THE FEDERAL REPUBLIC OF SOMALIA

MINISTRY OF ENVIRONMENT AND CLIMATE CHANGE

SOMALIA'S FIRST BIENNIAL UPDATE REPORT

UNDER THE UNITED NATIONS FRAMEWORK CONVENTION ON CLIMATE CHANGE (UNFCCC)

September 2022

Somalia's First Biennial Update Report (BUR) to the United Nations Framework Convention on Climate Change

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FOREWORD

Somalia joined the United Nations Framework Convention on Climate Change (UNFCCC) in 2009, and ratified the Kyoto Protocol and Paris Agreement in 2010 and 2016, respectively.

H.E. Amb. Khadija Mohamed Al-Makhzoumi

As a signatory to UNFCCC, the Federal Republic of Somalia submitted its INC1 in 2018, and it is required to prepare and submit a Biennial Update Report (BUR) to UNFCCC, which is the first BUR to be submitted.

The report contains a comprehensive national greenhouse gas inventory that includes energy, waste, Industrial Process And Product Use (IPPU), Land-Use, Land-Use Change and Forestry (LULUCF), agriculture, information on mitigation, and a measurement reporting and verification system.

In the past three decades, Somalia has faced numerous obstacles, including climate shocks that have caused loss of life, livelihoods, displacement, and disruption of national economy. Even though Somalia contributes a negligible amount to the problem of Greenhouse Gas (GHG) emissions that cause climate change, it remains one of the most vulnerable nations to climate hazards. The most severe of these hazards, droughts, riverine floods, flash floods, and storms, have increased in magnitude, frequency, and intensity over the past two decades, with dire repercussions for food security, water availability, ecosystem sustainability, and livestock production, the bedrock of our rural economy.

Consequently, the Federal Government of Somalia (FGS) is committed to contributing to global efforts to combat climate change. The FGS submitted its updated Nationally Determinant Contributions (NDC) to the UNFCCC in July 2021, and it is now time for NDC implementation and acceleration of climate actions.

As part of its response to climate change, Somalia has established a number of institutional arrangements, policies, and regulatory frameworks to enhance the adaptive capacities of its citizens and contribute to the global effort to mitigate climate change.

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Amb. Khadija Mohamed Al-Makhzoumi

Minister of Environment & Climate Change,

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ACKNOWLEDGEMENTS

The Ministry of Environment and Climate Change, Federal Government of Somalia would like to acknowledge the inputs from various stakeholders including public, private, academia and civil society organizations to enhance Somalia's first Biennial Update report. We also thank all the consultants who supported Somalia to prepare this report.

We also like to extend our first and foremost gratitude to the Global Environmental Facility (GEF) for providing financial support for the preparation of the BUR and the United Nations Development Programme (UNDP) for their partnership and supervision throughout the project period.

EXCUTIVE SUMMARY

In accordance with the United Nations Framework Convention on Climate Change (UNFCCC), the Federal Republic of Somalia is hereby submitting its First Biennial Update Report (BUR). The report follows the UNFCCC's BUR Reporting Guidelines for Parties not included in Annex I to the Convention. Preparation and submission of Biennial Update Report (BUR) is not only an obligation under UNFCCC but also details information required by the country to shape its mitigation actions and policies while highlighting its needs and constraints.

The report consists of the following six chapter: Chapter 1: National circumstances; and National Policy and Institutional Frameworks; Chapter 2: National greenhouse gas (GHG) inventory, Chapter 3: Mitigation actions and their effect; Chapter 4: Measurement, reporting and verification; Chapter 5; Financial resources, technology transfer, capacity building needs and technical support received and Chapter 6; on Additional Information.

i. National Circumstances and Institutional Arrangements

The Federal Republic of Somalia is situated on the eastern coast of the Horn of Africa, and lies between latitudes 2^{o} south and 11°59' north and longitudes between 41^{o} and 52^{o} east, with a land area of 637,540 km^2 and coastline of 3,333 km long with the width of 200 nautical miles. The country has a population of about 16 million. Agro-ecologically, Somalia is a dryland ecosystem with annual average rainfall of 280 mm which is unevenly distributed throughout the country. Somalia is one of the most climate-vulnerable countries in the world, with the least capacity to respond and recover for the extreme weather events.

Somalia gained independence in 1960 from the British and Italia. Currently the governing system of Somalia is a federal system with two levels of government; the federal government and federal member states' governments. The Ministry of Environment and Climate Change (MoECC) is the Nationally designated Authority responsible for environmental and climate change and focal point for UNFCCC

According to NDP-9, Somalia has a population of about 16 million, of which roughly 60 percent are nomadic and semi-nomadic pastoralists and 60 percent live in rural areas. Like many countries in sub-Saharan Africa, that population is predominantly young with 75 percent of it estimated to be under the age of 30, and almost 50 percent under the age of 51. Somalia's female population is estimated at 50.14% and the rest is male. Life expectancy at birth for both sexes is estimated at 58.3 years. The average household size is approximately six members per household. Somalia is also rapidly urbanising and, according to the 2017-2018 Somalia High-Frequency Survey, has 40 percent of the population residing in urban areas, including Mogadishu with 10 percent, while nomadic pastoralists make up 26 percent and agro-pastoralist communities' 23 percent.

Livestock is the backbone of the national economy contributing approximately 75% of the GDP while crop production contributes less than 20% of the GDP. Somalia has rich natural

[1] National Development Plan -9 (2020-2024)

resources that are foundations of economic, social, cultural and wellbeing of the Somali people. These natural resources include: marine and coastal resources, land, water, biodiversity, minerals and energy resources among others. Despite their importance, it is evident that the our country's natural resources is under immense pressure and degradation such as deforestation and loss of biodiversity, land degradation, overgrazing, waste disposal, water pollution aggravated by unsustainable utilization of natural resources Climate change has further exacerbated the situation hitting hard the vulnerable and climate sensitive sectors including agriculture and livestock which account for 65% of Somalia's GDP, water, energy, health sectors among others. Further, the COVID-19 pandemic has greatly disrupted Somalia's economic development with lives and livelihoods affected further increasing country's vulnerability. For prosperity and sustainable development of the country and our people, we have the obligation to sustainably protect, preserve, and utilize these rich natural resources for all generations.

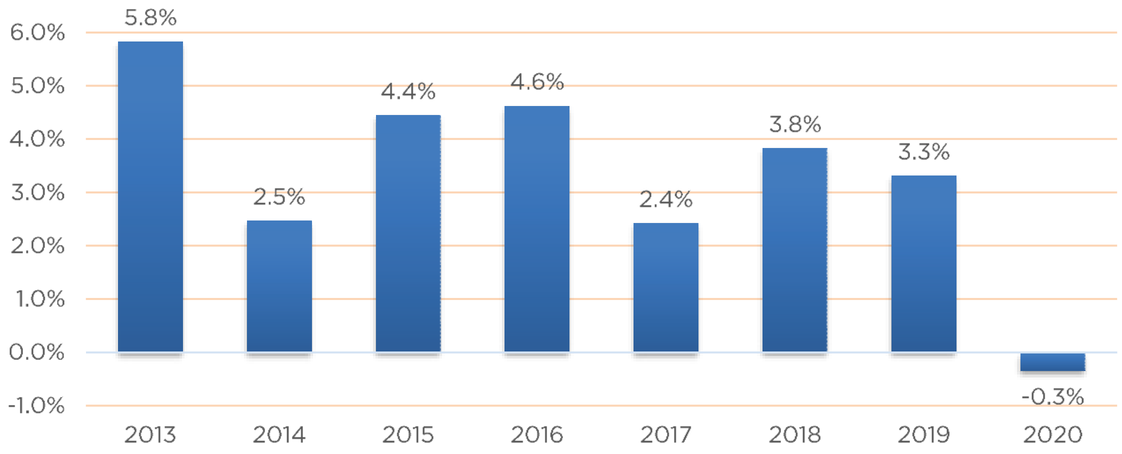


Figure 1: GDP growth 2013-2020 (Source: National Bureau of Statistics 202)

As a Least Developed Country (LDC) that is highly vulnerable to climate change, climate change adaptation and building resilience of various sectors and communities is Somalia's priority and thus mainstreamed into its national development plans. The country has low emissions and within the context of international climate change policy, the country aims to contribute to global mitigation efforts in the context of sustainable development and poverty eradication.

ii. National Policy and Institutional Frameworks

In the last decade, Somalia has made great strides in establishment of political, social, environmental, and economic systems that are showing great signs however fragile. The country is gradually transiting from insecurity and emergencies towards peace and stability, paving the way for the development of long-term policies and strategies to achieving sustainable development. Somalia has also enacted critical natural resource management and climate change relevant policies and legislative frameworks. Policies relevant to the climate change include the National Environment Policy (2020), Climate change policy, Nationally Determined Contributions (2021) under UNFCCC, the National Voluntary Land Degradation Neutrality Targets (2020), the National Biodiversity Strategy and Action Plan (2015) among others. However, clear gaps remain in the policy and regulatory landscape. The National

Climate Change Policy, 2020 recently approved by Somalia Cabinet provides for the institutional arrangements for climate change. Some of these institutions are yet to be fully operationalized. The main entities established by the policy include:

Ministry of Environment and Climate Change (MoECC) has the mandate of formulating federal level climate policies and coordination of activities. It also serves as UNFCCC National Focal point and the National Designated Authority (NDA) for Green Climate Fund.

National Climate Change Committee (NCCC) - The NCCC has the mandate for coordinating and supervising the implementation of the climate change policy. The NCCC is a multi-stakeholder, high level policy coordination committee and is responsible for the overall coordination and supervision of climate change activities in Somalia.

Federal Member State Governments - Somalia's federal system has established six federal member states (FMS) and one special status region which are Galmudug, Hirshabelle, Jubaland, Puntland, Somaliland, Southwest State and the special region of Benadir. The FMSs have mandates and responsibilities over natural resources and local environmental issues and oversee policy development and implementation in their respective regions.

Sectoral-Ministries -The climate change Policy recognises that climate change is a multi-sectoral undertaking and that success depends on the cooperation of Government agencies/ministries responsible for various aspects of environment.

The private sector and CSOs play an important role in Somalia's climate change response.

iii. Greenhouse gas inventory

The GHG inventory for Somalia's 1st BUR, and reports GHG emissions and removals by sinks for the period between 2000 and 2019 was prepared using IPCC 2006 guidelines. The inventory reports emissions and removals of greenhouse gases for the activity data that was able to be obtained for the emitting sectors. The gases include carbon dioxide (CO2), methane (CH4), and nitrous oxide (N2O) from five sectors: energy, industrial processes, agriculture (including livestock), land use, land-use change and forestry and waste. This is in line with the Modalities, procedures and guidelines (MPG) for the transparency framework for action and support referred to in Article 13 of the Paris Agreement (decision -CMA.1), that allows developing country Parties that need flexibility in the light of their capacities to report at least three gases (CO_2, CH_4 and N_2O) as well as any of the additional four gases (HFCs, PFCs, SF_6 and NF_3).

The Inventory preparation was spearheaded by the Ministry of Environment and Climate Change, Federal Government of Somalia. MoECC is the principal institution responsible for all matters regarding climate change including the preparation of the National Communications, NDC and BURs for the Federal Republic of Somalia. The Ministry established a team of officers to be trained, assist and support the modelling of the GHG inventory development process. The Sector teams were constituted based on the five IPCC sectors namely Energy (including transport), Industrial processes, Agriculture, Forestry, Land Use and Waste.

In estimating GHG emissions or removals for the Federal Government of Somalia, the IPCC 2006 Inventory Software has been used. The purpose of this software is to implement Tier1 and Tier2 methodologies in the 2006 IPCC Guidelines for the preparation of national GHG inventories either for complete inventories or for separate categories or groups of categories. In its most basic form, the method used to estimate an emission or removal from a specific source is as follows:
Emission estimate = Activity data x Emission factor
where:
Activity data: - describe the annual, national magnitude of an activity
Emission factor: - is the mass of GHG emitted per unit

Activity data was mainly sourced from FAO/FAOSTAT website and this was used with default emission factors in a Tier 1 approach to estimate emissions, since Somalia, like many other developing countries, does not have country specific emission factors.

National trends in Somalia`s emissions and removals

Figure 2 shows trends in total CO_2eq emissions for the time series 2000 to 2020. In general, total emissions show an *increasing* trend. In 2020, the total greenhouse gas emissions were equivalent to 41, 131 Gg of CO_2eq including the LULUCF Sector. Total CO_2 emissions for the year 2020 are estimated to be 23,781 Gg CO2eq without contribution from LULUCF.

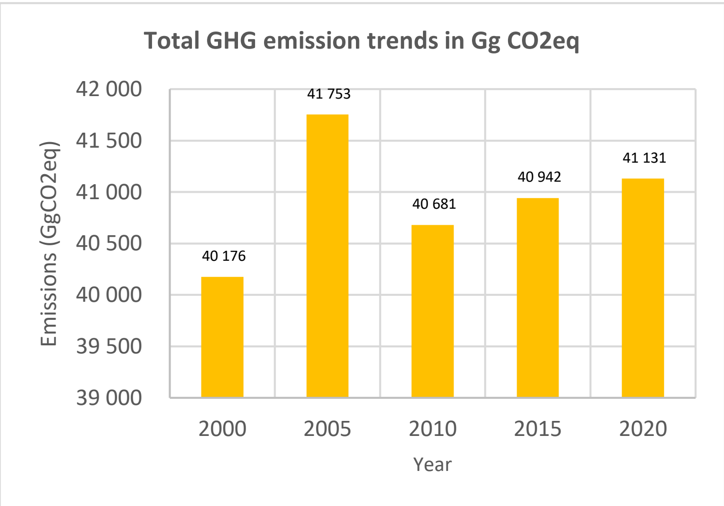


Figure 2: National Emissions trends

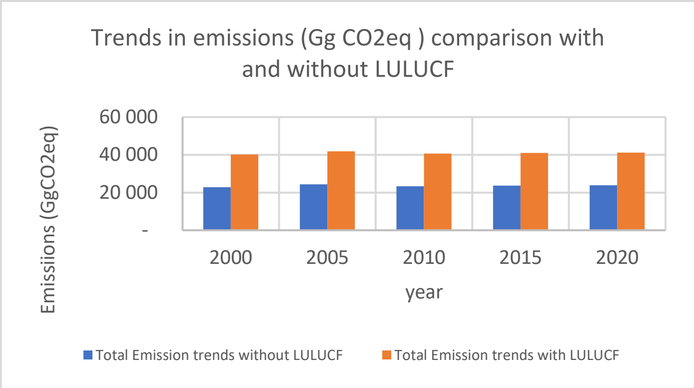


Figure 3: National emissions trends- comparison with and without LULUCF

Table 1 shows sectoral greenhouse gas emissions results for the period 2000-2020. It shows that Somalia`s GHG emissions are dominated by agriculture (mainly livestock) emissions. In 2020, Agriculture emissions totaled about 20508 GgCO_2eq, followed by LULUCF at 17350 GgCO_2eq.

Energy sector including transport produced about 1667 GgCO_2eq and waste emissions totaled about 1170 GgCO_2eq (Table 1). Greenhouse gas emission estimate methodologies, activity data, default emission factors and contribution for each of the IPCC categories are discussed in details in chapter 2

Table 1: Emissions trends for modeled sectors (categories).

Sector/Year	2000	2005	2010	2015	2020
Agriculture	21,178	22,494	21,074	20,933	20,508
LULUCF	17,350	17,350	17,350	17,350	17,350
Energy	1,159	1,289	1,491	1,704	2,103
Waste	488	620	767	955	1,170
Total Emission trends without LULUCF	**22,826**	**24,403**	**23,331**	**23,592**	**23,781**
Total Emission trends with LULUCF	**40,176**	**41,753**	**40,681**	**40,942**	**41,131**

Gaps and Constraints

There are several sources which remain “not estimated” (NE), in this GHG Inventory including IPPU sector categories (e.g mineral and chemical industries) and in Agriculture (Liming and Urea application) due to lack of data. For the LULUCF sector it is a fact that the global datasets usually have a lot of generalization and hence may have a bigger error margin. Lack of country activity data could contribute to large uncertainty for Somalia’s emission estimates. Thus data collection for all sectors should be number one priority in order to improve future GHG inventories.

iv. Mitigation actions and their effects

Somalia has little historical or current responsibility for global climate change; the country's Greenhouse Gas (GHG) emissions are estimated at 41.1 MT CO2e as of 2020 representing less than 0.03% of total global emissions (Based on the BUR 1 modelling). Agriculture, Forestry, and other Land use (AFOLU) contribute to over 92% of the country's emissions while the energy sector, waste and IPPU contribute 4%, 3% and 1% percent respectively.[2] The emissions are likely to grow with the relative stability experienced and as the country strives to meet its development objectives. The preparation of the mitigation chapter adopted a mix of methodologies including literature reviews, computation and triangulation, and stakeholder's consultation.

Somalia emission is mainly attributed to the Agriculture, forestry and other Land use changes (AFOLU) through enteric fermentation and mineralization of soil organic compounds and emission from forest degradation. Other sources of emission are energy related emission which are mainly demand related emission from residential sector and electricity generation which is predominantly fossil fuel based. The waste sector emissions are mainly attributed to municipal solid waste collection and disposal and domestic waste waters.

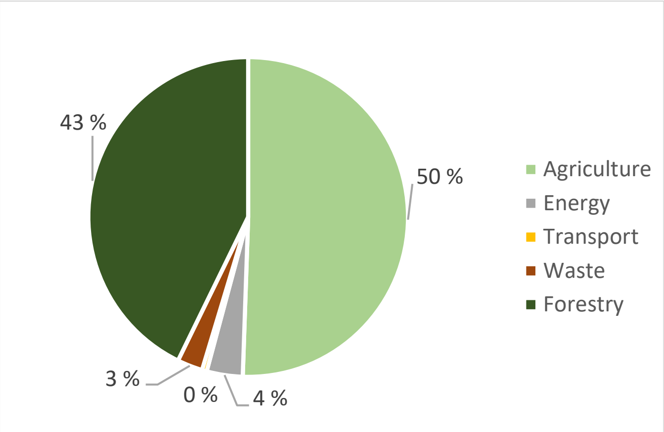


Figure 4: National Emissions shares by sectors

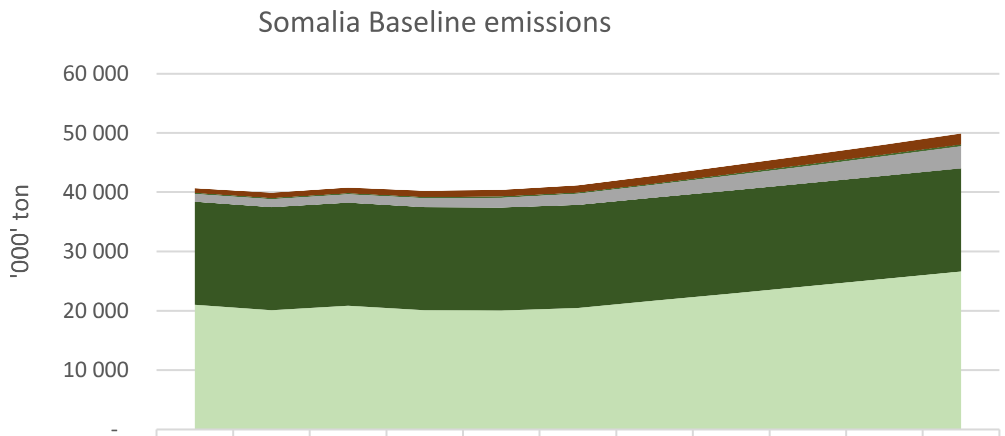
The transport sector in Somalia consists mainly of road transportation, aviation industry, ports, and shipping sector. The road sector is the focus of this analysis as it is estimated to account for most of transport GHG emissions. The smaller size of the water transport sub-sector makes them less attractive from the point of view of identifying mitigation options.

Baseline emission projection and Mitigation Scenario

Somalia baseline GHG emission is projected to increase from 41-million-ton CO2eq in 2020 to about 50 million to CO2eq in 2030. Forestry and agricultural sectors are the greatest emitters contributing to a total of 92% of overall GHG emissions. Agricultural total emission in 2020 was determined to be 20.5MtCO2eq whereas forestry sector emission is 17.4MtCO2eq. Energy sector emission accounted for 4% (1.5 MtCO2eq) of total GHG emission while the waste sector contributed to 3% (1.2million tCO2eq) of total GHG emission. The total GHG emission in the

[2] National GHG inventory for BUR 1, 2022

transport sector was estimated at 0.2million tones CO2eq in 2020. This estimation was based on the transport fuel importation UNstat statistics database. The gasoline fuel was consolidated as motor gasoline used in private cars, vans and motorcycles and diesel used in ship bunkering and trucks. Projection to 2030, shows an increasing emission trend especially in the energy and waste sector from about 1.5MtCO2 eq in 2020 to about 2.9 $MtCO_2eq$ for energy and 1.1MtCO2 eq to 1.8 5MtCO2 eq per year for waste.



	2 010	2 012	2014	2016	2018	2020	2022	2024	2026	2028	2030
Waste	767	850	919	994	1 076	1 170	1 278	1 397	1 526	1 667	1 822
Transport	176	169	176	188	188	194	208	222	238	255	273
Energy	1 315	1 402	1 487	1 575	1 683	1 939	2 214	2 587	2 912	3 324	3 765
Forestry (Based on WRI)	17350	17350	17350	17350	17350	17350	17350	17350	17350	17350	17350
Agriculture	21 074	20 128	20 875	20 118	20 079	20 508	21 732	22 964	24 202	25 447	26 701

Figure 5: Somalia baseline emissions

The mitigation actions resulting to Somalia abatement while fostering sustainable economic development and also described in Somalia NDC 2021 include: -

- Promotion of sustainable intensification pathways for the livestock sector including improved feeding and water accessibility points, breeding and veterinary services as well as improved manure management
- Planting of nitrogen fixing plants to reduce fertilizer usage protection and conservation of existing forests.
- Smart agriculture and intensification of crop production
- Rangeland restoration and rehabilitation and sustainable Land Management including climate
- Energy efficiency in residential, commercial, and industrial sectors as well as reduction of transmission and distribution losses
- Development of renewable energy electricity (Solar and Wind) and distributed systems
- Promote standalone solar home system by reducing tax on solar PV products
- Afforestation, agroforestry and Reforestation of degraded including mangrove restoration

- Improvement of road conditions/road investments increasing fleet flow. Bus rapid transit (BRT) system implementation resulting in replacement of between 10% - 30% of its ridership.
- Sustainable waste management practices such as sanitary landfill with methane recovery reduce the waste and introducing robust waste segregation at source, and implementation of refuse, reduce, reuse, recycle (RRRR) waste management principal.

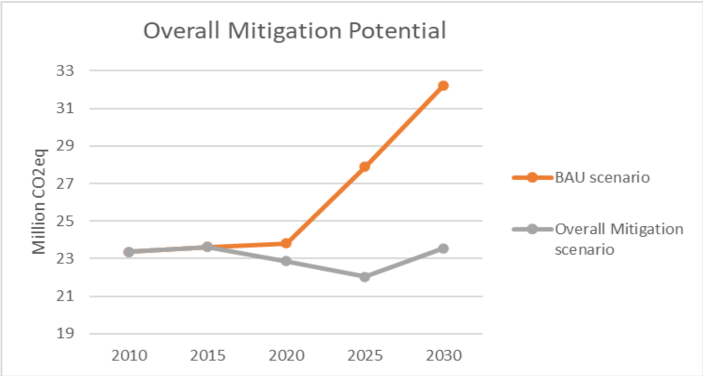


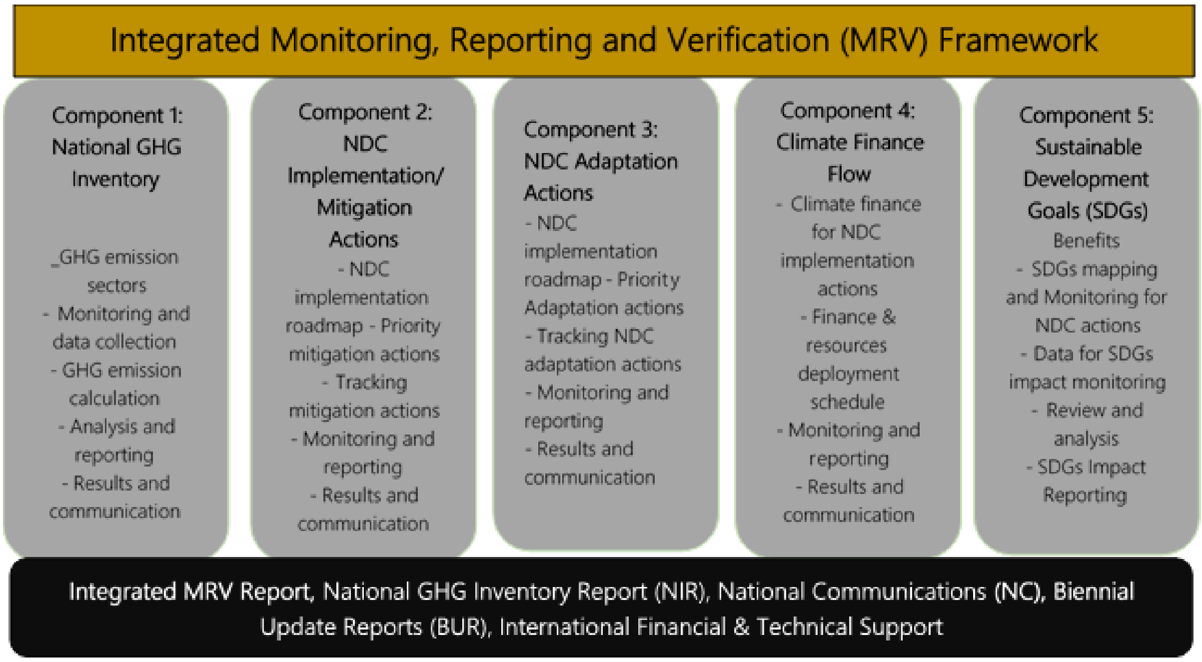
Figure 6: overall mitigation potential

Albeit, with limited and inconsistent data, modeling the mitigation scenarios demonstrated that overall, the country will potentially reduce combined reduction of 9MtCO_2 equivalent against the baseline which is 20% abatement potential from key sectors. The energy sector emission reduction was determined to be about 1MtonCO_2eq, waste sector reducing about 2MtCO2eq as Agriculture sector reducing about 6MtCO2eq in 2030.

5. **Measurement, Reporting and Verification of climate change**

Somalia's has no elaborate Measurement, Reporting and Verification (MRV) system in place. The country is in the process of developing an adaptation action monitoring tool. The First Biennial Update Report includes proposal for development of an MRV system for climate change. The proposed web-based platform integrates adaptation, mitigation and support and will help tracking, analysis and enhancement of progress towards Somalia's transition to a low-carbon economy and climate-resilient pathway.

The Monitoring, Reporting, and Verification (MRV) system is critical for Somalia to meet its global commitment to combat climate change because it provides information on emission sources and trends, allows tracking progress toward climate change-related targets, and directs mitigation actions to meet the targets. It provides for the tracking of adaptation actions and assistance, including funding, capacity building, and technology. MRV systems are critical components in ensuring the transparency, quality, and comparability of climate change data in all applications.



Noting Somalia's overall Monitoring and Evaluation systems is at the infancy stage with challenges of vertical and horizontal coordination mechanisms at the State and Federal Levels, the MRV chapter is limited to providing context to M&E mechanisms, challenges and opportunities to set the stage for building a fully-fledged MRV system for Somalia.

6. Financial, technical, and capacity building needs and support received

According to decision 2/CP.17, non-Annex I Parties are to provide updated information on constraints and gaps, and related financial, technical and capacity-building needs, as well as updated information on financial resources, technology transfer, capacity-building and technical support received. Parties included in Annex II to the Convention and other developed country Parties, the Green Climate Fund and multilateral institutions for activities relating to climate change, including for the preparation of the current BUR. To implement the mitigation actions, we take recognition of the various constraints including: -

a) Incomplete and weak policy and regulatory frameworks
b) Inadequate financial resources especially for core institutions
c) Weak institutional arrangements including deficiency of mandates and lack of effective coordination on climate change
d) Lack of technical capacity on climate change including to mobilise resources for climate action
e) Low levels of knowledge on climate change among key stakeholders including private sector in the country
f) Lack of technological development, innovation and transfer as well critical barriers for technology development, deployment and uptake in the country
g) Lack of monitoring and reporting systems for climate action
h) Insecurity in some areas of the country

Somalia's updated NDC submitted to UNFCCC in July 2021 highlights the country's mitigation options and related costs. The estimated cost of implementing Somalia's NDC is approximately USD 55.5 billion for the period 2021- 2030 with a significant portion of Somalia's NDC priorities being adaptation and resilience building. Mitigation actions will require support in terms of finance, technology and capacity building to the tune of approximately USD 7Billion.

Moreover, there is a need for enhanced capacity building of various institutions and strengthening policy and legislative frameworks to support Somalia and enhance its adaptive capacities to climate change. In particular, the country requires support to enhance capacities to access multilateral and bilateral climate finance sources, address barriers and enhance private sector investments and establish effective institutional mechanisms to enhance mobilization and effective utilization of climate finance. The country requires support to establish a national MRV system and strengthen its institutional set-up with adequate infrastructure and human resources to track climate actions.

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ACRONYMNS

AGB	Above-ground biomass
AFOLU:	Agriculture, Forestry and Other Land Uses
AR5	Fifth Assessment Report (IPCC 2014)
BCEF	Biomass conversion and expansion factor
BEF	Biomass expansion factor
BNF	Biological nitrogen fixing
BOD	Biological oxygen demand
Bl/d	Barrels per day
BAU:	Business as Usual
BUR	Biennial Update Report
CO_2:	Carbon dioxide
CO_2eq	Carbon dioxide equivalent
COP	Conference of Parties to the UNFCCC
CH4:	Methane
CRF	Common reporting format
DM	Dry matter
DMD	Dry matter digestibility
DOM	Dead organic matter
MoECC:	Ministry of Environment and Climate Change
EF	Emission factor
FAO:	Food and Agriculture Organization of the United Nations
FOD	First order decay
FRS:	Federal Republic of Somalia
GDP	Gross domestic product
GEI	Gross energy intake
GHG:	Greenhouse Gas
GHGI	Greenhouse Gas Inventory
GIS	Geographical Information Systems
GPG.	Good Practice Guidance
GPG-LULUCF	Good Practice Guidance for Land Use, Land-Use
GWP	Global Warming Potential
HWP	Harvested wood products

INC:	Initial National Communication
IEA	International Energy Agency
IPCC:	Intergovernmental Panel on Climate Change
IPPU	Industrial Processes and Product Use
ISO	International Organization for Standardization
LDC:	Least developed Country
LEAP	Low Emissions Analysis Platform
LPG	Liquefied petroleum gas
LULUCF	Land Use, Land-Use Change and Forestry
MCF	Methane conversion factor
MEF	Manure Emission Factor
M&E	Monitoring and Evaluation
MDA	Ministries, Departments and Agencies
MRV	Monitoring Reporting and Verification
MW:	Megawatt
WMO	World Meteorological Organizations
$MtCO_2eq$:	Million tonnes (megatonnes) of carbon dioxide equivalent
NAMAs	National Appropriate Mitigation Actions
NIR	National Inventory Report
NAPA	National Adaptation Programmes of Action
NCCP:	National Climate Change Policy
NDC:	Nationally Determined Contribution
NDP	National Development Plan
NDP-9	Ninth National Development Plan
NE	Not estimated
NGHG	National Greenhouse Gas Inventories (IPCC, 2000)
NGHGIS	National Greenhouse Gas Inventory System
N_2O	Nitrogen dioxide
PMP	Power Master Plan
PRP	Pastures, rangelands and paddocks
QA/QC	Quality assurance/quality control
RAC	Refrigeration and Air Conditioning
R & D	Research and Development

REDD+:	Reducing emissions from deforestation and forest degradation
SDGs:	Sustainable Development Goals
TAM	Typical animal mass
TJ	Terajoule
TM	Tier method
TMR	Total mixed ratio
TOE	Tonne of Oil equivalent
TOW	Total organics in wastewater
TWG	Thematic Working Group
UN	United Nations
UNDP:	United Nations Development Programme
UNFCCC:	United Nations Framework Convention on Climate Change
UNEP	United Nations Environment Programme
VS	Volatile solids
WMO	World Meteorological Organization
WRI	World Resources Institute

1. CHAPTER ONE: NATIONAL CIRCUMSTANCES AND INSTITUTIONAL ARRANGEMENTS

1.1. Geographical profile

The Federal Republic of Somalia is situated on the eastern coast of the Horn of Africa, and lies between latitudes 2^{o} south and 11°59' north and longitudes between 41^{o} and 52^{o} east, extending about 300 km southward from the Equator (Figure 7). It stretches approximately 1,550 km from north to south, and 1,095 km from west to east. The country is a half island adjacent to the Arabian Peninsula that ranges from the Gulf of Aden in the north to the Indian Ocean in the east and the south, with a coastline of 3,333 km long and land area of 637,540 km^{2}. Somalia's mainland is bounded by Djibouti and Gulf of Aden to the north, by Ethiopia to the west, by Kenya to the south and by the Indian Ocean to the east. The land boundary with Djibouti is 58 km, with Ethiopia 1,626 km and with Kenya is 682 km. The maritime boarder dispute between the Federal Republic of Somalia and the Republic of Kenya was solved through the International Court of Justice (ICJ). On 12th of October, 2021 the ICJ drew a new maritime border between Kenya and Somalia.

Figure 7: Somalia's map

The following table (2) summarizes the main geographical features of Somalia.

Table 2: Summary of the Geographical Information of Somalia (FAO-SWALIM, 2013

Geographical features	**Details**
Location	Somalia is located on the eastern coast of the Horn of Africa, and lies between latitudes 2° south and 12° north and longitudes between 41° and 52° east.
Land area	637,540 km^2
Coastline	3,333 km with the width of 200 nautical miles
Boarders	Somalia's mainland is bounded by Djibouti and Gulf of Aden to the north, by Ethiopia to the west, by Kenya to the south and by the Indian Ocean to east.
Rivers	No navigational rivers. Somalia has two perennial rivers; Juba and Shabelle rivers that originate from eastern Ethiopian highlands. River Shabelle is the longest river in Somalia, within Somalia the length of the river is about 1,100 km long. It enters the country at Feerfeer about 48 km north of Beledweyne and ends near Jamaame and sometimes joins River Juba at Jamaame. River Juba is wider than Shabelle river, and its length within Somalia is about 800 km long. It enters the country at Doolow (Gedo region) and flow into the Indian Ocean at Gobweyn approximately 13 km north of Kismayo.
Terrain	The northern and north-eastern regions are mostly mountainous because of Karkaar Mountain range. The average elevation of the mountain range is about 1,950 meters above sea level; the highest point is 2,407 m at Shimber Berris. In the south the terrain generally consists of plateaus and plains.
Climate	Agro-ecologically, Somalia is arid and semi-arid lands (ASALs) which is susceptible for any environmental changes and prone to recurring droughts and floods. It is generally dry and hot all year round, and there is little seasonal change in temperature.
Rainfall	Rainfall is low and erratic. Average rainfall is about 360 mm. The northern and northeastern coastal plains are extremely hot and arid with average annual rainfall less than 50-100 mm; with approximately 400 mm of rainfall in the south, and 700 mm in the south-west and lower Juba. The rainfall received in the central semi-arid parts of the country receive 250 mm.
Natural resources	Uranium and largely untapped reserves of iron ore, tin, gypsum, bauxite, copper, salt, natural gas, likely oil reserves.
Agriculture	
Arable land	1.7534 % of the total land area
Irrigated agriculture	1% (6377 km^2)
Rain-fed agriculture	Appro. 7% (23,446 Km2)
Natural vegetation from closed to sparse	83% (528,400 Km^2),
Bare area	11.7 % (74,819 Km^2)
Water body	1.6% (10,320 Km^2)
built areas	0.1% (650 Km2)

1.2. Climatic Conditions

Somalia is arid and semi-arid lands (ASALs) with bi-modal rainfall, because of the zenith passages of the sun and occurs in two seasons, from April to mid-June the major rain (the *Gu rain*) and from October- November autumn the light rain (the *Dayr rain*). The annual average rainfall is 280 mm that varies throughout the country; in north-eastern and northern regions average rainfall is less than 250 mm, in central regions the annual precipitation is about 400 mm; while the far southern regions receive the highest precipitation of about 700 mm (Eklöw & Krampe, 2019). The warm and cool phases of *El Niño and La Niña* have also a great influence on the rainfall patterns. During the warm phase of ENSO, the rainfall is above the normal range, while during the cool phase the rain is below the normal range. As the country lies on the equator, there is no much seasonal variation in terms of temperature, and the annual mean temperature is about 30 C$^{o.}$

The rainfall is generally low and unevenly distributed**,** influenced by the Inter-Tropical Convergence Zone (ITCZ), the north-south movement, which results in two rainy seasons and two dry seasons in a year. January to March is the dry and hot winter season locally called "*jilaal*", it results from ITCZ emerging from the dry Arabian Peninsula; followed by major rainy season that usually begins mid-April and lasts till June; Then followed by the dry summer "*hagaa*" season from July to September, which is associated with cool sea breezes from the Indian Ocean that results in light coastal ―Hagaa rains in July and August. The fourth season is the autumn season "*dayr*" light rainy season that commerce in October and November.

However, as climate change has intensified, Somalia in particular and the Horn of Africa at large experience more frequency and prolonged drought spells that threatened the ecosystem sustainability and the lives and livelihoods of the people.

1.3 Impacts of Climate change

Somalia is generally exposed to droughts, floods and insects' outbreak as natural disasters. It is one of the most climate-vulnerable countries in the world, with the least capacity to respond and recover for the extreme weather events. The geographic location and high sensitivity to climatic variability make Somalia highly susceptible to the impacts of climate change and climate variability. In addition to climate-vulnerability, Somalia is a fragile state that experiences diverse challenges in terms of governance, security, and poverty, that exacerbate existing vulnerabilities. Climate change is adversely altering the ecosystem sustainability and affecting the ways in which people live.

As over 72% of the population is involved in traditional forms of farming system i.e. depend on rain-fed agriculture, free-grazing extensive livestock production and forestry make the rural population of Somalia more vulnerable to the impacts of climate change.

Therefore, the lives and livelihoods of the Somali population has been challenged by climate shocks such as cyclic droughts and floods that interact with other anthropogenic factors that led to state of degraded conditions; with far-reaching ecological, economic and social consequences. These climate extremes had undermined the ecosystem sustainability, constrained food security and the adaptive capacity and strategies of the people that are now facing increasing vulnerability.

Drought: For the last two decades horrific famines gripped Somalia as result of intense cyclic droughts which are frequently intensifying. Droughts endangered and exacerbated poverty in Somalia, where an average household is estimated to lose 40%[3] of its livestock in each drought event. The effects of the drought are not only limited to the loss of livestock, but comprise also food deficiencies, food quality, high rate of land degradation, loss of human life, loss of wildlife and a drastic reduction of the water resources particularly of pastoral communities (Fig. 7). By their very nature, agriculture in the drylands is exposed to the vicissitudes of an irregular rainfall pattern or frequent drought. Uncertainty in production due to fluctuations in total rainfall and changes in its distribution, decrease in relative productivity in rainfed lands etc. affect the livelihoods of many poor and marginalised pastoral and agro-pastoral communities in the country.

Thus, climate change is forcing rural communities in Somalia to leave their homes in search of new alternative livelihoods. According to WB (2021) over 2.6 million people have been already displaced from their habitual environment in Somalia by climate hazards and became climate refugees within their own country. The 2016-2017 drought has affected 6.7 million and displaced about 0.8 million people. The 2021 extensive drought and the subsequent famine severely killed approximately 80% of the livestock in Jubaland state; affected approximately 3.4 million people and displaced over 380,000 people (OCHA 2021[4]).

Floods: High intensity periodic flood is among the most devastating natural disaster that occur in Somalia. The country is prone to three types of flooding; riverine flooding, flash floods and coastal floods. For the last two decades, due to climatic fluctuation and human induced degradations, flooding in the riverine areas along the Juba and Shabelle rivers have increased in scale and recurrence, causing human and economic loss, and population displacement annually. In 2020 over-flooding of River Shabelle devastated the riverine regions, the entire Beledweyne town in Hiran region was inundated, leaving the 400 000 inhabitants in the town displaced and become homeless; also, public infrastructures, private buildings and economic lifelines destroyed.

This is often followed by overwhelming post-flood crises that affected national and regional governments, and household economies. After the flooding incident, waterborne and victor-born disease outbreaks occur, crops and farmlands destroyed and humanitarian crises and food insecurity become apparent. Obviously, reconstruction of destroyed public infrastructures and

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[3]Hassan et al. 2014. An Assessment of the Socio-Economic and Ecological Impacts of Environmental Changes on Rural Livelihood: A Study Across Addado, Buhodle and Northern Galkaayo of Central and Northern Somalia. Agriculture, Forestry and Fisheries. Vol. 3, No. 4, 2014, pp. 279-291. doi: 10.11648/j.aff.20140304.20
[4] OHCA, 2021. Somalia: Drought Conditions Update (As of 26 April 2021)
https://reliefweb.int/sites/reliefweb.int/files/resources/Drought%20Update_snapshot_Somalia_1.pdf

community economic recovery takes longer and many households become destitute. Localized swift and extreme flow of runoff (flash flooding) also occur in most parts of the country as a result of intense rainfall. A Tropical Storm called (*GATI*) with moderate to heavy rainfall, periodically develop in the northern Indian Ocean and move towards the coastal areas of Puntland and Somaliland. The storm sometimes drive water inland and cause significant coastal flooding, and affects also the shipping lane that links Somalia and Gulf states.

1.4 Population Profile

Somalia had population of 16 million by September 2020[5] with female population estimated at 50.14% and the rest being male. Life expectancy at birth for both sexes is estimated at 58.3 years. The average household size is approximately six members per household. Somalia is a young and rapidly expanding nation with an annual population growth of 3% and the country has the fourth-highest fertility rate in the world[6]. The country has five diverse livelihood systems; pastoralists, Agro-pastoralists, fishing and coastal communities, urban population and internally displaced people. About 49% of the population live in rural areas and about 46% of employed people work in agriculture, 25% in crop cultivation, 9% in herding, 4% in fishing, and 7% in related activities such as forestry and Agro-processing. Pure pastoralists are about 26% of the total population and they live in all rural areas of the country and most of them are nomadic poor. Agro-pastoralists account about 23% of the population depending on both settled crop production and livestock rearing or only crop production. People living in cities and towns represent around 42% of the population[7].

The economy of Somalia has always been based on its natural resources. Its rangelands, grass, trees, and shrubs feed the livestock that dominates exports, provide sustenance and cash income to its pastoralists and Agro-pastoralists, and underpin the food security of most of Somalis, making the country vulnerable to the impacts of climate change. The country has been experiencing significant impacts of climate change, some of which include changing weather patterns, drop in water levels, and increased frequency of extreme weather events. The pastoralist and rural poor and those Internal Displaced Persons (IDPs) are especially vulnerable as they have a lower capacity to cope with and adapt to the impacts of climate change. Women, children, the elderly, and persons with disabilities are especially vulnerable in terms of food insecurity and water and energy scarcity. Thus, climate change has threatened the existence of livestock as well as the livelihoods of nomadic and pastoralist communities due to the loss of pasture lands and reduced access to water resources. This has further resulted in deadly conflicts among the pastoralist communities that have claimed many lives. Needless to mention that the country is home to one of the largest livestock populations in Africa (40 million livestock in 2015[8]).

[5] Ministry of National Statistics (DNS) and Ministry of Planning, Investment and Economic Development (MoPIED)-2020
[6] WHO Somalia Country Cooperation Strategy 2019-23.
[7] Somalia: Rebuilding Resilient and Sustainable Agriculture (2018): International Bank for Reconstruction and Development/The World Bank and the Food and Agriculture Organization of the United Nations
[8] Somalia: Rebuilding Resilient and Sustainable Agriculture (2018): International Bank for Reconstruction and Development/The World Bank and the Food and Agriculture Organization of the United Nations

Traditional subsistence livestock and crops dominate the Somali economy with the majority of the population depend on and remain the main sources of economic activity, employment, and exports in Somalia. Agriculture's share of Gross Domestic Product (GDP) is approximately 75% and represents 93% of total exports, mostly linked to robust livestock exports in the recent pre-drought years. Agricultural production in Somalia is affected by many factors jointly with high rainfall variability, insecurity, recurrent drought periods, continuous degradation of the soil, frequent pest outbreaks and lack of an effective research and extension services. Despite the country's rich fish stocks, coastal fishing has remained small-scale and artisanal while foreign commercial vessels have enjoyed both legal and illegal harvesting offshore.

Since the establishment of the internationally recognized Federal Government in 2012, a great deal of progress and improvements have particularly occurred. This includes improvements in the general economy, despite difficulties in revenue collection and generation, with steady economic growth and low inflation[9]. Despite prolonged civil conflict and the devastating impact of the 2016-2017 drought, the Somali economy is currently emerging from the crises and is forging a path forward and may well witness sustained growth in the third decade of the 21st century particularly post–2020[10]. Somalia is one of the most promising countries in the Eastern part of Africa in terms of oil and gas. Estimates put Somalia's oil reserves as high as 110 billion barrels. It has also been projected that Somalia's offshore holds huge reserves of natural gas fields[11]. The country has untapped reserves of numerous natural resources including Oil, Uranium, copper, tin, iron ore, gypsum, salt, bauxite and other precious stones. The country's economy has recorded a moderate growth at 2.5% in 2017, 2.8% in 2018, 2.9% in 2019 and 3.2% in 2020[12].

Table 3: Assumption for GDP growth[13]

Scenario	Period of forecast %	
	2018-2027	2028-2037
Baseline	4.9%	2.5%
High	4.9%	7.5%
Low	2.5%	2.5%

1.5 Economy

Somali economy is estimated to grow at an average range of 2.5 to 2.9 percent and in 2018, Somalia's GDP growth was estimated at 2.8 percent. The economy is largely dependent on

[9] Ali Yassin. Ali et.al. (2017) Determinants of Economic Growth: Evidence from Somalia: International Journal of Economics and Finance; Vol. 9, No. 6; 2017 Published by Canadian Center of Science.
[10] Somalia Economic Update, World Bank: August 2019.
[11] Ahali, Aaron Yao Efui and Ackah, Ishmael (2014) Oil Resource Governance in Somalia: Are They Susceptible to the Resource Curse? The University of Buckingham, UK., University of Portsmouth, UK
[12] National Development Plan for Somalia (2020-2024): P.45. The Ministry of Planning, Investment and Economic Development
[13] National Development Plan for Somalia (2020-2024): P.45. The Ministry of Planning, Investment and Economic Development

livestock, remittance and money transfer companies, and telecommunications. The Gross Domestic Product (GDP) per capita was estimated to be only US$446 in 2017, having grown at only 2% per year over the last four years.[14] Remittances alone in 2016 were estimated at US$1.2–2 billion, equivalent to 23 to 38 percent of GDP. Remittances augment household income and create a buffer against shocks, however, remittances are vulnerable not only to changing habits of diaspora as a new generation comes of age but also to de-risking in the international financial system.

The economy is largely dominated by the informal sector based on international trade networks controlled by a small group of wealthy businessmen. The majority of the population lives at the subsistence level and is engaged in small-scale businesses, as petty traders, livestock or grain producers. The private sector has demonstrated resilience and vitality in areas such as telecommunications, livestock, financial sector, water, electricity and fisheries. The private Telecommunication firms provide wireless services in most major cities and offer the lowest international call rates on the continent. Further, the extensive Somali community in the diaspora has played a major role in injecting a significant inflow of funds using strained banking systems. In the absence of a formal banking sector, money transfer/remittance services have sprouted throughout the country, handling up to $1.6 billion in remittances annually. Due to the incidences of terrorism, the international concerns over the money transfers into Somalia continue to threaten the existing financial services.

Despite the relative economic growth, most Somalis live in poverty (69 % live under the international poverty line of US$1.90 a day) and vulnerability with 2.3 million people living on the margins of food insecurity and 1.1 million are internally displaced15. Disaggregated data, along with the levels of severity of poverty, indicate that internally displaced persons (IDPs) and the rural population (both agro-pastoralists and nomads) have the highest rates of monetary poverty. An additional 10 percent of the population live within 20 percent of the poverty line, making almost 80 percent of the entire Somali population vulnerable to external shocks such as natural disasters, conflict and economic disruption, however small.

The economic growth of Somalia is often hindered by devastating climate induced shocks particularly droughts, famine and floods, since agriculture (livestock and crop production) still remain the backbone of the national economy as it contributes 75% of the GDP. The projected growth rate of 3.2% in 2020 was interrupted by the devastating COVID-19 pandemic, locust's infestation and floods that caused the economy to contract by 0.3 %, and average annual inflation rate of 4.11 %. The Pandemic containment measures reduced federal and state revenue collection and increased pressure to spend more on health and disaster response (WB 2021[16]).

[14] World Bank Electricity access report in Somalia
[15] National Development Plan 2020-2024
[16] WB 2021. **Somalia's Economy Rebounding from 'Triple Shock'**
https://www.worldbank.org/en/news/press-release/2021/09/14/somalia-s-economy-rebounding-from-triple-shock

1.6 Energy

In the absence of a national electric grid, for the past three decades, electricity services in Somalia have been a role of the dynamic Somali private sector. The system of delivering the electrical energy to users comprises of a network of isolated distribution grids with isolated generation on providers. These networks are anchored to specific urban centers with dedicated Electricity Supply Providers (ESP). Each ESP owns and operates its complete generation on-distribution customer-revenue chain using a radial distribution island network.

The country is among the lowest consumers of electricity in Africa in terms of consumption per capita. However, the current base of Somalia's energy consumption is fuel and that makes the country the highest in the world. The current electricity generation capacity is estimated at 106 megawatts (MW). It is however projected that the consumption rate from 2027 to 2037 will increase by 23% per year and such consumption would imply the following peak demand of 700 MW in 2027 and 4,600 MW in 2037. In 2020, the total percentage of the population with access to electricity was estimated at 35.26%. 57.2% of the population living in urban areas have access to electricity versus only 11.6% in the rural areas which most of the population live[17].

Charcoal and firewood make up about 85-90% of energy used in rural areas. A consumption at this size also contributes to deforestation and Co2 emissions. In Somalia, the resources currently mobilized for energy consumption fall into two prime categories. The first is energy resources intended for the generation of electricity and its subsequent use, and the second category is the energy used for genera heat. Current primary sources for providing heat are (i) sunlight, (ii) biomass, (iii) ed kerosene, (iv) compressed LP gas and (v) electricity. The primary sources for providing electricity are highspeed diesel generation sets (HSDGs) with limited use of grid solar photovoltaic (PV) and minimal use of grid- d asynchronous wind power turbines.

Somalia is rich in renewable energy resources and has an untapped potential for a year-round supply of renewable energy, particularly wind, untapped hydropower, extensive geothermal energy resources and solar. In recent years there has been great interest by both the public and private sectors to invest in hybrid systems that draw on solar and wind energy resources. Somalia has the highest resource potential of any African nation for onshore wind power and could generate between 30,000 to 45,000 MW. It is estimated that solar power could potentially generate an excess of 2,000 kWh/m2. Few electricity providing companies are currently implementing sustainable energy. National Energy Corporation of Somalia (NECSOM[18]) headquartered in Garowe city is one of these companies currently generating 59% of its electric power from solar wind turbines. Benadir Electric Company (BECO) has also installed five MW solar fields in the outskirt of Mogadishu.

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[17] The Power Master Plan for Somalia (2019) Ministry of Energy & Water Resources, Federal Government of Somalia

[18] NESCOM in the past few years has invested in wind, solar and other types of energy production alternatives and that has resulted in significant reduction of the CO2 emissions by 600 tonnes by year.

The National Development Plan (NDP) for Somalia lays out a strategy for action towards overcoming challenges confronting the country on the supply side of the energy through four strategies (1) Developing renewable and non-renewable energy sources to increase supply (2) Establishing a national regulatory authority for energy market governance (3) Strengthening the administrative and technical capacity of the federal and states ministries of energy and (4) Ensuring the needs of vulnerable groups – particularly women, the youth and displaced persons in intervention design and implementation.[19]

1.7 Infrastructure

Somalia ranks lowest of African countries on the infrastructure development index, both social and physical. The country is still reeling from the effects of a decade's long conflict that has destroyed almost all economic and social infrastructure. In general, Somalia currently has a deteriorating infrastructure that has seen little improvement in the last three decades. The country does not have railway infrastructure, nor does it have coastal shipping other than small artisanal fishing boats used as cargo vessels transporting goods and passengers from port towns to remote fishing villages. Roads, thus, remain the primary mode of domestic connectivity but out of its 22,000 km of road networks the country currently has, only 2,860 km are paved, leaving most of the rural areas inaccessible to motor vehicles, especially, during the rainy seasons. Due to their age and lack of maintenance over the last 30 years, 90% of the paved roads have deteriorated to the extent that they are no longer classified as all-seasons roads.
Investments in the road sector are also non-existent as no major road or highway has been built over the past thirty years[20]. The country has seven airports with paved runways and 55 unpaved landing gravel airfields.

Despite Somalia has the longest coastline of mainland Africa and is at the entry and departure point of one of the most important international commercial shipping lanes in the world, through which the bulk of global sea-borne trade moves, the country does have only four ports with sheltered deep-water facilities handle. Telecom and internet services in Somalia have grown substantially over the past ten years and the country currently offers some of the most competitively priced telecommunications services in Africa. However, the absence of regulation led to problems with frequency spectrum coordination and interconnection between networks.

1.8 Waste sector

Over 40% of Somalia's population is living in urban centres, and the rate of urbanization in cities and towns is increasing. The high urbanization rate and lack of designated plots have resulted in the expansion of informal settlements in its towns and cities, characterized by a lack

[19] National Development Plan for Somalia (2020-2024): P.221. The Ministry of Planning, Investment and Economic Development

[20] 2016: https://www.afdb.org/en/documents/document/the-africa-infrastructure-development-index-aidi-2016-89476: Accessed August,2020.

of access to essential services, including waste collection and disposal. Lack of proper waste collection, transportation, disposal, landfills, dumpsites, sanitation and management is a key problem in Somalia. Currently, only a fraction of solid garbage and rubbish collected from major cities and towns are collected through contracting local companies, transported, and dumped in landfills located in suburbs of major towns and cities without the separation process of hazardous and non-hazardous waste. There is no distinction of the nature of waste; whether solid, liquid, or any other form, waste will be considered as waste and dumped in the dumping sites.

Somalia does not have a recycling industry; thus, two commonly used materials like plastic bags and bottles, are dumped or sometimes burned. Households, agriculture, fisheries, and commerce industry are the main sources of waste. Waste is a major environmental problem in Somalia, and it affects people's and animal health, coastal and marine environments, and affects the socio-economic conditions of the people. Despite existing rules and regulations forbidding, dumping hazardous waste material and the coastal areas and near the ports continue unchecked. Waste alters the atmosphere's chemical composition by a build-up of GHGs, primarily Co2, Nitrous Oxide (NO2), and Methane (CH4) emitted from the decomposition of organic wastes in landfills.

1.9 Forestry

According to FAO 2016, Somalia total land area 62.7million ha. Agricultural areas accounts for 44.1million ha of the total land area and about 6.3 million ha of forest, majority classified as low-density wood and closed forest cover of no more than 3% indicating the dry nature of Somalia's geography[21]. In the 1980s, Somalia's total forest cover was estimated at about 62% of the country's landmass. Somali's remaining forest resources including tropical vegetation along rivers Shabelle and Juba and nearby floodplains, juniper trees in the Northern Golis mountain range and coastal mangroves are faced with threats of commercial exploitation that have been increasing for some time especially after the civil wars of the 1990s.

The forest sector has faced tremendous pressure since the civil war leading to the reduction of forest cover to about 10% of Somalia's total landmass in 2016 against 12% in 2000. Each year, on average the country lost 1.1% of its forest which equivalent to an average loss of 84,841 hectares annually. The destruction of the forests has also affected the availability of forage for livestock and wildlife habitats leading to the reduced potential of livestock and wildlife sector productivity in Somalia.[22]

Traditional biomass fuels mainly firewood and charcoal account for 82% of Somalia's total energy consumption indicating overdependence on unsustainable energy sources for majority of the populations whether in rural or urban settings. The demand for firewood is higher in rural areas while demand for charcoal is higher in urban areas and the export market which is the biggest push factor for the forest degradation in Somalia. Increased population growth,

[21] "FAO Country Profiles:Somalia," Food and Agriculture Organization of the United Nations, accessed November 21, 2021, http://www.fao.org/countryprofiles/index/en/?iso3=SOM.
[22] FAO. 2014. Forest Resources Assessment: Somalia Country Report. Rome

insecurity, poverty, rapid urbanization, absence of alternative sources of energy coupled with climate change impact on already vulnerable livelihood sources remains major drivers for increased involvement in the destructive but lucrative charcoal business in Somalia. The charcoal industry employs thousands of people right from the grassroots, middlemen and the exporters of charcoal especially to Gulf countries where demand has increased recently due to lifestyle changes such as the use of Shisha that requires ample supply of charcoal.

1.10 Agriculture

Agriculture (crops, livestock and fisheries) is the backbone of the Somali economy. The sector contributes to over 90% of the country's total exports, 60% of its GDP and employing over 80% of its population.[23] Though Somalia was close to feeding its own population in the early 1980s, the collapse of the state and consequent loss of infrastructure and institutions led to a drastic drop in productivity. Somalia's agriculture is severely underdeveloped due to inadequate government support, recurrent droughts and poor technical skills. According to World Bank report 2017, Somalia will be highly dependent on food imports and foreign aid for the foreseeable future. Somalia does not maintain national food reserves, nor does it have an import policy to regulate food prices as a form of public protection, which leaves it's poor (80% of the total population) exposed to food security risks when hit by the volatility of global food prices. Somalia's foreign trade was and still is mostly in agricultural products. Agricultural exports represented about 93 percent of total export.[24]

Frequent droughts and the negative impact of two decades of conflict have hampered the sector's potential and contribute significantly to food insecurity. The government is determined to recover and restore the full productive capacity of the sector so that it can play its role in achieving food security and building peace and political stability through, among other strategies, job creation, and, eventually, sustainable economic growth for the country. Other root causes of this extreme food insecurity include the collapse of irrigation and flood-control infrastructure, poverty; gender inequity; high population growth; limited access to water, sanitation, and health services.

1.11 Climate Change priorities of Somalia

Climate change poses a significant threat to the development of Somalia due to over-dependence on agriculture, livestock production, water, and forestry resources which are very susceptible to weather and climate variations. Climate change adaptation is thus country priority. The National Development Plan (NDP-9) is a comprehensive development plan that aims to contribute to poverty reduction efforts that improved security. The NDP identifies resources use conflicts, environmental degradation, and climate-related disasters such as droughts and floods as the key challenges to the stability and development of the country. The plan prioritizes most strategic interventions with multiple benefits including economic benefits alongside environmental sustainability, conflict reduction, strengthened governance and

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[23] Somalia NDP-9 2010-2024

[24] World Bank/FAO 2018 Rebuilding Resilient and Sustainable Agriculture in Somalia

reduced exclusion. Overall, the plan integrates climate change across development intervention design and implementation for the period. Among the priority, interventions include strengthening Somali institutions' commitment and capacity for effective political and environmental governance.

On the other hand, Somalia has little historical or current responsibility for global climate change. The country's Greenhouse Gas(GHG) emissions is 41 Mt CO2e as at 2019 representing less than 0.03 % of total global emissions, with Agriculture, Forestry and other Land uses (AFOLU) contributing most. The emissions are likely to grow significantly as the country strives to meet its development objectives; with agriculture, forestry and energy sector leading. The country is committed to remain low emitter and contribute to global climate change mitigation efforts in the context of sustainable development and poverty eradication. This is elaborated in the country's updated Nationally determined contributions(NDC) 2021 that describes priority mitigation actions in the agriculture, forestry, energy, transport and waste sectors.

1.12 Government structure

Somalia gained independence in 1960 from the British and Italia. In the north, the former British Somaliland got independence from the British on 26th June 1960, and in the South, the former Italian Somaliland got its independence on 1st of July 1960, and the same day (1^{st} of July, 1960) the two regions united and formed the republic of Somalia. Currently, Somalia is a federal Republic comprising a federal government and five federal member states, Banadir rgion and Somaliland (Fig.2). The main features of the government structures of the country are summarised in Table 4.

From the beginning of the 1990s the country has been troubled by conflict and civil strife that ruined the national security, incapacitated government institutions, destroyed public infrastructures necessary for socioeconomic and ecological development including government facilities, Hospitals, Schools, Universities, government facilities, communication systems, factories and other economic productive sectors. However, for the last two decades, Somalia's governance system has made remarkable progress in establishing an internationally recognized federal government.

The Federal Republic of Somalia ratified number of international environmental agreements, among them are: The United Nations Convention to Combat Desertification (hereafter UNCCD) signed in 2002, the Convention on Biological Diversity (CBD) signed 2009 and the United Nations Framework Conventions on Climate Change (UNFCCC) signed in 2016. Somalia submitted its first Initial National Communication under the United Nations Framework Convention on Climate Change to the UNFCCC Secretariat in 2018.

Table 4: Summary of the governing system and constitution structure of Somalia

Feature	**Details**
Form of state	Somalia is a Federal Republic, with two levels of government; the federal government and federal member states' government, the autonomy and powers of each of the levels of government is defined by the Provisional Constitution.
Legal system	Mixed legal system consisting of; civil, Sharia and customary law
National Legislature	The Federal Republic of Somalia has a bicameral Parliament elected every four years, that consist 54 seats Upper House (*Aqalka Sare*), represent the Federal Member States, and elected by the respective members of the parliament of their respective FMS, and 275 seats the House of the People (*Golaha Shacabka Soomaaliyeed*) (syn. Lower House), seats elected by the people
Electoral system	Currently the country uses clan-based Indirect voting system; every MP is elected by 101 voters
Head of state	The president is elected by the two houses of the Federal Parliament of Somalia in a joint session for a period of four years by a two-thirds majority vote and he is eligible for re-election.
Language	The official language of the country is Somali
Population	Appr. 16 million (2020).
Currency	Somali Shilling
Capital	Mogadishu
Flag	

1.13 Institutional Arrangements for climate change

Somalia has established a number of institutional arrangements to improve the implementation of climate change adaptation and mitigation policies and measures. With regard to the review of the constraints and barriers related to institutional, legal, financial, technical and human capacity affecting the implementation of commitments under the UNFCCC that was provided in the Initial National Communication, improvement has been made in institutional arrangements and environmental policies. The institutional arrangements necessary for the preparation of the Biennial Update Report in a continued way were identified with the existing relevant entities at the federal and federal member states.

The Ministry of Environment and Climate Change (MoECC) is the Nationally designated Authority responsible for the formulation of national environmental and climate change policies, coordinate activities and harmonise entity plans i.e. the federal line ministries, FMS, international partners, and other stakeholders on environment and climate change governances. MoECC) is also UNFCCC Focal Point and responsible for coordinating activities and entity plans at the international level.

The MoECC has set up the following two committees to enhance the effort towards mainstreaming climate- resilient development.

1) **National Climate Change Committee (NCCC)** which is a Cross-Sectorial, multi-stakeholder, high level policy coordination committee responsible for the supervision of the overall climate change activities in Somalia, and supervise the implementation of the National Climate Change Policy. The Committee consists of the Deputy Prime Minister (chairman), the Director General of MoECC, Sectorial Ministries (federal level), Directors of line Governmental Agencies, Federal Member States' Ministers of the ministries of Environment, representatives from Champers of Commerce and representatives from the civil societies.

2) **Cross-Sectoral Committee on Climate Change (CSCC)** is a cross-sectoral platform that brings together Sectoral Ministries' departmental directors for consultation and information sharing to drive climate change policies implementation.

1.14 Policy relevant to MRV framework in Somalia

A legal and regulatory framework is crucial for a national Measurement, Reporting and Verification(MRV) system of climate change action to succeed. These frameworks provide legitimacy, regulate conduct, and establish sanctions that can ensure compliance. Because of the potential impact of climate change on the country's development, and in furtherance of the UNFCCC principles, the government has put in place the necessary policy, legal frameworks. These provide a basis for MRV, however, further strengthening of the climate and sectoral legal frameworks will be required to ensure effective MRV. An analysis of the legal frameworks to identify potential areas for strengthening provisions for MRV include:

National Development Plans

The five-year National Development Plan (NDP) guides the strategic areas the country will focus on to deliver economic growth and reduction of poverty. within the next five years. The country's ninth development plan (NDP-9) [2019-2024] is the most comprehensive development plan for the country outlining Somalia's short to medium-term development priorities as well as providing an analysis of Somalia's current development status, challenges, and opportunities. The plan consists of four main pillars, namely; inclusive and accountable politics, improved security and the rule of law, inclusive economic growth, and improved social development. The plan also has a cross-cutting part integrated into each pillar, representing an essential strategy for both targeting and prioritizing interventions. The plan undertakes climate change mitigation and adaptation initiatives to reduce climate change impacts on the population, environment, and economy and lays out a clear strategy for action towards overcoming challenges confronting the country and gearing towards low carbon resilient development pathways.

The country has a national monitoring and evaluation framework that is coordinated by the Ministry of national statistics. The National Director of Statistics has the prime responsibility for collecting and/or consolidating statistics gathered from line ministries or other agencies as related to the indicators for NDP-9[25]. The plan also outlines progress in building capacity for monitoring and evaluation including the strengthening of the national M&E system, deepening the capacity of the national statistics body and establishment of regular data collection systems. A national M&E Strategy was completed and approved the country intends to map all indicators, pipeline and current ones, to SDG indicators. These efforts are important for an MRV system.

National Climate change policy

The National climate change policy is under the premise of an economy that is reliant on climate-sensitive sectors such as agriculture, livestock, water, and forestry and the imminent threat of a changing climate. Somalia may face a major threat because of the projected changes in climate. In response, the country's climate change policy sets out the vision to attain a prosperous and climate-resilient economy through the adoption and successful implementation of appropriate and effective climate change adaptation and mitigation measure[26]. The policy will: (i) Promote a harmonized, articulate, and effective response to challenges and opportunities that accompany climate change. (ii) Deliver a framework that will guide the establishment and operationalization of interventions and action plans. (iii)Safeguard the safety and health of citizens, their prosperity, and states development in the advent of climate change through enhancement of resilience and implementation of the adaptive ability to climate variability.

The policy outlines the need for monitoring and evaluation of climate change responses and impact and proposes the monitoring and evaluation system that is needed to track climate change (policy interventions and impacts of climate change).

The policy elaborates on the climate governance for the country. This is further discussed in the section (institutional arrangements). The policy is thus the anchor policy for climate change action and its associated monitoring.

National Adaptation Program of Actions (NAPA)

Somalia's NAPA provides the basis for mainstreaming adaptation into the country's development plans. It is the first national-level document that identifies urgent and immediate climate change adaptation needs of the most vulnerable groups. The NAPA seeks to build community awareness, increase monitoring, and risk forecasting and support the adoption of government policies and strategies to improve climate change resilience among vulnerable groups. Monitoring and evaluation have been considered in the NAPA and include a Monitoring plan, with defined benchmarks, indicators, and targets. The NAPA initially takes a project-based approach where the project coordinator is tasked with the preparation of reports. Given that adaptation is a cross-cutting issue there is a need to incorporate reporting mechanisms that will involve other government sectors, civil society organizations, the private sector, and academia. The NAPA identifies the need to establish necessary institutional and management arrangements as well as a detailed monitoring and evaluation plan.

[25] The Ministry of Planning, Investment and Economic Development. Somalia National Development Plan 2020 to 2024

[26] Federal Ministry of Environment and Climate Change. National Climate Change Policy 2020

Initial National Communication 2018

Somalia submitted its Initial National Communication (INC) to UNFCCC in August 2018. The INC reports the total greenhouse gases in the country as being 69.92MtCO2e, with the Forestry and Land use sector being the major contributor at 96% of total emissions. The mitigation analysis in the INC also identifies various policies and measures that the country can adopt to abate current and future emissions and include options in the energy, industrial, forestry, agriculture, livestock, and waste sectors. The vulnerabilities of the country are also analyzed, and adaptation measures are provided. The INC thus makes the recommendation for a robust MRV system that will ensure the country can track progress in these sectors. A proposed institutional arrangement for GHG is made in this report. The INC also makes recommendations for the strengthening of data collection systems including data generation, gathering, archiving, and analyzing. It also recommends improved coordination with the Ministry of National Statistics and strengthening collaboration with other government Ministrys at the various ministries. In terms of capacities, it recommends the building of human resources and capacity development.

Updated Nationally Determined Contribution (NDC)

The country prepared an Intended Nationally Determined Contribution (NDC) in 2018 and has prepared its updated NDC. These documents make commitments by the country to address climate change through adaptation and mitigation. The updated NDC submitted on 31st July 2021 sets a baseline of emissions and actions that will be taken to reduce the emissions by 30% against a business-as-usual scenario of 107.4 MtCO2e by 2030. The updated NDC will require financing of USD 48.5 Billion and articulates the need for a robust MRV system to track progress in achieving the country's ambitions. The updated NDC denotes the need for enhancing technical capacity, research, and coordination of stakeholders and sets out to track progress on a biennial basis in alignment with the enhanced transparency framework. The Ministry of Environment and Climate Change (MoECC) has the responsibility to monitor and evaluate through regular stakeholders' consultative engagement. This will ensure the effective coordination, resource mobilization, and implementation of the NDC target. Monitoring and evaluation of the Mitigation and adaptation actions/projects will be harmonized.

National Energy Policy 2018

The overall objective of the NEP is to increase access to efficient, affordable and sustainable energy for urban and rural communities; for the private sector to thrive; and for the public sector to meet national energy demand in order to provide better essential services, boost economic growth and reduce poverty. The policy promotes widespread production, use and storage of renewable energy through diversification, innovation, technical cooperation, and technology transfer, as a way of reducing deforestation pressures for biomass energy generation, and to promote investment in modern, integrated and commercially viable models of energy supply. Energy Policy elaborates on specific strategies for the development of the energy sector in the country.

- Supporting increase in private sector capacities to promote energy provision scaling up
- Enhancing the efficiency of the current generation, transmission and distribution capacity by increasing the skill set of engineers, technicians and labors
- Promoting investment in clean cooking technologies such as efficient charcoal stoves and LPG stoves

There also exist many sectoral policies related to climate change which also provide further provisions for monitoring of climate change action. Some of these are:

- Fishers Policy 2016
- National Petroleum and Mineral Policy 2016
- Wetlands policy 2016
- Wildlife policy 2016
- Forest Policy 2016
- Biodiversity Policy 2016, and
- Tourism Policy 2016

CHAPTER TWO: NATIONAL INVENTORY OF GREENHOUSE GASES FOR SOMALIA

2.1. Introduction

In response to the risk of global climate change; the United Nations Framework Convention on Climate Change (UNFCCC) established on 21st March 1994, provides an intergovernmental platform for tackling the challenge of global warming and the impacts of the resulting changes. Somalia has been a Party to the UNFCCC since December 2009, as a non-Annex 1 country and ratified the Kyoto Protocol in July 2010. Paragraph 1 of Article 4 of the United Nations Framework Convention on Climate Change (UNFCCC) requires parties to develop, update periodically and submit to the Conference of the Parties (COP), national inventory of all anthropogenic greenhouse gases emissions not controlled by the Montreal Protocol by sources and removals by sinks, to the extent their capacities permit, using comparable methodologies agreed upon and promoted by the COP. This inventory is for the Federal Government of Somalia 1st BUR, and reports GHG emissions and removals by sinks for the period between 2000 and 2020 following IPCC 2006 guidelines. The development of this inventory was supported by the UNDP and the Federal Government of Somalia.

Under the GEF's support for preparation of National Communication, Federal government of Somalia submitted its first Initial National Communication (INC) in 2018. In addition to the requirement that countries submit NC, the Conference of Parties at its sixteenth session (COP 16) requested developing countries to submit Biennial Update Report (BUR). The report should contain information on updates of national GHG inventories, including a national inventory report and information on mitigation actions, needs and support received. The BUR is expected to be submitted every two years, either as a summary of parts of their national communication in the year when the NC is submitted or as a stand-alone updated report.

This Chapter on GHG Inventory for this Ist BUR for the Federal Government of Somalia, describes the methods, activity data, emission factors and conversion factors that were used to develop the national inventory based on the IPCC 2006 Inventory Software. The 2006 IPCC Guidelines were used for the selection of methods and default emission factors and conversion values applied in the inventory process. The GHG Inventory was prepared to not only fulfil Somalia's reporting obligation to the UNFCCC but also to fulfil her National obligations, support formulation of policies, sustainable development and green growth strategies.

2.2 Institutional Arrangements for Inventory Preparation

The GHG inventory has been prepared based on UNFCCC guidelines on BUR for Non-Annex I parties. The scope of the updates on national GHG inventories is consistent with capacities, time constraints, data availability and project budget. The inventory involves a consistent time series back to the years reported in Somalia's initial national communication, for the period 2000-2019/2020 and in some cases going back to the base year of 1990.

The Ministry of Environment and Climate Change, Federal Government of Somalia, established a team of officers to be trained, assist and support the modelling of the GHG inventory development process, from the five emitting sectors. These officers were drawn from key sector Ministries, Departments and Agencies including but not limited to the departments responsible for Energy, Transport, and Industrial processes, Agriculture, Forestry, Land Use and Waste. **The Ministry of Environment and Climate Change** is the principal institution responsible for all matters regarding climate change including the preparation of the National Communications, NDC and BURs for the Federal Republic of Somalia.

Figure 8 illustrates the institutional arrangements used to develop this GHG inventory. Each Sector was led by a sector lead coordinating data collection and information for the sector. These teams will need to be sustained to provide continued data collection, comprehensive documentation and archiving. This will strengthen the institutional frameworks and coordination to ensure periodic GHG inventory updates in future.

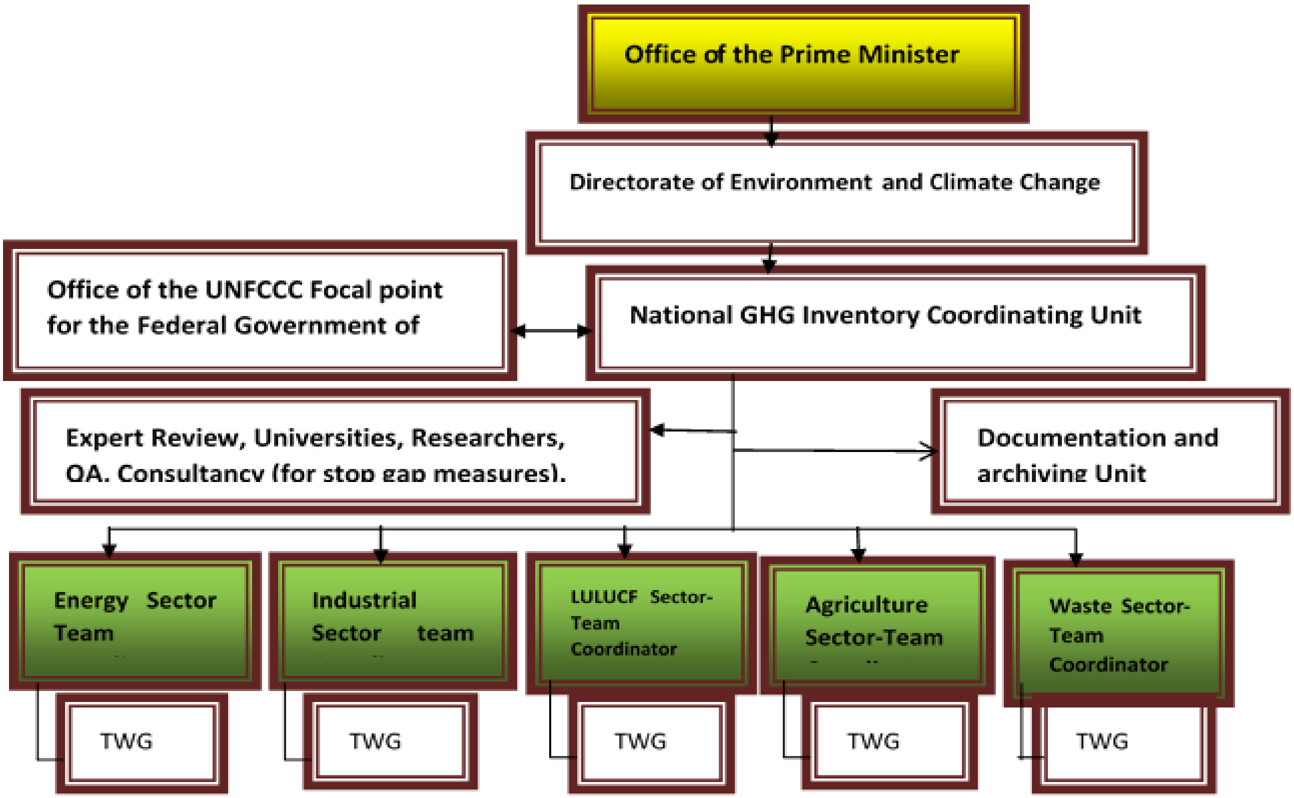

Figure 8: Institutional Arrangement for GHG inventory development (TWG-Thematic Work Group)

During the inventory process a series of workshops were carried out to engage the national stakeholders in the preparation of the Somalia GHG Inventory. The participation of stakeholders was meant to enhance ownership of the national GHG inventory.

The collection of data and information is still a huge challenge when compiling the GHG inventory. The stakeholder participation enabled gathering and assessing information required for the development of the National GHG Inventory for Somalia. However, some of the data gaps were filled with information published on the Federal Government of Somalia by FAOSTAT database, World Bank, UNDP, UNEP, USAID etc.

2.3 Methodologies and data sources used

In estimating GHG emissions or removals for the Federal Government of Somalia, the IPCC 2006 Inventory Software has been used. The purpose of this software is to implement Tier1 and Tier2 methodologies in the *2006 IPCC Guidelines* for the preparation of national GHG inventories either for complete inventories or for separate categories or groups of categories.

The main GHG sectors considered were Energy (including transport); Industrial Processes Product Use (IPPU); Agriculture; Forestry and other Land Uses (AFOLU); and Waste. The gases estimated for the compilation of the inventory included direct GHG: carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O).

In its most basic form, the method used to estimate an emission or removal from a specific source is as follows:

Emission estimate = Activity data x Emission factor

where: ***Activity data-*** describe the annual, national magnitude of an activity

Emission factor- is the mass of GHG emitted per unit

In many cases, the activity data available are not exactly what is required given the particular emission factor that is used. In these cases, the activity data is derived by applying "**conversion factors**" to other data, and hence the equation is modified and vary from one sector to the other. The country does not have country specific emission factors leading to application of default emission factors in a Tier 1 approach and Activity data sourced from FAOSTAT website. More detailed methodology for each sector and source category are presented in the specific sector.

2.4 A SUMMARY OF TRENDS IN EMISSIONS

2.4.1 National Emission trends for greenhouse gases[27]

In 2020, the total greenhouse gas emissions were equivalent to **41, 131** Gg of CO_2eq including the LULUCF Sector. (Figure 9). Total CO2 emissions for the year 2020 are estimated to be **23, 781** Gg CO2eq without contribution from LULUCF. Trends in total CO2e emissions for the time series 2000 to 2020 are shown in figures 9. Figure 10 compares emissions with LULUCF included and without LULUCF included. Emissions in 2005 appear to have been higher due to contribution by higher number of livestock population from the data set obtained from FAOSTAT for that particular year, and in general there has been a steady increase in emission since 2010 due to the increasing human population and associated increase in energy demand and consumption.

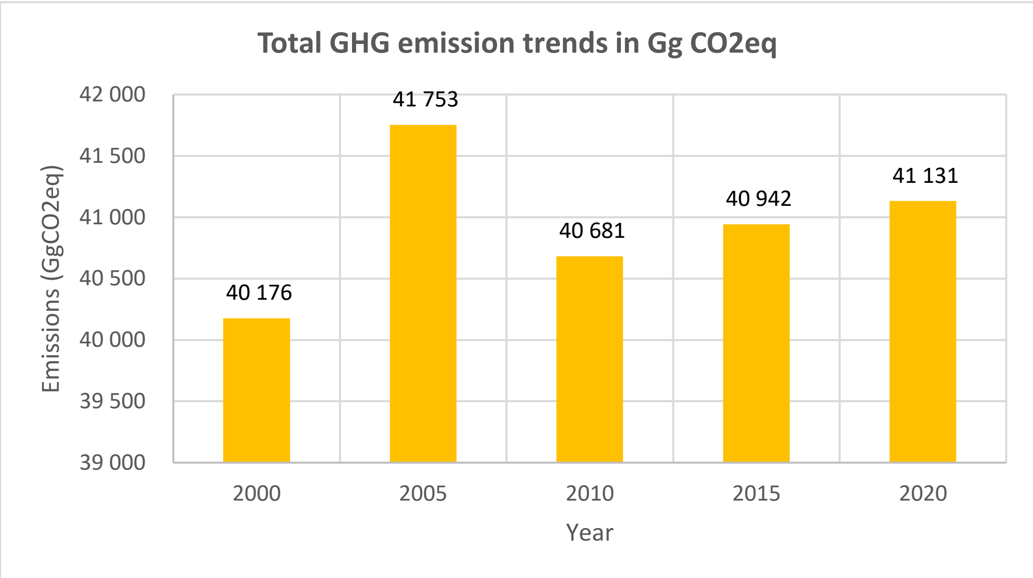

Figure 9: National Emissions trends

[27] This requires real activity data for all fuels, industries, livestock, in the IPCCC software, which is lacking for Somalia. Emissions have been estimated from surrogate data vs population growth.

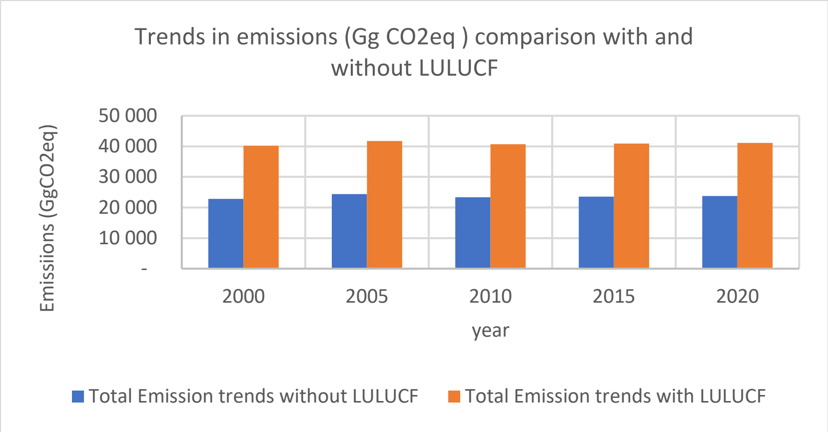

Figure 10: National Emissions trends –comparison with and without LULUCF[28]

2.4.2 Emission trends by Source-Sector

The Federal Government of Somalia GHG emissions are dominated by Agriculture (mainly livestock) and LULUCF sectors. Table 5 shows sectoral greenhouse gas emissions results. In 2020, Agriculture emissions totaled about **20,508** GgCO_2eq, followed by LULUCF sources at **17,350** GgCO_2eq. Energy sector (including transport) produced about **2103** GgCO_2eq and waste emissions totaled about **1170** GgCO_2eq (Table 5).

Table 5: Emission trends for modelled sectors (categories)

Sector/Year	2000	2005	2010	2015	2020
Agriculture	21,178	22,494	21,074	20,933	20,508
LULUCF	17,350	17,350	17,350	17,350	17,350
Energy	1,159	1,289	1,491	1,704	2,103
Waste	488	620	767	955	1,170
Total Emission trends without LULUCF	**22,826**	**24,403**	**23,331**	**23,592**	**23,781**
Total Emission trends with LULUCF	**40,176**	**41,753**	**40,681**	**40,942**	**41,131**

Greenhouse gas emissions contribution by each sector are discussed in details in the following sections.

2.5 ENERGY SECTOR

2.5.1 Overview of the Energy Sector

The scope of the energy sector accounts for emissions from fuel combustion activities in *Energy Industries, Manufacturing Industries and Construction, Transport and Other sectors (commercial/institutional, residential, and agriculture/forestry/fishing*). The Energy sector activities in Somalia are largely driven by the combustion of fossil fuels used for generating electricity and energy for transportation, Manufacturing and construction, residential and institutional energy use. Carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O) are

[28] This was generated from the Global datasets used in the analysis. This data has not been validated to get to know the accuracy and as always global datasets tend to portray a lot of generalization. The only way out to solving this would be to work on the country specific data for Somalia.

the GHGs released in the combustion of fuels. Also released in the process are the GHG precursors carbon monoxide (CO), nitrogen oxides (NOx), and non-methane volatile organic compounds (NMVOC‘s).

The energy sector is a key sector in any economy as it accounts for emissions from conversion of the chemical energy in fuels to other forms of energy e.g. heat and electricity. This may be in stationary devices like power plants or in mobile devices like motor vehicles. The conversion and therefore emissions occur in different facets of the economy including transportation, industries and even households. The fuels may be solid, liquid or gaseous and may be fossil or biogenic. Emissions from the conversion of waste to energy, if any, is also counted under energy sector.

Some of the existing energy categories in line with IPCC 2006 Guidelines, in Somalia are listed in table 6.

Table 6: *Energy Sector categories and status in Somalia*

IPCC Code	**Name**	**Description**
1.A.1	Energy Industries	Emissions from fuels combusted by the fuel extraction or energy-producing industries. In Somalia, electricity generation is still dominated by diesel generators despite the growth in renewable energy (RE) options like solar.
1.A.2	Manufacturing Industries and Construction	Emissions from combustion of fuels in industry. Also includes combustion for the generation of electricity and heat for own use in these industries. Post war stability in the country has triggered sprouting of manufacturing industries including fish-canning and meat-processing plants in the northern parts of the country, about 25 manufacturing factories in the Mogadishu area, which manufacture mineral water, pasta, confections, fabrics, detergents and soap, plastic bags, hides and skins, aluminum, fishing boats, foam mattresses and pillows, fishing boats, carry out packaging, and stone processing. However adequate data from this manufacturing industries could not be not be found at the time of developing this inventory.
1.A.3	Transport	Emissions from the combustion and evaporation of fuel for all transport activity (excluding military transport), regardless of the sector. In Somalia the transport sector is dominated by road transportation of which most are powered by petroleum fuels; diesel or gasoline.
1.A.4	Other Sectors	Emissions from combustion activities in Commercial/Institutional, Residential and Agriculture/Forestry/Fishing/Fish farms, including combustion for the generation of electricity and heat for own use in these sectors. The commercial and residential sector in Somalia, which includes households and commercial

IPCC Code	Name	Description
		establishments has grown proportionately with the population growth.
1.A.5	Non-specified	All remaining emissions from fuel combustion that are not specified elsewhere. Include emissions from fuel delivered to the military in the country and delivered to the military of other countries that are not engaged in multilateral operations. This type of data could not be found at the time of developing this inventory for Somalia.

2.5.2 Methodological Issues for energy emission estimation

Greenhouse gas emissions from the energy sector have been calculated using an IPCC Tier 1 approach. Activity data (fuel consumed) are multiplied by the emission factors of specific fuels. Activity data was provided by relevant institutions from the Federal Government of Somalia, supplemented by international sources. GHG emissions from the energy subcategories were calculated using equation 2.1, Volume IPCC guidelines.

$$Emissions_{GHG,\,fuel} = FuelConsumption_{fuel} \times EmissionsFactor_{GHG,\,fuel}$$

Where

- Emissions $_{GHG,\,fuel}$ = emissions of a given GHG by type of fuel (kg GHG)
- Fuel Consumption $_{\mathrm{Fuel}}$ = amount of fuel combusted (TJ)
- Emission Factor $_{\mathrm{GHG,\ fuel}}$ = emission factor of a given GHG by type of fuel (kg gas/TJ).

Where there is no country specific emission factors, default emission factors for fuel types may be used from the IPCC 2006 guidelines Volume 2: Energy. The Activity Data is the amount of a given fuel combusted whereas the Emission Factors used is the default emission factor as published in the Emission Factor Data Base (EFDB) for that fuel.

It is *good practice* to apply both a sectoral approach and the reference approach to estimate a country's CO_2 emissions from fuel combustion and to compare the results of these two independent estimates. The reference approach requires data on the production, imports, exports, transfers to international marine and aviation bunker and changes in stocks for all primary and secondary fuels. The sectoral approach on the other hand requires sector specific fuel consumption data for energy industries, manufacturing and construction, transport, residential, commercial and institutional sectors, as well as fuel consumption in agriculture, forestry and fishing. Due to limited availability of data on fuel consumptions in the Federal Government of Somalia, these two methods could not be compared.

2.5.3 Energy Emission trends

The emissions of greenhouse gases have been on a gradual upward trajectory driven mainly by population growth. The total energy sector emissions have risen from **1,159 Gg-CO_2e** in 2000 to **2,103 Gg-CO_2e** in 2020; this is about 81% growth from the 2000 levels (table 7 and Figure

11). Growth in the population has necessitated an expansion of services e.g. transport and electricity, which are carbon intensive.

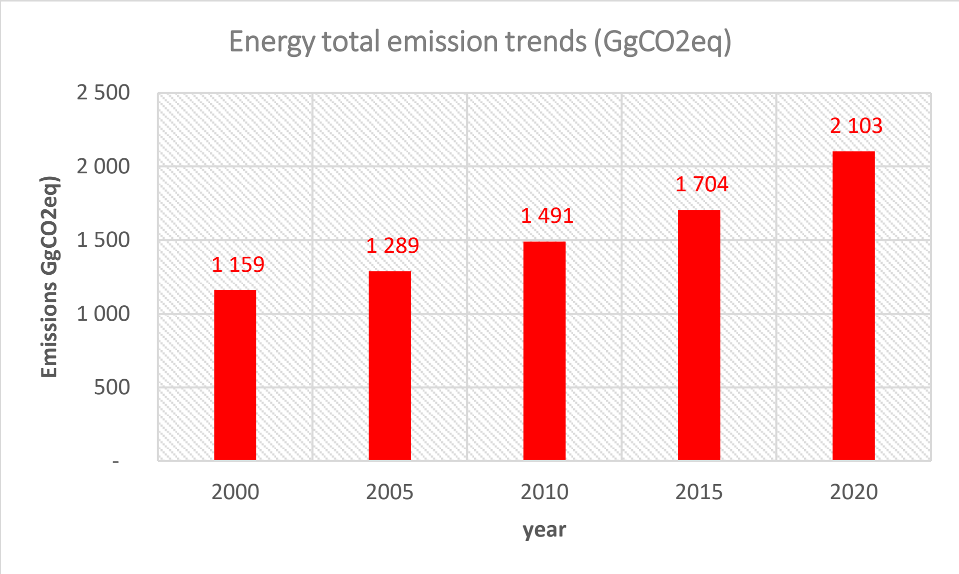

Figure 11: Energy Sector emissions trends 2000-2020

The transport sector is dominated by road transportation which is mostly powered by petroleum fuels; diesel or gasoline. The same case applies to waterborne navigation and civil aviation which are petroleum reliant. Emissions from transport sector were estimated to be about **194**GgCO2eq in 2020 (table 7).

Electricity generation is still dominated by diesel generators despite the growth in renewable energy (RE) options like solar. The relative peace and stability that has been experienced over the past several years has witnessed an uptick of electricity connectivity particularly in the urban centres which host nearly half of the Somali population. Emissions arising from electricity generation rose from **187** $GgCO_2eq$ in 2000 to **437** $GgCO_2eq$ in 2020 (table 7).

Charcoal Production which falls under manufacture of solid fuels in energy is a major activity in Somalia. Emissions trends resulting from charcoal production increased from **220 Gg-CO_2e** in 2000 to **436 Gg-CO_2e** in 2020

The commercial and residential sector which includes households and commercial establishments has grown proportionately with the population growth. The urban areas, while still dominated by biomass energy from charcoal and firewood for cooking, have other options like kerosene and LPG (which are still carbon intensive) whereas the rural areas are almost entirely biomass dominated. Emissions arising from both commercial and residential sectors rose from **548** $GgCO_2eq$ in 2000 to about **1035** $GgCO_2eq$ in 2020 (table 7).

Table 7: Energy Sector Emissions 2000 - 2020 ($GgCO_2e$)

Energy-sub-sector/category/year		2000	2005	2010	2015	2020
Energy Industry	Electricity generation	187.2	217.1	244.8	262.1	437.5
Manufacture of solid fuels and other energy industries	Manufacture of solid fuels (charcoal production)	219.8	262.6	309.1	367.4	436.4
Transport	Road Transport	204.3	175.6	175.7	175.7	194.4
Other energy sectors	Commercial and Industrial	68.5	68.5	90.3	89.7	118.1
	Residential	479.3	565.3	671.0	809.5	916.8
	Total Energy emission	**1,159**	**1,289**	**1,491**	**1,704**	**2,103**

2.6 INDUSTRIAL PROCESSES AND PRODUCT USE (IPPU)

2.6.1 Industrial Sector Overview

According to the IPCC guidelines, Industrial Processes and Product Use (IPPU) sector includes anthropogenic emissions from production processes in industry and industrial product use. Categories mainly estimated under IPPU include Mineral,, Other process use of carbonates, Chemical, Metal and Electronic Industries (2006 IPCC Guidelines, volume 3). The Mineral Industry Category includes the cement and lime sub-categories. Soda ash is an important sub-category in the Chemical Industry Category. The other important category is Product Uses as Substitutes for Ozone Depleting Substances (ODS), specifically, Refrigeration and Stationary Air-Conditioning, and Mobile Air Conditioning sub-categories could also be significant sources of GHG emissions. However while some of these categories do exist in Somalia on a small scale, activity data on industrial production could not be obtained to model the IPPU sector.

2.7 AGRICULTURE, FORESTRY, AND OTHER LAND USE

2.7.1 AFOLU Sector Overview

This section includes GHG emissions and removals from Agriculture as well as Land Use and Forestry. Based on the IPCC 2006 guidelines the following categories are included in the emission estimates:

Livestock

Enteric fermentation (3A1)

Manure management (3A2)

Land

Forest land (3B1)

Cropland (3B2)

Grassland (3B3)

Wetlands (3B4)

Settlements (3B5)

Other land (3B6)

Aggregate sources on non-CO2 emissions on land

Biomass burning (3C1)

Liming (3C2)

Urea application (3C3)

Direct N_2O emission from managed soils (3C4)

Indirect N_2O emission from managed soils (3C5)

Indirect N_2O emission from manure management (3C6)

Rice Cultivation (3.C.7)

The calculation of Livestock emissions was completed using the Tier 1 methodology, using IPCC *2006* Revised IPCC Guidelines.

The Land Use component includes land remaining in the same land use as well as land converted to another land use. Emission estimates in the Land sector was based on a Tier 1 approach.

Section 3C (Aggregate sources and non-CO2 emissions) deals with GHG emissions related to activities other than livestock and land. They include CH4 and N2O from biomass burning, CO2 from Urea application, direct and indirect N2O from managed soils and indirect N2O from manure management as well as CH4 emissions from rice cultivation. Tier 1 approach has been used for the a few categories in aggregated sources where data could be obtained from FAO.

The three categories under the AFOLU sector that is, Agriculture-Livestock (3A), Land (3B) and Aggregated and Non-CO_2 Emissions Sources (3C) are discussed in more detail in section 2.7.2, 2. 7.3 and 2. 7. 4.

2.7.2 Agriculture and Livestock Sector

2.7.2.1 Overview of Agriculture and livestock sectors

Livestock and crops remain the main sources of economic activity, employment, and exports in Somalia. Largely because of the dramatic expansion of the relative economic importance of livestock production and exports, agriculture's share of GDP has risen significantly from its pre-war level of about 62 percent to possibly 75 percent or higher. Thanks to livestock, total agricultural exports have climbed every year since the late 2000s, to a peak in 2015 of $634 million, more than five times the value before the civil war (World Bank and FAO 2018). Livestock and livestock products represent almost 61 percent of GDP, according to the most recent estimates by the World Bank and International Monetary Fund (IMF) of expenditure-based GDP and estimates. The other main products in the economy include fish, charcoal and bananas, sorghum and corn. Irrigated farming systems—which grow maize, sesame, other food crops, bananas, other fruits, and vegetables—face many constraints (World Bank and FAO 2018).

Agricultural activities contribute to greenhouse gas emissions through a variety of different processes. CH_4 and N_2O are the significant greenhouse gases emitted by the Agriculture Sector. CH_4 emissions arise from enteric fermentation and manure management associated with livestock, as well as, rice cultivation and prescribed burning of savannah and crop residues. N_2O Emissions arise primarily from synthetic and natural fertilizers (i.e., manure, crop residues) applied to cultivated soils and are based on IPCC assumptions regarding atmospheric deposition and leaching from soils. Other N_2O emission sources include rice cultivation and prescribed burning of savannah and crop residues.

Livestock production has been the backbone of the Somalia economy for centuries. It is also the most important source of income for the predominantly rural population. Meat and milk production accounts for 55 percent of the calorific intake of the entire population in Somalia. Most recent projections estimate livestock numbers at about 5.2 million cattle, 12 million sheep, 12 million goats and 7.2 million camels, with cattle being concentrated mainly in the south and camels in the northern part of the country (World Bank and FAO 2018). Table 8 shows activity data or the population of livestock obtained from FAOSTAT database.

Table 8: Historical Livestock Population (Head of Livestock), 1990 - 2019

Year	**1990**	**1995**	**2000**	**2005**	**2010**	**2018**	**2019**
Units	**Head**	**Head**	**Head**	**Head**	**Head**	**Head**	**Head**
Cattle, dairy	1040000	1350000	1150000	1200000	1176449	1167990	1058961
Cattle, non-dairy	2960000	3850000	3989000	4300000	3623551	3578829	3173452
Sheep	13000000	13500000	13808000	14700000	12000000	10457119	11687422
Goats	18500000	12500000	12300000	14600000	11500000	11432240	11466768
Camels	6700000	6100000	7001600	7230000	7000000	7230058	7243792
Horses	920	700	800	850	850	893	899
Mules	23000	19000	19000	22000	22000	22156	22206
Assess	25300	19500	20000	22000	22000	22605	22717
Swine, breeding	1000	400	390	480	400	389	386
Swine, market	9000	3600	3510	4320	3600	3497	3473

Source: [1]. FAOSTAT Database. Food and Agriculture Organization of the United Nations, accessed 12-Aug-2021

The Livestock production activities produce Methane (CH_4) emissions from enteric fermentation and both Methane and nitrous oxide (N_2O) emissions from livestock manure management systems. Methane emissions produced by live animals as a by-product of a digestive process by which carbohydrates are broken down into simple molecules for absorption into the bloodstream and is categorized as enteric fermentation. Ruminant animals (e.g. cattle, goats) are the largest source of methane emission from enteric fermentation with little amount of methane produced from non-ruminant animals (e.g. swine, horses). The amount of CH4 emitted from the animal depends on the type, age, and weight of the animal; the quality and quantity of feed; and the energy expenditure of the animal. Greenhouse gases are also emitted from the management of animal manure. Methane is produced from decomposition of manure under anaerobic conditions, which usually occur in manure stored in large piles. During storage of manure, some nitrogen in manure are oxidized and converted into N2O.

2.7.2.2 Emission trends in Livestock

The Livestock emissions totaled to **17, 700** Gg-CO_2eq in 2019 arising from both enteric fermentation as well as manure management. *E*missions in this sub sector have been fluctuating rising from **17972** in 1990 to **18669** Gg-CO_2eq in 2000 and dropping slightly to **17700** Gg-CO_2eq in 2019. Table 9 and Figure 12 indicates the trend in emissions from 1990 to 2019. The highest emissions were observed in 2005, likely to a large population of livestock, but since then there has been a steady decrease in emissions which could be associated with the growing trade in livestock (livestock products and export represent almost 61 percent of GDP) and the frequent drought in the region that contribute to the decreasing population of livestock.

Table 9: Livestock Emissions by source category (in Gg-CO_2eq), 1990 – 2019

YEAR	2000	2005	2010	2015	2018	2019	Change 2000-2019
3.A.1 - Enteric Fermentation CH4 Gg CO2eq	17628.3	18705.1	16979.4	17357.7	17063.2	16703.2	-5.2%
3.A.2 - Manure Management (1) CH4 (Gg CO2 eq)	800.4	846.3	776.0	794.5	784.7	775.6	-3.1%
3.A.2 - Manure Management (1) N2O (Gg CO2 eq)	240.8	254.8	239.2	243.4	237.3	221.3	-8.1%
Total 3A-livestock Emissions Gg CO2 eq	18669.51	19806.21	17994.54	18395.61	18085.16	17700.2	-5.2%

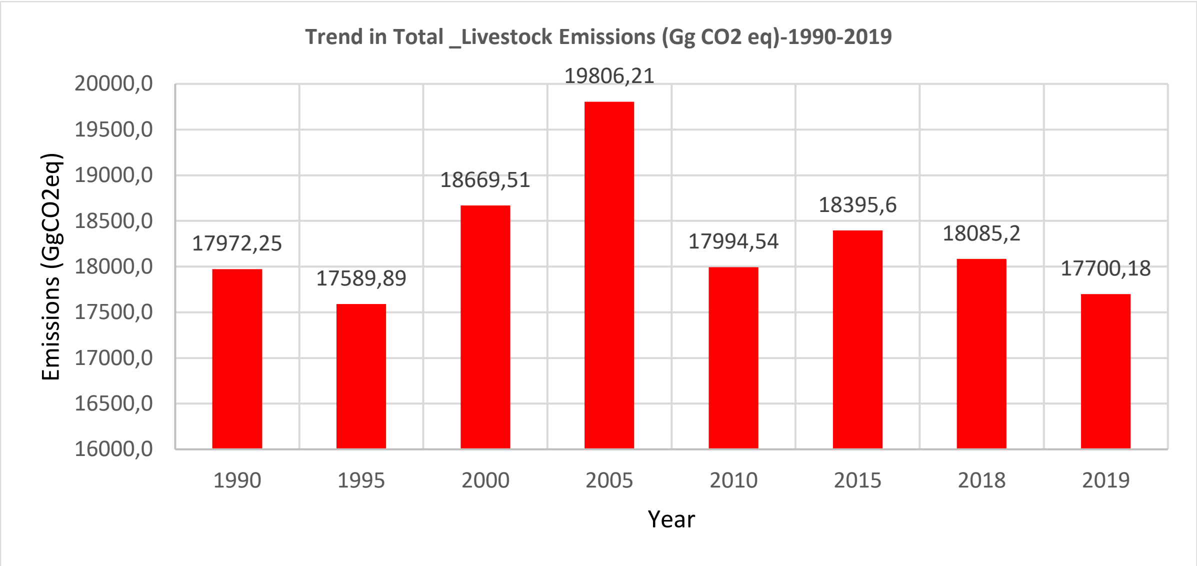

Figure 12: Emissions trends in Livestock, 1990 - 2019

Emissions of CH_4 from enteric fermentation dominated the sub-sector contributing about 94 percent share of emissions in the category. Manure Management contributed 5 percent from Methane (CH_4) and 1 percent from Nitrous Oxide (N_2O) (figure 13).

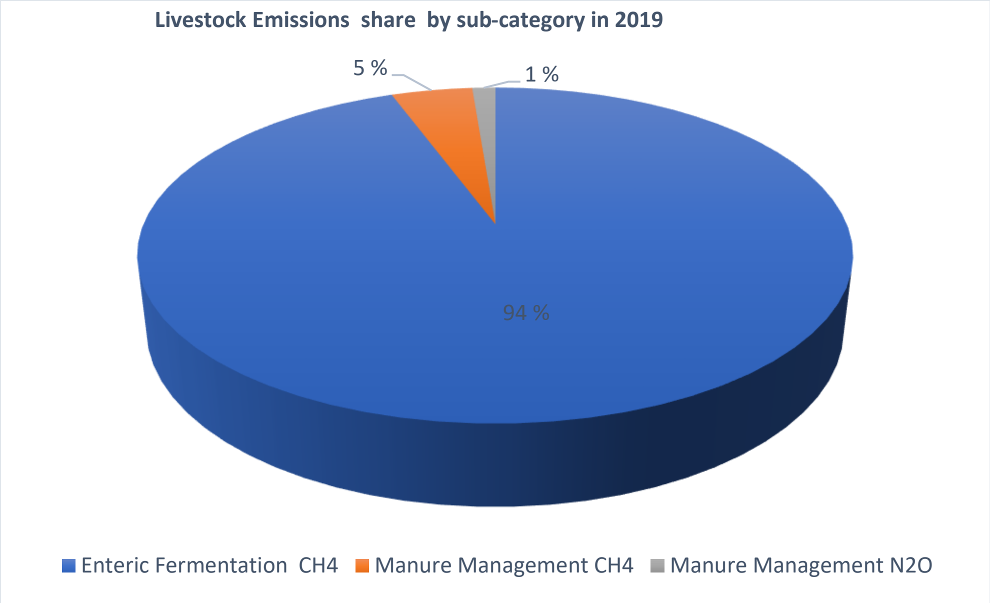

Figure 13: Somalia Share of Livestock Emissions in 2019 by Sub-category

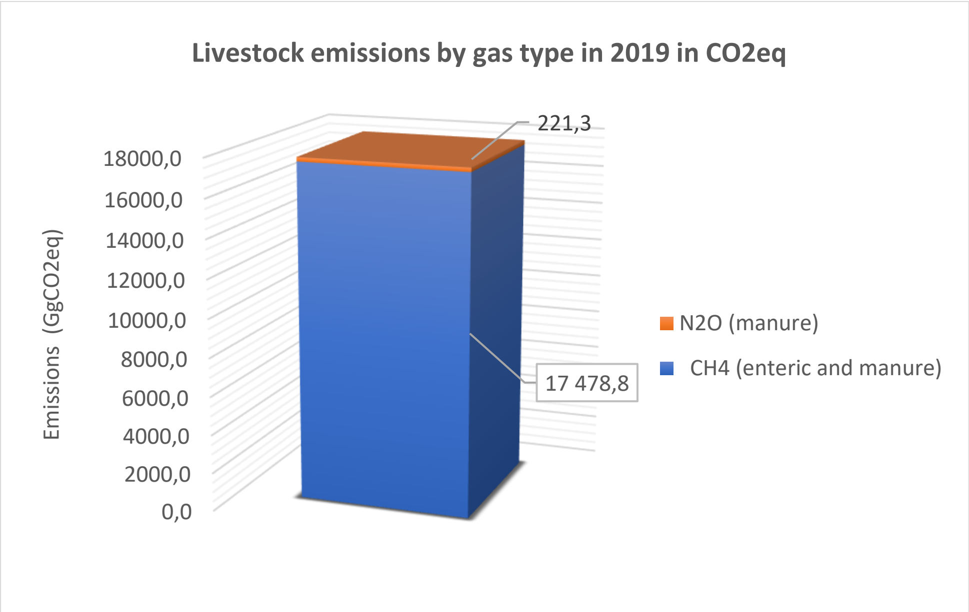

Figure 14: Somalia Share of Livestock Emissions by Gas Type in 2019

Total Methane emissions from Livestock amounted to **17478.9** Gg-CO_2eq while Nitrous Oxide Emission amounted to **221.3** Gg-CO_2eq in 2019. (Figure 14).

Detailed results by livestock source sub-categories for the inventory period 1990 to 2019 are discussed in the sections below.

2.7.2.3. Enteric fermentation (3.A.1)

Source Description for Enteric fermentation

Methane (CH_4) is the main greenhouse gas produced as a by-product of digestion in ruminants, e.g. cattle, and some non-ruminant animals such as pigs and camels. Ruminants are the largest source of CH_4 as they are able to digest cellulose. The amount of CH_4 released depends on the type, age and weight of the animal, the quality and quantity of feed and the energy expenditure of the animal. Somalia has no country-specific methane emission factors from enteric fermentation hence, tier 1 approach was applied in the estimation of emissions.

Methane Emission trends from Enteric Fermentation

Somalia, **Methane** (CH_4) emissions from enteric fermentation amounted to **16,703** Gg- CO_2eq in 2019, (Figure 15).

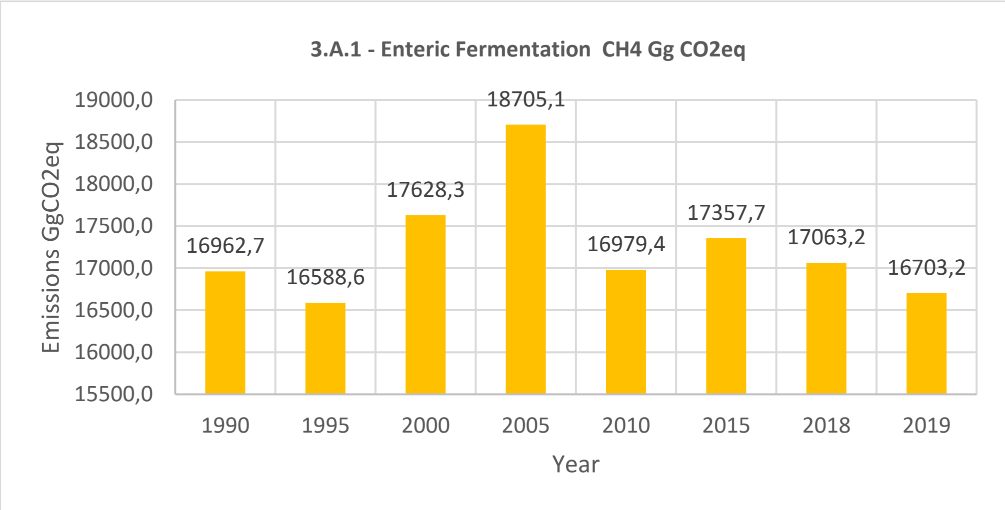

Figure 15: Emissions trends of Methane from Livestock Enteric Fermentation (Gg- CO2eq)

Table 10 shows emissions from livestock type for 2019. Camels are the largest contributors to enteric fermentation emissions with 56 percent share, followed by other cattle (non-dairy cattle) at 16 percent. Goats and Sheep, each contributed about 10 % share of enteric fermentation emissions in 2019, while dairy cattle contributed 8%. Donkeys, swine and horses enteric fermentation emissions were negligible, (Figure 16).

Table 10: Total Methane Emissions from Enteric Fermentation, 2019, (Gg CO2eq)

ENTERIC FERMENTATION CH4 EMISSIONS	2019
Dairy Cattle	1363.9
Other Cattle	2754.6
Sheep	1636.2
Goats	1605.3
Camels	9330.0
Horses	0.5
Mules and Asses	12.6
Swine	0.1

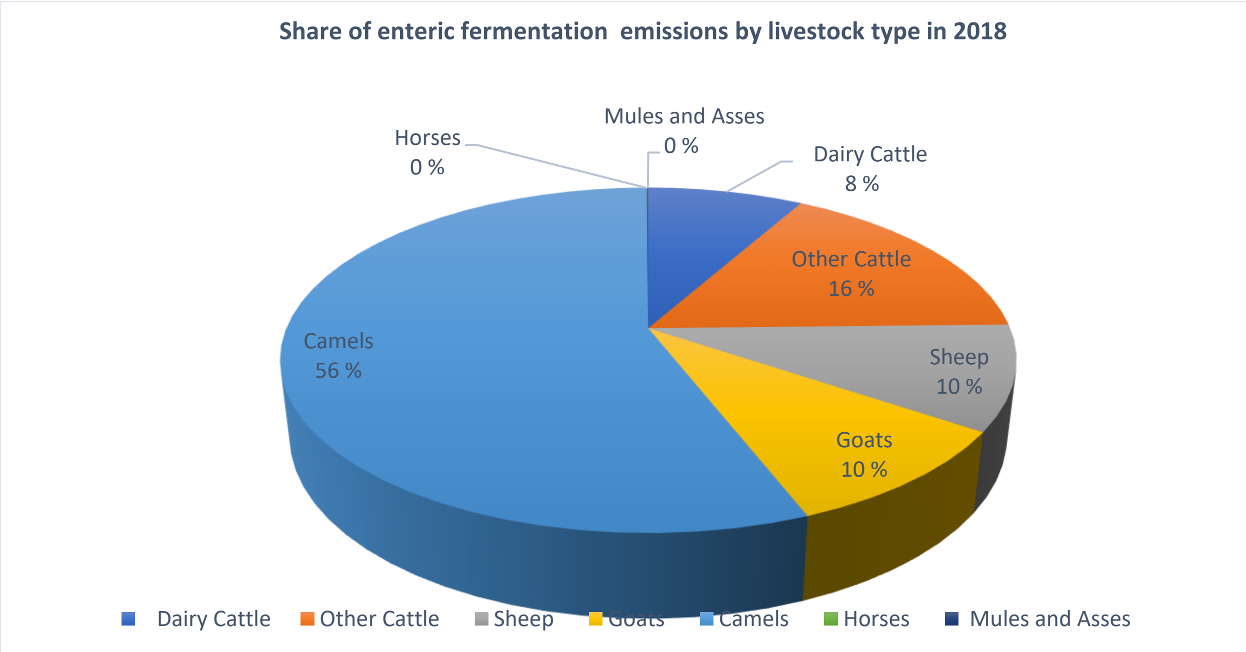

Figure 16: Contribution of Livestock type to Enteric Fermentation CH_4 Emissions in 2019

Methodological issues in Enteric Fermentation CH_4

The calculation of methane emissions from enteric fermentation was completed using Tier 1 methodology from the 2006 Revised IPCC Guidelines, using n default emission factors and the populations of different livestock obtained from FAOSTAT (Table 8).

The estimation was done using equation 10.19 of 2006 IPCC here represented as:

Methane Emissions = Σ Population of Livestock (head) x Emission Factor (kg CH_4 per head per year)

Emission Factors and Coefficients in Enteric Fermentation CH4

Default emission factors were drawn from the 2006 Revised IPCC Guidelines Volume 4, Chapter 10.

Uncertainties and Time-Series Consistency in enteric fermentation

Emission factors estimated using the Tier 1 method have uncertainty of about ± 30% (IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories. Livestock populations have a lower degree of uncertainty, and expert judgement is that uncertainty in this activity data is about ± 10%. This results in a combined uncertainty of ± 32%.

2.7.2.4. Manure Management (3.A.2)

Manure Management Source Description

Livestock manure is composed principally of organic material. When the manure decomposes in the absence of oxygen, methanogenic bacteria produce CH_4. The emissions of CH_4 are related to the amount of manure produced and the amount that decomposes anaerobically. These conditions often occur when large numbers of animals are managed in a confined area (e.g., dairy farms, beef feedlots, and swine and poultry farms), where manure is typically stored in large piles or disposed of in lagoons. This category also includes emissions of N_2O related to manure handling before the manure is added to the soil. The amount of N_2O released depends on the system of waste management and the duration of storage.

Methane Emission trends from Manure Management

Figures 17 illustrate the emissions from manure management methane (CH_4). Manure management produced **781** Gg of CH_4 in 1990, increasing to **800** in 2000 and decreasing slightly to **775.6 G**g-CO_2eq in 2019. Table 11 provides manure management emissions by livestock type in 2019.

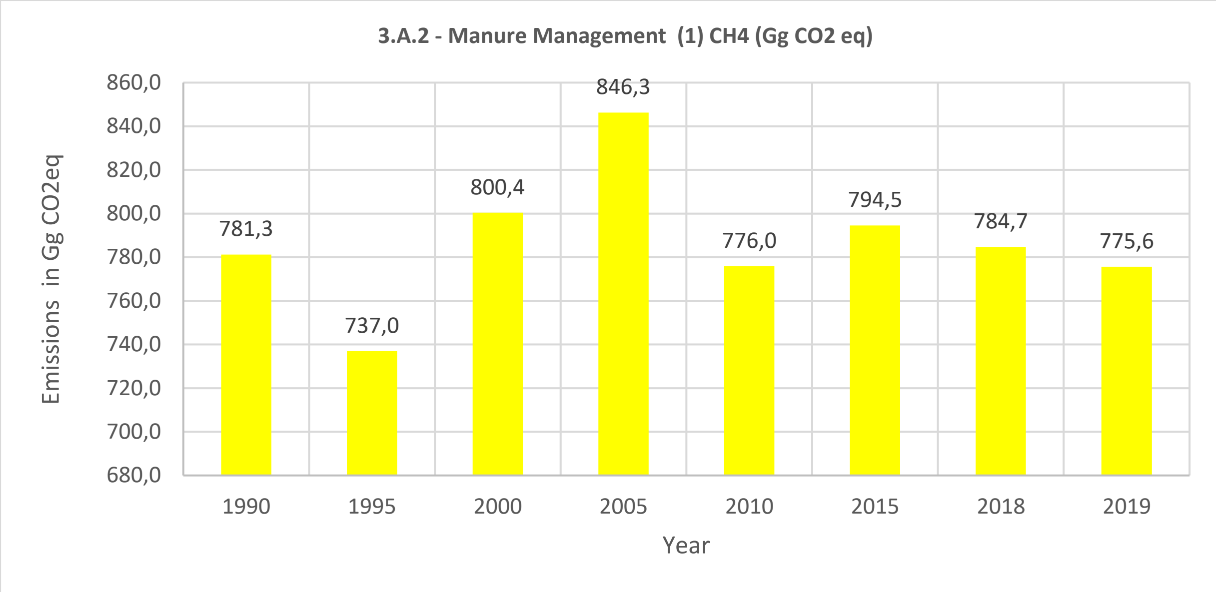

Figure 17: CH_4 emissions trends from Livestock Manure Management (Gg-CO2eq) 1990 – 2019

Table 11: CH_4 emissions from Manure Management in 2019 by Livestock type

3.A.2 - Manure Management CH4 EMISSIONS	**2019**
Dairy Cattle	29.7
Other Cattle	88.9
Sheep	65.4
Goats	70.6
Camels	519.2
Horses	0.1
Mules and Asses	1.5
Swine	0.2

Figure 18 shows the share of manure management methane emissions by livestock type. The largest contributor to the manure management methane emissions were camels (an average of 67 percent), followed by other cattle (an average of 12 percent) goats at 9%, sheep at 8%, while dairy cattle at 4%.

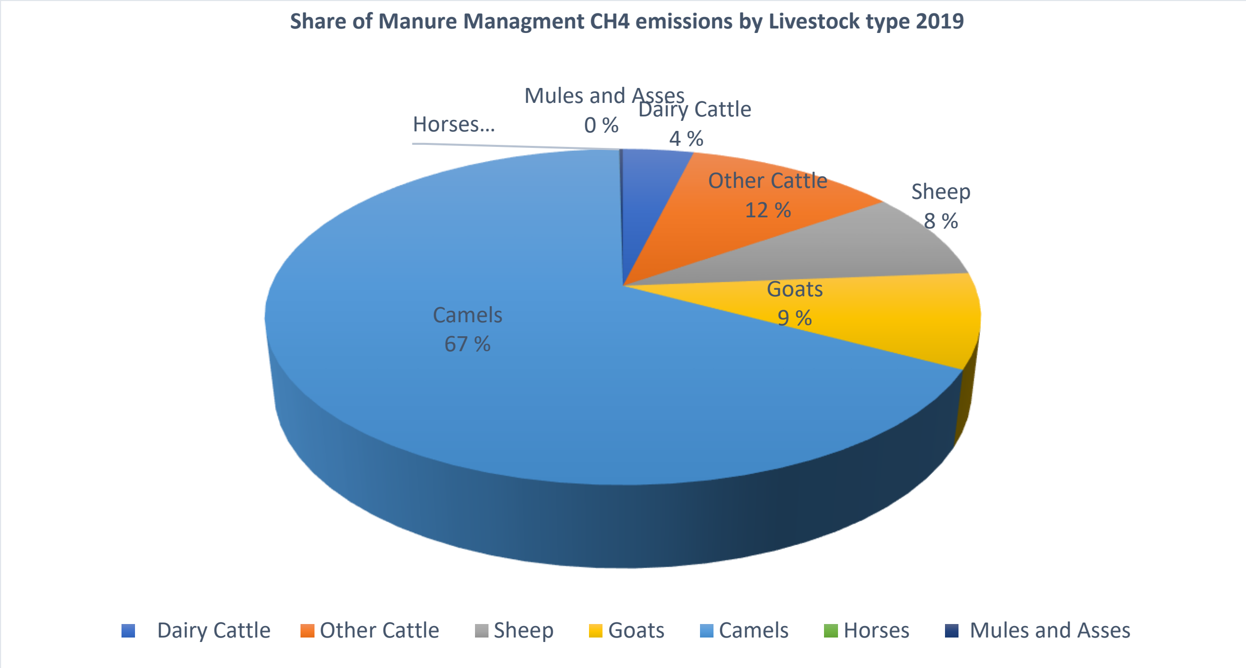

Figure 18: Contribution by Livestock Type to Manure Management CH4 Emissions 2019

N_2O Emission trends from Manure Management

Figure 19 shows manure management nitrous oxide (N_2O) emissions. Manure management produced **228** Gg of N_2O in 1990, increasing to **240** in 2000 and decreasing slightly to **221 G**g-CO_2eq in 2019.

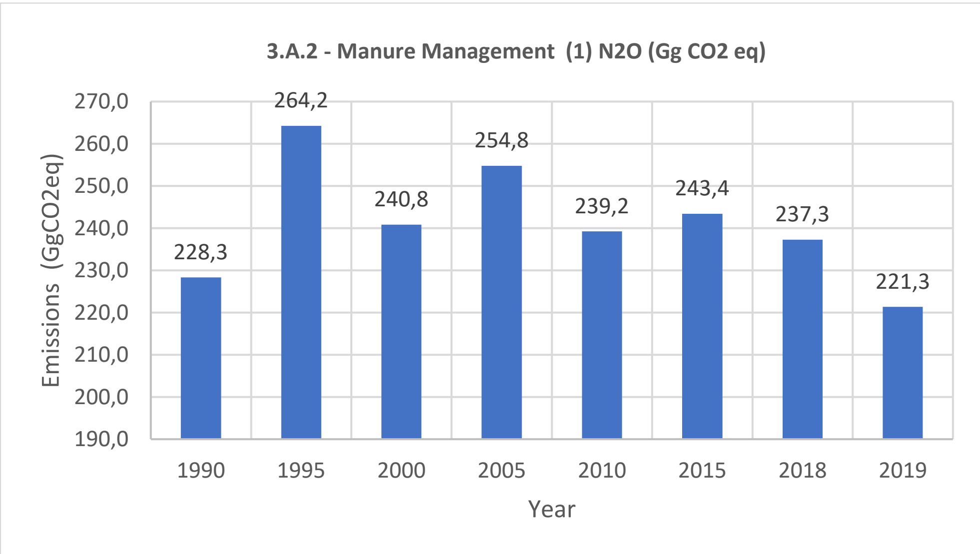

Figure 19: N_2O emissions trends from Livestock Manure Management (Gg-CO_2eq) 1990 - 2019

Table 12 and figure 20 illustrates the contribution by livestock type to Manure Management N_2O Emissions in 2019. The largest contributor to the N_2O emissions from manure management were dairy cattle, 66 percent, followed by camels at 12 percent, other local cattle at 7% , goats 8% and sheep at 7%.

Table 12: N_2O emissions from Manure Management in 2019 by livestock type

3.A.2 - Manure Management N20 EMISSION	**2019**
Dairy Cattle	146.1
Other Cattle	15.2
Sheep	14.5
Goats	17.9
Camels	27.5
Horses	0.0
Mules and Asses	0.1
Swine	0.0

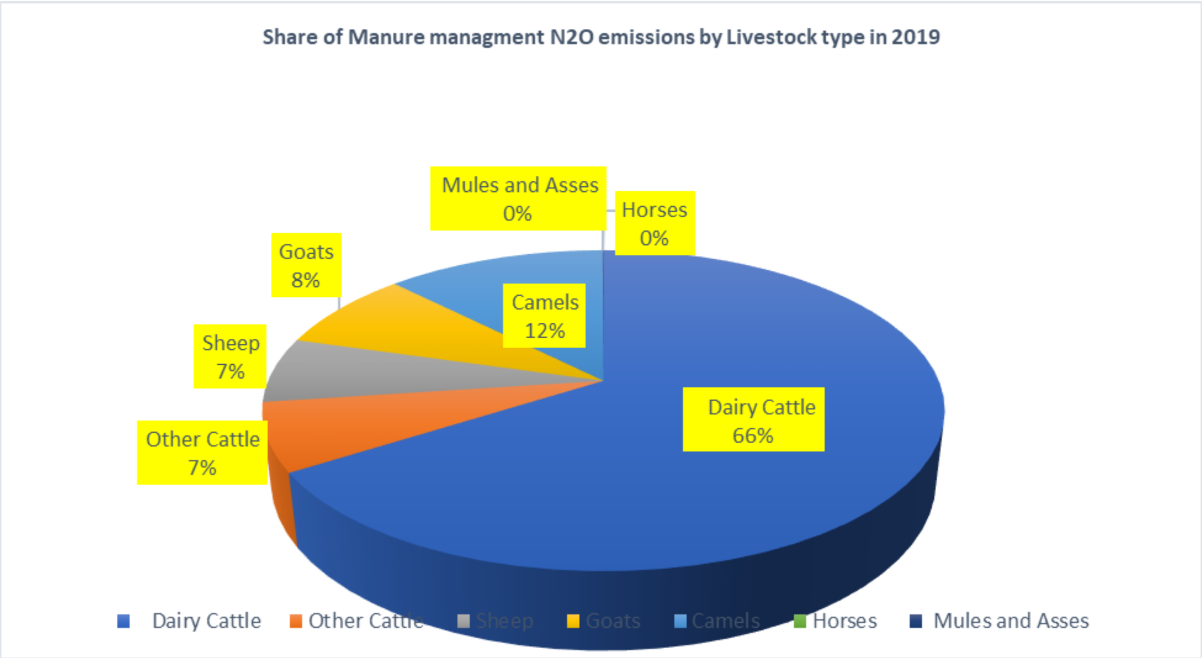

Figure 20: Share contribution by Livestock Type to Manure Management N_2O Emissions, 2019.

Methodological issues in Manure Management

The calculation of methane emissions from manure management was completed using the Tier 1 methodology from the 2006 Revised IPCC Guidelines. This method relies on default emission factors and country population data of different livestock.

Methane Emissions (kg/yr) = Σ Population of Livestock (head) x Emission Factor (kg CH_4 per head per year)

IPCC default emission factors for manure management are available for different categories of livestock based on the climate region.

Livestock population data is similar to what was used in enteric fermentation in table 8. In addition to livestock population, data is required on the climatic region where livestock populations are raised as this impact on manure management emissions. In this modelling case an average temperature of ≥ **28** degrees centigrade was assumed for the entire country.

Emission Factors and Coefficients in Manure management

Default emission factors were drawn from the 2006 Revised IPCC Guidelines Volume 4, Chapter 10, Table 10.14 and 10.15, and are presented in Table 13.

Table 13: Manure Management Emission Factors for Different Livestock Types. (Source: 2006 Revised IPCC Guidelines)

Type of Livestock	Dairy Cattle	Other Cattle	Sheep	Goats	Pigs	Asses and donkeys	Camels	Poultry
Emission Factor Manure Management CH_4/head/yr	1	1	0.15	0.17	1	0.9	1.92	0.02

Proportions for Manure Management Systems were developed using expert judgment as shown in Table 14. Direct N_2O emissions from manure management were calculated from equation 10.25 and equation 10.30 of the IPCC Guidelines, Volume 4, Chapter 10.

EQUATION 10.25

DIRECT N_2O EMISSIONS FROM MANURE MANAGEMENT

$$N_2O_{D(mm)} = \left[\sum_S \left[\sum_T \left(N_{(T)} \bullet Nex_{(T)} \bullet MS_{(T,S)} \right) \right] \bullet EF_{3(S)} \right] \bullet \frac{44}{28}$$

Where:

$N_2O_{D(mm)}$ = direct N_2O emissions from Manure Management in the country, kg N2O yr-1

$N_{(T)}$ = number of head of livestock species/category *T* in the country

$Nex_{(T)}$ = annual average N excretion per head of species/category *T* in the country, kg N animal-1 yr-1

$MS_{(T,S)}$ = fraction of total annual nitrogen excretion for each livestock species/category *T* that is managed in manure management system *S* in the country, dimensionless

$EF_{3(S)}$ = emission factor for direct N2O emissions from manure management system *S*, in the country in kg N_2O-N/kg N

S = manure management system

T = species/category of livestock

44/28 = conversion of $(N_2O\text{-}N)_{(mm)}$ emissions to $N_2O_{(mm)}$ emissions

EQUATION 10.30
ANNUAL N EXCRETION RATES

$$Nex_{(T)} = N_{rate(T)} \bullet \frac{TAM}{1000} \bullet 365$$

Where:

$Nex_{(T)}$ = annual N excretion for livestock category *T*, kg N animal^{-1} yr^{-1}

$N_{rate(T)}$ = default N excretion rate, kg N (1000 kg animal mass)$^{-1}$ day^{-1}

$TAM_{(T)}$ = typical animal mass for livestock category *T*, kg animal^{-1}

Nitrogen excretion rates (N_{rate}) were obtained from the Africa default values (IPCC, 2006, Table 10.19) while the annual nitrogen excretion for livestock Nex was estimated using the equation 10.30 from the guidelines (IPCC 2006). Default IPCC values from 2006 guidelines were used for Typical Animal Mass (TAM) for the various livestock categories. IPCC 2006 default Nitrous Oxide emission factors were used for the various manure management systems (IPCC 2006 Table 10.21).

Uncertainties and Time-Series Consistency in Manure management

The Tier 1 default emission factor values employed may have a large uncertainty for Somalia because the African values used may not reflect conditions within the country. It is estimated that uncertainty is ± 20% (Revised 2006 IPCC Guidelines for National Greenhouse Gas Inventories: Reference Manual). Data on manure management storage systems under different livestock categories was not available, with estimates being based on expert opinion and information from the various livestock industries thus introducing some uncertainty (Table 14).

Table 14: Livestock Manure Management Percentage Usage for Different Livestock Categories and Associated N_2O Emission Factors

Dairy Cattle	**% of MMS**	**Emission factors for N_2O for MMS**
Pasture / Range/ Paddock	43%	0
Solid Storage	30%	0.005
Dairy Spread	7%	0
Dry lot	20%	0.02
Non-dairy		
Pasture / Range/ Paddock	95%	0
Solid Storage	5%	0.005
Sheep and Goats		
Pasture / Range/ Paddock	95%	0
Solid Storage	5%	0.005
Swine		
Solid storage	70%	0.005
Pit storage	30%	0.002
Poultry		
Pasture/ Range/ Paddock	95%	0
Pit storage	5%	0.002
Camels		
Pasture/ Range/ Paddock	95%	0
Solid storage	5%	0.005
Donkey		
Pasture/ Range/ Paddock	95%	0
Solid storage	5%	0.005

Source: Emission factors -IPCC guidelines Volume 4, proportions of manure management system -expert judgement

2.7.3 LAND EMISSIONS

2.7.3.1 FOLU Sector Overview

Emissions from the Land (IPCC category 3.B) resulting from deforestation, forest degradation, afforestation/reforestation and sustainable management of forests were estimated. Emissions from the land category were divided into six land representations, namely; (3.B1 -Forest land), (3.B2 Cropland), (3.B3- Grassland), (3.B4 - Wetland), (3.B5 Settlement) and (3.B6 - Other Lands (Box 1). The tier for reporting emission estimates entirely depend on availability of the country specific data. Hence for the Federal Government of Somalia tier 1 method was utilised.

Further the 2006 IPCC guidelines, Volume 1 on General Guidance and Reporting and Volume 4 on Agriculture, Forestry and Other Land Use, provides detailed methodologies and guidance on this sector. These guidelines have therefore been adhered to in the processes of; Classification and stratification of lands, Generation and Calculation of the Activity Data (AD), Selection of Emission factors to be applied and Estimation of the emissions and Removals. In summary therefore, the process of reporting in the FOLU sector has followed the steps of:-

- Stratification of land to appropriate strata.
- Developing national land classification system for the 6 IPCC classes.
- Analysis of data for each land category.
- Estimation of CO2 emissions/removals at appropriate tier as per the TCCCA principles.
- Estimation of uncertainties.
- Generating emissions/removals for each land use and strata.
- Reporting the emission/removals as per reporting tables' guidance.
- Documenting and archiving all the relevant information as per the reporting.
- Identifying gaps, challenges and setting priorities for future improvement purposes.

Data sources

Land cover mapping was done following the recommendations from the CCI-LC which is a simplification of the Global Land Service and shares many classes with PROBA-V classification (PROBA-V is a miniaturized European Space Agency (ESA) satellite which was launched on 7 May 2013 to map land cover and vegetation growth across the entire planet after every two days). This dataset has mapped the 6 land use categories as defined by the IPCC namely; Forestland, Grassland, Cropland, Wetland, Settlement and other land. However, there were also areas of No data noted in the dataset and these are areas not covered by the CCI-LC datasets but falls within the Somali administrative boundary. The spatial resolution of the data is 300m with a temporal resolution being 1992-2018.This therefore presented availability of even historical datasets to choose for the analysis purposes.

This website[29] provides an interface for downloading different types of datasets including landcover. It also gives you an option of defining the kind of data required, setting the area of interest and even defining the boundary as shown in the figure 17 below;

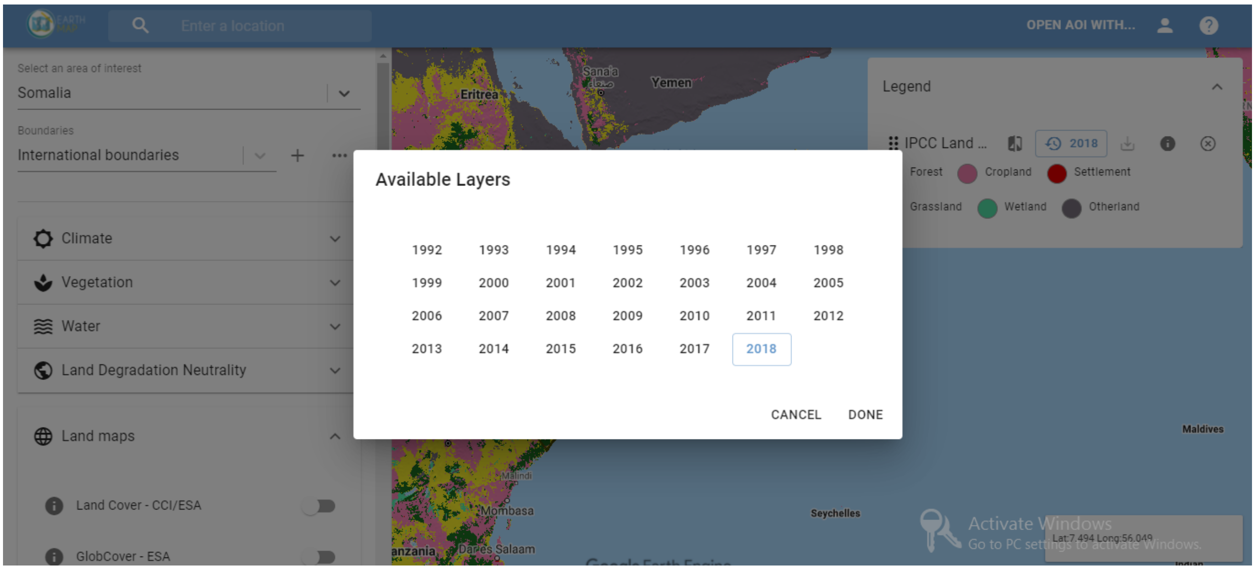

Figure 21: Illustration of Earthmap website

[29] The datasets were downloaded from the **Earthmap** website; https://earthmap.org/?aoi=so&boundary=level0&layers=%7B%22IPCC_PROBAV%22%3A%7B%22opacity%22%3A1%7D%7D&map=%7B%22center%22%3A%7B%22lat%22%3A5.201009646993562%2C%22lng%22%3A46.20491514770367%7D%2C%22zoom%22%3A5%2C%22type%22%3A%22roadmap%22%7D.

Box 1: IPCC Landcover classes adopted for analysis (source: IPCC guidelines)

Forest Land: This category includes all land with woody vegetation consistent with thresholds used to define Forest Land in the national greenhouse gas inventory. It also includes systems with a vegetation structure that currently fall below, but in situ could potentially reach the threshold values used by a country to define the Forest Land category.

Cropland: This category includes cropped land, including rice fields, and agro-forestry systems where the vegetation structure falls below the thresholds used for the Forest Land category.

Grassland: This category includes rangelands and pasture lands that are not considered Cropland. It also includes systems with woody vegetation and other non-grass vegetation such as herbs and brushes that fall below the threshold values used in the Forest Land category. The category also includes all grassland from wild lands to recreational areas as well as agricultural and silvi-pastural systems, consistent with national definitions.

Wetlands: This category includes areas of peat extraction and land that is covered or saturated by water for all or part of the year (e.g., peatlands) and that does not fall into the Forest Land, Cropland, Grassland or Settlements categories. It includes reservoirs as a managed sub-division and natural rivers and lakes as unmanaged sub-divisions.

Settlements: This category includes all developed land, including transportation infrastructure and human settlements of any size, unless they are already included under other categories. This should be consistent with national definitions.

Other Land: This category includes bare soil, rock, ice, and all land areas that do not fall into any of the other five categories. It allows the total of identified land areas to match the national area, where data are available. If data are available, countries are encouraged to classify unmanaged lands by the above land-use categories (e.g., into Unmanaged Forest Land, Unmanaged Grassland, and Unmanaged Wetlands). This will improve transparency and enhance the ability to track land-use conversions from specific types of unmanaged lands into the categories above.

NOTE: There is an additional class of **No Data** and this include areas that isn't covered by the global dataset used but falls within Somalia national boundary

2.7.3.2 Methodological issues in forest and land emissions

Land emissions or (Land use, land-use change and forestry-LULUCF) inventory has been completed using Tier 1, IPCC 2006 guidelines, Volume 4. Consistent land cover data covering the country for sufficient time series was considered to carry out change detection and calculate percentage land cover for the IPCC Six land use categories namely: Forestland, Cropland, Grasslands, Wetland, Settlements and Other lands. For each land-use category, a carbon stock change was estimated for all *strata* or subdivisions of land area (e.g. climate zone, ecotype, soil type, management regime etc.).

Depending on activity data from each land use change transitions over a given period and associated carbon stock for each land use subcategory, carbon dioxide emissions was calculated using the **Stock-Difference Method** which requires biomass carbon stock inventories for a given land area, at two points in time. Annual biomass change is the difference between the biomass stock at time t_2 and time t_1, divided by the number of years between the inventories.

A five-year period was adopted for analysis starting from 1995 to 2015. The initial (1992) and the last (2018) year were also included in the analysis. However, it's worth noting that the two years (first and last) have a shorter time interval of 3 years. The extent of Somalia boundary was therefore uploaded to the earth map site and data downloaded as a single band image and processed to extract the 6 different IPCC classes of including No Data areas.

The data was projected to a spatial reference of WGS 1984, UTM Zone 38N. The classes were extracted in ENVI software and color coded for visualization with RGB values as shown in Table 15.

Table 15: Showing Landcover classes, codes and the RGB values

IPCC Class Category	Class Code	Display Colour (RGB) codes
Forestland	1	0, 139, 0
Grassland	2	255, 255, 0
Cropland	3	238, 0, 238
Wetland	4	127, 255, 212
Settlement	5	255, 0, 0
Otherland	6	216, 191, 216
No Data	7	255, 165, 0

The entire process was guided by the 2006 IPCC guidelines specifically on data identification, collation, selection & processing, methods, use of emission factors and application of underlying assumptions in a consistent and transparent manner as per the IPCC 2006 principles. The landcover data has been downloaded for the years; 1992, 1995, 2000, 2005, 2010, 2015 and 2018 (Table 17) giving seven data points for analysis. This data show the trend of land use areas for the period 1992 – 2018. This is very important in analyzing the possible areas facing deforestation and degradation which by extension contributes to emissions.

Land cover maps and Land use Area

Land cover maps were generated from the global datasets downloaded from earth map site for the seven years under review (Figure 22). The maps contain all the six classes as described in Box 1. The area for each land use category based on pixels was calculated in ERDAS Imagine software and presented in hectares. The class Grassland is the most dominant class as presented by the results with approximately over 60% in all the years mapped. The results also indicate a slight increase in forestland and other land but a decrease in grassland. However the class cropland has remained relatively stable over the years as shown in the table 16 below;

Table 16: Landcover data 1992-2018

Class Name	**Area in Ha**						
	1992	**1995**	**2000**	**2005**	**2010**	**2015**	**2018**
Forestland	3,354,570	3,354,552	3,407,949	3,533,175	3,601,359	3,668,670	4,028,850
Grassland	43,447,752	43,443,675	43,040,772	42,813,252	42,579,513	42,555,177	42,345,027
Cropland	6,270,021	6,270,291	6,310,422	6,321,681	6,341,292	6,340,005	6,280,236
Wetland	62,442	62,424	62,064	62,001	61,992	61,992	61,164
Settlement	33,975	36,117	43,551	44,460	46,557	49,644	53,424
Other-land	11,083,023	11,088,342	11,396,421	11,486,592	11,630,457	11,585,700	11,492,433
No data	113,985	110,367	104,589	104,607	104,598	104,580	104,634
Total	**64,365,768**	**64,365,768**	**64,365,768**	**64,365,768**	**64,365,768**	**64,365,768**	**64,365,768**

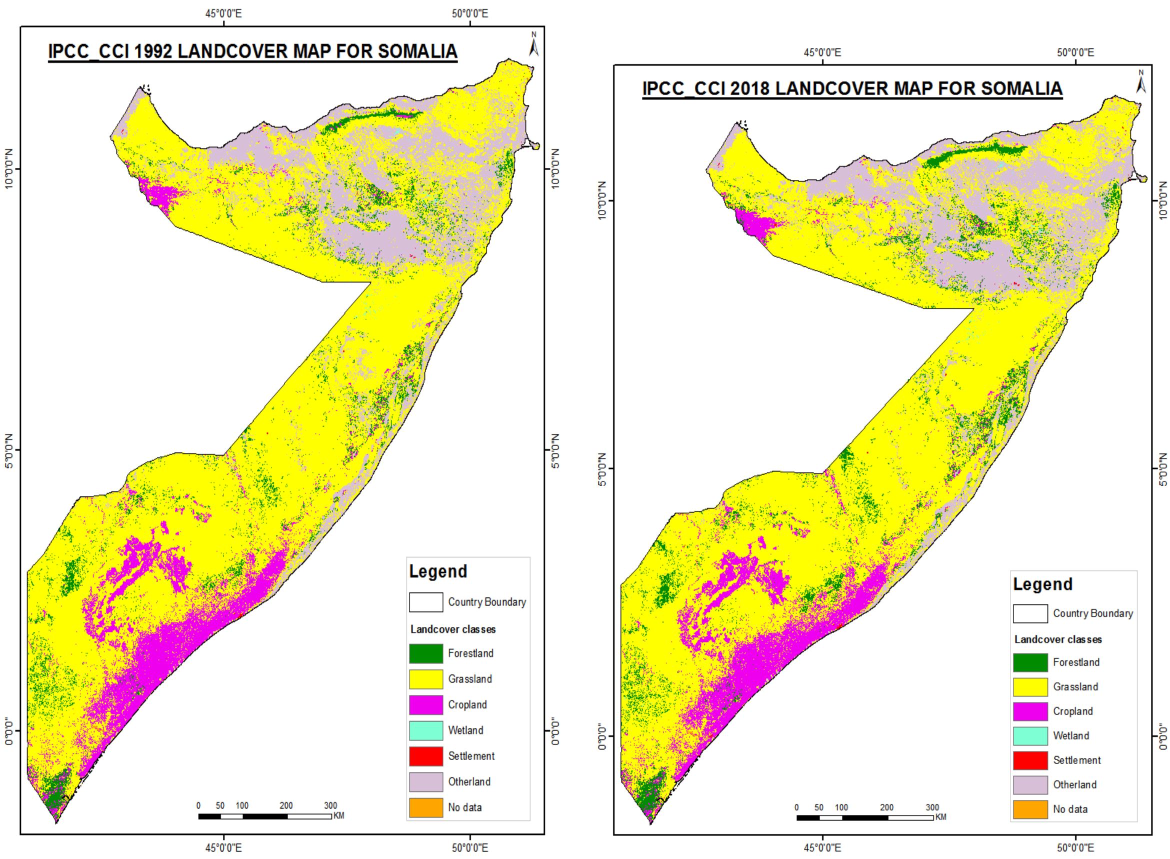

Figure 22: Illustration of Land cover maps generated.

Land cover change and Activity data

Analysis of the land cover change forms the basis for generation of the activity data. Analysis of the time series data was done at 5-year interval and comparison made from two time period sequentially (e.g. 1992 and 1995, 1995 and 2000…) Calculation of total emissions/removals from a land use category was then based on two main change activities namely: -

I. Land use remaining the same over a given period
II. Lands converted to another land use type over a given period.

Further the stratification data to be overlaid on the change maps was generated to calculate areas of changes in each land use categories by strata. This generated datasets similar to what is shown in table 17 below which would also comprise data for generation of matrix for land use change activities.

Table 17: Showing classes of Lands remaining the same and Land converted to other category

Category	Land Remaining the same land use sub-category	Land converted to another land use sub-category
Forestland	Forestland-=>Forestland	Land => Forestland
Grassland	Grassland => Grassland	Land => Grassland
Cropland	Cropland=> Cropland	Land => Croplands
Wetlands	Wetlands => Wetlands	Land => Wetlands
Settlements	Settlements => Settlements	Land => Settlements
Otherland	Otherland=> Otherland	Land => Otherland

Stratification and Emission Factors

The six IPCC land cover classes need to be stratified further using the best stratification method on the basis of either land-use practices or bio-physical characteristics to create more homogeneous spatial units required in estimation of emissions in the country. Stratification data was therefore required for the country Somalia. 2006 IPCC guidelines allows land to be classified based on climate domain and ecological zones and forest crown cover classes since the carbon stock varies with climate, biome or even forest type (2006, IPCC guidelines, V4, Ch4). Therefore, for this analysis, the Global Agro-Ecological Zones data was adopted for the stratification. This also helped in selection of the emission factors to be applied in each stratum. Therefore, since Somalia falls within four global AEZ as shown in Figure 23, the stratification data was overlaid to the change data (activity data) generated to calculate areas of change in each landuse category as illustrated in Table 18. This process was then repeated for all the time periods under review.

For the Forestland category, IPCC default values were adopted in the calculation of the above-ground biomass for each stratum. The value for Tropical dry forest (Africa) was therefore applied in the entire stratum as shown in Table 19. Below-ground biomass was also calculated from the shoot/root ratio as per the IPCC default values (Table 19). The total biomass (above and below ground) was then converted into carbon stocks and CO_2 emissions using the IPCC default values. Default values were adopted for the non-forest classes (i.e. Grassland, Cropland, Wetland, Settlement and Otherland).

To calculate the change in carbon stocks due to afforestation (i.e. Land converted to Forestland), growth rate values (2006 IPCC guidelines) for forests less than 20 years in the Tropical dry forest (Africa) was adopted as shown in Table 20 (IPCC guideline Volume 4, table 4.9).

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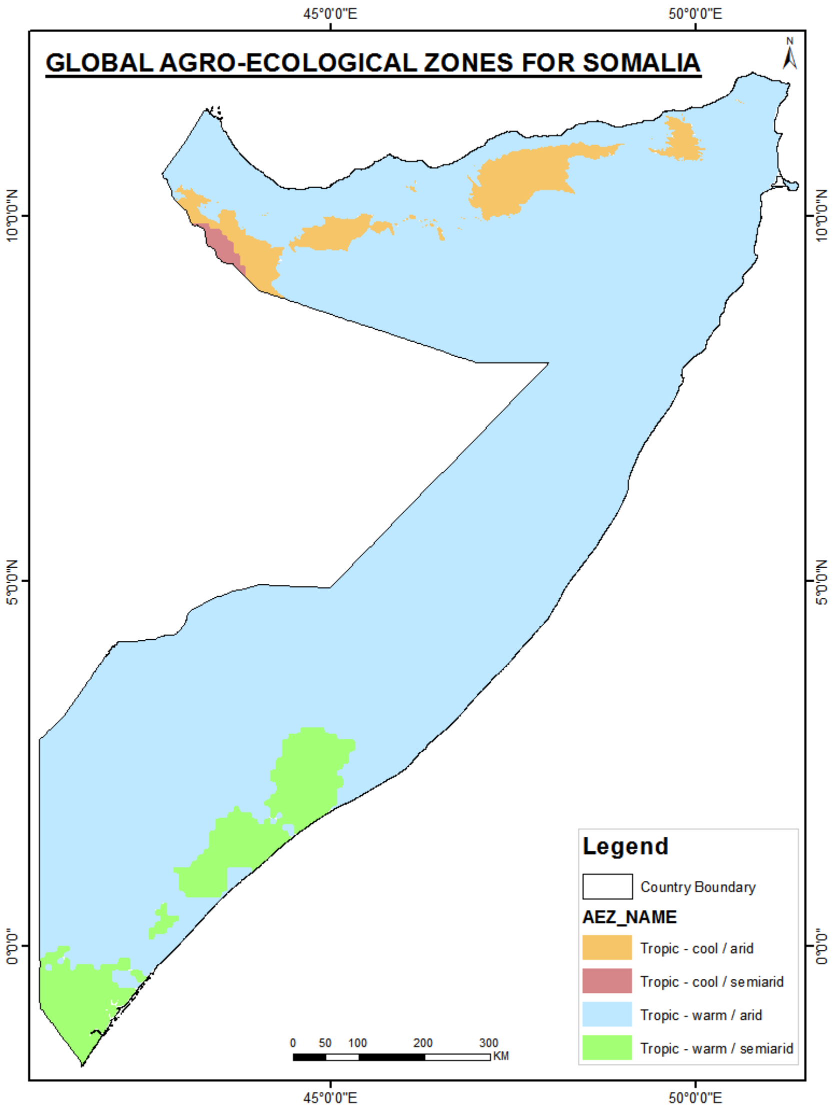

Figure 23: Somalia Global Agro-Ecological Zone

Table 18: Illustration of land use changes in Ha for the period 2005-2010[30]

LC Classes		2010						
		Forestland	Grassland	Cropland	Wetland	Settlement	Other-land	No Data[31]
2005	Forestland	3475188	9054	585	9	0	2556	0
	Grassland	68382	41947128	22104	0	1179	224406	0
	Cropland	8460	3789	6262911	0	36	81	0
	Wetland	18	0	0	60921	0	0	0
	Settlement	0	0	0	0	43749	0	0
	Otherland	2340	74457	9090	0	855	11149227	9
	No Data	0	0	0	0	0	27	103248
Key		Afforestation	Deforestation	Non-forest to Non-forest			No Change	

Data Source[32]:

[30] , This Data Was generated from the Global Datasets used In the analysis.
[31] The No data areas are areas that are not covered by the CCI-LC datasets but falls within the Somali administrative boundary. So, they must be accounted for.
[32] https://earthmap.org/?aoi=so&boundary=level0&layers=%7B%22IPCC_PROBAV%22%3A%7B%22opacity%22%3A1%7D%7D&map=%7B%22center%22%3A%7B%22lat%22%3A5.201009646993562%2C%22lng%22%3A46.20491514770367%7D%2C%22zoom%22%3A5%2C%22type%22%3A%22roadmap%22%7D.

Table 19: Total Carbon stocks per hectare based on IPCC 2006 defaults

Stratum	**IPCC Ecological Zone equivalent for Forestland**	**AGB t/ha**	**Above-ground Carbon stock tC/ha (IPCC 2006 Default)**	**Ratio of below-ground carbon to above-ground carbon (IPCC 2006 Default)**	**Total Carbon stock tC/ha**
Tropic Cool Arid	Tropical Dry Forest	120.00	56.4	0.28	72.19
Tropic Cool Semiarid	Tropical Dry Forest	120.00	56.4	0.28	72.19
Tropic Warm Arid	Tropical Dry Forest	120.00	56.4	0.28	72.19
Tropic Warm Semiarid	Tropical Dry Forest	120.00	56.4	0.28	72.19
Non-Forest classes					
Grassland		8.70	4.09	0.2	4.90
Cropland			0.00		
Wetland			0.00		
Settlement			0.00		
Otherland			0.00		
No Data			0.00		

Source: 2006 IPCC Guidelines (table 4.7)

Table 20: Emission factor used for calculating forest growth due to afforestation

Stratum	**Biomass gain in tonnes**			**CO2 sequestration**	
	IPCC table 4.9 equivalent AGB value	**IPCC table 4.9 equivalent BGB value**	**(AG+BG) Annual Total Carbon stock growth rate for trees < 20yr**	**One year**	**5 years**
Tropic Cool Arid	2.40	0.28	3.07	3.07	15.36
Tropic Cool Semiarid					
Tropic Warm Arid					
Tropic Warm Semiarid					

Source: 2006 IPCC Guidelines (table 4.9)

2.7.3.3. Emission Trends in the different agro-ecological zones.

CO_2 emission/removal was calculated as activity data (AD) multiplied by the emission factor (EF) for the period under review.

From the analysis, the emissions increased from 81, 592 tCO_2 **(or 81.5 Gg)** to 5,336,316 tCO_2 (or **5336 Gg**) in the period 1995-2000 before dropping to -1,942,765 tCO_2 for the period 2000-2005. There was an increase in emissions the following period of 2005-2010 followed by a steady decrease in the following two time periods as shown in Figure 24. All the strata were net emitters during the period 1992-1995, 1995-2000 and 2005-2010 but became sinks in the other monitoring periods.

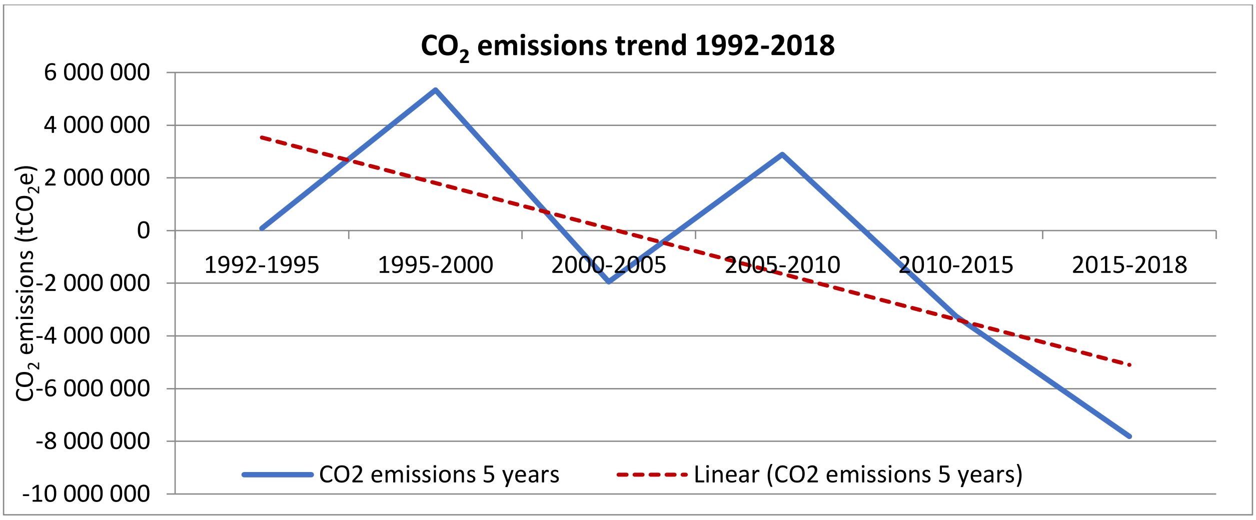

Figure 24: Emissions trend 1992-2018

The analysis further shows that the Tropic warm arid strata which covers the largest area, contributed greatly both as an emitter and a sink followed by the Tropic warm semi-arid strata. Interestingly though the amount of co_2 removed in the monitoring period of 2015-2018 (3 years) increased to -7,815,866 from -3,250,329 tCO_2 in the previous period of 2010-2015 (Table 21).

Table 21: Summary of the CO2 emissions (tonnes, CO_2) per ecological Zones between 1992 and 2018

Strata	**CO_2 emissions (tCO_2e)**					
	1992-1995	**1995-2000**	**2000-2005**	**2005-2010**	**2010-2015**	**2015-2018**
Tropic cool arid	9,238	1,343,699	289,451	-59,375	-576,524	-788,956
Tropic cool semiarid	0	142,785	265,960	-17,881	-229,338	-52,928
Tropic warm arid	69,274	3,831,898	-1,710,071	3,641,116	-1,782,985	-5,532,089
Tropic warm semiarid	3,079	17,934	-788,104	-669,789	-661,482	-1,441,893

CO_2 emissions 5 years	81,591	5,336,316	-1,942,765	2,894,071	-3,250,329	-7,815,866
Annual CO_2 emissions	27,197	1,067,263	-388,553	578,814	-650,066	-2,605,289

However global datasets are associated with high uncertainties and therefore the annual average value of emissions was calculated to reflect the LULUCF emissions for Somalia. Figure 25 illustrates the average emissions from LULUCF. Though emissions from this sector fluctuated during the period under review an average emission value of **17350** Gg CO_2eq per annum was estimated, attributed to *increased encroachment on* forest land, charcoal burning and demand for agricultural land.

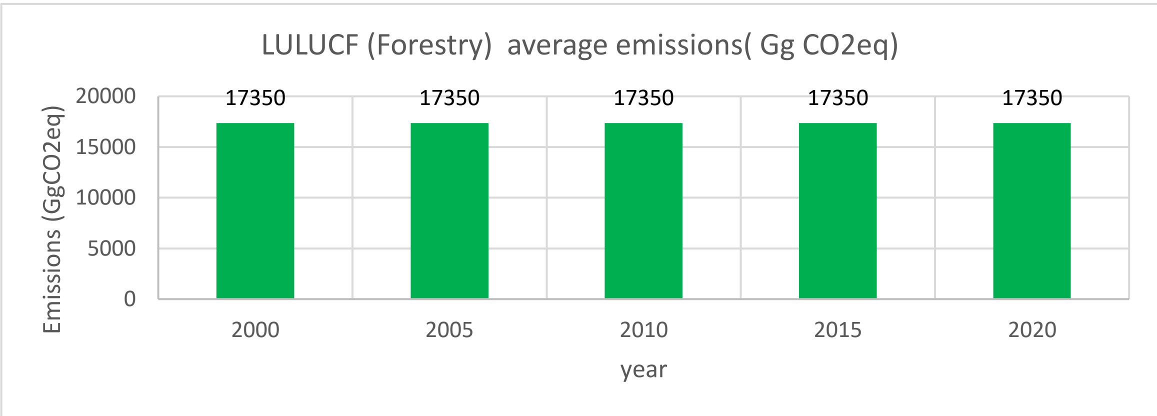

Figure 25: LULUCF-average annual emission trends for the period 2000-2020(data Source CAIT)

2.7.4 AGGREGATED SOURCES AND NON- CO_2 EMISSIONS

2.7.4.1 Aggregated Sources overview

Aggregated sources and non- CO2 emissions- are AFOLU-GHG emissions related to activities other than livestock and land. They include CH_4 and N_2O from biomass burning, CO_2 from Urea application, direct and indirect N_2O from managed soils; and indirect N_2O from manure management as well as CH_4 emissions from rice cultivation. N_2O Emissions arise primarily from synthetic and natural fertilizers (i.e., manure and crop residues) applied to cultivated soils and are based on IPCC guidelines regarding atmospheric deposition and leaching from soils. Other N_2O emission sources include; rice cultivation, biomass burning in grassland and biomass burning in cropland (crop residues). These are based on land areas or production quantities combined with default IPCC emission factors. Based on the availability of data for the sub-categories mentioned, input data will include: (a) areas of land type (forest, crop, grassland) affected by fire (b) annual crop area and yield from major stable crops (c) nitrogen fertilizers and urea consumption and mode of application, (d) area of rice cultivation. Tier 1 approach and IPCC guidelines Volume 4 was used to estimate emissions from aggregated sources, with activity data downloaded from FAOSTAT.

The Aggregated sources and non- CO_2 emissions category is one of the source of N_2O emissions in Somalia and for this inventory the following sub-categories were considered:

Biomass burning in forest lands (3.C.1.a)

Biomass burning in croplands (3.C.1.b)

Biomass burning in grasslands (3.C.1.c)

Biomass burning in all other land (3.C.1.d)

Liming (3.C.2)

Urea application (3.C.3)

Direct N_2O Emissions from managed soils (3.C.4)

Indirect N_2O Emissions from managed soils (3.C.5)

Indirect N_2O Emissions from manure management (3.C.6)

Rice cultivations (3.C.7)

Activity data for aggregated sources was obtained and sourced from FAOSTAT and the summary of data used for modelling is provided in table 22 below. Detailed results by source sub-categories in aggregated sources for the inventory are discussed in the sections below.

Table 22: Sample activity data for aggregated sources (source FAO/FAOSTAT website)

FOREST TYPE	data type	units/year	2000	2005	2010	2015	2019
Other forest	Biomass burned (dry matter)	tonnes	2728.0	0	0	missing	missing
	Burned Area	ha	50.4	0	0	missing	missing
	data type	**units/year**	**2000**	**2005**	**2010**	**2015**	**2019**
Closed shrubland	Biomass burned (dry matter)	tonnes	19083.9	11982.7		missing	missing
	Burned Area	ha	714.8	448.8		missing	missing
CROP LAND	**data type**	**units/year**	**2000**	**2005**	**2010**	**2015**	**2019**
Maize	Biomass burned (dry matter)	tonnes	182180	170000	87843	189825	100000
Rice, paddy	Biomass burned (dry matter)	tonnes	550	1467.95	907.5	770	621.5
Sugar cane	Biomass burned (dry matter)	tonnes	4030	3575	4030	4210.05	4056.65
Wheat	Biomass burned (dry matter)	tonnes	1040	1240	1032	1042.8	1037.2
GRASSLAND TYPE	data type	units/year	2000	2005	2010	2015	2019
Tropical Grassland	Biomass burned (dry matter)	tonnes	20818.6	129459.4	117680.6	14112.9	10890.2
	Burned Area	ha	4003.6	24896.0	22630.9	2714.0	2094.3
Savanna	**data type**	**units/year**	**2000**	**2005**	**2010**	**2015**	**2019**
	Biomass burned (dry matter)	tonnes	23301.1	1495.9	149.6	448.8	3590.2
	Burned Area	ha	3328.7	213.7	21.4	64.1	512.9

Data obtained from FAOSTAT was missing for some years, thus limiting the estimations for most of the sub-categories above. The following sub-categories were not estimated due to lack of data.

Liming (3.C.2)

Urea application (3.C.3)

Furthermore, synthetic fertilizer and manure application data could not be obtained limiting the estimations of both Direct and Indirect N2O emissions from managed soils. The analysis of emissions from aggregated sources for the available data are summarized below.

2.7.4.2 Emission Trends in the aggregated sources

Figure 26 and Table 23 illustrate the emissions from Aggregated sources and non- CO_2 emissions for the categories modelled. Aggregated sources emissions fluctuated during the period under review, rising from **4472**Gg in 2000, to **4854** in 2005, and decreased to **4001** Gg-CO_2eq in 2019. These fluctuations could be associated with variations in number of hectares burned in the respective years and uncertainties in the data from FAOSTAT data. Livestock population contribute to both direct and indirect N2O emissions from the dung/urine they generate and thus the livestock decreasing population (due to increasing trade and export of livestock products from 2005) is having an impact on reducing N2O emissions.

Table 23: Emission trends in aggregated sources in GgCO2eq 2000-2019

Year	**2000**	**2005**	**2010**	**2015**	**2019**
Aggregated Sources-Biomass burning	29.97	37.99	28.63	25.88	17.37
Aggregated Sources-Direct and Indirect N2O	4438.5	4806.6	4191.1	4250.1	3979.2
Aggregated Sources -Rice Cultivation	3.6	9.7	6.0	5.1	4.7
TOTAL Aggregated sources emissions	**4472.1**	**4854.2**	**4225.7**	**4281.0**	**4001.3**

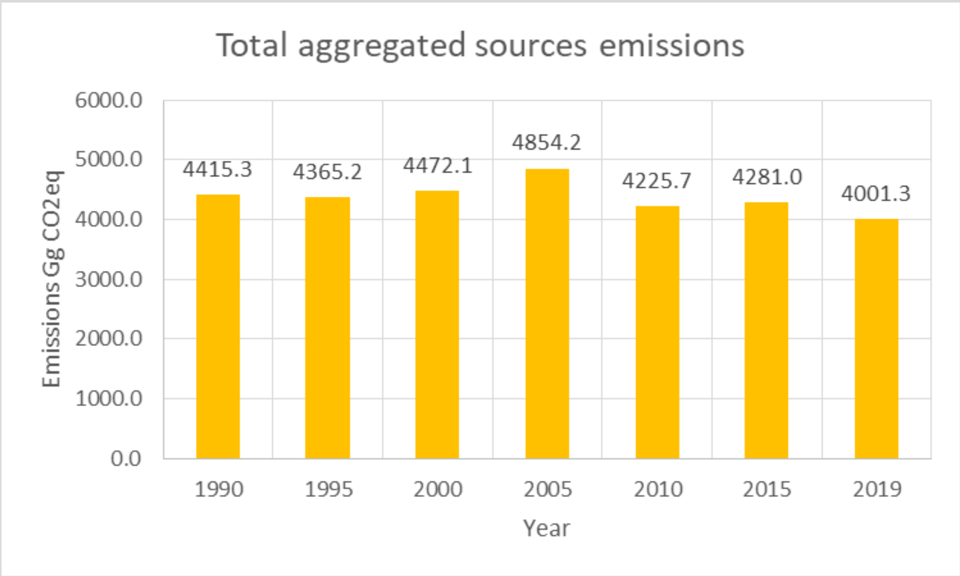

Figure 26: Emission trends in aggregated sources in $GgCO_2eq$ 1990-2019

2.7.4.3. *Biomass Burning*

Biomass burning source description

Biomass burning is an important ecosystem process in Somalia as it is in most African Countries. Fire plays an important role- in maintaining ecological health. In addition to carbon dioxide, the burning of biomass results in the release of other GHGs or precursor of GHGs that originate from incomplete combustion of the fuel. The key greenhouse gases from burning of biomass are CO_2, CH_4 and N_2O, but also precursors such as NO_x, NH_3, NMVOC and CO.

Methodological issues in Biomass Burning

Fire is treated as a disturbance that affects not only the biomass (in particular, above-ground), but also the dead organic matter. Only non-CO_2 emissions are considered, with the assumption that the CO_2 emissions would be counterbalanced by CO_2 removals from the subsequent re-growth of the vegetation within one year. This assumption implies maintenance of soil fertility – an assumption which countries may ignore if they have evidence of fertility decline due to fire. Non-CO_2 greenhouse gas emissions are estimated for all fire situations. Under Tier 1, non-CO_2 emissions are best estimated using the actual fuel consumption and appropriate emission factors.

A generic methodology to estimate the emissions of individual greenhouse gases for any type of fire is summarized in Equation 2.27 of the IPCC guidelines Volume 4.

EQUATION 2.27
ESTIMATION OF GREENHOUSE GAS EMISSIONS FROM FIRE

$$L_{fire} = A \bullet M_B \bullet C_f \bullet G_{ef} \bullet 10^{-6}$$

Where:

L_{fire} = amount of greenhouse gas emissions from fire, tonnes of each GHG e.g., CH_4, N_2O, etc.

A = area burned, ha

M_B = mass of fuel available for combustion, tonnes ha^{-1}. This includes biomass, ground litter and dead wood. When Tier 1 methods are used then litter and dead wood pools are assumed zero, except where there is a land-use change (IPCC guidelines- volume 4).

C_f = combustion factor, dimensionless (default values in Table 2.6 in the IPCC guidelines)

G_{ef} = emission factor, g kg^{-1} dry matter burnt (default values in Table 2.5 in the IPCC guidelines)

Note: Where data for M_B and C_f are not available, a default value for the amount of fuel actually burnt (the product of M_B and $C_{f)}$ can be used (Table 2.4 in the IPCC guidelines) under Tier 1 methodology.

The amount of fuel that can be burned is given by the area burned and the density of fuel present on that area. The fuel density can include biomass, dead wood and litter, which vary as a function of the type, age and condition of the vegetation. The type of fire also affects the amount of fuel available for combustion. For example, fuel available for low-intensity ground fires in forests will be largely restricted to litter and dead organic matter on the surface, while a higher-intensity 'crown fire' can also consume substantial amounts of tree biomass.

Data for Areas in (HA) burned and Biomass burned in tonnes was obtained from FAOSTAT portal (http://www.fao.org/faostat/en/#data). For each forest strata, crop type and grassland strata, Emissions were estimated for CH_4 and N_2O, using equation 2.27 and the emission factors in table 24 below, then converted to the CO_2eq.

Table 24: Default Emission Factors and parameter used for Biomass burning

		M_B	C_f	Emission Factor G_{ef} for CH_4	Emission Factor, G_{ef} for N_2O
Tropical forest	Other Forest	51.049	1	6.56	0.2
	Closed shrubland	26.7	1	2.3	0.2

Cropland (Agricultural residues)	Maize	1	1	2.7	0.07
	Rice	0.55	1	2.7	0.07
	Sugarcane	0.65	1	2.7	0.07
	Wheat	0.4	1	2.7	0.07
Grassland	Tropical Grassland	5.2	1	2.3	0.21
	Open shrubland	14.3	1	2.3	0.21
	Savanna	7	1	2.3	0.21
	Woody savanna	6	1	2.3	0.21

Source: IPCC guidelines Volume 4, tables 2.4 and 2.5

Emission trends in Biomass Burning

Figure 27 show the trend in emissions from biomass burning in 3 land use types (forest, crop and grass lands). Emissions from biomass burning show a reducing trend from **51.3 Gg** in 1990 to **29.9** in 2000 reducing further to **17.4 Gg**-in 2019. However, there were serious gaps in data, which could contribute to high uncertainty in the trend. These fluctuations and decrease in emissions could be associated with variations in number of hectares burned in the respective years and uncertainties in the data from FAOSTAT data.

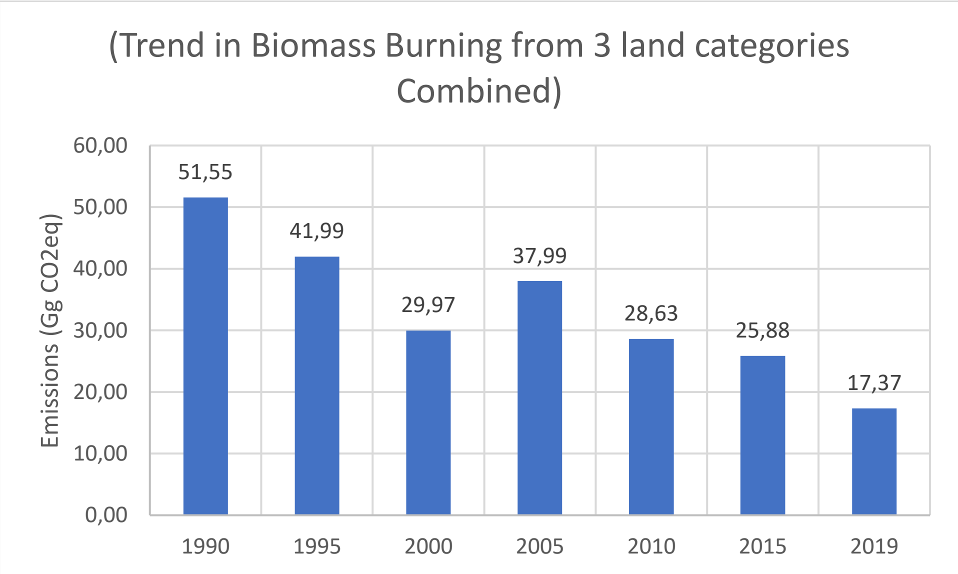

Figure 27: Emission trends in biomass burning in GgCO2eq 1990-2019

The specific biomass burning in different land types are illustrated below.

Emissions Trends in biomass burning in Forest lands

Figure 28 illustrate the emissions from biomass burning in Forest lands. Emissions in forest lands have remained relatively stable with an average value of **5.6** Gg-CO_2eq per year. However the trend may have large uncertainties due to lack of county specific activity data. The decrease in the year 2000 in biomass burning in forest land, could be associated with reduction in number of hectares burned in the respective years and uncertainties in the data from FAOSTAT.

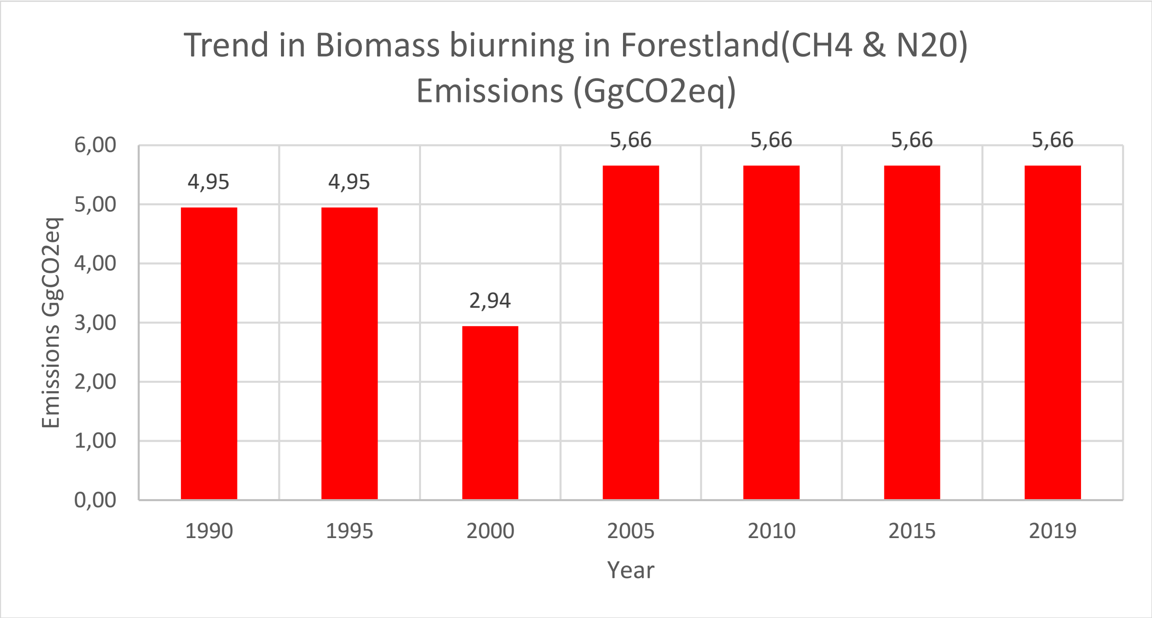

Figure 28: Emission trends in biomass burning in Forest lands (GgCO2eq) 1990 -2019

Emissions Trends in biomass burning Crop lands

Figure 29 illustrates the emissions from biomass burning in Crop lands. Emissions in Crop lands show a decreasing trend dropping to **10** Gg-CO_2eq in 2019. However, the trend may have large uncertainties due to lack of county specific activity data. The decreasing trend in biomass burning in crop land, could be associated with variations in number of hectares burned in the respective years and uncertainties in the data from FAOSTAT data

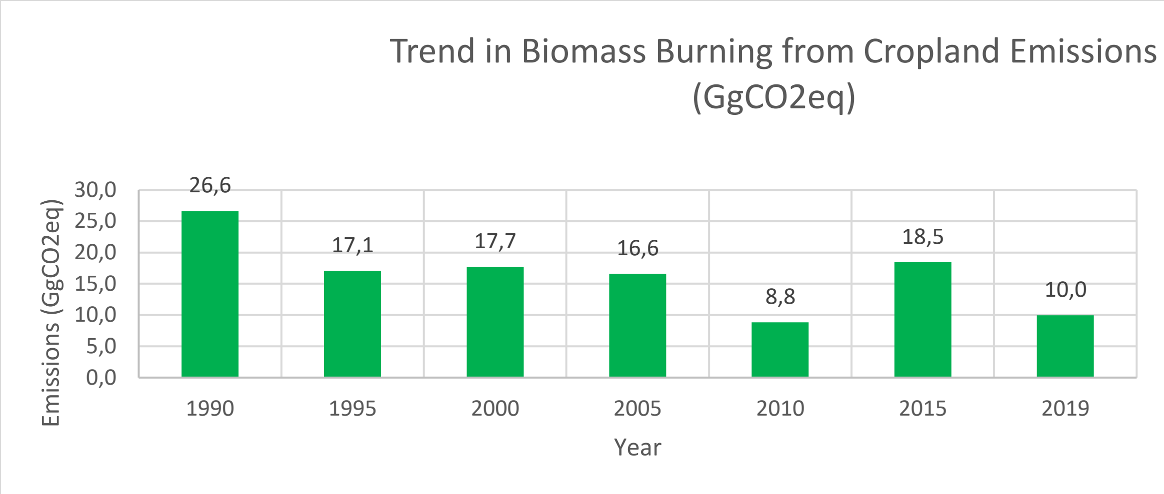

Figure 29: Emission trends in biomass burning in Crop Lands GgCO2eq 1990-2019

Emissions Trends in biomass burning in Grass lands

Figure 30 illustrates the emissions from biomass burning in Grass lands. Emissions in Grass land show a decreasing trend in recent years dropping from 9.3 in 2000 to 1.8 Gg-CO_2eq in 2019**.** This fluctuation and decreasing trend in emissions could be associated with variations in number of hectares burned in the respective years and uncertainties in the data from FAOSTAT data.

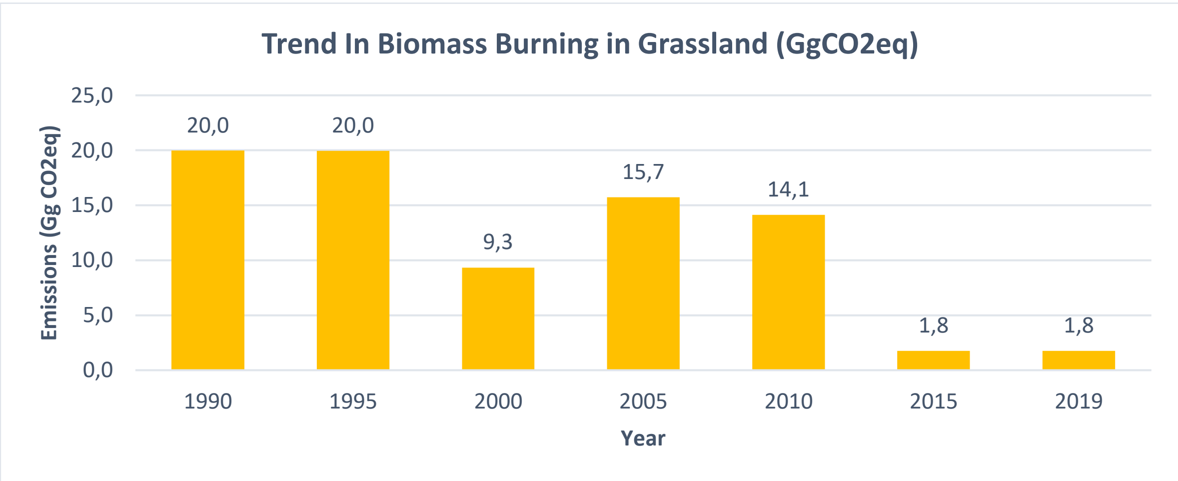

Figure 30: Emission trends in biomass burning in Grass Lands GgCO2eq 1990-2019

2.7.4.4 Direct and Indirect N2O Emissions

Description of Direct and Indirect N2O Emissions

Direct and indirect N_2O emissions from managed soil comprise nitrogen inputs from crop residues, application of synthetic nitrogen fertilizers and land-use practices associated with land-use change. Both sources produce largest emissions under 3C. (Aggregated sources and non-CO2 emissions from land)

Emissions from this sub-category comprises of:

- Direct N_2O emissions from Managed soils (3.C.4)
- Indirect N_2O emission from Managed soils (3.C.5)
- Indirect N_2O emissions from Manure Management (3.C.6)

In order to calculate N_2O emissions from soils, animal production, and from the application of fertilizers, the amount of nitrogen input from synthetic fertilizers, animal waste, nitrogen fixing in crops is required. Direct and indirect N_2O releases to the atmosphere are then estimated from these inputs using default IPCC emission factors. For the Somalia case the input from synthetic fertilizer was missing and thus estimates were largely relied on animal waste (livestock).

Emission Trends from Direct and Indirect N2O from managed soils & manure management

Table 25 and Figure 31 illustrate the emissions trend from direct and indirect N2O sources. Emissions from direct and indirect N2O sources remained relatively stable with a slight decreasing trend from **4438.5** Gg CO2eq in 2000 to **3979** GgCO2eq in 2019. However the trend may have large uncertainties due to lack of county specific activity data. The highest emissions were observed in 2005, likely to a large population of livestock (N2O from livestock dung and urine), but since then there has been a steady decrease in emissions which be associated with the growing trade in livestock (and the frequent drought in the region that contribute to the decreasing population of livestock.

Table 25: Emission trend for Direct and Indirect N2O emissions sources

Year	1990	1995	2000	2005	2010	2015	2018	2019
3.C.4 - Direct N2O Emissions from managed soils	4277.2	4245.6	4376.1	4729.3	4116.0	4179.2	4035.8	3917.0
3.C.5 - Indirect N2O Emissions from managed soils	18.6	6.9	13.7	13.7	16.1	10.9	9.4	9.2
3.C.6 - Indirect N2O Emissions from manure management	41.5	66.3	48.7	63.6	59.0	60.0	58.1	53.0
Total direct and indirect N2O	**4337.3**	**4318.8**	**4438.5**	**4806.6**	**4191.1**	**4250.1**	**4103.3**	**3979.2**

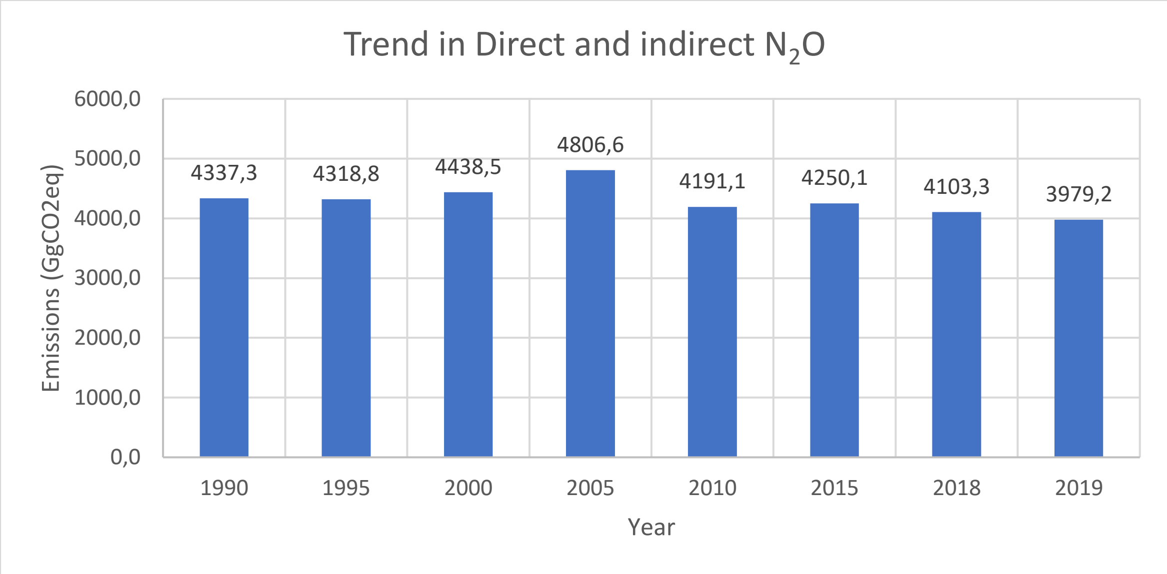

Figure 31: Emission trends in biomass burning in Grass Lands GgCO2eq 1990-2019

Methodological Issues of Direct and Indirect N2O emissions from Managed Soils

In most soils, an increase in available N enhances nitrification and denitrification rates which then increase the production of N_2O. Increases in available N can occur through human-induced N additions or change of land use and/or management practices that mineralize soil organic N.

Direct N_2O emissions from agricultural soils are derived from:

- The use of synthetic fertilizers
- Animal manure used as fertilizers
- The cultivation of N-fixing crops(legumes crops)
- Crop residues that remain in soils
  Organic soils cultivation

Both Direct and Indirect N2O emissions were calculated applying tier 1 approach using default emission factors. As an example, the equation for Direct N_2O emissions from managed soils is equation 11.1 from the IPCC guidelines.

2.7.4.5. Rice Cultivation (3.C.7)

Overview of Rice cultivation

In 2009, the FAO implemented an irrigation rehabilitation project in the Middle Shabelle region funded by the European Union and the World Bank (World Bank 2011a). The project appears to have only stemmed the post war trend of declining rice production, although it did strengthen the 'Jowhar Rice Growers' Association, which was established before the war and survived the conflict. The varieties of rice that were introduced in the pre-war period (and contributed to an increase in the area under rice cultivation from zero to a peak of 6,500 hectares in 1989 at the eve of the civil war) are still in use. These varieties from the International Rice

Research Institute make rice growing still profitable in the region. By the early/mid-2010s rice was being grown on only about 750–1,500 hectares (FAO/WB 2018).

The Mogambo Rice Project-The Mogambo Rice Project was developed in 1982–86 to cover 2,052 hectares of paddy rice fields and 163 hectares of sprinkler-irrigated land planted with cotton (Sir McDonald & Partners Ltd. 1982). Associated farms benefited from the project's irrigation and drainage canals, offices, houses, and office building. The civil war began right after the first phase of the project was completed. As a result, the plant was swiftly looted and never produced the 10,000 tons of rice a year it had planned to produce. Because the project's irrigation infrastructure and upstream flood control embankments were not maintained, the farmland is also no longer cultivated.

Anaerobic decomposition of organic material in flooded rice fields produces methane. Upland rice fields which are not flooded do not produce significant methane emissions. CH_4 is released into the atmosphere through diffusion loss across the water surface, bubbles and rice plants themselves. Methane emissions potential from rice cultivation depend on the percent share of the total rice cultivation areas under rain fed upland, rain fed lowland and irrigated areas. It is also a function of the period the cultivated area is inundated. Data on annual rice cultivation area were obtained from FAOSTAT.

Emission Trends from Rice Cultivation

Figure 32 illustrate the trend in emissions from rice cultivation. Methane emissions from rice cultivation have remained on a decreasing trend from a high of **26.5** in 1990 to **6** Gg- CO_2 eq in 2010 to **4.7** Gg -CO_2 eq in 2019. The decrease in methane emissions could be attributed to the post war trend of declining rice production and lack of maintenance of irrigation infrastructure in the Federal Government of Somalia.

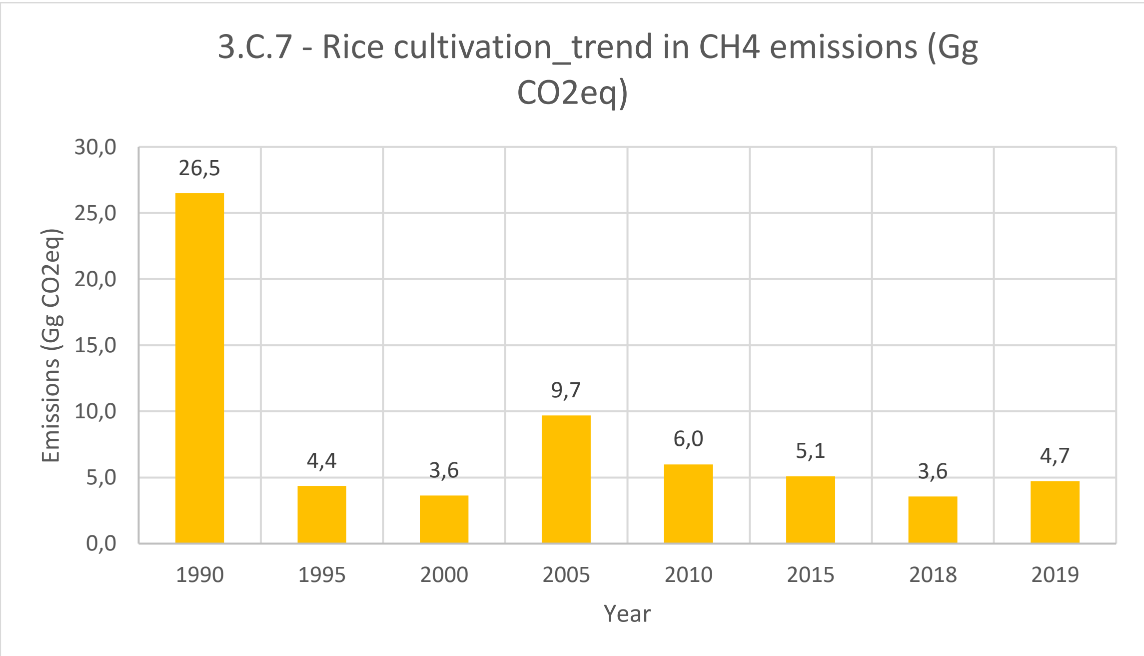

Figure 32: Emission trends in Rice Cultivation, 1990-2019

Methodological Issues in Rice cultivation

The IPCC Tier 1 methodology and default emission factors for rice cultivation were used. The annual amount of methane emissions from a given area of rice is a function of:

Cultivation period (days)

Water regimes (before and during cultivation period)

Organic amendments applied to the soil

Others which include soil type, temperature, rice cultivar

Emissions of methane from rice fields can be represented by IPCC guidelines equation 5.1, 5.2 and 5.3.

EQUATION 5.1

CH_4 EMISSIONS FROM RICE CULTIVATION

$$CH_{4\ Rice} = \sum_{i,j,k} (EF_{i,j,k} \bullet t_{i,j,k} \bullet A_{i,j,k} \bullet 10^{-6})$$

Where:

$CH_{4\ Rice}$ = annual methane emissions from rice cultivation, Gg CH_4 yr^{-1}

EF_{ijk} = a daily emission factor for i, j, and k conditions, kg CH_4 ha^{-1} day^{-1}

t_{ijk} = cultivation period of rice for i, j, and k conditions, day

A_{ijk} = annual harvested area of rice for i, j, and k conditions, ha yr^{-1}

i, j, and k = represent different ecosystems, water regimes, type and amount of organic amendments, and other conditions under which CH4 emissions from rice may vary.

Emission Factors and Coefficients for Rice

Default scaling factors for methane emissions, correction factors for organic amendments and seasonally integrated emission factors were drawn from the 2006 IPCC Guidelines Tables 4-10 and 4-11, and are presented in table 26.

EQUATION 5.1

CH_4 EMISSIONS FROM RICE CULTIVATION

$$CH_{4\ Rice} = \sum_{i,j,k} (EF_{i,j,k} \bullet t_{i,j,k} \bullet A_{i,j,k} \bullet 10^{-6})$$

$$\textbf{EQUATION 5.2}$$
ADJUSTED DAILY EMISSION FACTOR

$$EF_i = EF_c \bullet SF_w \bullet SF_p \bullet SF_o \bullet SF_{s,r}$$

Where:

EF_i = adjusted daily emission factor for a particular harvested area

EF_c = baseline emission factor for continuously flooded fields without organic amendments

SF_w = scaling factor to account for the differences in water regime during the cultivation period

SF_p = scaling factor to account for the differences in water regime in the pre-season before the cultivation period

SF_o = scaling factor should vary for both type and amount of organic amendment applied

$SF_{s,r}$ = scaling factor for soil type, rice cultivar, etc., if available

Where:

EQUATION 5.3
ADJUSTED CH_4 EMISSION SCALING FACTORS FOR ORGANIC AMENDMENTS

$$SF_o = \left(1 + \sum_i ROA_i \bullet CFOA_i\right)^{0.59}$$

Table 26: Default emissions factors and coefficients for rice (Source: 2006 Revised IPCC Guidelines).

Water Management Regime	Baseline Emission Factor EF_c	(SF_w)	(SF_p)	(ROAi)	(CFOAi)	(SF_o)	($SF_{s/r}$)	Cultivation Period (days)
Irrigated – Continuously Flooded	1.30	0.52	1.9	2	1	1.9	1	120

2.8 WASTE SECTOR (4A)

2.8.1 Waste Sector Overview

Waste management is a major challenge in Somalia and its authorities. In all the regions, states where most of the waste is collected, waste is really not well managed. Landfills are non-existent and designated open dumpsites are operated by the regional governments. Open burning of waste that doesn't find its way to the Solid Waste Disposal Sites (SWDS) is widely practiced. There is also the practice of clinical waste incineration but due to its legal formalities and structure, clinical waste incineration data is scanty and absent at the same time. Wastewater mainly from the households and industries and especially in the urban centers find its way in open sewers and is likely to be treated together in common.

Waste generation is one of the multiple factors affecting the environment and human health that increases directly with growing population, social and economic development. Municipal solid waste disposal sites and their management create climatic challenges with one of the main problems being high bio-waste content that has direct repercussions on the increase of greenhouse gas (GHG) emissions.

Waste is one of the sources of greenhouse gases but also becomes a potential resource which can be recycled and re-used for the benefits of the whole society and generations. Waste generation is affected by the level of income of the population, the economic status, population growth and environmental conditions. As the rate of urbanization increases, so is the waste generated.

In the Federal Government of Somalia, the main disposal sites for solid waste are in shallow landfills and open burning is widely practiced as part of solid waste management. Waste composition for both solid and liquid is influenced by the population's standards of living, the geographical position, sources of energy as well as the weather.

According to IPCC, 2006 Guidelines, GHG emission types from the Waste sector are categorized as; Solid Waste Disposal (SWD), Biological Treatment of Solid Waste, Waste Incineration and Open Burning of Waste and Wastewater Treatment and Discharge (DWTD). GHG emissions from the waste sector are Methane (CH4), Carbon Dioxide (CO2), Nitrous Oxide (N2O) and Nitrogen Oxides (NOx). Methane from the SWDS is emitted during the anaerobic decomposition of organic waste while Carbon Dioxide (CO2) occurs from open burning of waste.

2.8.2 Emission Trends in the Waste Sector

Somalia's GHG emissions by source and sub categories from the waste sector for the period 2000- 2020 are presented in Table 27 while Figure 33 indicates the trends of total emissions from the waste sector for the same period. The total GHG emissions from the waste sector increased from **488 Gg CO2e** in 2000 to **1170 Gg CO2e** in 2020. This increase was as a result of growth in population, urbanization and industrial growth with associated commercial enterprises.

Table 27: Waste sector emissions in CO2 equivalent values

Emission from waste categories in $GgCO_2eq$					
Year	2000	2005	2010	2015	2020
Solid Municipal Waste(CH_4)	276.3	347.8	426.2	526.3	643.1
Open Burning (CO_2)	1.2	1.6	2.0	2.5	3.1
DWTD (CH_4)	176.3	226.7	283.0	356.6	438.3
DWTD (N_2O)	34.5	44.4	55.4	69.8	85.8
Total Waste Emissions (Gg CO_2eq)	**488.4**	**620.5**	**766.6**	**955.2**	**1,170.3**

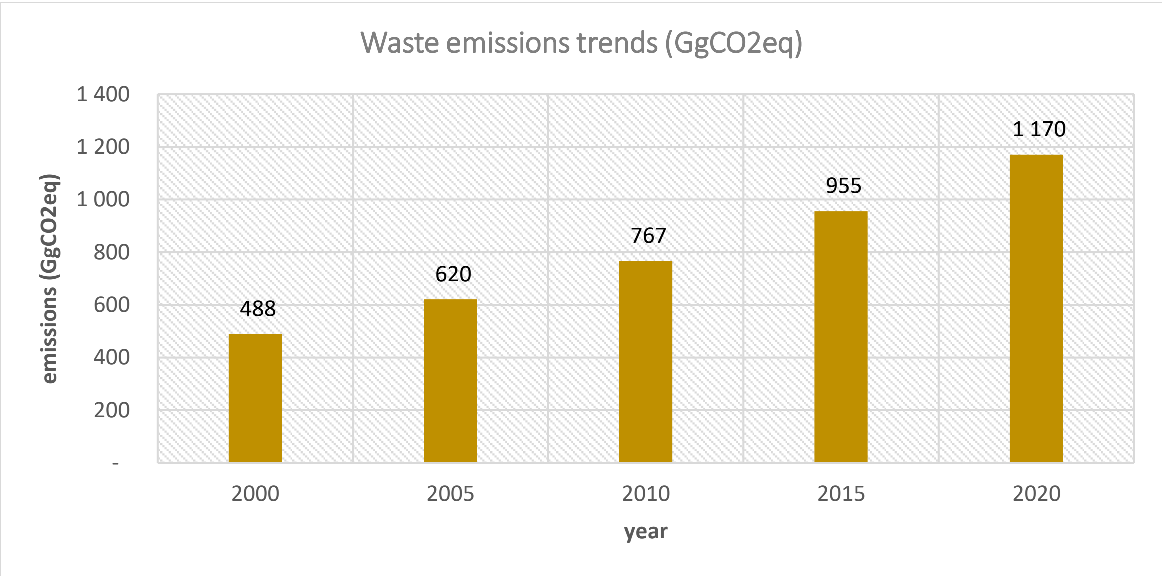

Figure 33: Emission trend (in Gg CO2e) for the Waste Sector

Table 28 provides emissions trends from the waste sector between 2000 and 2020.

Table 28: Waste sector emissions trends in CO_2 equivalent values

Year	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Total Waste Emissions (Gg CO2eq)	**488.4**	**510.5**	**533.0**	**561.3**	**590.5**	**620.5**	**651.4**	**628.1**	**672.1**	**718.1**	**766.6**

Year	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Total Waste Emissions (Gg CO2eq)	**817.4**	**849.9**	**883.5**	**918.6**	**955.2**	**993.6**	**1,033.7**	**1,075.8**	**1,119.7**	**1,170.3**

Emission Trends by gas

As indicated in figure 34, Methane is the largest contributor to Somalia's waste GHG emissions accounting for 93% emanating from Solid Waste Disposal and Domestic Wastewater Treatment and Discharge. Nitrous oxide emissions account for 7% emanating from Domestic Wastewater Treatment and Discharge, while CO_2 accounts for less than 1% from open burning of waste in 2020.

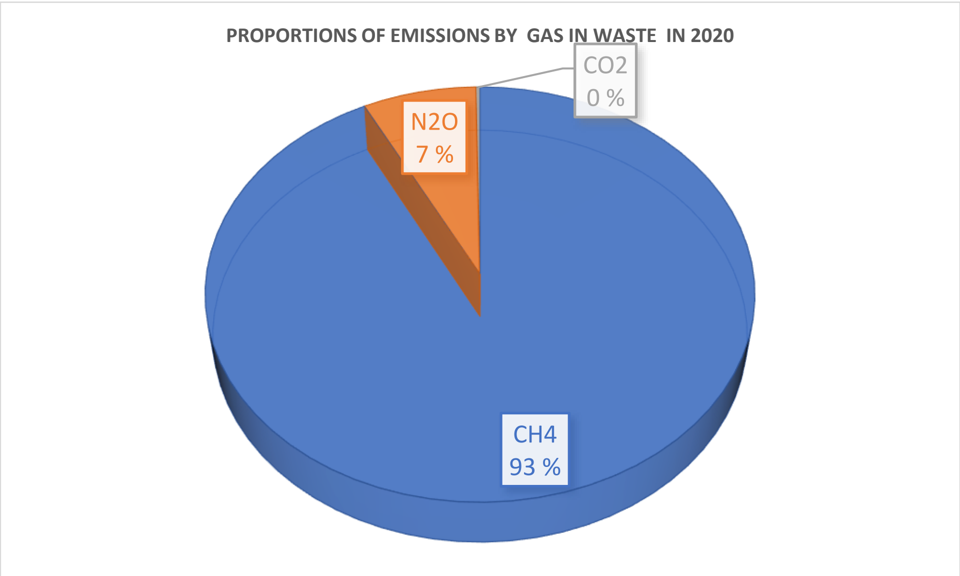

Figure 34: Proportion of Waste Emissions by Gas in 2020

2.8.3 Waste emission trends specified by source category

Figure 35 below shows the percentage contribution of waste emissions by category. Emissions from Solid waste disposal account for 55%, while Domestic Wastewater Treatment and Discharge sums upto 45%. Burning of waste accounts for a less than 1% of emissions in 2020.

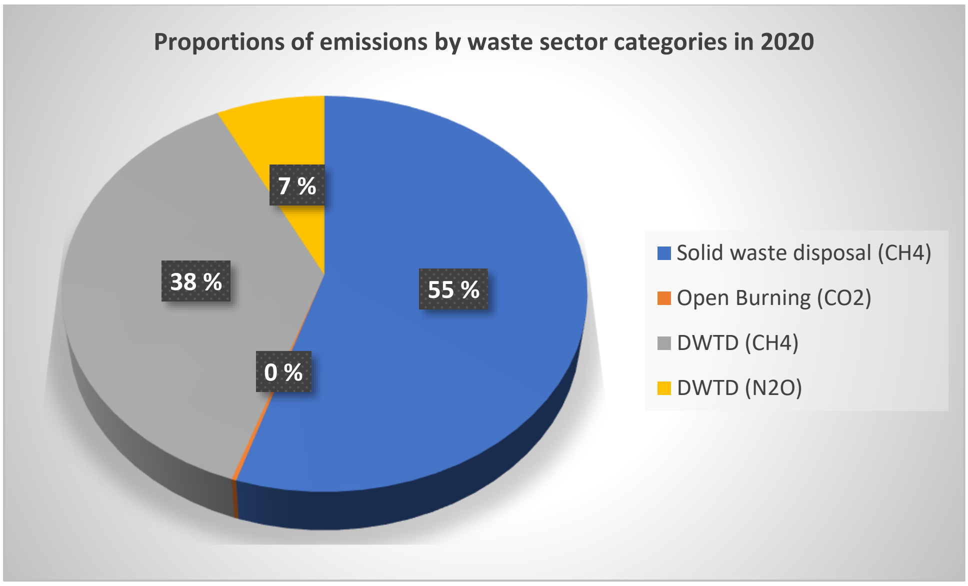

Figure 35: Percentage contributions of emissions by waste source category in 2020

Figure 36 illustrates the model times series emissions output from waste sector modelling.

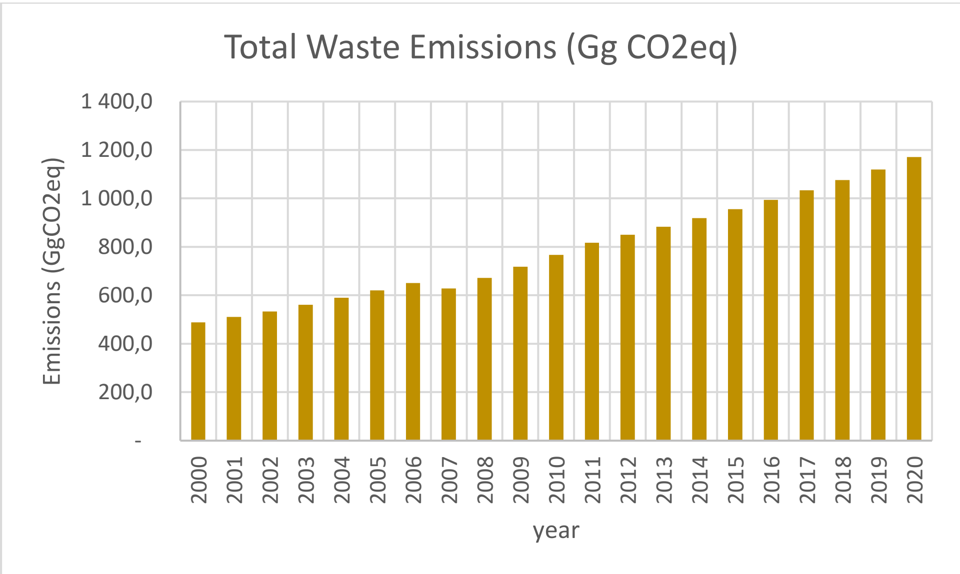

Figure 36: Waste Baseline Emissions (in Gg CO2e) time series- model output

2.8.4 Methodological Issues for Waste sector

The methodological choices and assumptions applied on the activity data and emission factors used are adopted from the IPCC 2006 guidelines under tier 1 approach. The guidelines provide guidance on data collection, methodological choices and the use of relevant assumptions in consistency and transparency.

The activity data for solid waste disposal was obtained from The World Bank which is population data for national, rural and urban population for the inventory period 2000 to 2020.

Other parameters used were default values for the DOC (Degradable Organic Component) for both Municipal Solid Waste and Industrial Waste and Methane Correction Factor (MCF),

2.8.5 Solid Waste Disposal (4A)

Overview of Solid Waste Disposal (SWD)

Approximately 40% of Somalia's population lives in urban centers hence an increasing rate of urbanization in cities and towns which has resulted in the expansion of informal settlements that are characterized by lack of services like waste collection and disposal. This is a major problem that is affecting the country's proper waste collection and management. This problem has translated to only a small fraction of solid garbage being collected from major cities and towns through contracting local companies which transport and dump the waste without separation of hazardous and non-hazardous waste in the dumping sites.

Due to the lack of a recycling industry in the country, dumped materials like plastic bags, disposed bottles and other kinds of waste from the households, agriculture sector, fisheries and commerce industry prove a major environmental problem which affects the socio-economic conditions of its people. This waste thus alters the atmosphere's chemical composition as a result of buildup of GHG's such as methane which is emitted from the decomposition of organic waste in dumpsites, nitrous oxide from liquid waste and carbon dioxide from open burning of waste.

Solid waste generation was closely linked to population as surrogate data, urbanization and the standards of living. CH_4 and non-fossil CO_2 were the main gases associated with solid waste disposal through biological (anaerobic) decomposition. Based on the type of management at the disposal site, solid waste disposal activities were further divided into the sub-categories; unmanaged waste disposal sites (4.A.2) and uncategorized waste disposal sites (4.A3). The main data input was population, waste generation per capita, solid waste streams, annual total waste generation, and fractions of waste disposed-off by different means. Methane emissions from solid waste deposited in different sites (dumpsites) were estimated for in the inventory.

Emission Trends from Solid Waste Disposal

The Solid waste disposal (SWD) emissions rose from **276** Gg-CO_2eq in 2000 to **643** Gg- CO_2eq in 2020. This increase is attributed largely to the growth in population, urbanization and industrial growth with associated commercial enterprises as seen in Figure 37 and table 29.

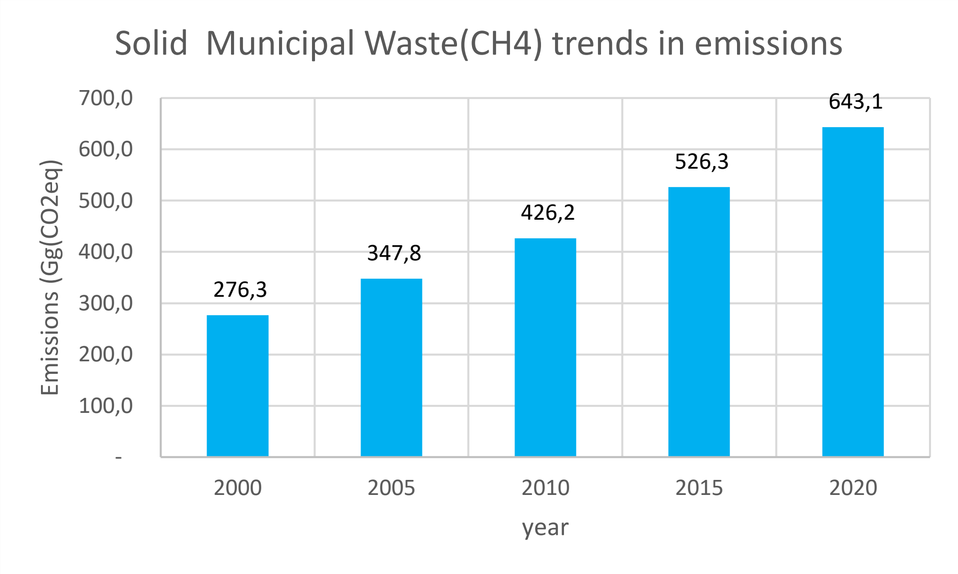

Figure 37: Emission Trends for Methane from Solid Waste Disposal in CO2e

Table 29: Emission Trends for Methane from Solid Waste Disposal

Year	urban population (millions)	waste per capita (kg/capita/ year)	total msw (Gg)	percentage to swds (%)	CO_2 Equivalent
2000	2.949757	290	855.43	69	**276.3**
2005	3.793358	290	1,100.07	69	**347.8**
2010	4.734452	290	1,372.99	69	**426.2**
2015	5.966601	290	1,730.31	69	**526.3**
2020	7.33329	290	2,126.65	69	**643.1**

Methodological Issues for Solid Waste Disposal

Default value sets from the IPCC, 2006 guidelines were applied due to lack of adequate activity data and required parameters in Somalia. Some of the default values that were used in this category are the DOC (Degradable Organic Component, Methane generation rate constant (k), waste per capita, % to SWDS, MCF (Methane Correction Factor).

The activity data comprised of;

Population (Urban population sourced from the World Bank data)

Waste generation per capita

Rate constants (eg waste per capita, % to SWDS, composition of waste, FOD, MCF, DOCf)

Methane (CH4) emissions from SWD in a single year are estimated using the IPCC Chapter 3, Volume 5 (Waste) equations 3.1.

CH_4 emissions from this category were calculated using the Tier 1 FOD (First Order Decay) method which assumes that emissions will be realized on the thirteenth month after deposition hence no emissions are calculated on the initial year. It was assumed that rural population's waste is not collected and is mostly disposed-off in illegal dumpsites or openly burnt. There are negligible emissions from the biological treatment of solid waste category in Somalia which are likely to be captured in the higher Tiers in future hence were not considered in this report. Methane recovery data was not readily available hence was not accounted for in this report for the period and was hence termed as negligible due to lack of sufficient data to support it.

Uncertainties in Solid Waste Disposal Emission estimates

The 2006 Good Practice Guidance recognizes that the uncertainty of estimates cannot be completely eliminated but there should be neither underestimates nor overestimates, while at the same time seeking to improve estimate precision. Attempts should be made to ensure that the best activity data and emission factors available are used. A general evaluation of Inventory precision should be conducted based on expert judgment and knowledge of the Inventory. The precision associated with activity data and emission factors should be expressed as a percentage based on a 95% confidence level. The greatest uncertainty associated with estimation of activity data for CH4 is mostly from solid waste. It is assumed that on average 69% of solid waste is disposed at the designated dump sites for the urban areas in Somalia which is a default that is provided for in the IPCC, 2006 Software. Per capita waste generation is assumed to be the default value of 290Kg/year.

Time series consistency in Solid Waste Disposal Emission estimates

Population data was sourced from the World Bank which provided for a consistent time series activity data for this category. Increased Partnerships would bring about more verifiable data for better estimations of Somalia's emissions.

2.8.6 Biological Treatment of Solid Waste (4B)

The key emission gases that result from this waste sub-category are CH_4 and N_2O. Very little solid waste is treated biologically in Somalia. There is no data available on Category 4.B. Therefore, this category was not analyzed for this BUR.

2.8.7 Incineration and Open Burning of Waste (4c)

Overview of Incineration (4.C.1) and Open Burning of Waste (4.C.2)

Incineration of Waste (4. C.1)

Solid waste incineration is a practice that requires the approval and licensing from the existing bodies of the federal government in relation to and responsible for clinical (medical) and hazardous waste disposal. All the institutions that deal with any of the kind of hazardous wastes e.g. health institutions are required to comply with the regulations set as such. GHG's emitted from incineration of waste are CO_2, CH_4, NOx and N_2O. Due to lack of sufficient data provided, this report did not cover this sub-category as improvements are being made in terms of data collection and all legal structures being put in place.

Open Burning of Waste (4.C.2)

Open burning of waste in the Federal Republic of Somalia is a common practice both in the urban and rural populations. GHG's emitted from open burning of waste are CH_4, N_2O and CO_2. In this report estimation of emissions emanating from open burning in urban areas was obtained by the use of urban population and assuming a 15% value of urban population that practice it.

Emissions Trends from Open Burning of Waste (4.C.2)

Emissions resulting from this sub-category rose from 1.23 Gg CO2e in 2000 to 3.0 Gg CO2e in 2020 as seen in figure 38 and table 30.

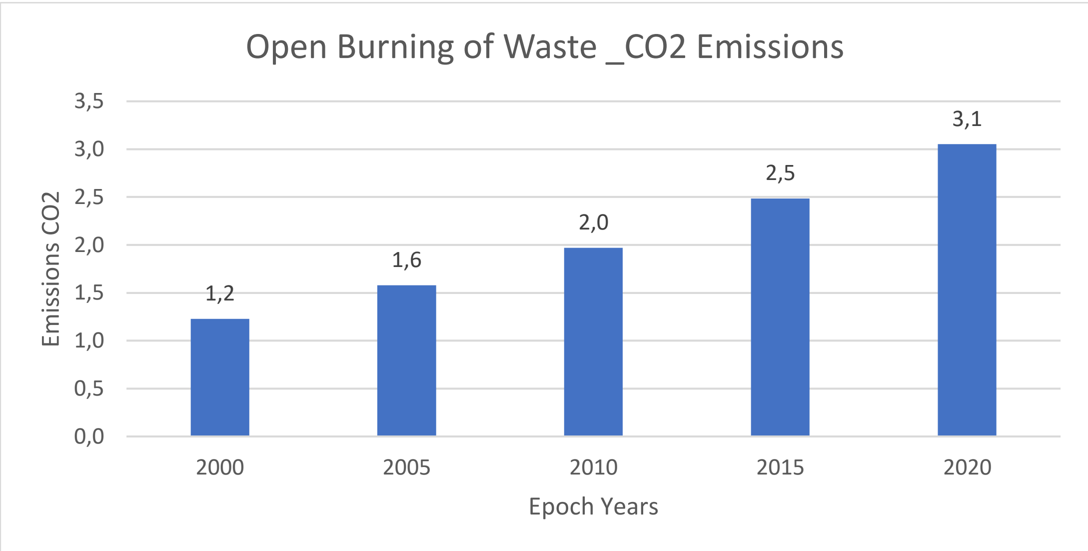

Figure 38: Emission trends in Open Burning of Waste

Table 30: Emission Trends for CO_2 Emissions from Open Burning of Waste

Year	**Urban Population (capita)**	**Fraction of population burning waste (fraction)**	**Total Amount of MSW open-burned (Gg/yr)**	**Oxidation Factor-OF (fraction)**	**Fossil CO_2 Emissions (Gg)**
2000	2,949,757	0.15	79.13	0.58	1.23
2005	3,793,358	0.15	101.77	0.58	1.58

2010	4,734,452	0.15	127.01	0.58	1.97
2015	5,966,601	0.15	160.07	0.58	2.48
2020	7,333,290	0.15	196.73	0.58	3.05

Open burning of waste should be illegal according to a number of national, federal and international legal statutes but this is not the case in most of the urban cities and towns in Somalia. Municipal waste can be seen burning in shallow open pits, dumpsites and in open areas as well as in homesteads. Most of this waste that is openly burnt is municipal solid waste.

This vice of open burning of municipal waste in the urban areas is very intentional and spontaneous except for the explosion of methane in controlled dumpsites. In this analysis it is assumed that 15% of the urban population in Somalia openly burn waste. Future improvement would also require the inclusion of the rural populations that practices open burning.

Methodological Issues in Open Burning of Waste

Percentages resulting from the difference in the collected MSW are to be apportioned for waste that is open-burned, incinerated, recycled, re-used, salvaged or composted. Expert judgement was used to apportion a percentage of urban population that practices open-burning (assumed to be 15% of the urban population of Somalia). MSW that does not find its way to the SWDS should be divided well as it would be key here in terms of data reliability and a better way of estimation of emissions.

For this sub-category, the dry matter, fraction of carbon in dry matter, fraction of fossil carbon in total carbon and the oxidation factor values were all default values provided for by the IPCC Software.

Uncertainties in Open Burning of Waste

There is lack of sufficient data on MSW, Industrial waste, sewerage sludge and hazardous waste incinerated. Open burning is a widespread practice in Somalia regardless of the region or its affinity to urbanization. The rural population forms the bulk of the Federal republic of Somalia's population hence the apportionment of the 15% of urban population practicing open burning comes out as an uncertainty.

Time series consistency in Open Burning of Waste

Urban population data sourced from the World Bank provided for a consistent time-series activity data for open burning. Open burning of MSW data or any waste in the rural or urban is not readily available as much as the vice is still an illegal activity in Somalia**.**

2.8.8 Wastewater Treatment and Discharge (4.D)

Overview of the Wastewater Treatment and Discharge

This category comprises of Domestic Wastewater Treatment and discharge (DWTD) and Industrial Wastewater Treatment and discharge (IWTD). CH_4 and N_2O are the main gases emitted from this category. Emissions from DWTD are as a result of the different means of disposal and treatment of sewage. Estimation of emissions from IWTD covers 5 main industrial sectors including:

paper and pulp,

beer and malt,

dairy products,

meat and poultry and

beverage processing and manufacturing.

Wastewater in the open and especially stagnant sewers is normally exposed to the sun which allows for anaerobic reactions to take place hence emitting CH_4.The Biological Oxygen Demand (BOD) indicates the level of aerobically biodegradable Carbon in the wastewater which contains a high level of organic waste that is produced from the households and industries. Increased urbanization without proper piping of water is a major issue in most urban cities in Somalia which translates to the increase in volumes of wastewater generated hence the rise in emissions of GHG's.

Trends in Emissions from Domestic Wastewater Treatment and Discharge

Figures 39 and 40 and tables 31 and 32 show the trends for Methane and Nitrous Oxide emissions respectively from Domestic Wastewater Treatment and Discharge. Methane Emission rose from 176.3 Gg CO_2eq in 2000 to 438.3Gg CO_2eq in 2020, while that of N_2O rose from to 34.5Gg CO_2eq to 85.8Gg CO_2eq.

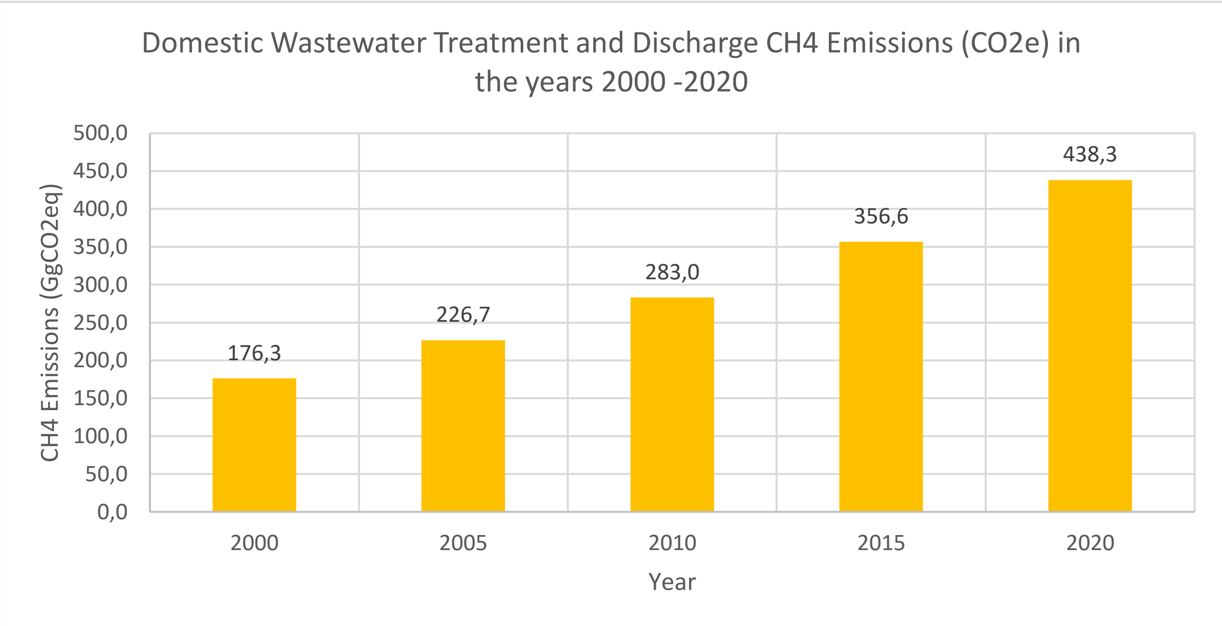

Figure 39: Emission Trends from Methane (CH_4) in Domestic Wastewater Treatment and Discharge

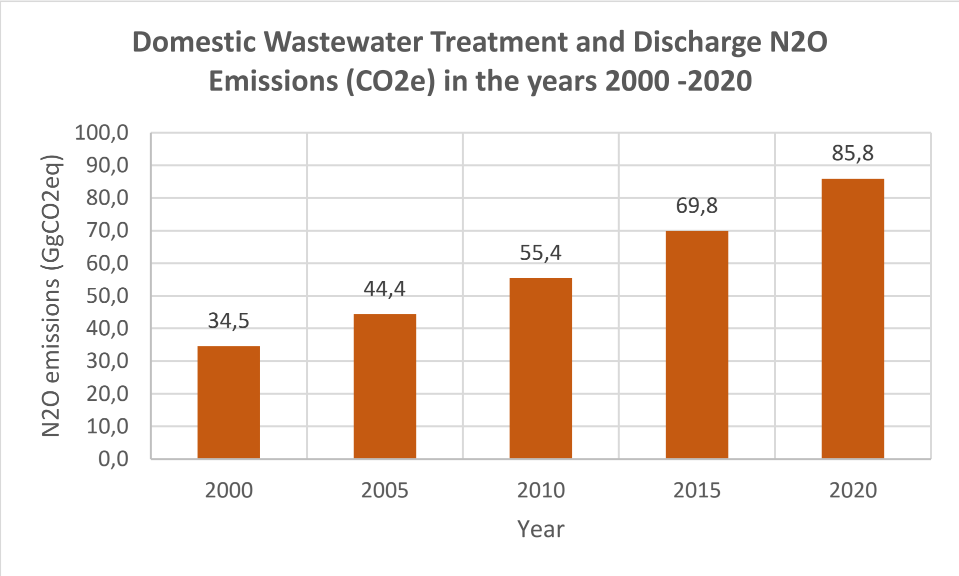

Figure 40: Emission Trends from Methane (N_2O) in Domestic Wastewater Treatment and Discharge

Table 31: Emission Trends for CH_4 Emissions from Domestic wastewater treatment and discharge

Year	Urban Population (Capita)	Degradable Organic component - BOD (Kg BOD/capita /yr)	Correction factor for industrial BOD discharged in sewers (I)	Organically degradable material in wastewater - TOW (Kg/BOD/Yr)	Net Methane Emissions (Kg CH4/Yr)	Domestic Wastewater Net Methane Emissions (Gg CH4/Yr)	CO_2 Equivalent
2000	2,949,757	13.505	1.25	49,795,586	8,395,536	8.40	176
2005	3,793,358	13.505	1.25	64,036,625	10,796,575	10.80	227
2010	4,734,452	13.505	1.25	79,923,468	13,475,097	13.48	283
2015	5,966,601	13.505	1.25	100,723,683	16,982,013	16.98	357

2020	7,333,290	13.505	1.25	123,795,102	20,871,854	20.87	438

Table 32: Emission Trends for N_2O Emissions from Domestic wastewater treatment and discharge

year	Population (urban)	Per capita protein consumption (protein) (kg person/year)	Total nitrogen in effluent (Neffluent) (kg N/yr)	Emission factor (Kg N2O - N/Kg N)	N2O Emissions (Kg N2O/yr)	N2O Emissions (Gg N2O/yr)	Co2 Equivalent
2000	2,949,757	17.16	14,172,992	0.005	111,359	0.11	34.52
2005	3,793,358	17.16	18,226,327	0.005	143,207	0.14	44.39
2010	4,734,452	17.16	22,748,095	0.005	178,735	0.18	55.41
2015	5,966,601	17.16	28,668,324	0.005	225,251	0.23	69.83
2020	7,333,290	17.16	35,234,992	0.005	276,846	0.28	85.82

Methodological Issues in Domestic Wastewater Treatment and Discharge

The extent of CH_4 production depends primarily on the quantity of degradable organic material in the wastewater, the temperature, and the type of treatment system. With increases in temperature, the rate of CH_4 production increases. The principal factor in determining the CH_4 generation potential of wastewater is the amount of degradable organic material in the wastewater. CH_4 emissions are a function of the amount of organic waste generated and an emission factor that characterizes the extent to which this waste generates CH_4. The total amount of organically degradable material in the wastewater (TOW) is a function of human population and BOD generation per person which is expressed in KgBOD/year.

Activity data needed for estimating N_2O emissions is the nitrogen content in the wastewater effluent, country population and average annual per capita generation (Kg/person/Year) which is then multiplied by an emission factor from domestic wastewater nitrogen effluent and this is well provided for in the IPCC, 2006 Inventory Software.

Expert judgement was used to establish the fraction of a city's or town coverage of access to a sewer system. BOD(mg/l) is required to treat wastewater received and what amount of sewerage is treated in a day as a function of the Degradable Organic Component.

Uncertainties in Domestic Wastewater Treatment and Discharge

Estimates and calculations of domestic wastewater emissions for the urban centers of Somalia include industrial wastewater. There is lack of adequate data that is representative to all urban centres individually which is a major uncertainty in Somalia Waste estimates. Assuming a constant value of 14.6 kg BOD/cap/yr degradable organic component was also a cause of uncertainty for the entire period of a 20 year time series. Industrial wastewater is also treated together with domestic wastewater because it doesn't have its own channel in all urban areas of Somalia**.**

2.9 QUALITY CONTROL AND QUALITY ASSURANCE FOR THE SOMALIA GHG INVENTORY

Quality control and assurance (QA/QC) m contributes to good practice in inventory development, namely to improve transparency, consistency, comparability, completeness, and accuracy of national greenhouse gas inventories.

For quality control, a training workshop was held both virtually and in person in Mogadishu on 15-16 October 2021 that had put in place sectoral teams to review data collection templates, collect data and review inventory draft reports. During the actual preparation of this inventory, a Tier 1 QC checklist was followed. General QC procedures were applied routinely to all categories by sector experts responsible for each category and to the inventory report as a whole. Checks were performed on selected sets of data and processes and a representative sample of data and calculations from every category.

Quality assurance review procedures is conducted by personnel not directly involved in the inventory compilation/development process. For this inventory QA was carried out by UNEP and UNDP, which analyzed and made comments on the inventory reports, and (comments) were included in the final report.

2. 10. GENERAL UNCERTAINTY ASSESSMENT

Activity data used to estimate emissions in all the sectors were largely derived from international sources and publications. This data is not disaggregated hence expert judgement was applied, which is a source of uncertainties. Furthermore Somalia doesn't have any study on uncertainty neither for activity data, nor for emission factor. For this reason, default values of uncertainty for some of the modelled sectors ranged from ± 20% to ± 30%.

2. 11. GENERAL ASSESSMENT OF THE COMPLETENESS

A complete inventory refers to an inventory which includes estimates for all relevant sources and sinks and gases, and that covers all the applicable geographic area of the country concerned. As far as possible the Somalia GHG inventory include the most important sectors of emissions and removals, but still, missing are the key categories of emissions from fertilizer application (in agriculture) and industrial production processes and use (IPPU), due to inadequate data.

2. 12. PLANNED IMPROVEMENTS

2.12.1. Planned improvement in institutional arrangement

There is need to `institutionalize` the GHGI development process since the current arrangements are rather `informal'. A sustainable GHG inventory system is best served by a strong lead institution that has a sound and capable expert team to develop inventories without extensive support from external consultants. It is recommended that the Ministry of Climate Change and Ministries/Departments be strengthened to collect activity data in their respective sectors. This should involve some training on data collection template for each of the GHGI sectors. It is recommended that data collection templates be shared with all stakeholders in the federal republic of Somalia, and that data collection and updating be made on a continuous process to build Somalia database on activity data.

2.12.2. Planned improvement on Capacity building

Despite the knowledge acquired during the preparation of Somalia 1st BUR there is still need for more capacity and empowerment of staff and institutions. Capacity building needs listed below are require in short term. The duration of training would be at least two continuous weeks including theoretical training and practical exercise and should cover, amongst others:

- Approach to data collection and filling of sector specific data collection templates;
- Use of IPCC 2006 modeling software in all sectors , and GIS in LULUCF sector;
- Key Category Analysis;
- Trend Assessment;
- Quality Control;
- Uncertainty Assessment;
- Completeness Assessment;
- Report writing.

2.12.3. Planned improvement in Energy sector

The Somalia inventory report has shown that activity data in the energy sector is inadequate. There is need to collect data on imports for all fossil fuels that enter the territory of Somalia. There is also lack of disaggregated data. Therefore, the following data both historical and current need to be collected in the short term to mid-term period:

a) Collect data on liquid fuel consumption in road, aviation and water transport as well as fuel consumption in households, institution and off-grid industries; and fuel use in electricity generation;

b) Collect data on biomass consumption in industries, commercial institutions (like restaurants) as well as wood fuel for charcoal production;

c) Collect data on imported fossil fuels at entry into the territory of Somalia;

d) Address data gaps in Oil, Natural Gas and Fugitive emissions from Fuels

2.12.4. Planned improvement in IPPU sector

The post war stability in Somalia has triggered sprouting of some industries but production data from these industries still remain a challenge. There is need for the government to work closely with industrial players/stakeholders to establish a more robust system to track the amount of production especially from Mineral, Chemical and Metal Industries, Tracking of imports, use and disposal of refrigeration and air conditioning gases and appliances would be equally important.

2.12.5. Planned improvement in AFOLU sector

For the Agriculture/Livestock sector, country specific activity data (both historical and current) need to be collected for all categories to avoid use of data from international sources. There is need to improve the monitoring of manure management systems under different livestock categories, as current values for manure management system are based on expert opinion. There is need to work closely with relevant institutions to track quantities of lime, urea, synthetic fertilizer (disaggregated with specific N content) imported and exported, accurate tracking of Animal manure used as fertilizers, Crop residues that remain in soils, annual area of managed/drained organic soils, in hectares, annual amount of N in mineral soils, etc.

In the Land use Land Use Change and Forestry (LULUCF) sector, a number of studies indicate that there is a lot of forest destruction in Somalia. What is clear from the modelling exercise-is that global datasets at a spatial resolution of 300m, as used in the analysis are associated with high uncertainties. It is a fact that the global datasets usually have a lot of generalization and hence a bigger error margin. Therefore, further data and work will need to be done to improve/adjust the estimation of LULUCF emissions on the following namely**:**

- National Forest definition
- National forest invnentory
- National projection system
- Stratification of the forest/land
- Emission Factors

Furthermore, for future GHG inventory in LULUCF, Somalia should use Collect Earth methodology[33] which is described in box 2 below:

Box 2: Collect Earth Methodology

The methodology involves the use of publicly available satellite images and machine learning classification models to classify and estimate the various types of land and the conversion that may exist between them. For this purpose, tools like Google Earth Engine cloud, Sentinel Hub, Google Earth platforms could be used for the collection and analysis of the satellite images. Machine learning models such as Classification and Regression Trees, Support Vector Machine, Random Forest, etc can be examined and the best performing algorithm or model selected.

[33] https://collect.earth/downloads/CEO_Manual_DataCollector_EN_20210331.pdf; https://collect.earth/about

Satellite imagery are pass as input data to machine learning models, these models then return the classified land and any changes that may occur.

Data

Publicly available satellite imagery such as Landsat 7, Landsat 8, Sentinel 1 and 2 have widely been used for LULUCF monitoring. Specific sensors on board these satellites enables changes in the vegetation, elevation, biomass etc to be detected including the times of these changes. It is important to note that various satellite have different coverages and as such decisions has to arrive at on the specific satellite to be used. For example, Landsat 7 has 15 to 30 meter coverage with multispectral data which repeats coverage of a specific site every 16 days from 1999 to present. As a result, studies aiming at long time (several years behind) changes effectively use Landsat 7 imagery.

Data processing

Satellite imagery data processing involves the collection and extraction of useful features that will be helpful in determining the changes that occur on the land. Examples of such processing includes removing cloud covers, reconstruction of lost pixels, pan-sharpening (merging high-resolution panchromatic and lower resolution multispectral imagery to create a single high-resolution colour image) etc. For example, optical satellites such as Landsat 7 is often affected by cloud conditions, therefore, in order to proceed to use them for purposes of GHG inventory, cloud cover percentages has to be set (this ensures that only imagery meeting certain thresholds are used). This procedure limits the noise levels in the data prior to the usage.

2.12.6. Planned improvement in Waste sector

Waste management still remain a challenge in Somalia and the following are some of the areas for improvement:

- Waste Volumes- weighing of waste generated in urban areas at disposal sites.
- Improve data collection and management both in urban and rural areas.
- Make surveys of population data of all urban centres that are connected to sewerage systems, more input from the waste sector experts on the population's BOD, MCF (as a function of Emission Factors) and data on segregation of degree of utilization of some
- amenities in terms of income groups (i.e rural, urban high income and urban low income).

3. CHAPTER THREE: MITIGATION ACTIONS AND THEIR EFFECT

3.1. Introduction

Somalia has little historical or current responsibility for global climate change; the country's Greenhouse Gas (GHG) emissions is 41 Mt CO2e as of 2020 representing less than 0.03% of total global emissions. Agriculture, Forestry and other Land use (AFOLU) contribute to over 92% of the country's emissions while the energy sector and waste contribute 4% and 3% percent respectively.[34] The emissions are likely to grow as the country strives to meet its development objectives.

Somalia is committed to pursuing a low emission sustainable development pathway. Under the updated NDC, Somalia has set a target of achieving 30% emissions reductions against the Business As Usual (BAU) scenario by 2030. The updated contributions are in line with

[34] National GHG Inventory under BUR 1, 2022

Somalia's National Planning processes, strategies and actions in the energy, agriculture, forestry, transport and Waste sectors.

This chapter presents an updated information regarding recently updated Nationally Determined Contribution (NDC) concerning the climate change mitigation actions and policies and their effects. The chapter provides detailed description of country's emission scenario and key mitigation actions, detailing the methodology that was used to estimate countries business as usual emission (BAU); key emission drivers, the baseline/BAU and mitigation emission projections to 2030. The assessment was conducted in different sectors (i.e Agriculture, Energy, Forestry, transport and Waste and information proposed mitigation actions and their effects tabulated based on guidance of UNFCCC Decision: 2/CP.17 - Annex III UNFCCC biennial update reporting guidelines for Parties not included in Annex I to the Convention.

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3.2. Methodology

The mitigation chapter analysis constituted literature review to establish the baseline activity data and energy and emission intensity data, stakeholders consultation for data validation and participatory scenarios development and modelling Somalia BUR as elaborated in the subsequent sub-sections.

3. 2.1 Literature search and data capture

Literature review and data mining was a critical step in developing the mitigation actions. We reviewed national surveys report, statistical reports, sectoral studies, government policies and strategies as well as national policies, strategies and plans. The national set of literature was complemented by international literatures and IPCC guidelines in areas where there were data gaps. Other important international databases that were used included IEA, FAOSTAT, World Bank Statistics, UNFCCC, and UN Data. In certain aspects, peer reviewed articles were used to strengthen assumptions in scenarios.

3.2.2. Stakeholders' consultations

The consultation and stakeholders engagement was done in three aspects of engagement:

a) Focus group discussion with key and relevant government officials from different sectors. The consultative dialogue amongst other things was used to clarify national development status and trends by sector, provide key data sources and discuss on plausible national development pathways and scenarios.

b) Key informant interviews were more technical and strategic discussing with experts on specific fields and disciplines on technical questions that needed clarification for instance, specifics about power plants operations and efficiencies and;

c) validation and reporting workshop was organized at main milestone steps to present the results and seek for stakeholders' comments and inputs.

We acknowledge the challenge that was posed by COVID 19 and as such most of the engagement were online with limited physical interaction.

3.2.3. Modelling and analytical tools

Low Emissions Analysis Platform (LEAP) was used in modeling the mitigation scenarios. The tool uses activity level parameters such as number of households, vehicle kilometers, GDP contribution, livestock population and respective energy and emission intensities (GJ/household, liters of gasoline per vehicle kilometer, tCO_2/GJ, tCO_2eq/Ton cement produced etc.) for final energy demand emissions analysis.

LEAP scenarios included business as usual or baseline scenario and mitigation scenarios. Business as usual scenario for instance, forecast emissions based on historic growth or development trends. It uses key drivers such as GDP growth trends, demographic trends, population growth rates to project energy and non-energy demand and emission trajectories.

It draws from the IPCC database emission factors for various emission sources including stationary combustion technologies[35], transport emissions[36] and non-energy sector emissions[37] such as agriculture, waste, and industrial processes. For instance, LEAP assigns tier 1 emission factor - tCO_2/GJ or tCO_2/kWh – for energy generated from a particular source or technology. LEAP structure is as illustrated in figure 44 below: -

35 IPCC, "2006 IPCC Guidelines for National Green House Gas Inventories."

36 IPCC.

37 IPCC, "Chapter 10: Emissions from Livestock and Manure Management," in *2006 IPCC Guidelines for National Greenhouse Gas Inventories*, 2006, https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/4_Volume4/V4_10_Ch10_Livestock.pdf; IPCC, "Module 5: LAND-USE CHANGE &FORESTRY," in *Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories*, 1996, https://www.ipcc-nggip.iges.or.jp/public/gl/guidelin/ch5wb1.pdf.

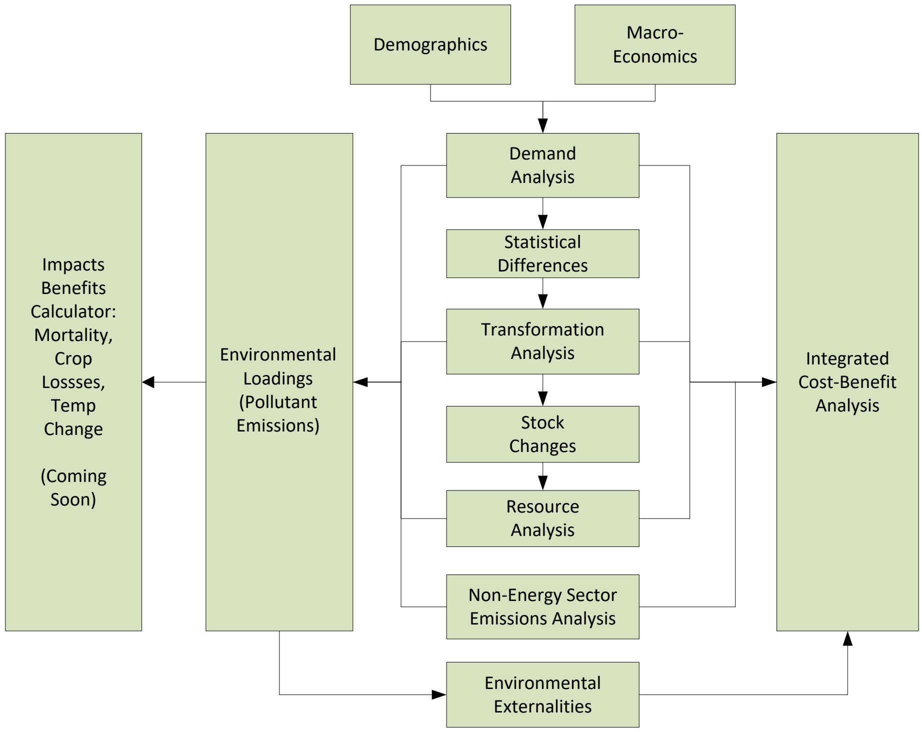

Figure 41: LEAP structure

The mitigation scenario modelling follows the approach estimating reduced energy demand thus reduced mitigation emission (m) in (tCO2eq). The difference of the baseline emission (n) and mitigation emission (m) is the avoided emissions estimates. Similarly, in the non-energy sector, the activity level could be for example, enteric fermentation in cattle. In this case, the activity data is the number (population) of cattle disaggregated by farming methods (free-range or zero grazing) multiplied by the emission factor per cattle of the type – farming method. Summation of these disaggregated calculation in the base year provide a national estimate of base year total emission and projected difference upon taking action present national GHG abatement potential.

Excel Spreadsheet

LEAP has capability unique capability to interface with software such as Excel spreadsheet where we import and export data. In the modeling, further refinement of charts and crosstabs correlation of data was done in excel. Results from LEAP were exported to excel tool and further refinement of analysis and chart was done.

3.3. Emissions drivers

This section of the report captures some of the factors which contribute and accelerate GHG emissions. The drivers are profiled into four major categories namely, energy sector emissions, Agriculture sector emission, forestry and other land use (FOLU) and lastly emissions from waste.

3.3.1. Energy demand and supply

The energy sector discourse for Somalia narrows to residential energy use, industrial sector energy, charcoal export, and electricity generation. Energy sector in Somalia is highly biomass dependent with charcoal and firewood dominating especially in the residential sector. The Country Environment Analysis report estimates upto 250,000tons[38] of charcoal for export and about 1188kg/households/year using charcoal. Total energy demand was 75.6million GJ residential accounting for 69GJ, while commercial and industrial accounting for 2.1million GJ and 5million GJ equivalent of charcoal exported as illustrated in figure 46 below.

The electricity generation in Somalia is rather non-coordinated private sector ventures. There are three main minigrid generators who distribute the power in a localized distribution network. Somalia electricity tariff currently is the highest in the region about USD 0.8-1.2 per KWH[39]. Majority Somalians (80-90%) therefore fail to shift from charcoal, and wood fuel to electricity as their primary source of energy[40]. Somalia ranks in the upper 5% globally power cost and in the upper 15% globally on expenditure on power as a share of GNI per household. Electricity generation mostly come from thermal generators (burning fossil fuels), and accounts for 97% of the total generation with limited supply from hydropower and of late solar and wind energy sources. The country consumes more than 121,000L of diesel fuel per day just to support power generation. It is projected that the figure will grow with additional installation of power generation capacity. The total daily consumption of diesel is projected to reach 694,000L in the medium term, something attributed to increasing urbanization in the country. The trend multiplies drives the countries emission higher[41]. What is worsening the situation in the insufficient technology of the generation capacity, inefficient use of the power generated, high technical and commercial losses in transmission networks, and fragmented generation and distribution.

Additionally, the commercial and industrial sector energy demand also heavily relies on fuel oil for generation of heat. There is however very high prospects of further energy demand in the industrial sector as numerous manufacturing sectors are sprouting due to the peace that is gradually emerging in the country.

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[38] The World Bank, "Somalia Country Environmetal Analysis: Diagnostic Study on Trends and Threats for Environmental and Natural Resources Challenges," 2020.

[39] *DP* NDP-9 The Path to a Just, Stable and Prosperous Somalia *-9 The Path to a Just, Stable*

[40] African Development Bank, 2015 "Somalia: Energy Sector Needs Assessment and Investment Program,

[41] The Federal Republic of Somalia 2018, The Initial National Communication for Somalia To The United Nations Framework Convention on Climate Change

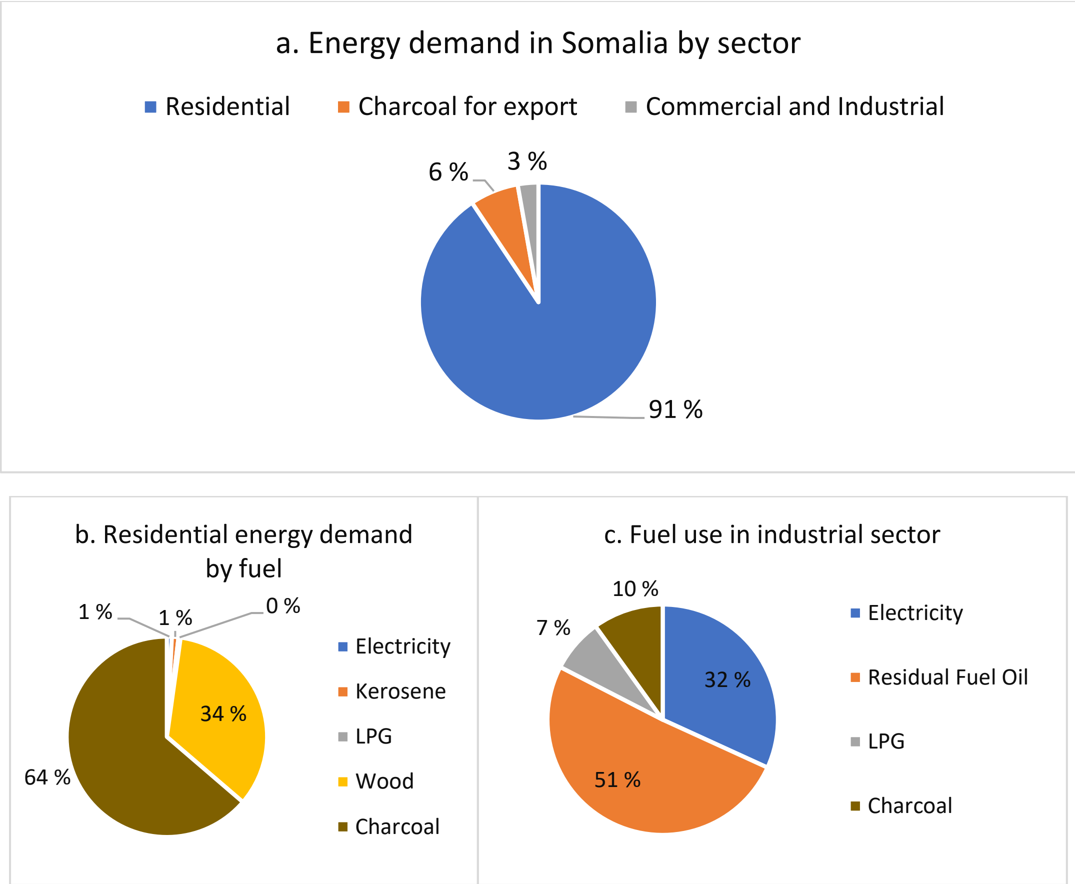


Figure 42: Energy demand by sectors in 2019

3.3.2. Industrial Processes and product use

Somalia has experienced a low level of industrialization due to the protracted conflicts making investments in the sector less viable. The manufacturing sector accounted for 10% of Somalia's GDP in 2000 with a focus on the domestic market. However, in the last few years, small and medium level manufacturing has emerged related to soft drinks and beverage, soap making, milk processing, textile industries, fish-canning and meat-processing plants, furniture, cement among others. As a result, investments in light manufacturing in Somalia have increased with the majority of the private investments and businesses based in Mogadishu, Hargeisa, Kismayu, and Bosaso. However, the insecurity situation and general harsh environment make major investments in the manufacturing sector risky hence low productivity.[42] The current manufacturing sector comprises of light industries.

As described in section 2.6.1 above, whereas there are micro-industrial processes, it was not possible to fine meaningful data to support emission modelling in the IPPU sector in Somalia thus not considered for mitigation in this report.

[42] World Bank. (2018). Somalia Economic Update. Washington DC, USA: World bank Group.

3.3.3. Agriculture, forestry, and other land use

Agriculture and forestry remain the leading contributor to Somalia's GDP, contributing about 68%. The livestock sector alone contributes about 40% of GDP and more than 50% of the country's export earnings. The total emission in MtCO2e of Somalia was estimated to about 62.92 with per capita emission of 2.06 – 2.17 in the initial communication. Gross emission from Agriculture, Forestry and Other Land Use (AFOLU) is therefore a big concern in Somalia. AFOLU sector comprises of all anthropogenic land use activities which produce GHGs. AFULO emission is segmented into three sub-sectors namely, Livestock emission, Land used-based emission, forestry activities emission (Aggregate Sources and non-CO_2 Emission Sources)

3.3.1. Crop production and fertilizer use

The major greenhouse gases of concern include mainly Carbon dioxide (CO2), Nitrous Oxide (N_2O) and methane (CH_4). The amount of CO_2 in the atmosphere and ecosystem is primarily determined by natural and artificial process. The natural processes include consumption and emission process. Consumption process is photosynthesis while emission process includes decomposition, respiration (fermentation), and incomplete combustion of organic matter. N_2O on the other hand is mainly emitted from the ecosystem as a by-product of nitrification and denitrification processes in the nitrogen cycle. The emission is accelerated by use of nitrogenous fertilizer in farming. Other human activities such as wastewater management, fuel combustion, and industrial processes are increasing the amount of N_2O in the atmosphere. Nitrous oxide is also naturally present in the atmosphere as part of the Earth's nitrogen cycle, and has a variety of natural sources. Methane is emitted through methanogenesis process under anaerobic conditions in solid and manure storage, enteric fermentation (production of methane from the digestive system of cattle, sheep, swine, goats), and during incomplete combustion of organic matter. Methane can also come from leaks from natural gas[43].

Agricultural soils are equally on the spot for production of GHGs through three avenues. Firstly, CO_2 through soil organic matter losses as a result of land use changes, CH_4 from anaerobic soils such as rice paddies and N_2O from intensive use of fertilizer use during crop cultivation. There are three main pathways through which nitrogen input in the soil can instigate emission of N_2O into the atmosphere. These pathways include (i) Nitrogen input through nitrogen fixing crops residues, organic fertilizers (compost manure, animal manure and sewage sludge) and synthetic nitrogen based-fertilizers; (ii) loss of soil organic matter from mineral soils following changes in land use and (iii) Deposits of animal manure on paddocks, rangelands and pastures[44]. These land use emissions is as attributed by the type and nature of farming. Main crops under cultivation are as illustrated in table 33. Below. The crop areas have been increasing marginally with highest increase observed in sugarcane growing. In the model, we used respective growth rate of various farm types but the few whose growth rate were over 3% were caped at 3% growth.

[43] The Federal Republic of Somalia 2018, The Initial National Communication for Somalia To The United Nations Framework Convention on Climate Change

[44] Ibid

Table 33: Land under crop production in Hectares Source: FAOSTAT

	2000	2005	2010	2015	2019
Beans	57000	67738	80592	89159	94154
Cassava	7000	8711	9083	9649	9743
Groundnuts	2100	10000	6797	7835	8084
Maize	182180	170000	87843	189825	100000
Onions	1520	3094	3893	4132	3860
Rice paddy	1000	2669	1650	1400	1130
Cotton	15000	16500	17000	17706	17751
Sesame	54682	61908	51196	80000	80000
Sorghum	349593	370704	526561	253272	250000
Sugarcane	6200	5500	6200	6477	6241
Sweet potatoes	550	800	787	843	868
Tobacco	250	263	330	355	371
Tomatoes	2160	10482	13151	15751	16506
Wheat	2600	3100	2580	2607	2593

Similarly, fertilizer application would also result to the mineralization of soil organic compounds**.** Fertilizer application in farming is quite low in Somalia. Whereas there is no literature providing quantity of fertilizer use for farming, the ministry of agriculture strategic plan identifies fertilizer, import, distribution and trade although in a non-regulated and monitored way. The plan seeks to raise the use of fertilizer to about 30% in order to increase national crop yields to meet food demand for the growing population. The plan identifies that 10% of the crop land is under irrigation and 90% rainfed. On the other hand, a study in other African countries identify that the area under fertilizer application has grown from 36% to 53% in just about a decade (Africa Agriculture status report, 2018).

We use this discourse to build an assumption that a conservative 45% of total agricultural land is applied with fertilizer at half rate of 0.059 kg of nutrients/ha of arable land.

Finally in the agricultural production methane emission from rice cultivation is often considered major source of GHG emission. Rice production was tremendously affected by the civil conflict (Fig. 43). It has had an up and down trends and whereas the country if currently just above 1000 hectares under rice production, its potential in the pre-war period reached over 19,000 hectares of land.

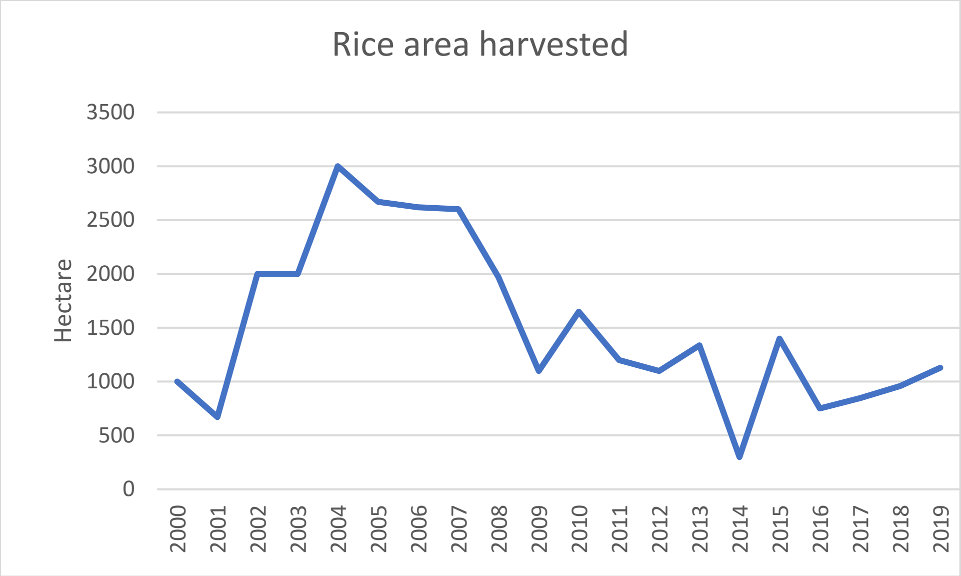


Figure 43: the evolution of agriculture production in Somalia

Source: FAOSTAT

Livestock population

As has been highlighted, livestock activities produce significant amounts of methane emission mainly from enteric fermentation and emission from manure management systems. The process of digestion particularly from ruminant livestock (Cattle, Sheep, goat, Carmel) is the main producer of methane in Somalia (Figure 44). These livestock are the most predominant agricultural backbone in Somalia and the most promising economic activity based on the export earning the country earn from livestock. Since there is room for more investments into the lucrative venture, the country will record more methane emission. The situation is worsened by the fact that it is a natural process which is beyond human control. Emission from manure management system will directly correspond to growth in livestock production. More livestock will imply more manure piles and thus more anaerobic decomposition translating to more methane emission. The same will also contribute to more N_2O because nitrogen from the manure gets oxidized into N_2O.

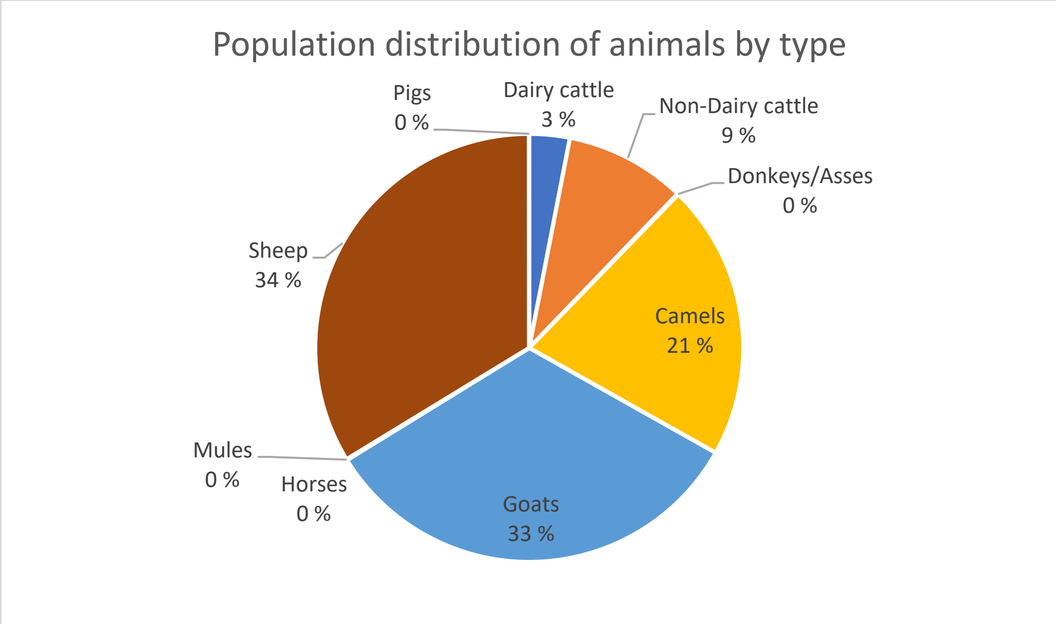


Figure 44: Population distribution of animals by type

Land use land use change and forestry emissions

The critical role of Somalia's natural resources including forests to national development has been recognized in its National Adaptation Programme of Actions(NAPA), National Development plans 2020-2024 and most importantly Somalia's constitutions that states "every person has the right to an environment that is not harmful to their health and well-being, and to be protected from pollution and harmful materials; and that every person has the right to have a share of the natural resources of the country, whilst being protected from excessive and damaging exploitation of these natural resources".

According to FAO 2016, Somalia total land area 62.7million ha. Agricultural areas accounts for 44.1million ha of the total land area and about 6.3 million ha of forest, majority classified as low-density wood and closed forest cover of no more than 3% indicating the dry nature of Somalia's geography[45]. In the 1980s, Somalia's total forest cover was estimated at about 62% of the country's landmass. Somali's remaining forest resources including tropical vegetation along rivers Shabelle and Juba and nearby floodplains, juniper trees in the Northern Golis mountain range and coastal mangroves are faced with threats of commercial exploitation that have been increasing for some time especially after the civil wars of the 1990s.

The forest sector has faced tremendous pressure since the civil war leading to the reduction of forest cover to about 10% of Somalia's total landmass in 2016 against 12% in 2000. Each year, on average the country lost 1.1% of its forest which equivalent to an average loss of 84,841 hectares annually as illustrated in figure 45 below. The destruction of the forests has also

[45] "FAO Country Profiles:Somalia," Food and Agriculture Organization of the United Nations, accessed November 21, 2021, http://www.fao.org/countryprofiles/index/en/?iso3=SOM.

affected the availability of forage for livestock and wildlife habitats leading to the reduced potential of livestock and wildlife sector productivity in Somalia.[46]

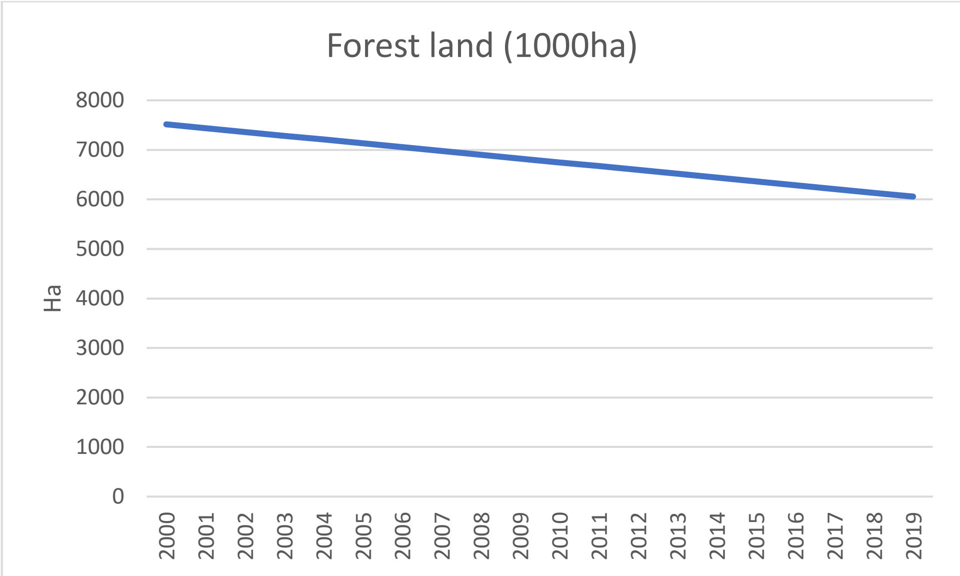


Figure 45: Annual deforestation rate

Traditional biomass fuels mainly firewood and charcoal account for 82% of Somalia's total energy consumption indicating overdependence on unsustainable energy sources for majority of the populations whether in rural or urban settings. The demand for firewood is higher in rural areas while demand for charcoal is higher in urban areas and the export market which is the biggest push factor for the forest degradation in Somalia. Increased population growth, insecurity, poverty, rapid urbanization, absence of alternative sources of energy coupled with climate change impact on already vulnerable livelihood sources remains major drivers for increased involvement in the destructive but lucrative charcoal business in Somalia. The charcoal industry employs thousands of people right from the grassroots, middlemen and the exporters of charcoal especially to Gulf countries where demand has increased recently due to lifestyle changes such as the use of Shisha that requires ample supply of charcoal.

To address the threat posed by illegal charcoal trading, the Federal Government of Somalia has drafted The National Charcoal Policy of Somalia whose goal is to attain "Total stop of charcoal export from Somalia; and conservation of the country's remaining forests through better management of domestic consumption of charcoal in a sustainable manner minimizing negative socio-economic and environmental impacts of the charcoal production.[47]"

Also, Article 47 of the Draft Environment Management Bill 2020 considers deforestation of any kind other than cutting down invasive plant species, illegality and further prohibits the engagement of both import and export of charcoal from Somalia or to Somalia. The act advocates for use of alternative energy sources other than charcoal through support for poor vulnerable populations that are dependent on charcoal business and incentivization of

[46] FAO. 2014. Forest Resources Assessment: Somalia Country Report. Rome
[47] The National Charcoal Policy of Somalia

alternative energy sources provision by all stakeholders especially private sector players. Incentives provided are in the form of tax breaks and subsidies for investments in clean energy including solar, wind, biogas and liquefied natural gas.[48]

Furthermore, the country has a long stretch of coastline of approximately 3,333 kilometers in length, the longest of mainland Africa. The coastal zone is becoming a major settlement area throughout the country leading to the destruction of coastal resources such as mangrove forests. Mangroves support rich biodiversity in the coast and provide a valuable nursery habitat for fish and crustaceans. In addition to the core objective of biodiversity conservation, mangrove forests sequester a significant amount of carbon and thus contribute to Somalia's objectives of low carbon development as well as global efforts on climate change mitigation under the Paris Agreement

3.3.4. Waste

Waste generation in Somalia continues to increase with the rapid pace of population growth, economic growth coupled with high urbanization rates especially in bigger cities such as Mogadishu, Hargeisa, Kismayu, and Bosaso. This has not only increased the volume of waste generated but also the complexities of managing the wastes due to different source categories requiring different disposal mechanisms. Each person is estimated to generate 0.56 kg of waste daily with organic matter accounting for the majority and the rest made of waste paper, plastic waste, glass wastes among others.[49]

Methane released during the breakdown of organic matter in landfills accounts for the majority of greenhouse gas emissions in the waste sector in Somalia. Solid waste management including open burning of waste, wastewater treatment and discharge are the main sources of methane emissions.

Mitigation actions within the waste sector includes liquid waste management, toxic waste in the marine environment as well as solid waste. Specifically key activities will include, waste to energy generation through managed landfill with methane recovery and combustion for electricity generation, anaerobic waste water treatment and gas recovery through lagoons, fecal sludge treatment and thermal application of heat generated from combined heat and power plants from solid waste incineration. In this case instead of emitting CH_4, which a gas with high global potential (GWP), CO_2, which has a lower GWP will be released to the atmosphere.

3.3.5. Transport

The transport sector in Somalia consists of mainly road transportation, aviation industry, ports, and shipping sector. Road transport is the major mode of transport. The aviation industry in Somalia has shown tremendous growth in the last decade after it suffered heavily during the civil wars which destroyed the existing airports and aviation infrastructure in Somalia. The port and shipping industry of Somalia has remained operational despite the challenges of insecurity and lack of effective and demarcated governance structure in place. Currently, there are four

[48] Draft Environment Management Bill 2020

[49] The Initial National Communication for Somalia(INC) -2018

operational ports in the country, mainly Mogadishu, Kismayo, Bosaaso, and Berbera ports that provide shipping transportation in the country.

The road sector is the focus of this analysis as it is estimated to account for most of transport GHG emissions. The smaller size of the water transport sub-sector makes them less attractive from the point of view of identifying mitigation options.

Somalia is estimated to have 132,000 registered vehicles[50]. Due to the prolonged wars in the last three decades, much of the road networks are in bad conditions thus undermining the smooth flow of goods and services. Also, the situation is made worse by the conditions of the high number of old vehicles on the roads with no regulations on the import of second-hand vehicles or generally older vehicles. In major cities such as Mogadishu, Hargeisa, Kismayu among others, road transportation is characterized by unsafe roadways and traffic jams especially during high traffic hours in early morning and evenings when most of the populations are commuting to and from work.

Somalia currently lacks a transport policy and aviation policy that could ensure effective implementation of standards such as the ban of old second vehicles importations and tax exemption mechanisms for private investors dealing in environmentally friendly vehicles among others. This undermines enforcement mechanisms of the relevant ministries which are also faced with challenges including institutional capacity and resources for the development of policies and implementation mechanisms.

Somalia transport sector is largely under-development hence high opportunity in sustainable and low carbon pathway development. According to the updated NDC, transport sector mitigation option is targeting on proper infrastructure reducing congestion, optimizing on driving speed and thereby reducing fuel use intensity per ton-km. Additionally, the country will promote policies on higher engine efficiency vehicle and Euro IV-VI emission vehicle standards.

3.4. Baseline emission projection and Mitigation Scenarios

The subsection present detailed modelling analysis of the Somalia BUR1. Section 4.4.1 gives highlights of various key assumptions for the baseline and mitigation scenarios, section 4.4.2 presents the overall baseline and mitigation actions emission projection and section 4.4.3 presents scenarios by sector, elaborating on energy, agriculture, forestry, and other land uses and waste.

3.4.1. Baseline and mitigation actions assumptions

a. Base year and business as usual (BAU) assumptions

Somalia business as usual projection include historic and 10 years forecast to 2030 on key economic drivers. This is so because the country is transitioning from civil strife to a stable

[50] AfDB, 2017 Somalia Transport Sector Needs Assessment and Investment Programme

nation and the historic trends may not accurately depict future transition. Indeed, there is likelihood of steep growth in certain sectors as the country takeoff. As such, we adopt assumption as described in Somalia NDC of high growth scenario depicting 4.9% GDP growth rate between 2020 – 2028 and a much higher growth trend of 7.5% between 2028 – 2037[51]. Somalia National plan projects midterm development trajectory of 3.2% in 2020 and at 3.5% in 2024[52]. The Somalia mitigation potential has thus been computed against the baseline scenario. Moreover, we assume with increased stability, the country is on the path to re-establish its major infrastructures including the grid electricity transmission and distribution[53]. This will boost the electrification and electricity connection. We thus assumed a 90% urban electrification and a 40% rural electrification in 2030. Table 34 below is a summary of key assumptions in the baseline scenario. Other specific assumptions are described in respective emission sectors.

Table 34: Key assumptions

S.No	Assumption description	Base year (2019) value	Source
1	National Population	15442900 people	World Bank Statistics
2	Urban Population	7034861 people	World Bank Statistics
3	Rural population	8408044 people	World Bank Statistics
4	Population growth rate	3%	World Bank Statistics
5	Urbanization rate	4.7%	World Bank Statistics
6	Average household size	5.9 persons	World Bank Statistics
7	GDP	4958 Million USD	National Development Plan, 2020-2024
8	GDP growth rate	4.9% (from 2020-2022) and 7.5% (from 2028 – 2040)	Updated NDC; 2020
9	National electricity access (2015)	16% (270,000 connections) *	AfDB
10	Urban Electricity access	33% (393575 connections)	World Bank
11	Rural electricity access	4% (57004 connections)	

*The referenced access is 2015 estimated national connections proportion

b. Mitigation actions and measures

Climate change mitigation actions were derived from existing government strategies and policies. The assumptions summarized in table 40 are modelled in LEAP using functions or time series arguments. This would include simple extrapolation expression such as percentage growth (%growth), change in percent share (from x% to y%), linear and logarithmic regressions amongst others. Table 35 elaborates various key mitigation action assumptions that informed the modelling and mitigation analysis.

Table 35: Summary priority mitigation actions

[51] Ministry of Environment and Climate Change, "Updated Nationally Determined Contribution of the Federal Republic of Somalia," Draft Report (Somalia, 2020).

[52] Ministry of Planning Investment and Economic Development, "Somalia National Development Plan (2020 - 2024)."

[53] Ministry of Planning Investment and Economic Development.

No	Sector priorities and targets	Current adoption level	Target in 2030
1.	**Agriculture**		
	● Promotion of sustainable intensification pathways for the livestock sector including improved feeding, breeding and veterinary services as well as improved manure management with an intention of reducing livestock population against the baseline by 15%	-	15%
	● Planting of nitrogen fixing plants to reduce fertilizer usage protection and conservation of existing forests. The nitrogen fixing plant as well as use of organic fertilizers reduces application of synthetic fertilizer against the baseline	-	20%
	● Smart agriculture and intensification of crop production reduce the growth rate o agricultural fields by 50% hence annual growth of new farms increase at slower rate of about 1.5% annually	3% growth rate	1.5% growth rate
	● Intermittent irrigation of rice adopting modern technologies allowing more aeration	-	30%
	● Rangeland restoration and rehabilitation	-	-
	● Sustainable Land Management including climate	-	-
2.	**Energy**		
	● Increased adoption of Energy efficient cooking (Traditional charcoal stove has 20% efficiency and improved charcoal has 35% efficiency; and traditional wood 12% and efficient wood is 32%)	14%	50%
	● Clean and Energy efficient Cookstoves (LPG stoves)	10%	40%
	● Clean and Energy efficient Cookstoves (Biogas in rural areas)	-	10%
	● Solar lantern lamps replacing kerosene lamps	-	30%
	● Energy efficient light bulbs (50% of the connected)	-	50%
	● Development of renewable energy electricity (Solar and Wind) to constitute 30% electricity mix	-	30%
	● Reduce transmission losses	40%	12%
	● Promote standalone solar home system by reducing tax on solar PV products	-	50%
	● Industrial energy efficiency	-	15%
3.	**Forestry**		
	● Implement Agroforestry on 400,000Ha farmland	-	400,000Ha
	● Afforestation and Reforestation of Degraded		
	● Forests including mangrove restoration (5%) -	-	1.17M Ha
	● Reducing emissions from deforestation and forest degradation – implement charcoal policy/REDD+ readiness and activities		
4.	**Transport**		
	● Improvement of road conditions/road investments increasing fleet flow. This in turn will reduce traffic resulting to about 6% fuel use reduction	-	6%
	● Bus rapid transit (BRT) system implementation resulting to replacement of between 10% - 30% of its	-	5%

	ridership.		
	● Improved vehicle stock efficiency	-	10%
5.	**Waste**		
	● Sanitary landfill with methane recovery and 0.8MW electricity generation capacity	-	About 90% low carbon
	● Reduce the waste by 40per cent in 2030 through introducing robust waste segregation at source, and implementation of refuse, reduce, reuse, recycle (RRRR) waste management principal		
	● Development of 2 sanitary land fills		

3.4.2. Overall BAU and Mitigation Scenarios

As aforementioned in chapter 4.2.3, LEAP tool uses activity data, energy activity and emission factor to estimate base year and historic years to establish GHG inventory. Business as usual scenario emission is hence a projection based on the demographic and micro-economic factors which are the key drivers of demand and thus anthropogenic course of emissions. Such demographic factors include population growth rate, urbanization, and household size. While population is expanding energy demand is expected to increase, waste generation rises and need for more agricultural produce. Moreover, GDP value addition by sector transforms emissions in the economic sectors such as industry, transportation, service, and agriculture. It is a consistent story line on how the future is expected to evolve based on changing demographic and economic trends.

Similarly, mitigation scenarios are low carbon development pathways described in national development plans and policies or reached upon stakeholder consensus on how they would like to see a sector transforms. As aforementioned LEAP uses functions and expressions to model the expected transformation based on these targets.

a. Overall business as Usual scenario

Somalia baseline GHG emission was hence projected to increase from 41MtCO2eq in 2020 to about 50 MtCO_2eq in 2030. Forestry and agricultural sectors are the greatest emitters contributing to a total of 92% of overall GHG emissions. Agricultural total emission in 2020 was determined to be 20.5million tCO_2eq whereas forestry sector emission is 17.4MtCO_2eq. Energy sector emission accounted for 4% (1.5 MtCO_2eq) of total GHG emission while the waste sector contributing to 3% (1.2MtCO_2eq) of total GHG emission. The transport sector is not well developed in most areas with total road connectivity reported to be 22,000km with only about 3000km of paved road[54]. The total GHG emission in the transport sector thus was estimated at 0.2MtCO2eq in 2020. This estimation was based on transport fuel importation UNstat statistics database. The gasoline fuel was consolidated as motor gasoline used in private cars, vans and motorcycles and diesel used in ship bunkering and trucks.

Projection to 2030, shows an increasing emission trends especially in the energy and waste sector from about 1.5MtCO2eq in 2020 to about 2.9MtCO2eq for energy and 1.1MtCO2eq to 1.8 MtCO2eq per year for waste (Fig. 46, 47 and Table 36).

[54] Ministry of Environment and Climate Change, "Updated Nationally Determined Contribution of the Federal Republic of Somalia."

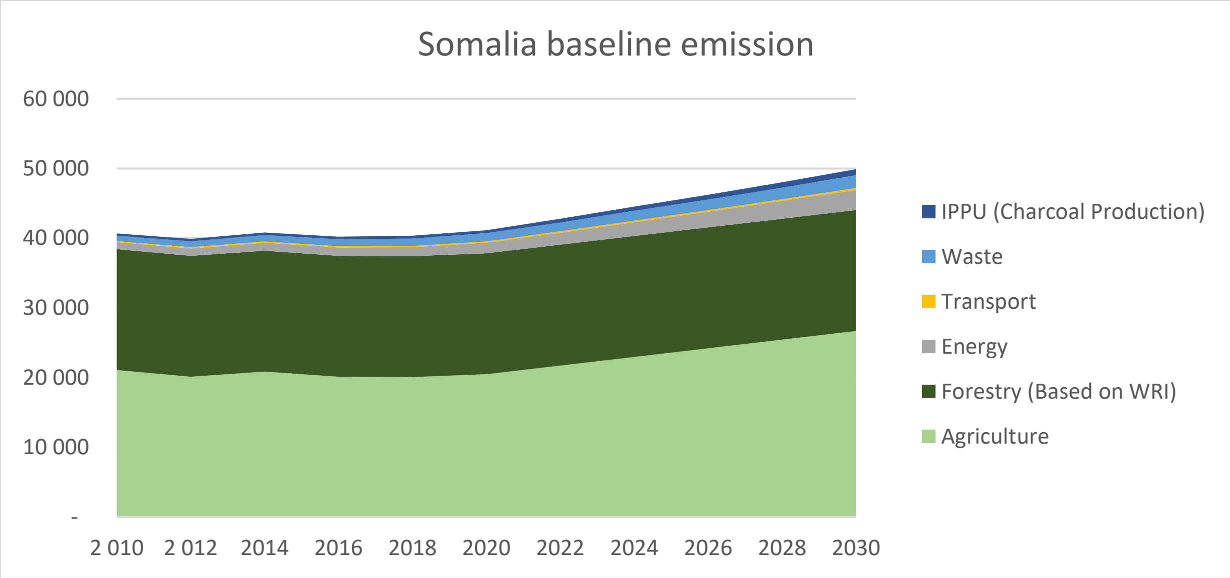


Figure 46: illustrate aggregated emission in the baseline for all sectors in 2020 and in 2030.

The growth shows rising trends with high growth in Energy, agriculture and waste sectors

Table 36: Baseline emission projection for Somalia '000' tons CO2 equivalent

	2010	**2012**	**2014**	**2016**	**2018**	**2020**	**2022**	**2024**	**2026**	**2028**	**2030**
Agriculture	21,074	20,128	20,875	20,118	20,079	20,508	21,732	22,964	24,202	25,447	26,701
Forestry (Based on WRI)	17350	17350	17350	17350	17350	17350	17350	17350	17350	17350	17350
Energy	1,315	1,402	1,487	1,575	1,683	1,939	2,214	2,587	2,912	3,324	3,765
Transport	176	169	176	188	188	194	208	222	238	255	273
Waste	767	850	919	994	1,076	1,170	1,278	1,397	1,526	1,667	1,822
Total	**40,681**	**39,899**	**40,807**	**40,225**	**40,376**	**41,162**	**42,782**	**44,520**	**46,228**	**48,044**	**49,911**

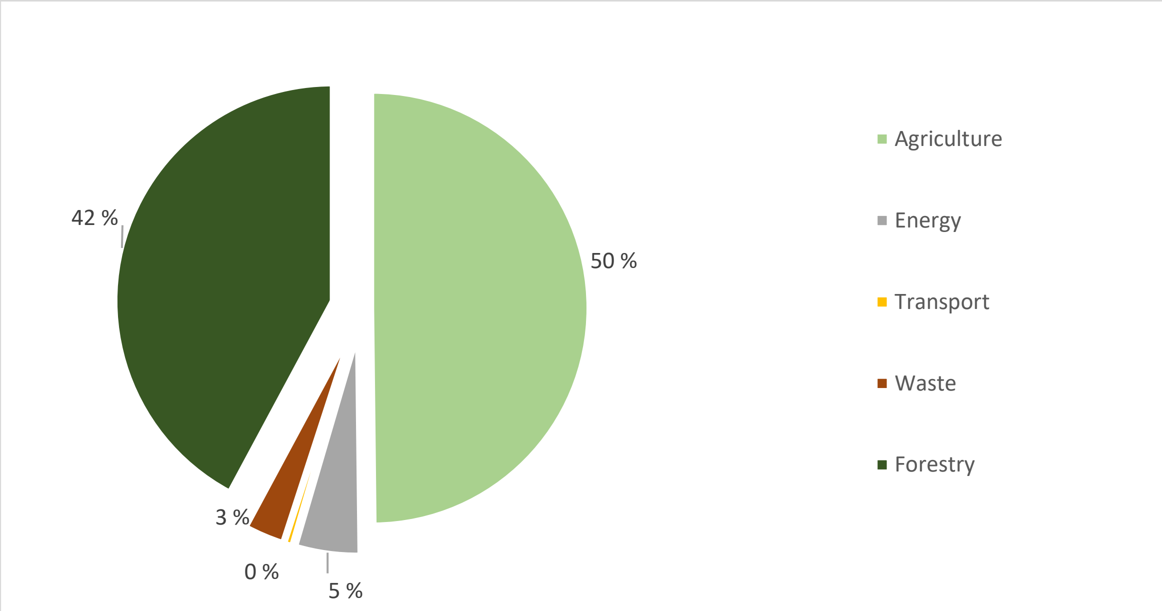


Figure 47: Emission contribution from other sectors in the BAU in 2019

Methane from agriculture and waste management constitute highest source of GHG mission (Table 37). In agriculture, enteric fermentation constitutes to about 93% of total methane emission whereas manure management accounts for only about 7% of total livestock emission. On the other hand, energy and IPPU methane and nitrous oxide emission are as a result of pyrolytic wood conversion to charcoal and charcoal burning.

Table 37: Projected emission by GHG type in the BAU '000' tCO_2eq in 2020

	Nitrous Oxide	*Methane*	*Carbon Dioxide*	*Total*
Agriculture	*2,560*	*17,948*	-	*20,508*
Energy	*291*	*674*	*943*	-
Transport	*0*	*1*	*196*	*198*
Waste	-	*1,170*	-	*1,170*
	2,851	***19,793***	***1,140***	***23,784***

b. *Overall mitigation scenarios in all sectors*

Albeit, with limited and inconsistent data, modelling the mitigation scenarios demonstrated that overall, the country will potentially reduce combined reduction of 10$MtCO_2$ equivalent against the baseline which is 20% abatement potential from key sectors. There is no observable emission reduction in transport sector interventions. The energy sector emission reduction was determined to be about 1$MtonCO_2eq$, waste sector reducing about 2MtCO2eq as Agriculture sector reducing about 6MtCO2eq. Elaborate discussion of sectors is presented in the subsequent chapters.

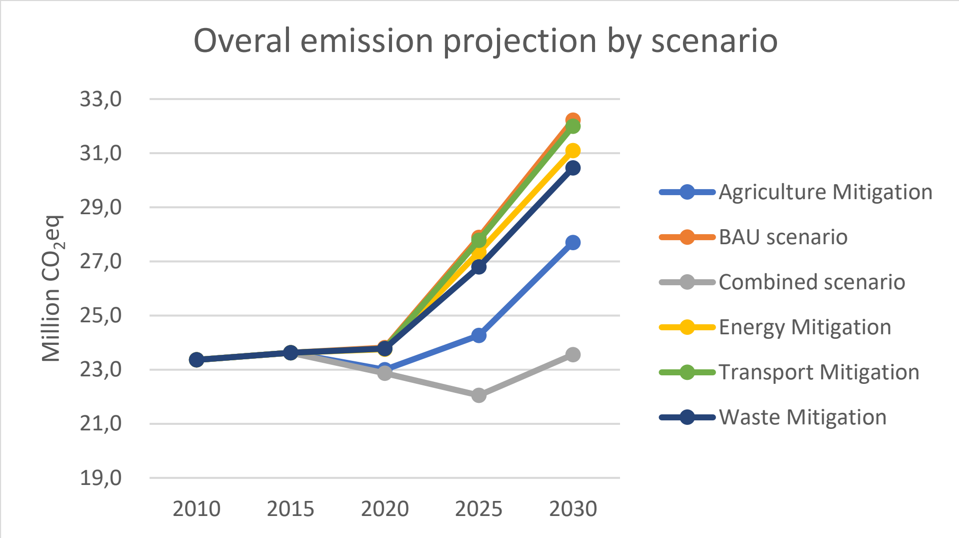


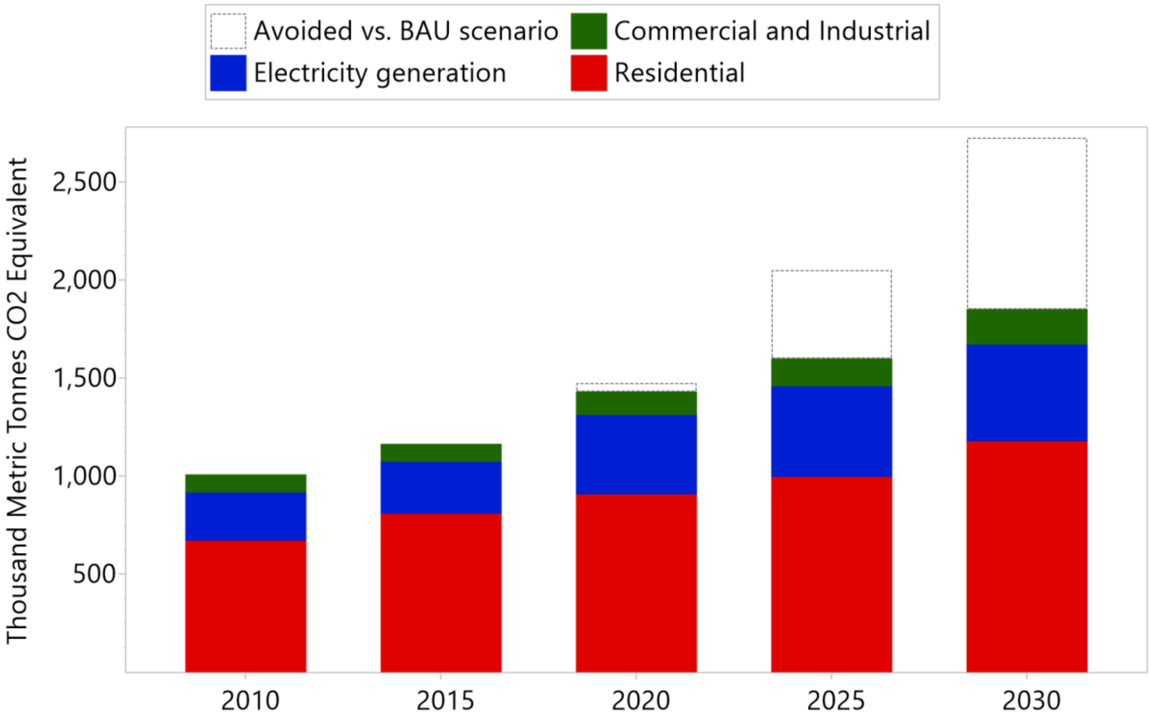
Figure 48: Overall emission reduction

3.4.3 Sector Specific BAU and Mitigation scenarios

3.4.3.1. Energy Sector

The Somalia energy sector is quite intertwined and mostly lost in inadequacy of data and conflicting information. This is due to loss of infrastructure during the civil strife and inadequate surveys and studies in the region. Energy sector emission is described to be generated from three broad source categories, energy demand in residential, commercial and industries, transport energy demand and electricity supply.

Overall energy sector emission reduction is 0.876Million tCO_2eq.



	'000' tons CO2 eq				
Branch	2010	2015	2020	2025	2030
Commercial and Industrial	90	90	118	140	177
Electricity generation	245	262	405	460	495
Residential	671	810	906	998	1,176
Avoided vs. BAU scenario	-	-	43	454	876
Total	1,006	1,161	1,472	2,051	2,724

Figure 49: Somalia's energy sector BAU and avoided emissions scenarios

i. BAU Energy demand emissions

As aforementioned the energy sector emissions are attributed to three main emission sectors, residential energy demand, industrial and commercial energy demand and electricity generation. Total sector emission is projected to increase to about 2.8 million tCO_2eq equivalent

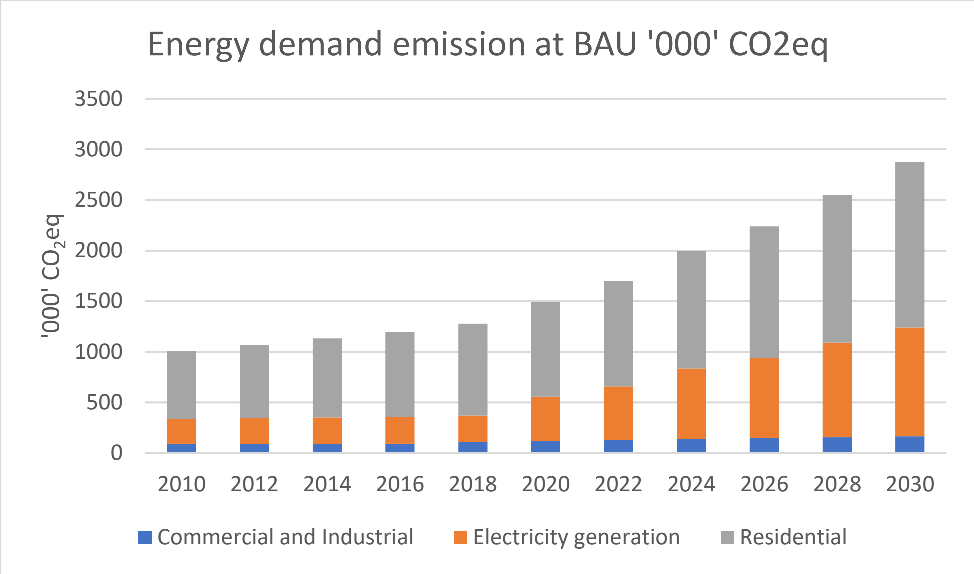


Figure 50: Emissions by main sub-sectors

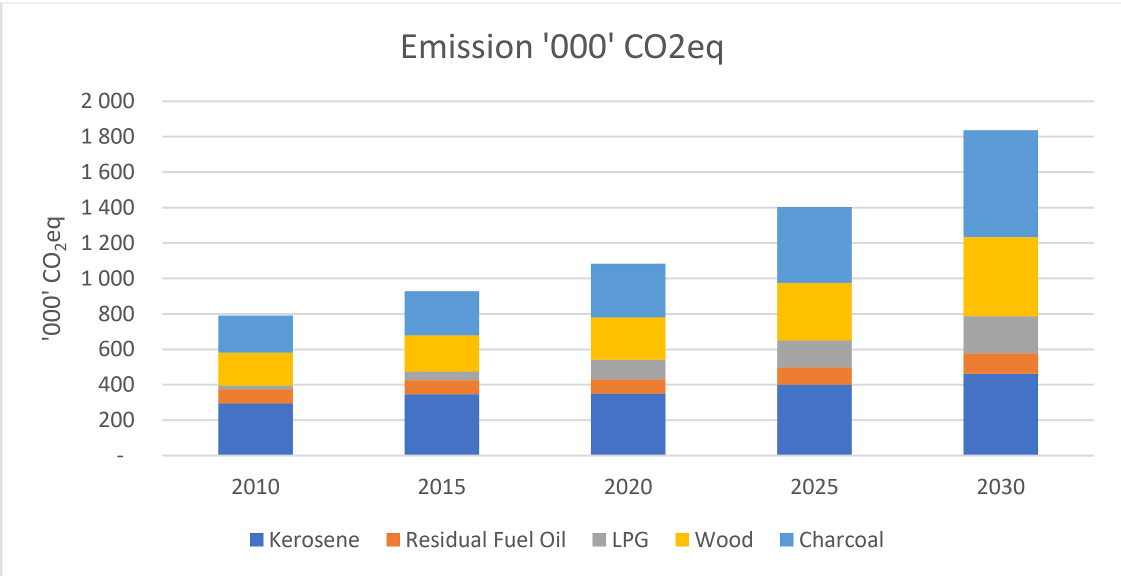


Figure 51: Energy demand emissions by fuel

Table 38: Energy demand emission by GHG type ‘000’ tons of CO_2eq in 2030

Fuel	Nitrous Oxide	Methane	Carbon Dioxide	Total
Kerosene	0.3	0.5	120.8	121.6
LPG	0.3	0.7	204.6	205.7
Wood	40.3	319.6	-	360.0
Charcoal	26.4	556.9	-	583.3
Residual Fuel Oil	0.3	0.6	143.4	144.3
Total	**67.6**	**878.3**	**468.8**	**1,414.8**

a. Residential sector energy demand emissions

The residential sector energy demand is dominated by firewood and charcoal accounting for about 80%-90% of total energy needs (AfDB, 2015). The massive loss of vegetation cover is attributed to highly unsustainable harvesting of charcoal and wood for domestic use and export.

Charcoal use

AFDB report estimates that about 4million tons (approx. 1700ton/household) of charcoal is consumed annually. On the other hand, ESD, 2007 estimated about 1188ton of charcoal/year and computed from Farah and Olavi estimates of between 2.7sacks – 4 sacks per person per year (each sack weighing 23.3kg) brings an estimate to 371kg - 550kg/hhd per year. Yet again the United Nations statistics estimated about 1.3million tons production of charcoal in 2018. Most of the reports however corroborates that most of this charcoal is produced in the rural areas and used in the cities. ESD (2007) report estimated 73.9% share proportion of urban population using charcoal and 21.2% in rural households whereas Farah and Olavi and AfDB estimates about 90% use of charcoal in urban areas. Table 39 below illustrates various assumption in residential energy demand for rural and urban.

Table 39: Residential and commercial sector energy demand

Fuel	**% Urban proportion of household**	**% Rural proportion of household**	**Energy Intensity Urban**	**Energy Intensity rural**
Electricity	33%	4%	338 kWh/hhd*	338 kWh/hhd*
Firewood	24%	77.7%	1095 kg/hhd	1095 kg/hhd
Charcoal	90%	21.2%	1188 kg/hhd	845.1 kgs/hhd
Kerosene	5%	1.8%	240 liters/hhd	240 liters/hhd
LPG	10%	0.2%	108 kgs/hhd	108 kgs/hhd

*338 kWh/hhd was computed based on UN statistics of total electricity consumption in million kWh and total number of connections

Additionally, ESD 2007 report described institutional charcoal consumption as presented in table 40 below.

Table 40: Institutional charcoal consumption

	Number of establishments	Charcoal use intensity (Kg/Month)	Total requirement (Tons/year)
NGOs	645	340	2632
Tertiary institution	11	850	112
hospitals and inpatient clinics	115	510	704
secondary schools	41	650	320
primary schools	688	340	2807
Industries (staff canteens)	70	340	286
Class A hotels and restaurants	41	850	418
Bakeries	7	1020	86
Total			7364

Source: esd, 2007

LPG use

There is however limited use of LPG and kerosene. A study by ESD in 2007 reported LPG use in Somalia as summarized in table 41 below.

Table 41: LPG uses by Member states

Somaliland	8000kg/month
Puntland	3000kg/month
South Central	200kg/month

According to ESD, 2007 report, the main challenge for LPG adoption was the cost that ranged between 2.9-3.2 USD/kg of gas. The greater majority of LPG is used in hotels and restaurants and foreign mission guest houses in vast of the regions. AfDB (2015) report also states that LPG is used for cooking by the better-off urban population, and kerosene is used mainly for lighting by the less affluent urban and rural populations. However, in Puntland about 65% of households used LPG (ESD, 2007). Because it is not clear how to distribute the LPG use between residential and commercial use and with the knowledge that most of the application is in the commercial, we assume a 60:40 distribution between commercial and residential use of LPG. And that all the residential use of LPG is limited to the urban areas. from the import pattern as depicted in table 42 below on LPG consumption, the demand growth is rather very rapid with high growth percentages. This could be attributed to three factors, increased use of the LPG and its intensity in commercial sector, high rates of adoption by local population and increased residential use intensity. Considering the total LPG used in the residential and the number of household using the LPG estimated about 166kg LPG use intensity per household (equivalent to about a 13kg LPG cylinder).

Table 42: Annual LPG imports

Year	Qty of LPG imported (Metric ton)	% Growth from previous year
2017	9672	
2018	16582	71%
2019	21380	29%
2020	29446	38%

Source: Somalia ports authority

Table 43: Final energy demand in residential by fuel type (million GJ)

	2010	2015	2020	2025	2030
Electricity	0.4	0.5	0.6	0.8	1.2
Kerosene	0.3	0.5	0.8	0.9	1.2
LPG	0.1	0.1	0.2	0.4	0.5
Wood	19.6	21.6	24.4	28.8	34.1
Charcoal	31.2	38.1	46.1	57.3	71.2
Total	51.5	60.8	72.2	88.3	108.2

Residential energy mitigation scenario

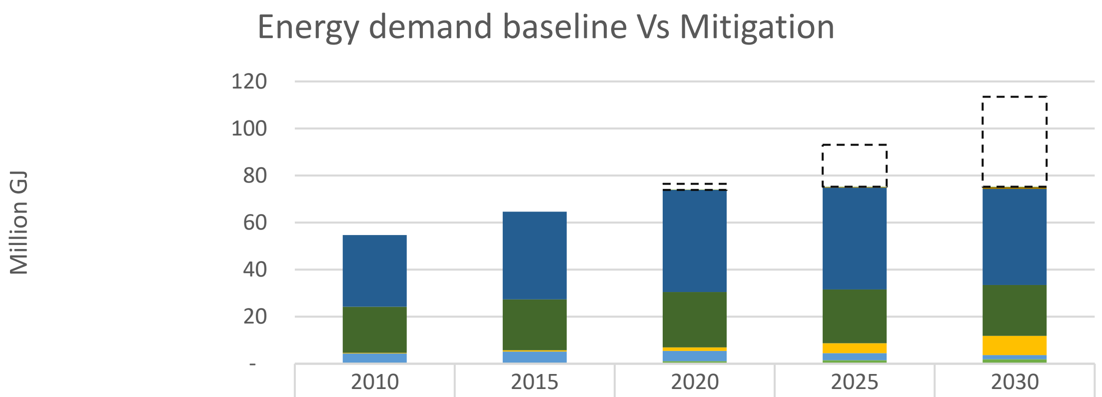
Residential sector mitigation included adoption of efficient cookstoves and transition to clean cooking technologies. Somalia national determined contribution and mitigation analysis and costing report sort for increased adoption of efficient cooking technologies from the status of 14% to 50% by 2030 while replacing the use of firewood, charcoal, and kerosene with LPG for urban areas and biogas adoption in rural households.

As illustrated in the Somalia updated NDC, the mitigation measures in the residential considerations sub-sector included increased adoption of improved cookstoves to 50% share from the base year value for both charcoal and firewood stoves, transition to clean cooking stoves including LPG in urban areas with a 40% population using LPG whereas rural population adoption was more conservative to 20% for cooking in 2030. However, in rural we also assumed and about 10% of rural households adopting biogas technology for cooking.

On the other hand, charcoal use for cooking was assumed to reduce by 40% from 90% population to 50% share of population using charcoal for cooking. Whereas in the rural areas, the proportion of household relying on firewood as primary fuel reduced to 47.7% share from 77.7%share.

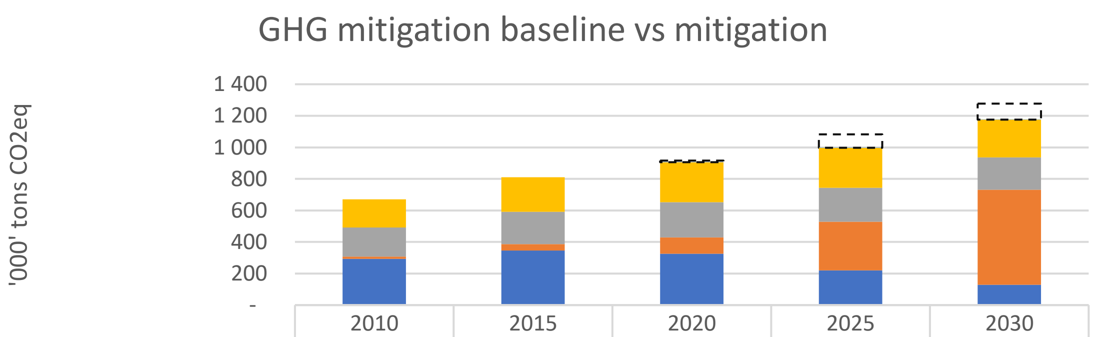
Household lighting for electrified homes both in rural and urban was assumed to be dominated by electricity with incandescent bulbs. In the mitigation scenario, we assumed that by 2030, about 50% of the households will be adopting efficient CFL bulbs. However, the non-electrified homes in urban and rural homes Kerosene dominated the lighting energy source. Due to unavailability of data, we assumed that there is unknown number of households using solar lanterns and solar home systems hence in the model we assumed a zero level in the baseline and that by 2030, about 30% of the households will be adopting solar lantern as about 50% adopting solar home systems. The national plan seeks to increase adoption of solar home systems by 150000 per year.

The residential sector mitigation actions would yield to about 38 million GJ of energy saved and about 0.1 MtCO2eq mitigated as illustrated in in figure 52 and 53 below.



	2010	2015	2020	2025	2030
Avoided vs. BAU scenario	-	-	2	18	38
Solar	-	-	0	0	0
Biogas	-	-	0	0	1
Charcoal	31	37	43	43	41
Wood	20	22	24	23	22
LPG	0	1	1	4	8
Kerosene	4	5	4	3	2
Electricity	0	0	1	2	2

Figure 52: Energy consumption saving



	2010	2015	2020	2025	2030
Avoided vs. BAU scenario	-	-	10	84	100
Biogas	-	-	0	0	0
Charcoal	179	219	255	254	239
Wood	185	205	223	216	205
LPG	13	40	103	309	603
Kerosene	294	346	326	220	129

Figure 53: GHG Mitigation potentials

Woody biomass is considered carbon neutral, hence CO_2 emission from biomass is often accounted for the forestry sector. However, methane and Nitrous Oxide emission are prevalent in biomass burning and wood conversion to charcoal. The IPCC guideline shows that combusting biomass on stationary devices for residential has emission factors of Carbon dioxide 112tCO_2/TJ , methane 300kg/TJ and Nitrous oxide 4kg/TJ whereas LPG emission contribution for carbon dioxide is 63.1tCO_2/TJ, methane 5kg/TJ and only 0.1kg/TJ as such there is tendencies to realize higher emissions (depicted by negative tendency in urban areas) while transitioning to LPG as depicted in figure 54 below in the urban areas furthermore figure 55 below illustrate emission by fuel in urban and rural in the baseline and energy mitigation scenario.

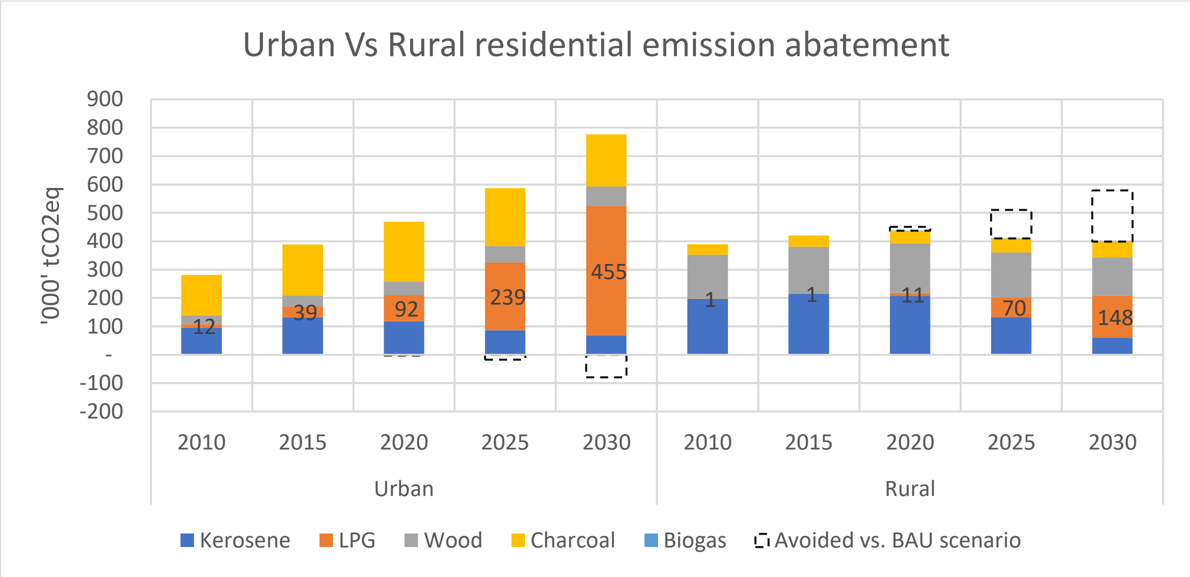


Figure 54: Urban Vs residential emission abatement

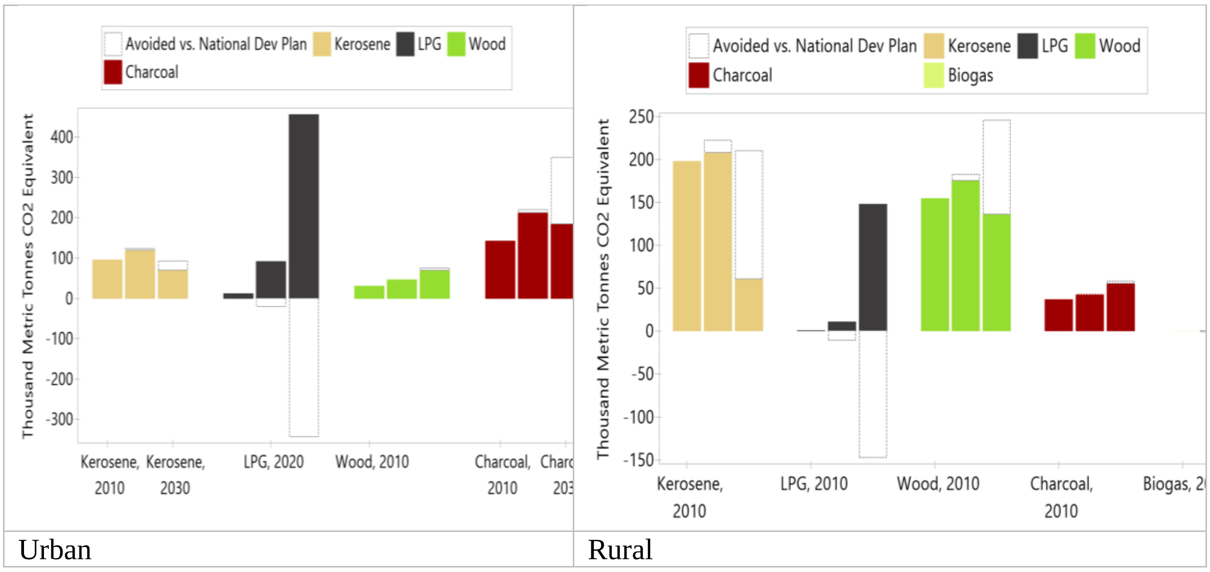


Figure 55: Urban Vs rural GHG emissions

b. ***Industrial and commercial sector energy mitigation***

The industrial and commercial sector energy demand was mostly derived from United Nations statistics and a more top-down approach was used in demand estimation. Somalia industrial commercial sector is very lean and mainly comprise of cottage manufacturing, hotels and restaurants, diplomatic community guest houses and other commercial buildings. Mostly the sector relies on electricity, charcoal, and LPG (for hotels and diplomatic mission guest houses), and fuel oil for local manufacturing. The industrial sector energy demand projection was based on Higher GDP growth as presented in the updated NDC report of 4.9% from 2020 and 7.5% from 2028. As illustrated in figure 16 below, electricity and heavy fuel oil are the most demanded energy sources mainly for the cottage industries. GHG emission mitigation as described in the updated NDC seek for 15% energy efficiency in the industrial sector. Industrial energy efficiency hence would result to a 0.032 MtCO2eq abatement as illustrated in figure 56 below.

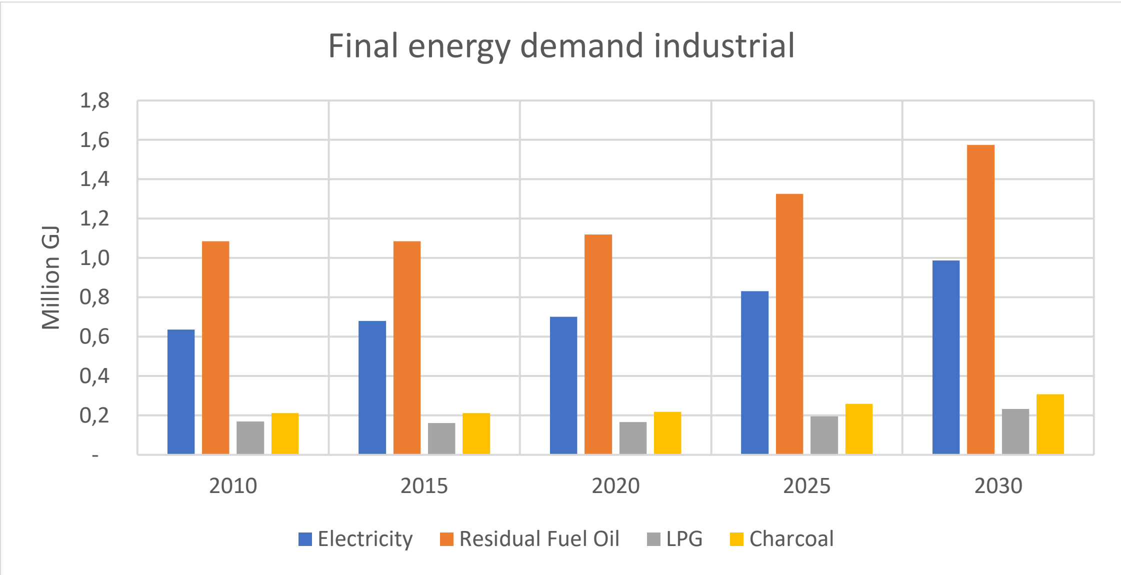
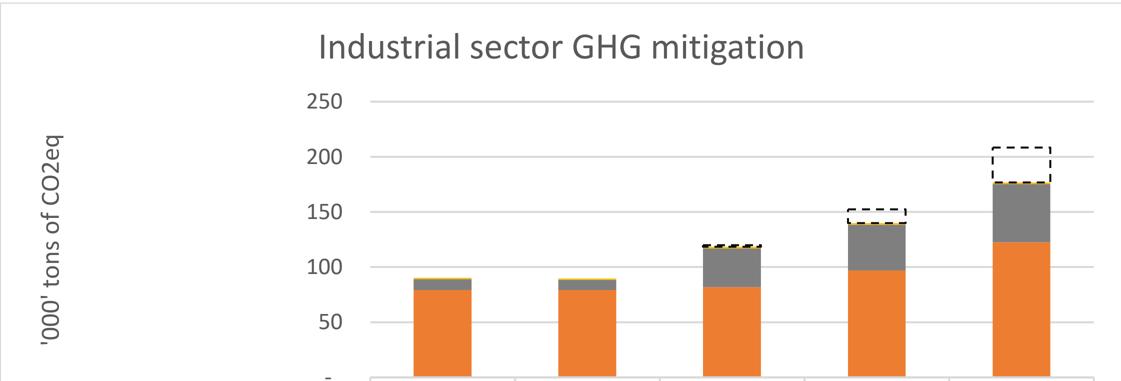


Figure 56: Final Energy demand by fuel types for industrial and commercial use



	2010	2015	2020	2025	2030
Avoided vs. National Dev Plan	-	-	2	13	32
Charcoal	1	1	1	1	2
LPG	10	9	35	42	53
Residual Fuel Oil	79	79	82	97	123

Figure 57:Industrial GHG emission mitigation a result of industrial energy efficiency

ii. Electricity generation emissions

a. Baseline emission

As described in the Somalia National Plan, the electricity sector is quite underdeveloped, partly due to civil war. In the wake of the millennium, Somalia main urban center was electrified through the national utility in low voltage line. Currently the country is electrified through three main minigrids in Puntland, Somaliland, and Central Somalia. A total installed capacity of 103.4MW nationally is estimated to connect about 400,000 customers in 2019. The electricity sector is purely generated from heavy fuel oil generators that supports mainly light load appliances in the residential sector.

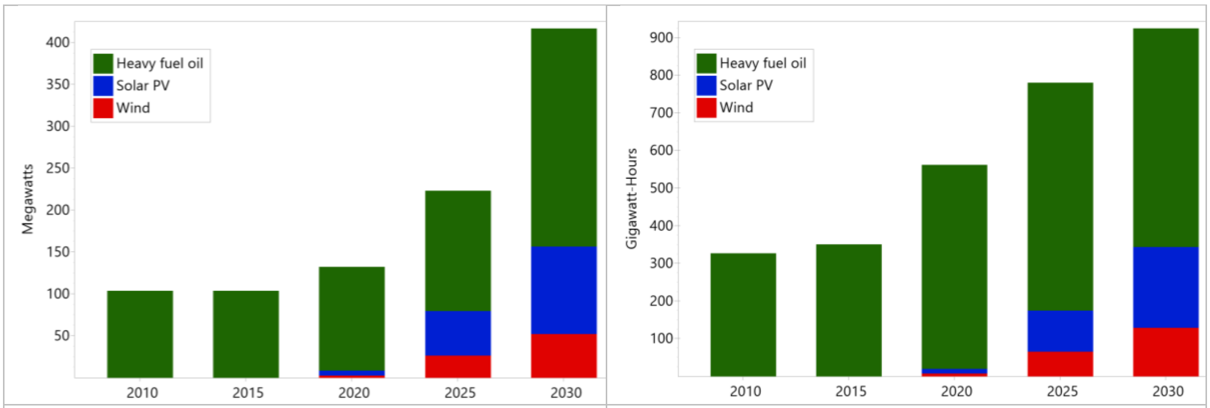
It was however assumed that about 60% of the total electricity generation is used in the commercial and manufacturing industries to provide lighting, plug-ins, and small motor operations.

Mitigation scenario

The electricity sector strategies seek to prioritize renewable electricity development. The updated NDC seeks for Increase of the clean and carbon-neutral energy, construction of a hydroelectricity plant,

Increase the energy supply from both renewable and fossil fuel sources, and as result increase access to energy from 15per cent to 45per cent of population by 2024; or 6per cent growth in access per year. On the other hand, the mitigation analysis report seeks to meet the increasing electricity demand, Somalia will expand its share of renewables in its energy mix and meet the NDC targets will require substantial deployment of renewable energy technologies. According to the Power Master Plan there is to expand electricity generation and distribution system in the country. The installed capacity will increase from 100MW to about 300 MW in 2030 and to 1000MW in 2037.

Based on these two literatures and need for expansion of the electricity sector and seeking for at-least 35% renewable energy resources from wind and solar, we assumed a steady growth of solar and wind to achieve a 35% electricity mix. Thus, a required capacity of 104MW capacity of solar PV will be required and a total capacity of 52MW of wind. These capacities would result to 37% renewable electricity mix in the grid contributing to 344GWh of electricity output.



a. Required capacity in MW | b. Required generation in GWh

Figure 58: Required installation capacity and generations

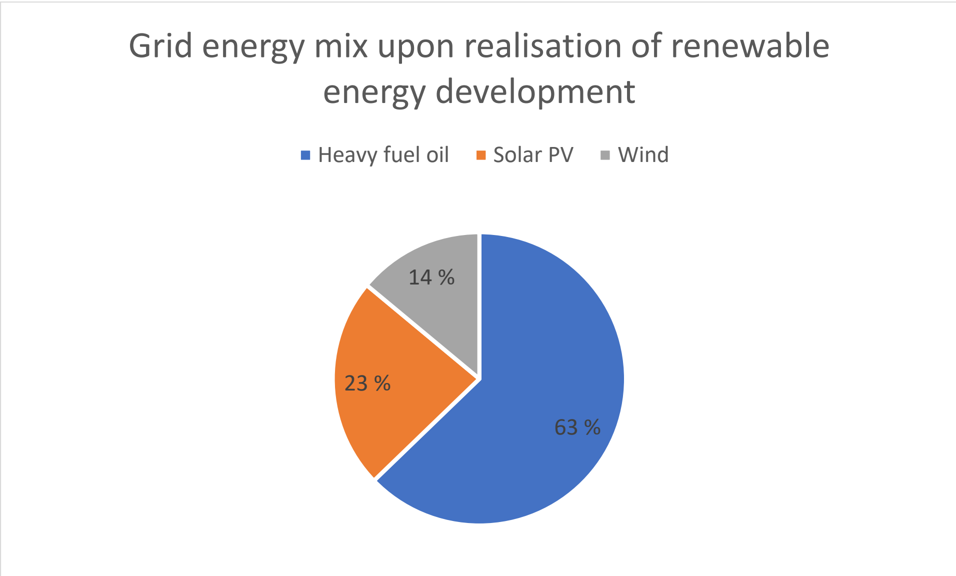


Figure 59: Energy mix upon development of renewables

However, this production assumed a reduction in electricity transmission and distribution losses from about 40% to just about 12%. Reducing Transmission and distribution loses would save the country 329GWh of electricity that would increase connectivity.

The resultant GHG emission abatement in the ambitious renewable electricity generation was determined to be 0.648million tCO2equivalent as illustrated in figure 60 below.

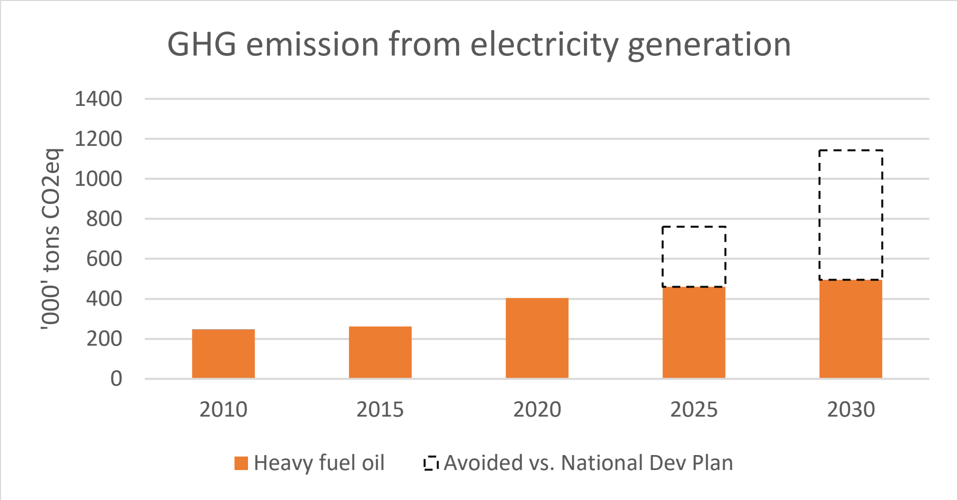


Figure 60: GHG avoidance in electricity generation and supply

iii. Charcoal production emission

a. Baseline

Charcoal export has been of major concern on destruction of natural resource. The national action plan estimates that between 100,000 tons – 250,000 tons of charcoal is produced for the export market. Moreover, it is the main energy source for most Somalia people. The GHG emission is projected to rise from 0.4 million tons CO2eq in 2019 to 0.7million tons CO2eq in 2030 as illustrated in figure 61 below.

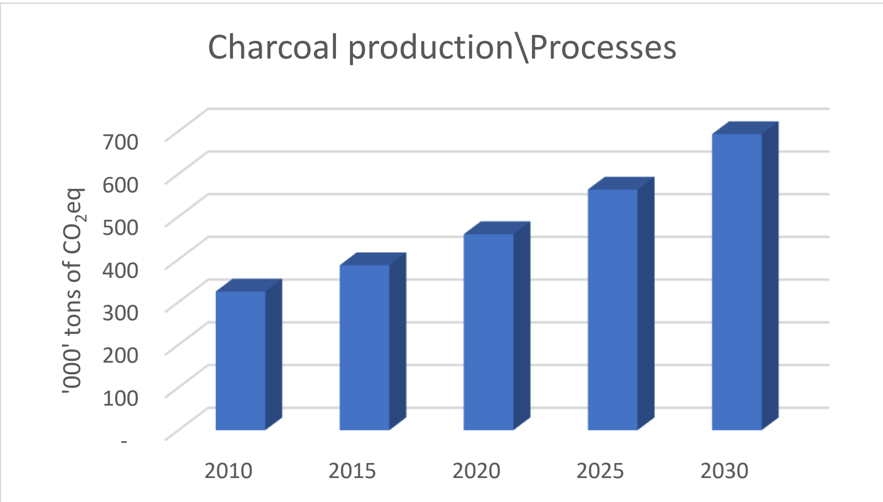


Figure 61: emissions in charcoal production

b. Mitigation scenario

In the mitigation scenario, we consider as transition to more efficient charcoal production kilns (figure 62) and reduced use of charcoal in residential demand resulting from transition to cleaner energy technologies (LPG and biogas) figure 70. The assumption was gradual shift from traditional charcoal making to efficient charcoal production in 2030 by 50% of the charcoal producers adopting efficient technologies. The efficient kilns are estimated to have 45% thermal efficiency against 22% thermal efficiency of traditional kilns.

Acting by enhancing charcoal kiln efficiency without demand side mitigation action would not reduce charcoal demand however will reduce primary requirement for charcoal making by 5.7millon tons of wood in 2030 and emission reduction of 0.17MtCO_2eq.

On the other hand, concerted efforts to ensure charcoal production efficiency and still encourage demand side resource conservation through charcoal conversion appliances and transition to cleaner fuels such as LPG and biogas would result to avoidance of 9.7million ton of wood required for charcoal production and emission abatement of 0.25 MtCO_2eq.

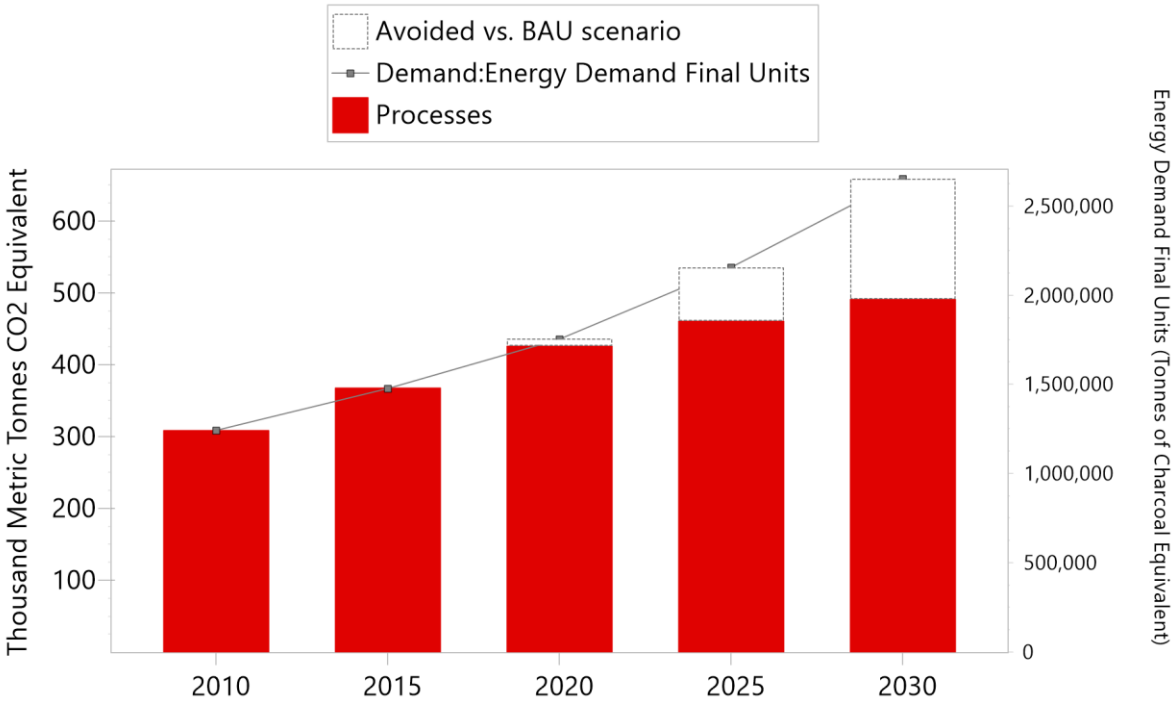


Figure 62: GHG emissions reduction due to implementation of efficient charcoal kilns

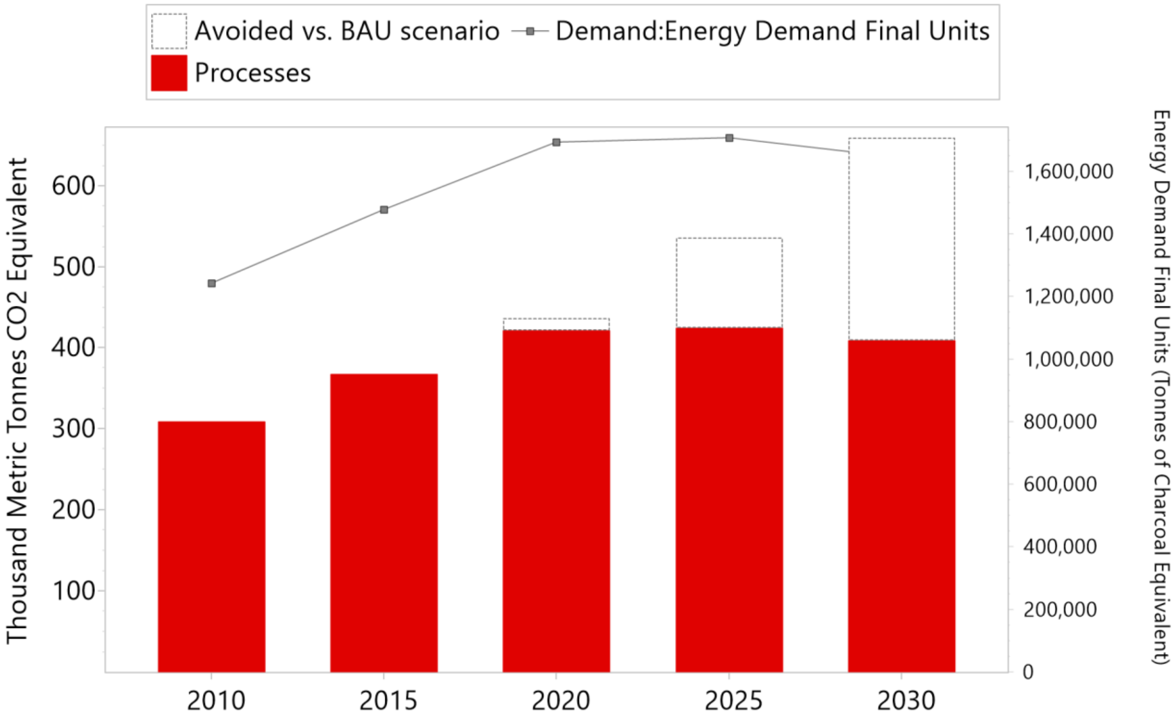


Figure 63: GHG reductions due to implementation of both efficient kilns and demand side energy resource conservation and transition to efficient stoves.

About 1 million ton of charcoal is avoided.

3.3.3.2 Transport sector energy demand emissions

a. BAU emission

AfDB (2015) report states that Petroleum products (essentially for transport, electricity generation, and minor quantities for cooking and lighting) account for about 10% of total energy use. Like in the industrial sector, a top-down approach was similarly used in the transport sector[55]. The report describes in detail the various modal transport and progress on infrastructural development of the transport sector. The report further depicts that passenger road transport constitute 3.2billion passage kilometers as freight constituted 1.2billion ton kilometer in 2016. The number of trucks accounts for about 52% of total vehicle population in Somalia while only about 42%. Because of inadequate statistics to support a bottom-up analysis such as vehicles fuel economy, millage vehicle-km annually we adopted a top-down approach in the analysis. UNStatistic provided high level data on total fuel imported for the transport sector. Gasoline and diesel are used in the transport sector and historic demand data was

[55] AfDB, "Somalia, Transport Sector Needs Assessment and Investment Programme" (AfDB, 2016), https://www.afdb.org/fileadmin/uploads/afdb/Documents/Publications/Somalia_Transport_Sector_Needs_Assessment_and_ Investment_Programme.pdf.

obtained from UNStat database. The transport sector future demand was projected based on national GDP growth pattern showing an almost double demand for diesel and gasoline in 2030 illustrated in figure 64 below. Gasoline demand in 2010 was 36,000 TOE and is projected to rise to 66,000TOE whereas diesel demand in 2010 was 23,000 TOE and was projected to increase to 49,000TOE.

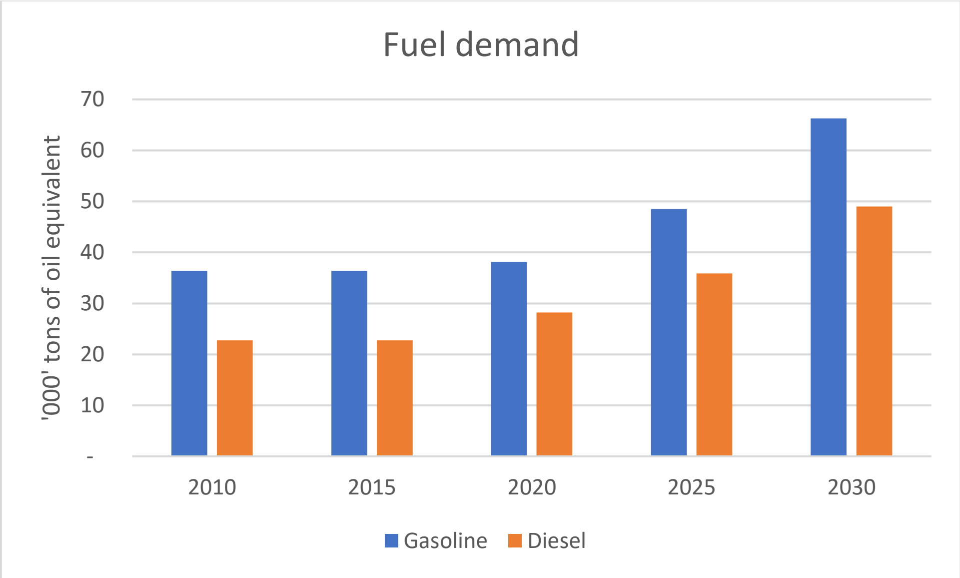


Figure 64: Diesel and gasoline demand in transport sector in BAU

B. Mitigation scenario

Transport sector mitigation strategies as described in the updated national determined contribution and the mitigation analysis and cost report described sort for mainstreaming climate change into existing transport management plan to strengthen emission control. Furthermore, strengthening institutional capacity for developing strategies for integrated transport services; developing technical and safety standards and the enforcement of policies including emission control and to develop emission reduction and tracking system of pollutants from vehicles and improve the quality and reliability of transport infrastructure and services

The priority action areas included improvement of road conditions reducing traffic snarl-up and blockages. The mitigation analysis paper estimated 6% fuel use reduction against that BAU. Second mitigation area is enhancing vehicle engine efficiency by enforcing policies and regulations for imported secondhand cars. An estimation of 10% engine efficient vehicles from the time of regulation was expected. And finally, introduction of bus rapid transit that would shift 10%-30% of commuters from public and private vans to BRT mass transport. In this case, we assumed a conservative 5% reduction in fuel consumption against the BAU.

Implementing these action points an estimated emission reduction of 0.072MtCO_2eq was projected in 2030.

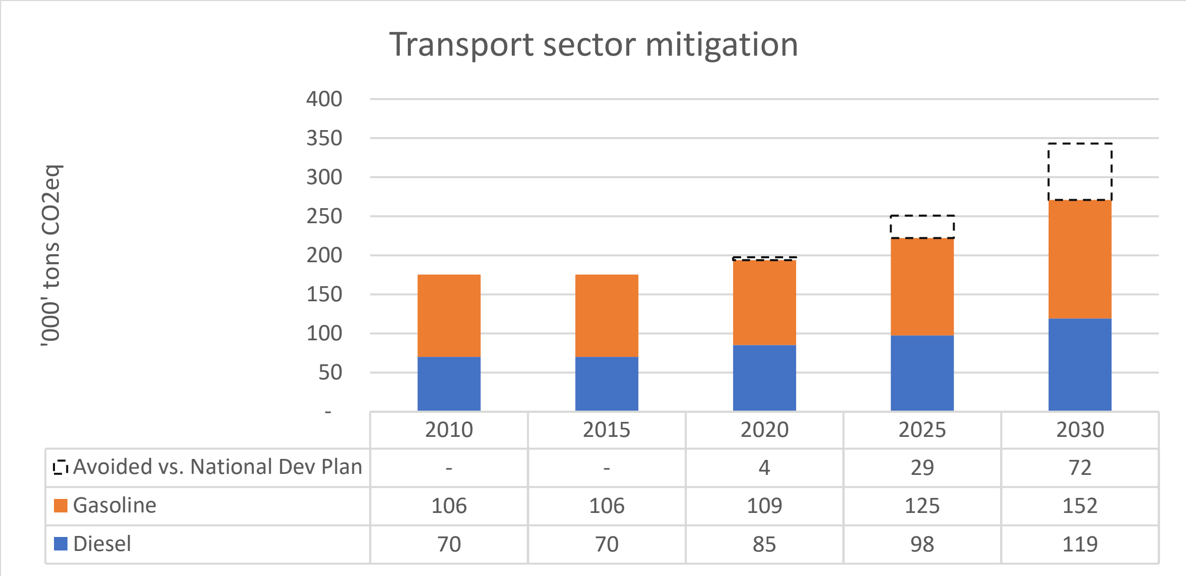


Figure 65: Transport sector mitigation

4.3.3.3. Agriculture, Forestry and Other land use

The AFOLU sector contributes to 92% of total GHG emission, agriculture contributing to 50% of GHG emission as forestry contributing to 42% of the GHG emission. In the agricultural sector, enteric fermentation constitutes the greatest share of 84% of total emission and mineralization of soil organic matter accounting for about 16% in 2020 and 88% for enteric fermentation and 12% for mineralization of soil organic compound in 2030. Fertilizer application and methane from rice cultivation, although exist are negligible compared to the two.

i. Agriculture

BAU scenario

Agricultural sector emission is mainly attributed to methane emission from enteric fermentation, mineralization of soil organic compounds, fertilizer application on farms and emission from rice cultivation.

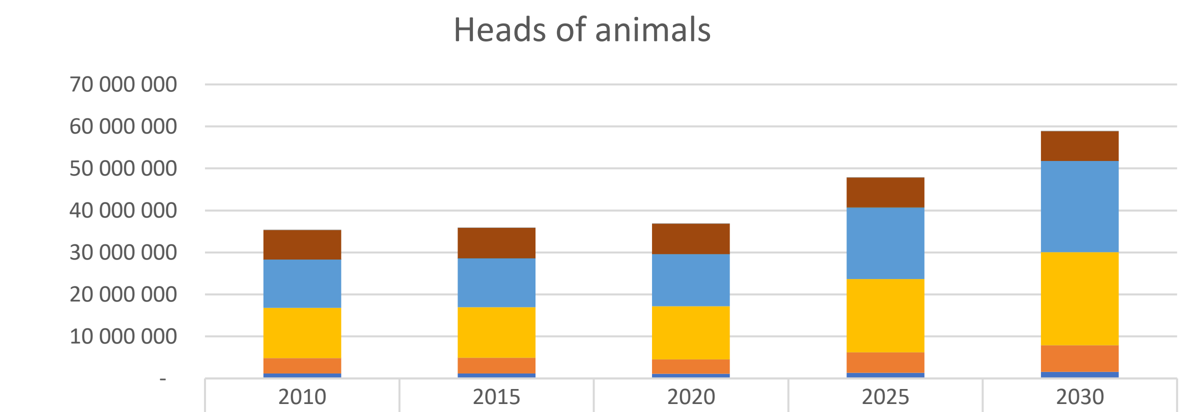
a. Methane emission from enteric fermentation and manure management

The drivers of agricultural emission are based on heads of animals in the country. Based on historic trend, there is gradual decline in most of the animal categories and marginal growth of some categories as illustrated in table 44 below. However, as the country gains stability, it is expected to regain growth in its and growth economic pillars including agriculture. Thus, in a conservative growth trend of 1.5% (about 50% of current rate of GDP growth) was used in the

BAU projection of recovery of livestock production. Figure 66 below shows how the herds of animals is expected to evolve in the future.

Table 44: Average growth rate by type

	Average historic growth trend (%)
Assess	0.6%
Carmel	0.4%
Cattle	-1.2%
Goats	0.0%
Horses	1.1%
Mules	0.2%
Pigs	0.9%
Sheep	-0.7%



	2010	2015	2020	2025	2030
Mules	22 000	22 015	22 187	22 094	22 000
Carmels	7 000 000	7 214 325	7 228 599	7 152 633	7 076 667
Asses	22 000	22 080	22 652	22 326	22 000
Horses	850	855	895	872	850
Goats	11 500 000	11 646 431	12 396 755	17 046 691	21 696 627
Sheeps	12 000 000	12 039 813	12 641 147	17 409 774	22 178 401
Pigs	4 000	3 727	4 124	5 450	6 776
Non Dairy cattles	3 623 551	3 692 755	3 458 027	4 880 899	6 303 772
Dairy cattles	1 176 449	1 196 615	1 104 428	1 331 762	1 559 096

Figure 66: Growth of animals by type in 2030

Baseline GHG emission in agricultural sector is illustrated in table 45 below. There is a tendency of higher emission from enteric fermentation and manure management in livestock production, fertilizer application and mineralization of soil organic carbon. A steady decline in methane emission from rice cultivation was observed in the BAU as the area under farming has been in the declining trend in the past two decades.

Table 45: Agricultural sector GHG emissions in '000' tons of Co2eq

	'000' tons CO_2eq				
Branch	2010	2015	2020	2025	2030
Livestock Enteric fermentation and manure management	18,063	18,482	18,138	19,540	21,050
Fertilizer application	0.05	0.04	0.04	0.05	0.05
Mineralization of soil organic matter	3,417	2,873	2,560	2,869	3,224
Methane from rice cultivation	7.6	6.5	4.9	3.6	2.6
Total	21,488	21,361	20,703	22,413	24,276

Mitigation scenarios

Based on the updated NDC and Mitigation analysis report, the following mitigation actions were assessed.

- Promotion of sustainable intensification pathways for the livestock sector including improved feeding, breeding and veterinary services as well as improved manure management with an intention of reducing livestock population against the baseline by 15%
- Planting of nitrogen fixing plants to reduce fertilizer usage protection and conservation of existing forests. The nitrogen fixing plant as well as use of organic fertilizers reduces application of synthetic fertilizer against the baseline. This would reduce the use of artificial fertilizer demand by 20% against the baseline while maintaining the productivity.
- Smart agriculture and intensification of crop production reduce the growth rate o agricultural fields by 50% hence annual growth of new farms increase at slower rate of about 1.5% annually
- Intermittent irrigation of rice adopting modern technologies allowing more aeration
- Rangeland restoration and rehabilitation
- Sustainable Land Management including climate

These actions yielded to total of 5.8milion tCO2eq abatement in 2030. Further to the above actions, we assumed that the households who will adopting biogas technologies are those with dairy cattle. Linking to the energy demand, 3% of total rural household (about 60,000households) will be adopting biogas technology enhancing manure management at the farm levels and reducing GHG emission.

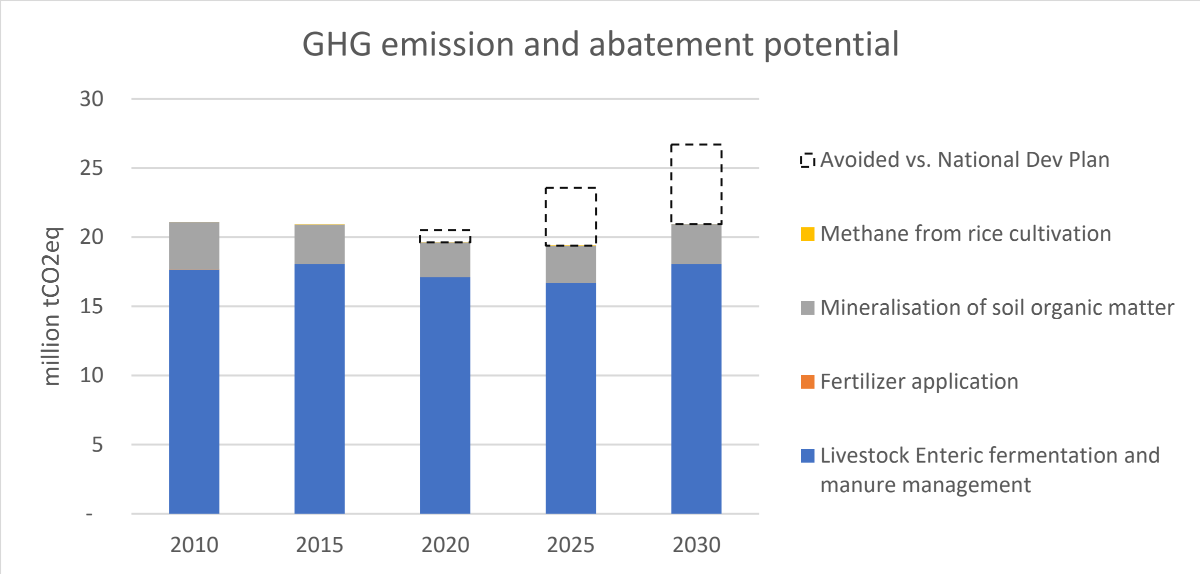


Figure 67:GHG emissions and abatement potential in agriculture

ii. Forestry and other land uses

Baseline

The greenhouse gas inventory classifies land type in six distinct categories as defined by the IPCC namely, Forestland, Grassland, Cropland, Wetland, Settlement and other land.

1. **Forest Land:** This category includes all land with woody vegetation consistent with thresholds used to define Forest Land in the national greenhouse gas inventory. It also includes systems with a vegetation structure that currently fall below, but in situ could potentially reach the threshold values used by a country to define the Forest Land category.

2. **Cropland:** This category includes cropped land, including rice fields, and agro-forestry systems where the vegetation structure falls below the thresholds used for the Forest Land category.

3. **Grassland:** This category includes rangelands and pasture lands that are not considered Cropland. It also includes systems with woody vegetation and other non-grass vegetation such as herbs and brushes that fall below the threshold values used in the Forest Land category. The category also includes all grassland from wild lands to recreational areas as well as agricultural and silvi-pastural systems, consistent with national definitions.

4. **Wetlands:** This category includes areas of peat extraction and land that is covered or saturated by water for all or part of the year (e.g., peatlands) and that does not fall into the Forest Land, Cropland, Grassland or Settlements categories. It includes reservoirs as a managed sub-division and natural rivers and lakes as unmanaged sub-divisions.

5. **Settlements:** This category includes all developed land, including transportation infrastructure and human settlements of any size, unless they are already included under other categories. This should be consistent with national definitions.

6. **Other Land**: This category includes bare soil, rock, ice, and all land areas that do not fall into any of the other five categories. It allows the total of identified land areas to match the national area, where data are available. If data are available, countries are encouraged to

classify unmanaged lands by the above land-use categories (e.g., into Unmanaged Forest Land, Unmanaged Grassland, and Unmanaged Wetlands). This will improve transparency and enhance the ability to track land-use conversions from specific types of unmanaged lands into the categories above.

The land area of by land types is as summarized in table 46 below. It is observed growth in agricultural land typically associated with population and growth of crop lands. The crop land was observed to increase at an average rate of 1% annually as forest land was seen to decrease at a rate of 1% annually. Even so the greatest contributor of forest land degradation is charcoal burning. Built environment is equally rising steadily with population and urbanization.

Table 46: Different land types and conversion

						1000 Ha
	1990	**1995**	**2000**	**2005**	**2010**	**2015**
Total Land area	62734	62734	62734	62734	62734	62734
Agricultural land	44042	44056	44067	44377	44128	44125
Land under perm. meadows and pastures	43000	43000	43000	43000	43000	43000
Cropland	1042	1056	1067	1377	1128	1125
Forest land	8283	7899	7515	7131	6748	6364
Other land	10410	10779	11152	11226	11859	12245
Artificial surfaces (including urban and associated areas)		26.4	31.9	32.6	34.2	36.4
Grassland		7405	7198	7130	7038	7062
Mangroves		1.3	1.4	1.4	1.4	1.4

Source: FAOstat

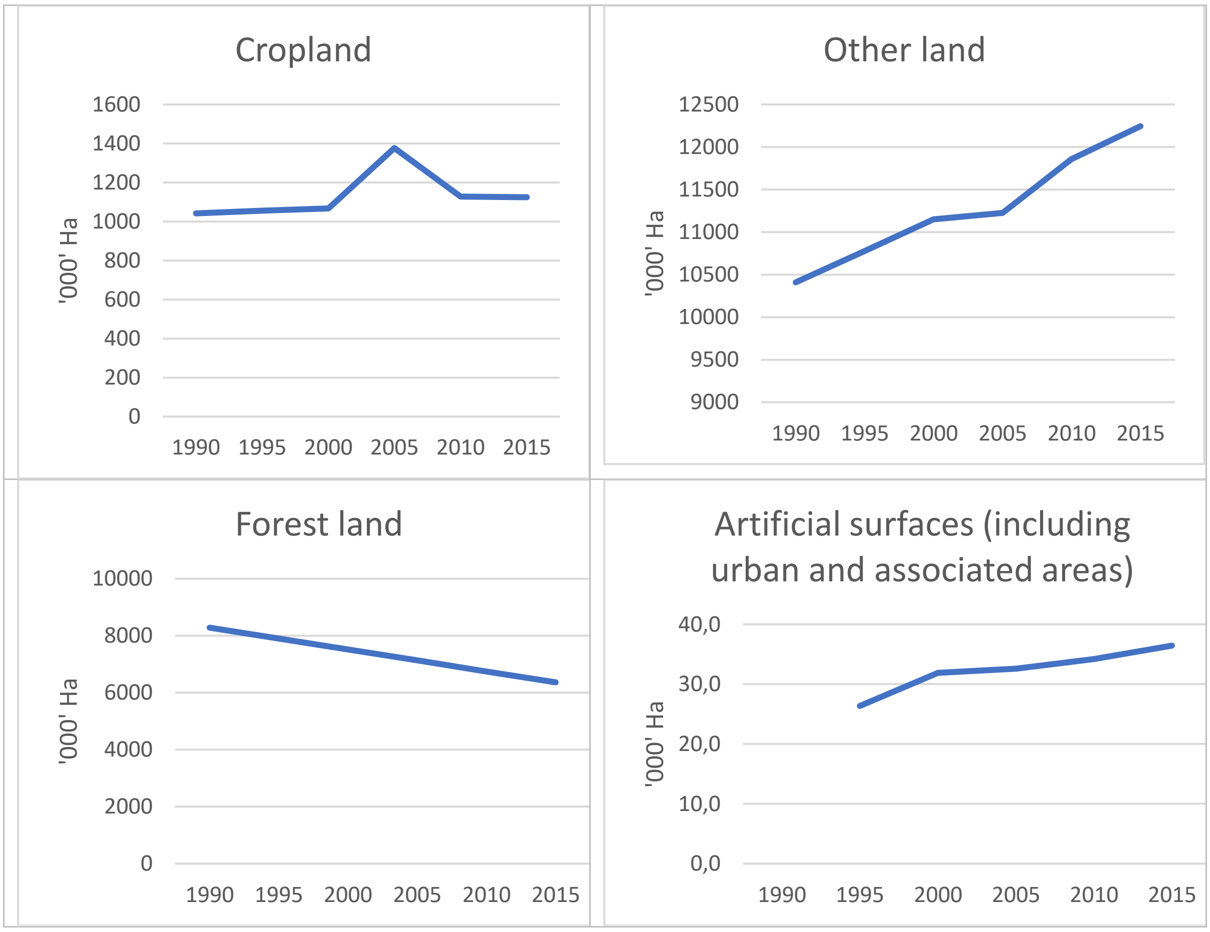


Figure 68: : Land conversion based on 4 main conversion types *Source: authors own plotted from FAOStat data*

In this respect, a forecast on change in forest cover in the business as usual with continued trends of deforestation is illustrated in figure 69 below. Somalia is typically a data scares country. The forest data provided is mostly calculated. Both FAO statistics depicts a loss of average 76750 hectares on an annual basis. Based on similar assumptions, and tier 1 GHG emission factor in accordance to 2006 IPCC guideline report. Annual amount of forest lost shall continue at the rate of about 76750 hectares annually. As such by 2030, the forest cover shall have net emission of 17350 tCO_2eq annually to 2030.

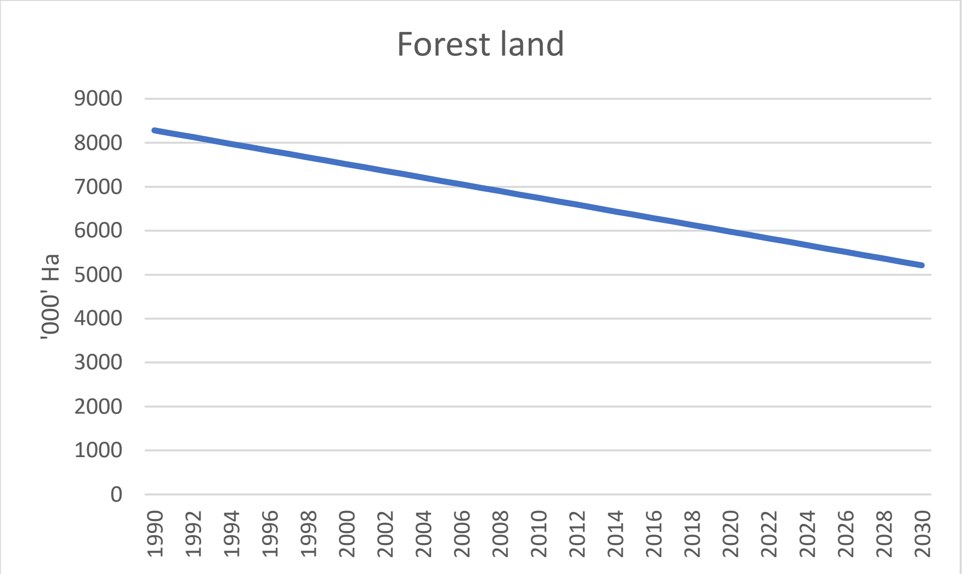


Figure 69: Forest forecast to 2030 *Source: Author forecast based on WRI and FAOstat*

It is thus observed that CO2 eq emission from the forestry sector and applying tier 1 of emission factor of 226 tCO2/ha of land from forestry sector.

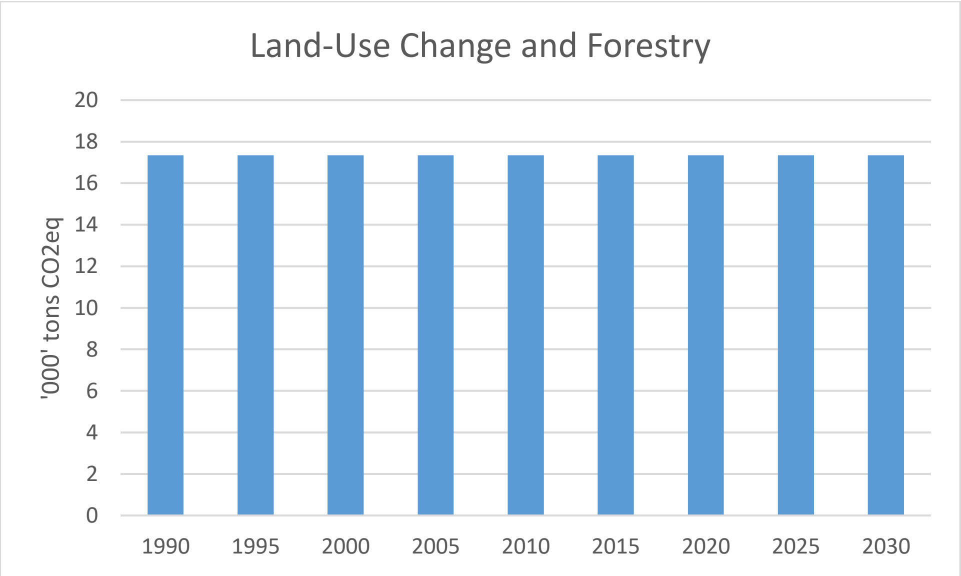


Figure 70: Emissions from LULUCF Sector

Mitigation scenario

Building from updated nationally determined contribution, Somalia aims to increase its forest cover by 5% that is equivalent to restoring over 1.17 million hectares by 2030. Preventing deforestation, undertaking massive reforestation and forest restoration measures have the potential to increase the overall contribution of Somalia's forest towards limiting global emissions from the sector, however small. The priority mitigation options are briefly described below:

- **Afforestation and Reforestation of Degraded Forests** - The afforestation and reafforestation programme will target forests including inter alia: dryland forest restoration activities; coastal forest restoration, awareness raising, consultation and demonstration; capacity building; development, testing and application of compensation and benefits-sharing mechanisms; measuring, monitoring and reporting; and research.
- **Reducing emissions from deforestation and forest degradation -** Reducing emissions through avoided deforestation would sequester considerable quantities of carbon in approximately 60,000 hectares of forest by 2030. While these forests would be protected, wood harvesting to meet energy demand would need to increase elsewhere and may accelerate deforestation in non-protected areas. This unintended consequence reduces overall greenhouse gas abatement potential, and it is estimated that only 25 percent of the total carbon sequestered in protected forests would be abated.
- Effective implementation of the identified key mitigation options in the sector will require the deployment of forestry technologies and enabling actions such as development of Forest legislation and finalization and implementation of the National Charcoal Policy.

Therefore, assuming an addition of 1.17million hectares of land through agroforestry as proposed in the NDC an estimated projection of mitigation emission is as shown in figure 71 below

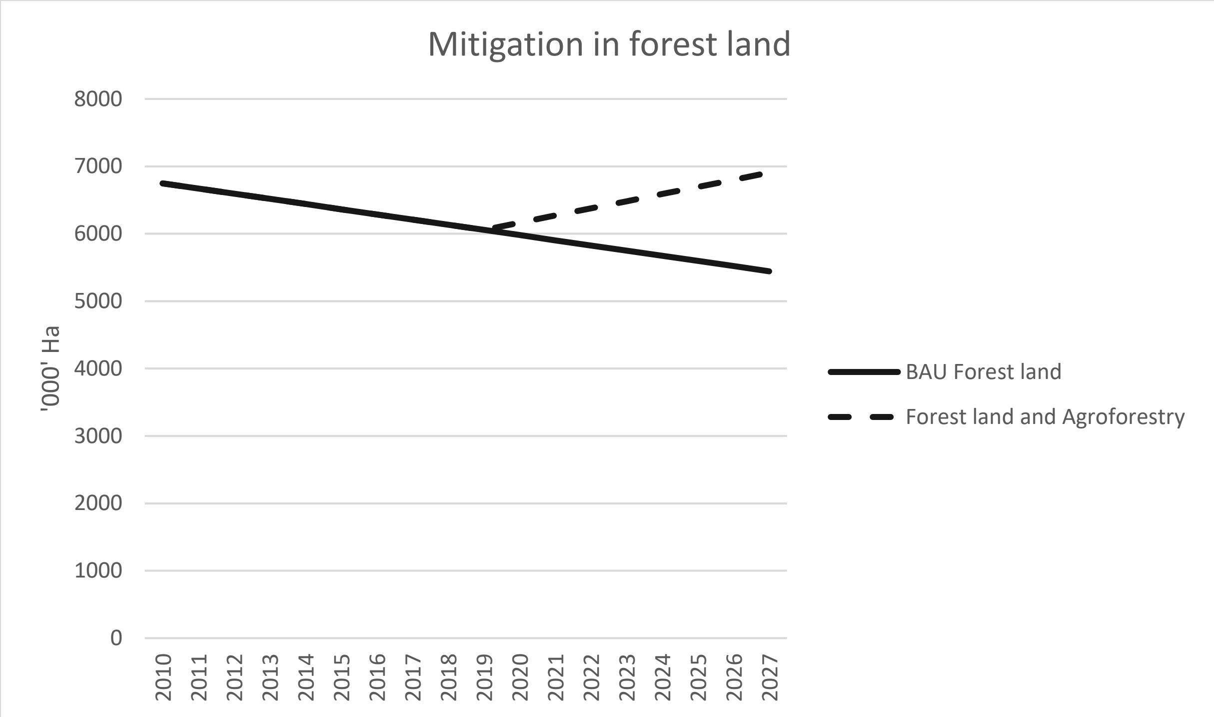


Figure 71: Change in forest cover imploring forest resource restoration *Source: Authors own*

Such an ambitious target would transform from loss of 76750 hectares annually to increasing forest cover by 106364 hectares annually. The achievement of which will result to net sink rather than GHG emission.

3.3.3.4. Solid and Liquid Waste emission

Baseline scenario

Waste sector emission estimation was based on methane emission from municipal solid waste. Urban population being the main source of municipal waste, the estimation was based on proportion of urban population whose waste are collected. In this case, we assumed that only about 25% of the urban population whose waste are collected. Not certain of whether they are disposed into managed dumping site, we assumed that they are not managed. Per-capita waste generation was equated to Kenya estimates of 208kg of waste annually and that 58% of this waste is biodegradable. As such the resultant emission from the waste sector is as illustrated in figure 72 below.

The projection shows that as urban population continues to grow in the BAU scenario, GHG emission from MSW will increase from 0.7million tons CO_2eq in 2010 to about 1.8million tons of CO_2eq in 2030.

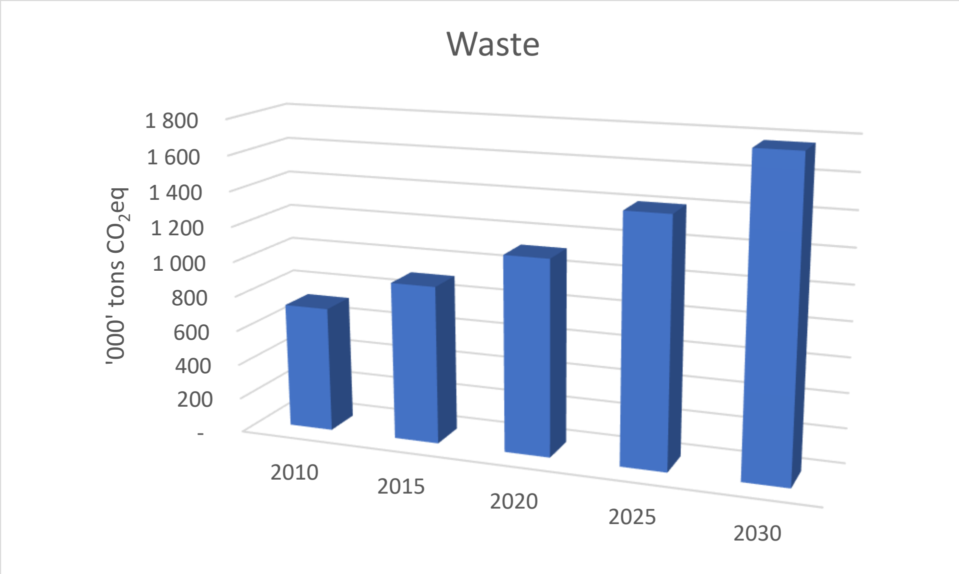


Figure 72: GHG emissions from waste sector

Mitigation scenarios

The waste subsector mitigation options included, reducing the waste generation and adoption of nationwide ecologically sound waste management system. Additionally, through the implementation of refuse, reduce, reuse, recycle (RRRR) waste management principal the country seeks to reduce the disposable waste by 40per cent in 2030 through introduction of robust waste segregation at source.

Control waste incineration and composting for organic manure as technological approaches to mitigate GHG emissions in the waste sector. Adoption of sanitary landfill with treatment facilities, gas collection and capture methane gas emitted from landfills and use it for fueling vehicles, cooking at home or generation of power.

For sustainability, further actions including strengthening of waste sector institutional capacity for proper management and development of waste management infrastructure in all major towns and cities and policies that that promotes private investment in waste management were proposed in the NDC.

In modelling we implemented single waste to energy derived from sanitary landfill. The assumption was based on conservative number of urban population whose waste are collected as 25% and that per capita waste generation is 201kg/year and 58% of the waste are degradable. The landfill shall gas shall be recovered for electricity generation. As such, utilizing all the degradable solid waste collected and disposed, a total capacity of 0.8MW waste to energy power plant would be installed to supply renewable electricity to grid. Effectively 1.6million tCO2equivalent would be abated from waste generation and disposal. The GHG emission resultant to landfill gas combustion is accounted for in the electricity generation under energy sector emission.

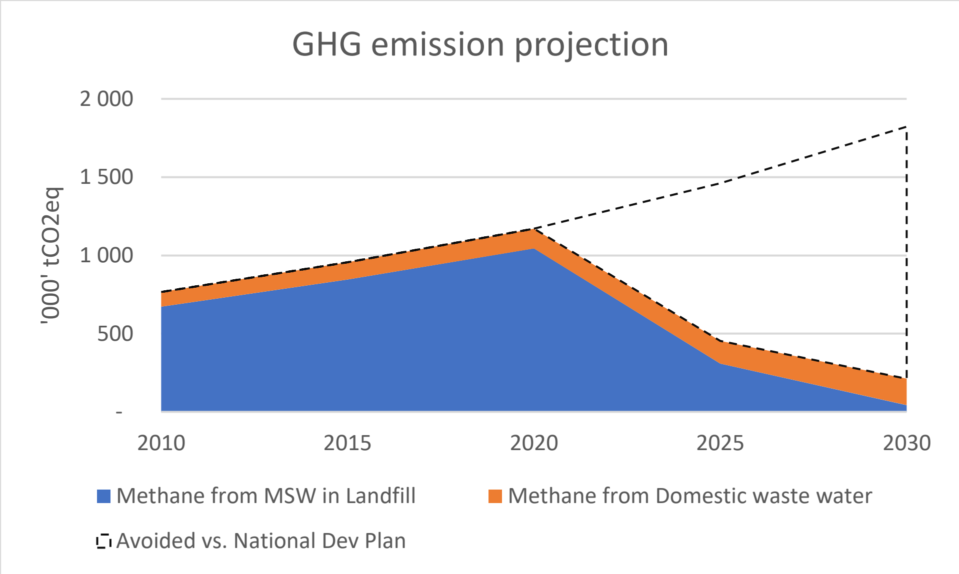


Figure 73: Emission abatement potential from waste recovery and sanitary landfills

3.5 International market mechanisms

So far there is no Clean Development Mechanism (CDM) project in Somalia. Nevertheless, there are various initiatives which have been taken in Somalia in attempts to comply with international requirement to reduce carbon footprint while pursuing the quest to sustainable development.

3.6 Impact of emission reduction and implementation plan

Below is a summary of NDC mitigation actions, emissions reduction potentials and their effects:

Table 47: Proposed mitigation actions & their effects

N°	Proposed mitigation measure	Short Description	Responsible (insitution)	Status (planned, in progress, ended)	Cost of implementation(USD)	Impact of mitigation measure ($MtCO_2$ eq in 2030)	Additional benefits
1.	Development of Renewable energy sources	This involves electric power supply expansion programme, over the ten-year period, would result in the installation of close to 200MW of power generation capacity of renewable energy for many unserved especially rural populations. This include: Solar Homes Systems/Solar minigrids and wind power. This will result in avoided emissions	Federal Ministry of Energy, FMSs Energy ministries, private power producers	Ongoing project by World Bank in Somaliland, Puntland. This involves additional 200MW of solar and Wind to be installed by 2030	900M	0.65	• Improved energy access and energy security • Enhancing learning opportunities • Enhanced commuication • Improved health • Enhanced business opportunities • Reduced costs of electricity • Promotion of gender equality and women empowerment
2.	Energy Efficiency in power transmission	Promotion of enhanced the efficiency of the current generation, transmission and distribution capacity by increasing the skill set of engineers, technicians and labors as well as invest in	Federal Ministry of Energy, FMSs Energy Ministries,	Onging training but need to support private actors and equip with right equipment		0.86	• Energy cost savings • More accessible energy • Most skilled personnel

		innovation, quality equipment and products. The NDC target aims to reduce transmission losses by 10% of the current proportion by 2030	private power producers				
3.	Clean and Energy efficient Cookstoves	Introduction of Energy Efficient Cook Stoves in households, schools, and amongst street food vendors who at present use inefficient cooking appliances would significantly improve the standard of living of the Somali people resulting in avoided deforestation	Federal/FMSs Ministries, CSOs,	30% penetration of energy efficient cookstokes (both household and commercial from 2021-2030	150M		• Health benefits with reduce indoor air pollution especially among women and children • Social benefits • Poverty reduction, by lowering households' expenditure for charcoal, fuelwood or kerosene • Reduced deforestation
4.	Distributed Renewable lamps/Potable solar lanterns	This involves upscaling of portable solar lanterns are already in use in offgrid areas and are best suited for nomadic pastoralists and small-scale traders in the market centres. The target is increasing adoption by atleast 50% of the technology in majority unconnected population	Federal/FMSs Ministries, CSOs,	Ongoing but distribution at scale required to reach 50% of population covered by 2030	100M	0.9MtCO_2eq	• Convenient for use for nomadic pastoralists, small scale traders • Enhanced security provided through provision of lighting in off grid areas • Displacement of kerosene lamps which are often expensive and dirty • Improve lighting output • Improved indoor health • Generate savings on the energy spending • Creates income and employment generating activities
5.	Energy efficient light bulbs	Distribution of energy efficient, quality, durable LED lamps to replace an incandescent bulbs for 16%	FGS/FMS energy ministry	Planned and to be implemented to 2030	90M		• Energy cost savings • Improved lighting

		connected especially in the urban areas.					
6.	Sustainable agriculture	Livestock breeding improvement, and organic farming	Federal & FMSs ministry in charge of agriculture	Reduced annual growth of new farms by 1.5% against the baseline	300M	6	• Increased food productivity and security • Reduced erosion
7.	Agroforestr y	Implementing agroforestry e.g for fruits across 400,000 ha from 2021 to 2030	Federal & FMSs ministry in charge of agriculture	Planned –small scale initiatives under consideration		3.8	• Increased the income earned and inputs saved through improvements in the farm resource base and products for sale. • Significant savings for households on fire wood, forage and fertilizer purchase. • improve medicinal plant conservation, domestication, and propagation; • enhancement of rural livelihoods leading to reduction of poverty • maintenance of soil fertility • trees planted on the farm saves on labor used mostly by women in collecting firewood for the household.
8.	Rangelands restoration and rehabilitatio n	Restore and rehabilitate the parts of the vast rangelands and promote grazing management in these areas and the focus under the NDC will be rehabilitation of approximately 472,227 ha of	Federal & FMSs ministry in charge of rangelands	rehabilitation of approximately 472,227 ha of land by 2030.	300 Million	1.8 MT of CO2eq in 2030.	• Reduces soil erosion • Improved agricultural yields

		land by 2030. This is consistent with National Land neutrality targets.					
9.	Sustainable Land Managemen t &Conservat ion	Implement SLM including conservation tillage across in Somalia's crop land. For conservation tillage focus on 5 percent of croplands from full tillage to conservation tillage	Federal & FMSs ministry in charge of agriculture	Planned - converting 115,000 hectares over ten years.		0.275	• Reduces soil erosion, conserves soil moisture, conserves energy, increases soil organic matter content, and consequently, soil quality • long-term viability of land resources thus enhancing food security • higher yields for farmers.
10.	Afforestatio n and Reforestatio n of Degraded Forests	Increase in forest cover and achieve 5% of forest/ tree cover by 2030 - 1.17 million hectares of forest are established in ten (10) years.	MoECC/F MSs Ministries incharge of environmen t	1.17 million hectares	3,850M	8.15	• increased incomes • rehabilitating Somalia's degraded lands and mitigate the effects of desertification
11.	Reducing deforestatio n through effective policy and enforcemen t	Establishing appropriate policy and institutional frameworks to reduce further deforestation in the country. This include : development of charcoal policy, FMSs level policy and institutions	MoECC/F MSs Ministries incharge of environmen t	60,000 hectares of forest		2.1MtCO_2e q	• Contribute to reversing forest loss and degradation • economic gains from the sale of forest products • combat desertification, and halt and reverse land degradation and halt biodiversity loss
12.	Improveme nt of road conditions	Investment in road infrastructure improvement targeting 30% of the 7,310km(2193km) - 500km	Federal Ministry responsible for transport	Planned	1,170M	0.072	• Reduced air pollution and road accidents • Easy access to markets all over the country thus creating a vibrant economy and overall GDP growth

		trunk road & 1693km feeder roads					
13.	Improving vehicle stock efficiency	Development of regulations on the importation of old second-hand vehicles beyond 12-15 years, vehicles engine efficiency improvement and incentivization for private sector investments in importing hybrid cars		Planned			• Enhance air quality and better environment • Improved health • Reduced vehicular related waste
14.	Development of properly engineered sanitary landfills	Establishing two official sanitary landfills to replace dumpsites in Mogadishu are Qashinweyne in Karan and Kaawo in Madina.	FMSs/Municipalities	Planned	50M	1.6	• eliminating dumping and minimizing release of hazardous chemicals and materials •

4. CHAPTER FOUR: MEASUREMENT, REPORTING, AND VERIFICATION (MRV)

4.1. Introduction

Somalia has been a Party to the UNFCCC since December 2009 and ratified the Kyoto Protocol in July 2010. By ratifying the Paris Agreement, United Nations Framework Convention on Climate Change (UNFCCC) and Kyoto Protocol, Somalia carries the burden of international reporting. At COP 13, through the Bali Action Plan, the Parties agreed on the principle of applying Measurement, Reporting, and Verification (MRV) for GHG mitigation actions and commitments, as well as support for GHG mitigation actions in developing countries

Under the Paris Agreement, it was agreed that all countries would provide emissions data and track progress against the achievement of their NDCs. The Somalia National Climate Change Policy 2020 called for the establishment of a Monitoring, Reporting and Verification (MRV) framework for monitoring GHG inventories towards compliance with NDCs requirements. This is in recognition that the effective MRV of emissions and emissions reductions is critical for understanding GHG sources and trends; informing the design of mitigation strategies and effective implementation thereof and; to enhance the credibility of Somalia's climate change policy and actions.

Somalia's MRV system is already backed by national policies and legislations. Somalia's constitution, Vision 2030 and the National Development Plan 2020 – 2024 recognize the need for promoting low carbon development pathways and climate change resilience including monitoring of progress on the same. The National Climate Change Policy (NCCP) provides strategic direction and coordinates climate change issues in Somalia primarily as pertains to adaptation and mitigation to climate change as well as social development. The policy also establishes an institutional framework through which effective MRV can be implemented. Other elements required for a robust MRV will need further prioritization more so institutional capacity that remains inadequate especially by state actors. The entry into force of the Paris Agreement ushered in new reporting requirements that will start by 2024. These further presses urgency on the need for building capacities for tracking progress including on support received and needed.

An MRV system traditionally focuses on MRV of emissions, mitigation actions and support received. MRV of GHG emissions that reports on estimated emissions over a defined period. A national GHG inventory that includes an account of emissions from the country for a particular period, is an example of this MRV. To this end, the country has developed its first inventory which was reported in the country's initial national communication submitted to UNFCCC in 2018.

The other kind of MRV is that of mitigation actions that involve assessing (ex-ante or ex-post) GHG emissions reductions and/or sustainable development (non-GHG) effects of policies, projects, and actions, as well as monitoring their implementation progress. It also involves assessing progress toward mitigation goals. Somalia has defined mitigation actions in its NDC. Priorities have been in the Agriculture, Forestry and Land Use (AFOLU) sector. The other priority sector is the energy sector where the country has outlined various actions including reducing fossil fuel emissions and promotion of solar and wind energy.

MRV of support emphasizes monitoring the provision and receipt of financial flows, technical knowledge, and capacity building, and evaluating the results and impact of support. In this case, Somalia could consider tracking climate-specific finance received through bilateral or multilateral channels.

According to the Government of the Federal Republic of Somalia (2021)[56] much of the country is vulnerable to climate change. These vulnerabilities stem from a combination of political, socioeconomic, and geographic conditions. With over 80% of the country being considered Arid and Semi-Arid Lands (ASALS) with livestock production and agriculture accounting for 70% of livelihood bases adaptation is a priority. The country's MRV system should thus include an element for monitoring progress on adaptation as well. The country has already developed a National Adaptation Programme of Actions[57] (NAPA) that has defined the adaptation actions the country will undertake. The NAPA prioritizes three areas namely: Sustainable Land Management (SLM), Water Resource Management (WRM) and Disaster Management. Efforts have been made where with support from the NDC partnership[58], the country has also developed an adaptation baseline that has a comprehensive list of measurable indicators.

4.2 MRV best practices in developed and developing countries

At COP 13, through the Bali Action Plan, Parties agreed on the principle of applying Measurement, Reporting, and Verification (MRV) for GHG mitigation actions and commitments, as well as support for GHG mitigation actions in developing countries. These MRV frameworks developed at the National level need oversight at the international level due to the differences in the needs, challenges, and practices applied by different countries around the world. Therefore, MRV frameworks developed at the National level should be guided by principles of the IPCC Good Practice Guidelines[59] for the purpose of maintaining National MRV systems integrity and adherence to the principle of Common but Differentiated Responsibilities and Respective Capabilities[60]. The Good Practice Guidelines include

[56] Government of the Federal Republic of Somalia (2021), Macro-Economic Impacts and Sustainable Development Benefits of Achieving Somalia's National Determined Contributions (Mitigation) Actions, Mogadishu. Ministry of Environment and Climate Change.

[57] Government of the Federal Republic of Somalia (2013). National Adaptation Programme of Actions on Climate Change, Ministry of Natural Resources.

[58] Government of the Federal Republic of Somalia (2020), Adaptation Baseline Report.

[59] UNFCCC. (2009). Cost of implementing methodologies and monitoring systems relating to estimates of emissions from deforestation and forest degradation, the assessment of carbon stocks and greenhouse gas emissions from changes in forest cover, and the enhancement of forest carbon stocks. Geneva, Switzerland: United Nations Office at Geneva

[60] Climate Action Network International. (2011). CAN-International submission on measurement, reporting and verification. Retrieved from http://unfccc.int/resource/docs/2011/smsn/ngo/258.pdf.

Consistency, Transparency, Accuracy, Comparability Completeness of the information provided.

For Somalia to develop an effective MRV System, it is important to consider best practices of MRV systems implemented regionally and Internationally. This would allow adoption of a well thought out simple and effective MRV system with opportunity to expand and improve continuously. A thorough review of MRV practices of sixteen (16) developing and developed countries were undertaken considering key aspects including:

- Identified as either developed or developing country (focus on Africa in the latter)
- National Communication to UNFCCC (more than once) with focus on existence of information on NAMAs
- Existence of two tier governance systems e.g. Federal and State, National and District/County
- All the developing countries chosen are from the African continent due to the relevance of other critical aspects including GDP from agriculture (including livestock and fisheries production), primary commodity export dependency, low level of industrialization among others.

The review of MRV best practices from different countries have the following key findings in relation to preparation of Somalia MRV system design:

- It is critical to build on already existing governance structures and reporting platforms at Federal and State level
- Existence of GHG inventory data is critical to the foundation of designing an MRV system, hence the need to ensure development of a GHG inventory with quality data
- The need for multi-stakeholder engagement in generation of data/information from Federal government, State governments and non-State actors involved in NAMAs, adaptation and MRV of support.
- Data quality control mechanisms is fundamental
- Data rights and ownership issues need to be managed so that it does not become a stumbling block to access to information and reporting processes
- Capacity building for relevant institutions and personnel at Federal level, State level and non-State actors in critical and continuous process
- Establishing an effective MRV system that meets the principles of the IPCC Good Practice Guidelines including Consistency, Transparency, Accuracy, Comparability Completeness of the information provided is a process not a one-time event.

4.3 MRV in Somalia

As a signatory to the UNFCCC, the Federal Republic of Somalia is undertaking its Initial BUR in accordance with UNFCCC guidelines as required by Article 12 of the Convention and Decision 2/ CP.1 Development of an MRV system forms a critical component of Somalia’s First Biennial Update Report.

5.3.1 Capacity for MRV Assessment –Somalia

Different types of capacity will be required for Somalia to have a sustainable MRV system. The entry point will be establishing the realities on the ground for monitoring emissions so that the MRV design is informed by the prevailing context., Given Somalia is undertaking its first BUR that involves MRV system designing, it requires a lot of strengthening of its systems regarding transparency and MRV processes which require financial resources from international development partners. Table 48 summarizes the capacities required and prioritization for the country.

Table 48:Somalia MRV capacity assessment

CAPACITY DESCRIPTION	KEY ELEMENTS AND REQUIREMENTS FOR THE COUNTRY
Human resources Somalia will require human resource to carry out the range of tasks and functions related to different types of MRV. These functions include: overall planning; coordination; management and technical oversight; conducting research, data collection and management; emission calculations; and quality assurance/quality control coordination.	● Capacity and skills of staff of the Ministry of environment and climate change, including managerial abilities and technical skills ● Recruitment and retention of skilled staff. Skills include modelling of emissions, M&E of adaptation, database management. ● Regular training of new and existing staff
Institutional capacity Performing MRV requires institutions that have the necessary mandate, and clear and efficient processes.	● Ability of institutions to perform their functions ● Effective institutional arrangements, processes and coordination mechanisms, leadership, and institutional mandates ● Capability to identify problems and develop and implement solutions ● For Somalia the tasked institution is the Ministry for Environment and Climate Change. Given the cross-cutting nature of climate change, there is need to strengthen key sector ministries on MRV as well as build linkage with the Ministry for National Statistics
Technical capacity Technical capacity translates to the availability of appropriate methodologies to obtain accurate data and adequate platforms for data collection and management.	● Availability and quality of data and information ● Retention of institutional memory, archiving, and documentation procedures ● Collection and dissemination of information ● Technical and technological infrastructure (e.g., data collection platforms and monitoring technology) ● Efforts to build technical capacities have been undertaken however there is need for continued deepening of this capacity. The Ministry of national statistics plays an important role in collection of national statistics as such there is a need to strengthen their role in collecting data related to climate change. ● Given their role in coordination of climate change the Ministry of climate change will need strong ICT infrastructure for archiving of data
Financial resources Financial capacity involves ensuring that sufficient resources are available	● Financial resources are needed to equip governments and other relevant entities for several MRV-related tasks, such as hiring qualified professionals dedicated exclusively to perform MRV, building capacity among stakeholders to support MRV implementation, putting in place effective institutional arrangements

to start and sustain the implementation of MRV.	and processes, and implementing new data collection systems and methods. ● Adequate financial resources to perform functions and achieve objectives ● Ability to manage these resource ● The national exchequer requires to provide an allocation of finance for MRV to the sectors and to the Ministry of environment and climate change to coordinate this effort. Given the competing financial resources for development work in the country, there is still need for support from development partners to support this work.

4.3.2 Proposed Institutional Arrangements for Somalia MRV

Institutional Arrangement provides the structure through which MRV coordination will be undertaken in the country. An effective institutional arrangement seeks to establish the political basis and technical knowledge through which climate-related risks are addressed and monitored. To address the impact of climate change, it is important to have a functioning institutional structure to coordinate and implement climate change initiatives across all sectors at the Federal and State levels. In alignment with the National Climate Change Policy, the MRV coordination will be led by the Ministry of Environment and Climate Change. Sectoral Ministries that will also play a critical role are the Ministry of Energy and Water Resources; Ministry of Humanitarian Affairs & Disaster Management; Ministry of Agriculture; Ministry of Fisheries and Marine Resources; Ministry of Livestock; Ministry of Natural Resources and Petroleum; Ministry of Public Works, Housing and Reconstruction (incl. roads authority) Ministry of Ports & Marine Transport; Ministry of Transport & Civil Aviation; Ministry of Post &Telecommunication; Ministry of Health and the Ministry of Education. The Ministry of Environment and Climate Change (MoECC) is the Designated National Authority for environmental management including climate change.

The Ministry is charged with the responsibility to ensure the sustainable use, management, and protection of the environment and its natural resources. Based on its mandate, the Ministry will foster participatory partnerships and will coordinate, along with other ministries and agencies, the full implementation of the policy. It will chair both the National Climate Change Committee and Cross-Sectorial Committee on Climate Change. The Ministry reports to the Cabinet, which in turn reports (annually) to the Parliament (House of the People). In relation to MRV, the Ministry is required to establish a Technical Monitoring & Evaluation Committee (TMEC) to follow up the implementation of the Policy; Establish a monitoring system for gathering information and reporting progress on the implementation of the policy interventions; Prepare periodic reports regarding the state of climate change in the country; Preparation and submission of reports to UNFCCC Secretariat.

A National Climate Change Committee (NCCC) has been established under the policy and it has the mandate for coordinating and supervising the implementation of the climate change policy. The NCCC is a multi-stakeholder, high-level policy coordination committee and is responsible for the overall climate change activities in Somalia. It comprises the Minister of Environment & Climate Change, Sectoral Ministries, Directors of Governmental Agencies, Member States' Ministers for Environment, the private sector, and civil society organizations. The primary roles of the NCCC are to supervise and provide overall coordination, at the policy level, to accelerate the implementation of the policy. Validate and secure government support for the implementation of the climate change policy. Report annually on progress made towards implementation of the climate change policy.

The Cross-Sectoral Committee on Climate Change (CSCC) brings together sectoral Ministries that are responsible for the sector-specific implementation of activities at the Federal level. The CSCCC encompasses all sectors (Sectoral Ministries listed above) which are said to have a stake in the policy implementation. It will bring together the officials from across government working on climate change; for information exchange, consultation, agreement, and support among the spheres of government regarding climate change and the government's response to climate change (Fig. 74).

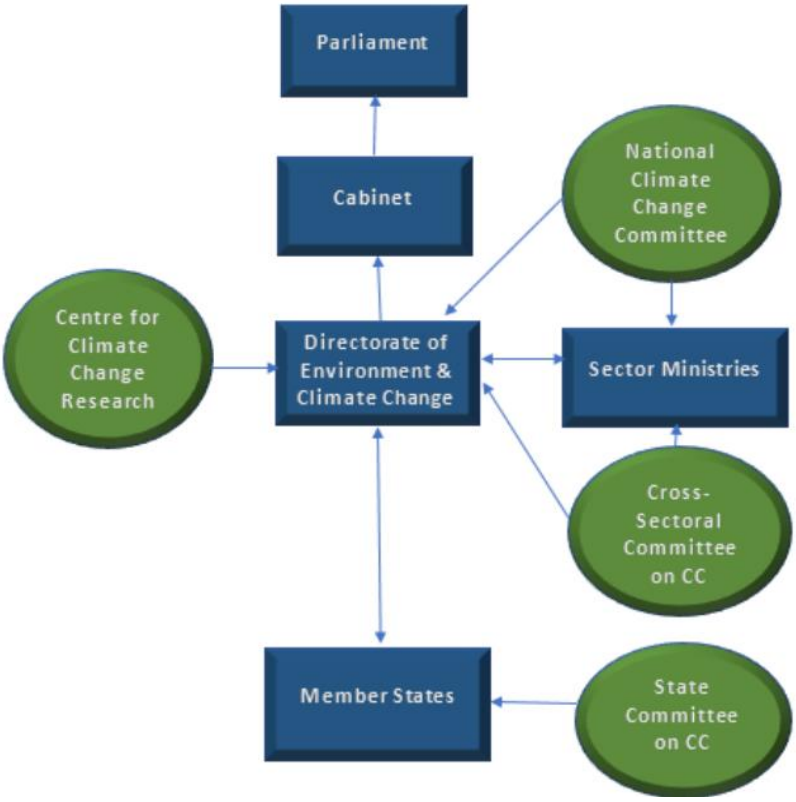


Figure 74: Institutional arrangements for climate change in Somalia

Source: National Climate change policy, 2020

4.4 Components of Proposed MRV for Somalia

4.4.1 Somalia GHG and National Communication

Somalia INC content included National circumstance, National GHG inventory, vulnerability assessment, adaptation, mitigation actions, support, and constraints to climate change actions implementation. The United Nations Development Programme (UNDP, Somalia), United Nations Environment Programme (UN Environment), and Global Environment Facility (GEF) provide support in developing Somalia's Initial National Communication.

GHG emissions by source and removals by sinks the period 1990-2015 was estimated using the Revised 2006 IPCC Guidelines. The GHG emissions/removal focused on seven gases including Carbon Dioxide (CO_2), Methane (CH_4), Nitrous Oxide (N_2O), Nitrogen Oxides (NO_X), Carbon Monoxide (CO), Non-Methane Volatile Organic Compounds (NMVOC), and Sulphur Dioxide (SO_2). As of 2015, Somalia contributed 62.92 Mt CO_2e to the global Greenhouse Gas emissions, an equivalent of less than 0.12 percent of total global GHG emissions. This is due to Somalia being an LDC with a significantly low level of industrialization. The Agriculture, Forestry and Other Land Use (AFOLU) sectors accounted for 92% of the GHG emission for Somalia while the rest contributed by the energy and Waste sectors.

4.4.2 MRV of Mitigation Actions

Mitigation actions refer to interventions and commitments, including goals, policies, and projects, undertaken by a government or another entity to reduce GHG emissions. These include national climate plans, nationally determined contributions (NDCs), policies setting emissions standards for vehicles, regional emissions trading systems, sustainable palm oil production policy, and rehabilitation projects to improve degraded land[61]. The estimation, reporting, and verification of the GHG and sustainable development effects and monitoring of their implementation constitute MRV of mitigation actions.

Since the submission of the Initial National Communication, Somalia has developed a number of climate change-related policies including the National climate change policy, The Ninth National Development Plan, The Power Master Plan for Somalia, Draft National Environmental Management Bill, National Voluntary Land Degradation Neutrality Targets 2020, The UN Strategic Framework Somalia among others.

Somalia submitted its Intended Nationally Determined Contributions (INDC) in 2015. Recently, it has submitted its updated Nationally Determined Contribution (NDC) to the UNFCCC signaling a commitment to a low emission sustainable development pathway. Current GHG emissions are relatively low, estimated at 53.70 $MtCO_2eq$, representing less than 0.03 percent of total global emissions. The Agriculture, Forestry, and Land-use sectors account for the majority of the emissions[62]. Overall, Somalia aims to achieve 30% emissions reductions

[61] Singh, N., Finnegan, J., Levin, K., Rich, D., Sotos, M., Tirpak, D., & Wood, D. (2016). MRV 101: Understanding measurement, reporting, and verification of climate change mitigation. World Resources Institute, 4-5.

[62] Government of Somalia (2021). Updated Nationally Determined Contribution (NDC) to the United Nations Framework Convention on Climate Change. Mogadishu, Somalia. Retrieved from

against the Business As Usual (BAU) scenario estimate of 107.39 MtCO2eq by 2030. These mitigation targets would be achieved from the implementation of the following priority mitigation actions in the Agriculture, Energy, Forestry, Transport, and Waste sectors. The Industry sector has not been considered a priority although an emerging construction boom from the building industry has been recognized.

4.4.3 SDG Benefits of NDC Mitigation Actions

As part of the NDC update, the sustainable development and Macroeconomic benefits of implementing the priority mitigation actions have been identified, for example, the agroforestry action identified as a priority mitigation action in the agriculture sector allows integration of tree planting, crop production, and livestock rearing. Economic risks are reduced when systems produce multiple products that contribute to enhancing household food security and attainment of SDG 1 (No poverty) and SDG 2 (Zero Hunger). Over-dependence on forests as a source of fuelwood, timber, and charcoal is reduced with the practice of on-farm tree growing (agroforestry) leading to increased forest cover and carbon sink SDG 13 (Climate change). Also, importantly, the implementation of the aforementioned priority action (agroforestry) reduces the time women and young girls spend collecting fuelwood as the household utilizes the on-farm trees for cooking. This allows women and young girls time to contribute to the household economy, get an education and spend time with their families. This in turn reduces the gender disparity gap in Somalia and thus contributes to efforts towards SDG 5 (Gender Equality).

4.4.4 Monitoring and evaluation of Adaptation

The objective of M&E is to ensure the measurability of progress across sectors, geographic scales, time and to be able to determine whether, as a result of its successive plans, a certain country or institution is less susceptible to climate change impact.

Somalia developed its National Adaptation Programme of Action on Climate Change (NAPA) in 2013 aimed at addressing climate risks especially droughts and floods on different vulnerable sectors including Water Resources; Agriculture and Food Security; Animal Husbandry, Grazing, and Rangelands; Health; Marine and Coastal Resources and Biodiversity. NAPA 2013 had a limited context of the M&E component that focused on project-level planning and monitoring. Somalia’s NDP9 identified a number of indicators by pillars with the recognition that some of these indicators did not have any baseline or were monitored by partner organizations or different government MDAs.

The Adaptation Baseline Report for Somalia prepared with support from Global Water Partnership (GWP) under the NDC Partnership’s Climate Action Enhancement Package (CAEP) provided an in-depth assessment and baseline information of specific priority sectors of agriculture (including livestock and fisheries), energy, forestry, water and public health and the related gender issues in the country. The Baseline Reported addressed the lack of baseline data in the aforementioned critical sectors and most importantly geared towards contributing

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https://www4.unfccc.int/sites/ndcstaging/PublishedDocuments/Somalia%20First/Final%20Updated%20NDC%20for%20Somalia%202021.pdf to the Somalia NDC update process. Several indicators were mentioned for climate change, agriculture, livestock, fisheries, energy, water, public health, and forestry. A prototype online tool has been developed as part of the Establishing Adaptation supported through GWP aimed at aggregating all the data in quantitative and qualitative format. However, the lack of an M&E framework with clear cut indicators across the board recognized and utilized by the Federal Government, States, development partners, and CSOs makes monitoring and evaluation of adaptation actions a challenge.[63]

The National Adaptation Plan (NAP) Framework for Somalia recognized the lack of National M&E evaluation systems for adaptation as most of monitoring and evaluation is project-specific. The Draft NAP Framework recommends the Establishment of an online national adaptation monitoring and evaluation system, Selection of suitable indicators, Establishment of effective climate adaptation coordination structures in which the M&E system can be embedded and a legal framework for M&E that require federal institutions, federal member states, and non-state actors to annually report on their adaptation activities.

Adaptation M&E systems for adaptation projects, policies and programmes should consider:

- Making use of existing monitoring and evaluation systems as much as possible.
- Engagement with wide range of stakeholders at all levels and across all relevant sectors (e.g. to identify and agree on certain criteria for indicators)
- Agreement on mechanisms, institutions and criteria, including roles and responsibilities, for M&E.

4.4.5 MRV of Support

Somalia has received financial resources, technical and capacity building in climate change-related actions implemented at both Federal and State levels. Through the Ministry of Environment and Climate Change, Ministry of Planning Investment and Economic Development, other MDAs, and Non-Governmental Organizations, a number of International and Regional partners (Bilateral and Multilateral) are involved in climate change-related projects, programmes, policy, and plans support among others. In 2019, Somalia developed the Aid Information Management System (AIMS), a one-stop-shop for information related to foreign assistance in Somalia. The Ministry of Planning Investment and Economic Development recognizes the tracking aid flow as crucial as ‘’It facilitates greater transparency and accountability between the government and the international community as well as with the citizens of Somalia. Analysis of aid flow data is an integral component of national planning and budgeting, aid and debt management, and monitoring and evaluation (M&E)[64]

[63] Government of Somalia (2021) Climate Change Adaptation Baseline Report.Mogadishu, Somalia.

[64] https://mop.gov.so/index.php/home/aims/

An integrated MRV system for Somalia will thus bring together these components and be designed on the principles of ease of use, flexibility, accommodating to national circumstances and participatory such that multiple stakeholders would be engaged in the design (Fig.75)

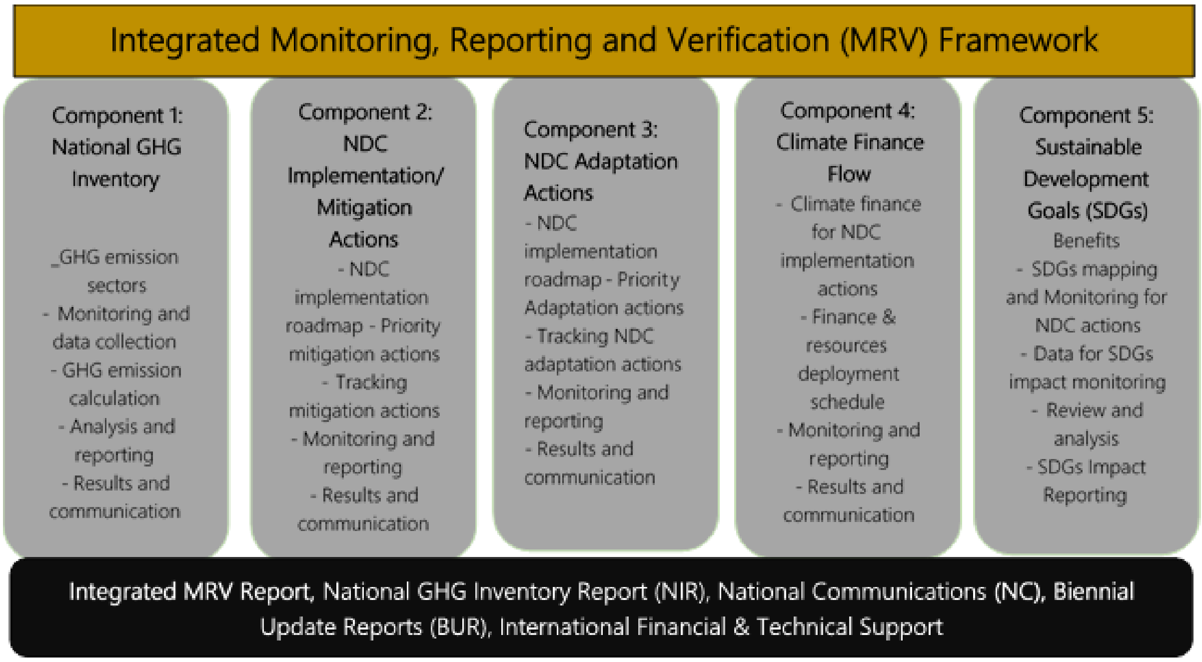

Figure 75: Components of proposed MRV For Somalia

4.5 Proposed Arrangement for MRV Governance

The Country should consider an online system that eases the flow of data submission and archiving. Activity data on GHG emissions, mitigation actions, adaptation actions, climate finance, and SDG benefits will be submitted and stored in a central repository that is managed by the MoECC who shall have overall responsibility for MRV Tool and MRV Reports. The MoECC will have a dedicated MRV unit that is led by the MRV Coordinator who shall review the MRV System and MRV reports periodically (quarterly, half-yearly) or at least once a year; shall also be responsible for backstopping and capacity building. Given the system is an online system, an MRV Administrator will be assigned the role of Master User with all privileges and rights; shall also approve, edit and delete user registration and access, approve/edit emission factors, database, etc. On recommendation. Other officers that will comprise the MRV unit include Nodal Officers that shall have the right to validate and verify the entered activity data. The sector working groups will be composed of members from the government-private sector, civil society organizations, and academia that will provide the data and provide details on ongoing climate change projects that will be monitored.

The integrated MRV tool considered utilizing both the Top-down and Bottom-up approaches (Fig.76) for monitoring and verification of the data. It was envisaged that the combined approach is considered appropriate for Somalia keeping in mind the financial, institutional, and manpower resources availability.

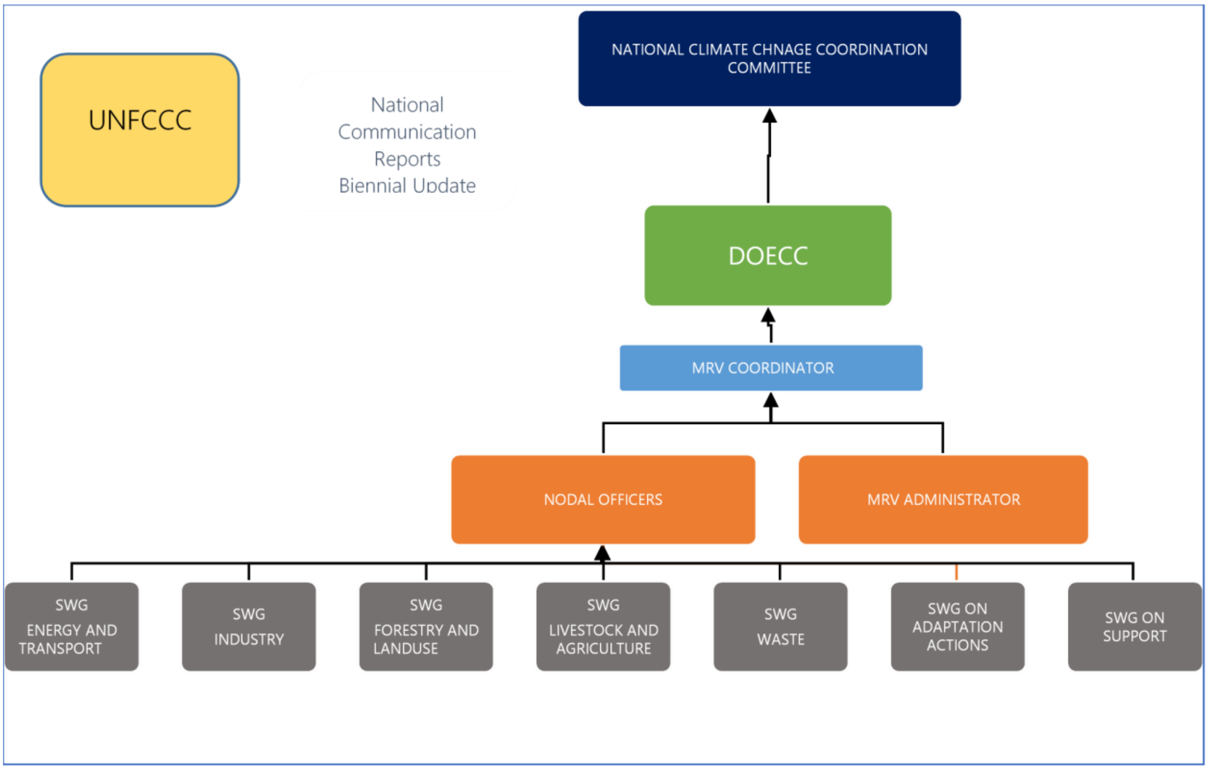

Figure 76: Proposed administrative structure of Proposed Somalia's MRV System

4.6 Somalia MRV System - Challenges, Gaps, Barriers and Opportunities

In the review of the country's preparedness to implement an MRV system, the following are some key constraints and gaps:

GHG inventories: The initial national communication highlighted several gaps, needs, and constraints identified during the preparation of the national GHG inventory. Gaps include not only the activity data but also with regards to the resources and capacity constraints. There is a strong need for institutional capacity building and training of government staff to carry out the necessary data collection and analysis required to reduce inventory uncertainties and improve the quality of activity data and emission factors used to generate the inventory.

Data: There are gaps in terms of both the quality and quantity of data required for mitigation assessment. To analyze the sectoral and sub-sectoral mitigation options data must be disaggregated as much as possible.

Data collection, Archiving, and Storage: There is a need for simple data templates that standardize the activity data collected over time including units of measurements. Data management will be done via online systems hence improving capacity for the archiving of the data easing the burden on future inventory compilers and making the process more seamless.

Climate Finance: The National Climate Policy sets out the need and structure for climate finance monitoring and tracking; however, the indicators and reporting framework have not been available and implemented for climate action. There is a need to develop a climate action-specific finance monitoring and reporting system.

Capacity Building: Somalia has made numerous capacity-building efforts. There are a number of civil societies, academic and research institutions, the private sector, and individuals involved at various stages of MRV training and capacity building. However, there is a gap in assessing the specific MRV requirements and the current practice. There is a need to develop an integrated and inclusive capacity-building program across the diverse stakeholders involved in the implementation and monitoring of climate actions in Somalia.

Quality assurance and Quality Control: To ensure the data provided for MRV is accurate the country will require templates on QA/QC procedures. These procedures will guide on what to look out for and may include the following:

Checks on assumptions and criteria for the selection of activity data provided

Checks for transcription errors in data input and reference.

Checks that emissions/removals are calculated correctly (for GHG and mitigation)

Check that parameter and emission/removal units are correctly recorded and that appropriate conversion factors are used.

Check the integrity of database files.

Check for consistency in data between categories.

Review of internal documentation and archiving.

Indicators: Need to review and strengthen the indicators that will be used for MRV to ensure they are comprehensive and adequate. The indicators should also be gender-responsive taking into account climate change impacts on all gender groups.

Institutional Arrangement: The Ministry will require a dedicated MRV unit that is led by an MRV coordinator and supported by ICT personnel. The proposed elements in the climate change policy will need to be operationalized in order to make MRV in the country functional.

4.7 MRV Conclusion and Recommendation

The principle of applying Measurement, Reporting, and Verification (MRV) for GHG mitigation actions and commitments, as well as support for GHG mitigation actions in developing countries, was agreed at COP 13, through the Bali Action Plan as well as under the Paris Agreement. This is implemented within the framework of the Biennial Update Report (BUR) which Somalia is currently undertaking. As recommended, Somalia aims to establish an MRV System design informed by existing systems

As a Least Developed Country, Somalia lacks a National Monitoring and Evaluation system for climate change change-related activities. There is a lack of quality data such as GHG emission from different sectors, absence of vertical and horizontal coordination among climate change actors, undefined adaptation indicators, capacity, financial and technological challenges thus undermining the setting up of an effective MRV system.

Therefore, there is a need to establish an elaborate M&E framework in which the MRV for Somalia can be embedded, there is a need for enhanced capacity building for the staff at the Ministry of Environment and Climate Change (DECC), mitigation sector stakeholders as well as adaptation.

There is a need for enhanced coordination among the various stakeholders involved in climate change-related activities including Federal and State Governments, Development Partners, private sector, Non-Governmental Organizations (NGOs), Research Institutions among others. There is a need for financial support for the fragile institutions involved in climate change-related policy development, projects, and programmes.

There is a need for improvement on overall climate change governance mechanisms so that the next Biennial Update Report (BUR 2) can be used as an opportunity to design and implement an MRV system for Somalia building on the current MRV development under First Biennial Update Report (BUR 1) for Somalia.

5. CHAPTER FIVE: FINANCIAL AND CAPACITY NEEDS AND SUPPORTS RECEIVED

5.1 Introduction

According to decision 2/CP.17, non-Annex I Parties are to provide updated information on constraints and gaps, and related financial, technical and capacity-building needs, as well as updated information on financial resources, technology transfer, capacity-building and technical support received. Parties included in Annex II to the Convention and other developed country Parties, the Green Climate Fund and multilateral institutions for activities relating to climate change, including for the preparation of the current BUR. Accordingly, this section presents information on the financial, technological and capacity building needs, constraints and financing received.

5.2 Support received

Somalia has received support from various bilateral partners and multilateral organizations to implement its climate change action agenda particular in adaptation and addressing humanitarian issues related to climate change. The table below summarizes key support received and the respective objectives of the projects, including for preparation of BUR:

Table 49: Summary of Support received

	Source of Support	Project title	Period	Amount (USD)
1.	Global Environment Facility -through UNEP and UNDP	Preparation of the Somalia First National Communication to UNFCCC	2016-2018	500,000
2.	Global Environment Facility -through UNEP and UNDP	Preparation of First BUR for Somalia	2018-2022	385,000
3.	Global Environment Facility through UNEP	Preparation of Somalia's Technology Needs Assessment Report	2020-2023	120,000
4.	GEF through UNDP	Environmental Governance - Cross Cutting Capacity Development		1,700,000
5.	GEF through UNDP	Integrated Water Resources Management for Building Climate Resilience of Agro-pastoral Communities		10,000,000
6.	GEF	Rural Livelihoods Adaptation to Climate Change (RLACC II)		10,000,000
7.	Sweden, EU, Italy - AICS, UNDP	Joint Programme for Sustainable Charcoal Reduction and Alternative Livelihoods (PROSCAL)		5,000,000
8.	Green Climate Fund through UNDP	NAP readiness Support	2021-2024	2,700,000
9.	EU	Community Resilience in Somaliland and Puntland (CRISP)		1,522,399
10.	USAID and FAO	Improving and sustaining food security in rural Somalia		16,863,000
11.	EU	Resilient, Inclusive and Competitive Agriculture Value Chain Development in Southern and Central Regions of Somalia (OUTREACH)		5,580,000
12.	World Bank	Somalia Crisis Recovery Project (SCRP)		45,000,000

13.	World Bank	Biyoole Project - Water for Agro-pastoral Productivity and Resilience		42,000,000
14.	Sweden	SOMALIA RESILIENCE PROGRAM		8,600,000
15.	Germany	Improving disaster risk management and food security to strengthen resilience in Somaliland		11,000,000
16.	Germany	Sustainable Land Management in Somaliland, Somalia		8,000,000
17.	Africa Development Bank	Say no to Famine: Short Term Regional Emergency Response Project (STRERP)		27,500,000
18.	Africa Development Bank	Water Infrastructure Development for Resilience In Somaliland (WIDER)		6,000,000

5.3 Constraints, Gaps, Capacity building and technology transfer

The country is faced with myriad of constraints and gaps in effectively addressing climate change. These include:

i) Incomplete and weak policy and regulatory frameworks
j) Inadequate financial resources especially for core institutions and for projects implementation
k) Weak institutional arrangements including deficiency of mandates and lack of effective coordination on climate change
l) Human capacity gaps and Lack of technical capacity on climate change including to mobilise resources for climate action eg in developing proposals
m) Low levels of knowledge on climate change mitigation opportunities among key stakeholders including private sector in the country
n) The high cost of technology as a barrier to the development, deploymnet, adoption and subsequent transfer of key technologies is a reality in Somalia
o) There is limited infrastructure including institutions and personnel to support technology development and innovation
p) Lack of monitoring and reporting systems for climate action
q) Insecurity in some areas of the country

5.4 Resource needs

Somalia's updated NDC submitted to UNFCCC in July 2021 highlights the country's planned mitigation and adaptation actions and related costs. The estimated cost of implementing Somalia's NDC is approximately USD 55.5 billion for the period 2021- 2030 with significant portion of Somalia's NDC priorities being adaptation and resilience building. The implementation of adaptation actions across eight broad priority sectors will require USD 48.5Billion for the NDC period while mitigation actions will require support to the tune of approximately USD 7Billion. The details of costs of mitigation actions is also elaborated in table 42. As an LDC country with unique national circumstances, the Government of Somalia does not have the fiscal capacity to mobilize financial resources for the implementation of the NDC actions. Therefore, the successful implementation of NDC actions thus requires provisions of adequate and predictable financial resources, transfer of environmentally sound technologies, and capacity-building support.

5.5 Recommendations:

The following actions are recommended to enhance Somalia's capacity to effectively implement its NDC and contribute to global mitigation efforts:

a) There is a need for enhanced capacity building of various institutions and strengthening policy and legislative frameworks to support Somalia and enhance its adaptive capacities to climate change.
b) Establishment of specific department or Institute that is responsible for Air Quality and Emission Control; calculating emissions and emission factors, conduct research and monitor national GHG emissions;
c) The country requires support to enhance capacities to access multilateral and bilateral climate finance sources, address barriers and enhance private sector investments and establish effective institutional mechanisms to enhance mobilization and effective utilization of climate finance.
d) The country requires support to establish a national MRV system and strengthen its institutional set-up with adequate infrastructure and human resources to track climate actions.
e) Trained personnel for emission data collection, data input, processing, analysis, reporting and monitoring system;
f) Capacity-build for Statistical agencies at federal and regional level in data collection and statistics that are essential for compiling GHG emissions inventories;
g) Investment for building national GHG inventory database; in terms of hardware, software and the operating system for data collection, measurement and management.
h) Setting up a monitoring system and impose authorization permit to emission contributing private firms for the creation of own emission databases;
i) Increase public awareness regarding climate change and potential climate change impacts
j) Establish Federal Climate Change Fund to raise innovative sources of national climate finance and enhance coordination
k) Promote public-private partnerships (PPPs) and facilitated so that the private sector can contribute to the financing the proposed Climate Mitigation actions
l) Address barriers to climate technology innovation, deployment and uptake in the country, including financial and capacity building gaps at all levels and for all stakeholders
m) Promote climate research and development including on implementing the NDC's gaps, indicators and opportunities, and with clear recommendations for policy actions

6. CHAPTER SIX: OTHER RELEVANT INFORMATION

6. 1 BUR preparation process

The preparation of Somalia's First Biennial Update (BUR1) kicked off with a consultation meeting with the federal ministries of; Agriculture and Irrigation, Energy and water Resources, fisheries and marine resource, Ports and Marine Transport, planning investment and economic development and the MoECC. The consultation focused on the lessons learnt from preparation of the Initial National Communication (INC) in terms of data gaps and how the ministries can improve data collection to inform the BUR and future projects.

Following the first consultation with the federal authorities, a consultation workshop was organized in Garowe and Hargeia, between 27th of October – 8th of November 2019 with the aim of introducing the project to the relevant key stakeholders and sensitizing the technical staff who participated in the INC data collection on the data requirements for the BUR. The project coordinator also had separate meetings with Director Generals of the relevant ministries to discuss the respective role each ministry can play in the BUR project.

In cooperation with Cross-Cutting Capacity Development Project (CCCDP) with the aim of strengthening the country's international environmental governance for major Rio-conventions and an In-depth analysis of national circumstances was conducted. The main objective of the SWOT analysis was to assess how the development policies and plans for each member state and the federal government have mainstreamed the environmental aspects (Rio-Convention).

As noted from the in-depth analysis, each member state and the federal level has listed a number of policies and development plans which shows the fact that there are sectoral policies and development plans in each level of governance which are less harmonized. Moreover, there are development plans and policies that exist at member states but are yet to be developed at the federal level.

A high-level three-days national Environmental Conference was organized by the MoECC with support from UNDP Somalia. The conference was held on 23rd - 25th April 2019 in Mogadishu. The Conference brought together over 60 participants from different stakeholders at federal and state level representatives including the state level Ministers of the Environment (Apart from Somaliland & Puntland), environmental experts, researchers, civil society and the media.

MoECC commenced Somali's first Biennial Update Report (BUR) training workshops that lasted between 15-17th of October 2021, to establish a process for building a robust national system for the preparation of Greenhouse Gases (GHG) emission inventories, Climate Change Mitigation and its linkages to Measure, Reporting and Verifications (MRV). The overarching objectives of the workshops were to improve the technical capacity of the stakeholders to collect and register their GHG data and to assess their contribution to the overall mitigation in global emissions.

The training workshops has brought together respective stakeholders from Federal and State Level Governments, private sector and CSOs representing the main sectors, Energy, transport; Industrial Processes Product Use (IPPU); Livestock, Agriculture; Forestry and other Land Uses (AFOLU); and Waste. Adaptation and SDG relevant sectors/players from key stakeholders. Greenhouse Gas emission inventory data collection was conducted with support of the trained individuals in cooperation with institutions identified during consultation workshop.

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