation of the direct greenhouse gases, i.e., CO_2, CH_4, N_2O and HFC and the indirect emissions were only estimated in the Biomass Burning subcategory (3.C.1) of the AFOLU sector. The estimation of the indirect gases in all the sectors should be recommended for future inventories. Generally, indirect emissions such as NO_X and CO results from incomplete combustion of biomass burning activities. In this inventory, emissions from biomass burning were estimated for Forestland, Eastern Savanna sub-category, precisely, Akagera National Park where planned burning is permitted and done annually for Savannah landscape management since 2013. The emissions of CO_2 were accounted for under 3B while the emissions from wildfires have not

been included. The assumption applied for biomass burning in Grassland is that the same proportion of the park is burnt on yearly basis (maintaining the area size given in the TNC).

Table 2.5 Summary of estimated indirect gas emissions

Year	Area burnt (ha)	NO_X (Gg)	CO (Gg)
2013	29,045	2.628	43.800
2014	57,037	5.161	86.012
2015	58,344	5.279	87.983
2016	30,700	2.778	46.298
2017	35,920	3.250	54.168
2018	28,880	2.613	43,552

Table 2.5 shows the estimated NO_X and CO emissions for the period 2013-2018. The estimated indirect emissions showed a fluctuating trend reflecting the fluctuations in the burnt area (**Table 2.5**). The CO emissions dominated over the NO_X for the whole period.

2.8 Key categories

In this inventory, the key categories and corresponding key gases were identified based on the Approach 1 methodology of the 2006 IPCC guidelines and both level and trends analyses were conducted. The percentages of contributions to GHG emissions levels were calculated and sorted in descending fashion using the 2006 IPCC software and a 95 % cumulative contribution threshold has been applied as an upper boundary for key category identification. While the results of the trend analysis are presented in the national inventory report, a summary of the results of the level assessment is presented here. The results of the level analysis are summarized in **Table 2.6**.

Table 2.6 Key categories from level assessment in 2018

Sectors	IPCC Category	GHG	GHG emissions (Gg CO_2 eq.)	Contribution to level (%)	Cumulative contribution to level (%)
AFOLU	Enteric Fermentation (3.A.1)	CH_4	3,196.97	60.52	60.52
Energy	Road Transportation (1.A.3.b)	CO_2	1,286.77	7.66	68.17
AFOLU	Land Converted to Cropland (3.B.2.b)	CO_2	938.53	5.58	73.76
AFOLU	Cropland Remaining Cropland (3.B.2.a)	CO_2	671.04	3.99	77.75
Waste	Solid Waste Disposal (4.A)	CH_4	446.39	2.66	80.41
AFOLU	Direct N_2O Emissions from managed soils (3.C.4)	N_2O	405.92	2.42	82.82
Energy	Other Sectors - Biomass (1.A.4)	CH_4	401.51	2.39	85.21

Sectors	IPCC Category	GHG	GHG emissions (Gg CO_2 eq.)	Contribution to level (%)	Cumulative contribution to level (%)
AFOLU	Rice cultivation (3.C.7)	CH_4	280.74	1.67	86.88
AFOLU	Land Converted to Settlements (3.B.5.b)	CO_2	266.27	1.58	88.46
AFOLU	Land Converted to Grassland (3.B.3.b)	CO_2	170.98	1.02	89.48
Waste	Wastewater Treatment and Discharge (4.D)	N_2O	163.25	0.97	90.45
		CH_4	145.21	0.86	91.32
IPPU	Cement production (2.A.1)	CO_2	132.81	0.79	92.11
Energy	Manufacturing Industries and Construction - Solid Fuels (1.A.2)	CO_2	130.82	0.78	92.88
Energy	Energy Industries - Gaseous Fuels (1.A.1)	CO_2	101.61	0.60	94.18
Energy	Energy Industries - Liquid Fuels (1.A.1)	CO_2	90.27	0.54	94.71
AFOLU	Manure Management (3.A.2)	CH_4	80.69	0.48	95.19

Sixteen key source/sink categories were identified. As it could be seen from the table, identified key categories are mostly from Agriculture, Forestry, and Other Land Use (AFOLU) and Energy sectors, which are the main economic activities in Rwanda. According to the level assessment, half of the key categories are from the AFOLU sector while other sectors share the rest with the Energy sector having four categories. The dominance of the AFOLU sector was also confirmed by the results from the trend analysis, in which the AFOLU sector had eight key categories, and others are shared by the Energy and Waste sectors.

2.9 Quality Assurance and Quality Control procedures

The quality control (QC) was conducted at all the steps of the inventory development through data validation and methodology checks from all the working groups. Activity data were collected from the national official documents and in the recent surveys conducted by REMA to fill the data gaps. All the data appearing in these official documents were further cross-checked with relevant institutions working in their respective sectors. Specific and relevant data were also obtained from research work published locally and in international journals as well as annual and technical reports from the different research institutions. All the data used were reviewed during peer review meetings with stakeholders and research staff. Furthermore, the inventory process was carried out under close supervision of REMA to ensure compliance with IPCC guidelines. The overall report quality assurance was conducted and checked by an external reviewer and validated *via* various stakeholders' meetings.

2.10 Uncertainty assessment

The uncertainty assessment constitutes an important element of a complete and transparent GHG emissions inventory. Uncertainty and time-series assessments were conducted using the Approach 1 methodology following the 2006 IPCC guidelines. The main source of the uncertainties is the use of default emission factors. The emissions evaluated in this inventory report represent the current best estimates in Rwanda's GHG inventory. However, it is worth mentioning that in some cases estimates were based on extrapolated data, assumptions, and approximation methodologies. These methodological issues also contributed significantly to higher and more fluctuating uncertainties. Rwanda's GHG inventory working group will continue to improve, revise, and recalculate its GHG emission estimates, as new sources of information are available. In addition, it should be recommended that, in future inventories, an effort should be made to develop country-specific emission factors to overcome high uncertainties in estimated GHG emissions and removals.

2.11 Recalculations

Due to improvement in the methodology and data quality and the discovery of new datasets in the Energy, AFOLU, and Waste sectors, a recalculation of the latest GHG emissions and removals published in the Third National Communication (TNC) was conducted for the period 2006-2015. **Table 2.7** shows the summary of the recalculated GHG emissions and removals. As it is seen from the table, the main recalculations were conducted in the AFOLU sector and more GHG emissions were obtained in the Land Use (3B) and enteric fermentation (3A1). The latter led to higher GHG emissions in the AFOLU sector compared to the previous inventory. The main reasons for the recalculations include the following:

- Data disaggregation
- Discovery of new datasets in the Land use and waterways transportation categories.
- The addition of Land Use data derived from the Land Use class area per district by comparing the maps of 2000 and 2019.
- Inclusion of the newest study on forest cover, which updated the current forest area and uncovered deforestation extent.
- Corrected calculation of emissions from urea application (in the previous inventory reported in the TNC, the urea data in kg were counted as tonnes, which led to an overestimate of the emissions).
- Use of Tier 2 for dairy cattle using the recently measured data on mean live weight and adjustment of default value for local African cows from 275 kg to locally measured values for Rwandan dairy cows, which are mostly crossbred (60 % of the female population) to 384.6 kg, which significantly increased emissions from enteric fermentation.
- Use of updated manure management systems from BUR surveys in AFOLU (REMA, 2019d);

- Females, males, and heifers of Dairy cows were counted under the "Dairy Cattle" category in one sheet in the new version of the software 2006 IPCC, and not under the "other cattle" category as it was done in TNC.
- Inclusion of emissions from rabbits' enteric fermentation with default emission factor available in the new version of the 2006 IPCC software (released in January 2020) and not included in the previous version of the 2006 IPCC software.
- Improvement of waste composition information for the whole inventory period, due to survey results on waste composition in Rwanda conducted in 2019 by REMA and the EICV 5 data on the main mode of waste management in Rwanda.
- Improvement of the methodology used in the Waste sector by considering the emissions from at least the last 50 years from the year 1965 while during the TNC the inventory started from 2004.

Table 2.7 Results of the National Inventory recalculations

1-Energy										
1.A.1 - Energy Industries										
Period	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**
PD (Gg CO_2eq.)	91.73	95.94	58.03	104.99	105.67	130.34	143.78	179.54	176.84	144.99
LD (Gg CO_2eq.)	115.65	120.31	82.89	131.97	135.86	159.85	179.96	221.36	229.95	193.32
%-Diff.	26.08	25.40	42.84	25.70	28.57	22.64	25.16	23.29	30.03	33.33
1.A.2 - Manufacturing Industries and Construction										
PD (Gg CO_2eq.)	38.34	48.85	48.66	46.55	43.09	48.84	47.32	56.29	73.26	92.6
LD (Gg CO_2eq.)	75.46	84.62	82.74	82.03	81.46	85.52	84.15	91.1	113.67	134
%-Diff.	96.82	73.22	70.04	76.22	89.05	75.10	77.83	61.84	55.16	44.71
1.A.3 - Transport										
PD (Gg CO_2eq.)	301.94	369.4	432.87	394.17	355.5	393.54	458.29	468.53	489.56	547.35
LD (Gg CO_2eq.)	359.52	414.79	501.11	545.64	597.71	679.21	778.96	879.95	942.53	1,031.63
%-Diff.	19.07	12.29	15.76	38.43	68.13	72.59	69.97	87.81	92.53	88.48
1.A.4 - Other Sectors										
PD (Gg CO_2eq.)	627.77	624.92	624.62	618.94	645.43	675.68	693.78	717.1	728.56	741.44
LD (Gg CO_2eq.)	358.56	362.53	366.48	369.71	395.94	397.91	405.55	417.89	433.03	449.35
%-Diff.	-42.88	-41.99	-41.33	-40.27	-38.65	-41.11	-41.54	-41.73	-40.56	-39.39
2-Industrial Process and Product Use (IPPU)										
No recalculations were conducted in IPPU										
3-Agriculture, Forestry and Land Use (AFOLU)										
3.A.1 - Enteric Fermentation										
Year	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
PD (Gg CO_2 eq.)	979.55	1116.74	1181.37	1213.23	1303.64	1207.01	1173.80	1174.16	1147.18	1283.75
LD (Gg CO_2 eq.)	2450.56	2695.37	2827.73	2939.95	3191.28	2848.87	2832.72	2847.82	2852.91	3197.07
%-Diff.	150.17	141.36	139.36	142.32	144.80	136.03	141.33	142.54	148.69	149.04
3.A.2 - Manure Management										
PD (Gg CO_2 eq.)	488.53	524.05	613.31	653.29	690.66	692.42	702.49	698.53	676.56	672.99
LD (Gg CO_2 eq.)	79.34	91.08	95.74	100.71	108.63	101.98	108.62	109.56	109.02	109.25

%-Diff.	-83.76	-82.62	-84.39	-84.58	-84.27	-85.27	-84.54	-84.32	-83.89	-83.77
3.B.1 - Forest land										
PD (Gg CO_2 eq.)	-10728.64	-10798.32	-10868.49	-10938.82	-10969.46	-11101.13	-11219.13	-11255.49	-11317.96	-11359.85
LD (Gg CO_2 eq.)	-5415.96	-5569.15	-5725.90	-5854.29	-5994.21	-6139.53	-6283.44	-6451.03	-6522.10	-6663.47
%-Diff.	-49.52	-48.43	-47.32	-46.48	-45.36	-44.69	-43.99	-42.69	-42.37	-41.34
3.C.3 - Urea application										
PD (Gg CO_2 eq.)	3858.88	4014.94	4171.01	4375.39	5359.86	6344.32	5694.18	6610.53	7526.87	8443.21
LD (Gg CO_2 eq.)	1.55	2.17	1.86	3.98	2.40	3.64	5.96	8.49	2.21	7.74
%-Diff.	-99.96	-99.95	-99.96	-99.91	-99.96	-99.94	-99.90	-99.87	-99.97	-99.91
3.C.4 - Direct N_2O Emissions from managed soils										
PD (Gg CO_2 eq.)	381.15	403.39	511.36	594.85	629.14	662.27	565.77	522.11	478.64	551.15
LD (Gg CO_2 eq.)	33.61	38.06	39.58	49.55	45.20	47.84	71.44	57.03	52.12	52.07
%-Diff.	-91.18	-90.56	-92.26	-91.67	-92.82	-92.78	-87.37	-89.08	-89.11	-90.55
3.C.5 - Indirect N_2O Emissions from managed soils										
PD (Gg CO_2 eq.)	132.28	140.43	175.31	201.78	212.08	222.46	196.57	185.07	170.12	191.03
LD (Gg CO_2 eq.)	49.07	54.35	56.99	59.71	64.96	58.97	60.96	61.38	61.68	65.84
%-Diff.	-62.90	-61.30	-67.49	-70.41	-69.37	-73.49	-68.99	-66.83	-63.74	-65.54
3.C.6 - Indirect N_2O Emissions from manure management										
PD (Gg CO_2 eq.)	108.02	119.03	129.99	136.87	147.58	138.49	145.47	146.77	146.08	148.18
LD (Gg CO_2 eq.)	49.07	54.35	56.99	59.71	64.96	58.97	60.96	61.38	61.68	65.84
%-Diff.	-54.57	-54.34	-56.16	-56.37	-55.98	-57.42	-58.09	-58.18	-57.78	-55.57
3.C.7 - Rice cultivation										
PD (Gg CO_2 eq.)	118.54	181.40	166.69	177.66	117.20	130.89	103.11	100.17	90.98	98.33
LD (Gg CO_2 eq.)	212.42	242.92	298.77	318.42	210.07	227.07	171.74	175.91	198.16	220.10
%-Diff.	79.19	33.91	79.24	79.23	79.24	73.48	66.56	75.61	117.80	123.83
4-Waste										
4.A - Solid Waste Disposal										
	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
PD (Gg CO_2 eq.)	24.04	41.51	54.68	64.93	73.04	79.82	85.70	119.22	152.82	186.99
LD (Gg CO_2 eq.)	175.36	189.71	204.09	219.92	235.69	257.13	278.25	300.02	326.41	351.18
%-Diff.	629.45	357.02	273.24	238.70	222.69	222.14	224.68	151.65	113.59	87.81
4.D - Wastewater Treatment and Discharge										

PD (Gg CO_2 eq.)	231.67	237.11	243.97	250.11	256.97	263.54	269.98	276.47	282.88	289.63
LD (Gg CO_2 eq.)	224.48	227.16	236.09	241.98	251.64	258.12	264.94	274.25	280.63	287.43
%-Diff.	-3.11	-4.20	-3.23	-3.25	-2.08	-2.06	-1.87	-0.80	-0.79	-0.76
4.B - Biological Treatment of Solid Waste										
PD (Gg CO_2 eq.)	105.50	110.44	115.62	121.04	126.71	132.65	140.36	145.38	152.19	159.33
LD (Gg CO_2 eq.)	140.02	143.66	147.39	151.23	163.41	167.66	172.16	152.54	156.06	159.64
%-Diff.	32.73	30.08	27.49	24.94	28.97	26.39	22.66	4.92	2.54	0.20
4.C - Incineration and Open Burning of Waste										
PD (Gg CO_2 eq.)	1.06	1.08	1.12	1.14	1.17	1.20	1.23	1.26	1.29	1.32
LD (Gg CO_2 eq.)	1.32	1.35	1.39	1.42	1.46	1.50	1.53	1.57	1.60	1.64
%-Diff.	24.50	24.50	24.50	24.50	24.50	24.50	24.50	24.50	24.50	24.50
4.D - Wastewater Treatment and Discharge										
PD (Gg CO_2 eq.)	231.67	237.11	243.97	250.11	256.97	263.54	269.98	276.47	282.88	289.63
LD (Gg CO_2 eq.)	224.48	227.16	236.09	241.98	251.64	258.12	264.94	274.25	280.63	287.43
%-Diff.	-3.11	-4.20	-3.23	-3.25	-2.08	-2.06	-1.87	-0.80	-0.79	-0.76

PD: Previous Data, LD: Latest Data

2.12 Planned improvements

The list of the identified future improvement areas is presented in **Table 2.8.** The key planned improvements in various sectors encompass the improvement in methodology (including QA/QC, uncertainty assessment and completeness at sectoral level), an improvement in capacity building and information sharing, and strategies for long-term improvement.

Table 2.8 List of planned improvement activities

Sectors	Category	Sub-category	Challenge	Planned improvement
General	All	All	Insufficient capacity to conduct higher tier inventories and insufficient research on local emission factors to address the gaps mentioned below	Further capacity building to the inventory team.
	All	All	Limited of a specific methodology for uncertainty management	Development of the uncertainty management system and training of the GHG inventory team on the uncertainty management
Energy sector	Energy industries	Other energy industries	Limited activity data in charcoal production	In the future, these gaps could be filled by improving the reporting system and encouraging all the companies and cooperatives involved in charcoal production to keep records of their data activities.
		Electricity generation	Limited country-specific data	Conduct measurements of the physical characteristics of various fuels used in electricity generation
		Fugitive emissions	Lack of country-specific data	In the future, this challenge could be handled through appropriate research and technical advisory for the

Sectors	Category	Sub-category	Challenge	Planned improvement
				companies involved in energy generation.
	Manufacturing industries and construction	All	Limited country-specific data	Future improvements should focus on the activity data recording and reporting as well as the development of country-specific emission factors.
	Transportation	All	Limited country-specific data	In the future, country-specific physical characteristics of fuels.
	Other sectors	All	Limited updated activity data	• Conduct regular surveys on fuel consumption in the building • Conduct research to develop the country-specific emission factors
IPPU sector	Mineral industries (2.A)	Cement production	Limited accurate data on clinker fraction	An ongoing study to obtain clinker fraction used in cement production is being conducted using financial resources from GEF (CBIT project)
		Lime production	Limited country-specific emission factor	Lime-producing industries in Rwanda should continue to record their production and provide the data to MINICOM to ease future inventories without conducting surveys.
	Metal industries (2.C)	All	Limited disaggregated data	There is a need to develop methodologies for data collection for metal industries
	Non-Energy Products from	All	Limited data on the use of paraffin wax	Further improvement can be made through surveys

Sectors	Category	Sub-category	Challenge	Planned improvement
	Fuels and Solvent Use (2.D)			on the different uses of paraffin wax at the national level. In addition, a survey at Rwanda Energy Group is needed to provide detailed information on the consumption of Sulphur hexafluoride (SF_6) used in electrical equipment as gas-insulated switchgear and substations, and gas circuit breakers.
AFOLU sector	Livestock (3A)	3.A.1 Enteric fermentation	Limited regular official data for livestock population structure and characteristics – mass, feeding habits, N excretion	A more complete database should be built for livestock populations by type and their characterizations, including mass, feeding habits and other factors related to GHG emissions such as N excretion and N fraction managed in different manure management systems.
	Land (3B)	3.A.2 Manure management systems (MMS)	Limited information on N fraction in different MMS	Collect information on N fractions managed in different MMS.
		All	Limited data on CH_4 emissions from different groups of swine, e.g., breeding swine and other	Conduct research to determine CH_4 emissions from swine
			Limited access to land use maps;	There is an ongoing initiative to establish a GHG inventory and GIS

Sectors	Category	Sub-category	Challenge	Planned improvement
				lab REMA that will facilitate the analysis of land use maps and other related spatial data
			Inconsistencies between land use classes reported by different public institutions, especially, for Agriculture – the harvested area from all crops exceeds the total area available for Agriculture due to intercropping;	Conduct verification and validation meeting between RLMUA, NISR, MINAGRI, RAB and REMA to crosscheck inconsistencies and sources of differences, agree on land use change patterns over time and share land use map for more harmonized use.
			Limited disaggregated data on land use and land use change data.	The GHG inventory and GIS lab will facilitate the data disaggregation process
	Land (3B)	All	Difficulty to differentiate maize area from grassland on land use maps;	Use crosscheck with data reported by Districts to MINAGRI to help disaggregation.
			Limited local data on carbon stock and its change with land use for each AE Zone;	Conduct study on carbon stock and its change vs past soil surveys and published information analysis for an update of all available information
			Level of data disaggregation (having data at district level leaves to make assumptions/conclusion on Land Use Change extent which is less precise as if it would be	Conduct GIS assessment with disaggregated data up to sector and cell levels. Land use and Land Use Change matrix going below the level of the district could facilitate the certainty of the Land Use Change detailed data.

Sectors	Category	Sub-category	Challenge	Planned improvement
			if data were at the sector level);	
		3.B.1 Forestland 3.B.2 Cropland	Lack of National statistics on harvested wood products.	Discuss with NISR to include data on wood harvest into Statistical Yearbook reports (annually)
			Limited data on Agroforestry and carbon removal from agroforestry trees;	Conduct survey to assess wood harvest from agroforestry trees, and GIS analysis to document agroforestry cover via maps, otherwise, available forest survey data.
			Limited data on soil carbon stock in different AE Zones and	Conduct an extensive study on C-stock in main cropland sub-categories and its change using available soil map data
	Agriculture (3C)	3.B.4 Wetlands	Limited mapping of peatlands and their proportions used for peat extraction and agricultural use on annual basis;	Conduct surveys to assess the extent of peat extraction and GIS data analysis from available soil data to assess the proportion of peatland and other wetlands under cropland use.
		3.C.1 Biomass burning	Limited National statistics on fire on land (cropland, forest, grassland)	Discuss with NISR to include data on fires in different Land Use classes into Statistical Yearbook reports (annually)
		3.C.2 Liming 3.C.4 Direct N_2O emission from	Limited official statistics on lime production, origin, and types	Discuss with NISR to include data on agricultural and industrial lime production into Statistical Yearbook reports (annually)

Sectors	Category	Sub-category	Challenge	Planned improvement
		managed soils	Limited measured data on crop residues and manure applied over the whole season and the proportion of crop residues used for livestock feeding and other purposes.	Determine real quantities of crop residues and manure applied over the whole season, including not just crop biomass at harvest, but in addition, weeds removed
			Lack of local data on N content in crop residues	Determine N content in crop residues and weeds;
			Lack of local data on soil C and N and their dynamics in different Land Use Change patterns	Determine changes in soil N and C after Land Use Change and their dynamics (longer-term research on soil restoration.
Waste sector	Solid waste disposal (4A)		Limited disaggregated data and data collection methodologies	Future improvements should focus on developing methodologies for data collection in the Waste sector through the partnership of NISR, which regularly collects national data
	Biological Treatment of Solid Waste (4B)	All	Limited disaggregated data and data collection methodologies	Planned improvement should focus on developing methodologies for data collection in the biological treatment of the solid Waste sector through the partnership with the NISR, which regularly collects national data.
	Incineration and Open Burning of Waste (4C)	All	Due to limited activity data, only clinical waste was considered for the estimation of emissions	Future improvement should consider the survey of other types of waste incinerated. In addition,

Sectors	Category	Sub-category	Challenge	Planned improvement
			from incineration of solid waste.	there is a need to plan for the best way for the data collection on the quantity of waste incinerated at each hospital in Rwanda.
	Wastewater Treatment and Discharge (4 D)	All	Limited activity data for some industries	Future improvements should focus on improving the methodology for data collection and consider other types of industrial wastewater such as vegetables, fruits, juices, soap, and detergents, etc. based on the available data.

Chapter 3. Mitigation actions and their effects

3.1 Introduction

This chapter presents the update of the information published in the recently updated Nationally Determined Contribution (NDC) concerning the climate change mitigation actions and policies and their effects. The assessment was conducted in different sectors (i.e., Energy, IPPU, AFOLU and Waste) for the years 2020-2030 based on the guidance and UNFCCC requirements decision described in paragraphs 11-13 2(a) of UNFCCC Decision: 2/CP.17, Annex III. According to the provided guidance, Non-Annex I Parties should provide information, in a tabular format, on actions to mitigate climate change, by addressing anthropogenic emissions of all GHGs not controlled by the Montreal Protocol.

For each mitigation action or group of mitigation actions including, as appropriate, those listed in document FCCC/AWGLCA/2011/INF.1, developing country Parties should provide the following information to the extent possible:

- Name and description of the mitigation action, including information on the nature of the action, coverage (i.e., sectors and gases), quantitative goals and progress indicators.
- Information on methodologies and assumptions.
- Objectives of the action and steps taken or envisaged to achieve that action.
- Information on the progress of implementation of the mitigation actions and the underlying steps taken or envisaged, and the results achieved, such as estimated outcomes (metrics depending on the type of action) and estimated emission reductions, to the extent possible.
- Information on international market mechanisms.

To comply with these requirements, an overview of the mitigation actions previously reported in the Third National Communication (TNC) and updated in the recent NDC has been conducted to report on the previous emission reduction target as well as other non-GHG benefits, progress achieved to date and how that progress was monitored. Since the implementation period of most of the mitigation actions proposed in the recent NDC was 2019-2030, the estimate of the GHG mitigation achieved for most of the mitigation actions was not estimated.

3.2 Voluntary national emissions targets

In its recent NDC submitted to UNFCCC in 2020, Rwanda has committed to a voluntary reduction of around 4.6 million tCO_2 eq.

Table 3.1 Mitigation targets contributions against BAU baseline

Scenario	2015	2020	2025	2030
Total emissions ($MtCO_2$ eq.)				
BAU reference case	5.33	7.42	9.61	12.06
Domestic NDC measures	5.33	7.27	8.26	10.16
All NDC measures	5.33	6.59	6.64	7.50
GHG reduction relative to BAU				
Domestic NDC measures	-	2%	14%	16%
All NDC measures	-	11%	31%	38%

Source: (GoR, 2020)

GHG emission in 2030 against the BAU emissions in the same year of 12.1 million tCO_2 eq. This reduction in GHG emission was split into two different components:

- Unconditional contribution: A reduction of 16 %relative to BAU in the year 2030; equivalent to an estimated mitigation level of 1.9 million tonnes of carbon dioxide equivalent (tCO_2 eq.) in that year. This is an unconditional target, based on domestically supported and implemented mitigation measures and policies.
- Conditional contribution: An additional reduction of 22 % relative to BAU in the year 2030; equivalent to an estimated mitigation level of 2.7 million tCO_2e in that year. This represents an additional targeted contribution, based on the provision of international support and funding. The combined unconditional and conditional contribution is therefore a 38 % reduction in GHG emissions compared to BAU in 2030, equivalent to an estimated mitigation level of up to 4.6 million tCO_2e in 2030.

3.3 Energy sector

3.3.1 Overview of mitigation actions in the Energy sector

The most recent mitigation actions in the Energy sector as reported in the recently published updated NDC were taken as a basis of the analysis. An overview description of the 17 mitigation actions for the Energy sector and related GHG mitigation potential, as well as cost-benefit analysis, are provided in **Table 3.2** through
Table 3.6.

Table 3.2 Mitigation actions in electricity generation

ENERGY/ELECTRICITY GENERATION		
	ID	E01
Overview	Mitigation measure	Grid-connected hydropower
	Sector/gases	Energy/Electricity generation; gas – CO_2, CH_4 and N_2O
	Short description	Expanded hydropower is part of the GoR priorities to expand the grid-connected electricity from low carbon indigenous energy sources. It aims at establishing new grid-connected renewable electricity

ENERGY/ELECTRICITY GENERATION		
		generation capacity in the form of large and small-scale hydro. These include the development of 119.2 MW large hydro capacity by 2028 (Rusizi III, 49 MW; Rusumo Falls, 26.7 MW; Nyabarongo II-1, 43.5MW and 71.7 MW small and mini-hydro projects by 2030.
	Objective	Low carbon energy supply
	Status	Ongoing: Some of the proposed hydropower projects have already started and others are in the preparation phase. They include Rusumo Falls Hydropower plant (26MW in 2021), Rusizi III (48.3MW in 2023), and Nyabarongo II (43.5 MW in 2024).
	Indicator	Installed hydropower capacity (MW)
	Implementing institution	REG/EDCL/MININFRA
	Timing of project	Gradual construction of both large and small-scale hydro based on the REG plans as published in the Least Cost Power Development Plan (LCPDP)
	Alignment to SDG	
	Related policy/program	• Electricity Access Roll-out Program (EARP) • Least Cost Development Plan (LCDP)
GHG mitigation	Mitigation effect	Displacement of GHG from current and new build fossil-based electricity generation
	Estimated mitigation in 2030	0.482 Mt CO_2 eq.
	Total mitigation (2020-2030)	3.72 Mt CO_2 eq.
Cost-benefit analysis	Description of costs	Costs are estimated to include planning, construction and operation as detailed in ESSP and LCPDP.
	Description of benefits	The power plant can generate electricity below current costs, reducing tariffs for customers. Other benefits include job creation.
	Economic assessment period	20 years
	Discount rate	6 %
	NPV of project	263 M USD
	Notes on economic analysis	Economic cost analysis based on the implementation costs published in the ESSP
	Abatement cost	-58.76 USD/tCO_2 eq.
	ID	E02

ENERGY/ELECTRICITY GENERATION		
Overview	Mitigation measure	Solar minigrids
	Sector/gases	Energy/Electricity generation; gas – CO_2, CH_4 and N_2O
	Short description	With a potential of 4.5 kWh per m^2 per day and approximately 5 peak sun hours, solar energy has a huge potential in Rwanda. The country has already engaged private sector participation in solar solutions as a lighting substitute for remote areas. Currently, over 258,000 households have benefited from access to electricity with solar energy through IPPs countrywide. Households located from the planned national grid coverage are encouraged to use Mini-grid Solar PV to reduce the cost of access to electricity. The project is thus aligned with the Government's Rural Electrification Strategy.
	Objective	Rural electrification
	Status	Ongoing: Currently, 84 mini-grids (78 DC and 6 AC) are installed with a total capacity of around 250kW. Awareness campaigns on off-grid electrification program ongoing, Detailed Feasibility studies of identified mini-grids sites will be carried out under SEFA/AfDB funds and BRD/Enabel and tendered out to private developers for mini-grid development. Taxes exemption on solar materials
	Indicator	Share of renewables in total electricity supply (%)
	Implementing institution	REG/EDCL/MININFRA
	Timing of project	Construction of micro-grids between 2020 and 2024. The operation is to last until 2050.
	Alignment to SDG	
	Related policy/program	Rural electrification strategy National Electrification Plan (NEP)
GHG mitigation	Mitigation effect	Displacement of emissions generated by Jabana power plant (HFO)
	Estimated mitigation in 2030	0.132 Mt CO_2 eq.
	Total mitigation (2020-2030)	1.301 Mt CO_2 eq.
Cost-benefit	Description of costs	Capex and opex.
	Description of benefits	Avoided purchase of HFO, avoided investment in transmission infrastructure, employee earnings from solar jobs and indirect jobs.

ENERGY/ELECTRICITY GENERATION		
	Economic assessment period	15 years
	Discount rate	6 %
	NPV of project	164.34 M USD
	Notes on economic analysis	N/A
	Abatement cost	-126.36 USD/tCO_2eq.
ENERGY/ELECTRICITY GENERATION		
	ID	E03
Overview	Mitigation measure	Solar LED streetlights
	Sector/gases	Energy/Electricity generation; gas – CO_2, CH_4 and N_2O
	Short description	The analysis assumes that approximately 10,000 solar-powered LED streetlights will be installed to replace existing High-Pressure Sodium lights. While traffic lights are not separately addressed in the analysis, their costs and benefits are included under streetlights.
	Objective	Energy efficiency measures
	Status	A pilot project was implemented by the City of Kigali to replace high-pressure sodium (HPS) lamps with LEDs in streetlights.
	Indicator	# Solar LED streetlights # Solar traffic lights
	Implementing institution	MININFRA/REG/RTDA
	Timing of project	Beginning in 2019. Ending in 2044 (although may continue).
	Alignment to SDG	
	Related policy/program	ESSP
GHG mitigation	Mitigation effect	Energy efficiency (reduced grid power).
	Estimated mitigation in 2030	0.008 Mt CO_2 eq.
	Total mitigation (2020-2030)	0.100 Mt CO_2 eq.
Cost-benefit	Description of costs	Cost of LED streetlights, batteries and installation
	Description of benefits	Energy efficiency savings

ENERGY/ELECTRICITY GENERATION		
	Economic assessment period	15 years period. While the documentation gives no clear indication, we assume the project will last for 25 years (for consistency with other projects).
	Discount rate	6 %
	NPV of project	18.23 M USD
	Notes on economic analysis	The cost analysis was based on the implementation cost sourced from the ESSP.
	Abatement cost	-181.96 USD/tCO_2 eq.

Table 3.3 Mitigation actions in manufacturing industries energy use

ENERGY/MANUFACTURING INDUSTRIES		
	ID	E04
Mitigation measure	Mitigation measure	Energy-efficient brick kilns
	Sector/gases	Energy/gas – CO_2, CH_4 and N_2O
	Short description	The project aims at replacing the existing traditional kilns with energy-efficient brick kilns to reduce fuel consumption in the construction sector. The project is aligned with the GoR policy to reduce biomass consumption in industries and promote cleaner production.
	Objective	Reduce the fuel consumption in brick kilns
	Status	The current annual consumption of biomass in bricks/tiles making industries is estimated at 224,167 tonnes.
	Indicator	# Efficient brick kilns
	Implementing institution	MININFRA/RHA/brick companies/MOE/REMA
	Timing of project	The project is assumed to start in 2020 through 2030 and beyond.
	Alignment to SDG	
	Related policy/program	• Rwanda Resource Efficient and Cleaner Production • Rwanda Green Building Minimum Compliance
GHG mitigation	Mitigation effect	Energy efficiency.
	Estimated mitigation in 2030	0.1426 Mt CO_2 eq.
	Total mitigation (2020-2030)	0.916 Mt CO_2 eq.
Co	Description of costs	Capex for energy-efficient brick kilns.

ENERGY/MANUFACTURING INDUSTRIES		
	Description of benefits	Avoiding the purchase of residual fuel. Health benefits from reduced pollution.
	Economic assessment period	10 years.
	Discount rate	6 %
	NPV of project	42.35 M USD
	Notes on economic analysis	Health benefits were not estimated. The analysis does not include figures on the costs of establishing the programme and developing a database to monitor the programme.
	Abatement cost	-46.21 USD/tCO_2 eq.
	ID	E05
Mitigation measure	Mitigation measure	Energy efficiency in agro-processing industries
	Sector/gases	Energy/gas – CO_2, CH_4 and N_2O
	Short description	Implementation of energy efficiency equipment and management systems within tea (e.g., tea driers) and coffee.
	Objective	Reduce the fuel consumption in the tea estate
	Status	The annual consumption of firewood in tea factories is estimated at 15,738 tonnes.
	Indicator	Fuel consumption per tonne of produced tea
	Implementing institution	MININFRA/RHA/tea companies/MOE/REMA
	Timing of project	The project is assumed to start in 2020 through 2030 and beyond.
	Alignment to SDG	
	Related policy/program	• Rwanda Resource Efficient and Cleaner Production • Rwanda Green Building Minimum Compliance
GHG mitigation	Mitigation effect	Energy efficiency.
	Estimated mitigation in 2030	0.1426 Mt CO_2 eq.
	Total mitigation (2020-2030)	0.916 Mt CO_2 eq.
Cost-benefit	Description of costs	Capex for energy-efficient brick kilns.
	Description of benefits	Avoiding the purchase of residual fuel. Health benefits from reduced pollution.
	Economic assessment period	10 years.

ENERGY/MANUFACTURING INDUSTRIES		
	Discount rate	6%
	NPV of project	42.35 M USD
	Notes on economic analysis	Health benefits were not estimated. The analysis does not include figures on the costs of establishing the programme and developing a database to monitor the programme.
	Abatement cost	-46.21 USD/tCO_2eq.
	ID	E06
Mitigation measure	Mitigation measure	Energy-efficient cement industry
	Sector/gases	Energy/gas – CO_2, CH_4 and N_2O
	Short description	The project aims at replacing the use of residual fuel oil with wood wastes (rice husks and sawdust) within the cement industry. The project is aligned with the GoR policy to reduce biomass consumption in industries and promote cleaner production
	Objective	Replacement of residual fuel oils by wood wastes.
	Status	The cement production is still carbon-intensive with the introduction of coal as fuel. However, the existing initiatives to reduce the clinker ratio will lead to a significant reduction in energy consumption and GHG emissions.
	Indicator	Cement (% non-fossil energy use)
	Implementing institution	CIMERWA Ltd.
	Timing of project	The project is assumed to start in 2020.
	Alignment to SDG	
	Related policy/program	• Rwanda Resource Efficient and Cleaner Production • Rwanda Green Building Minimum Compliance
GHG mitigation	Mitigation effect	Energy efficiency.
	Estimated mitigation in 2030	0.1426 Mt CO_2 eq.
	Total mitigation (2020-2030)	0.916 Mt CO_2 eq.
Cost-benefit analysis	Description of costs	Capex for energy-efficient brick kilns.
	Description of benefits	Avoiding the purchase of residual fuel. Health benefits from reduced pollution.
	Economic assessment period	10 years.
	Discount rate	6%

ENERGY/MANUFACTURING INDUSTRIES		
	NPV of project	42.35 M USD
	Notes on economic analysis	Health benefits were not estimated. The analysis does not include figures on the costs of establishing the programme and developing a database to monitor the programme.
	Abatement cost	-46.21 USD/tCO_2 eq.
	ID	E07
Mitigation measure	Mitigation measure	Electric motor replacement in mining
	Sector/gases	Energy/gas – CO_2, CH_4 and N_2O
	Short description	The project aims at phasing out fossil fuel use in the mining industries and replacing it with onsite-generated electricity and/or grid-connected electricity. Reduction in diesel consumption will reduce the associated GHG emissions and other related air pollutants The project is aligned with the energy efficiency in industries and the cleaner production program.
	Objective	Replacement of existing fossil fuel motors with electric motors in mining companies.
	Status	Ongoing
	Indicator	Electric motor capacity Replaced (MW)
	Implementing institution	RMB/Various mining companies
	Timing of project	From 2020 onwards.
	Alignment to SDG	
	Related policy/program	Green growth and climate resilience strategy (GGCRS)
GHG mitigation	Mitigation effect	Energy efficiency.
	Estimated mitigation in 2030	0.011 Mt CO_2 eq.
	Total mitigation (2020-2030)	0.056 Mt CO_2 eq.
Cost-benefit analysis	Description of costs	Capex (via grants for replacement of motors), opex (management and operation of the programme).
	Description of benefits	Avoiding the purchase of diesel
	Economic assessment period	10 years
	Discount rate	6%

ENERGY/MANUFACTURING INDUSTRIES		
	NPV of project	0.31 M USD
	Notes on economic analysis	Assessment does not include the costs of establishing the programme and developing a database to monitor the programme.
	Abatement cost	-5.53 USD/tCO_2 eq.

Table 3.4 Mitigation actions in transportation

ENERGY/TRANSPORTATION		
	ID	E08
Overview	Mitigation measure	Vehicle fuel economy standards
	Sector/gases	Energy/gas – CO_2, CH_4 and N_2O
	Short description	This project aims at setting vehicle emission standards for new imported road vehicles and enforcement regulations. I will be integrated with the national transportation planning.
	Objective	An efficient resilient transport system
	Status	Range of policies and measures introduced to increase vehicle emissions performance of national vehicle fleet, including tax incentives and scrappage of older vehicles.
	Indicator	Average fuel economy for newly registered vehicles (litres per 100 km)
	Implementing institution	MININFRA/RTDA/RURA
	Timing of project	Phased-in from 2022
	Alignment to SDG	
	Related policy/program	Green Growth and Climate Resilience Strategy (GGCRS)
GHG mitigation	Mitigation effect	Improved technology and standards for conventional ICE vehicles in road transport, resulting in avoided fossil fuel emissions
	Estimated mitigation in 2030	0.154 Mt CO_2 eq.
	Total mitigation (2020-2030)	0.696 Mt CO_2 eq.
Cost-benefi	Description of costs	Incremental technology costs for efficient vehicle models within each class/type; policy set-up and ongoing administration costs.

ENERGY/TRANSPORTATION		
	Description of benefits	Avoided costs of imported diesel and gasoline. Does not quantify health benefits.
	Economic assessment period	10 years
	Discount rate	6%
	NPV of the project (Million USD)	58.83 M USD
	Notes on economic analysis	N/A
	Abatement cost	-84.55 USD/tCO_2 eq.
	ID	E09
Overview	Mitigation measure	Electric vehicles
	Sector/gases	Energy/gas – CO_2, CH_4 and N_2O
	Short description	Introduction of electric vehicles from around 2023 onwards, reaching up to 3,000 new passenger car EVs by 2030. Requires support to overcome additional CAPEX associated with vehicles and charging points. This project is consistent with the e-mobility initiative, a program that is being developed by the GoR.
	Objective	An efficient resilient transport system
	Status	Background and Feasibility studies have been conducted
	Indicator	# EV motorcycles # EV buses # EV LDVs
	Implementing institution	MININFRA/RTDA/RURA
	Timing of project	From 2023 onwards
	Alignment to SDG	
	Related policy/program	E-mobility
GHG mitigation	Mitigation effect	Displacement of conventional ICE vehicles in road transport, resulting in avoided fossil fuel emissions
	Estimated mitigation in 2030	0.002 Mt CO_2 eq.
	Total mitigation (2020-2030)	0.008 Mt CO_2 eq.

ENERGY/TRANSPORTATION		
Cost-benefit analysis	Description of costs	Additional CAPEX for EV vehicles, rapid charger infrastructure and electricity costs.
	Description of benefits	Avoided costs of imported diesel and gasoline.
	Economic assessment period	15 years
	Discount rate	6%
	NPV of the project (Million USD)	-1.16 M USD
	Notes on economic analysis	N/A
	Abatement cost (USD/tCO_2eq.)	140.20 USD/tCO_2 eq.
	ID	E10
Overview	Mitigation measure	Public transportation measures
	Sector/gases	Energy/gas – CO_2, CH_4 and N_2O
	Short description	This project aims at bus promotion as part of public transport development, replacement of minibuses by modern buses and promotion of mass rapid transportation.
	Objective	An efficient resilient transport system
	Status	Bus Rapid Transit (BRT) System
	Indicator	# Buses in public transport
	Implementing institution	MININFRA/RTDA/RURA
	Timing of project	From 2020 onwards
	Alignment to SDG	
	Related policy/program	Mass Rapid Transport
GHG mitigation	Mitigation effect	Displacement of conventional ICE vehicles in road transport, resulting in avoided fossil fuel emissions
	Estimated mitigation in 2030	0.008 Mt CO_2 eq.
	Total mitigation (2020-2030)	0.054 Mt CO_2 eq.

ENERGY/TRANSPORTATION		
Cost-benefit analysis	Description of costs	Capital costs are estimated based on the cost of buses, minibuses.
	Description of benefits	Avoided costs of imported diesel. Does not quantify health benefits.
	Economic assessment period	15 years
	Discount rate	6%
	NPV of the project (Million USD)	-8.59 M USD
	Notes on economic analysis	N/A
	Abatement cost	158.63 USD/tCO_2 eq.

Table 3.5 Mitigation actions in buildings energy use

ENERGY/BUILDINGS		
	ID	E11
Overview	Mitigation measure	Rooftop solar in commercial buildings (grid back-up)
	Sector/gases	Energy/gas – CO_2, CH_4 and N_2O
	Short description	Most commercial buildings and institutional buildings in remote areas of Rwanda use diesel generators as the main source of electricity. Diesel generators are also used for grid backup. The project aims at installing a cumulative 10 MWp in three years and is aligned with the Rwanda rural electrification strategy.
	Objective	Replacement of diesel generators by rooftop solar in commercial and institutional buildings
	Status	The guidelines for installation have been formulated in the Rwanda green building minimum compliance system
	Indicator	# commercial/institutions with rooftop solar/Rooftop solar (MWp)
	Implementing institution	MININFRA/RHA
	Timing of project	The project is assumed to begin in 2019 with a few pilots and be completed within 3 years.
	Alignment to SDG	

ENERGY/BUILDINGS		
	Related policy/program	Rwanda rural electrification strategy Rwanda green building minimum compliance system Rwanda Universal Energy Access Program (RUEAP)
GHG mitigation	Mitigation effect	Displacement of diesel used in backup generators
	Estimated mitigation in 2030	0.029 Mt CO_2 eq.
	Total mitigation (2020-2030)	0.279 Mt CO_2 eq.
Cost-benefit analysis	Description of costs	Capex of about $28 million. Opex includes system O&M and does not consider the replacement of batteries.
	Description of benefits	Displacement of diesel generation costs, displacement of grid electricity, solar jobs.
	Economic assessment period	10
	Discount rate	6%
	NPV of project	47.02 M USD
	Notes on economic analysis	The project will boost employment opportunities, estimated to activate or create new jobs in SMEs for 3,790 men and 4,166 women (due to availability of power during outages).
	Abatement cost	-168.76 USD/tCO_2 eq.
	ID	E12
Overview	Mitigation measure	Efficient cookstoves
	Sector/gases	Energy/gas – CO_2, CH_4 and N_2O
	Short description	The type of stove has a significant impact on the amount of fuel required and the health of households. Most households (66%) use three-stone cookstoves (a simple cookstove, made by placing a pot on three stones, which are positioned around a fire) or traditional cooking stoves. These normally use firewood. The average household uses around 1.8 tonnes of firewood each year with this type of cookstove. The average monthly consumption per household on firewood is RWF 1,930 (USD 2.27). A Government programme to support the use of improved cooking technologies has been running since the 1980s with 30 % household penetration. Private sector-led efforts are also distributing cookstoves that are up to three times more efficient than the traditional 3-stone stove and can reduce biomass consumption by anywhere between 68-94%. This will

ENERGY/BUILDINGS		
		free up the time spent by women and children in collecting firewood. The project aims to halve the number of households using traditional cooking technologies to achieve a sustainable balance between the supply and demand of biomass through the promotion of biomass efficient technologies. The project aligns with the ESSP targets.
	Objective	Halve the number of HH using traditional cooking technologies to achieve a sustainable balance between supply and demand of biomass through the promotion of the most energy-efficient technologies
	Status	80.37 % of Rwandan Households use firewood for cooking; however, there is a significant increase in the use of alternative cooking technologies manifest in the increase in the use of LPG now at 5.65 % of households on average compared to under 1.15 % reported in EICV5. LPG consumption is concentrated in urban areas, used by 25.6 % of urban households, but only 0.4 % of rural households.
	Indicator	Efficient stoves (# HH)
	Implementing institution	MININFRA/RHA/REG/EDCL
	Timing of project	2019-2030
	Alignment to SDG	
	Related policy/program	Biomass Energy Strategy (BEST)
GHG mitigation	Mitigation effect	Avoided charcoal and firewood consumption
	Estimated mitigation in 2030	0.195 Mt CO_2 eq.
	Total mitigation (2020-2030)	1.896 Mt CO_2 eq.
Cost-benefit analysis	Description of costs	Costs include training and monitoring on kiln use (certification).
	Description of benefits	Avoided cost of charcoal and firewood, job creation
	Economic assessment period	10 years
	Discount rate	6%
	NPV of project	263.17 M USD

ENERGY/BUILDINGS		
	Notes on economic analysis	The economic impact will be achieved progressively with the expansion of improved cookstoves use.
	Abatement cost	-138.79 USD/tCO_2 eq.
	ID	E13
Overview	Mitigation measure	Solar water heaters in the residential sector
	Sector/gases	Energy/gas – CO_2, CH_4 and N_2O
	Short description	A major ongoing initiative is the SolaRwanda Solar Water Heater Program, which promotes the use of solar water heaters, to reduce the use of electricity from the grid for water heating. The program was initiated in 2009 with the support of development partners and was formally launched in March 2012 with a pilot phase of 100 SWHs. Loans and grants are used to subsidise the cost of purchasing an SWH. Implementation commenced in April 2013 and 2,256 SWHs have been installed. This project focussed on the implementation of the Rwanda Green building compliance system. It aims at encouraging commercial buildings to install solar water heaters instead of using electricity.
	Objective	Installation of solar thermal water heaters within urban residential buildings supported using loans and grants to subsidise purchase costs, as part of the National Green Building Code minimum compliance system.
	Status	Implementation commenced in April 2013 and 2,256 SWHs have been installed.
	Indicator	# SWH installations
	Implementing institution	MININFRA/RHA/REG/EDCL
	Timing of project	2019-2030
	Alignment to SDG	
	Related policy/program	ESSP/Solar Water Heater Program
GHG mitigation	Mitigation effect	Avoided charcoal and firewood consumption
	Estimated mitigation in 2030	0.195 Mt CO_2 eq.
	Total mitigation (2020-2030)	1.896 Mt CO_2 eq.

ENERGY/BUILDINGS		
Cost-benefit analysis	Description of costs	Costs include training and monitoring on kiln use (certification).
	Description of benefits	Avoided cost of charcoal and firewood, job creation
	Economic assessment period	10 years
	Discount rate	6%
	NPV of project	263.17 M USD
	Notes on economic analysis	The economic impact will be achieved progressively with the expansion of improved cookstoves use.
	Abatement cost	-138.79 USD/$tCO_{2\ eq.}$
	ID	E14
Overview	Mitigation measure	Off-grid solar electrification (SHS and mini-grids)
	Sector/gases	Energy/gas – CO_2, CH_4 and N_2O
	Short description	Considering the challenges associated with grid-connected electricity, the government of Rwanda considers access to off-grid electricity as the primary mean through which the electricity access could be expanded through the country. In recent years, off-grid electricity has been one of the key achievements of the electricity sector with growth from 0 % to around 11%, equivalent to 258,670 households in 2017. According to the government plans, the latter access will be increased via solar home systems and solar mini-grid.
	Objective	Halve the number of HH using traditional cooking technologies to achieve a sustainable balance between supply and demand of biomass through the promotion of the most energy-efficient technologies
	Status	As of July 2018, the Off-grid connectivity rate was 11.33 % of Rwandan households. From 2018 through December 2020, the share of off-grid connected households has increased to 15.9 %.
	Indicator	Share of Rwanda households with off-grid solutions (%)
	Implementing institution	MININFRA/RHA/REG/EDCL
	Timing of project	Universal access to be achieved by 2025.
	Alignment to SDG	

ENERGY/BUILDINGS		
	Related policy/program	Rural Electrification Strategy
GHG mitigation	Mitigation effect	Displacement of kerosene used for lighting in rural households, and to a lesser extent, diesel/petrol used in small gensets.
	Estimated mitigation in 2030	0.010 Mt CO_2 eq.
	Total mitigation (2020-2030)	0.075 Mt CO_2 eq.
Cost-benefit analysis	Description of costs	According to REG estimates, total capital costs include the solar PV mini-grids and SHS, per REMA estimates. Total amounts to $200 million. The main operating cost is the cost of the replacement of solar batteries. While the SHS/mini-grid market is expected to be private sector-led, a public support programme to offer training, financing, etc. has been factored in in the cost.
	Description of benefits	Avoided consumption of more basic forms of energy (kerosene, candles, batteries, phone charging services, etc.), plus job creation benefits.
	Economic assessment period	15 years
	Discount rate	6%
	NPV of project	9.76 M USD
	Notes on economic analysis	Other benefits of solar technologies vs other sources (pollution, health, fuel independence, the better quality of light, etc.) were not quantified.
	Abatement cost	-130.91 USD/tCO_2 eq.

Table 3.6 Mitigation actions in agriculture energy use

ENERGY/AGRICULTURE		
	ID	E15
Mitigation measure	Mitigation measure	Domestic on-farm biogas
	Sector/gases	Energy/gas – CO_2, CH_4 and N_2O
	Short description	The project, which is aligned with ESSP targets, will aim at enforcing the promotion and use of biogas. Biogas utilisation is proposed as a potential alternative to biomass. The 2007 National Domestic Biogas programme supported the use of biogas, targeting 9,500 rural households with at least two cows. Since 2007, around

		3,700 digesters, based on standard construction design using local materials, have been disseminated. The government provided a 50 % subsidy and the remaining was provided through local credit institutions. However, recent site visits suggest that the use of biogas digesters is limited, with users citing unreliability and insufficient fuel. At the institutional level, there have been 68 installations, with 11 out of 14 prisons reached and the remaining 3 under development.
	Objective	30,000 on-farm small-scale biodigesters (capacity 4-20 m^3) to replace (mainly) fuelwood used for cooking; roll-out of government support programme (awareness, training, subsidies)
	Status	Ongoing
	Indicator	# Installed biodigesters
	Implementing institution	MININFRA/REG/EDCL
	Timing of project	From 2020 onwards.
	Alignment to SDG	
	Related policy/program	National Domestic Biogas programme
GHG mitigation	Mitigation effect	Avoided emissions from manure. Avoided deforestation.
	Estimated mitigation in 2030	0.117 Mt CO_2 eq.
	Total mitigation (2020-2030)	0.869 Mt CO_2 eq.
Cost-benefit analysis	Description of costs	Capital and annual costs estimated based on SNV feasibility studies
	Description of benefits	Quantified: Avoided cost of fuelwood, the replacement cost of fertiliser, revenue from the utilisation of bio-slurry. Not quantified: job creation, reduced workload for rural households, health benefits.
	Economic assessment period	10 years
	Discount rate	6%
	NPV of project	33.20 M USD
	Notes on economic analysis	N/A
	Abatement cost (	-38.22 USD/tCO_2eq.
ENERGY (AGRICULTURE)		

	ID	E16
Mitigation measure	Mitigation measure	Solar pumping for irrigation
	Sector/gases	Energy/gas – CO_2, CH_4 and N_2O
	Short description	According to NST1, the national area under irrigation will increase from 48,508 ha (2017) to 102,284 ha in 2024. Priority will be given to the scale-up of marshland and small-scale technologies for irrigation, considered most cost-effective. This project aims at an irrigation area of 84,505 Ha by 2030. Investment in small-scale solar irrigation as opposed to diesel pumps for 84,505 Ha. Public-support programme to create awareness, help farmers finance investment (through credit and/or subsidies) and train technicians). Rwanda Agriculture Board (RAB) implements and Coordinates SSIT countrywide where a subsidy of 50 % is given to farmers and funds are earmarked to selected districts while MINAGRI and RAB mobilize farmers to adopt climate-resilient methods, which include irrigation equipment.
	Objective	This project aims at an irrigation area of 84,505 Ha by 2030
	Status	Ongoing: 1000 Ha are irrigated by solar systems in Nasho and Kirehe and 350 Ha are irrigated by solar systems.
	Indicator	Ha irrigated by renewable energy sources
	Implementing institution	MINAGRI, MININFRA/REG
	Timing of project	Implementation/investment over 5 years between 2020 and 2024 (assumption based on NST1).
	Alignment to SDG	
	Related policy/program	NST1
GHG mitigation	Mitigation effect	Displacement of diesel consumption in small-scale irrigation schemes, targeting 84,505 Ha.
	Estimated mitigation in 2030	0.150 Mt CO_2 eq.
	Total mitigation (2020-2030)	1.202 Mt CO_2 eq.
Cost-	Description of costs	Capital costs include the solar irrigation system equipment (PV modules, mounting structure, pump controller, pump, distribution and water storage) and its installation, compared to the cost of a

		diesel irrigation system of equivalent performance. Minimal O&M costs. The cost of a 5-year public-support programme is also included.
	Description of benefits	Avoided costs of imported diesel fuel (and its transportation to farms), plus job creation benefits.
	Economic assessment period	10 years
	Discount rate	6%
	NPV of project	106.77 M USD
	Notes on economic analysis	The economic analysis assumes solar pumps are used throughout the year (as opposed to seasonal use).
	Abatement cost	-88.80 USD/tCO_2 eq.

3.3.2 Indicator targets and reporting institutions

This section provides the indicator targets and the reporting institutions for all identified mitigation actions in the energy sector. The reported information is based on the recently published updated NDC (2020) as well as its Measuring, Reporting and Verification framework (Republic of Rwanda, 2021).

Table 3.7 Indicator targets and reporting institutions for Energy sector mitigation actions

Indicator	Reporting institution(s)	Mitigation action ID	Target for 2021-2030
Hydropower capacity (MW)	REG/EDCL/MININFRA	E01	With a target to have universal access in 2024. The share of domestic hydropower is expected to increase to 52 % by 2024 and imported hydropower to 2 %
Share of Off-grid electrification/Solar mini-grids (MWp)	REG/EDCL/MININFRA	E02	With a target to have universal access in 2024. The share of off-grid is expected to reach 42 % with 326,884 HHs connected through solar minigrids
# Solar street lighting	MININFRA/REG/RTDA	E03	With a target to have universal access in 2024.

Indicator	Reporting institution(s)	Mitigation action ID	Target for 2021-2030
			Street lighting is expected to expand to all populated areas and main roads
# Efficient brick kilns	MININFRA/RHA/brick companies/MOE/REMA	E04	This is a new indicator and appropriate targets will need to be set
Fuel consumption per tonne of produced tea	MININFRA/RHA/tea companies/MOE/REMA	E05	This is a new indicator and appropriate targets will need to be set
Cement (% non-fossil energy use)	CIMERWA Ltd.	E06	The cement production is still carbon-intensive with the introduction of coal as fuel. However, the existing initiatives to reduce the clinker ration will lead to a significant reduction of the energy consumption and GHG emissions
Electric motor capacity Replaced (MW)	RMB/Various mining companies	E07	80 new mining facilities are expected to be connected by 2024
Average fuel economy for newly registered vehicles (litres per 100 km)	RTDA/MININFRA/RURA	E08	This is a new indicator and appropriate targets will need to be set
# EV motorcycles # EV LDVs # EV buses	MININFRA/RTDA/RURA	E09	Introduction of electric vehicles from around 2023 onwards, reaching up to 3,000 new passenger car EVs by 2030.
# Efficient busses	MININFRA/RTDA/RURA	E010	This is a new indicator and appropriate targets will need to be set.
Rooftop solar (MWp)	REG/MININFRA	E011	Penetration of off-grid solar and rooftop solar PV panels consistent with the

Indicator	Reporting institution(s)	Mitigation action ID	Target for 2021-2030
			ESSP targets of around 1,500,000 households to be electrified through, equivalent to 250,000 connections per year. Displacement of grid power and diesel consumption and associated GHG emissions.
Efficient stoves (# HH)	REG/MININFRA	E012	Dissemination of modern efficient cookstoves to 80 % of the rural population and 50 % of the urban population by 2030, achieving a more sustainable balance between supply and demand of biomass and reducing firewood and fossil energy consumption for cooking. This will lead to a reduction of the percentage of households relying on firewood as a source of energy for cooking from 83.3 % to 42 %.
# HH with solar off-grid	REG/EDCL/MININFRA	E013	1,274,180 HHs are targeted in 2024
# SWH installations	REG/MININFRA	E014	The solar water heater program is under review to provide new targets
# CFL replacements	REG/MININFRA	E015	Further dissemination of CFL and LED lamps in residential, commercial and institutional buildings. Supported by government

Indicator	Reporting institution(s)	Mitigation action ID	Target for 2021-2030
			subsidies and VAT exemptions on energy-saving lamps. Reduction of grid-based GHG emissions.
# On-farm biodigesters	RAB/REG/Districts	E016	The biogas program is being revised and new targets will be set
Solar irrigation (Ha)	REG/RAB	E017	Displacement of diesel consumption in small-scale irrigation schemes, targeting 84,505 Ha.

3.3.3 Progress on implementation of Energy sector mitigation projects

The following section provides a summary of progress achieved to date and the planned next step for identified mitigation actions. In general, there are different ongoing efforts to develop policies, strategies, enabling environment, and reporting framework and build capacity in key institutions to implement most of the identified mitigation actions.

Table 3.8 Progress on implementation of the Energy mitigation actions and planned next steps

ID	Mitigation measure	Progress achieved to date	Mitigation achieved (tCO_2 eq.)	Planned next steps
E01	Grid-connected hydropower generation Development of 56.75 MW large hydro capacity (capacity > 5 MW), 24.5 MW small and mini-hydro projects (capacity <5MW) and 75 MW regional projects by 2030. Displacement of	As of June 2020, Rwanda's grid installed capacity was 228.102 MW; where 41.37 % was from domestic Hydro, 5.26 % from the regional shared plant (Rusizi II)	**12,764.85 from 2015 to 2018**	A more detailed analysis of the mitigation achieved will be conducted

ID	Mitigation measure	Progress achieved to date	Mitigation achieved (tCO_2 eq.)	Planned next steps
	GHG emissions from fossil fuel power generation (peat, diesel oil).			
E02	Solar mini-grids 68 MWp of solar mini-grids to be installed in off-grid rural areas by 2030, as reflected in the Rural Electrification Strategy. Displacement of traditional biomass fuels, diesel and kerosene for domestic energy use.	Currently, 84 mini-grids (78 DC and 6 AC) are installed with a total capacity of around 250kW.	**2,105,289.12 from 2015 to 2018**	• Regular data collection is needed to follow up on the progress of implementation • A detailed methodology for estimating the GHG emissions reduction achieved will be developed
E03	Solar street lighting Installation of solar lighting and LED systems to replace high-pressure sodium (HPS) lamps for street lighting and public spaces within populated areas and main roads by 2024. Reduction of grid-based GHG emissions.	By the end of June 2019, 13.5 km of street installation completed in Ntendezi-Gisakura. 4 km out of 32 km completed in Pindura-Bweyeye and 80 % of 28 km completed on Kitabi-Pindura	Not estimated	Regular and disaggregated data collections will be needed to be able to report on the progress.
E04	Efficient brick kilns Phasing out the use of clamp kilns, and applying energy efficiency measures	A recent survey conducted by NIRDA has shown that the traditional brick kilns have a dominant	Not estimated	• Data on the types of the existing kilns, the fuels consumptions should be collected

ID	Mitigation measure	Progress achieved to date	Mitigation achieved (tCO_2 eq.)	Planned next steps
	in the brick manufacturing industry.	fraction of 87.21 % of the existing kilns in Rwanda.		by the cooperatives and the individuals involved in the sector. • Regular surveys will be conducted to estimate the number of bricks/tiles and the fuel consumption in the brick kilns
E05	Energy efficiency in agro-processing A range of energy efficiency measures focused on reducing firewood and electricity consumption in the coffee and tea sector.	The annual CO_2 emissions from the factory are estimated to be 10,600 tonnes, equivalent to 2.7 kg CO_2 eq. /kg tea. FONERWA is conducting a study on various tea factories under the green Gicumbi project. This study will be done on 5 tea factories namely: Mulindi Tea Factory, Nyabihu Tea Factory, Gisovu Tea Factory, Kitabi Tea Factory and Pfunda Tea Factory. One of the key objectives of the project is to propose an appropriate and efficient alternative energy source other than firewood to be used in tea heating	Not estimated	• Conduct surveys in all the tea factories to collect data on energy efficiency technologies • Collect regular data on the fuel type and fuel consumption

ID	Mitigation measure	Progress achieved to date	Mitigation achieved (tCO_2 eq.)	Planned next steps
		according to its efficiency, affordability and determine requirements for implementation.		
E06	Energy-efficient cement production Use of waste heat recovery (WHR) and increased use of rice husks as fuel within clinker production.	This is still pending	Not estimated	A follow up on the projects proposed to the private sector will be needed for implementation and data collection in the progress
E07	Climate compatible mining Phasing out of diesel gensets for on-site electricity consumption, to be replaced with grid and/or on-site renewable power production.	This is a new project and no specific progress is registered so far	Not estimated	• Regular surveys to collect data on the number of the phased out gensets and installed renewable power will be needed • A detailed methodology for estimating the GHG emissions reduction will be needed
E08	Vehicle emissions standards Range of policies and measures introduced to increase vehicle emissions performance of	Various standards have already been developed by the Rwanda Standard board including: • Emission limits — Specification — Part 1: Road vehicles	Not estimated	• Data on fuel economy should be added to the list of data recorded by RRA for new vehicles • A detailed methodology for

ID	Mitigation measure	Progress achieved to date	Mitigation achieved (tCO_2 eq.)	Planned next steps
	national vehicle fleet, including tax incentives and scrappage of older vehicles. Reduction of GHG and local emissions from gasoline and diesel use.	• Emission limits — Specification — Part 2: Non- Road mobile machinery		estimating the GHG emissions reduction will be needed
E09	Electric vehicles (EVs) The e-mobility programme plans for the phased adoption of electric buses, passenger vehicles (cars) and motorcycles from 2020 onwards, resulting in displaced conventional vehicle sales, transport fuel imports and associated GHG emissions.	Currently, there are 150 operational electric motorcycles with 8 charging stations and 7 battery-swapping stations for motorcycles, 20 e-golfs fuelled by two charging stations operated by Siemens and 20 operational PHEV with corresponding domestic charging units.	Not estimated	• Regular data collection on the electric vehicles will be needed to be able to assess the progress • A detailed methodology for estimating the GHG emissions reduction will be needed
E010	Public transport infrastructure Wide range of measures including bus rapid transport (BRT) project, bus lanes, non-motorised transport lanes, and other modal shift projects	• Various initiatives have started including the Kigali ride and the upgrading of the transport infrastructure including the roads • A feasibility Study and Preliminary Design for a Bus Rapid Transit (BRT) System	Not estimated	• Regular data collection will be needed to be able to assess the mitigation potential • A detailed methodology on estimating the GHG emission reduction will be

ID	Mitigation measure	Progress achieved to date	Mitigation achieved (tCO_2 eq.)	Planned next steps
	contained in the Transport Sector Strategic Plan as part of the NST1.	for the City of Kigali has been conducted and approved		needed to assess the progress
E011	Rooftop solar in commercial buildings (grid back-up)	517 hospitals have rooftop solar systems installed.	Not estimated	An improvement in data collection on the rooftop solar in commercial and institutional buildings is needed
E012	Efficient cookstoves Dissemination of modern efficient cookstoves to 80 % of the rural population and 50 % of the urban population by 2030, achieving a more sustainable balance between supply and demand of biomass and reducing firewood and fossil energy consumption for cooking.	• Promotion of the LPG use was conducted in partnership with the private sector • The use of firewood as the main source of energy for cooking has reduced to 79.9 % in 2019 from 86.3 % in 2011. • An extensive awareness campaign to promote clean cooking technologies has been conducted in 30 districts	**3,938,092.50 from 2015 to 2018**	Regular surveys are needed to collect data on the efficiencies of the stoves and the biomass consumption in households
E013	Solar water heater (SWH) programme Installation of solar thermal water heaters within urban residential buildings supported using loans and grants to subsidise purchase costs, as part of the	The program was initiated in 2009 with the support of development partners and was formally launched in March 2012 with a pilot phase of 100 SWHs. Loans and grants are used to subsidise the cost of	**5,090.99 from 2015 to 2018**	Data collection surveys will be needed to collect data on the installed SWH in the commercial and household buildings

ID	Mitigation measure	Progress achieved to date	Mitigation achieved (tCO_2 eq.)	Planned next steps
	National Green Building Code minimum compliance system.	purchasing an SWH. Implementation commenced in April 2013 and 2,256 SWHs have been installed.		
E014	Off-grid and rooftop solar electrification Penetration of off-grid solar and rooftop solar PV panels consistent with the ESSP targets of around 1,500,000 households to be electrified through, equivalent to 250,000 connections per year. Displacement of grid power and diesel consumption and associated GHG emissions.	Off-grid access in Rwanda has been increased from around 0 % to over 7 %, equivalent to 189,069 households. This has largely been achieved through SHS.	**3,513.77 from 2015 to 2018**	• Regular surveys will be needed to collect data on off-grid connection • A detailed methodology on estimating the GHG emissions reduction achieved will be needed
E015	Promotion of on-farm biogas for energy Increased use of on-farm anaerobic digestion of manure for bioenergy (bio-digestors).	• At the institutional level, there have been 68 installations, with 11 out of 14 prisons reached and the remaining 3 under development • 727 biogas plants have been inspected in collaboration with the districts and biogas construction	**14,200.60 from 2015 to 2018**	• Regular surveys on the installed biogas plants and their status will be conducted • A detailed methodology on estimating the GHG emissions reduction achieved will be needed

ID	Mitigation measure	Progress achieved to date	Mitigation achieved (tCO_2 eq.)	Planned next steps
		companies. 113 were rehabilitated		
E016	Solar pumping for irrigation Use of solar water pumping systems for irrigation within agricultural production to replace diesel pumps, displacing fossil fuel use and associated GHG emissions.	Since the beginning of the Small-Scale Irrigation Technology (SSIT) project, 885 hectares are equipped with this technology. To alleviate climate change-induced droughts which are now threatening Rwanda's twin goals of food security and poverty reduction, Rwanda has been obliged to accelerate the development of sustainable, affordable, farmer-owned irrigation systems by providing 50 % subsidy to individual farmers or cooperatives, the Government also developed irrigation system with support from a buffet in Kirehe which is hybrid. The irrigation uptake through this program increased and now farmers and the Government are investing in solar-powered irrigation	Not estimated	• Data on irrigated Ha will be regularly collected and kept for monitoring and evaluation • A detailed methodology for reduced GHG emissions will be needed to assess the achievement

ID	Mitigation measure	Progress achieved to date	Mitigation achieved (tCO_2 eq.)	Planned next steps
		systems since the operation cost is highly reduced because no fuel is bough and the maintenance costs are minimized. Solar-powered irrigation initial investment is expensive, that is why its development is slow.		

3.4 Industrial Processes and Product Use (IPPU) sector

3.4.1 Overview of mitigation actions

An overview description of the selected projects in IPPU and related GHG mitigation potential, as well as cost-benefit analysis, is presented in **Table 3.9** for the two projects, viz., Clinker substitution (i.e., increased use of pozzolanas in cement) and Gradual substitution of F-gases by less polluting substitutes.

Table 3.9 Mitigation actions in IPPU

IPPU/ CLINKER SUBSTITUTION		
Overview	ID	I01
	Mitigation measure	Clinker substitution: increased use of pozzolanas in cement
	Sector/gases	Mineral industry / CO_2
	Short description	The project considers a rational 5 % substitution of clinker with pozzolanas from the current 70 % (cement to clinker ratio) and this has started to be implemented. CIMERWA Ltd plant envisages producing the cement of 50 % clinker ratio for non-structural application. It is assumed that 20 % of the total cement production is used for non-structural concrete use.

	Objective	Production of cement by substitution of clinker with pozzolanas alternative to reduce the GHG emission while at the same time reducing the cost of cement production.
	Status	Ongoing
	Indicator	- Pozzolana use (t) - Clinker/cement ratio (%)
	Implementing institution	MINICOM, NIRDA
	Timing of project	2020-2030
	Alignment to SDG	
	Related policy/ programme	GGCRS (PoA 7: Green industry and private sector investment, PoA 8: Climate compatible Mining) NST 1 and the 'Made in Rwanda' policy (2017).
GHG mitigation	Mitigation effect	Reduced CO_2 emissions from the calcination reaction of clinker and reduction in fossil fuel use such as electricity and coal.
	Estimated mitigation in 2030	0.138 Mt CO_2 eq.
	Total mitigation (2020-2035)	1.58 Mt CO_2 eq.
Cost-benefit analysis	Description of costs	Capital costs estimated at 1.2 M USD; pozzolana material costs estimated to total around 7M USD through 2030 based on 6 USD/tonne assumption
	Description of benefits	The use of local materials results in new job opportunities, GHG reduction in clinker process emissions. In addition, energy-related emissions (coal; electricity) will be reduced from the reduction of fossil fuel combustion in clinker production. Thus, the increase of pozzolanas in cement while reducing the clinker to cement ratio means lower emissions and lower energy use.
	Economic assessment period	15 years from the starting of the project
	Discount rate	6 %
	NPV of project	118.5 M USD

	Notes on economic analysis	Economic gains are significant from both technical and sustainability perspectives, as well as from an aesthetic point of view. Pozzolana substitute typically costs less than clinker and for non-structural application; a rational substitution should be made.
	Abatement cost	-75.21 USD/tCO_2eq.
IPPU/F-GAS SUBSTITUTION		
Overview	ID	I02
	Mitigation measure	Gradual substitution of F-gases by less polluting substitutes
	Sector/gases	The product uses as substitute for ODS / F-gases
	Short description	The category 2F emissions will be reduced to comply with the Kigali Amendment of the Montreal Protocol on substances that deplete the ozone layer (UN, 2016). 2F gases are mainly imported for refrigeration, stationary air conditioning and mobile air conditioning. By using climate-friendly alternatives to HFCs, emissions are projected to reduce by 30 % in 2021 to 65 % in 2030 relative to BAU.
	Objective	The aim is for the gradual replacement of the ODS alternatives that were surveyed in Rwanda on the list of controlled substances as per Annex F of the Montreal Protocol, such as HFC-134a, HFC-125, HFC-143a and HFC-32 (UN, 2016). The project assumes the substitution of existing F-gases with hydrocarbon refrigerants such as R290.
	Status	Ongoing
	Indicator	- Imported HFC (kg) - F-gas use (list the gases and amounts in kg) - F-gas substitution (%)
	Implementing institution	MINICOM, NIRDA
	Timing of project	2021-2030
	Alignment to SDG	
	Related policy/ programme	In line with the National cooling Strategy (2019), the Kigali Amendment to the Montreal Protocol (entered into force in January 2019) and the Rwanda green building minimum compliance system.
GHG	Mitigation effect	Reduction of F-gases, with higher GWP, from refrigeration and servicing sector.

	Estimated mitigation in 2030	0.03 Mt CO_2 eq.
	Total mitigation (2021-2035)	0.28 Mt CO_2 eq.
Cost-benefit analysis	Description of costs	Additional costs associated with importing climate-friendly alternatives to HFCs (R290) are estimated to have capital costs of 3.2 million USD and material costs of around 20 million USD through 2030.
	Description of benefits	HFCs are greenhouse gases with high global warming potential (GWP). The solution is to shift to low GWP substitutes. The lower the GWP, the more climate-friendly the substance. Reduced cost of imported HFC R-134a gases estimated at around 17 million USD through 2030.
	Economic assessment period	15 years from the starting of the project
	Discount rate	6 %
	NPV of project	2.16 M USD
	Notes on economic analysis	Because of the relatively high cost of refrigerants, strong regulations and economic incentives should exist to gradually replace the F-gases. Due to data limitations, it was not possible to account for the climate cost associated with the reduction of the total equivalent warming impacts.
	Abatement cost	7.59 USD/tCO_2 eq.

3.4.2 Indicator targets and reporting institutions

This section provides the implementation plan for fulfilling the mitigation actions that were recommended in the IPPU sector. It is worth noting that the mitigation implementation plans were adapted based on the updated NDC of Rwanda (2020) as well as its draft Measuring, Reporting and Verification framework (GoR, 2021). For each mitigation action, related indicators and targets are proposed.

Table 3.10 Indicator targets and reporting institutions for IPPU mitigation actions

Indicator	Reporting institution(s)	Mitigation action ID	Target for 2021-2030
- tonnes of pozzolana use - Clinker/cement ratio (%)	MINICOM NIRDA	I01 Clinker substitution: increased use of pozzolanas in cement	(i) Increasing the share of volcanic pozzolanas used within national cement production beyond the current cement-to-clinker ratio of 0.7, with a target for an incremental

Indicator	Reporting institution(s)	Mitigation action ID	Target for 2021-2030
			5 % substitution of clinker with pozzolana through 2030. (ii) To produce the cement of 50 % clinker ratio for non-structural application through 2030.
- Imported HFC (kg) - F-gas use (list the gases and amounts in kg) - F-gas substitution (%)	MINICOM NIRDA	I02 Gradual substitution of F-gases by less polluting substitutes	The ODS alternatives that were surveyed in Rwanda (2020) on the list of controlled substances as per Annex F of the Montreal Protocol should not exceed the following percentages (F-gases): (a) 2020 to 2024: 95%; (b) 2025 to 2028: 65%; (c) 2029 to 2033: 30%.

3.4.3 Progress on implementation of mitigation projects in the IPPU sector

The following section provides a summary of progress achieved to date and the planned next step for identified mitigation actions. In general, there are different ongoing efforts to develop policies, strategies, enabling environment, and reporting framework and build capacity in key institutions to implement most of the identified mitigation actions.

Table 3.11 Progress on implementation of the IPPU mitigation actions and planned next steps

ID	Mitigation measure	Progress achieved to date	Mitigation achieved	Planned next steps
I01	Clinker substitution: increased use of pozzolanas in cement	The activity was done but they are still some data collection problems	Not estimated	MINICOM will collect data on Pozzolana use (t) and Clinker/cement ratio to allow an accurate estimate of mitigation achieved.
I02	Gradual substitution of F-gases by less polluting substitutes	Rwanda has already ratified the Kigali amendment and has put in place different actions to curb HFCs including the development of the	Not estimated. Data for F-gas substitution (%) should be collected.	Through NDC MRV, MINICOM will report on related indicators. Other steps envisaged include developing a national action plan for phasing down HFCs consumption, which will

ID	Mitigation measure	Progress achieved to date	Mitigation achieved	Planned next steps
		cooling strategy (2019), and minimum energy efficiency standards. The survey for data collection has started.		include legislation, licensing system, and limitation of HFCs import into the country, targeted training and awareness-raising.

3.5 Agriculture, Forestry and Land Use (AFOLU) sector

3.5.1 Overview of mitigation actions in the AFOLU sector

Alternative scenarios for GHG emission projections were developed for mitigation options for the period 2020-2030 to quantify emissions reduction potential, associated cost and financial needs. A review of published literature was done to identify different mitigation technologies. The focus was made on the options, which were evaluated under similar agro-ecologies, or which have shown high mitigation potential. Within agriculture, among the potential options for mitigation are soil conservation measures. These include terracing, conservation tillage, multi-cropping and crop rotation practices. For livestock, an increase of productivity through an increase of crossbreeds and improved cows has the potential to reduce enteric fermentation if the cow population is controlled from expansion. In forestry and other land use, mainly agroforestry and forest landscape restoration projects were also considered because other potential mitigation projects are related to efficient use of forest and wood products, which were thought to be covered in other sectors such as IPPU and energy sectors. Harvested wood products need to be recorded on regular basis, as due to the lack of such data, this category was left from GHG emission inventory estimates.
The selection and proposal of potential mitigation activities for 2020-2030, gave priority to the options described in the Updated NDC for Rwanda document. The different selected and proposed mitigation actions are briefly described in **Table 3.12** and **Table 3.13**.

Table 3.12 Mitigation actions in agriculture

AFOLU/AGRICULTURE		
	ID	A01
Overview	Mitigation measure	Nutrient use efficiency (Compost production)
	Sector/gases	AFOLU/Agriculture; gas – CO_2
	Short description	The project aims to increase compost production and application with the target to achieve compost production and application on 220,000 ha at a rate of 5 tonnes/ha per year by 2030. This quantity

AFOLU/AGRICULTURE		
		may be achieved if about 367,000 rural households will produce about 3tonnes of compost per year.
	Objective	To provide an improved supply of organic nutrients and lead to reduced use of mineral fertilizers alone and increased carbon addition to soil.
	Status	Ongoing.
	Indicator	The amount of compost produced and the area where compost is applied.
	Implementing institution	RAB and Districts
	Timing of project	2020-2030
	Alignment to SDG	
	Related policy/program	PSTA-4; CIP/RAB
GHG mitigation	Mitigation effect	Increased compost application will increase C-stock in soil, especially where soils have been cultivated without fallow and rotation. The use of crop biomass for compost production will reduce the storage period for manure as it will be used for compost making and it will reduce emissions from manure management
	Estimated mitigation in 2030	0.312 Mt CO_2 eq.
	Total mitigation (2020-2030)	1.716 Mt CO_2 eq.
Cost-benefit analysis	Description of costs	Training, implementation and monitoring of composting units and compost application
	Description of benefits	Compost will supply nutrients and generate yield with reduced use of mineral fertilizers per unit area. Other benefits include reduced GHG emissions, improved soil physical structure; increased carbon in nutrient-depleted soils, and job creation (it can be done for CIP consolidated sites and cooperatives).
	Economic assessment period	Economic assessment of the effect of compost use would be done starting from year 2 and collecting regular data on the quantity of enriched compost applied, crop area and yield in key sites selected for monitoring.
	Discount rate	6%
	NPV of project	-3.191 M USD

AFOLU/AGRICULTURE		
	Notes on economic analysis	The increased production of compost will generate revenues from compost sales, and an economic study on improved crop productivity and return from the combined use of compost and mineral fertilizers would be conducted as part of project monitoring.
	Abatement cost (USD/tCO_2eq.)	-1.860 USD/tCO_2 eq.
	ID	A02
Overview	Mitigation measure	Nutrient use efficiency (Deep fertilizers/biomass management in rice)
	Sector/gases:	AFOLU/Agriculture; gas – CO_2; CH_4
	Target/progress indicator	All rice area with deep fertilizer and reduced biomass applied on rice by 2030/ Number of ha of rice with deep fertilizer placement and reduced by 1 tonne of biomass applied on rice
	Short description	The project focuses on improved biomass and fertilizer management in rice. The practice of reduced biomass application infield will be practised on the whole rice area and mineral fertilizers will be applied at deep placement, which will improve nutrient use from mineral fertilizers and reduce fertilizer quantities by 30 % while assuring same or better yield levels.
	Objective	To promote more efficient mineral fertilizer, use on rice along with practices leading to lesser emissions of methane from rice fields through the reduced application of rice biomass back to rice fields.
	Status	Planned but not started yet
	Indicator	Number of hectares where deep fertilizer placement and biomass management are applied
	Timing of project	2020-2030
	Alignment to SDG	
	Related policy/program	AgriTAG; Rwanda Agricultural Policy (2017, PSTA-4)
GHG mitigation	Mitigation effect	Deep fertilizer placement maintains or slightly increases yield with a 30 % reduction in mineral fertilizer use. Reduction of rice biomass applied back to rice fields strongly reduced methane emissions from rice field growing. Both technologies can be applied and complement their mitigation effect.
	Estimated mitigation in 2030	0.042Mt CO_2 eq.

AFOLU/AGRICULTURE		
	Total project mitigation (2020-2030)	0.352 Mt CO_2 eq.
Cost-benefit analysis	Description of costs	Training, implementation and monitoring of composting units and rice fields
	Description of benefits	Reduced organic amendment in form of rice biomass application in rice fields will reduce methane emissions; there will be reduced N_2O emissions, as mineral N-fertilizer use will be reduced to produce the same or better yields using deep fertilizer placement.
	Economic assessment period	Economic assessment of the effect of compost use would be done starting from year 2 and collecting regular data on the quantity of enriched compost applied, crop area and yield in key sites selected for monitoring.
	Discount rate	6%
	NPV of project	46.801 M USD
	Notes on economic analysis	The economic benefits of the project are calculated using the avoided costs of mineral fertilizer use (i.e., lesser mineral fertilizer quantities will be applied per unit area) for rice.
	Abatement cost	-121.294 USD/tCO_2 eq.
Overview	ID	A03
	Mitigation measure	Soil and water conservation (Terracing)
	Sector/gases	AFOLU/Agriculture; gas – CO_2
	Short description	The project targets to achieve terracing on 165,000 ha by 2030. Implementing agency NGOs, MINAGRI, and districts.
	Objective	The project will establish terracing which will result in better water conservation, a stable increase of soil C-stock, and thus, improved crop yields.
	Status	Ongoing, reported through MIS
	Indicator	Number of hectares under radical and progressive terraces
	Implementing institution	MINAGRI and RAB
	Timing of project	2020-2030
	Alignment to SGD	
	Related policy/programme	PSTA-4; Rwanda National Agricultural Policy (2017)

AFOLU/AGRICULTURE		
GHG mitigation	Mitigation effect)	Increased carbon supply to soil; reduced CO_2 emissions from bare soil
	Estimated mitigation in 2030	0.271 Mt CO_2 eq./year
	Total mitigation (2020-2030)	1.606 Mt CO_2 eq.
Cost-benefit analysis	Description of costs	Costs include terracing work.
	Description of benefits	The new terraces will reduce carbon loss from the soil with reduced erosion and improved crop yields; terracing preparation will provide employment for the rural community.
	Economic assessment period	Economic assessment of the effect of terracing on crop yields would be done after 5 years of terrace use.
	Discount rate	6%
	NPV of project	-134.639 M USD
	Notes on economic analysis	The economic benefits of the project are based on increased crop production after the application of the suggested mitigation options.
	Abatement costs	83.831 USD/tCO_2eq.
Overview	ID	A04
	Mitigation measure	Soil and water conservation (Crop rotation)
	Sector/gases	AFOLU/Agriculture; gas – CO_2
	Short description	The project targets to achieve 660,000 ha under crop rotation schemes by 2030.
	Objective	To expand and diversify crop rotation and introduce crop rotation schemes
	Status	Planned
	Indicator	Number of hectares under crop rotation
	Implementing institution	MINAGRI and districts
	Timing of project	2020-2030
	Alignment to SDG	
	Related policy/programme	PSTA-4, Rwanda Agricultural Strategy (2017), NDC (2020)
GHG mitigation	Mitigation effect	Reduction of N_2O emissions from reduced mineral N-fertilizer use per unit area as it will be used in combination with increased compost quantities and increased rotation with leguminous N-fixing crops.

AFOLU/AGRICULTURE		
	Estimated mitigation in 2030	0.551 Mt CO_2 eq./year
	Total mitigation (2020-2030)	3.028 Mt CO_2 eq.
Cost-benefit analysis	Description of costs	Costs include training, implementation and monitoring.
	Description of benefits	The introduction of regular crop rotation will increase N-fixation in soil; increase yields and biomass production; reduce pests and diseases.
	Economic assessment period	The economic assessment may be conducted in year 2.
	Discount rate	6%
	NPV of project	353.671 M USD
	Notes on economic analysis	The economic benefits of the project are based on increased crop production after the application of the suggested mitigation options.
	Abatement cost	-116.81 USD/tCO_2 eq.
Overview	ID	A05
	Mitigation measure	Soil and water conservation (Coffee-Banana intercropping)
	Sector/gases	AFOLU/Agriculture; gas – CO_2
	Short description	The project targets to introduce coffee into banana systems on 25,000ha by 2030. Implementing agency – NAEB and districts
	Objective	The project will provide training, technical support and follow up of the planned expansion targets of coffee-banana intercropping to sustainably improve soil and water conservation, which will result in a stable increase of soil C-stock, and thus, improved crop yields.
	Status	Planned
	Indicator	Number of ha of coffee-banana intercropping
	Implementing institution	NAEB and Districts
	Timing of project	2020-2030
	Alignment to SDG	
	Related policy/programmes	PSTA-4; AgriTAG; Green Growth and Climate Change Strategy
GHG mitigatio	Mitigation effect	Intercropping of coffee and banana will lead to increased C-fixation in biomass in coffee-banana systems. This will offset GHG emissions and keep more carbon in the soil, coffee and banana

AFOLU/AGRICULTURE		
		biomass, as well as accumulation of litter and increased addition of carbon in form of dead organic matter in the soil.
	Estimated mitigation in 2030	0.066 Mt CO_2 eq./year
	Total mitigation (2020-2030)	0.158 Mt $CO_{2\ eq.}$
Cost-benefit analysis	Description of costs	Costs include training, implementation and monitoring.
	Description of benefits	Coffee-banana intercropping will provide economy of space and improve the quality of coffee berries, increase soil carbon and carbon sequestration in banana and coffee biomass, reduce bare soil extent and reduce solar insolation with mulching as essential management practice contributing to soil moisture and increased C addition to soil.
	Economic assessment period	For Coffee-banana intercropping, the assessment would be conducted in year 8 when coffee tree yields have reached medium values and growth.
	Discount rate	6%
	NPV of project	4.988 M USD
	Notes on economic analysis	The economic benefits of the project are based on increased crop production after the application of the suggested mitigation options.
	Abatement costs	-31.475 USD/tCO_2 eq.
Overview	ID	A06
	Mitigation measure	Soil and water conservation (Conservation agriculture - zero tillage)
	Sector/gases	AFOLU/Agriculture; gas – CO_2
	Short description	Expand conservation tillage on 275,000ha by 2030. Implementing agency – RAB and Districts
	Objective	The project will provide training, technical support and follow up of the planned expansion targets of terracing, crop rotation, coffee-banana and conservation tillage options to sustainably improve soil and water conservation, which will result in a stable increase of soil C-stock, and thus, improved crop yields.
	Status	Planned
	Indicator	Number of ha with conservation tillage
	Implementing institution	MINAGRI and RAB
	Timing of project	2020-2030

AFOLU/AGRICULTURE		
	Alignment to SDG	
	Related policy/programmes	PSTA-4; Rwanda Agriculture policy (2017)
GHG mitigation	Mitigation effect	Reduced CO_2 emissions from bare soil, less N mineralization in soil, increased carbon in the soil, more soil biota in intact soil
	Estimated mitigation in 2050 ($MtCO_2eq./yr$)	0.411 Mt CO_2 eq.
	Total project mitigation ($MtCO_2e$)	7.371 Mt CO_2eq.
Cost-benefit analysis	Description of costs	Costs include training, implementation and monitoring.
	Description of benefits	Tillage will contribute to increased accumulation of carbon stock in soil and slowing down decomposition of soil organic matter happening with regular tillage. Other benefits include reduced GHG emissions from agricultural soils, the improved physical structure of soil
	Economic assessment period	An assessment study would be conducted five years after the beginning of the project. Yield and soil carbon change would be measures and impact recorded.
	Discount rate	6%
	NPV of project	77.919 M USD
	Notes on economic analysis	The economic benefits of the project are based on increased crop production after the application of the suggested mitigation options.
	Abatement costs	-65.987 USD/tCO_2 eq.
Overview	ID	A07
	Mitigation measure	Improved livestock husbandry (Fodder)
	Sector/gases	AFOLU/Livestock; gas – CH_4
	Target/progress indicator:	87,500 ha of fodder to feed 337,500 cows by 2030
	Short description	The target for the proposed project to improve livestock husbandry is to expand fodder species (e.g., Calliandra, Leucaena, Medicago and Brachiaria spp. For different agro-ecologies) using terrace edges and roadsides to reach 75,500 ha and use the production of improved

AFOLU/AGRICULTURE		
		fodder to feed 377,500 cows by 2030. Implementing agency – RAB and districts
	Objective	To support the establishment of improved fodder species and to follow up their expansion
	Status	Planned
	Indicator	Number of ha of improved fodder and number of cows fed with improved fodder
	Implementing institution	RAB and Districts
	Timing of project	2020-2030
	Alignment to SDG	
	Related policy/programme	Livestock Development Master plan (2017); PSTA-4.
GHG mitigation	Mitigation effect	An increase of soil carbon through the supply of organic matter through root underground biomass increased aboveground biomass produced per unit area and reduced soil losses due to erosion.
	Estimated mitigation in 2030	0.133 $MtCO_2$ eq./year
	Total mitigation (2020-2030)	0.626 $MtCO_2$ eq.
Cost-benefit analysis	Description of costs	Include planting material, establishment and monitoring of Brachiaria fields.
	Description of benefits	Fodder plants will increase soil carbon, provide quality nutrition for cows and goats thus increasing milk production and improved growth. Besides, planting them on roadsides and terrace edges will reduce soil erosion and runoff thus contributing to soil and water conservation.
	Economic assessment period	Economic assessment of the effect of fodder on improved milk production will be done after 3 years of collecting regular data on the use of improved fodder in livestock feed and its production per unit area
	Discount rate	6%
	NPV of project	-42.807 M USD
	Notes on economic analysis	The economic benefits of the project are calculated using the increased milk production resulting from improved fodder use.
	Abatement cost	68.372 USD/tCO_2 eq.

AFOLU/AGRICULTURE		
Overview	ID	A08
	Mitigation measure	Improved livestock species and population
	Sector/gases:	AFOLU/Livestock; gas – CH_4
	Target/progress indicator:	Replace 260,000 local cows with 130,000 crossbreeds by 2030/ Number of local cows removed, number of crossbreeds disseminated/survived artificial insemination
	Short description	The target for the project is to replace 260,000 local cows with 130,000 improved cows (pure and crossbreed) to achieve a reduction in enteric fermentation and increase cow productivity per head. Implementing agency – RAB and districts.
	Objective	The project will provide training, technical support, follow up of the planned replacement of local cows within the set target, and thus lead to reduced emissions from enteric fermentation.
	Status	Planned
	Indicator	Number of local cows removed; the number of crossbreeds disseminated/survived artificial insemination
	Implementing institution	RAB
	Timing of project	2020-2030
	Alignment to SDG	
	Related policy/programme	
GHG mitigation	Mitigation effect	The main mitigation effect will be through reduction of emissions from enteric fermentation from a reduced number of cows while maintaining and improving the production of milk
	Estimated mitigation in 2030	0.126 $MtCO_2$ eq./year
	Total mitigation (2020-2030)	2.034 $MtCO_2$ eq.
Cost-benefit analysis	Description of costs	Costs are estimated in USD and include training, cost of improved cows, compensation for local cow replacement and monitoring
	Description of benefits	Higher milk production will be achieved with a lower population of cows and lower emissions from enteric fermentation

AFOLU/AGRICULTURE		
	Economic assessment period	Economic assessment of the effect of cow replacement would be done after 4-5 years when the project will achieve the target partially and the cow population will be at the milking stage.
	Discount rate	6%
	NPV of project	-166.364 M USD
	Notes on economic analysis	The economic benefits of the project are calculated using the sales of milk and manure from improved cows.
	Abatement cost	160.953 USD/tCO_2eq.
Overview	ID	A09
	Mitigation measure	Improved manure management
	Sector/gases	AFOLU/Livestock; gas – N_2O; CH_4
	Short description	The target for the project is to promote collective cow keeping and kraals with improved manure management facilities (1,100 new kraals) achieve improved manure management in existing farms targeting 550,000 cows and 550,000 goats with more frequent manure removal; use of manure covering and straw for manure storage, and promotion of slurry systems.
	Objective	To expand the application of improved manure management practices
	Status	Planned
	Indicator	Number of collective farms, number of improved manure storage systems
	Implementing institution	RAB
	Timing of project	2020-2030
	Alignment to SDG	
	Related policy/programme	PSTA-4; Green Growth Climate Change Strategy
GHG mitigation	Mitigation effect	GHG emissions will be reduced with promotion and expansion of coverage of manure, using higher straw quantity in stored manure and by covering manure during storage, and promotion of slurry systems.
	Estimated mitigation in 2030	0.064 MtCO_2 eq.
	Total mitigation (2020-2030)	0.384 MtCO_2eq.

AFOLU/AGRICULTURE		
Cost-benefit analysis	Description of costs	Costs are estimated in USD and include training, construction of improved manure storage facilities and monitoring.
	Description of benefits	The proposed improved manure management options will result in generating a better quality of manure with higher nutrients, especially nitrogen. Since the losses will be reduced, manure yield in terms of quantities will also be increased.
	Economic assessment period	Economic assessment of the project would be done from year 4 after collecting regular data on the quantity and quality of manure
	Discount rate	6%
	NPV of project	2.534 M USD
	Notes on economic analysis	The economic benefits of the project were calculated considering the sales of manure and milt from the cows in new kraals with a slurry system.
	Abatement cost	-6.592 USD/TCO_2eq.

Table 3.13 Mitigation actions in forestry

AFOLU/FORESTRY		
Overview	ID	F01
	Mitigation measure	Agroforestry for fruits
	Sector/gases	AFOLU/Forestry; gas – CO_2
	Short description	The target for the project is to expand the new fruit area to 100,000ha.
	Objective	To promote fruit trees on the farm
	Status	Planned
	Indicator	Number of ha planted per each species
	Implementing institution	RFA, NAEB and Districts
	Timing of project	2020-2030
	Alignment to SDG	
	Related policy/programme	New Agroforestry strategy 2018-2024; PSTA 4; Green Growth and Climate Resilience strategy 2011
GHG mitigatio	Mitigation effect	The project will lead to GHG mitigation offset via accumulation of carbon in tree biomass and soil due to reduced erosion, accumulation of organic matter from litter and tree roots

AFOLU/FORESTRY		
	Estimated mitigation in 2030	0.470 Mt CO_2 eq./year
	Total mitigation (2020-2030)	2.784 MtCO_2 eq.
Cost-benefit analysis	Description of costs	The estimated cost in USD includes the training, seedling production and tree planting, and follow up.
	Description of benefits	Fruit trees will increase carbon stock in soil, provide nutrients via nitrogen fixation, improve soil quality, increase agriculture production, reduce erosion, provide fuelwood, stalks for climbing beans and fodder, produce high market value fruits and nuts.
	Economic assessment period	Economic assessment of agroforestry components will be done after 8 years when trees are established. An increase in yields may be expected after trees are well established.
	Discount rate	6%
	NPV of project	2.534 M USD
	Notes on economic analysis	The full economic benefits of the project would be seen after trees grow to maturity (after 2030).
	Abatement cost	-42.726 USD/tCO_2 eq.
Overview	ID	F02
	Mitigation measure	Afforestation (Protective forests on slopes)
	Sector/gases	AFOLU/Forestry; gas – CO_2
	Short description	The project will focus on the production and planting of trees in areas identified for protection as degraded lands, steep slopes, and prone to flooding (a total of 42,440 ha) in rural areas with Eucalyptus, Pinus and Alnus spp.
	Objective	To increase trees/forest on steep slopes.
	Status	Planned and being already implemented through various ongoing projects with similar targets but started before NDC approval.
	Indicator	Number of ha of trees planted per each species
	Implementing institution	RFA
	Timing of project	2020-2030
	Alignment to SDG	
	Related policy/programme	Forest Investment Policy, Green Growth and Climate Resilience to Climate Change Policy; Forestry sector strategic plan

AFOLU/FORESTRY		
GHG mitigation	Mitigation effect	Significant C sink will be produced and this will offset GHG emission through increasing C storage in tree biomass and soil.
	Estimated mitigation in 2030	0.348 $MtCO_2$ eq.
	Total project mitigation	1.045 $MtCO_2$ eq.
Cost-benefit analysis	Description of costs	Costs are estimated in USD
	Description of benefits	The newly planted forests will generate sinks, protect soil from erosion or floods, some landslides, produce wood and firewood.
	Economic assessment period	The economic assessment of this project would be done after 15-20 years through assessment of ecosystem services and health benefits for urban citizens as urban forests are not supposed for producing wood and firewood products.
	Discount rate	6%
	NPV of project	-13.935 M USD
	Notes on economic analysis	The main economic benefit from newly planted forests will come after 2030 for the greater part of the emission reduction, wood harvest, and firewood source.
	Abatement cost	13.336 USD/tCO_2 eq.
Overview	ID	F03
	Mitigation measure	Afforestation (Urban forests)
	Sector/gases	AFOLU/Forestry; gas – CO_2
	Short description	The project will plant 2,100 ha as urban forests in Kigali City. The project recommends indigenous trees and bamboo spp. For urban forests, the strategy will be using multiple species mix as an option of higher ecological productivity.
	Objective	To increase the area under urban forests and parks
	Status	Planned
	Indicator	Number of ha of trees planted per each species
	Implementing institution	RFA
	Timing of project	2020-2030
	Alignment with SDG	

AFOLU/FORESTRY		
	Related policy/programme	Forest Investment Policy, Green Growth and Climate Resilience to Climate Change Policy, Forestry sector strategic plan
GHG mitigation	Mitigation effect	Significant C sink will be produced and this will offset GHG emission through increasing C storage in tree biomass and soil.
	Estimated mitigation in 2030	0.004 $MtCO_2$ eq.
	Total mitigation (2020-2030)	0.015 $MtCO_2$eq.
Cost-benefit analysis	Description of costs	Costs are estimated in USD
	Description of benefits	The newly planted forests will generate sinks, protect soil from erosion or floods, some landslides, produce wood and firewood.
	Economic assessment period	The economic assessment of this project would be done after 15-20 years through assessment of ecosystem services and health benefits for urban citizens as urban forests are not supposed for producing wood and firewood products.
	Discount rate	6%
	NPV of project	-1.029 M USD
	Notes on economic analysis	The main economic benefits from newly planted urban forests will be health benefits for urban citizens, as these forests will not produce firewood and will only serve recreational and conservation purposes.
	Abatement cost	70.963 USD/tCO_2 eq.
Overview	ID	F04
	Mitigation measure	Sustainable forest and landscape management
	Sector/gases	AFOLU/Forestry; gas – CO_2
	Short description	The project will focus on the production and planting of trees (indigenous and bamboo species) in areas identified as wetland perimeters and riparian buffer forests zones (80,100 ha). The implementing agency would be RFA.
	Objective	To increase indigenous and bamboo tree planting
	Status	Planned and being already implemented through various ongoing projects with similar targets but started before NDC approval.
	Indicator	Number of ha of trees planted per each species
	Implementing institution	RFA

AFOLU/FORESTRY		
	Timing of project	2020-2030
	Alignment to SDG	
	Related policy/programme	Rwanda National Forestry Policy (2018); NST 1, Forest Investment Policy, Green Growth and Climate Resilience to Climate Change Policy
GHG mitigation	Mitigation effect	Production of sinks that will offset CO_2 emissions in tree biomass and soil.
	Estimated mitigation in 2030	0.596 Mt CO_2 eq./year
	Total mitigation (2020-2030)	2.349 Mt CO_2 eq.
Cost-benefit analysis	Description of costs	Costs are estimated in USD
	Description of benefits	The newly planted forests will generate sinks, protect soil from erosion or floods, some landslides, produce wood and firewood.
	Economic assessment period	The economic assessment of this project would be done after 20 years period when wood and firewood products will be harvested.
	Discount rate	6%
	NPV of project	-1.029 M USD
	Notes on economic analysis	The main economic benefit from newly planted forests will come after 2030 for the greater part of the emission reduction, wood harvest, and firewood source.
	Abatement cost	13.345 USD/CO_2 eq.

3.5.2 Indicator targets and reporting institutions

This section provides the implementation plan for fulfilling the mitigation actions that were recommended in the AFOLU sector. It is worth noting that the mitigation implementation plans were adapted based on the updated NDC of Rwanda (2020) as well as its draft Measuring, Reporting and Verification framework (Republic of Rwanda, 2021) For each mitigation action, related indicators and targets are proposed.

Indicator	Reporting institution(s)	Mitigation action ID	Target for 2021-2030
Number of tonnes compost produced and number of ha where compost is applied	MINAGRI	A01	The project aims to increase compost production and application with the target to achieve compost production and application on 220,000 ha at a rate of 5 tons/ha per year by 2030. This quantity may be achieved if about 367,000 rural households will produce about 3tonnes of compost per year.
Number of hectares where deep fertilizer placement and biomass management are applied	MINAGRI	A02	The project is focused on improved biomass and fertilizer management in rice on the whole rice area, with the target for rice, the practice of reduced biomass application infield will be practised on the whole rice area, and mineral fertilizers will be applied at deep placement, which will improve nutrient use from mineral fertilizers and reduce fertilizer quantities by 30 % while assuring same or better yield levels.
Number of hectares under radical and progressive terraces	MINAGRI	A03	The project targets to achieve terracing on 165,000 ha by 2030. Implementing agency NGOs and MINAGRI and districts.
Number of hectares under crop rotation	MINAGRI	A04	The project targets to achieve 660,000 ha under crop rotation schemes by 2030.
Number of ha of coffee-banana intercropping	NAEB	A05	The project targets to introduce coffee into banana systems on 25,000ha by 2030. Implementing agency – NAEB and districts
Number of hectares under conservation tillage	MINAGRI/ RAB	A06	Expand conservation tillage on 275,000ha by 2030. Implementing agency – RAB and Districts, MINAGRI
Number of ha of improved fodder and	MINAGRI/ RAB	A07	87,500 ha of fodder to feed 337,500 cows by 2030

Indicator	Reporting institution(s)	Mitigation action ID	Target for 2021-2030
number of cows fed with improved fodder			
Number of local cows removed; the number of crossbreeds disseminated/survived artificial insemination	MINAGRI/ RAB	A08	Replace 260,000 local cows with 130,000 crossbreeds by 2030/ Number of local cows removed, number of crossbreeds disseminated/survived artificial insemination
Number of collective farms, number of improved manure storage systems	MINAGRI	A09	The target for the project is to promote collective cow keeping and kraals with improved manure management facilities (1,100 new kraals) achieve improved manure management in existing farms targeting 550,000 cows and 550,000 goats with more frequent manure removal; use of manure covering and straw for manure storage, and promotion of slurry systems.
Number of ha planted per each species	NAEB	F01	The target for the project is to expand the new fruit area to 100,000ha by 2030.
Number of ha of trees planted per each species	RFA	F02	The project will focus on the production and planting of trees in areas identified for protection as degraded lands, steep slopes, and prone to flooding (a total of 42,440 ha) in rural areas with Eucalyptus, Pinus and Alnus spp.
Number of ha of trees planted per each species	Kigali City	F03	The project will plant 2,100 ha as urban forests in Kigali City. The project recommends indigenous trees and bamboo spp. For urban forests, the strategy will be using multiple species mix as an option of higher ecological productivity.

Indicator	Reporting institution(s)	Mitigation action ID	Target for 2021-2030
Number of ha of trees planted per each species	RFA	F04	The project will focus on the production and planting of trees (indigenous and bamboo species) in areas identified as wetland perimeters and riparian buffer forests zones (80,100 ha).

3.5.3 Progress on implementation of mitigation projects in the AFOLU sector

According to Rwanda's Updated NDC, the implementation of selected mitigation projects will oversee the governmental institutions for unconditional projects. Additionally, the achievements from the externally funded projects will be evaluated for mitigation effect. The Updated NDC targets were approved by the Government of Rwanda in May 2020. Since then, some work is going on to develop Monitoring, Evaluation and Reporting mechanisms (the MRVs) and has not been completed so far (CAEP and World Bank ongoing work under Ministry of Environment). This is of particular importance, that the different institutions implementing activities with mitigation effect start to be assigned officially for the monitoring and reporting on the progress of these activities officially for tracking the progress of the Rwanda Updated NDC. Some of the mitigation projects in the Updated NDC are new and have not been reported so far within the existing monitoring and reporting framework. For example, the coffee-banana intercropping experiment conducted during the past four years by RAB in collaboration with NAEB has demonstrated an increase in yield per unit area for both crops, bigger coffee berries and superior cup quality of shaded coffee. However, no guidelines were given to farmers to authorise banana planting into existing or new coffee plantations or coffee into existing banana plantations, however, NAEB has recognized all the economic and environmental benefits of banana-coffee intercropping and this option has been approved by MINAGRI and included in the NDC. Therefore, for this option, coffee-banana intercropping must be included in NAEB recommendations for coffee expansion and progress to be incorporated into the reporting of NAEB targets to MIS at MINAGRI. Reduced tillage, cow replacement and manure management projects are other innovative options, which were not previously considered by the existing plans and targets but can be adapted for reporting from the existing activities. However, this will require adequate communication between MoE, REMA and MINAGRI to adjust the existing targets and reporting framework to the Updated NDC, and thus agree on an appropriate MRV mechanism to be agreed by the implementing institutions. Therefore, it seems too early to report on the existing MRV as they have not been adapted to the recently approved Updated NDC. However, we attempted to give an overview of the current situation with mitigation projects as at least some of them (e.g., terracing) are being implemented and well-reported but were not included in earlier mitigation assessments (e.g., in Third National Communication).

A review of progress on implementation of recent projects with mitigation impact in AFOLU is provided in **Table 3.14**. The Forestry mitigation options are presented separately in and **Table 3.15** as there is currently a lack of information on progress and targets.

Table 3.14 Progress on implementation of the Agriculture mitigation actions

ID	Mitigation measure	Progress achieved to date	Mitigation achieved	Planned next steps
A01	Nutrient use efficiency: Composting	There was a lack of data for compost production for 2015-2018. Data for compost are collected by Districts and captured in MIS since 2019.	-	Data on compost production are planned to be captured in MIS /MINAGRI from 2018-2019 based on reports from Districts
A02	Nutrient use efficiency: Deep fertilizer & biomass mgt in rice	This is a new activity, no data was collected.	-	Harmonize data collection and include it in MIS
A03	Soil conservation: Terracing	New terraces: 2014-15=19,068.1ha 2015/16=3,904.5ha 2016-17-7,123.6ha 2017-2018=17,029ha	51,624.3 tonnes CO_2 eq.	Data on the area under radical and progressive terraces established will be taken annually at the district level and reported to MIS/MINAGRI. C increase in soil on terraces=195kg/ha per year. **2014-15: =40,938.2tCO_2eq** =19,068.1x0.195tCx3yrs=11,154.8 tonnes C x 3.67=40,938.2CO_2-eq.; **2015-2016: =5,588.5tCO_2eq.** =3,904.5x0.195tCx2yrs; **2016-2017: =5,097.6tCO_2eq.** =7,123.6x0.195x1yrx3.67 **For 2017-2018-no effect yet.**
A04	Soil conservation: Crop rotation	According to CIP seasonal reports on land consolidation, approximately half of	-	Indicators (area under crop rotation) should be introduced by MINAGRI and reported by districts via RAB compilation. RAB is to develop crop

ID	Mitigation measure	Progress achieved to date	Mitigation achieved	Planned next steps
		land, about 300,000ha under annual crops is with 2 crops rotation scheme		rotation schemes per district. No published data available for crop rotation so far.
A05	Soil conservation: *Banana-Coffee intercropping*	Research trial completed in Kirehe, Bicumbi and Nyamasheke.	-	New activity awaiting approval by NAEB. Need to include indicators (area of banana-coffee intercropped) in MIS.
A06	Soil conservation: Conservation tillage	5 ha under research trials on- in 2017-2018(SIMLESA project)	3.6 tonnes CO_2 eq.	New activity. Indicators (area under conservation tillage) should be introduced by MINAGRI and reported by districts via RAB compilation.
A07	Improved livestock husbandry: Fodder	New activity but with fragmented data in project reports. 5ha fodder established at Muhanga	1.21 tonnes CO_2 eq.	New activity. Indicators (area under fodder) should be introduced by MINAGRI and reported by districts via RAB compilation.
A08	Improved livestock: Cow replacement	Activity did but data collection problems.	Not estimated	New activity included in Updated NDC for Rwanda; No data was recorded in MIS/ MINAGRI; Need to harmonize data collection within the existing activities It is planned to authorize and officially request that these data are collected.
A09	Improved manure management	New activity	Not estimated	New activity

Table 3.15 Progress on implementation of some forestry projects with mitigation effect

ID	Mitigation measure	Progress achieved to date	Mitigation achieved	Planned next steps
F01	Agroforestry for fruits	Fruit tree planting is done annually by NAEB but data is not captured.	-	NAEB develops fruit tree planting within its annual action plan. Data on the area planted per species needs to be included in MIS/MINAGRI.
F02	Afforestation: Protective forests on slopes			
	Landscape Approach to Forest Restoration and Conservation in Gishwati-Mukura landscape (LAFREC)/2014-2020	Achieved: Forest restoration on 2500 ha	32,530.8 tonnes CO_2 eq.	The Project is ending in 2020. =2,500x3yrsx3m^3/yrx0.66x0.47x1.27
	6. FMBE project/ENABEL, 2016-2020	4,882 ha new forest planted	14,116.9tonnes CO_2 eq.	The project ended in 2020. =4,882x1yrx2m^3x0.66x0.47x1.27x3.67
F03	Afforestation: Urban forests	New project. Tree planting is done by Kigali City but data is not collected to be captured at RFA or MoE	-	Need to develop data collection and reporting under NDC
F04	Sustainable forest management			
	Forest Landscape Restoration-IUCN (2016-2018)	6,953ha agroforestry planted; 218ha new	20,105.4tonnes CO_2 eq.	The project ended in 2018. =6,953x1yrx2m^3x0.66x0.47x1.27x3.67

ID	Mitigation measure	Progress achieved to date	Mitigation achieved	Planned next steps
		woodlots planted; 1051ha forest rehabilitated; 64ha protective forests planted		
	Landscape Restoration and Integrated Water Resources Management in Sebeya and other Catchments /Netherlands	Project to start in 2019.	-	Landscape restoration activities and tree planting are planned in the Sebeya catchment.
	Green Gicumbi project – Sustainable forest management and sustainable energy/2019-2025	Achieved: 1375 ha agroforestry, 50 ha of Protective forestry, 1250 ha of forest rehabilitated	-	The project plans to expand on protective forestry, promote agroforestry and rehabilitate the existing forest resources in the targeted sectors of the Gicumbi district.
	Green Mayaga Forest Landscape Restoration project/Started in 2020	Area for forest plantation identified, tree nurseries established	-	The Project targets to plant 555 ha to restore natural forest, as well to restore 263,270 ha of agricultural lands; and to plant 1000 ha forest plantation. The projected mitigation would be 4,701 Gg CO_2 eq. by 2025
	Rwanda Sustainable Woodland	300 ha natural forests	8,096.5 tonnes CO_2 eq.	The Project ended. Rehabilitated forest estimated annual increment 3m^3/ha per year; new

ID	Mitigation measure	Progress achieved to date	Mitigation achieved	Planned next steps
	Management and Natural Forest Restoration (PAGReF project)/2011-2015	restored; 2,500 ha new private woodlots planted; 2,700 ha rehabilitated public forest plantations		forests annual increment 7t/ha, same for annual forest. Mitigation in 2015: 2,500+300 = 2,800ha*2yrs*1.27*0.47*0.66*3.67
	Farmers Managed Natural Regeneration/ 2012-2017	47ha agroforestry established	135.9 tonnes CO_2 eq.	The Project ended =47x2x0.66x1.27x0.47x3.67
	Sustainable forestry, agroforestry and biomass energy management for climate resilience in Gatsibo District (DFNC project)	500 ha rehabilitated forest	1,445.8 tonnes CO_2 eq.	The Project ended 2015: 500hax2t/hax0.66x0.47x1.27x3.67
	Management (agroforestry) of terrestrial ecosystems and forest resources (DFNC Annual action plan)/2015-2016	8,157 ha rehabilitated forest; 46,200 ha agroforestry planted	57,708.1 tonnes CO_2 eq.	The Project ended. =8,157x2x1.27x0.47x0.66x3.67=23,587 tonnes CO_2eq. 47,200x0.5x1yrx1.27x0.66x0.47x3.67=34,121.1 tonnes CO_2eq.

3.6 Waste sector

3.6.1 Overview of mitigation actions in the Waste sector

An overview description of the selected projects in the Waste sector and related GHG mitigation potential, as well as cost-benefit analysis, is presented in **Table 3.16** through **Table 3.18** for four projects, i.e., Landfill gas utilization, Waste to Energy (WtE) plants (W02), Aerobic biological treatment (composting), and Wastewater treatment and reuse.

Table 3.16 Mitigation assessment in the solid waste disposal

WASTE/ LANDFILL GAS UTILIZATION		
Overview	ID	W01
	Mitigation measure	Landfill gas utilization
	Sector/gases	Solid waste disposal / CH_4
	Short description	Generation of electric power from landfill gas (LFG) collection and their burning applied to sanitary landfills. The project also will improve solid waste collection in urban areas. Approximately 86 % of primary energy in Rwanda comes from biomass, in the form of firewood (57%) and charcoal, together with smaller amounts of crop residues and peat (6%). Thus, LFG will provide alternative renewable energy by capturing a large portion of CH_4 and oxidizes it in combustion.
	Objective	The objective of the project includes Landfill sites preparation, waste sorting, landfill gas (methane) generation estimate, landfill gas collection and utilization options, and financial income generation and other government support programmes (awareness, training, subsidies).
	Status	Planned
	Indicator	- # Sites with LFG capture - LFG generation (MW)
	Implementing institution	MININFRA, CoK, WASAC, RURA
	Timing of project	2021-2030
	Alignment to SDG	
	Related policy/ programme	In line with the National Sanitation Policy (2016), Rwanda National Environment and Climate Change Policy (2019), NAMA (2015) and NST 1 (2017-2024) objectives

WASTE/ LANDFILL GAS UTILIZATION		
GHG mitigation	Mitigation effect	Reduction of methane (CH_4) emissions from landfill sites and avoided Carbon Dioxide (CO_2) from the displacement of fossil-based electricity use. The use of methane landfill gas will reduce methane emissions from 30 % to 60 % between 2021 and 2030.
	Estimated mitigation in 2030	0.34 Mt CO_2 eq.
	Total mitigation (2021-2035)	4.16 Mt CO_2 eq.
Cost-benefit analysis	Description of costs	Investment for LFG Plants of 6 MW and improved landfills is estimated at 28 million USD. The electricity generation capacity of 3 MWh is estimated from the very beginning of the project from 2021 to 2025 and 6 MWh from 2026 to 2030. The capital costs will be involved in purchasing materials, design and construction of landfill gas collection system and landfill gas cleaning and treatment system. Operating costs will be focused on landfill gas flaring system, gas storage and compression system, and in LFG utilization system as fuel (estimated at around 9 million USD through 2035).
	Description of benefits	Quantified: Avoided cost of fuel from biomass, the compensation cost of electricity demand, revenue from the utilization of landfill gas, and generated additional financial income for the landfill site operations (estimated at over 80 million USD through 2030). Not quantified: job creation, welfare improvements, and reduced workload for rural households, health benefits, improved air, water and soil quality, reduction of leachate and improvement of on-site conditions.
	Economic assessment period	15 years from the starting of the project
	Discount rate	6%
	NPV of project	49.44 M USD
	Notes on economic analysis	It is assumed that this project will boost employment opportunities, activating or creating new jobs. Landfill gas Utilization will meet and contribute to electricity demand and avoided costs of electricity in Rwanda and this will harness economic growth within the country.
	Abatement cost (USD/tCO_2e)	-11.87 USD/tCO_2 eq.
Ov	ID	W02

WASTE/ LANDFILL GAS UTILIZATION		
	Mitigation measure	Waste to Energy (WtE) plants
	Sector/gases	Solid waste disposal / CH_4
	Short description	This project seeks to implement national strategies to recover energy from waste by conversion of non-recyclable waste materials into usable heat or electricity through different processes. The WtE plants will only consider the conversion of non-recyclable waste material from an urban area into usable energy. The WtE plant should have a capacity of processing up to 800 tonnes of solid waste per day and shall be able to generate a power capacity of 15 MW per hour by 2021, which will increase to 30 MW from 2025 to 2030.
	Objective	The project will implement and establish a WtE plant for the collection of all wastes for disposal and their transformation into energy by incinerating all wastes, thus preventing future emissions from the same waste.
	Status	Planned
	Indicator	- # WtE sites - WtE generation (MW)
	Implementing institution	MININFRA, CoK, WASAC, RURA
	Timing of project	2021-2030
	Alignment to SDG	
	Related policy/ programme	In line with the National Sanitation Policy (2016), Rwanda National Environment and Climate Change Policy (2019), NAMA (2015) and NST 1 (2017-2024) objectives.
GHG mitigation	Mitigation effect	Reduction of methane (CH_4) emissions from landfill sites and avoided Carbon Dioxide (CO_2) from the displacement of fossil-based electricity use.
	Estimated mitigation in 2030	0.41 Mt CO_2 eq.
	Total mitigation (2021-2035)	5.17 Mt CO_2 eq.
Cost-	Description of costs	Assumes investment for WtE plant in an urban area with the capacity of 800 tonnes of solid waste per day and 15 MW of electricity

WASTE/ LANDFILL GAS UTILIZATION		
		generation with an estimated investment cost of 161 million USD per plant, and other government support programmes and maintenance costs estimated to total around 8 million USD per year.
	Description of benefits	Quantified: WtE electricity generation will translate into revenues per year for job creation and economic growth, estimated at up to around 50 million USD per year. Not quantified: job creation, improved quality of the environment, electricity generation, GHG reduction, high public awareness about the efficacy and potency of renewable energy technologies.
	Economic assessment period	15 years from the starting of the project
	Discount rate	6%
	NPV of project	135.68 M USD
	Notes on economic analysis	With the increase of urbanization and improvement of living standards, waste to energy projects will provide job opportunities, respond to electricity demand and increase the GDP by ensuring access to affordable and clean energy.
	Abatement cost (USD/tCO_2e)	-26.24 USD/tCO_2 eq.

Table 3.17 Mitigation actions in Biological Treatment of Solid Waste

WASTE/AEROBIC BIOLOGICAL TREATMENT (COMPOSTING)		
Overview	ID	W03
	Mitigation measure	Aerobic biological treatment (composting)
	Sector/gases	Biological Treatment of Solid Waste / CH_4 and N_2O
	Short description	The project implements the windrow composting method at the household level. Organic waste is placed into rows of long piles called windrows and aerated by turning the pile periodically by either manual or mechanical methods. Usually, a height of 1.2-2.4 m allows oxygen to flow to the windrow's core.
	Objective	The project envisages the recovery and reuse of organic waste by neighbouring households, i.e., village/umudugudu to restore and maintain soil fertility. The project will be implemented in rural households where solid waste is typically collected into small pits for composting.

WASTE/AEROBIC BIOLOGICAL TREATMENT (COMPOSTING)		
	Status	Planned
	Indicator	- Amount produced (t) - Composting rate (% organic waste composted)
	Implementing institution	MINAGRI, MININFRA, CoK, WASAC, RURA
	Timing of project	2021-2030
	Alignment to SDG	
	Related policy/ programme	In line with the National Sanitation Policy (2016), Rwanda National Environment and Climate Change Policy (2019), NAMA (2015) and NST 1 (2017-2024) objectives.
GHG mitigation	Mitigation effect	The aerobic process of composting does not generate methane because methane-producing microbes are not active in the presence of oxygen (i.e., methane avoidance).
	Estimated mitigation in 2030	0.04 Mt CO_2 eq.
	Total mitigation (2021-2035)	0.43 Mt CO_2 eq.
Cost-benefit analysis	Description of costs	At the community level, composting offers an attractive economic advantage because the existing land area for composting will be used. The major cost is labour cost collecting and turning the pile periodically. Labour costs can be reduced by the proximity of households involved in the projects. The assessment assumes a capacity-building needs and programs implementation cost of 5 million USD and annual costs of up to 6 million USD based on a unit labour cost assumption of 20 USD/tonne compost.
	Description of benefits	Composting requires relatively simple and scalable technology. In addition to methane gas emissions reduction, composting offers numerous other climate change adaptation co-benefits such as: improving retention of soil fertilizer, reducing compostable waste, enhancing soil buffering capacity and moisture-holding capacity, adding a source of organic matter that stimulates biological activity, improving the pool of nutrients, adding a liming effect on the soil, soil structure improvement. Compost sales of up to 7 million USD per year are estimated based on the unit price assumption of 22 USD/tonne.

WASTE/AEROBIC BIOLOGICAL TREATMENT (COMPOSTING)		
	Economic assessment period	15 years from the starting of the project
	Discount rate	6%
	NPV of project	3.44 M USD
	Notes on economic analysis	Considering the economic and technological context of Rwanda and the country waste management approach in rural areas, windrow composting is seen as a viable option at the household level. Due to the lack of data, benefits such as reduced import of fertilisers and increased agriculture yield were not included in the analysis.
	Abatement cost (USD/tCO_2e)	8.07 USD/tCO_2 eq.

Table 3.18 Mitigation assessment in Wastewater Treatment and reuse

WASTE/ WASTEWATER TREATMENT AND REUSE		
Overview	ID	W04
	Mitigation measure	Wastewater treatment and reuse
	Sector/gases	Wastewater Treatment and Discharge / CH_4 and N_2O
	Short description	The proposed project will involve the construction of a sewerage network and wastewater treatment plant (WWTP). The planned projects include: (i) Kigali central WWTP in Nyarugenge and (ii) the Centralized Sewerage System for Kibagabaga and Kinyinya Catchments in Gasabo District, etc. In addition, there are other initiatives of semi-centralized wastewater treatment systems in Kigali.
	Objective	In the short term, treating wastewater is the priority while in the long run, reuse of the treated water is targeted to address increasing water scarcity, and increase drought resilience as well as restoring and maintaining soil fertility.
	Status	Planned
	Indicator	- # WWTP facilities - # Households connected to WWTP
	Implementing institution	MININFRA, CoK, WASAC, RURA
	Timing of project	2024-2030

WASTE/ WASTEWATER TREATMENT AND REUSE		
	Alignment to SDG	
	Related policy/ programme	In line with the National Sanitation Policy (2016), Rwanda National Environment and Climate Change Policy (2019), NAMA (2015) and NST 1 (2017-2024) objectives.
GHG mitigation	Mitigation effect	Reduction of methane (CH_4) and Nitrogen oxide (N_2O) emissions from wastewater and providing a nutrient-rich digestate that can be used as a fertilizer.
	Estimated mitigation in 2030	0.02 Mt CO_2 eq.
	Total mitigation (2021-2040)	0.33 Mt CO_2 eq.
Cost-benefit analysis	Description of costs	Capital costs of 89 million USD per 1 WWTP (178 million USD in total for 2 plants) were estimated based on the project of the Kigali central wastewater treatment plant. Capital costs will cover the consolidation of basic infrastructures in terms of collection of sewage and operational costs and other costs will be attributed to the functioning of the wastewater treatment plant. O&M costs are estimated at around 1.5 million USD per year in total.
	Description of benefits	Quantified: The project has benefits of reduced costs of on-site treatment and emptying of pits/septic tanks. Other benefits include job creation, increased tourism due to cleanliness, increased agriculture production due to wastewater reuse, reduced water footprint, and groundwater recharge (estimated to total around 32 million USD per year). Not quantified: Quantifying the economic benefits of improved river water quality and health is a complex task, which would require a collection of substantial amounts of data that is beyond the scope of this project.
	Economic assessment period	20 years from the starting of the project
	Discount rate	6%
	NPV of project	36.72 M USD
	Notes on economic analysis	The project will boost employment opportunities and creating new jobs. The project will promote cost savings from wastewater reuse and will

WASTE/ WASTEWATER TREATMENT AND REUSE		
		save the costs related to environmental decontamination and health diseases previously due to wastewater discharge.
	Abatement cost (USD/tCO_2e)	112.94 USD/tCO_2 eq.

3.6.2 Indicator targets and reporting institutions

The following sections provide the implementation plan for fulfilling the mitigation actions that were recommended. It is worth noting that the mitigation implementation plans were adapted based on the updated NDC of Rwanda (2020) as well as its draft Measuring, Reporting and Verification framework (GoR, 2020). For each mitigation action, related indicators and targets are proposed. The indicated Ministries will not necessarily collect the relevant data but in some cases, data are collected by their affiliated institutions. In addition, it should be noted that in January 2021 Rwanda's cabinet approved a Ministerial Order 005/2021 of April 8, 2021, relating to the National Report on Climate Change. The Ministerial Order, among others, determines the procedures of preparing the national reports on climate change the responsibilities of the organs involved in the data collection and reporting on, *inter alia*, the GHG inventory, mitigation, adaptation, and projections.

Table 3.19 Indicator targets and reporting institutions for waste mitigation actions

Indicator	Reporting institution(s)	Mitigation action ID	Target for 2021-2030
- # sites with LFG capture - LFG generation (MW)	MININFRA, CoK, WASAC, RURA	W01 Landfill gas utilization	Extraction and utilization of landfill gas (LFG) for power generation in connection to semi- or fully-controlled landfills for urban areas. Electricity generation capacity of 3 MWh for the period 2021 to 2025 and 6 MWh from 2026 to 2030.
- # WtE sites - WtE generation (MW)	MININFRA, CoK, WASAC, RURA	W02 Waste to Energy (WtE) plants	The WtE plant processing up to 800 tonnes of solid waste per day and generating a power capacity of 15 MW per hour from 2021, which will increase to 30 MW from 2025 to 2030.
- Amount produced (t) - Composting rate	MINAGRI, CoK, WASAC	W03 Aerobic biological	Implement a windrow composting system that compost at least 22 % of

Indicator	Reporting institution(s)	Mitigation action ID	Target for 2021-2030
(% organic waste composted)		treatment (composting)	waste collected at household in the rural area. The estimated compost quantity varies from 52,000 to 216,000 tonnes/ year, respectively from 2021 to 2030.
- # WWTP facilities - # households connected to WWTP	MININFRA, CoK, WASAC, RURA	W04 Wastewater treatment and reuse	GoR targets to construct the Kigali centralized sewerage system including construction of WWTP of 12,000 m^3/day, construction of 89 km sewer network and 3.1 trunk main sewer. The government is also planning to construct a Centralized Sewerage System for Kibagabaga and Kinyinya Catchments in Gasabo District, etc. In addition, there are other initiatives of semi-centralized wastewater treatment systems in Kigali.

3.6.3 Progress on implementation of Waste sector mitigation projects

The following section provides a summary of progress achieved to date and the planned next step for identified mitigation actions. In general, there are different ongoing efforts to develop policies, strategies, enabling environment, and reporting framework and build capacity in key institutions to implement most of the identified mitigation actions.

Table 3.20 Progress on implementation of the waste mitigation actions and planned next steps

ID	Mitigation measure	Progress achieved to date	Mitigation achieved	Planned next steps
W01	Landfill gas utilization	Planned through updated NDC (2020). National Sanitation Policy (2016) was established.	Not estimated	(i) Feasibility studies for Solid waste management in the city of Kigali including detailed engineering design for sanitary landfill- This is under the financing of the Swedish fund and will identify practical solutions for solid

ID	Mitigation measure	Progress achieved to date	Mitigation achieved	Planned next steps
				waste management in the City of Kigali (by 2021). (ii) Development of National Integrated Solid Waste Management- The strategy will highlight in more detail sustainable solid waste management for both rural and urban areas (by 2021). (iii) Feasibility studies for solid waste management in satellite cities (by 2022) (iv) Construction of sanitary landfill in Musanze, Rubavu, Karongi and Rusizi districts (by 2022)
W02	Waste to Energy (WtE) plants	Planned through updated NDC (2020). National Sanitation Policy (2016) was established.	Not estimated	(i) Feasibility studies for Solid waste management in the city of Kigali including detailed engineering design for sanitary landfills are ongoing. This project financed by the Swedish fund will identify practical solutions for solid waste management in the City of Kigali (by 2021). (ii) Development of National Integrated Solid Waste Management- The strategy will highlight in more detail sustainable solid waste management for both rural and urban areas (by 2021). (iii) Feasibility studies for solid waste management in satellite cities (by 2022)
W03	Aerobic biological treatment (composting)	Planned through updated NDC (2020). National Sanitation Policy	Not estimated	(i) Feasibility studies for Solid waste management in the city of Kigali including detailed engineering design for sanitary landfill- This is under the financing of the Swedish fund and will

ID	Mitigation measure	Progress achieved to date	Mitigation achieved	Planned next steps
		(2016) was established.		identify practical solutions for solid waste management in the City of Kigali (by 2021). (ii) Development of National Integrated Solid Waste Management- The strategy will highlight in more detail sustainable solid waste management for both rural and urban areas (by 2021). (iii) Feasibility studies for solid waste management in satellite cities (by 2022) (iv) Rural Urban nexus project implemented by the International Institute of Tropical Agriculture (IITA) in Kamonyi District
W03	Aerobic biological treatment (composting)	Planned through updated NDC (2020). National Sanitation Policy (2016) was established.	Not estimated	(i) Faecal sludge treatment plant was built in districts of Nyagatare, Kayonza and Nyanza in 2018 with a total capacity of 45m^3/day. In addition, other similar projects are planned in districts of Musanze, Rubavu, Karongi, Rusizi and Kigali. (ii) Construction of Kigali WWTP with a capacity of 12,000m^3/day is planned to be completed by 2023.

3.7 International carbon market mechanisms

The carbon market was introduced by the Kyoto Protocol to allow more flexibility on the greenhouse gas emissions reduction boundaries. It thus offers developed countries (Annex I Countries) with Kyoto commitments, a possibility to invest in more cost-effective mitigation options, which might, in turn, lead to increased global ambition in GHG emissions reduction. The Carbon market includes the market mechanisms established under Kyoto Protocol (i.e., Clean Development Mechanism, International Emissions Trading and Joint Implementation) regulated by the UNFCCC and the Voluntary Carbon Market. The Voluntary Carbon Market allows

individuals and companies to offset and/or reduce GHG emissions through appropriate financing mechanisms.

Only Clean Development Mechanism (CDM) and Voluntary Carbon Market (VCM) are applicable in Rwanda. Despite its low level of carbon emissions, Rwanda has potential for many types of carbon market projects due to its vision to become a developed low carbon and climate-resilient economy by 2050. However, like many other African Countries, Rwanda did not benefit much from the carbon market.

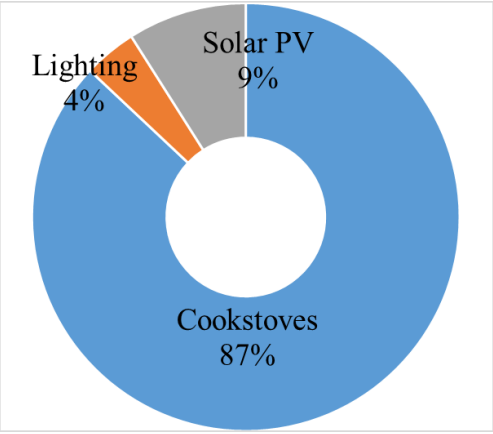


Figure 3.1 Carbon credits in Rwanda

Source: REMA

As of December 2020, in total over 2,250,000 carbon credits have been issued in Rwanda from the CDM and the VCM. All CDM activities have issued 724,320 Certified Emission Reductions (CERs) while the VCM activities have issued 1,525,680 Voluntary Emission reductions (VERs). **Figure 3.1** shows the breakdown of the carbon credits in Rwanda are dominated by improved cookstoves with 87% of total CERs issued, while lighting and solar PV together represent 9% and 4% respectively.

Chapter 4. Domestic measurement, reporting and verification

4.1 Rwanda's MRV review process

According to the UNFCCC, all Parties to the Convention are required to implement a domestic MRV system that can annually quantify national GHG emissions by sources and removals by sinks and report the specific actions made to identify and implement mitigation measures (GoR, 2020). In Rwanda, this information is generally reported in the national communications and the BURs. Rwanda has submitted its three Initial, Second and Third communications in 2005, 2012, 2018, respectively. The estimates of GHG emissions and removals are undertaken for four major sectors, viz., Energy; Industrial Process and Products Use (IPPU); Agriculture, Forestry and Land Use (AFOLU) and Wastes. In general, Tier 1 and Tier 2 methodologies are applied to estimate emissions of direct greenhouse gases (CO_2, CH_4, N_2O, HFCs) for all sectors using available country-specific data. However, various efforts are underway to develop the country-specific emissions factors and improve the methodology for emissions measurement.

The GHG emissions and removals are compiled in the National Inventory Reports (NIR) and their summaries are reported in the national communications. The national communication also reports on the actions made to identify and implement the mitigation and adaptation measures. The data used in the preparation of these reports are provided and verified by the national institutions under the GHG sector working groups, which are aligned with the IPCC sectors. The national communication reports are verified and validated *via* various workshops with sector experts and the national institutions under coordination of REMA. These reports, which are compiled and verified by REMA and an external reviewer, are submitted by the MoE to the UNFCCC secretariat.

The Paris Agreement contains several additional MRV requirements which, when taken together with the existing UNFCCC arrangements, provide an enhanced basis for Rwanda's international reporting requirements. New requirements are mainly covered by Article 13, which establishes a new Enhanced Transparency Framework (ETF) through which Parties must regularly account for their NDCs alongside other reporting requirements like those contained in National Communications (NCs), BURs and the International Consultation and Analysis (ICA). In May 2020, Rwanda has submitted its updated NDC to UNFCCC in compliance with the Paris agreement. One of the recommendations from the updated NDC was to build a more robust MRV system framework that could enable the country to monitor the effectiveness of its mitigation and adaptation measures and facilitate its access to climate finance. The developed NDC MRV system highlighted three key components of the MRV framework and provided its institutional arrangement (Republic of Rwanda, 2021). The keys components of the domestic MRV system as published in the revised MRV system are detailed in subsequent sections.

4.2 Data Collection, Compilation and Reporting on Indicators

The reporting under the Paris agreement requires a strong MRV system for data collection, compilation and reporting on indicators. The existing MRV system provides a framework for collecting and compiling the data related to GHG inventories, GHG-related mitigation impacts, mitigation actions, adaptation actions, capacity building and technology transfer. The collected data are either compiled in the national GHG emissions inventories or used to compile the emissions for tracking the progress on the implementation of the mitigation and adaptation actions and other indicators related to the international reporting requirements.

The existing MRV as proposed in the recent NDC provide a detailed description of the institutional arrangement for Rwanda's NDC MRV implementation that describes the role and responsibilities of all the institutions, ministries and other entities contribution to the data collection, compilation and reporting on indicators. The MRV system emphasize on the linkage between the national reporting systems and the data collection process and validation as a starting point. This raw data is provided and validated by the national institutions including the ministries, other institutions and local government institutions (districts), High learning institutions and Private sector. The Ministry of Environment (MoE), which is the chair of the environment and natural resources sector working group has the role of overseeing the whole process and report to the UNFCCC. It has a role and responsibility to oversee the timelines for the fulfilment of the international reporting obligations.

REMA as a technical arm of MoE chairs the environment and climate change thematic subsector-working group. It plays a key technical role in the preparation of the international reports (i.e., National GHG Inventory reports, National Communications, Biennial Update Reports, Nationally Determined Contribution and evaluation of the indicators. While MINECOFIN has a role of overseeing the data collection, calculation and reporting on indicator related to finance, NISR has a mandate to oversee the data collection, calculation and reporting on indicator related to Greenhouse Gas (GHG) Inventories, Capacity building Mitigation Adaptation and technology. **Table 4.1** shows the details on the line ministries contributing to data collection and indicator compilation. It is worth mentioning that ideally, each of the above-mentioned Ministries should have a department responsible for NDC MRV indicators compilation and reporting, with at least 2 staff members.

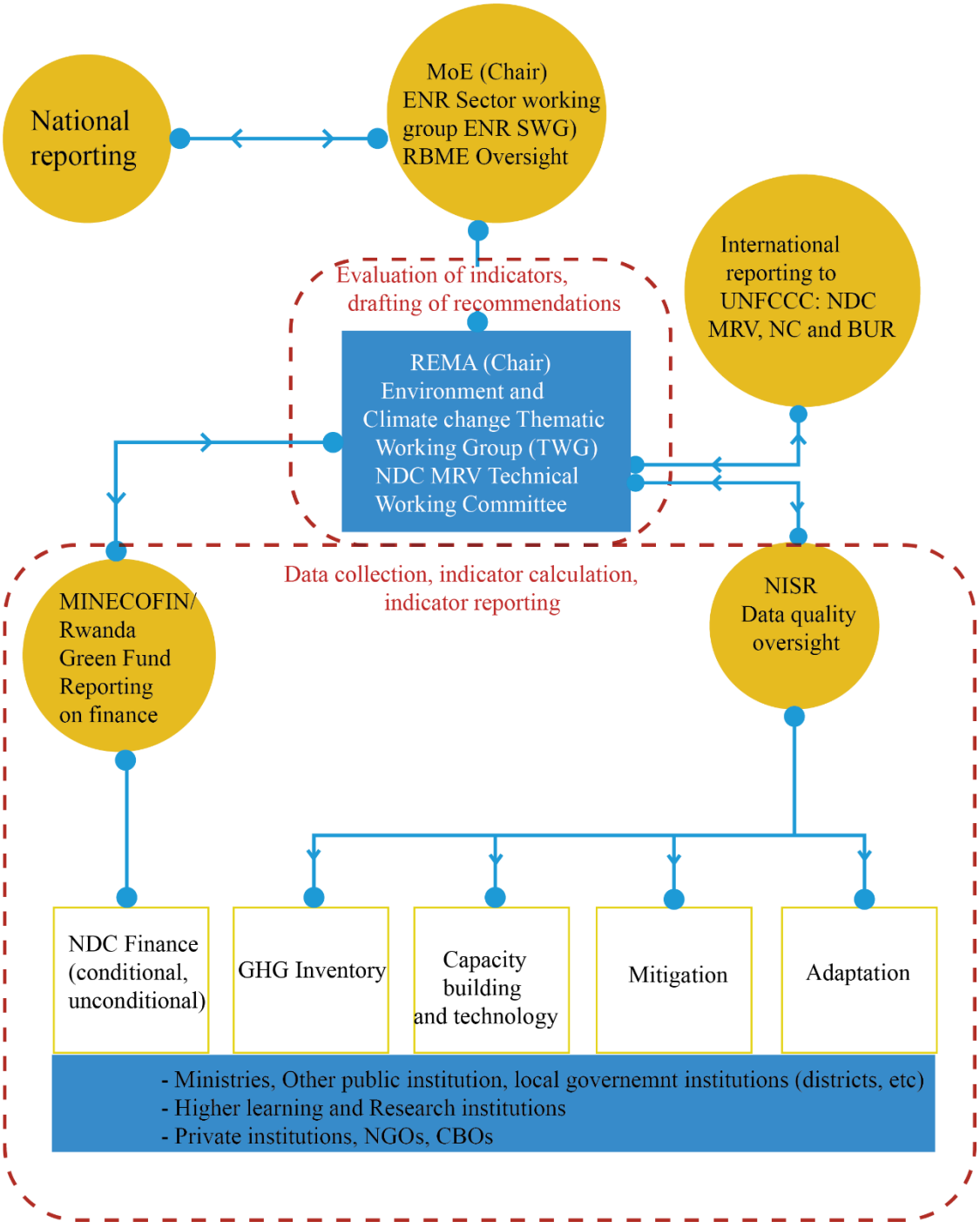


Figure 4.1 Institutional arrangements for tracking Rwanda's NDC MRV implementation

Table 4.1 Responsibility for data collection by type of indicators

Type of indicator	Responsibility for data collection and indicator compilation
Indicators related: ▪ **to mitigation impacts and other information on mitigation actions** ▪ **to adaptation** ▪ **to capacity building and technology transfer** ▪ **to "other factors", which qualitatively present progress with implementation or policy development**	Data collection and indicator compilation: ▪ MININFRA for the energy (incl. transport) and waste sector, water ▪ MINICOM for the industrial processes and other product use (IPPU) sector ▪ MINAGRI for the agriculture sector, ▪ MoE for the forestry and land-use change sector ▪ Ministry for Emergency Management (MINEMA) for disaster management
Indicators related to the GHG inventory (GHG emissions or activity data)	Data collection: ▪ MININFRA for the energy (incl. transport) and waste sector ▪ MINICOM for the IPPU sector ▪ MINAGRI for the agriculture sector, ▪ MoE for forestry and land-use change sector Indicator compilation: REMA, as part of the GHG inventory compilation process
Indicators related to the BAU scenario	To be compiled by REMA as part of the regular scenario updating process, using GHG inventory data as starting point as well as sectoral assumptions from: ▪ MININFRA for the energy (incl. transport) and waste sector ▪ MINICOM for the IPPU sector ▪ MINAGRI for the agriculture sector ▪ MoE for forestry and land-use change sector
Indicators related to climate finance	Collected and compiled by MINECOFIN through the IFMIS system (to be updated to enable this task)

The existing domestic MRV also suggests an indicator compilation process. In this process, the designed departments/offices provide the necessary data to the line ministries through internal reporting sharing processes and/or Data sharing template backed by the Ministerial Order on Climate. The line ministries compile the indicator and feed them in the RBME (MoE) and MIS systems (MINEMA, MINAGRI, and MININFRA for the water, sanitation and hygiene sector only, MINISANTE for health only). It is important to note that some of the line ministries do not report in these systems. Their data are reported in their annual reports and other designed reports such as the backward looking and forward looking for energy sector data reported by MININFRA. However, there is a long-term plan to integrate all the climate change and environment indicators reporting through RBME system.

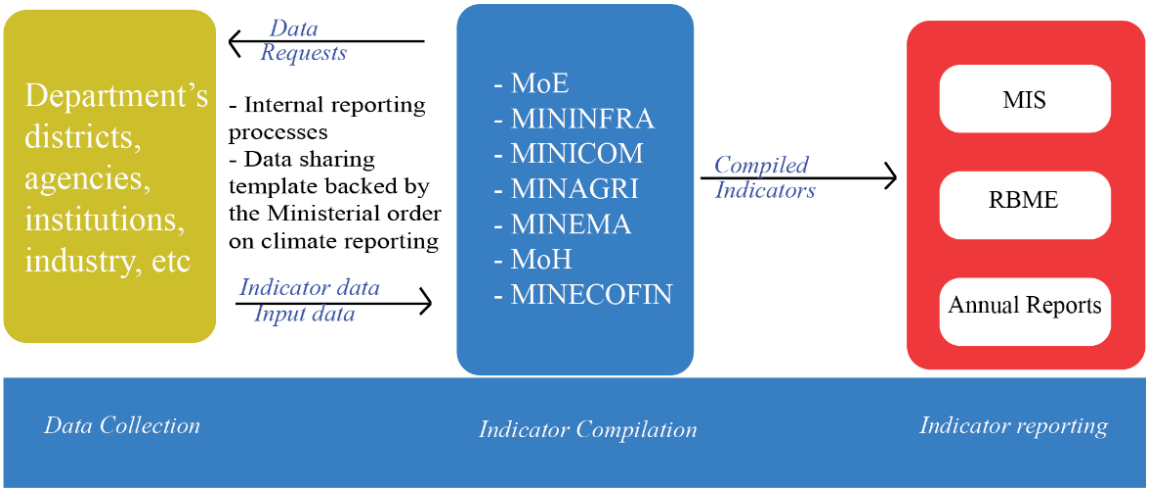


Figure 4.2 Indicator compilation and reporting process

4.3 Evaluation and development of policy recommendations

As aforementioned, the evaluation and development of policy recommendation are the responsibility of REMA. The existing domestic MRV suggests that REMA collects all the necessary indicators from the relevant sources (MIS, RBME, reports) and conducts a first assessment of developments together with draft policy recommendations.

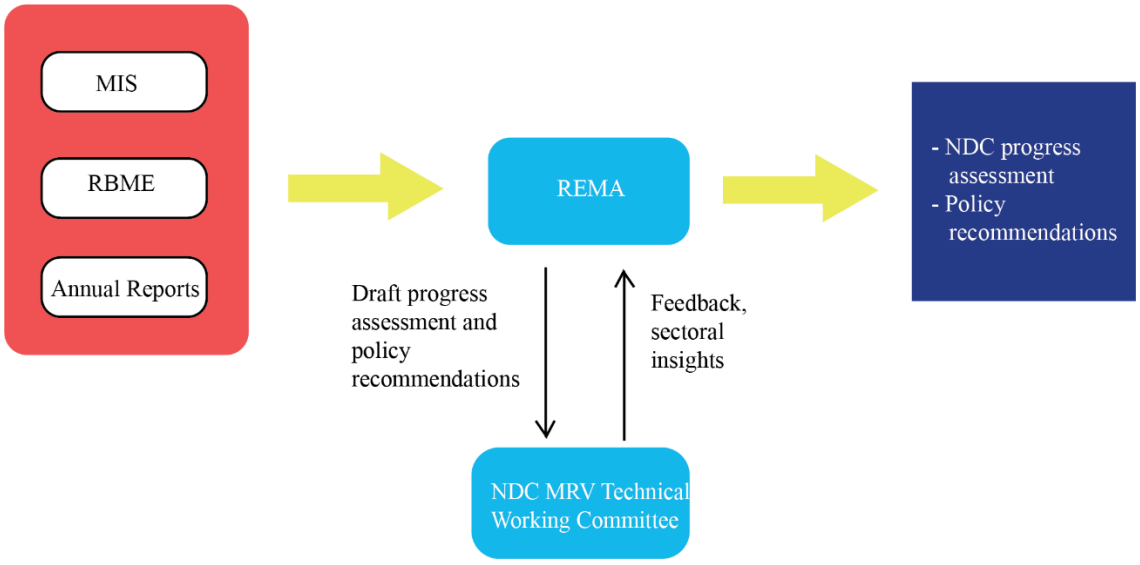


Figure 4.3 Indicator evaluation and development of policy recommendations

Thus, it is recommended that, REMA should be enabled to obtain the NDC indicators with minimal effort. Integration with international reporting under the UNFCCC.

In the short and medium term, this can be achieved, by the line ministries including all NDC indicators under their responsibility into their annual reports, using the indicator tables in Rwanda's updated NDC. REMA could thus simply collect the information from these publicly available reports. However, in the longer term, most indicators could be reported through MIS and with the planned integration of the MIS and the RBME system. This will make the information readily available to REMA (

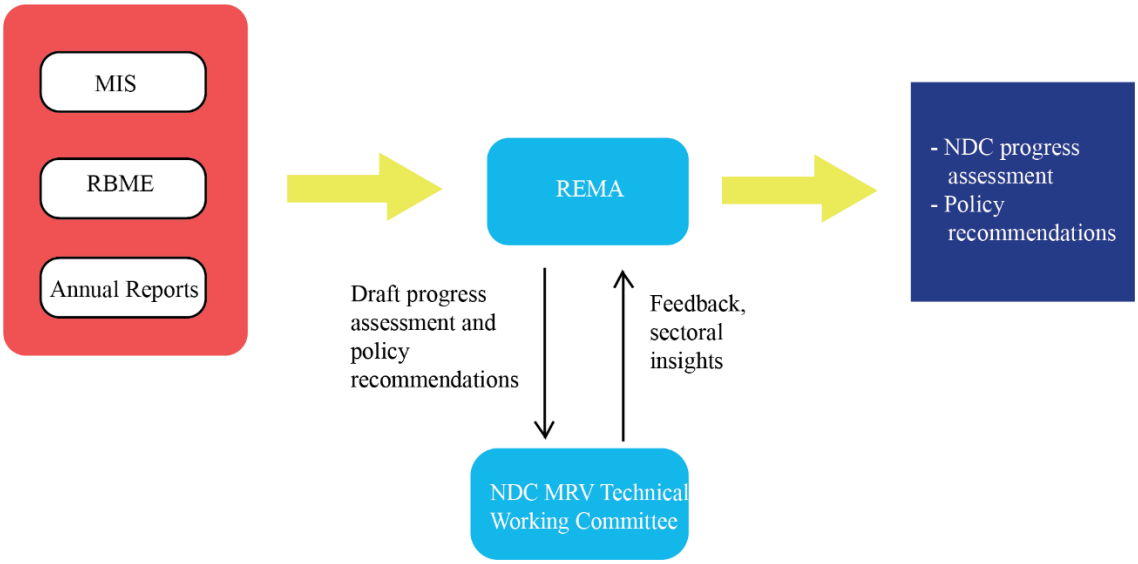


Figure 4.3). After the preliminary evaluation and the drafting of the policy recommendations, the latter are discussed with the NDC MRV Technical Working Committee, which provides feedback based on its sectoral insights. After receiving the feedback, REMA updates the evaluation and recommendations and publish them for public review.

4.4 Integration with international reporting

As aforementioned, the process followed in indicator evaluation and policy recommendation should be aligned with the international reporting under the UNFCCC, particularly the reporting of Biennial Transparency Reports (BTR).

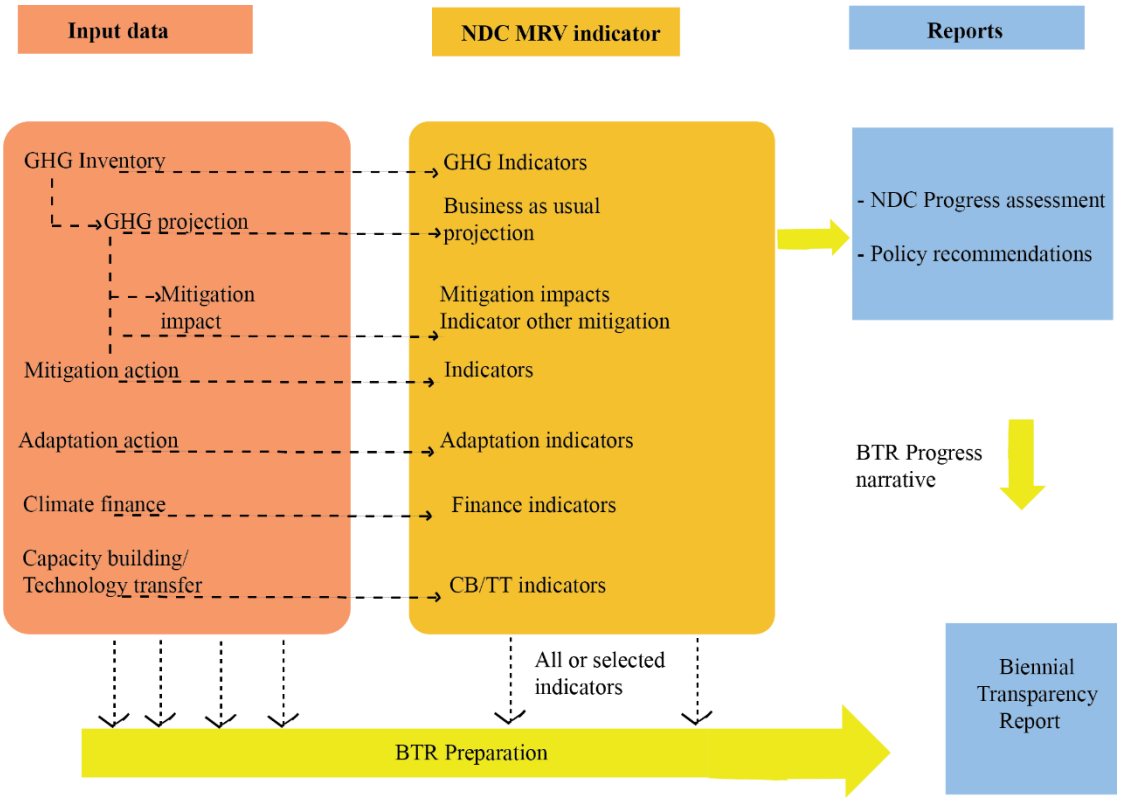


Figure 4.4 Integration of the BUR preparation and the NDC MRV process

These reports strongly overlap in the areas covered by the NDC MRV indicator framework: GHG inventory, indicators expressing progress towards the NDC, mitigation actions, projections, adaptation, climate finance, capacity building and technology transfer. The reporting under the UNFCCC is not mandatory for all these topics.

Figure 4.4 shows how the compilation of the NDC MRV indicators and the preparation of the BTR could be integrated. Both processes rely on a very similar dataset. The input data to the NDC MRV indicators also serves as input data for the preparation of the Biennial Transparency Reports. The main difference is that information for the NDC MRV indicators is mostly quantitative, whereas the information required for the BTR also requires qualitative data, e.g., descriptions of mitigation and adaptation measures and of trends in the national GHG emissions.

The reporting requirements under the ETF request that selected NDC MRV indicators with relevance to Rwanda's NDC are to be included in the Biennial Transparency Report. Rwanda is of course free to include all NDC MRV indicators into the BTR, if so desired.

Chapter 5. Constraints, gaps, support received and needs

5.1 Constraints and Gaps

The gaps and constraints are aligned with those identified by the Rwanda Third National Communication. These include insufficient data for the National GHG Inventory and tracking progress of mitigation and adaptation actions, limited capacity of national experts in implementation of climate change activities as well as low adaptive capacity of local communities to climate change impacts.

Rwanda's Third National Communication also highlighted financial challenges including insufficient funds to deliver on national climate change adaptation and mitigation targets, limited budget for climate action and limited involvement of private sector investment in the environment and climate change activities. Furthermore, the TNC indicated a need for more bilateral and multilateral financial support (GoR, 2020).

5.1.1 Technical and Capacity Building constraints and gaps

It does not need to be overemphasized that some constraints and gaps, especially in the database and used emission factors, were detected in National Communication reports and some of them were addressed during the preparation of this first Biennial Update Report. There is still an issue of emission factors fitting with the Rwandan context as well as technical and capacity constraints and gaps, which are still hindering the smoothness of GHG emissions inventory and mitigation assessment. More emphasis is required on limited capacity for adoption and diffusion of climate technology as well as knowledge gaps in climate change vulnerable communities. Table 5.1 shows a summary of the main technical and capacity constraints and gaps, that if addressed, will improve climate change reporting and achievement of climate targets in Rwanda.

Table 5.1 Summary of technical and capacity constraints, gaps and actions to be taken

Activities	Constraints and Gaps	Actions to be taken	Responsible entity
GHG Inventory/ Mitigation/ Adaptation	Specific data collection in sector institutions for GHG Inventory, mitigation and adaptation is limited	Results-based monitoring and evaluation RBME was established and managed by the Ministry of Environment to gather regularly all data related to the environment and natural resources.	MoE, REMA
GHG Inventory/ Mitigation/ Adaptation	There is still limited capacity in methodologies for national experts in GHG Inventories, mitigation and adaptation assessments	Technical assistance and capacity building through training on the use of 2006 IPCC GHG Inventory Software	MoE, REMA
GHG Inventory, Mitigation & Adaptation	There is lack of exhaustive and reliable databases as well as regular surveys to inform and update National GHG Inventories	Regular surveys to get more accurate data	MoE, REMA and other stakeholders in the environment and climate change sector
GHG Inventory, Mitigation & Adaptation	Some GHG emitting categories are not included in the IPCC Software for estimation of GHG emissions such as methane gas extraction for electricity generation	Incorporate this methane gas in IPCC software and determination of specific emission factors and Net Calorific Values of methane gas	MoE, REMA
GHG Inventory, Mitigation & Adaptation	Limited data and information on the impacts of adopted mitigation/adaptation actions in various sectors	Conduct a regular survey and scientific studies	MoE, REMA and other stakeholders in the environment and climate change sector

Activities	Constraints and Gaps	Actions to be taken	Responsible entity
Mitigation & Adaptation	Limited capacity and highly skilled technicians in operation and management of electric vehicles, wastewater treatment technologies	Technical assistance and capacity building to the technicians	REMA, MININFRA, NIRDA, MINALOC and Private sector
Mitigation	Limited infrastructure to facilitate operation of Electric mobility	Financial support to avail build the e-mobility infrastructures	MININFRA, REMA, RTDA, RURA, FONERWA and Private Sector
Mitigation & Adaptation	Low domestic capacity in manufacture of green technology and products particularly solar photovoltaic systems, modernised agriculture machinery	Technology transfer is required to boost the green manufacturing and other climate technologies	MININFRA, MoE, REG, REMA, and Private Sector
Mitigation & Adaptation	Limited skill in green project proposal development and resource mobilisation	Enhance private engagement in resource mobilization and targeted capacity building for state and non-state actors	FONERWA, REMA
Mitigation & Adaptation	Local communities have minimum capacity to effectively utilise technologies particularly energy from biogas, solar home systems, drip irrigation tubes, etc	Provide regular technical assistance to communittees on use and maintainance of green technologies, and support them to have an access to other technologies	MoE, REMA, REG, MINAGRI

5.1.2 Financial Constraints and Gaps

The implementation of environment and climate change action requires a lot of funds mainly from the public budget. However, due to insufficient public funds to allocate to prioritized mitigation and adaptation actions. The impacts of climate change that have been felt through floods, drought, landslides are to a large extent, because of global increased GHG emissions. Thus, Bilateral and Multilateral funds and other mechanisms such as the carbon market are essential toward adaptation to climate change impacts and building climate change resilience in Rwanda.

5.1.3 Limited fund for environmental and climate change activities

The most recent climate change vulnerability assessment conducted in 2018 indicated that Rwanda's sensitivity to climate change is high and its adaptive capacity is low. Five sectors were noted for special attention: Health, Water, Agriculture, Energy and Forestry. Four districts were assessed as having the highest vulnerability in Rwanda, 3 of them located in the Southern Province: Gisagara, Huye and Ruhango districts together with Karongi district in the Western Province (REMA, 2019a). **Figure 5.1** shows the budget allocated to various districts in 2017-2018. Although these districts are shown to be highly vulnerable to climate change, the public funds allocated for implementation of environment and climate change activities are still limited (REMA, 2019a).

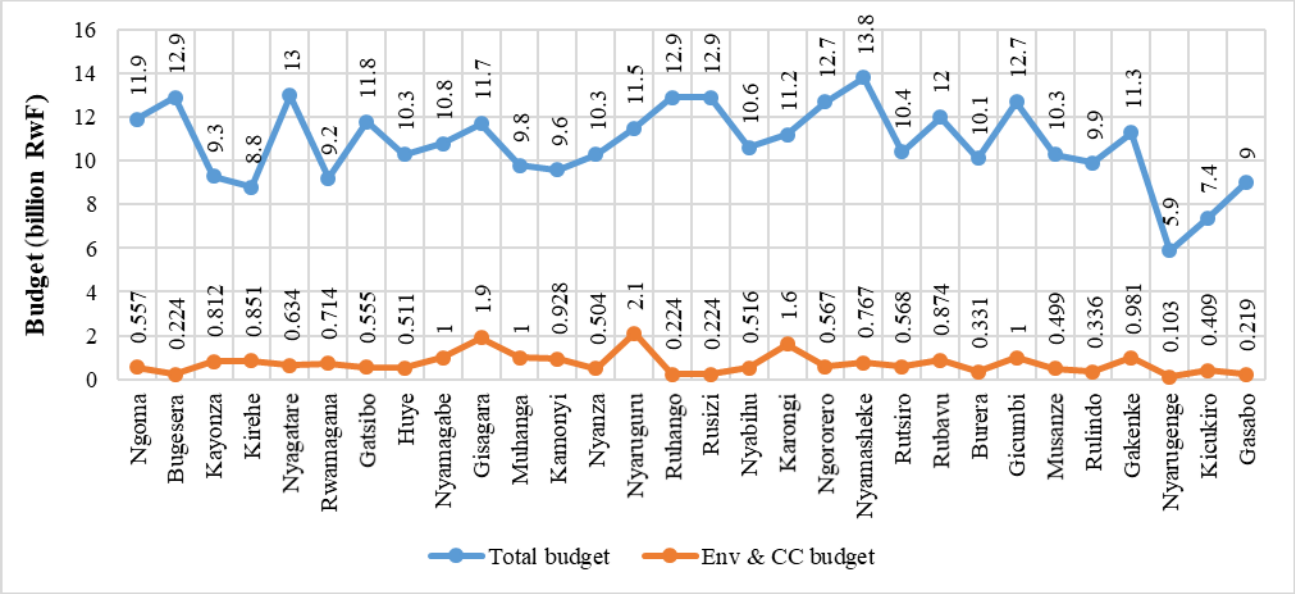


Figure 5.1 Budget allocated to the environmental and climate change activities from districts' budgets in 2017/2018

Source of data: REMA, 2019

The figure above indicates that all districts in 2017/2018 were given the total budget of 324 billion Frw and only 21.508 billion Frw (less than 10 % of their total budget) were allocated to environmental activities while about 53 % of the total Rwandan population are engaged in rain-fed agriculture which yielded about 33 % of Rwandan GDP in 2018 (EICV 5, 2018).

5.2 Support received and needed

5.2.1 Financial support received

The Government of Rwanda have received funds from various international source, such as the Global Climate Fund (GCF), Global Environment Facility (GEF), UN agencies (UNDP, UNEP) Bilateral and multilateral cooperation. The support received helped to address the impacts of

climate change and to achieve the target set to reduce the GHG emissions. To further boost the access to climate finance, Rwanda have established the Green Fund (FONERWA) that act as a Public-Private Partnership Vehicle that uses public financing mechanisms such as grants, lines of credit, loan guarantees, public venture capital, and equity capital.

5.2.2 Involvement of partners in financing environmental and climate change activities

Some partners fund environmental and climate change activities through FONERWA, and the government of Rwanda provides an annual contribution of Rwf 500,000,000 to FONERWA. According to MINECOFIN, from 2012 to June 2018, a sum of USD 109,630,444 in external development finance was mobilized to include resources from DfID, KFW, UNDP, the World Bank, the Climate and Development Knowledge Network (CDKN), Adaptation Fund, Green Climate Fund (GCF), Least Developed Countries Fund (LDCF), AfDB and the Global Green Growth Institute (GGGI). USD 33,232,670 of this total amount was mobilized in 2017/18 (all from GCF) (MINECOFIN, 2019). Moreover, FONERWA reported having mobilized USD 127,763,110,124 from 2013 to 2020 as detailed in **Table 5.2**.

Table 5.2 List indicating the resource mobilization for 2013- 2019

SN	Source of funds	GBP/Euro	Amount (Rwf)	Amount (USD)
1	DFID grant (GBP)	22,560,000	25,343,904,000	37,161,150
2	KFW grant	6,700,000	6,293,779,000	8,978,287
3	UNDP		3,475,203,292	5,095,606
4	World Bank		1,244,473,704	1,500,000
5	CDKN grant (leveraging)	360,000	404,424,000	592,997
6	GoR contribution		4,747,598,356	6,961,288
7	Adaptation fund grant (leveraging)		6,939,900,000	9,900,000
8	GCF NDA support and PPF (leveraging)		1,227,600,000	1,800,000
9	LDCF/AfDB (leveraging)		5,732,038,818	8,404,749
10	Projects Match financing		9,798,222,127	14,366,895
11	BRD		1,714,284,710	2,513,614
12	GGGI (GBP)	1800000	2,022,120,000	2,964,985
13	GCF GRANT		28,151,274,117	32,794,442
14	KFW grant. Feasibility study (GCP Kigali)	2,200,000	2,641,408,000	2,948,000
15	SIDA(SEK)	39,000,000	3,942,400,000	4,400,000
16	UNDP		3,942,400,000	4,400,000
17	KFW grant (EURO)	7,000,000	8,404,480,000	9,380,000
18	DFID grant (GBP)	2,000,000	2,956,800,000	3,300,000

SN	Source of funds	GBP/Euro	Amount (Rwf)	Amount (USD)
19	Projects Match financing		8,780,800,000	9,800,000
Grand Total			127,763,110,124	167,262,013

Source of data: FONERWA, 2020

Table 5.3 Total GEF Funding Received by Rwanda up to May 2020

Trust Fund	Project Type	Up to March 2017		Up to May 2020	
		Number of Projects	Total Co-Financing (USD)	Number of Projects	Total Co-Financing (USD)
GEF	National	11	125,990,955	18	234,891,80
	Regional/	20	441,782,546	26	2,402,423,478
	Total	31	567,773,501	44	2,637,315,279
LDCF	National	4	94,955,600	6	96,917,000
	Regional/	-	-	-	-
	Total	4	94,955,600	6	96,917,000
MTF	National	1	51,596,000	1	100,000
	Regional/	1	9,200,000	1	9,200,000
	Sub-total	1	60,796,000		9,300,000
	Total		723,525,101	1	2,743,532,279

Source: https://www.thegef.org/country/rwanda, accessed on 30/05/2020

Table 5.3 shows the GEF funds as of March 2017 and May 2020. A clear increase from USD 723,525,101 in 2017 to USD 2,743,532,279 in May 2020 is observed implying much involvement of GEF in environmental and climate change activities in Rwanda. The Government of Rwanda partners with GEF Agencies on proposal development and management of these projects. GEF agencies working in Rwanda include African Development Bank (AfDB), Food and Agriculture Organization of the United Nations (FAO), International Fund for Agricultural Development (IFAD), United Nations Development Programme (UNDP), United Nations Environment Programme (UNEP), United Nations Industrial Development Organization (UNIDO), and The World Bank, World Wildlife Fund (WWF). These GEF agencies help the Government of Rwanda to develop, implement and execute its projects.

It is important to mention that, like other developing countries, Rwanda receives financial supports for domestic MRV. In this framework, the Government of Rwanda has received financial support of USD 500,000 from the Global Environment Facility (GEF), as an operating entity of the Financial Mechanism of the Convention for the preparation of National Communications. Additionally, GEF provided USD 352,000 for BUR1 preparation and submission. **Table 5.4** provides a list of projects implemented through bilateral and multilateral grants from 2014 through 2020.

Table 5.4 List of projects implemented through bilateral and multilateral grants (2014-2020)

SN	Project name	Project funder	Starting year	Ending year	Budget amount	Main objective
1	Nyandungu Urban wetland Eco-tourism Park (NUWEP) (Part II)	UNEP ITALIAN GOVERNMENT	2016	2021	USD 2,287,496	The project aims to restore and conserve Nyandungu wetland ecosystems, promote the sustainable management of natural resources and support livelihood diversification to enhance incomes for local communities
2	Vulnerable ecosystem rehabilitation and protection (VERP)	FONERWA	2014	2018	Rwf 3,300,000,000	To strengthen and sustain the conservation and management of natural resources in Bugesera, Burera, Musanze and Rusizi districts (Adaptation project).
3	Landscape Approach to forest Restoration and Conservation (LAFREC)	GEF/ WB	2015	2019	USD 9,532,000	To demonstrate landscape management for enhanced environmental services and climate-resilient livelihoods.
4	Building resilience of communities living in degraded forests, savannas and wetlands of Rwanda through an ecosystem management	GEF/UNEP	2016	2020	USD 5,500,000	To build the resilience of communities living in degraded wetlands, forests and savannas in Rwanda, using an Ecosystem-based Adaptation (EbA) approach

SN	Project name	Project funder	Starting year	Ending year	Budget amount	Main objective
	approach (LDCF II)					
5	Poverty-Environment Action for SDGs (PEA)	UNEP /UNDP	2018	2021	USD 1,600,000	Increased and enhanced investments that deliver concrete and significant results in poverty reduction, environmental and natural resource sustainability and resilience building at national and district levels
6	Capacity Building Initiative for Transparency (CBIT)	GEF- CI	2020	2021	USD 746,438	To build capacity to meet transparency requirements under Paris Agreement.
7	Strengthening climate resilience of rural communities in Northern Rwanda (SCRNRP)	GCF	2019	2025	USD 32,800,000	To restore and enhance the ecosystem in a sub-catchment of the Muvumba watershed, increase the capacity of communities to renew and sustainably manage forest resources, and support smallholder farmers to adopt climate-resilient agriculture.
8	National Adaptation Readiness and	GCF	2020	2022	USD 1,819,474	To enhance Rwanda's capacity to respond to climate change in high-risk zones by implementing a NAP for flood and

SN	Project name	Project funder	Starting year	Ending year	Budget amount	Main objective
	Preparatory Support for Building Flood Resilience Capacities in Rwanda					landslide risk in urban areas by developing the capacity of the National Designated Authority (NDA) and strengthening coordination with relevant stakeholders to plan and respond to the most urgent needs for mitigating climate-induced hazards.
9	Readiness and preparatory Support to Capacitate Rwanda Subnational level actors in Green Growth and Climate Resilience	GCF	2020	2021	USD 699,940	To increase the capacity of Rwanda Government's Thematic Sector Working Groups (TSWGs) with a focus on strengthening their functions and activities to inform sub-national level actors on green growth and climate resilience that will lead to the delivery of climate actions in their respective sectors, subsectors, and communities
Other projects						
10	Readiness and preparatory support to NDA to accelerate access to GCF resources	GCF	2016	2018	USD 300,000	To facilitate strategic planning and strengthen the government's convening power to engage national stakeholders. Partners from various sectors, including other government entities, the private sector, CSOs, and the National Women's Council

SN	Project name	Project funder	Starting year	Ending year	Budget amount	Main objective
11	Readiness and Preparatory support to implement Green City Development Projects in Rwanda's Secondary Cities.	GCF	2018	2019	USD 600,000	To support one of the six secondary cities of Rwanda, to elaborate an integrated visionary green city conceptual and detailed physical plan guided by the city green growth and socio-economic development potentialities.
12	Developing Capacity for Climate Resilient Road Transport Infrastructure	Nordic Development Fund	2019	2022	EURO 3,382,000	To strengthen road transport infrastructure adaptive capacity by integrating climate change aspects into planning and design
13	Improving efficiency and sustainability of charcoal and wood fuel value chain	**World Bank**	2018	2021		To improve woodlot management and seed quality, more efficient charcoal production and support the promotion of more efficient source of energy
13	Strengthening climate resilience of rural communities in Northern Rwanda (Green Gicumbi project)	GCF	2019	2025		The project will restore and enhance the eco system services in one of the sub catchments in the degraded Muvumba watershed, increase the capacity of communities to renew and sustainably manage forest resources and support small holders to adopt climate resilient agriculture

SN	Project name	Project funder	Starting year	Ending year	Budget amount	Main objective
14	Forest Landscape Restoration in the Mayaga Region	GEF	2020	2026	USD 6,200,000	Securing biodiversity and carbon benefits and strengthening livelihoods resilience through forest landscape restoration
15	Landscape Restoration and Integrated Water Resource Management in Sebeya and other catchments		2019	2023		Increasing livelihood and conservation benefit in Sebeya and other catchments from restoration and improved natural resource management

Source of data: REMA, 2020

Table 5.4 lists the 11 projects that have been financed through bilateral and multilateral grants awarded to the Government of Rwanda from 2014 through 2020. The additional project was financed through FONERWA as forementioned. However, these provided financial supports from various sources are not enough to cope efficiently and effectively with the adverse impacts of climate change across Rwandan territory.

Table 5.5 depicts that FONERWA has supported 37 projects valuing Rwf 37, 921,316,736 since 2013 up to 2019. Notwithstanding that, most of the supported projects were executed by governmental institutions and 13 private partners were awarded project supports by FONERWA. This shows the integration and involvement of the private sector in the execution of environmental and climate change activities.

Table 5.5 Projects supported by FONERWA for 2013-2019

SN	Project title	Lead organization	Type of organization	Year	Amount in Rwf
1	Sustainable Management and Environmental Rehabilitation for Poverty Reduction	Send A Cow Rwanda (SACR)	NGO	2014	465,608,168
2	Rainwater Harvesting project in high-density areas of Nyarugenge, Gasabo, Kicukiro, Musanze, Nyabihu and Rubavu districts	Rwanda Natural Resources (RNRA)	Government	2014	2,255,846,638
3	Integrated land, water resources and clean energy management toward poverty reduction project in Musanze District	Musanze District	District	2014	701,461,152
4	Vulnerable ecosystem recovery programme towards climate change (VERP)	REMA	Government	2014	3,724,188,800
5	National e-waste management strategy for Rwanda to support the establishment of sustainable recycling industries	Rwanda Resource Efficiency and Cleaner Production Centre (RRECPC): E-waste Management Project/MINICOM	Government	2014	1,473,647,300
6	Gaseke Minis-Hydro Power Plant	Novel Energy Limited	Private Sector - line of credit	2014	770,000,000
7	Strengthening Meteo Rwanda's Weather and Climate Services to Support Development	Meteo Rwanda	Government	2015	1,645,740,200
8	Supporting the Integration of Greening District Development Plans	Ministry of Local Government (MINALOC)	Government	2014	526,190,000

SN	Project title	Lead organization	Type of organization	Year	Amount in Rwf
9	Technical & Structural Studies for Incorporating Resource-efficient and Environmentally friendly Features into Family Homes at CACTUS GREEN PARK (CGP), Gasabo District, and Kigali City.	Horizon Group Limited	Private Sector	2014	126,862,297
10	Sustainable biodiversity: mapping and domesticating the mycological riches of Rwanda's forests	Kigali Farms	Private Sector	2015	36,172,000
11	Akanyaru Watershed Protection Project - GISAGARA	Gisagara District	District	2014	2,125,218,594
12	Karongi District integrated greening village Program	Karongi District	District	2014	738,301,350
13	Congo Nile Ridge Foothills Integrated Environmental Management Project in Muhanga District	Muhanga District	District/Caritas Diocese	2015	1,585,721,485
14	Zero carbon affordable housing solution in Rwanda	Zero Carbon designs Ltd, Rwanda	Private Sector	2015	158,911,350
15	Rice Husk (biomass) to power project	Novel Energy Limited	Private Sector - line of credit	2015	81,200,000
16	Restoring Yanze River and watershed through scaling up agroforestry technologies for resilience to climate change	Rulindo District	District	2015	1,597,743,000
17	Environmental Protection in and around Refugee Camps	MIDMAR	Government	2015	1,084,870,733
18	Sustainable forestry, agroforestry and biomass energy management for climate resilience in Gatsibo District	RNRA	Government	2015	1,469,171,600
19	RUSULI Comminity Led /WHH	WHH	NGO/WHH	2015	533,722,000

SN	Project title	Lead organization	Type of organization	Year	Amount in Rwf
20	Integrated Project of Ecosystem Rehabilitation and Green Village Promotion (IPERGP)	Nyamasheke District	District	2015	725,124,000
21	Sustainable forest and watershed resources management in Nyagatare district	Nyagatare District	District	2015	632,475,165
22	Rainwater Harvesting and Reuse in Kamonyi District	Kamonyi District	District	2015	1,022,914,900
23	The Water-Energy-Food Security Nexus in the Akagera Watershed: Linking evidence collection, local action and stakeholder dialogue for sustainable development and climate change resilience.	ARCOS	ARCOS	2015	573,289,490
24	Supporting sustainable, climate-resilient livelihoods for poor farming households in Bugesera	AVVAIS CSO	AVVAIS CSO	2015	458,044,827
25	MWOGO Watershed Protection Project	Nyamagabe District	District	2016	640,334,000
26	Nyandungu Urban wetland Eco-tourism Park (NUWEP) (Part I)	REMA	Government	2016	2,413,699,149
27	Off-Grid Solutions / Waka Waka Rwanda Ltd.	Off-Grid Solutions / Waka Waka Rwanda Ltd.	Private Sector	2016	30,739,811
28	Rushashi Environmentally Friendly Mining Project (REFMP)	Standard Mining Company LTD	Private Sector	2017	92,750,000
29	Local partnership for rehabilitation of biodiversity and ecosystems in Nyabarongo Watershed.	Ngororero district	District	2017	1,702,936,220
30	Rwanda Air Quality and Climate Change Monitoring Project	REMA	Government	2017	927,341,175
31	MINAGRI MAINSTREAMING	MINAGRI	Government	2017	1,917,639,242

SN	Project title	Lead organization	Type of organization	Year	Amount in Rwf
32	Electric Motors	Ampersand Rwanda Ltd	Private sector	2019	189,901,702
33	Greening Girinka: piloting climate-smart approaches in crop-livestock intensification	Rwanda Agriculture Board in partnership with SACR	Government/NGO	2019	780,000,000
34	Transforming RNP into an efficient and low-carbon energy consumption institution	Rwanda National Police (RNP)	Government	2019	865,700,000
35	Supporting the Integration of Village greening Program	Rwanda Housing Authority (RHA)	Government	2019	485,850,388
36	Mainstreaming climate change to mitigate floods in Nyabugogo commercial area.	The city of Kigali in partnership with RWFA	Local Government	2019	2,500,000,000
37	River Nyabarongo Ecosystem Rehabilitation to increase resilience to climate change effects by Improving Youth and Women Livelihoods	Local Administrative Development Agency (LODA)	Local Government	2019	862,000,000
	Grand total				**37,921,316,736**

Data source: FONERWA, 2020

5.2.3 Technical and Capacity Building support received

Technical Assistance for climate action has been provided to Rwanda through the Government and its partners. As emphasized, there is a need for intensive capacity building efforts to support adoption and diffusion of climate technologies, enabling activities related to climate change reporting under the UNFCCC and Enhanced Transparency Framework of the Paris Agreement as well as building climate change resilience of local communities.

The technical assistance and capacity building support from the UN-Global Support Programme (GSP) for the preparation of the First Biennial Update Report strengthened the capacity of sector institutions in methodologies for development of National GHG Inventories, mitigation assessment and vulnerability and adaptation assessment. This support was provided through Eastern Africa and Southern Measurement Reporting and Verification (MRV) Network through regional and national training workshops, guidance materials/publications and access to information/capacity-building opportunities such as the training series for the Technical Team of Expert training series, CGE training materials, etc. The Global Support Programme also trained national institutions on National GHG Inventory Systems that meet Enhanced Transparency Framework requirements under the Paris Agreement.

Rwanda has also been supported with the Belgian NDC Support Initiative to strengthen the National GHG Inventory by establishing a National Data Management System to archive and periodically update data for GHG Inventories. Tools such as Resources for Inventory Safety and Quality (RISQ) that utilize templates comparable to IPCC have been developed for all sectors with technical support from Centre Interprofessional Technique and Studies de la Pollution Atmospherique (CITEPA). In addition, the UN Food and Agricultural Organisation (FAO) provided technical and capacity building support through equipment support, training workshops and technology transfer

5.3 Support Needs

5.3.1 Financial Support Needs

Rwanda's vision to become a developed, climate-resilient and low-carbon economy by 2050 will be only achieved if the most appropriate mitigation action and adaptation options are adopted in due time. **Table 5.6** shows the required investment for all mitigation measures.

Table 5.6 Investment requirements for all mitigation measures (USD Million)

Sector	2020-2025	2026-2030	2020-2030
Electricity generation	495	57	552
Industry energy	6	19	26
Transport	506	585	1091
Buildings	510	150	660
Agriculture energy	306	20	327
Energy-total	**1,824**	**831**	**2,655**

IPPU-total	4	0	4
Fertilizer use and composting	179	540	719
Manure	15	15	30
Livestock	206	231	437
Soil and water conservation	299	1,160	1,459
Agriculture-total	**700**	**1,946**	**2,645**
Solid waste	194	0	194
Wastewater	89	89	178
Waste-total	**283**	**89**	**372**
Total	2,811	2,866	5,677

Source: (GoR, 2020)

In total, 5, 677 USD million will be required for various mitigation measures for the period of 2020-2030. The investment levels for each sector broadly correspond to the estimated mitigation shares across each emitting sector, with agriculture and energy projects accounting for the majority (each accounting for 46.77 % of the total 2020-2030, respectively). Soil and water conservation is expected to take a higher portion (25.7%) of required investments in the agriculture sector) as well as transport (19.2%) in the energy sector. The investments in waste facilities account for the bulk of the remaining requirement. The adaptation interventions will need almost the same amount (5,364 USD million for the 2020-2030 period) as it is detailed in **Table 5.6**.

Reference to the submitted Forest Investment Plan to the Climate Investment Fund (CIF) in 2017 aiming to mobilize funds to deal with the key overarching issues to be tackled of the huge imbalance in wood supply and the low productivity of trees and forests, there is a need of 95 million USD to invest in the forest sector in Rwanda. Rwanda's FIP Investment Plan has three target areas: (1) Support for Sustainable Agriculture through Agroforestry; (2) Support for Sustainable Forest and Landscape Management; and (3) Wood Supply Chain, Improved Efficiency and Added Value. This Investment Plan includes a clear country context, justification for implementing the proposed projects, analysis of existing legal, policy and institutional frameworks for implementation and summarizes the wide range of expected benefits to rural livelihoods, national development programs and the contribution to GHG emission reductions. It also itemizes the specific components for each target area, proposes geographical intervention areas and quantifies the resources that will be required (Ministry of Lands, and Forestry, 2017).

Furthermore, Rwanda's Strategic Programme for Climate Resilience (SPCR), which is a holistic and multi-sectoral plan of the climate resilience investment, was prepared in 2017. It demonstrates the country's commitment to building broad-based climate resilience as well as to the high-impact investment opportunities in the dynamic and results-oriented economy that seek to achieve the national sustainable development objectives. The SPCR would be implemented through four integrated programmes namely agriculture driven prosperity, water security for all, climate-resilient human settlements and a stable and sustainable landscape. The implementation of the SPCR activities will require over USD 534,316,750. The promotion of agriculture driven prosperity will need USD 44,365,200 with USD 310,475,000 to achieve

Water Security for all and USD 150,727,500 for Climate Resilient Human Settlements while USD 28,749,050 are needed for Stable and Sustainable Landscapes (MoE, 2019c).

The GGCRS stipulates that Cost-Benefit Analysis (CBA) was carried out in 2015 by REMA for the energy, water, agriculture and forestry as the backbone sectors of the Rwandan economy. Thus, a budget of USD 800 million was estimated for achieving a High Green Growth Scenario for the Energy sector in 2030 for "Low carbon mix of power generation for the national grid energy sector" and "Sustainable small-scale rural energy installations". The costs would cover the required investments in electricity generation from renewable sources for (i) Increased diversity of supply (ii) Security of supply (iii) Reduction of CO_2 emissions; and in achieving a balanced supply and demand of wood fuel, improving health and achieving positive gender impacts through (i) Market transformation to efficient cook stoves and (ii) Moving away from charcoal by 2030.

The same study estimated USD 2.8 billion for achieving a High Green Growth Scenario (HGGS) for the water sector in 2030. The cost estimates were made to (i) increase climate resilience and supply reliability through rainwater harvesting, re-use and conservation, decentralized small-scale irrigation systems, (ii) achieve 100 % wastewater collection and treatment in urban and industrial areas, (iii) multi-use of water infrastructure; increased piped distribution; increased per capita use for rural productive use, (iv) promote sectoral integration and decentralized governance for effective home-grown solutions, (v) increase funding for permits and monitoring for equitable allocation and use.

A budget of USD 0.7 billion was also estimated for achieving a High Green Growth Scenario for the agriculture sector in 2030. The costs were estimated for (i) scaling up land and water husbandry best practices, (ii) mainstreaming agroecology into the Crop Intensification Programme, and (iii) strengthening the National Post-harvest and value-addition Capacity. Furthermore, the same CBA carried out in 2015, estimated USD 54.6 million to promote agroforestry by (i) promoting growing of multi-purpose agroforestry trees in all farming systems, (ii) availing improved seeds and other germplasms, (iii) upscaling forest management towards sustainability, (iv) promoting participatory forestry development and improved Charcoal Kilns, (v) strengthen forestry and agro-forestry research, (vi) promoting value addition technologies to wood and non-wood forest products and (vii) promoting urban forestry development in the secondary cities.

Notwithstanding that the above-mentioned projects may generate income; private companies are still reluctant to invest in them because it requires a high amount of money to undertake any of the projects on large scale. Fluctuations and inflation affecting the costs of equipment for the project implementation (e.g., solar PV, Small Hydropower (SHP), a plug-in hybrid electric vehicle (PHEV), rainwater harvesting, small irrigation technology, etc.) were seen as one of the economic and financial barriers making private companies hesitate to invest in them. High capital and maintenance costs, limited incentives and subsidies, the inexistence of local manufacturing units of raw materials for project implementation and competition with large scale government projects were also mentioned among the discouraging factors for the private

investors to be involved in sectoral climate change resilience projects. Moreover, a call is made to set appropriate mechanisms to overcome the above-mentioned challenges and barriers.

The involvement of key stakeholders at national and sub national level through the integration of climate change issues in their planning and budgeting is a key to successfully implement mitigation and adaptation actions. Additional support is required to extend existing climate change mainstreaming to sub national level.

5.3.2 Technical and capacity building needs

To deal with the above-mentioned constraints and gaps, particularly with the National GHG Inventory, there is a need for continuous and regular data collection and analysis for all sectors in close reference to 2006 IPCC guidelines. This requires additional training of national experts on the National Inventory Process, climate change mitigation and adaptation technologies as well as raising awareness of the communities on how to mitigate and adapt to climate change. There is also need for continuous climate change vulnerability assessments to inform government action towards building resilience and adapting to climate change.

Rwanda is also making efforts to improve and upgrade to Tier 2 reporting of GHG emissions and removals. Technical and capacity building support is, therefore, essential in development of country specific data, disaggregation of activity data, etc. Technical assistance is also needed in conducting quality assurance of sectoral GHG inventory reports and/or National Inventory Reports developed by national experts. In addition, in house capacity building for REMA as the GHG Inventory compiler is required towards improvement of GHG data management, documentation and archiving.

Technical Guidance and project support is required in assessment/tracking of progress of Rwanda's updated NDC actions. There is a need to assess regularly the progress made in achieving mitigation targets based on business as usual and mitigation scenarios at national and sectoral levels. This facilitates the Government of Rwanda to understand the aggregate impact of mitigation actions to be able to update the country's mitigation pathway. Monitoring mechanisms of the implementation of prioritized mitigation measures/technologies (e.g., implementation of renewable energy generation measures, low carbon transport measures, waste management projects, etc) should be put in place to assess timely achievements towards fixed targets.

Regular tracking of adaptation actions of the NDC by sector institutions and regular assessment of vulnerability and climate change adaptation are also key in achieving Rwanda's NDC target. There is need for support in impact evaluation of landscape restoration projects, Integrated Water Resource Management, etc. There is need for improvement of disaster preparedness and early warning system of extreme weather events at central/local administrative and community level. Technical knowledge and skills gaps of national institutions and key stakeholders such as the Red Cross Society Rwanda, National Police, etc need to be addressed.

Technology needs assessments conducted for urbanisation, industry, energy and agriculture showed various barriers to related to technical skills in adoption of climate technologies. Examples include irrigation in agriculture, installation and maintenance of green seed and green storage systems, designing and planning for development and diffusion of large solar photovoltaic systems, wastewater treatment and recycling, etc. National institutions in Rwanda and particularly, the private sector, need capacity building to better understand carbon market mechanism requirements and development of projects that enable them to benefit from the carbon market.

Chapter 6. Other information

6.1 Integration of environment and climate change into national planning

The Government of Rwanda has integrated climate change adaptation and mitigation into national plans and strategies through revision of the 2005 National Environment Policy and updating its Vision 2020. Through Rwanda's Vision 2050, Rwanda aspires to become an upper middle-income country by 2035 and high-income country by 2050. It also considers growth and development will follow a sustainable path in terms of use and management of natural resources while building resilience to cope with climate change impacts (MINICOFIN, 2020).

The National Environment and Climate Change Policy published in June 2019 identified key issues and challenges including high population density, water, air and soil pollution, land degradation, fossil-fuel dependency, high-carbon transport systems, irrational exploitation of natural ecosystems, lack of low-carbon materials for housing and green infrastructure development, inadequate waste treatment for both solid and liquid waste, an increase of electronic, hazardous chemicals and materials waste, among others. The policy goal is for "Rwanda to have a clean and healthy environment resilient to climate variability and change that supports a high quality of life for its society (MoE, 2019a). The policy is designed within the context of national, regional and global development commitments (such as Vision 2050 aspirations, National Strategy for Transformation (NST 1), Green Growth and Climate Resilience Strategy (GGCRS), Nationally Determined Contributions (NDCs), Sustainable Development Goals (SDGs), Agenda 2063, East African Community - EAC Vision 2050, etc.).

Specific objectives of the new Environment and Climate Change policy include greening economic transformation which will be achieved through creating favourable conditions to attract investments in green job creation and strengthening the use of environmental assessments (SEAs, EIAs) in productive investments and enforcing implementation of environmental management plans. The Rwanda Green Fund (FONERWA) for instance, has created up to 161, 552 green jobs and supported 44 projects.

The policy indicated how the climate change adaptation, mitigation and response will be promoted. This is being done through promotion of ecosystem-based approaches to climate change adaptation in local development agendas, afforestation and reforestation of critically-degraded and residential areas, renewable energy to achieve universal access to electricity and enforcement of air pollution emission standards and regulation. The Government of Rwanda is implementing projects such as LDCF II, which is using the Ecosystem based approach to build the resilience of communities living in degraded wetlands, forests and savannas in the districts of Gasabo, Kayonza, Ngororero and Bugesera. Landscape restoration projects such as Landscape Approach to Forest Restoration and Conservation (LAFREC) project in the Gishwati – Mukura has restored up to 1313.875 ha outside the protected area through planting of native tree species.

In this same regard, the revision of the 2011 Green Growth and Climate Resilience Strategy

(GGCRS) and updates of the State of Environment and Outlook Report (SOER) and Environment and Climate Change Sub Sector Strategic Plan are in their final stages.

6.2 Environmental technology transfer

6.2.1 Technology Needs Assessment

Rwanda through Rwanda Environment Management Authority (REMA) conducted the first Technology Needs Assessment (TNA) in Energy and Agriculture in 2012[2] as the key sectors for the economic development of the country and with the highest vulnerability to climate change. The purpose of TNA is to assist Rwanda to identify and analyse technology needs in mitigation and adaptation to climate change. Such technologies should be the basis for a portfolio of Environmentally Sound Technology (EST) projects and programmes. Therefore, there should be clear mechanisms for these ESTs. Therefore, REMA is currently conducting a second Technology Needs Assessment in urbanization and industry sectors as priority areas for National Strategy for Transformation (NST 1).

6.2.2 Enabling Environment and Mechanism for technology transfer

Rwanda currently putting in place the potential enabling environments for adopting and diffusion of environmentally sound technologies. In electric vehicles, the government set up incentives for encouraging the private sector and other practitioners to uptake e-mobility where for example the exemption of import and excise duties on electric vehicles, spare parts, batteries and charging station equipment and be treated as VAT zero rated products. The government have also promoted the clean energy use by households, commercial/institutional buildings by subsiding the use of LPG in cooking, to phase progressively phasing out the use of biomass use. It has also incentivised the local communities to adopt use of improved cooking stoves through distribution to pilot target groups in the Northern and southern Province (include the number of improved cook stove distribute through projects and its intervention areas). To diffuse the environmentally sound technology, Rwanda have adopted the green model village approach as a climate change adaptation intervention. This model involves establishment of low-carbon and climate resilience technologies, such as biogas and rainwater harvesting.

In addition, Rwanda has set up the institution frameworks that facilitate the adoption of green technologies for state and non-state actors. Through the Ministry of Trade and Industry, a Climate Innovation Centre was established at former Rwanda Resource Efficiency and Cleaner Production Centre (RRECPC); now known as the Cleaner Production and Climate Innovation Centre (CPCIC). The CPCIC works to ensure that all technologies, processes, services and choices made by the private and the public sector embrace the best practices in terms of climate change resilience and cleaner/efficient production.

[2] https://unfccc.int/ttclear/tna/reports.html

6.2.3 Capacity building for technology transfer programmes

The CPCIC offers the trainings on resource efficiency, cleaner production and climate technologies to improve industrial production processes and promote climate-friendly technologies. In addition, the Rwanda Agriculture and Animal Resource Board hosts a department of Crop Research and Technology Transfer which responsible for coordination, monitoring and implementation of Government policy related to Crop research and Technology Transfer through its programs and stations. It is responsible for increasing production of both Food and industrial crops through input use, adoption and training on good agriculture practices and innovative research and technology transfer to the farming community.

6.3 Climate Research and Systematic Observation

Meteo Rwanda has exponentially strengthened its capacity to respond to Rwandans needs including weather forecasting services, aviation, and climate services for economic sectors in Rwanda. The institution provides weather forecasts for a variety of end users including the general public and the agriculture sector.

Given the importance of weather and climate data for responding to climate change, significant investments have been made to boost the capacity of Meteo Rwanda. This has been done through an investment from the Rwanda Green Fund called 'Strengthening Rwanda's Weather and Climate Services to Support Development'. This initiative provided new monitoring equipment and increased the technical skills that lead to improvement of the range of weather and climate information available to inform decision making at all levels in Rwanda.

Other interventions were made by the Landscape Approach to Forest Restoration and Conservation (LAFREC) project implemented by REMA through the World Bank technical and financial support and it included a sub-component to improve the technical capacity of hydrologic/hydraulic assessment and flood forecasting. The project has developed a fully integrated early warning system (EWS) to reduce economic losses and risk to life in the flood-prone 286 km^2 Sebeya River Basin and a National Early Warning Platform that generates early warning alerts to be sent to end users in hazard prone regions.

Currently, there other important ongoing initiatives that are enabling Rwanda to better understand its climate today and more accurately predict how it will change into the future. For example, the Rwanda Climate Change Observatory was initiated in 2011 by the Rwanda Ministry of Education in collaboration with the Massachusetts Institute of Technology (MIT) to measure the greenhouse gases (GHG) and meteorological parameters as well as building skills in storing, processing and archiving GHG data from different sectors (REMA, 2021).

The Climate Change Observatory is part of WMO's Global Atmosphere Watch network measuring greenhouse gases and air quality. As a World Meteorological Organisation Global Atmosphere Watch station, it contributes to an international network of observation systems supporting the global response to climate change. This initiative has strengthened research on

climate change and atmospheric sciences, presented education opportunities for Rwandans and trained them on effective climate data maintenance and analysis.

In addition, the countrywide air quality monitoring system to provides data have been improved with twenty-three sites across the country. The Air Quality Monitoring System was developed through the Air Quality and Climate Change Monitoring Project, which has been funded by the Rwanda Green Fund (FONERWA). It was designed in collaboration with Massachusetts Institute of Technology and implemented by Rwanda Environment Management Authority and the Ministry of Education.

To ensure effective climate change adaptation, work is underway to build Rwanda's capacity to advance the national adaptation planning process and is being implemented by Meteo Rwanda and the Rwanda Environment Management Authority. One of the activities is climate change projections for Rwanda on different timescale such as 2030, 2040, 2050 and 2080. Those projections will be used to develop climate risk assessments and to inform policy-makers and planners about climate risks (REMA, 2021).

6.4 Education, training and public awareness

Research findings and other environmental and climate change information may be communicated through formal, non-formal and informal education, training and workshops or conferences/meetings. Since 2006, REMA has been involving schools in environment protection activities to equip the youth with necessary skills that would enable them to ensure a sustainable future for our country. Environmental clubs have been established in primary, secondary and higher learning Institutions.

The Department of Environmental Education and Mainstreaming (DEEM) in REMA is working with Rwanda Education Board (REB) to facilitate the implementation of environment and climate change topics mainstreamed in the Competence-Based Curriculum (CBC) through teaching and learning process. Teachers from secondary schools were trained together with the teachers from Technical and Vocational Education Training (TVET) schools. Training manuals were developed to facilitate the training of teachers. In 2019, REB and stakeholders developed a teacher guide and student textbooks with environment and climate change topics mainstreamed in the competence-based curriculum for Teacher Training Colleges (TTCs). The TTC curriculum was revised to align it to the Competence-Based Curriculum for basic education to prepare teachers who are competent and confident to implement CBC. It is within this context, REMA worked together with REB to mainstream ECC in the curriculum of TTCs.

In 2018, REMA trained students from higher Learning Institutions to mainstream environment and climate change and sustainable management of natural resources. Other training on mainstreaming environment and climate change targeted cooperatives of farmers, District planners, environmental committees at the sector level, religious-based organizations, Customs Officer and other law enforcement agents, district officials in charge of youth, sport and culture, civil society organizations and other stakeholders.

REMA developed monitoring and evaluation checklists for assessing the level of greening initiatives in schools, environmental clubs' activities to ensure that they are active and provide technical support. Furthermore, informal education programs were developed to raise environment and climate change awareness through competitions, debates, public lectures, field tours and training workshops and climate change in media reporting. Association for Journalists who report regularly on the environment and climate change was created.

In June 2019, one journalist, three students, three districts, three private companies and youth entrepreneurs were awarded while in 2020 only 5 youth entrepreneurs received their awards. In addition, REMA organized a football tournament between 4 districts (Rubavu, Rutsiro, Ngororero and Nyabihu district) and awarded the winning team. This tournament was an opportunity to raise awareness for the surrounding community on the protection of Gishwati-Mukura National Park and sustainable livelihood.
REMA in collaboration with Rwanda Polytechnic have developed a teacher training manual on environment and climate change topics integrated into TVET curriculum for level 3. Before dissemination of training manuals to schools, REMA conducted a pilot training of teachers from level 3 on the content captured in the manual. The training was organised to test the manual and to equip teachers with professional knowledge, attitudes and skills to enable them to teach environment and climate change topics effectively and confidently. This training manual serves as a guiding and supporting tool for teachers in the context of teaching environment and climate change contents mainstreamed.

Rwanda Polytechnic together with Akazi kanoze project implemented by EDC has initiated the development of agriculture curriculum for RTQF level 2. REMA supported the development of Safety, Health and Environment module to integrate environment contents in this curriculum for level 2. Curricula in Crop production, Livestock and Food processing were developed together with Basic Education (literacy, numeracy.) and soft skills (SHE, ICT. Trainer and trainee training manuals were developed for teaching the contents of curriculum. Also, in line of supporting the integration of ECC in school programme, REMA in collaboration with Rwanda Education Board, supported development of teacher guidebooks and students' textbooks of teacher training colleges curriculum for year 1 to years 3. All textbooks were completely developed are now used by teachers. To build capacity of teachers on new contents mainstreaming in TTC curriculum, REMA organised training Worksop of teachers in line to increase their knowledge on ECC and equip them with capacity to teach environment and climate change in all subjects.

REMA has also worked with Rwanda Environment Awareness Organization (REAO) which is an NGO implementing programs aiming to promote awareness, education, protection and conservation of natural resources through environmental education and actions. REAO worked with Nine Year Basic Education students and teachers through the training workshop, study tour for visiting natural places including the National Parks and support students to undertake actions to preserve and conserve natural resources. A training of schools (GS Gikondo, GS Kicukiro, GS Masaka, GS Remera Protestant and GS Gahanga, GS Rutunga, GS Bumbogo,) was conducted and visited Akagera National Parks. Schools were also engaged in World environment Celebration through competition and awarding the winners.

In line of engaging youth in green investment and innovation, REMA has organised a workshop for District Officials in charge of Culture, Youth, Sport and mapping youth innovation activities in District. Together with a developed training manual, a training of youth mapped from districts were trained on green investment and innovation towards sustainable use of national resources for socio-economic development and to encourages youth to integrate environment and climate change issues in their projects and initiatives and contribute to solving environmental problems. Youth were also introduced to the available opportunities and investment in environment and climate change.

In 2020, REMA in collaboration with UNDP convened a training workshop on the climate proofed rural settlement, to exchange on the lessons learnt, sharing experience on the challenges identified in the implementation of Integrated Development Programmes (IDP Model Village) and green villages and get prepared on the upcoming project of LDCFIII.

REMA has also developed training manuals on gender equality and gender mainstreaming in environment and climate change. This training manual has been developed to enhance the knowledge and gender mainstreaming skills in policy cycle, including gender analysis and the integration of gender –environment nexus into the design, planning and budgeting of high-priority sectors interventions for environment and climate change. This manual is particularly relevant for environment and natural resources-related interventions and practices that seek to promote participation and reduce the inequality that exists between natural resources-dependent women and men, especially among the poor or marginalized people living in rural areas. This training manual also aims to help trainers facilitate a learning process that focuses on the development of knowledge and skills to mainstream gender-environment into other strategies and policies interventions.

Through the National Environmental week 2019, REMA organised football tournament for district teams from Rubavu, Ngororero, Nyabihu and Rutsiro districts that bordering National Park of Gishwati-Mukura. The purpose of this tournament was to raise awareness on conservation and protection of environment and natural forest of Gishwati-Mukura. Training of Environmental clubs in HLIs through environmental awareness programmes and hands on activities, for imparting knowledge, skills and attitudes required to foster sustainable development among young people was organised and held at Rubavu District.

In line with increasing the capacity of national experts in government institutions, line ministries, higher learning institutions and private sector on climate change causes, impacts and climate action in Rwanda through BUR1 project a training workshop was organised for Higher learning lecturers and students to raise awareness on Multilateral Environment Agreement, sources of Ozone Depleting Substances (ODS), and Rwanda's role in implementation of the Climate Change Related Agreements. This workshop aims to build capacity of lecturers, research experts and students on the role of Rwanda in implementation of UNFCCC. Also, REMA in collaboration with Rwanda Agriculture Board (RAB) and Cultural Conservation Act (CCA) a local CSO conducted a training workshop for farmers members of CCA, in Musanze District, on green agriculture and advocate for the transition to a greener agriculture.

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