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SIMPLIFIED GUIDELINE ON CLIMATE CHANGE

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About this guideline

This guideline on climate change is a handbook on climate change and resilience which will be used by various stakeholders, especially CSOs partners of the CRA project funded by the European Union and implemented by a consortium led by CCOAIB and comprising of OXFAM and Duterimbere NGO for policy engagement, training of smallholder farmers and dissemination of knowledge in communities.

This handbook is complementary to other tools developed by this project including training modules and hand out in climate change and agro-ecology.

Contents

1. GENERAL INTRODUCTION TO CLIMATE CHANGE

Climate change refers to a change in the state of the climate that can be identified by changes in the mean and/or the variability of its properties and that persists for an extended period, typically decades or longer (IPCC, 2007). Climate change is global issue and felt at regional as well as national level. It is worth noting that changing climate affects everyone, but it is the world's poorest and those in vulnerable situations, especially women and girls, who bear the brunt of environmental, economic and social shocks. In 1992, 165 nations signed an international treaty, the UN Framework Convention on Climate Change (UNFCCC). They have held meetings annually ever since (called "Conference of the Parties" or COP), with the aim of developing goals and methods to reduce climate change as well as adapt to its already visible effects. Today, 197 countries are bound by the UNFCCC.

According to the Royal Society and the US National Academy of Sciences in their update 2020- Climate Change Evidence & Causes, the impacts of climate change on people and nature are increasingly apparent. Unprecedented flooding, heat waves, and wildfires have cost billions in damages. Habitats are undergoing rapid shifts in response to changing temperatures and precipitation patterns. The 2020 Global Risks Perception Survey from the World Economic Forum ranked climate change and related environmental issues as the top five global risks likely to occur within the next ten years. Yet, the international community still has far to go in showing increased ambition on mitigation, adaptation, and other ways to tackle climate change.

Since the mid-1800s, scientists have known that CO2 is one of the main greenhouse gases of importance to Earth's energy balance. Human activities have significantly disturbed the natural carbon cycle by extracting long buried fossil fuels and burning them for energy, thus releasing CO2 to the atmosphere. In nature, CO2 is exchanged continually between the atmosphere, plants, and animals through photosynthesis, respiration, and decomposition, and between the atmosphere and ocean through gas exchange. The CO2 level in 2019 was more than 40% higher than it was in the 19th century. Most of this CO2 increase has taken place since 1970, about the time when global energy consumption accelerated.

Like all Parties to the Paris Agreement, in May 2020, Rwanda has updated its Nationally Determined Contribution (NDC) to fulfill the commitments in its Nationally Determined Contribution (NDC) and achieve inclusive and sustainable development. These contributions are the instruments that guide Rwanda's climate action to limit the increase in global average temperature, raise global resilience and mobilize public and private investments. Collectively, our task is to move forward on a path towards sustainable development while balancing environmental, social and economic variables.

Climate change is causing enormous damage to the natural environment and has resulted in the loss of life and livelihoods. Recognizing the consequences of inaction, Rwanda remains steadfastly committed to the Paris Agreement and has dedicated the resources required to achieve substantial emissions reductions.

This guideline intends to provide essential information to community, especially to stakeholders of the CRA project funded by the European and implemented by a consortium led by CCOAIB and composed of Oxfam and Duterimbere NGO, required information towards better understanding the climate change and its impact on the livelihood and therefore increasing their awareness and commitment to improve sustainably the community climate resilience.

2. DEFINITION OF KEY TERMS

2.1. Weather

Weather is the collection of states of the meteorological factors that occur in the atmosphere at a specific period of time, such as sunshine or rain, hot or cold, damp or dry, etc. Weather refers to the state of the atmosphere, including temperature, atmospheric pressure, wind, humidity, precipitation, and cloudiness

2.2. Climate

Climate is the average state of the weather in a certain area, i.e. a province, a country or a continent based on history data series (by month or back to millions of years ago, usual evaluation is 30 years – according to the World Meteorological Organization - WMO). Climate describes the typical weather conditions in an entire region for a very long time — 30 years or more. Climate means all weather conditions for a given location over a period of time. Climate is the long-term pattern of weather in a particular area. A region's weather patterns, usually tracked for at least 30 years, are considered its climate.

2.3. Climate Change

Climate change is a long-term shift in global or regional climate patterns. Often climate change refers specifically to the rise in global temperatures from the mid-20th century to present. Climate is sometimes mistaken for weather. But climate is different from weather because it is measured over a long period of time, whereas weather can change from day to day, or from year to year. Climate change may cause weather patterns to be less predictable. These unexpected weather patterns can make it difficult to maintain and grow crops in regions that rely on farming because expected temperature and rainfall levels can no longer be relied on. Climate change has also been connected with other damaging weather events such as more frequent and more intense hurricanes, floods, downpours, and winter storms.(National Geographic Society, May 2022: https://education.nationalgeographic.org/resource/climate-change).

Climate change is a change in climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods. (UNFCCC).

The following working definitions have been used in this Strategy and are taken directly from DFID documentation. "Climate change is a new and constantly evolving agenda. There is continuing discussion between stakeholders, not least within the international negotiations, as to what is really meant by terms like adaptation and mitigation.

2.4. Climate System

Different parts of the world have different climates. Some parts of the world are hot and rainy nearly every day. They have a tropical wet climate. Others are cold and snow-covered most of the year. They have a polar climate. Between the icy poles and the steamy tropics are many other climates that contribute to Earth's biodiversity and geologic heritage. A climate system has five major components: (i) the atmosphere, (ii) the hydrosphere, (iii) the cryosphere, (iv) the land surface, and (v) the biosphere. The atmosphere is the most variable part of the climate system.

The composition and movement of gases surrounding the Earth can change radically, influenced by natural and human-made factors. Among natural factors, there are topography and vegetation and biosphere.

The topography and vegetation influence climate by helping determine how the Sun's energy is used on Earth. The abundance of plants and the type of land cover (such as soil, sand, or asphalt) impacts evaporation and ambient temperature.

The biosphere is the sum total of living things on Earth and profoundly influences climate. Through photosynthesis, plants help regulate the flow of greenhouse gases in the atmosphere. Forests and oceans serve as "carbon sinks" that have a cooling impact on climate.

Living organisms alter the landscape, through both natural growth and created structures such as burrows, dams, and mounds. These altered landscapes can influence weather patterns such as wind, erosion, and even temperature

2.5. Climate Mitigation

Climate mitigation is an action taken to stop climate change by reducing the amount of greenhouse gasses in the atmosphere. The goal of mitigation is to avoid significant human interference with Earth's climate, "stabilize greenhouse gas levels in a timeframe sufficient to allow ecosystems to adapt naturally to climate change, ensure that food production is not threatened, and to enable economic development to proceed in a sustainable manner" (from the 2014 report on Mitigation of Climate Change/ the United Nations Intergovernmental Panel on Climate Change, page 4).

2.6. Climate Adaptation

Climate adaptation is an action taken to deal with climate change impacts and reduce the effects on lives, livelihoods and ecosystems. Given the scale of climate change, and the fact that it will affect many areas of life, adaptation also needs to take place on a greater scale. Our economies and societies as a whole need to become more resilient to climate change impacts. This will require large-scale efforts, many of which will be orchestrated by governments. Roads and bridges may need to be built or adapted to withstand higher temperatures and more powerful storms. Some cities on coastlines may have to establish systems to prevent flooding in streets and underground transport. Mountainous regions may have to find ways to limit landslides and overflow from melting glaciers. Some communities may even need to move to new locations because it will be too difficult to adapt. This is already happening in some island countries facing rising seas. (https://www.un.org/en/climate change/climate-action)

2.7. Greenhouse Gas

Greenhouse gases are gases in the Earth's atmosphere that produce the greenhouse effect. Changes in the concentration of certain greenhouse gases, from human activity (such as burning fossil fuels), increase the risks of global climate change. Greenhouse gases include water vapor, carbon dioxide (CO2), methane, nitrous oxide, halogenated fluorocarbons, ozone, perfluorinated carbons, and hydro fluorocarbons. These gases surround and insulate the Earth like a blanket. They allow the sun to reach and warm the Earth's surface then block the warmth from escaping back into space. Human activities, including those mentioned above, have continued to increase and have upset the balance of the natural system for several greenhouse gases: methane, nitrous oxide, fluorinated gases and especially carbon dioxide. As these gases continue to be emitted into the atmosphere, they form a thicker layer. And just like the blanket, the thicker it is, the more heat it holds.(Terry Gibb, Michigan State University Extension - December 21, 2015)

3. OVERVIEW OF CLIMATE CHANGE

3.1. Global overview

3.1.1. Greenhouse Gases Emission

Increases in the atmospheric concentrations of these gases cause Earth to warm by trapping more of this heat. Human activities—especially the burning of fossil fuels since the start of the Industrial Revolution—have increased atmospheric CO2 concentrations by more than 40%, with over half the increase occurring since 1970. Since 1900, the global average surface temperature has increased by about 1 °C (1.8 °F). This has been accompanied by warming of the ocean, a rise in sea level, a strong decline in Arctic sea ice, widespread increases in the frequency and intensity of heat waves, and many other associated climate effects. Much of this warming has occurred in the last five decades. Detailed analyses have shown that the warming during this period is mainly a result of the increased concentrations of CO2 and other greenhouse gases

3.1.2. The Climate Is Warming

The Earth's average surface air temperature has increased by about 1 °C (1.8 °F) since 1900, with over half of the increase occurring since the mid-1970s [Figure 1a]. A wide range of other observations (such as reduced Arctic sea ice extent and increased ocean heat content) and indications from the natural world (such as pole ward shifts of temperature-sensitive species of fish, mammals, insects, etc.) together provide incontrovertible evidence of planetary-scale warming.

Since the mid-1800s, scientists have known that CO2 is one of the main greenhouse gases of importance to Earth's energy balance. Direct measurements of CO2 in the atmosphere and in air trapped in ice show that atmospheric CO2 increased by more than 40% from 1800 to 2019. Measurements of different forms of carbon (isotopes) reveal that this increase is due to human activities. Other greenhouse gases (notably methane and nitrous oxide) are also increasing as a consequence of human activities. The observed global surface temperature rise since 1900 is consistent with detailed calculations of the impacts of the observed increase in atmospheric greenhouse gases (and other human-induced changes) on Earth's energy balance

3.1.3. CO2 emissions from human activity is significant

Human activities have significantly disturbed the natural carbon cycle by extracting long buried fossil fuels and burning them for energy, thus releasing CO2 to the atmosphere. In nature, CO2 is exchanged continually between the atmosphere, plants, and animals through photosynthesis, respiration, and decomposition, and between the atmosphere and ocean through gas exchange.

The CO2 level in 2019 was more than 40% higher than it was in the 19th century. Most of this CO2 increase has taken place since 1970, about the time when global energy consumption accelerated. Deforestation and other land use changes have also released carbon from the biosphere (living world) where it normally resides for decades to centuries.

The additional CO2 from fossil fuel burning and deforestation has disturbed the balance of the carbon cycle, because the natural processes that could restore the balance are too slow compared to the rates at which human activities are adding CO2 to the atmosphere. As a result, a substantial fraction of the CO2 emitted from human activities accumulates in the atmosphere, where some of it will remain not just for decades or centuries, but for thousands of years.

3.1.4. Sources of human-emitted greenhouse gases

■ Carbon dioxide (CO_2)

It has both natural and human sources, but CO_2 levels are increasing primarily because of the combustion of fossil fuels, cement production, deforestation (which reduces the CO_2 taken up by trees and increases the CO_2 released by decomposition of the detritus), and other land use changes. Increases in CO_2 are the single largest contributor to global warming.

■ Methane (CH_4)

It has both human and natural sources, and levels have risen significantly since pre-industrial times due to human activities such as raising livestock, growing paddy rice, filling landfills, and using natural gas (which is mostly CH_4 , some of which may be released when it is extracted, transported, and used).

■ Nitrous oxide (N_2O)

Its concentrations have risen primarily because of agricultural activities such as the use of nitrogen-based fertilisers and land use changes.

■ Halocarbons, including chlorofluorocarbons (CFCs)

These are chemicals used as refrigerants and fire retardants. In addition to being potent greenhouse gases, CFCs also damage the ozone layer. The production of most CFCs has now been banned, so their impact is starting to decline. However, many CFC replacements are also potent greenhouse gases and their concentrations and the concentrations of other halocarbons continue to increase.

3.1.5. Other human causes of climate change

In addition to emitting greenhouse gases, human activities have also altered Earth's energy balance through, for example:

■ Changes in land use.

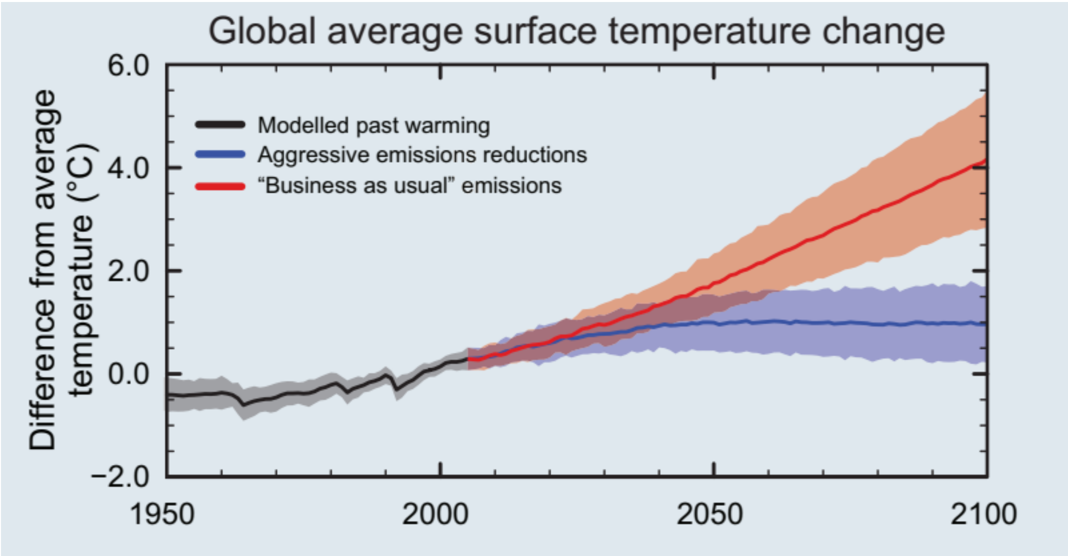
Changes in the way people use land — for example, for forests, farms, or cities — can lead to both warming and cooling effects locally by changing the reflectivity of Earth's surfaces (affecting how much sunlight is sent back into space) and by changing how wet a region is.

■ Emissions of pollutants (other than greenhouse gases).

Some industrial and agricultural processes emit pollutants that produce aerosols (small droplets or particles suspended in the atmosphere). Most aerosols cool Earth by reflecting sunlight back to space. Some aerosols also affect the formation of clouds, which can have a warming or cooling effect depending on their type and location. Black carbon particles (or "soot") produced when fossil fuels or vegetation are burned generally have a warming effect because they absorb incoming solar radiation.

3.1.6. Prediction of climate change in the future

Scientists have made major advances in the observations, theory, and modelling of Earth's climate system, and these advances have enabled them to project future climate change with increasing confidence. Taken together, all model projections indicate that Earth will continue to warm considerably more over the next few decades to centuries. If there were no technological or policy changes to reduce emission trends from their current trajectory, then further globally averaged warming of 2.6 to 4.8 °C (4.7 to 8.6 °F) in addition to that which has already occurred would be expected during the 21st century as shown in the figure below.



Source: IPCC; 2007

3.1.7. Some consequences of climate change

Earth's lower atmosphere is becoming warmer and moister as a result of human-caused greenhouse gas emissions. This gives the potential for more energy for storms and certain extreme weather events. Consistent with theoretical expectations, the types of events most closely related to temperature, such as heat waves and extremely hot days, are becoming more likely. Heavy rainfall and snowfall events (which increase the risk of flooding) are also generally becoming more frequent.

A warming climate can contribute to the intensity of heat waves by increasing the chances of very hot days and nights. Climate warming also increases evaporation on land, which can worsen drought and create conditions more prone to wildfire and a longer wildfire season. A warming atmosphere is also associated with heavier precipitation events (rain and snowstorms) through increases in the air's capacity to hold moisture. El Niño events favour drought in many tropical and subtropical land areas, while La Niña events promote wetter conditions in many places. These short-term and regional variations are expected to become more extreme in a warming climate.

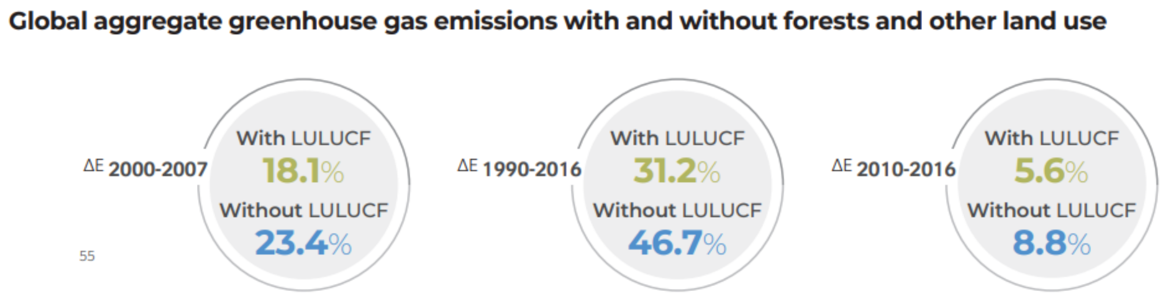
3.1. 8. Climate change message of the United Nations

"Our goals are clear and the science is non-negotiable. We must limit global temperature rise to 1.5 degrees and, on the road to doing so, achieve climate neutrality by 2050. This must be done urgently and cooperatively; a global project requiring the best efforts from all nations, all businesses and all people. The next two years offer a crucial window of opportunity for all nations—as well as non-State actors—to capitalize on our current framework, build on our existing momentum and make the changes we desperately need to avoid a climate catastrophe." By Patricia Espinosa, Executive Secretary of UN Climate Change, in UN climate change 2019 Climate action and support trends.

The data submitted by Parties indicate that global aggregate GHG emissions in 2016 totalled 49.05 Gt CO2 eq without emissions and removals from forests and other land use and 50.81 Gt CO2 eq with emissions and removals from forests and land use, putting global aggregate GHG emissions with and without forests and other land use in 2016 at 31.2 and 46.7 per cent, respectively, above the 1990 level.

The figure below shows the evolution of aggregate annual GHG emissions from 2000 to 2016 against the 1990 emission level. The increasing emission trend can be divided into three distinct periods in which the rate of emission growth was markedly different: » 2000–2007: rapid emission growth, averaging 2.4 and 3.1 per cent per year with and without forests and other land use, respectively; » 2008–2009: stabilization of emissions, with close to zero growth.

Figure: Global aggregate greenhouse gas emissions with and without Land Use, Land Use Change and Forestry (LULUCF)



Source: UN climate change, 2019

3.2. Climate change in Rwanda

The Government of Rwanda (GoR) is among the countries, which have ratified the United Nations Framework Convention on Climate Change (UNFCCC), and one among the first countries to sign and ratify the Paris Agreement COP21. This demonstrates its willingness, being a responsible member of the global community, to seek and achieve global solutions on climate change. One of the current major concerns of mankind is climate change. These are attributed directly or indirectly to human activities which lead to the increased emission of greenhouse gases (CO2, N2O, CH4, CO, NOx, NMVOC). It should be noted that these activities are directly related to economic development of different countries including Rwanda (Rwanda Third National Communication on Climate Change – 2018). The Ministry of Environment (MoE) is the key institution in charge of making policies and programmes related to the environment and climate change and the Rwanda Environment Management Authority (REMA) is the regulatory agency tasked to coordinate the implementation of those policies and programmes.

3.2.1. Location challenge

According to National Strategy on Climate Change and Low Carbon Development for Rwanda Baseline Report (2011), Rwanda is located astride two key climate regions, East Africa and Central Africa, with contrasting controls and drivers on climate. As a result the region is difficult to simulate in climate models, and climate projections are uncertain. Climate model scenarios show future increases in mean annual temperature of up to 3.25°C for the region by the end of the century. Changes in rainfall are more uncertain, though most of the models show that rainfall will increase.

3.2.2. Climate variability and underlying factors

The existing climate variability has significant economic costs in Rwanda. Periodic floods and droughts already cause major socioeconomic impacts and constitute an external shock that reduces economic growth. The physical impacts and economic costs of current climate variability and events in Rwanda are already very significant. The country has high land use pressures coupled with erosion from steep slopes, along with floods and rains, and in some eastern regions there are desertification trends due to droughts. Extreme events have had dramatic impacts across the key economic sectors of agriculture, infrastructure and health.

Factors contributing to Rwanda's underlying vulnerability include:

- High levels of poverty and low adaptive capacity

- High population density and shrinking land availability

- Reliance on rain-fed and low input agriculture for 90% of households

- Reliance on biomass energy

- Severe land and resource degradation.

The GoR has responded to the unplanned environmental degradation with a number of projects, including a national tree planting scheme and wetland restoration, for which Rwanda won the Green Globe Award in 2010.

Figure: projection of temperature and precipitation increase by 2080

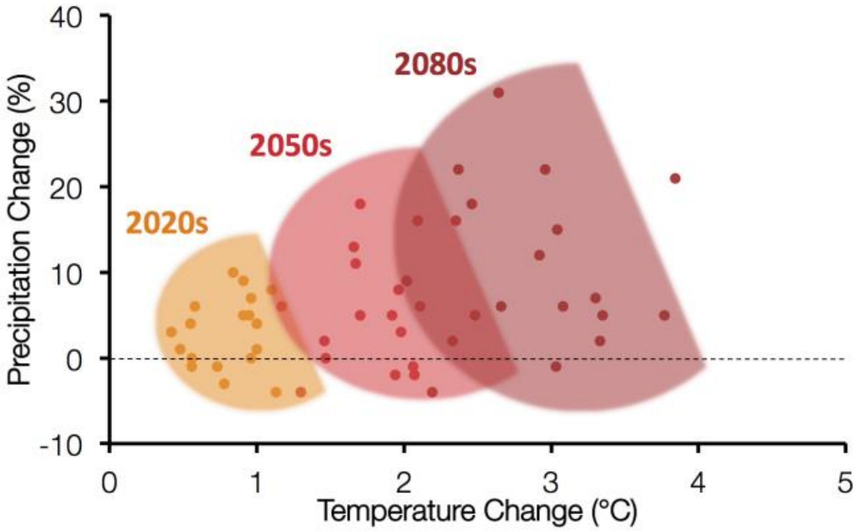


Figure 7: Predicted* annual change in temperature (°C) and precipitation for Rwanda for the 2020s, 2050s and 2080s.

*Projections are taken from the A1B scenario of 19 GCMs from CMIP3

Source: GoR, Green Growth and Climate Resilience National Strategy for Climate Change and Low Carbon Development Kigali October 2011

3.2.3. Rwanda's Greenhouse Gas (GHG) Emissions

According to Rwanda Third National Communication on Climate Change – 2018 (September 2018), During the period between 2006 and 2015, the dynamic of Rwanda's GHG emissions with and without FOLU showed an increasing trend with average annual increases 4.54 % and 4.8%, respectively, while net GHG removals showed a nearly constant trend with an annual increase of 0.63%. During the whole period, GHG emissions from AFOLU had a dominant contribution to net emissions, resulting in a net carbon sequestration. The increase in GHG emissions could be attributed to the growing Rwandan economy, the change in lifestyle, and the modernization of the agricultural sector. Rwanda recorded a rapid increase in GHG emissions during the period between 2014 and 2015. The GHG intensity (i.e., the amount of GHG emitted per GDP) decreased from 14.4 Gg/USD in 2006 to 10.54 Gg/USD. This decrease could be explained by the rapid increase in Rwandan economy. During the same period the GDP increased from USD 333 to USD 720. The increase in GDP was estimated at 53.75 % between 2006 and 2015, while that of GHG emissions was only 36.83 %. In addition, the GHG emissions per capita have increased from 532.39 to 676.23 kg per capita with an annual increase of 2.46% during the same period of time.

3.2.4. GHG Emission from some sectors

(a) Energy sector

Estimated GHG emissions from energy sector between 2006 and 2015 showed an increasing trend with an annual increase of 4.2%. The analysis of key gases revealed that the sectors – Biomass (CH_4), Road Transportation (CO_2), Energy Industries - Liquid Fuels (CO_2), Manufacturing industries and construction-liquid fuel (CO_2), Other Sectors – Biomass (N_2O), Sectors - Liquid Fuels (CO_2) are the top contributors to total GHG emissions from the energy sector.

(b) Industrial Processes and Product Use (IPPU) sector

During the period between 2006 and 2015, the IPPU sector had the least contribution to total GHG emissions in Rwanda. Overall greenhouse gas emissions in the IPPU sector have gradually increased during the ten-year period at an annual growth rate of 8 %. The gas-per-gas analysis showed that the main gas emissions were from carbon dioxide, which contributed 94% of the total emissions in ten years average. Whereas HFCs were only generated from the product use as substitute for ozone depleting substances, the CO_2 emissions were generated by mineral industries, metal industries, and nonenergy products from fuel and solvent use.

(C) Agriculture, Forestry and Other Land Use (AFOLU) sector

The GHG emissions in agriculture and livestock were estimated for enteric fermentation of livestock, manure management, and agricultural practices consisting of rice cultivation and mineral nitrogen fertilizer applications to soil, manure, compost and crop residues applications to soil, nitrogen mineralization in freshly cultivated soil following land use change, organic soils, urine and dung deposited on pastures and paddock, atmospheric volatilization of nitrogen from managed soils and manure management, leaching and runoff. AFOLU sector has more carbon sequestered than emitted and forests are the most important carbon sinks. During the period between 2006 and 2015, the dynamic of GHG emissions/removals from AFOLU sector showed fluctuating trend with an annual average increase of 2.37%. While FOLU had a modest increase of 0.63%, agriculture subsector showed a fluctuating trend with an annual average in emissions of 5.03 %. The annual average increase of 2.37 % was observed for the total GHG emission with AFOLU.

(d) Waste sector

Considering the period 2006-2015, the total annual emissions from waste sector have respectively increased from 362.26 Gg CO_2-eq to 637.27 Gg CO_2-eq. Comparing emissions source per subcategory, it has been evidenced that emissions from wastewater treatment and discharge subcategory are the highest with the contribution of 54.29 % to the total GHG emissions from waste sector followed by emissions from biological treatment of solid waste (28.23 %), solid waste disposal (17.23%) and incineration with negligible contribution of 0.25% in 2012.

3.2.5. GHG emissions projections by 2050 for agriculture and forestry sectors

(a) Agriculture

- Crop sub-sector

The crop sub-sector, accounting for more than 67% of GHG emissions in 2015, is projected to grow at the rate of 5% for business as usual. The major source of GHG emissions in the crop subsector is mineral fertilizer use through urea application. Under the BAU scenario, the GHG emissions from crop sub-sector will increase from 2,066.00 Gg CO2-eq. in 2012 to 8,354.00 Gg CO2-eq. in 2050

- Livestock sub-sector

Livestock, which was contributing less than 36% of the total Agriculture emissions in 2015, will most probably grow slowly due to limited resources for its further expansion, especially, large stock. The BAU scenario assumes implementation of current policies and GHG emissions trend prior to 2015, which is 3.3% annual increase. Under the BAU scenario, the GHG emissions from livestock will increase from 1,876.00 Gg CO2-eq. in 2012 to 3,780.00 Gg CO2-eq. in 2050 .

- Forestry and other land use

The business as usual (BAU) scenario for Forestry and Other Land Use assumes implementation of current policies and GHG emission removals trend prior to 2015, which is 0.6% annual increment, and increase of forest cover until 30% of country land area is reached. Under the BAU scenario, the GHG emission removals from Forestry and Other Land Use will increase from - 11,219.10 Gg CO2eq. in 2012 to -13,594.80 Gg CO2eq.

3.2.6. Climate change Mitigation in energy, agriculture and forestry sectors

(a) Energy sectors

- Electric power generation

The main mitigation scenario is the use of large renewable energies (Large hydro and solar PV plants) scenario. Compared to the BAU (business as usual) scenario, the electricity supply mitigation scenario is projected to generate a cumulative emissions reduction of 20,377.80 Gg CO2-eq. by 2050

- Energy use in industries

The mitigation scenario essentially consists in increasing efficiency in manufacturing processes in different industries. The implementation of mitigation measures will decrease the GHG emissions from various industries from 1,170.82 GgCO2-eq. in 2012 to 1,087.56 Gg CO2-eq. in 2050 (Table ES.3.2). This will result in a cumulative reduction of 884.75 Gg CO2-eq. by 2050

- Buildings

The proposed mitigation scenario also referred to as efficient building consists of the efficient and sustainable use in residential and commercial buildings, the use of the efficient lighting and the use of solar heaters for hot water in buildings. By the year 2050, the GHG emissions are projected to reduce from 6,145.42 GgCO2-eq. to 3,463.04 Gg CO2-eq. (Table ES.3.2). That is a cumulative GHG emissions reduction of 38,993.79 Gg CO2-eq.

(b) Agriculture

- Crop sub-sector

Major mitigation options in the crop sub-sector include replacement of urea by less volatile N fertilizers, more judicious use of fertilizers based on soil maps and specific crop requirements, and development of large quantity and high quality compost production, farmer training and compost quality control system to largely reduce N losses. Under the medium mitigation option A, the GHG emissions from the crop sub-sector will increase from 2,066.0 Gg CO2-eq in 2012 to 7,194.0 Gg CO2-eq in 2050

- Livestock sub-sector

Major mitigation options in the livestock sub-sector include replacement of local cows with the improved ones and reducing their number while maintaining milk production level, promotion of biogas and collective farm holdings, as well as building manure storage facilities and training in improved cow and manure management. Two mitigation scenarios were considered:

- ✓ Option A with Girinka scheme to medium levels (improved cow, better feed and biogas plants) and ;
- ✓ Option B with Girinka scheme to maximum levels with higher adoption and outscaling of the technologies (more improved cow, better feed and biogas plants).

Under the medium mitigation option A, the GHG emissions from livestock will increase from 1876 Gg CO2-eq in 2012 to 2466 Gg CO2-eq in 2050.

- ➢ Forestry and other land use

Based on strategies outlined in the government policy and program documents, major mitigation measures in Forestry and Other Land Use will include:

(i) Development of agroforestry for sustainable agriculture which will enable increasing the number of trees (multi-purpose trees) on farm per hectare;
(ii) Promotion of afforestation and reforestation of designated areas through improved germplasm and technical practices in planting and effective post-planting operations (maintenance/tending activities),
(iii) Rehabilitation and improved forest management of degraded forest resources,
(iv) Efficient wood conversion and sustainable biomass energy.

Under the mitigation option A, the GHG emission removals from Forestry and Other Land Use will increase from -11,219.1 Gg CO2-eq in 2012 to -26,150.3 Gg CO2-eq in 2050.

3.2.7. Climate change adaptation in agriculture, livestock and forestry sectors

(a) Agriculture

Since the 80s, the Rwanda country's agricultural sector faces a series of unique constraints. Because of a high population density and limited land resources, where most farmers mostly practice rain-fed agriculture (the use of organic and non-organic fertilizers is insufficient for nutrient replenishment).

The Rwanda Third National Communication on Climate Change – 2018 report provided a synthesis of vulnerability assessment and proposed adaptation strategies in Agriculture, Livestock and Forestry is provided in the table 4 below. The performance indicators are grouped in seven categories namely food security (yield), access to water for the sector, employment in the sector, health of people in the sector, rural infrastructure to access the production, economic growth and export from the sector.

Table: Synthesis of vulnerability assessment and adaptation strategies in Agriculture, Livestock and Forestry sector

Performance indicators	Climate indicators	Climate impacts (vulnerability)	Adaptation options
FOOD SECURITY	Rainfall and humidity	- Reduced water availability for irrigation. - Increased runoff, nutrient leaching and water loss due to rain variability - Reduced yield and production of crops, animal	- Incentivise mechanisation - Strengthen soil protection on slopes, in villages and roads; - Promote IFSM,

Performance indicators	Climate indicators	Climate impacts (vulnerability)	Adaptation options
		feed and livestock. - Reduced rainy days will reduce total water quantity absorbed/ retained by soil. - Greater rainfall quantity in one rain will likely destroy/damage the existing soil conservation structures, increase erosion, landslide risks and flooding, and reduce quantity of water for rain harvesting structures	irrigation and rain water harvesting; - Breed and disseminate varieties more resistant to pests and diseases; - Promote multipurpose trees; higher nutritive crops and fodder; - Broadcasting of weather forecasts and sowing dates; - Develop precise fertiliser recommendations; - Use IT for extension requests and feedback from farmers; - Promote drip irrigation and closed greenhouse systems; - Use private sector for input and training delivery
	Temperature	- Increased populations of crop and livestock pests; - Increased diseases; - Lower productivity of crops adapted to cool climate; - Increased water evaporation from crop foliage and soil	- Develop multi-cropping, rotation and system approach; - Zero tillage and mulch use; - Crop-Tree-Livestock integration; - Resource allocation from large to small stock; - Develop new feed formulations and alternative feeds - Expand aquaculture & poultry; - Reduce cattle and use more productive crossbreeds;

Performance indicators	Climate indicators	Climate impacts (vulnerability)	Adaptation options
			- Promote cooperative cattle farms; - Strengthen disease diagnostic, prevention and surveillance.
	Wind storms	Increased destruction of taller crops (e.g. banana, maize) and sometimes trees	Develop adapted crop varieties; creation of windbreaks using agroforestry
	Hailstones	Crop damage/destruction; yield reduction	- Mapping where this happens; - Promote thicker leaves crops
Access to water in the sector	Rainfall and humidity	Reduced water supply, - competition for use of water	- Incentivize rainwater harvesting; - Expand investment in water harvesting at settlement and community levels
	Extreme events	Disruption of infrastructure (e.g. water pollution)	Plan for higher cost of infrastructure maintenance
Employment in the sector	Rainfall and humidity	- With higher risks for agricultural production under climate impact, some labor will be attracted to other sectors such as forestry and mining. - Anthropogenic stress and increased deforestation and forest degradation due to climate hardships (e.g. crop failure due to drought)	- Promote technologies to offset the risks of agricultural production and other challenges; - Create rural non-agricultural employment and small businesses (e.g. in food processing); - Expand loans in agriculture sector as well as weather related crop insurance
	Temperature	With higher risks for agricultural production under climate impact, some labor will be attracted to other sectors.	Promote technologies to offset the risks of agricultural production and other challenges
Health of people in the sector	Rainfall and humidity	- Along with climate change/ increase of pests and disease vectors for crops, there may be increase of population of disease vectors (e.g. malaria), and more people employed in agriculture may be sick	Develop new strategies for disease vector control and prevention

Performance indicators	Climate indicators	Climate impacts (vulnerability)	Adaptation options
	Temperature	Along with climate change/ increase of diseases for crops, human disease vector increase (e.g. malaria) may affect human health	-Develop new strategies for disease vector control and prevention
Rural infrastructure	Rainfall and humidity	-The existing infrastructure was built without consideration for increased rainfall intensity and may now be destroyed/ damaged with heavy rainfall	Plan for higher maintenance cost for infrastructure and its renewal and expansion
	Temperature	Temperature increase will result in higher heating of tarmac roads and their shorter life	Plan for more frequent road repair/ maintenance
Environmental degradation	Rainfall and humidity -;	-Reduced forest productivity due to drought and extreme climate events (e.g. wind throws, floods and fires) will lead to clearing of more forests to meet demand of forest products	- Capacity building of forest product users; - Efficient use of forest products -Improve forest productivity
	Temperature -	- The risk of forest fire is expected to increase with increased temperatures and erratic precipitations due to climate change. Although increased CO2 will lead to increased productivity in some regions, increased temperature will likely increase tree stress particularly in arid or semi-arid areas, reducing their productivity and leading to dieback. - Water catchments will be affected by rainfall decline	- Planting more fire resistant tree species in fire prone areas -Taking precaution to prevent bush fires through creating and maintaining firebreaks in forests -Water harvesting technologies should be promoted
Economic growth	Rainfall and humidity	- Higher rainfall intensity will increase soil loss and nutrient leaching from soil, thus challenging agricultural productivity growth - Water stress and long droughts will likely favour some pests and diseases in forests	- Promote IFSM and precise fertilizer application; -Develop nutrient efficient varieties - Develop IPM strategies in forests -Carry out research and promote plantation of drought and pests resistant tree species -Plant the right tree species to the right place
	Temperature	- Higher temperature will lead to switch to crops with higher optimum temperature - Some forest species may not cope with increased temperatures. - Increased temperature and drought conditions may lead may lead to increased susceptibility of some tree species to pests and diseases	-Plan for crop change and make a roadmap for where this change has to happen -Use tree species adapted to local conditions during reforestation – Carry out silvicultural/ maintenance activities as per schedule - Plant the right tree species to the right place susceptibility of some tree

Performance indicators	Climate indicators	Climate impacts (vulnerability)	Adaptation options
			species to pests and diseases
Export from the sector	Rainfall and humidity.	- Increased rainfall will positively impact coffee, tea and banana production. - Some forest and horticultural crops will benefit too	-Prepare quality control and new market niches for increased coffee, tea, horticultural production, poles and lumber -Develop food processing industries
	Temperature - -	- Temperature increase will negatively affect tea and coffee production, but banana will produce in shorter cycle	- Develop value chain for increased banana production - Promote agroforestry in coffee and tea plantations

Source: Rwanda Third National Communication on Climate Change – 2018

3.2.8. Disasters are expected to increase

Recent studies in Kenya done by the Center for Tropical Agriculture (CIAT)in 2011 have predicted that temperature rise would increase the optimum altitude for growing tea from between 1,500m and 2,100m metres above sea level (masl) to between 2,000m and 2,300m by 2050. It means that Coffee and tea, Rwanda's cash crops, are likely to require higher altitudes as temperatures increase, which may reduce the amount of suitable land available due to differing soils and steeper slopes. It could also cause land use conflict as small-scale farmers of alternative crops, such as maize, cabbage, peas and passion fruit, compete for land with tea and coffee producers.

Climate change could affect water security and food security, and as a result, could increase levels of poverty and force subsistence farmers into informal urban settlements. Rwanda's energy security may be at risk as hydropower contributes 50% of electricity, making it vulnerable to variation in rainfall and evaporation. Droughts reduce generating capacity of hydroelectric dams, and floods increase soil erosion and siltation which can damage dams. A good example of this is the drought in 2004 in Rwanda which reduced hydropower capacity so much so that the government was forced to rent diesel power plants to meet domestic demand.

: Disaster effects in Rwanda (2016-2018)

Disaster effects	2016	2017	2018
Deaths	183	82	254
Injured	172	151	346
Houses damaged	5,821	5,802	15,910
Crops (Ha)	7,449	5,277.1	13,337.21
Live stock	932	590	815
Class rooms	82	203	73
Health centers	2	3	3
Roads	2	13	32
Churches	6	37	27
Bridges	40	49	64
Admin offices	13	18	12
Water supply	39	10	1
Transmission lines	2	79	26

Source: Ministry of Emergency Management, annual reports (2016-2018)

3.2.9. Coping with climate vulnerability and SDG 13 domestication in Rwanda

(a) Regulatory framework

According to 2019 Rwanda Voluntary National Review (VNR) report under UNSDGs:

- ✓ the Government of Rwanda (GoR) is among the countries, which have ratified the United Nations Framework Convention on Climate Change (UNFCCC), and
- ✓ one among the first countries to sign and ratify the Paris Agreement COP21 as well as ,
- ✓ the Kigali amendment to the Montreal protocol.

This demonstrates its willingness, being a responsible member of the global community, to seek and achieve global solutions on climate change. Rwanda has also submitted its Nationally Determined Contribution (NDC) to UNFCCC and developed NDC Partnership with key identified priorities to fast-track implementation

The Government of Rwanda recently approved:

- ❑ Revised National Environment and Climate Change Policy (2019) ,
- ❑ Revised National Land Policy (2019)

These policies aim at:

- ✓ Emphasizing on greening economic transformation;
- ✓ Enhancing functional natural ecosystems and;
- ✓ Managing biosafety and promoting climate change adaptation, mitigation and response among others.

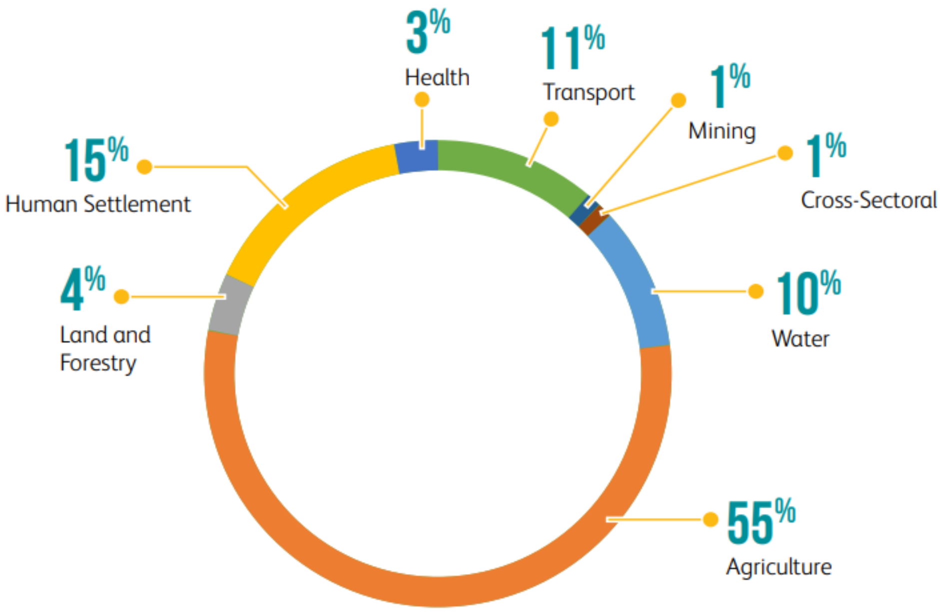
The GoR has also approved:

- ❑ The Revised National Land Policy (2019) aiming at strengthening land administration and management to ensure optimal allocation and use of land.
- ❑ The National Disaster Management Policy was adopted in 2012, providing an overarching framework for decision-making and coordination across disaster management sectors and actors, including government ministries, civil society organizations, international organizations and the private sector.

(b) The Rwanda's NDC

Like all Parties to the Paris Agreement, Rwanda must take the necessary actions to fulfill the commitments in its Nationally Determined Contribution (NDC) and achieve inclusive and sustainable development. These contributions are the instruments that guide Rwanda's climate action to limit the increase in global average temperature, raise global resilience and mobilize public and private investments

Figure: Adaptation investment levels from the total 5.3 billion USD through 2030



Source: Source: Republic of Rwanda, UPDATED NATIONALLY DETERMINED CONTRIBUTION, May 2020

4. CONCLUSION

Climate change is causing risks and pressures that increasingly force societies to rethink their priorities and principles for achieving societal well-being and economic development. Proactive and robust actions are crucial to safeguard the continued potential of sustainable development. If prioritized according to countries' objectives, needs, and risks, such actions can help reduce and manage climate risks, accelerating development and poverty reduction (World Bank, 2020).

Countries as well as Rwanda are committed to mitigate and adapt to climate change for a sustainable development. This climate change guide has provided basic and necessary knowledge and information towards empowering various actors to improve the community climate resilience. We expect that development actors, especially CSOs will use this tool to better build capacity of their respective constituencies towards innovative, sustainable and affordable interventions in the climate resilience domain.

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