THE FEDERAL REPUBLIC OF SOMALIA
MINISTRY OF ENVIRONMENT AND CLIMATE CHANGE

TECHNOLOGY NEEDS ASSESSMENT FOR CLIMATE CHANGE MITIGATION

Supported by
UNEP Copenhagen Climate Centre

supported by UNOPS

December 2022

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List of Abbreviations and Acronyms

AFOLU:	Agriculture, Forestry and Other Land Uses
BAU:	Business as Usual
CO_2:	Carbon dioxide
CFL:	Compact Fluorescent Lamps
COP:	Conference of Parties to the UNFCCC
CBOs:	Community Based Organizations
DoECC:	Directorate of Environment and Climate Change
ESP:	Electricity Service Providers
FAO:	Food and Agriculture Organization of the United Nations
FRS:	Federal Republic of Somalia
GDP:	Gross Domestic Product
GHG:	Greenhouse Gas
Gg:	Gigagram
INC:	Initial National Communication to the UNFCCC
IPCC:	Intergovernmental Panel on Climate Change
LDC:	Least developed Country
LED:	Light emitting diode
MW:	Megawatt
$MtCO_2eq$:	million tonnes (megatonnes) of carbon dioxide equivalent
MoECC:	Ministry of Environment and Climate Change
NDC:	Nationally Determined Contribution
NCCP:	National Climate Change Policy
NCCC:	National Climate Change Committee
NDP	National Development Plan
NPSC:	National Project Steering Committee
PMP:	Power Master Plan
SDGs:	Sustainable Development Goals
TNA:	Technology Needs Assessment
UNEP:	United Nations Environment Programme
UNDP:	United Nations Development Programme
UNFCCC:	United Nations Framework Convention on Climate Change

EXECUTIVE SUMMARY

Somalia is vulnerable least developed country with little historical or current greenhouse gas emissions that cause the global climate change. The country's national Greenhouse Gas (GHG) emissions was 62.92 MtCO2eq as of 2015 representing less than 0.03% of total global emissions. Agriculture, Forestry and other Land use (AFOLU) contribute to over 96% of the country's emissions while the energy sector and waste contribute 3% and 1% percent respectively.[1] These 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 efforts in the context of sustainable development and poverty eradication as detailed in the updated Nationally Determined Contribution (NDC) 2021 submitted to the UN Framework Convention on Climate Change (UNFCCC). For the country to achieve the NDC targets, finance and support, technology and capacity building will be essential.

This Technology Needs Assessment (TNA) report identifies and prioritise mitigation technologies for selected key sectors of energy and forestry based on the country development needs and priorities. The sectors were identified and prioritized on the basis of their contribution to overall national economic development and their potential to contribute to climate mitigation under the NDC. The report highlights the background to the TNA process and relevant regulatory and institutional frameworks.

The TNA process involved review of national development Plans, country reports and other secondary sources of literature as well as extensive stakeholder consultations. Technology prioritization for the selected sectors was done through a consultative process based on key criteria including costs of implementation, their socio economic and environmental benefits and other factors such as ease of implementation by applying the Multi Criteria Analysis (MCA). The developed technology fact sheets were used as reference materials in the technology prioritization process.

The analysis selected the following technologies in the Energy Sector in order of their priority. Energy Efficient Cookstoves, Portable Solar lighting devices/Solar lanterns; and Solar Home Systems (SHS). Similarly in the Forestry Sector, the following Technologies were prioritized as follows: afforestation, agroforestry and coastal forests rehabilitation. The development and implementation of necessary policy and legislative frameworks to curb deforestation and forests degradation was also selected as a cross cutting soft technology for implementation for the sector.

[1]Somalia's Initial National Communication to UNFCCC, 2018

CHAPTER 1: INTRODUCTION

1.1 About the TNA Project in Somalia

The Technology Needs Assessment (TNA) process originates from the Poznan Strategic Programme on Technology Transfer established at the Fourteenth Conference of the Parties (COP 14) to the United Nations Framework Convention on Climate Change (UNFCCC). The overall aim of the TNA is to scale up investment in technology transfer thus enabling developing countries such as Somalia to address their needs for environmentally sound technologies, decrease greenhouse gas emissions (mitigation) and/or to decrease vulnerability to climate change (adaptation).[2]

The objective of the TNA therefore is to identify, analyse, evaluate, and prioritize technological needs for achieving sustainable development and identify technologies which reduce emissions of greenhouse gases (GHGs). If properly conceived and implemented, a TNA can achieve a number of additional desirable ends, namely contributing to enhanced capacity to acquire environmentally sustainable technologies, developing important links among stakeholders to support future investment and barrier removal, and diffusing high priority technologies throughout the sectors of national economy. Hence the purpose of the TNA is to establish a baseline for a portfolio of programmes and projects to facilitate the transfer of and access to ESTs and know how in the implementation of Somalia's economic development plans and Programmes.

As a Party of the UNFCCC since 2009 and the Paris Agreement since 22nd April 2016, Somalia has endeavoured actively engage and implement climate change actions with adaptation as its priority. Undertaking of this TNA for Somalia is thus an important element in assisting country identify and implement environmentally sound technologies for both adaptation and mitigation that will support the country meet both its developmental and climate change aspirations. The TNA project was funded by the Global Environment Facility through the United Nations Environment Programme DTU Partnership and executed by the Ministry of Environment and Climate Change (MoECC) of the Federal Government of Somalia. This report focuses on climate change mitigation technologies for the energy and forestry sectors.

1.2 National Circumstances

1.2.1 Population

Somalia, Least Developed country (LDC) in the Horn of Africa is located at 10 00 North and 49 00 North with a total land mass of 637,657 square kilometres. The country has a population of approximately 16.8 million[3,] of which roughly 60 percent are nomadic and semi-nomadic pastoralists, 60 percent live in rural areas and 40 percent of the total population lives in the urban areas.[4] 50.14 percent of the population are female, and the rest are male while over 80 percent of the population is youthful.

Due to over 3 decades of protracted civil war that ended in 2002 with the inauguration of the Federal Government of Somalia, 69 percent of the population lives below the international poverty line, 43

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[2] Haselip, James Arthur; Narkeviciute, Rasa; Rogat Castillo, Jorge Enrique., 2015. A step-by-step guide for countries conducting a Technology Needs Assessment. DTU.

[3] https://www.unfpa.org/data/world-population/SO

[4] Somalia, Federal Republic of,. National Development Plan 2020-2024.9. Ministry of Planning, Investment and Economic Development.

percent in extreme poverty. The combination of climate change and insecurity over the past 3 decades has increased the vulnerability of the people especially women, children and internally displaced persons. 2.3 million live on the margins of food insecurity and 1.1 million are internally displaced. Somalia's Gross Domestic Product (GDP) per capita was estimated to be US$446 in 2017, having grown at only 2% per year over the last four years.[5]

Figure 1: Map of the federal Republic of Somalia (NAPA[6], page 14)

[5] World Bank, 2018. Somali Electricity Access Project P165497. Combined Project Information Documents / Integrated Safeguards Datasheet (PID/ISDS)

[6] Somalia, Federal Republic of., 2013. National Adaptation Program of Action on Climate Change. Ministry of Natural Resources. April 2013.

1.2.2 Climate

Somalia's climate is largely influenced by its location in the East Africa. The country is boarded by Kenya, Ethiopia and Djibouti to the West and has the longest coastline along Gulf Aden and the Indian Ocean that extends for over3,025 kilometres long. The Country's climate is therefore influenced by the Inter-Tropical Convergence Zone (ITCZ), monsoonal winds and ocean currents, jet streams including the Somalia Jetstream/Current, easterly waves, tropical cyclones and the neighbouring Indian Ocean and Red Sea Conditions[7]. Somalia is thus generally arid and semi-arid with two rainfall seasons. The annual average temperature is about 30 degrees centigrade throughout the country with maximum average monthly temperatures peaking in the months of April through to June. June to September is the hottest months in the north while December to March are hottest in the South.

Precipitation is generally low across the country with an average annual rainfall of 200 mm that presents as showers or localized torrential rains subject to spatial and temporal variability (Ibid). Rainfall is higher at average amounts of 400 mm in the south with the southwest receiving around 600 mm while the northwest coastline gets the least amount of only 50 mm. Somalia has two main wet seasons with the first one known as Gu starting in mid-March intensifying in April across the country and it starts to reduce in June. The second rainfall season known as Deyr starts in October through to December and is characterized by shorter and less amounts of precipitation.

The El Nino Southern Oscillation influences Somalia's climate variability bringing in more rainfall and flooding during the El Nino season and droughts in the La Nina years. In terms of climate change, a general warming trend has been observed in Sub Saharan Africa since the 1960s and as a whole, the East Africa has been experiencing precipitation increases in the Northern part and decreases in the Southern Region (Ibid).

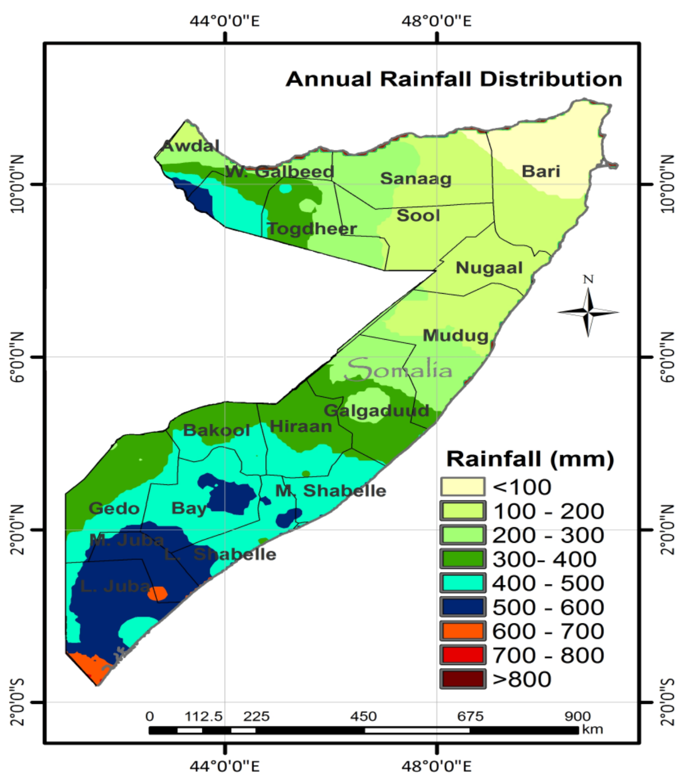

Figure 2: Somalia annual rainfall distribution NAPA, 2013, page 19)

[7] https://climateknowledgeportal.worldbank.org/country/somalia/climate-data-historical

1.2.3 Agro-ecological systems/Geography

Somalia's agro-ecological systems are typically rangelands dominated by Acacia woodlands, scrubs and grassland suitable mainly for pastoralism. Forests and woodlands cover 23 percent of the country but are threatened by recurrent drought and deforestation leading to soil erosion, loss of soil fertility and the resultant land degradation habitat loss and reduction in species richness. The Far north is characterized by the rugged east-west ranges of Karkaar Mountains that lie at varying distances from the Gulf of Aden Coast. The north has a maritime plain that parallels the Gulf of Aden Coast which is about 12 kilometres wide in the west narrowing to about 2 kilometres to the East[8]. The land then undulates to plains that are covered in a semi-arid scrub known as *guben* intertwined with shallow water courses that have beds of dry sand except in the rainy seasons. The southern and central regions have rugged terrain which gradually descends to the south forming an elevated plateau without perennial rivers (ibid). According to Somalia's National Adaptation Plan of Action's analysis of long term annual mean rainfall (1963 to 1990) for the country, it delineates four climatic zones for the country namely: the desert zone in the north-east; the arid zone in the central area of the country; and the semi-arid and humid zones in the south and parts of north-west. These zones have been derived using an eco-climate classification method through analysing the mean annual rainfall of selected weather stations across the country[9].

Somalia is a rich biodiversity hotspot hosting the Horn of Africa biodiversity hotspot and the Coastal Forests of the Eastern Africa Hotspot. The coastline is enriched by the confluence of surface ocean streams and thrives with a rich marine environment that represents a world of fisheries hotspot. Somalia's main environmental resources are water, land use, fisheries, forestry, biodiversity and economics. However, the lack of infrastructure, technologies and traditions attracts many illegal, unregulated and unreported foreign fishing vessels to these shores with dire consequences on fish stocks with losses due to illegal fishing estimated to range between 65 to 300 million US Dollars[10] and extensive charcoal production for export. In specific areas where water harvesting and moisture conservation technology are applied, agriculture is combined with pastoralism. However, livestock production under pastoralism and agro pastoralism is increasingly threatened by pasture and land degradation (Ibid). Major constraints to sustainable nomadic and agro pastoralism are lack of veterinary services, overgrazing, shortages of animal fodder during periodic and recurrent drought years and a weak fodder supply chain along the livestock routes for export to the Gulf States.

[8] Somalia, Federal Republic of. 2018. The Initial National Communication for Somalia to the UNFCCC. Office of the Prime Minister. The Federal Republic of Somalia.

[9] Somalia, Federal Republic of., 2013. National Adaptation Program of Action on Climate Change. Ministry of Natural Resources.

[10] El-Zabri, Tawfiq., Masiero, Mauro., Khouri, Nadim., Pisani, Elena., et al., 2011. International Forum for Rural Development in Somalia. Final Report. Technical Report. June 2011. DOI: 10: 13140/2.1.3825.8245.

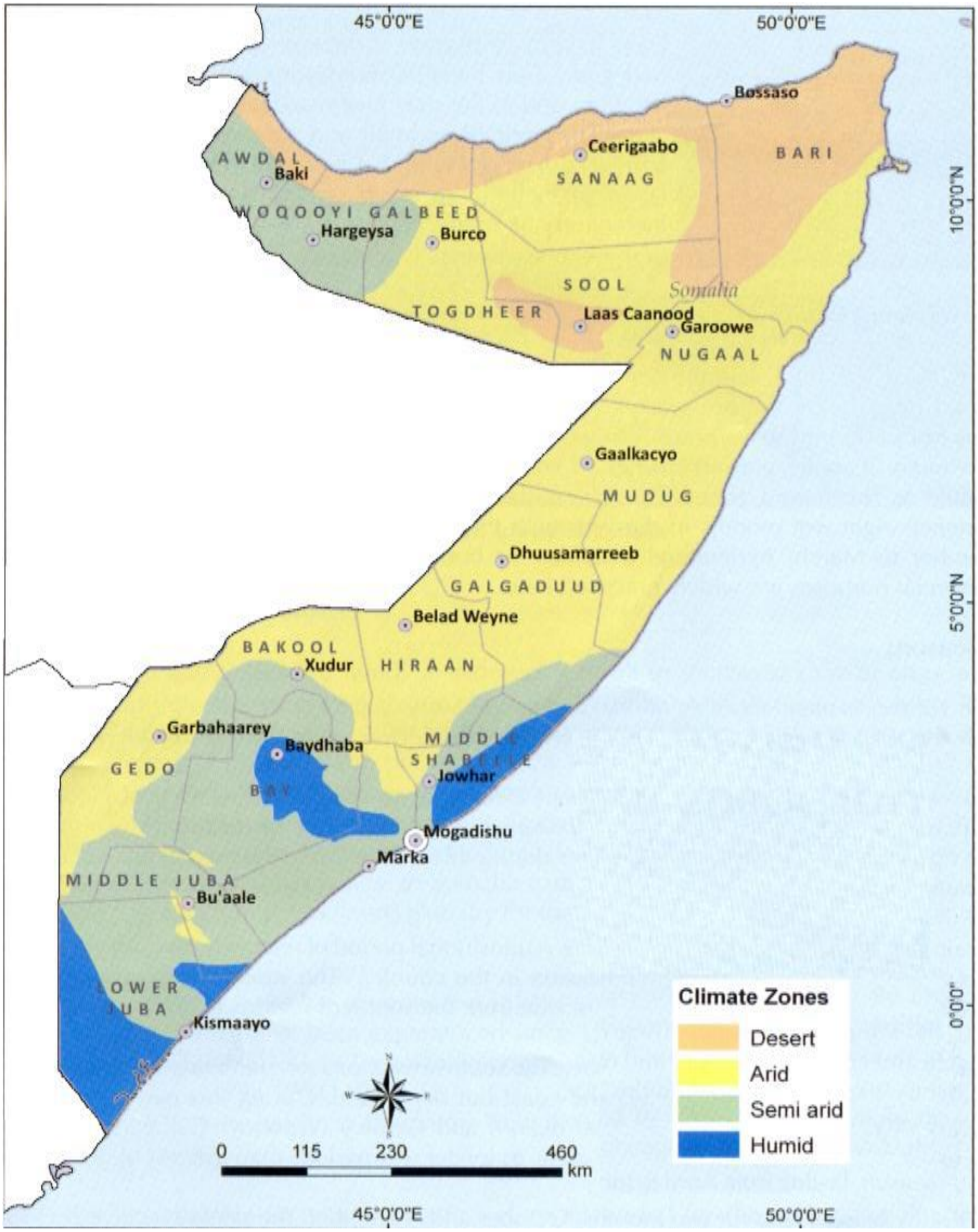

Figure 3:

Figure 3: Climate Zones delineated by rainfall. (Source: NAPA, page 21)

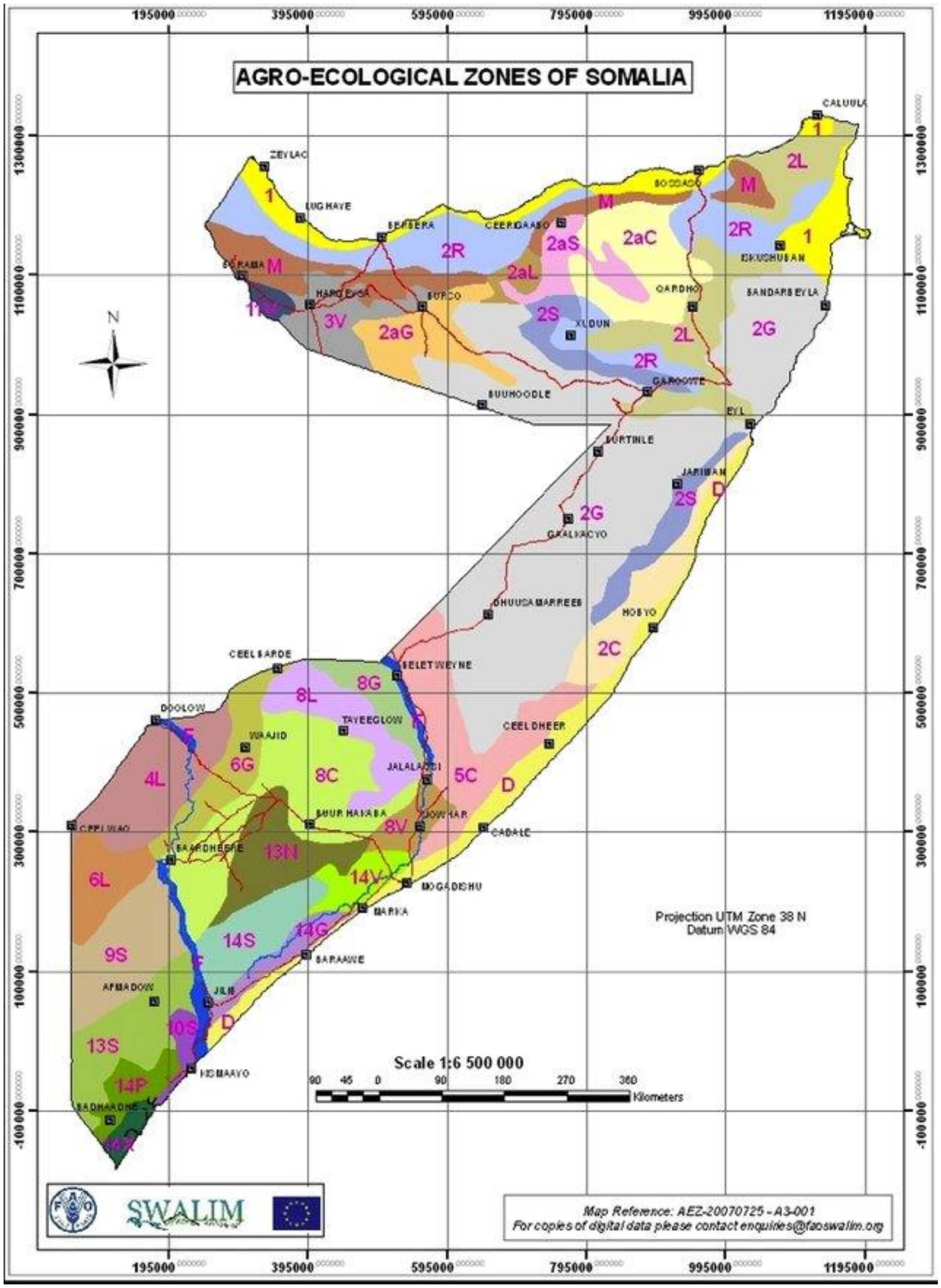

Figure 4: Agro-ecological zones in Somalia (Source: FAO)

1.2.4 Overview of the Economy

Although Somalia has suffered from over 3 decades of civil war, it has in recent years taken important steps towards recovery. According to the Somalia National Development Plan 2020-2024, the Country has in the recent past established a federal system of government and sound fiscal and monetary sectors which have supported moderate economic growth at an annual average rate of 3% GDP in 2018[11]. The GDP is estimated at USD 5.8 Billion in 2010 with a per capita GDP of USD 600. However, the country still has one of the lowest human development indicators in the world driven by extreme poverty, political instability, climate related disasters and a weak economy. 69% of Somalis live under the international poverty line of USD 1.90 a day (in 2011 PPP dollars) with internally displaced persons and rural populations having the highest rate of monetary poverty (Ibid). The National Development Plan indicates that the top four drivers of poverty are i) weak governance (ii) insecurity and absence of rule of law (iii) natural disasters and (iv) conflict and political instability. Further, the Somalia carries substantial international debt obligations that threaten to hinder development and burden future generations (ibid).

Agriculture including livestock production and its inter-connections with other economic sectors remains Somalia's main economic pillar and thus could represent a good starting point to not only achieve sustainable development and reconstruction but also contribute towards addressing climate change. Agriculture and forestry remain the main economic sources of income and the most important paid opportunity for the Somali people. In 1991, the agriculture sector contributed 63.6 percent of the GDP through the key sub sectors of livestock, crops, forestry and fisheries. It is now estimated that the agriculture sector accounts for 65% of the GDP with livestock accounting for 40% of the GDP and more than 50% of export earnings[12]. The main agricultural production is done in the southern Somalia by small scale farmers who grow sorghum, maize, sesame, cowpeas, sugarcane, rice and citrus fruits[13]. However, according to the National Development Plan 2020-2024, Somalia has an undiversified economy which is reliant on livestock and crops and thus disproportionately exposed to climate risk and disaster, with resulting higher poverty and displacement rates for the rural population. Food insecurity is widespread and is linked to climate risks and leads to a national reliance on imports, creating a large imbalance between exports and imports and to poor nutritional outcomes for the vulnerable. In 2018 exports totalled US$675 million of which US$409 million was livestock, while imports totalled almost US$3.5 billion – much of it is food. Unemployment rates among young adults and women are very high, with a mismatch between jobs and skills.

[11] Somalia, Federal Republic of. Somalia National Development Plan 2020 to 2024. Ministry of Planning, Investment and Economic Development.

[12] Somalia, Federal Republic of. 2018. Somalia Initial National Communication on Climate Change to the UNFCCC. Office of the Prime Minister. Federal Republic of Somalia.

[13] El-Zabri, Tawfiq., Masiero, Mauro., Khouri, Nadim., Pisani, Elena., et al., 2011. International Forum for Rural Development in Somalia. Final Report. Technical Report. June 2011. DOI: 10: 13140/2.1.3825.8245.

1.2.5 Environmental Factors

Somalia has a rich and diverse environment, and the climate plays a key role in regulating it. However, it is however facing several environmental challenges which include deforestation, overgrazing, soil erosion, desertification, declining ground water levels and overfishing. Other anthropogenic induced challenges include imported and internally produced toxic waste, resource exploitation, ecosystem disequilibrium and solid waste management in the urban areas. The dumping of solid waste by shipping vessels is evident but the scale and sources is difficult to validate but is documented in national document[14].

1.3 Existing Policies and Plans addressing about Climate Change Mitigation and Development Priorities

Somalia has in the recent past made significant progress in establishment of both national and sub-national policy, legislative and instructional structures including those related to environmental management and climate change. The Provisional Constitution of Somalia is the bedrock of environmental management in the country and states in its Article 25 that 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[15]. With regards to matters environment and climate change, the Ministry of Environment and Climate Change (MoECC) has a mandate to supervise and coordinate all matters related to the environment. It also has the responsibility formulate federal level climate policies, to coordinate and monitor activities by federal institutions, Federal Member States, local governments, international partners, and other stakeholders in the climate change. This section provides a summary of key national policies related to environment and climate change.

1.3.1 Somalia National Development Plan 2020-2024

The Somalia National Development Plan 2020-2024 is the 9th of its kind for this nation, and it builds on the progress and lessons learned from the 8th National Development Plan (NDP). The 9th NDP's goal is to reduce poverty and inequality through inclusive economic growth and employment, improve security and rule of law and strengthened political stability. In order to tackle poverty, the Plan anticipates achieving these through the aforementioned 4 main pillars namely:

i) *Inclusive accountable politics:* It is anticipated that this will be achieved through deepening the Federalization process; stabilization and establishment of local governance; finalization and implementation of the Constitution and prepare and conduct free and credible elections.
ii) *Improved security and rule of law:* This will be achieved through reforming and strengthening the security sector and strengthening the rule of law
iii) *Inclusive economic growth including increased employment:* The NDP anticipates at transforming the economy by improving the resilience of the traditional livestock and crop production industries to cope with the growing challenges of climate change. This will be achieved through spurring growth of the private sector in order to broaden and sustain growth and also to provide employment. The Plan also includes creating an enabling business

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[14] Somalia, Federal Republic of., The United Nations Climate Change Conference (COP 18) and the 18th Session of the Conference of Parties serving as the Meeting of Parties to the Kyoto Protocol (CMP 8). Statement at the High Level Segment by Honorable Buri M. Hamza, Head of Delegation

[15] Somalia, Federal Republic of., Provisional Constitution. Adopted on 1st August 2012, Mogadishu, Somalia.

environment, regulating the market and investing in traditional economic strengths of Somalia to promote sustainable development

iv) *Improved social protection*: This will be achieved through addressing challenges of low levels of education and poor access to other basic services of health, water and sanitation. The Federal Government of Somalia plans to achieve this through improving access to health services, improving education and training, strengthening social protection by among others addressing security nutrition and food security, disaster risk management and strengthening public service delivery.[16]

1.3.2 Somalia National Climate Change Policy 2020

This overarching national climate change policy and offers strategic direction on issues of climate change in Somalia including mitigation. The policy promotes low emissions and climate resilient development and recommends policy interventions to be implemented across all sectors (including energy, forestry, industry and waste) for enhanced mitigation actions. The policy enables better coordination of climate change work in the country and provide opportunities for cooperation and collaboration between the national and sub-national levels of government as well as with development partners, international and regional institutions.

1.3.3 Somalia Updated Nationally Determined Contribution to the Paris Agreement 2021

Somalia is an insignificant contributor of greenhouse gases, yet it remains one of the most vulnerable nations to the vagaries of climate change manifested through periodic droughts and flash floods that impoverish and displace thousands[17]. Somalia, a Party to the UNFCCC and the Paris Agreement submitted its Intended Nationally Determined Contribution in 2015 with a priority of sustainable development, peace building and adaptation to climate change. Somalia then submitted its updated it in July 2021 committing to take action to reduce 30 percent of its greenhouse gas emissions estimated at 107.40 metric tons of carbon dioxide equivalent by 2030. This, the country anticipates achieving in the context of sustainable development and poverty reduction with adaptation being a priority. In terms of budget estimates, adaptation will cost USD 48.5 billion, and it is anticipated that addressing climate change and natural resource degradation is an important element in achieving peace and stability in the country. Institutionally, climate change is coordinated by the Ministry of Environment and Climate Change whose mandate is to supervise all matters related to the environment.

According to Somalia's NDC, the agriculture, forestry and land-use sectors (AFOLU) are the major contributors of greenhouse gas emissions. Under the business-as-usual scenario (in view of increased peace and security that will spur economic growth), Somalia is expected to double its emissions to over 107.40 $MtCO_2eq$ by 2030 with significant emissions coming from the AFOLU and energy sectors. Other emissions will be from the transport and waste sectors in view of population growth, economic development and the resultant urbanization. Against this background, Somalia has prioritized the various mitigation actions many of which will have adaptation co-benefits as summarized in table 1 below. This technology needs assessment report will therefore select the sectors of forestry and energy for further development of technology action plans and fact sheets based on the fact that the sectors of forestry and energy have been prioritized as having the greatest mitigation potential at 18.10$MtCO_2eq$ and 6.0 $MtCO_2eq$ emission reductions as of 2030 respectively.

[16] Somalia, Federal Republic of., Somalia National Development Plan 2020-2024. Ministry of Planning, Investment and Economic Development.

[17] Somalia, Federal Republic of., 2021. Final Updated Nationally Determined Contribution (NDC).

Table 1: Prioritized Mitigation Measures per Sector in the NDC

	Sector and priority actions	Estimated Projected BAU emissions from the sector in 2030 ($MtCO_2eq$)	Emission reductions as per the NDC ($MtCO_2eq$)	Costs/investments (USD Million) for the NDC period
1.	Agriculture • Implement Agroforestry practices • Rangeland restoration and rehabilitation • Implement Sustainable Land • Management including climate smart agriculture practices	41.12	5.88	600
2.	Energy • Development of renewable energy electricity (Solar and Wind) including people centred decentralised solutions • Promotion of clean and energy efficient cooking • Promotion of distributed renewable lamps • Promotion of use of energy efficient light bulbs • Promote energy efficiency in electricity transmission	10.30	6.0	1,290
3.	Forestry • Afforestation and Reforestation of Degraded Forests including mangroves restoration • Promote programmes aimed at reducing emissions from deforestation and forest degradation including through REDD+ readiness activities and implementing charcoal policy	50.65	18.10	3,850
4.	Transport • Improvement of road conditions through investments in road infrastructure	2.5	1.40	1,170

	• Improved vehicle stock efficiency including for the three wheeled Tuk-tuks			
5.	Transport • Improvement of road conditions through investments in road infrastructure Improved vehicle stock efficiency including for the three wheeled Tuk-tuks	2.82	0.28	50
6.	Waste Development of 2 sanitary land fills	2.82	0.28	50
	Total	**107.39**	**31.66**	**6,960**

Table 1: Mitigation actions in Somalia Final Updated Nationally Determined Contribution 2021

1.3.4 The National Environment Policy, 2019

The National Environment Policy (NEP) approved by Cabinet, is a core document concerning the sustainable management of natural resources for Somalia. It treats climate change and disaster management as emerging environmental issues. In this policy document, the government seeks to adopt mitigation and adaptation approaches to deal with climate change.

This policy recognizes that many of the natural disasters in Somalia, such as floods, drought, are climate-related and that their negative impacts cut across all key sectors of the economy. The NEP is a core document concerning the sustainable management of natural resources for Somalia. It provides the necessary government policy towards climate change particulars in the areas of protection of biodiversity, reduction of GHGs emissions, waste, and clean technology. The NEP acknowledges that Somalia has a limited adaptive capacity to the impacts of climate change. The country's continued vulnerability to climate change and the threat this poses to achieving long-term development goals should thus be recognized. Further, the policy states that the government shall adopt various measures to overcome the many challenges brought by the climate change.

1.3.5 Energy policy 2018

The overall objective of the Policy is to increase access to efficient, affordable and sustainable energy for urban and rural communities; for the private sector to thrive, as well as for the public sector to meet its 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, technology transfer, as a way to reduce the pressures on deforestation for biomass energy generation, and to promote investment in modern, integrated and commercially viable models of energy supply.

1.3.6 The Power Master Plan for Somalia, 2019

The Power Master Plan captures the current situation within the Somalia power sector as well as suggests most efficient ways for improvement for enhanced energy access in the country. The plan indicates that 84% of the current 100MW installed capacity is from high-speed diesel generation with renewables accounting for only 10% of the installed capacity. The plan acknowledges the effects of electricity generation on the climate change including through use of diesel and wastefulness in transmission. For example, Somalia currently consumes in excess of 121,000 litres of diesel fuel per day to support the installed generation capacity, with much of this occurring in suboptimal and wasteful conditions. These figures will inevitably grow with additional capacity installed and the total daily consumption of diesel is expected to reach 694,000 litres in 2027, following the curve of increasing demand. The plan details projections of electricity supply of 700MW by 2027 and 4,600MW by 2037 based on demand. The plan acknowledges barriers to renewable energy investments in Somalia including lack of technical capability for implementing wind power, and integrating renewables and thermal generation for efficient hybrid electricity generation and costs. The plan recommends that the country's abundant renewable energy such as solar and wind power be given priority and promotes their integration into the electricity supply of urban centres to meet the national energy demand.

1.3.7 Somalia's National Biodiversity Strategy and Action Plan (NBSAP) 2015

The Strategy developed under the Convention on Biological Diversity in 2015, has direct linkages with biodiversity and climate change response in the country. The strategy envisions that by 2050 their biodiversity is restored and conserved followed by sustainable use. The document acknowledges deforestation including mangroves depletion as a major driver of biodiversity loss in the country and devise response measures. The strategy highlights, among others, gaps in capacity, policy and resource mobilization and coordination for effective management and monitoring of biodiversity. The strategy acknowledges technology gaps for effectively implementation of Somalia NBSAP and recommends a mechanism of technology development and transfer to reverse biodiversity loss trends. The priority issues highlighted in the NBSAP, and those under climate change actions are inherently interlinked and thus implementation of actions to address biodiversity loss will contribute to climate change mitigation and adaptation goals for Somalia and vice versa. The mitigation technologies identified are thus expected to make positive contribution in the biodiversity actions.

1.4 Relevance of TNA to National Development Priorities

The national development objective for the Federal Republic of Somalia is to pursue sustainable development, a kind of growth and development that takes into account the need for the introduction of low-carbon development technologies, adoption of other abatement technologies that curtail emissions and the development of a long-term vision that draws the nation's incredible solar resource and its biomass in the production of renewable energy.[18]

Somalia's contribution to climate change mitigation through low carbon development is anticipated to take place in the main economic sectors of agriculture and forestry sector. For this to take place, clean renewable energy is indispensable. Within the forestry sector, the country is concentrating on reducing deforestation and desertification.[19] This is especially so since a quarter million tons of charcoals are exported from Somalia to the Gulf States annually. In order to meet this demand, 4.4 million trees are cut, and more than 180,000 acres of land cleared leaving it unsuitable for agriculture and grazing thereby increasing the people's vulnerability since they rely on land for their livelihood. Other key barriers that threaten Somalia from achieving sustainable development and thus need environmentally sustainable

[18] Somalia, Federal Republic of., The United Nations Climate Change Conference (COP 18) and the 18th Session of the Conference of Parties serving as the Meeting of Parties to the Kyoto Protocol (CMP 8). Statement at the High Level Segment by Honorable Buri M. Hamza, Head of Delegation

[19] Somalia, Federal Republic of., 2018. The Initial National Communication of Somalia to the United Nations Framework Convention on Climate Change. Office of the Prime Minister. The Federal Republic of Somalia.

technological intervention are continued exploitation of terrestrial as well as marine resources; uncontrolled large scale charcoal production that leads to massive loss of biodiversity and illegal overexploitation of mangrove forests despite the United Nations Security Council Resolution 2036 which bans export of charcoal from Somalia (Ibid).

1.5 Overview of mitigation Sectors and projected greenhouse gas emission trends

In spite of the vagaries of civil war for over 3 decades and resultant insecurity coupled with impacts of climate change, Somalia continues to make commendable efforts towards addressing climate change. Somalia ratified the United Nations Framework Convention on Climate Change (UNFCCC) in 2009 and on 22nd April 2016, it became one of the first countries to fully commit to the Paris Agreement. This is in spite of being a Least Developing Country with almost negligible contribution to the global climate change challenge.

Somalia's contribution of greenhouse gas emissions of 62.92 Mt CO_2e as at 2015 to the total global GHG emissions is marginal, representing less than 0.12 percent of total global emissions in 2015. Of the 62.92 Mt CO_2e in 2015, about 96 % of GHG emissions came from the Agriculture, Forestry and Land Use Sector (AFOLU) while the Energy and Waste contribute 3% and 1% respectively and the Industrial Processes and Product Use (IPPU) sector is not considered significant.[20] According to Somalia's Initial National Communication to the UNFCCC, the main contributing sectors were AFOLU including Land Use Land Use Change and Forestry (LULUCF) at 96 % GHG emissions followed by Energy at 3%, and Waste at 1%. The GHG emissions, presented in carbon dioxide equivalent were distributed unevenly between the three gases at 59%, 29% and 12% for carbon dioxide, methane and nitrous oxide respectively. The results for CO_2-equivalent emissions and removals clearly indicate that the AFOLU and Energy sectors are most important sources of emissions, while the land-use change and forestry sector (LUCF) is the most important with respect to removals. Methane and carbon dioxide are the primary greenhouse gases emitted from the anthropogenic activities.

In developing Somalia's Updated Nationally Determined Contribution (NDC), a base year of 2015 is used with an implementation timeframe for both adaptation and mitigation actions being 2021 to 2030.[21] Further, Somalia commits to reduce and avoid its emissions by 2030 compared to the business-as-usual scenario (BAU) of 107.4 $MtCO_2$ equivalents through policies, measures and technologies in order to develop the country along a low emissions development pathway. The calculation of the BAU emissions and projections is based on the premise that the economy would grow at 4.9 % and the population at 3% per year by 2030. The maximum projected emissions growth scenario may occur under BAU at an economic growth of 7.5% by 2028 (Ibid). This BAU scenario assumes that Somalia could exploit its massive untapped fossil fuels predominantly oil and gas. The NDC prioritises all the UNFCCC mitigation sectors – energy, forestry, agriculture, transport, industry and waste. The sectors with the highest mitigation potential in the NDC are AFOLU and Energy Sectors.

1.6 Process, Criteria and Results of Sector Selection

The process for sector selection was based on a detailed literature review of the Somalia publications including the National Development Plan 2020-2024, Initial National Communication to the UNFCCC of 2018, Updated Nationally Determined Contribution 2021, sectoral reports including the Draft Energy Policy September 1st 2018 version and Somalia Electricity Access Project Report (P165497) of 2018 by

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[20] Somalia, Federal Republic of., 2018. The Initial National Communication for Somalia to the United Nations Framework Convention on Climate Change. Office of the Prime Minister. The Federal Republic of Somalia.

[21] Somalia, Federal Republic of., 2021. Updated Nationally Determined Contribution (NDC). Federal Republic of Somalia.

World Bank. Other national plans and strategies including the National Adaptation Program of Action (NAPA), online United Nations publications and other climate change related reports were also reviewed. With information from the review and use of expert knowledge, this TNA identified among other things:

i. National development priorities
ii. Key economic sectors and their contribution to the national economic development. These were identified as forestry and energy
iii. The sectors relationship to climate change mitigation potential of GHGs
iv. Involvement of stakeholders on the basis of sector interests through meetings and one to one engagement

The criteria used for sector selection for the TNA was identified as that which is prioritized in the Updated NDC namely: Contribution to the national economy and Contribution to climate change mitigation. As a result, forestry and energy sectors were selected for further analysis in the following chapters.

CHAPTER 2: INSTITUTIONAL ARRANGEMENT FOR THE TNA AND STAKEHOLDERS' INVOLVEMENT

2.1 Overview

Other than the aforementioned policies, actions, strategies and plans relevant for climate change in Somalia there exists critical institutions responsible for the different sectors including climate change, water, agriculture, marine and biodiversity among others. The Ministry of Environment and Climate Change (MoECC) is the main Federal level institution responsible for climate change and environmental issues in Somalia. The MoECC of the Federal Government of Somalia also serves as UNFCCC National Focal point and the National Designated Authority (NDA) for Green Climate Fund.

Additionally, the National Climate Change Policy recognises that environmental management is a multi-sectoral undertaking, and that success depends on the cooperation of Government agencies/ministries responsible for various aspects of environment. Effective environmental management requires commitments to environmental protection by sector ministries. Key Federal Ministries which play important roles in mitigation include Federal Ministry of Agriculture and Irrigation, Ministry of Livestock and forestry, Ministry of Energy and Water, Ministry of Transport and Civil Aviation and Ministry of Planning, Investment and Economic Development. Somalia's federal system has established six federal member states (FMSs) 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 climate change issues and oversee policy development and implementation in their respective regions. All the FMSs have ministries of environment responsible for managing the environment and climate change.

2.2 National TNA team

The Technology Needs Assessment process for the Federal Government of Somalia is national process involving various Federal ministries, Federal Member States, civil society organisations, academia and private sector.

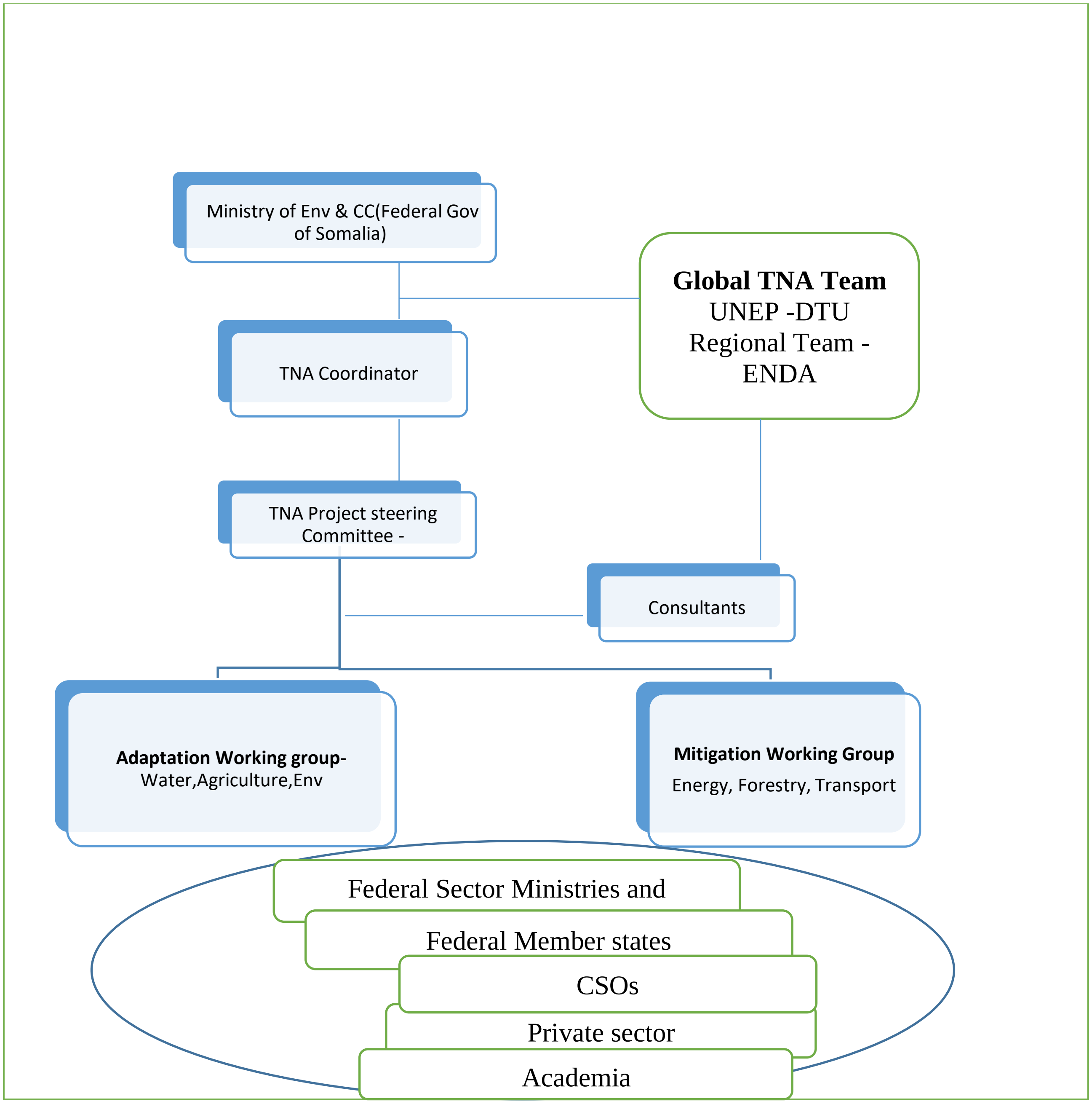

Figure 5: Somalia institutional arrangement for the TNA project

2.2.1 National Project Steering Committee (NPSC)

The National Project Steering Committee (NPSC) comprises members responsible for policymaking from all the relevant Federal ministries, as well as key stakeholders from the private sector. The National Climate Change Committee (NCCC) was utilized for the implementation of the TNA process as NPSC- 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. It comprises the Minister (or her designate)– Federal Ministry of Environment & Climate Change(MoECC), Sectoral Ministries, Directors of Governmental Agencies, Member States' Ministers for Environment, civil society organizations, and the private sector. The MoECC was established by the current government to elevate matters environment & climate change and thus replace the Directorate(DoECC) which was in place during the project inception and initial consultations.

2.2.2 The National TNA Coordinator

The TNA Coordinator is the focal point for overall TNA process management in Somalia and directly engages the Country Coordinators at UDP and the Regional Centres. The TNA coordinator works with the Ministry of Environment and Climate Change (MoECC) which is the official mandated institution responsible for the formulation of federal level climate policies and also serves as UNFCCC National Focal point. Importantly, the TNA Coordinator provides overall supervision and support for the TNA adaptation and mitigation consultants throughout the project.

2.2.3 The TNA Consultants

The TNA consultants were hired through a competitive process involving the UNEP DTU team, the TNA Coordinator and the Directorate of Environment and Climate Change(now MoECC). Horn of Africa Sustainability Solutions (HOASSO) consulting firm was selected, with both mitigation and adaptation consultants. In addition, under HOASSO, the technical consultants were supported by Mogadishu based national consultant who coordinated the consultation processes. The Consultants underwent training sessions together with other participants from participating countries on the TNA process. The trainings were facilitated by UNEP DTU Partnership and Environment and Development Action (ENDA)- regional centre.

2.2.4 Key Stakeholders

The Mitigation consultant in, consultation with the Ministry of Environment and Climate Change (MoECC), undertook the identification of stakeholders relevant for the TNA process. The stakeholder's mapping and engagement for the NDC revision process in 2021 informed the stakeholders selection for the TNA process. Stakeholders from energy, environment and forestry sectors from government (both federal and federal member states), civil society, academia, and the private sector were the main actors involved in the process. For this study, stakeholders are institutions that are in one way or another involved or have an interest in climate change technology development, promotion, transfer, or application as well as individuals who have taken a keen interest in climate change-related activities in the environment, forestry and energy sectors. The stakeholders were informed of the scope of TNA work and expectations clarified at the inception meeting. The list of stakeholders involved in the TNA mitigation is provided as annexes to this report.

2.2.5 Mitigation Sector Working Group

Through consultation with the Ministry of Environment and Climate Change (MoECC) and TNA Coordinator, key individuals from critical stakeholders (institutions) were identified, mitigation working group established and engaged throughout the process through virtual meetings, emails and phone calls to ensure the success of the TNA process. The mitigation technical working members list is attached as annex 1.3 of this report.

2.3 Stakeholder Engagement Process followed in TNA – Overall Assessment

The stakeholder engagement process followed during the TNA processes is as follows:

2.3.1 Through workshops and working sessions

These included:

- Inception workshop(virtual) organized by the TNA consultants in close coordination with then Directorate of Environment and Climate Change (DoECC) now MoECC and TNA Coordinator. The objective of the inception was to present an overview of the project, scope of work, confirm the priority sectors identified through the updated NDC 2021 process, to confirm the choice of the initial list of technologies and agree on stakeholders for the TNA mitigation and adaptation working groups.
- Technical working groups workshops/sessions – various TNA working sessions were held to identify the priority technologies and undertake prioritisation process for the technologies as presented by consultants and using the Multicriteria analysis process.

2.3.2 One to one engagement

The consultants, through the guidance of the Ministry of Environment and Climate Change (MoECC) continually engaged different relevant stakeholders to obtain the necessary information and build consensus on the process. Due to the challenge of COVID 19, volatile political situation and ensure successful stakeholders led process, the consultants undertook one on one calls/sessions to acquire the needed information including emails, social media (WhatsApp) and phone calls.

2.4 Consideration of Gender Aspects in the TNA process

Gender issues are cross-cutting priorities in Somalia. The government of Somalia is committed to mainstreaming gender equality across its development and climate change polices and plans. It recognizes the critical need to actively pursue greater involvement of women, youth, persons with disability and other marginalised groups in the development and implementation of the NDP, the NAP, and the NDC.

Climate change and its devastating effects on all sectors of the economy in Somalia has significant gender dimensions. Women and youth, and especially those in rural areas, are most affected due to their vulnerabilities, their reliance on natural resources and climate-dependent livelihoods, their responsibilities and role in safeguarding community survival. Adding to the challenge, conflicts have eroded many of the gains made in education, health care and employment prior to the civil war, perpetuating and deepening gender inequality. On the other hand, women have distinct knowledge and experience that allows them to contribute positively as agents of transformational change in the response to climate change at community and national levels. However, they are seldom involved in decision-making and management of these resources which makes them the most vulnerable to the climate crisis. The TNA project promotes gender mainstreaming throughout its activities and outputs including in consultations phase with key actors and stakeholders. The project ensures participation of different genders in actions such as research and literature review, identification of technologies, details about technologies captured in fact sheets and prioritization of technologies. The component of gender mainstreaming will be key in the development and implementation of technologies. The Ministry of Women and Human Rights Development (MoWHRD) was engaged and will play an important role as an entry point for gender-responsive climate change actions and technologies.

CHAPTER 3: TECHNOLOGY PRIORITIZATION FOR THE ENERGY SECTOR

3.1. Introduction

The energy sector has suffered from over two decades of neglect, including the absence of investments, due to both widespread insecurity and the disappearance of public resources and public oversight and thus the country has high levels of energy poverty. World Bank data[22] estimate that less than 3% of Somalia's population have access to clean energy. Investment in clean and renewable energy will play a major role as key driver of economic growth in Somalia's NDP-9. Despite the persistent challenges in the sector, Somalia is one of the countries in Africa which are richly endowed with unexploited renewable energy sources. There were discovered reserves of oil and natural gas, which remain un-drilled, potential for hydro-power and geothermal energy sources, suitable wind energy sites and ideal solar power positioning. Although the current levels of emissions in the sector is low, the sector has potential to significantly increase its share of emissions under the BAU scenario.

This chapter presents an overview of the energy sectors, projected GHG emission trends and technology options and prioritisation process. Somalia's Initial National Communication to the UNFCCC and its Updated Nationally Determined Contribution submitted to the UNFCCC in 2018 and 2021 respectively and stakeholder consultations were used for prioritization of the technologies.

3.2 Current Status of the Sector

Somalia has a rich variety of renewable energy that largely remains untapped. This includes wind, untapped hydropower, geothermal and solar. Biomass energy predominantly charcoal and firewood, although renewable in nature is the main source of energy in Somalia providing over 82 percent of the energy consumption thus steadily becoming unsustainable under the current scenario. Until recently, there has been little investment in energy infrastructure and the country has limited technical capacity and innovation. According to a World Bank Report, the Somali energy sector is thus one of the most underdeveloped in the region. It is characterized by low electrification rates in rural areas, high cost of power, high technical and commercial losses, dependency on imported petroleum products for electricity generation, and reliance on biomass resources for cooking[23]. This means that only a very small fraction of the Somali population has access to affordable, safe, reliable, and predictable energy services. Both public and private sector energy actors are highly capacity constrained, weak legal and regulatory frameworks, limited financing and investment, and lack of data for effective decision making continue to hold back sector development.

Based on the foregoing therefore, development of renewable energy in Somalia is hindered by several barriers which can be categorized into political, financial, institutional and infrastructural. The country still has inadequate strong legal and regulatory energy framework that enables energy security, widespread access and strong energy access and this therefore remains a top priority in order to regulate the sector. This has in turn generated a sense of insecurity hindering investors from perceiving Somalia as a viable market in energy provision.[24]

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[22] Available online https://ourworldindata.org/energy/country/somalia?country=~SOM

[23] World Bank. Somali Electricity Access Project (P165497)

[24] Somalia, Federal Republic of., 2018.National Energy Policy (NEP) Draft version. September 1 2018. Ministry of Energy and Water Resources.

The main source of electricity production in Somalia is diesel fuelled High Speed Generator Sets. The Draft Energy Policy for Somalia indicates that as of 2001, installed capacity was 70,000 kW and the total production was 250 million kWh. The country has limited numbers of solar photovoltaic generation that is mostly added to the existing high-speed diesel-powered generator systems by some electricity providers to establish synchronised diesel-solar PV electricity generating systems. At the domestic/residential level, pico photovoltaic and solar home systems are used in both rural and urban areas while charcoal and firewood are the main sources of energy for heating. There is gradual but very limited usage of liquefied petroleum gas (LPG) for heating and lighting. With regards to wind energy, installed wind turbine energy is limited to less than 0.1 percent of production.

Energy infrastructure in Somalia is not only limited but the existing one is largely inefficient. Energy infrastructure that was in place before 1991 when the civil war began has crumbled due to lack of use and obsolescence. Energy network for generation, transmission and distribution where existent is inadequate and inefficient. Therefore, access to clean and affordable energy remains a challenge when compared to similar economies with demand outstripping supply by a wide margin and energy access being at a paltry 4 percent in rural areas and 33 percent in urban areas. The primary sources for providing electricity in Somalia are high-speed diesel generation (HSDGs) (97% - according to INC) sets with limited use of grid-tied solar photovoltaic (PV) and very limited use of grid-tied asynchronous wind power turbines.

There is no physical national grid in Somalia. The system of delivering electrical energy to users comprises a network of isolated distribution grids with isolated generation providers. These island networks are anchored to specific urban centres with dedicated electricity service providers (ESPs). Each ESP owns and operates their complete generation- distribution-customer-revenue chain using a radial distribution island network.

Energy consumption is much skewed in Somalia. The urban areas such as Mogadishu are served with mostly household lighting through car batteries and kerosene lamps with gradual uptake of solar lighting devices. The rural communities largely use biomass and kerosene since the country does not have an electricity transmission network.

Due to inadequate infrastructure and regulatory framework, the supply is highly fragmented and therefore inefficient, leading to one of the highest prices in the world. Somalia's price of electricity can reach a maximum of US$1/kWh - one of the costliest places in the world to buy power. This is largely due to low efficiency in both the power generation and distribution systems. Private sector players supply more than 90 percent of power in urban and peri-urban areas using local private mini-grids, having invested in diesel-based systems of between 500 kVA to 5,000 kVA installed capacity per mini-grid.

There is also quite significant interest in, as well as utilisation of, Pico photovoltaic (PV) systems and Small Home Solar (SHS) PV electricity systems for residential lighting in both urban and remote areas. The addition of sizeable grid-tied solar PV generation to the HSDG-based systems of some of the various electricity service providers' (ESPs) electricity generation and distribution networks has resulted in some synchronised hybrid diesel-solar PV electricity generation systems across Somalia. Finally, there is limited wind-based generation installed. Power losses have been estimated at an average of 40%. This is more than four times the international standard of 10-12%. This drives the high cost of electricity and contributes to greenhouse gas emissions.

The figure below shows the proportion of various sources in the electricity generation mix as of 2018.

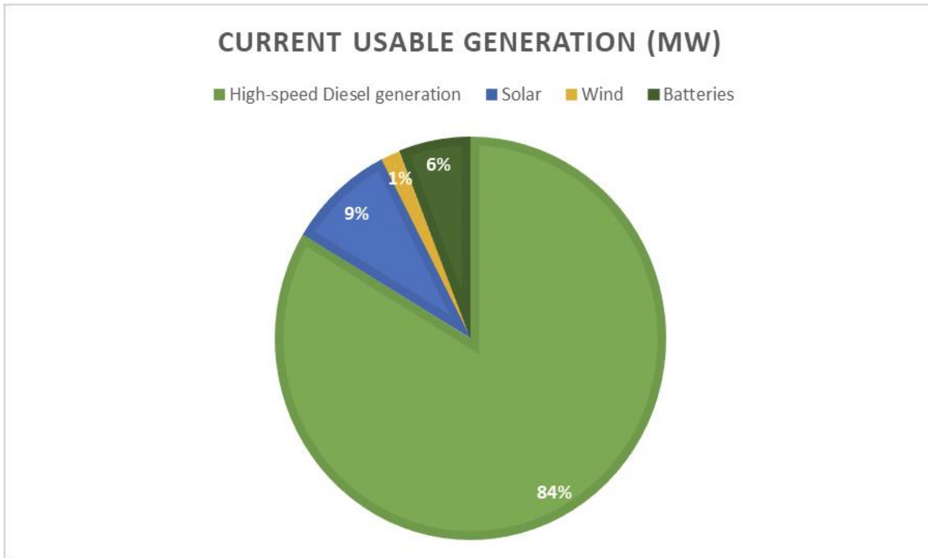

Figure 6: Current Energy Generation, Federal Ministry of Energy and Water Resources 2018(PMP)

3.3 Decision context

In addressing the many urgent needs of the Somali people, energy access in general and electricity access in particular will play a major role as these are widely recognised as major drivers of economic growth for the Government. The Federal Government of Somalia has prioritized development and use of renewable energy sources to contribute to spur economic and industrial growth, reduce poverty, enhance sustainable development, reduction of greenhouse emissions and enhance security.

The NDP -9 elaborates the following strategies to enhance energy access and expand electricity supply in the country including the following:

- Developing renewable and non-renewable energy sources to increase supply
- Establishing a national regulatory authority for energy market governance
- Strengthening the administrative and technical capacity of the federal and states ministries of energy
- Ensuring the needs of vulnerable groups – particularly women, the youth and displaced persons – in intervention design and implementation

According to the Draft National Energy Policy of 2018, it is envisioned that access to energy is a prerequisite for GDP increase as it leads to job creation in various sectors including manufacturing, services sector, agriculture, fisheries, ICT and livestock products processing. In order to catalyse this growth, the Federal Government has prioritized the following measures in order to develop its energy sector along a low carbon resilient pathway:

(i). Development of an energy policy, legislative and institutional structure at Federal Level and integrate these into the State Level (ii). Investment in institutional capacity, sectoral strategic planning and enactment of organizational structures and government procurement procedures

Key institutions that play a role in energy strategies in Somalia include:

- The Ministry of Energy and Water Resources of Somalia has the mandate to oversee operations in the electricity sector. It has introduced a system where participants in the electricity market must register with the Ministry and obtain a certificate. The Ministry maintains direct relations with the state-level governments and the authorities there are mandated with overseeing the electricity sector.
- Federal Member State institutions – Relevant Ministries/institutions have mandates over the energy sector, including electricity in the respective states.

3.4 Existing Technologies in the Sector

3.4.1 Solar Energy

According to the Initial National Communication, solar energy is largely used in solar resources are very adoptable in the country with a number of municipalities particularly Garowe using solar power. Other towns include Las anod and Sool region of North Somali where electricity is purely generated by a solar power. Furthermore, The European Union (EU) in collaboration with the Adventist Development and Relief Agency (ADRA) launched the 3 year "Somali Energy Transformation (SET) Project" whose objective is to provide 100,000 households in Somaliland, Puntland and South-Central Somalia with sustainable and affordable solar energy service that would contribute, also, to a low carbon development.

In the city of Mogadishu, there are plans by Banadir Electric Company (BECO), a leading private energy utility, to mount a 5 Megawatts solar equipment for two sites. Currently, power generation in Mogadishu by BECO is predominantly by diesel generators therefore the introduction of 15 MW of solar power would avoid the emission of greenhouse gasses by 75,000 tCO_2 (Ibid).

In spite of the usage of solar energy for electricity generation in Somalia, solar PV for rural electrification is still not affordable to many of the vulnerable communities. However, it remains a viable green technology option that can yield multiple benefits to the rural households and their economy. Somalia's Draft Energy Policy of 2018 envisions to support and invest in the use of solar energy by households, businesses, public and private sector

3.4.2 Hydroelectricity

Somalia has large untapped hydropower potential. A report by UNEP[25] estimated that hydropower could add between 100 to 120 megawatts of electricity to the Somalia Energy System. Before the civil war, the Fanoole Dam located in Middle Jubba had the potential to irrigate 13,000 ha and generate 4,600 KW of electricity. Its full potential was not fully exploited due to the civil war and the change of river course induced by the 1998 El Nino rains. The planned Baardheere Dam had an upstream potential of generating 493MW of electricity and this plan too was disrupted by the civil war of the river flow, but the dam still stands and needs extensive rehabilitation and directing the river to go through it. In addition, there was a plan to construct the Baardheere Dam, upstream with a generating capacity of 493 MW, but the onset of the civil war interrupted the project funding and implementation.

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[25] UNEP, Energy Profile Somalia. https://wedocs.unep.org/bitstream/handle/20.500.11822/20514/Energy_profile_Somalia.pdf?sequence=1&isAllowed=y#:~:text=Currently%20only%202.85%20per%20cent,river%20(REEEP%2C%202012).&text=A%20dam%20at%20Bardhere%2C%20in,Somalia%2C%20has%20also%20been%20planned and REEP (2012) https://www.reeep.org/somalia-2012

3.4.3 Wind Energy

The country has large areas of shallow sea along its coastline, particularly suitable for offshore wind power, with the added benefit that this resource is close to a number of major urban centres, including Mogadishu and Berbera. Studies estimate that approximately 50% of the land area of the country has suitable wind speeds for power generation and 95% could benefit, and profit, from replacing diesel-powered water pumps with wind systems. Wind speeds vary from 3-11.4 m/s. Four 50 kW turbines were installed in Mogadishu in 1988. Wind energy has also been utilized for water pumping, with installations made by the UN Trusteeship Administration of Somalia from as early as the 1940s. However, these facilities no longer exist or in use due to the prolonged civil war. Average wind speed in northern Somalia is 0.2 to 8.5m/sec. Hargeisa is one of the highest wind speed areas in the north, with an average of 17 m/sec31 in the month of July.

3.4.4 Charcoal Production

Charcoal plays an important role in both the energy sectors and economies of many African countries, and Somalia is no exception. Charcoal making provides a considerable amount of employment in rural areas, but the scale of this operation has escalated to such an extent that environmental degradation has now been reported from most parts of the country.

The output of charcoal in north-eastern Somalia was estimated to be 4.8 million bags (about 25-30kg each). Considering the fact that this volume of charcoal requires about 2.1 million Acacia bussei trees and an approximate average density of 60 trees per hectare, it can be deduced that the rate of deforestation is about 35 000 hectares per year28. Further, this can translate to 72916 hectares annual deforestation rate in the southern Somalia where 10 million bags (approximately 4.375 million trees) of charcoal are produced annually based on the 2011 export statistics29.

The Acacia bussei tree was put into IUCN Red List of threatened species in 2009 by the International Union for the Conservation of Nature (IUCN)30 following the very high rates of deforestation of the species in Somalia. The increasing loss of the natural resource base throughout Somalia is a key contributing factor in determining the severity of Humanitarian Crises– as evidenced during the most recent drought event to hit the region in 2010& 2016, the impacts of which are still in effect today.

Table 2: Somalia energy profile (source: International Renewable Energy Agency)[26]

Total Primary Energy Supply		
Energy type	**2013**	**2018**
Non-renewable (TJ)	8,898	8,969
Renewable (TJ)	127,963	143,131
Total (TJ)	136,861	152,100
Renewable share (%)	93	94
Renewable Energy Consumption		
Consumption by source	2013	2018
Electricity (TJ)	13	62
Heat (TJ)	0	0
Bioenergy (TJ)	97,903	109,766
Solar & thermal (TJ)	0	0
Total (TJ)	**97,916**	**109,828**
Energy Consumption by Sector		
Industry (TJ)	579	530

[26] International Renewable Energy Agency (IRENA). Somalia Energy Profile. https://www.irena.org/IRENADocuments/Statistical_Profiles/Africa/Somalia_Africa_RE_SP.pdf

Transport (TJ)	0	0
Households (TJ)	62,419	70,419
Other (TJ)	34,918	38,879

3.4.5 Kerosene and LPG

Kerosene is used for lighting in households which are not electrified in both the urban and rural areas. Most notably, it also finds limited application for cooking purposes in the urban households, which is 5% of the households (ADRA, 2009). The per capita kerosene consumption in the urban households was estimated at 84 litres per month, while in the rural households is at 2 litres per year (ADRA, 2009). The total consumption of kerosene in the urban and rural households was estimated at 10.4 and 8.9 kt, respectively. LPG is mostly used in the institutions located within the urban areas. Further estimations indicate that about 90% of LPG is used in the institutions while 10% is used in the households (ADRA, 2009). The consumption of LPG in the commercial and household sectors was 466 and 46.6 tonnes, respectively.

3.5 GHG emissions and projections for the sector

The INC reports that the energy sector GHG emissions contributions stands at 3% of the national emissions. This is mainly from fossil fuels. Carbon dioxide (CO_2) and methane are the largest contributors to Somalia's GHG emissions, accounting for 49% and 44% respectively in 2015. The majority of the CO_2 emissions result from the combustion of fuels for transport and manufacturing/construction while most of methane is resulting from the utilization biomass energy resources. Nitrous oxide (N_2O) emissions arise from activities such as transport and other combustion of fuel accounted for 7% of Somalia's emissions in 2015.

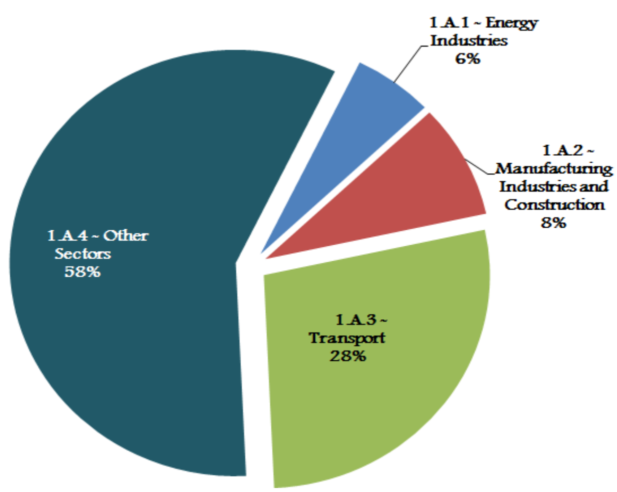

Figure 7: % contributions of emissions by source categories in the energy sector (INC 2018)

Additionally, given the dominant role of biomass as energy carrier in Somalia, total GHG emissions from energy use depend to a large extent on the assumption of how much percent of wood fuel used is harvested sustainably. The emission baseline in INC 2018 assumes that all the biomass used between the 2000 and 2030 consist of 80% unsustainable biomass. As a consequence, emissions from wood fuel dominate total energy use emissions in Somalia.

The other sector mostly residential generates most of the emissions in the energy sector accounting for 58% total GHG emissions. This is followed by transport at 28%, Manufacturing industries and construction at 8% and Energy industries at 6% of the total energy sector emissions in the year 2015.

The other sectors source category includes residential, commercial, institutional and agriculture/forestry/fishing. Figure10 shows the BAU projected emissions form the energy sector, indicating that the other sectors including residential subsector will continue to be the major source of emissions followed by transport.

The FDR has a plan to expand electricity generation and distribution system in the country. The installed capacity will increase from 100 MW to about 150 MW in 2025 and 300MW in 2030. The contribution of renewable power will be about 40–50MWp of renewable energy mainly solar energy. Other sources such as wind and hydro will also contribute to the electricity demand. It implied that the installed capacity will increase by about 7.0 per annum over the first next ten years then by 5.5%. The installed capacity is projected to increase to about 300 MW by 2030.

Energy Master Plan 2018, indicates that the base scenario assumes about 1,000 MW of installed capacity by year 2037 and at least 300MW of installed capacity by Federal States as indicated in the graph below:

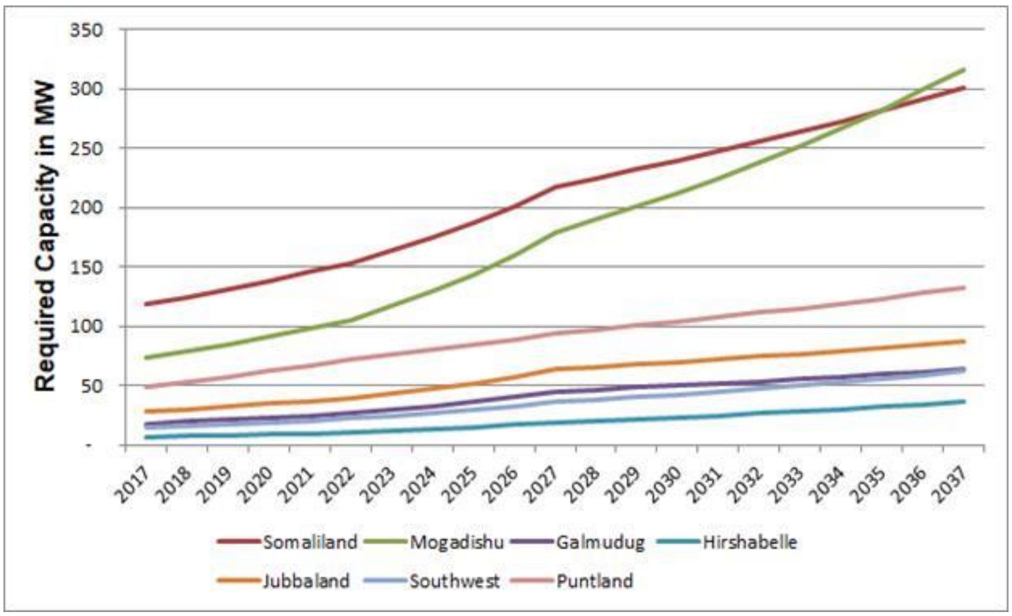

Figure 8: Required electricity capacity by states, Federal Ministry of Energy and Water Resources 2018(PMP)

According to INC 2018, In the BAU Scenario, the emission from the energy sector was estimated at 2 MtCO2eq in 2015 and projected to increase to 10 Mt CO2eq in 2030 to 15Mt CO2eq in 2040. Other sources including WRI Climate watch online data give an estimate of within the same range as the INC while Africa Development Bank Report 2018[27] estimates total emissions for the period 2014-2016 from the energy sector at 9.27Mt CO2eq.

It is expected that the biomass use in the rural areas and commercial sectors will account for the largest share of the total emissions in these sectors amounting to 13.5478 and 2.7096 $MTCO_2$eq, respectively. Furthermore, the biomass use for charcoal production will account for 9.37135 $MTCO_2$eq. of the total emissions followed by the charcoal consumption activities in the household and commercial sectors amounting to 7.85429 and 1.33173 MT CO_2eq respectively. The emission from thermal generator will

[27] African Development Bank, 2018, Somalia National Climate Profile

reach 0.8848 Gg in 2040. The generators are characterized by low efficiency and poor transmission and distribution lines. LPG use in the urban areas will constitute the least emissions as a result of the limited use of petroleum products for cooking applications since they are an expensive source of energy.

3.6 An overview of possible mitigation technology options in the Energy Sector

The mitigation technologies for the energy sector were identified through literature review of relevant documents and Somali's policy documents such as NDC and in consultation with experts in the mitigation technical working group who contributed to the assessment and also provided local expertise and knowledge on what fit best to the Somalia's conditions. Below is a brief summary of various mitigation technology options for the sector:

3.5.1 Distributed Solar PVs/Solar Home Systems (SHS)

The geographical position and climatic conditions of Somalia are extremely favourable for solar energy harnessing. Somalia is bestowed with high and stable solar radiation across the entire country. Somalia's solar energy potential is ranges from 5-7 kWh/ m2/day with 310 sunny days in a year amounting to 2500 to 3000 hours of sunshine per year. This makes Somalia an ideal candidate for harnessing solar energy[28]. There is some potential to use the abundant solar energy resources and indeed it is already being exploited. The most common uses include lighting, cooking and water pumping and heating in both public and private buildings.

Currently, there is a trend towards using direct electric devices with heating elements between 2.5 and 5 KW to heat hot water for the use in showers. This poses a challenge to electricity demand management, as their use tends to be focused during times in the morning and afternoon when there is peak demand for hot water. With support on the initial investments and the conduce regulatory environment this can be profitable and sustainable option for many businesses such as hotels.

The high upfront investment cost and the end-users being limited to the urban population has led to relatively modest assumptions on the adoption rates for this technology. The penetration of solar homes is assumed to increase by 5% a year, reaching 20% in 2040. In order to simplify the calculation, we assume that the solar thermal water heating systems would be used without fossil-fuel based or electricity-run back-up systems. Thus by 2040, GHG emissions of water heating are assumed to be 20% lower than in the reference case. Although there is already a regulation in place mandating solar thermal water heaters in all new buildings of a certain size, it is likely that significant additional support would have to be provided to achieve more than 20% total penetration by 2040.

3.5.2 Wind Power Technology

The extensive coastline with the presence of attractive offshore winds lends itself particularly to the generation of wind energy. Measurements of wind speeds have ranged from a low of 3 m/s to a high of 11.4 m/s (FGS, 2015). Wind energy has been exploited for over 70 years primarily for water pumping. REEEP (2012) estimates that about half the land area has suitable wind speeds for power generation and this could help alleviate some of the existing pressures on forests for biomass energy and replace some of the diesel electricity generators thus contributing to emissions reduction (REEEP, 2012).

3.5.3 Clean and energy efficient cookstoves

As a means to mitigate and reduce the significant use of wood fuel in the country, there is need to address clean and efficient cooking through cookstoves in a substantive way to achieve the emission

[28] Somalia, Federal Republic of., 2018. Initial National Communication on Climate Change to the UNFCCC.

reduction in the energy sector while contributing to sustainable development. Inefficient biomass cookstoves and over fire cooking contribute directly to GHG emissions in the energy sector through emissions of methane and nitrous oxide, as well as emissions of carbon dioxide originating from biomass that is unsustainably harvested. Additionally, inefficient cooking contributes to health complications among the vulnerable population especially women and children and exacerbate gender inequalities. The efficient cookstoves reduce the amount of charcoal and wood used and protect women from toxic chemicals produced by open fires and traditional stoves. There is also a need to increase awareness of improved cooking practices, increasing access to soft loans, building capacity of stove producers, and improving access to testing facilities.

It is expected that the use of efficient cookstoves will significantly reduce emissions in the household and commercial sectors. The efficiency of charcoal metal stoves and improved stoves is estimated at 18% and 30%, respectively. The INC 2018 estimates that increased penetration of improved cookstoves stoves from 2% in 2015 to 30% in 2040 will result in the emission reduction from 6.92 Mt CO2eq to 4.53 MtCO2eq (2.38MtCO2eq) in 2040. That is a reduction of about 35% from the BAU scenario.

On the other hand, the private sector is keen on using energy-saving cooking devices because they have more disposable income. The estimated efficiencies of the metallic stoves and improved stoves are 20 % and 35%, respectively. The penetration of efficient stoves for charcoal is projected to increase from 14% in 2015 to 50% in 2040.The INC estimates the resulting emissions are projected to decrease from 0.31MT CO2eq to 0.156 MTCO2eq which is 49%. There is no information on the current use of efficient fuelwood. It is estimated that 2% of the commercial sector uses efficient woodstoves, and is projected to reach 35% in 2040. The estimated efficiency of wood and improved stoves is 15% and 35%, respectively. The emissions will reduce from 3.251 MtCO2eq in 2015 to 2.140 MtCO2eq, i.e. 1.111 MtCO2eq in 2040. That reduction is due to the mitigations which will be 34% over the BAU Scenario.

Overall, with 30% penetration of energy efficient cook stokes (both household and commercial), which is about 3 million cookstoves during the NDC 2021 period will result in an estimated emissions reduction of 2.15 MtCO2eq per year in 2030.

3.5.4 Portable Solar lighting devices/Solar lanterns replacing Kerosene Lamps

Kerosene is the ubiquitous fuel used for lighting in off-grid rural communities including Somalia. While kerosene is described as a clean cooking fuel on par with LPG in terms of its potential to replace biomass in the 2007 IPCC assessment, the health impacts of kerosene cookstoves may be more severe than LPG cookstoves. When used in simple kerosene lamps, Kerosene leads to high indoor air pollution as well as to an increased risk of burns, fires and poisonings. Somalia –being a net fossil fuel importer – also experiences negative macro-economic effects, foreign exchange and balance of trade, related to the import of kerosene.

Replacing kerosene with a combination of light emitting diode (LED) lanterns in combination with compact renewable energy sources, such as solar photovoltaic (PV), can reduce these negative effects. Currently these products are available in the market and have experienced considerable price decreases over the past 5 years. However, there has also been negative experiences attributed to cheap products, mainly produced in Asia, as the performance of both the LED bulb and the solar PV panel may be less then stated by the manufacturer[i] and equipment may break soon.

Considering the importance pastoralism (mobile communities) in Somalia and the negative health effects of kerosene, replacement of Kerosene lamps with portable/mobile renewable technologies is considered a high priority action. We assume 30% adoption of renewable lighting technologies (for off-grid applications) by 2030(about 3M solar lanterns) and a programme to completely replace kerosene lamps in the future. This is expected to yield emissions reductions of 0.15 MtCO2eq per year in 2030.

3.5.5 Energy efficient LED bulbs

There is need to increase adoption rate of highly efficient LED bulbs and introduce programme to phase out incandescent bulbs, leading to significant lower electricity consumption for lighting.

Replacing incandescent bulbs with compact fluorescent lamps (CFL) decreases energy consumption by 80% per bulb, while CFL bulbs last roughly ten times longer. When compared to incandescent bulbs, due to the current low prices for CFL, the longer lifetime of CFLs alone already justifies the higher investment cost. When energy savings are taken into account the payback period falls and CFLs usually pay back within one year.

In Somalia it is unclear what the exact share of CFL currently is, but it can be safely assumed that especially in urban areas the penetration rates are relatively low. There is lack of a labelling scheme and the entry of low-quality, less efficient CFLs do not allow consumers to properly assess the options. The low investment cost of CFL and further cost reductions can lead to high adoption rates in the short term. In 2030 it is assumed that through an intervention phasing out incandescent bulbs an adoption rate of at least 50% can be achieved. This will lead to 40% lower electricity consumption for lighting versus the reference case by 2030.

The low investment cost of CFL and further cost reductions can lead to high adoption rates in the short term if there is a programme to phase out in the inefficient bulbs from the current connected population of Somalia (15-16%). In 2030 it is assumed that through an intervention at least 50% phasing out incandescent bulbs with an adoption rate of 5% can be achieved. This will lead to 40% lower electricity consumption for lighting versus the reference case by 2030. This will lead to emissions reductions of 0.15 MtCO2eq per year in 2030.

3.5.6 Energy efficiency improvements across industries

The industrial and commercial sector in Somalia is dominated by small to medium enterprises (SMEs) and includes the agriculture and food, pulp and paper, ICT and textile industry. These industries all use a wide variety of equipment and appliances typical to the product or service offered – unlike the previous example that focussed on general appliances. For each of sub-sector, mitigation options exist such as variable speed drives and improved boilers. However, the upfront costs associated often present a barrier to adoption. There are upscale existing start-up funds with support from international partners to provide ‘soft’ loans in combination with audits and technical training could provide the necessary stimulus for increased adoption of energy efficiency in industry.

This option would make more economic sense to commercial industries which could make savings in electricity consumption could be achieved through measures such as the use of more efficient pumps and motors However, especially SMEs which form a significant part of Somalia’s commercial and manufacturing sector, are likely difficult to reach with any intervention or support program encouraging investments into energy efficiency in industry.

3.5.7 Energy Efficiency in Power transmission

According to Somalia Power Master plan 2018, all the ESPs report that they have significant losses within their island distribution networks of up to 40%. The causes for these losses are both technical and commercial. Reportedly, these electricity distribution losses are the largest power (instantaneous energy) losses within any of the individual ESP island electricity networks. These electrical energy losses are within both the primary and secondary distribution lines and comprise both technical losses and commercial (non-technical) losses.

While some losses can be easily corrected, others require equipment changes, and some are just inevitable due to the physics of electricity. Total losses simply reflect the difference between the generated kWh and the load used and billed kWh. This value is generally referred to as T&D losses (Transmission and Distribution), and is the electricity amounts not paid for by load users-customers. Nevertheless, ESP generators must account for these in order to optimise their financial soundness.

3.7 Criteria and process of technology prioritisation for the Energy Sector

Based on consultations in the working group, the long list to technology options in the sector were reduced to five, which were considered for the prioritization process. The TNA coordinator and consultant facilitated the discussions where the shortlist of technologies was identified. Key consideration made during the discussions include the following:

i. Experience - Implementation of the technology in the country
ii. Significance barriers facing technology implementation
iii. Replicability and potential for implementation at scale in the country

As a result, technology related to energy efficiency in power transmission and energy efficiency across industry were eliminated in the first round of consultations. Key reasons being the fact that with the unique country situation, it is quite difficult to swiftly implement these technologies. For example, energy efficiency across transmission systems as the power sector is fragmented and private sector led. Additionally, this will require significant awareness and is not seen as a priority by Somalia government policy documents.

The next step was preparation of technology fact sheets by the consultant and also informed by local stakeholders. The factsheets are included in this report as annex 2.

Multi criteria analysis tool was used to rank the shortlist of the technologies with information in the fact sheets and stakeholder consultations determining the results of the prioritization process. Stakeholders went through a short capacity building session on the MCA process and the expectations for the technology prioritization process. Consultant presented a potential *list of c*riteria for prioritization during the workshop. Participants were also asked to critically review the list of criteria, make changes where necessary or even add additional criteria if necessary

The criteria agreed and used for prioritization of technologies for the energy sector were as follows:

i. **Contributions to economic development** – This criterion covers among other parameters; ability to increase employment creation, promoting private sector investments and improve energy security. This is an essential criterion as Somalia's objective is to address poverty and spur economic development. Any mitigation action should have economic contribution for it to make sense for implementation in the country.
ii. **Technology costs** – This includes the initial capital/investment costs and operations costs. This is important as the majority of the population are poor and thus technology uptake may be low if it is expensive.

iii. **Climate adaptation/resilience benefits** – Somalia is very vulnerable to climate change impacts; climate technologies have to first enhance adaptation and build resilience of the communities and the country. Climate adaptation is also mainstreamed into the country's economic development plans.

iv. **Climate mitigation contributions** – This is an assessment of the level of GHG emissions reductions potential achieved through implementation of the technology. This is a core part of the technology needs assessment for the climate mitigation technologies.

v. **Ease of implementation** – This includes aspects such as political, economic or cultural considerations that could either promote or present difficulties during the implementation of the technologies.

vi. **Social benefits** – Considering social dimensions of the technology including ability to or not to contribute to gender equality and social inclusion, health benefits among others. While Somalia has significant gender inequalities, the country strives to promote gender equity in its NDCs and other national policies, thus an important criterion for consideration.

The attached fact sheets provide information on each of the technologies including a description of the technology against the specific criterion.

3.8 Results of technology prioritisation for sector

The MCA tool was used to undertake technology prioritisation for the sector. Stakeholders did the scoring of technologies (with 0 least preferred and 100 most preferred). After discussion among the stakeholders on each of the criteria and scores, guided by the consultant, the mitigation working group experts voted for one criterion, based on expert judgement, at a time agreed on a particular score for each technology against each criterion. Additionally, the group agreed on weight for each of the identified criterion, with total weight score for all criteria summing up to 100. Below is a result of scoring exercise for different technologies by stakeholders after discussions and consensus in the working group.

Below is a result of scores given for each of the technologies and weight for each criterion:

Scoring Matrix							
Energy Sector Technologies	**Criteria for Prioritization**						
	Costs	Benefits				**Other**	
		Economic	**Social**	**Climate Change related**		**Ease of implementation**	
	Criterion A	**Criterion B**	**Criterion C**	**D-Resilience**	**E-Mitigation**	**Criterion F**	
i. Distributed Solar PVs/Solar Home Systems (SHS)	70	80	50	50	70	60	
ii. Wind Power Technology	40	70	40	50	70	40	
iii. Clean and energy efficient cookstoves	90	90	80	70	70	80	
iv. Portable Solar lighting devices/Solar Lanterns	90	80	70	70	50	80	
v. Energy efficient LED bulbs	95	40	40	50	30	90	
Scoring scale	0=very high cost --> 100=very low cost	0= Very low --> 100= Very high	0= Very low --> 100= Very high	0= Very low --> 100= Very high	0= Very low --> 100= Very high	0=Very Difficult -->100=Very Easy	
Criterion weight	30	25	12	10	8	15	100

Table 3: Scoring Matrix - energy technologies

The resulting weighted scores were summed up for each technology option to derive an overall score value. The aggregation of the weighted scores was also conducted using the UNEP-DTU MCA calculator. The results of the aggregation of the weighted scores resulted into decision matrix in table below from which the decision on the prioritized technologies was based. Table 4 shows the results of the scores of technology prioritization following the MCA process.

Decision Matrix: Weighted Scores								
Energy Sector Technologies		Benefits				**Other**	Total score	Rank
	Costs	**Economic**	**Social**	**Climate Change related**		**Ease of implementation**		
	Criterion A	**Criterion B**	**Criterion C**	**D-Resilience**	**E-Mitigation**	**Criterion F**		
i. Distributed Solar PVs/Solar Home Systems (SHS)	2100	2000	600	500	560	900	6660	3
ii. Wind Power Technology	1200	1750	480	500	560	600	5090	5
iii. Clean and energy efficient cookstoves	2700	2250	960	700	560	1200	8370	1
iv. Portable Solar lighting devices/Solar Lanterns	2700	2000	840	700	400	1200	7840	2
v. Energy efficient LED bulbs	2850	1000	480	500	240	1350	6420	4
Criterion weight	30	25	12	10	8	15	100	

Table 4: Decision matrix - Energy technologies

Below is a summary of the ranking of technologies based on the MCA process.

Rank	Technology	Average Scores
1	Clean and energy efficient cookstoves	0.84
2	Portable Solar lighting devices/Solar lanterns	0.78
3	Distributed Solar PVs/Solar Home Systems (SHS)	0.67
4	Energy efficient LED bulbs	0.64
5.	Wind Power Technology	0.51

Table 5: Ranking of technologies for energy sector

3.8 Sensitivity Analysis

In addition, sensitivity analysis was conducted to better assess the relevance of the results. Table 6 below shows the result of average of scores given by each of the members of the working group and the resultant decision matrix for the energy sector technologies.

Sensitivity - Scoring Matrix							
Energy Sector Technologies	**Criteria for Prioritization**						
		Benefits				**Other**	
	Costs	**Economic**	**Social**	**Climate Change**		**Ease of implementation**	
	Criterion A	**Criterion B**	**Criterion C**	**D-Resilience**	**E-Mitigation**	**Criterion F**	
i. Distributed Solar PVs/Solar Home Systems (SHS)	75	90	50	50	70	60	
ii. Wind Power Technology	40	60	40	50	70	40	
iii.Clean and energy efficient cookstoves	95	90	80	70	70	90	
iv. Portable Solar lighting devices/Solar Lanterns	95	80	80	75	50	90	
v. Energy efficient LED bulbs	95	50	40	50	30	90	
Scoring scale	0=very high cost --> 100=very low cost	0= Very low --> 100= Very high	0= Very low --> 100= Very high	0= Very low --> 100= Very high	0= Very low --> 100= Very high	0=Very Difficult -->100=Very Easy	
Criterion weight	30	25	12	10	8	15	100

Table 6: Sensitivity analysis scores - energy sector

Sensitivity - Decision Matrix: Weighted Scores								
Energy Sector Technologies		Benefits				**Other**	Total score	Rank
	Costs	**Economic**		**Environmental**		**Ease of implementation**		
	Criterion A	**Criterion B**	**Criterion C**	**D-Resilience**	**E-Mitigation**	**Criterion F**		
i. Distributed Solar PVs/Solar Home Systems (SHS)	2250	2250	600	500	560	900	7060	3
ii. Wind Power Technology	1200	1500	480	500	560	600	4840	6
iii.Clean and energy efficient cookstoves	2850	2250	960	700	560	1350	8670	1
iv. Portable Solar lighting devices/Solar Lanterns	2850	2000	960	750	400	1350	8310	2
v. Energy efficient LED bulbs	2850	1250	480	500	240	1350	6670	5
Criterion weight	30	25	12	10	8	15	100	

Table 7: Sensitivity analysis- decision matrix for the energy sector

Results from the sensitivity analysis of the energy sector technology rankings provided slight deviation in the total scores while maintaining their original ranking. This also confirms that clean cookstoves, portable lamps and distributed solar PVs are priority mitigation technologies for the sector. These technologies are also confirmed coherence with policy orientations both climate policies and development plans.

Findings and Recommendations:

1. Costs of the technologies and contribution to national economic development as criteria were given highest weights as the country's priority remains sustainable development and poverty eradication.
2. Clean and efficient cookstoves and portable solar lighting devices were given highest scores because of their potential for use in rural households and institution and the fact that the country has no national grid. These technologies have social benefits considering the effects of charcoal and firewood on the majority of women and children. Clean cook stoves and portable solar lighting devices offer an immediate solution and has potential to reduce ailments related to indoor pollution resulting from use of kerosene for lighting while at the same time contributing to reduction of GHGs emissions.
3. Additionally, decentralised solar power with Solar PVs provides a good option for the country's major unconnected population. However, this was given less scores due to considerable costs implications for the majority poor population.

CHAPTER 4: TECHNOLOGY PRIORITIZATION FOR THE FORESTRY SECTOR

4.1 Introduction

The critical role of Somalia's natural resources including forests to national development has been recognized in its National Adaptation Programme of Actions(NAPA), NDC, National Development plan 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." However, with the absence of a functioning government in the last few decades, deforestation has become very rampant with the problem being exacerbated by demand for wood fuel in rural areas and the lucrative charcoal business which is in demand in urban areas and ready export markets. The Forestry sector is a large contributor to Somalia's emissions and thus effective management of forest resources is both an important mitigation contribution but also has significant sustainable development benefits.

This chapter provides and overview of the sector in Somalia, GHG emissions from the sector, mitigation technologies options and prioritisation of the technologies.

4.2 Overview Status of the Forestry Sector in Somalia

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[29]. In the 1980s, Somalia's total forest cover was estimated at about 62% of the country's landmass. Somalia'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 58 below. 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.[30]

[29] "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.

[30] FAO. 2014. Forest Resources Assessment: Somalia Country Report. Rome

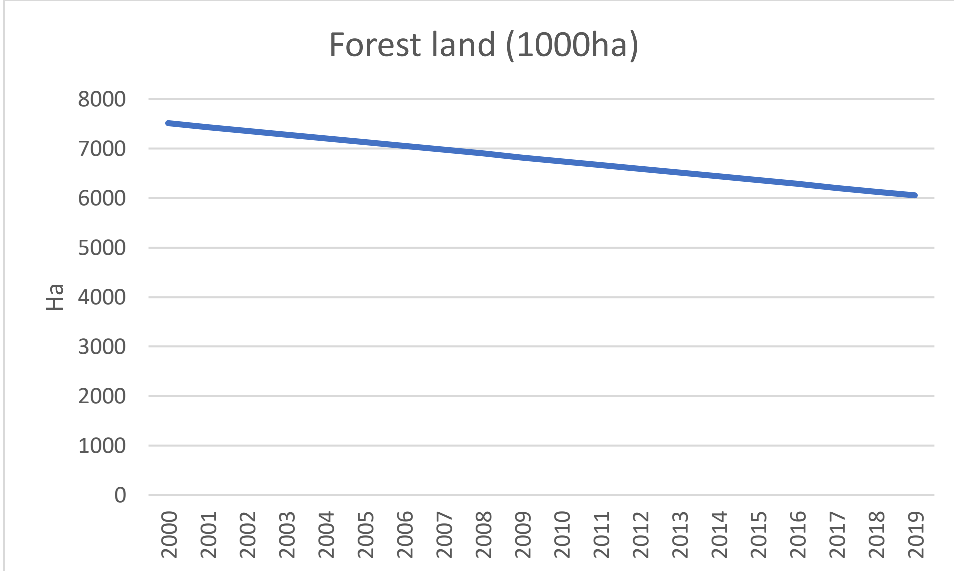

Figure 9: Annual deforestation rate

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.

Article 47 of the 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 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.[31]

Furthermore, the country has a long stretch of coastline of approximately 3,333 kilometres 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.

The forestry sector continues to face a number of challenges that hamper efforts towards sustainable management of the resources. These include: weak regulatory and institutional frameworks for

[31] Draft Environment Management Bill 2020

enforcement, insecurity, increasing international charcoal business, lack of alternative energy options and climate change impacts.

Region	Land area in hectares
Jubabbada Hoose	110,000
Jubbadda Dhexe	17,800
Shabeelaha Dhexe	6,800
Shabeelaha Hoose	6,350
Sanaag	5,290

Table 8: Somalia tree cover loss 2001-2017[26]

Region	Area of forest loss (hectares)
Jubbada Dhexe	155,000
Jubbada Hoose	131,000
Shabbellaha Hoose	393
Shabbellaha Dhexe	192
Bay	64

Table 9: Somalia tree cover loss 2001-2017[26]

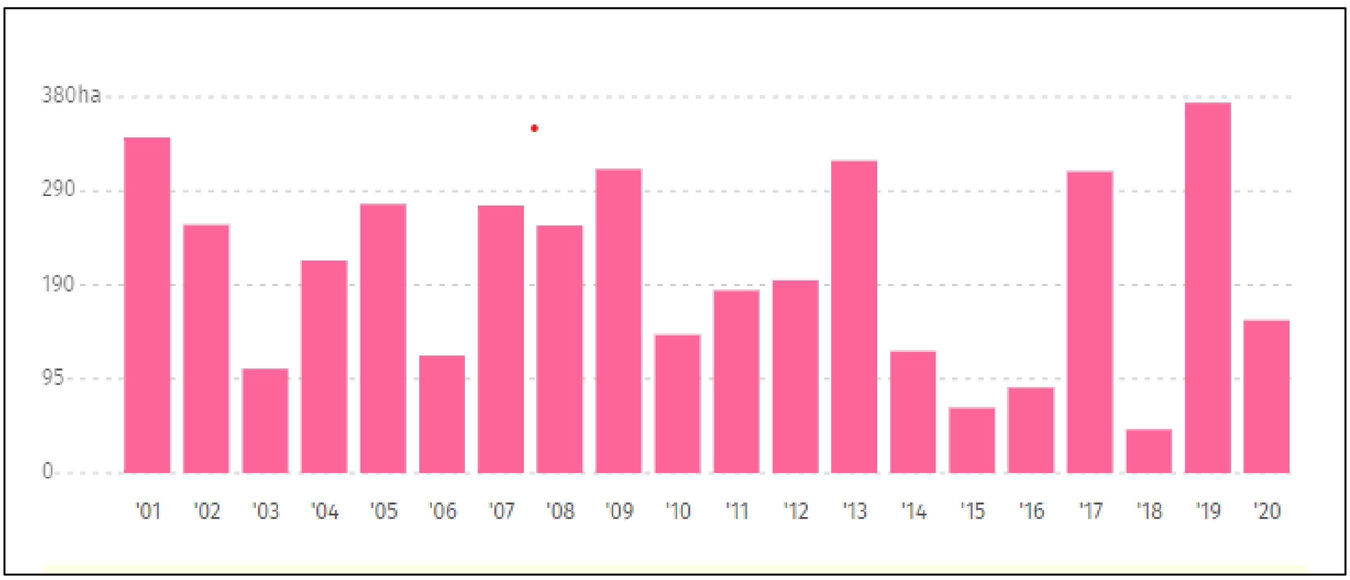

Figure 10: Tree cover loss in Somalia between the years 2001 to 2020. Source: Global Forest Watch[32]

4.4 National Decision context

The Federal government of Somalia recognizes the vital role the forestry sector plays in achieving national development agenda. The constitution considers protection and conservation of Somalia's natural resources including forests against unsustainable exploitation and guaranteeing an environment that safeguards everyone's rights as given. The constitution states that "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

[32]https://www.globalforestwatch.org/dashboards/country/SOM/

resources of the country, whilst being protected from excessive and damaging exploitation of these natural resources".

The NAPA 2013 considers forestry resources and aims to prevent deforestation, increase tree planting, improving rangelands, set regulations for rotational grazing and protection, and supervision of grazing areas in the country. The Somalia NDP 2020-2024 considers conservation and sustainable management of its forest resource as critical. The plan targets to attain the following: By 2020, ensure the conservation, restoration and sustainable use of terrestrial and inland freshwater ecosystems and their services, in particular forests, wetlands, mountains and drylands, in line with obligations under international agreements

- Promote the implementation of sustainable management of all types of forests, halt deforestation, restore degraded forests and substantially increase afforestation and reforestation globally

Overall mandate of Somalia's forest resources management falls under the Ministry of Livestock, Forestry and Range (MoLFR) in Somalia. Its mandate is "to create policies, regulations and frameworks as well as provide oversight of livestock development, conservation of forests and range management to promote sustainable economic development and food security in the country".

4.5 GHG Emissions

Land Use, Land-Use Change and Forestry (LULUCF) is a mitigation sector under the United Nations Framework Convention on Climate Change (UNFCCC) which covers emissions and removal of GHG gases from land use, land-use changes and forestry activities such as deforestation. The forestry sector is among the major contributor to estimated CO2 emissions in Somalia. Increased deforestation continues to threaten the available carbon sinks leading to more emissions from the forestry sector. Increased demand for wood fuel and charcoal has been a problem even after Somalia's government stabilized in the last decade. An estimated 8.2 million trees were cut down for charcoal between 2011 and 2017.

According to INC 2018, Forest and Land Use Sector account for 41.86 $MtCO_2$ eq in 2015 (this is apportioned to the AFOLU) as shown in fig 11 below. Carbon dioxide (CO2) emissions remain the major source of total emissions in the AFOLU sector in Somalia. It contributes 61 percent of sector emissions with Methane (CH4) and Nitrous Oxide contributing 27 percent and 12 percent respectively in 2015. Conversions of Forestlands to other land use activities such as croplands and grasslands are the major LULUCF activities which account for much of the Carbon dioxide (CO2) emissions in Somalia. This is shown below in the emission levels by gas in Somalia.[33]

[33] The Initial National Communication for Somalia -2018

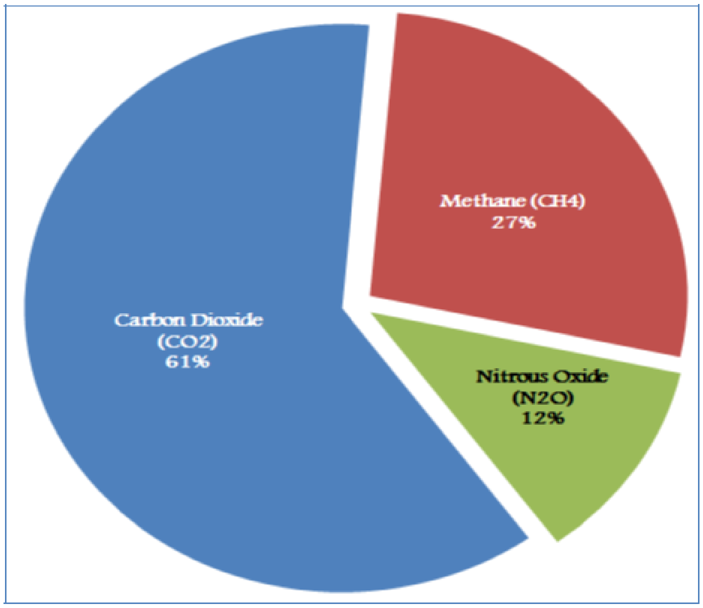

Fig11: Somalia Emissions by Gas -2015, INC 2018

This figure is contested national experts during consultations as information from other sources provided different data sets for the sector. It was noted that other international data including the WRI online climate watch data which estimates that the emissions from the sector at approximately 17.35 $MtCO_2$ eq in 2015. Using the average of the two figures; the emissions from the LULUCF sector is capped at 29.0 $MtCO_2$ eq. Using the same assumptions in the INC, the sectors emissions is likely to increase to 50.65 $MtCO_2$ eq in 2030.

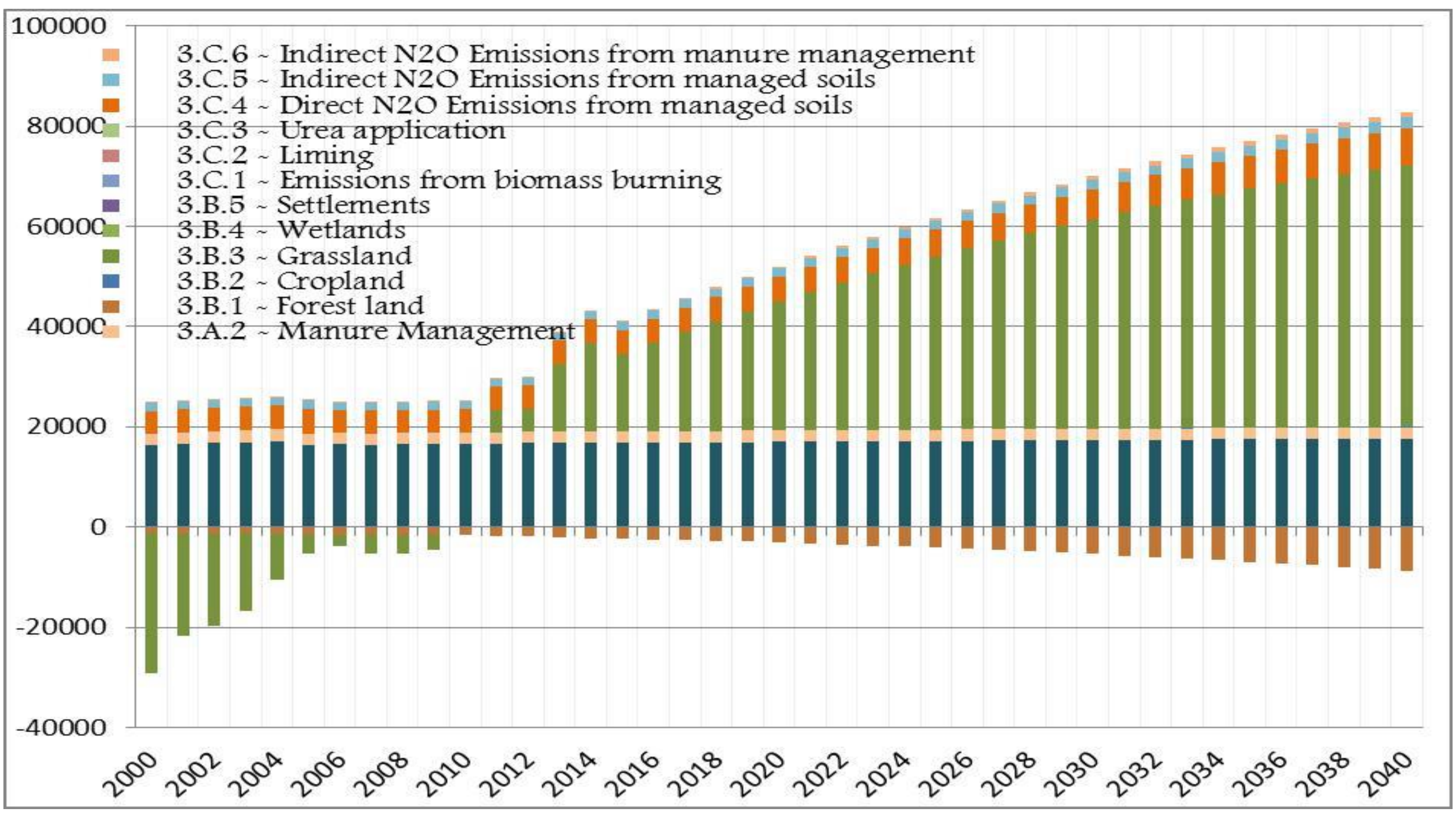

Figure 12: INC 2018; Business as Usual (BAU) projected emissions in the AFOLU sector from 2000-2040

4.6 Mitigation technology Options for the sector

In Somalia's NDC, Initial National Communication and the National Development Plan, afforestation and reforestation, agroforestry and reduction of land degradation have been prioritized as areas within the forestry sector for urgent policy, legislative and technological measures and actions to not only address climate change but also mitigate against natural disasters, restore food security, enhance resilience and spur economic growth.

During the TNA process, the stakeholders decided to unpack the broad mitigation measures to the following hard and soft technology options of the sector:

4.6.1Afforestation and reforestation activities

This involves undertaking reforestation actions such as the establishment of tree nurseries, production of tree seedlings and planting seedlings aimed at restoring the original status of the forest so that it regains its productivity and richness in species diversity. Afforestation measures such as tree planting can result in the establishment of plantations leading to massive carbon sequestration.

Assuming 5% of forest/ tree cover NDC target is achieved by 2030 would mean that 1.17 million hectares of forest are established in ten (10) years. This means establishing at least 117,000 Ha of forest per year. The afforestation and reafforestation programme will target forests including inter alia: dryland forest restoration activities, awareness raising, consultation and demonstration; capacity building; development, testing and application of compensation and benefits-sharing mechanisms; measuring, monitoring and reporting; and research. This is expected to abate up to 16.0MtCO2eq in 2030.

4.6.2 Development and implementation of Forest legislation and National Charcoal Policy

The country lacks effective policy and legislative framework for the management of forests both at national and federal levels. As a soft measure, the development of national forestry legislation and finalisation of national charcoal policy is a great step towards Somalia's mitigation measure under the sector. Such measures should also be implemented at the six federal states.

Reducing emissions through avoided deforestation would greatly contribute to environmental conservation and sequester considerable quantities of carbon. 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.

4.6.3 Coastal/mangrove forest restoration activities

The country has a long stretch of coastline of approximately 3,333 kilometres 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.

4.6.4 Agroforestry

Agroforestry is the mitigation option with the greatest emission reduction potential. Agroforestry is the interface between agriculture and forestry and encompasses mixed land-use practices. The term typically refers to land-use practices in which trees and other woody perennials are spatially or temporally integrated with crops and livestock on a given unit of land.

Somalia's higher rainfall and irrigated areas have the most potential for agroforestry. Agroforestry can benefit both small and large farmers. Small farmers require a large number of products from their land; food, fodder, and wood for fuel, construction and making implements. Agroforestry would be of benefit by increasing yields of certain crops, through soil protection and by providing other useful products. They are also likely to adopt a diverse farming system to minimize risk. Large farmers have capital that they can invest in expensive systems such as shelterbelts. According to Leslie 1991, a system that has much potential is that of alley cropping or establishing hedges using nitrogen-fixing tree species such as *Leucaena leucocephala. L. leucocephala* grows rapidly on irrigated land and grows well in some rainfed areas. Intercropping crops with legumes can enhance the fertility of the soil by increasing nitrogen levels that in turn can significantly increase crop yields.

The focus will be on Somalia's arable land of 8.1 M hectares as stated in the National Food Security and Nutrition (FSN) Policy 2020. With little data available on the existing prevalence of agroforestry systems, so a conservative target of converting 5% percent of fertile land to agroforestry systems was selected for the NDC. This was determined to be a feasible gross target (400,000 hectares), that would be converted over a ten-year period (2021-2030).

Implementing agroforestry across 400,000 ha between 2020 and 2030 would abate 0.14 MT CO2eq in 2020, rising to 3.8 MT of CO2eq by 2030. This would be a significant share of the agriculture sector's total emissions.

4.6.5 Value addition for tree/forest products

This involves use of non-timber forest products tools for conservation and sustainable development. Frankincense and gum arabica for cosmetic and pharmacies is on high demand and at the same time as the tree populations were declining, resource tenure security was weakening, drug use was increasing, and the supply chain was becoming more complex. These factors combine to incentivize short-term unsustainable practices, and the lack of traceability and transparency prevents international buyers from meaningfully engaging with the system. However, new technologies and approaches being employed mean that buyers will soon be able to clearly direct their purchasing in order to incentivize sustainable practices and purchase resin in an ethical manner.

4.6.6 Monitoring and satellite imaging

Mapping of forests and forests degradation is an important step towards effective forests management. Regular and accurate monitoring of forest cover, forest cover change and drivers of change provides the necessary information to support policies and management practices to protect, conserve and sustainably manage forests. Somalia lacks forest monitoring and remote sensing capacities which is essential to quantify forest degradation.

4.7 Criteria and process of technology prioritisation for the Forestry Sector

The technology prioritization is a stakeholder participatory process. Based on consultations in the mitigation working group involving relevant, the long list to technology options in the sector were reduced to six, which were considered for the prioritization process. The TNA coordinator and consultant facilitated the discussions where the shortlist of technologies was identified.

The next step was preparation of technology fact sheets by the consultant and also informed by local stakeholders. The factsheets are included in this report as annex 2.

Multi criteria analysis tool was used to rank the shortlist of the technologies with information in the fact sheets and stakeholder consultations determining the results of the prioritization process. Stakeholders went through a short capacity building session on the MCA process and the expectations for the technology prioritization process. Consultant presented a potential list of c*riteria* for prioritization during the workshop*.* Participants were also asked to critically review the list of criteria, make changes where necessary or even add additional criteria if necessary.

The criteria agreed and used for prioritization of the forestry sector technologies are:

1. Cost of implementation – This includes initial capital cost and operating costs of each of the technologies. Cheaper technologies were given clear preference compared to more expensive options.
2. Economic development benefits – This considers the ability of the technology to improve local and national economy; catalyze private investment; and create jobs.
3. Climate change benefits (adaptation/resilience benefits & mitigation) – Stakeholders considered wholistic climate benefits and effects in this criterion.
4. Social benefits including contribution to gender equality and health benefits or effects of the technologies
5. Environmental benefits – Considering the importance of forestry sector in the country's sustainable development, this criterion was given importance during the technologies prioritization process for the sector.
6. Ease of implementation – considering the unique situation is the country, attention was given to this criterion to assess the simplicity and ease of implementation by broad stakeholders in most regions of the country.

The attached fact sheets (Annex 2) provide information on each of the technologies including a description of the technology against the specific criterion. Expert judgement was also used in providing scores against each criterion.

4.8 Results of technology prioritisation for sector

The MCA tool was used to undertake technology prioritisation for the sector. Stakeholders did the scoring of technologies (with 0 least preferred and 100 most preferred). After discussion among the stakeholders on each of the criteria and scores, guided by the consultant, the working group voted for one criterion at a time agreed on a particular score for each technology against each criterion.

Additionally, the group agreed on weight for each of the identified criterion, with total weight score for all criteria summing up to 100. Below is a result of scoring exercise for different technologies by stakeholders after discussions and consensus in the working group.

Scoring Matrix							
Forestry Sector Technology		Benefits					
	Costs	**Economic**	**Social**	**Environmental**	**Climate (adaptation & Mitigation)**	**Ease of implementation**	
	Criterion A	**Criterion B**	**Criterion C**	**Criterion D**	**Criterion E**	**Criterion F**	
1. Afforestation and reforestation activities	80	70	70	90	70	80	
2.Develop & implement forest law and charcoal policy	40	60	70	90	70	50	
3. Coastal/mangrove forest restoration activities	60	70	40	90	80	70	
4. Agroforestry	80	80	60	90	70	70	
5. Value addition for tree/forest products	90	90	50	50	20	70	
6. Monitoring and satellite imaging	40	40	20	70	50	50	
Scoring scale	0=very high cost --> 100=very low cost	0= Very low --> 100= Very high	0= Very low --> 100= Very high	0= Very low --> 100= Very high	0= Very low --> 100= Very high	0=Very Difficult -->100=Very Easy	
Criterion weight	15	20	10	30	10	15	100

Table 10: Scoring matrix - Forestry sector

The resulting weighted scores were summed up for each technology option to derive an overall score value. The aggregation of the weighted scores was also conducted using the UNEP-DTU MCA calculator. The results of the aggregation of the weighted scores resulted into decision matrix in table 11 below from which the decision on the prioritized technologies was based.

Decision Matrix - Weighed Scores								
		Benefits				Other	Total score	
Forestry Technology	**Costs**	**Economic**	**Social**	**Environmental**	**Climate related**	**Ease of implementation**		Rank
	Criterion A	**Criterion B**	**Criterion C**	**Criterion D**		**Criterion F**		
1. Afforestation and reforestation activities	1200	1400	700	2700	700	1200	7900	1
2.Develop & implement forest law and charcoal policy	600	1200	700	2700	700	750	6650	4
3. Coastal/mangrove forest restoration activities	900	1400	400	2700	800	1050	7250	3
4. Agroforestry	1200	1600	600	2700	700	1050	7850	2
5. Value addition for tree/forest products	1350	1800	500	1500	200	1050	6400	5
6. Monitoring and satellite imaging	600	800	200	2100	500	750	4950	6
Criterion weight	15	20	10	30	10	15	100	

Table 11: Decision matrix - weighed scores

Following the prioritization process, the table below shows the results of the ranking of the top technologies:

Rank	Technology	Scores	Rank
1.	Afforestation & reforestation activities	0.790	1
2.	Agroforestry	0.785	2
3.	Coastal/mangroves restoration	0.725	3
4.	Develop & implement forest law and charcoal policy	0.665	4

Table 12: Ranking results forestry sector

4.9 Sensitivity Analysis

In addition, sensitivity analysis was conducted to confirm consistency of the results. This was done based on the secret voting, where participants sent through the preferences and individual votes directly to the consultants virtually. In some cases, there were differences in scores, but the sensitivity analysis did not change the overall results of the priority technologies in the sector. Below is the scoring and decision matrices of the sensitivity analysis

Sensitivity - SCORING MATRIX							
Technology		Benefits					
	Costs	**Economic**	**Social**	**Environmental**	**Climate related**	**Ease of implementation**	
	Criterion A	**Criterion B**	**Criterion C**	**Criterion D**	**Criterion E**	**Criterion F**	
1. Afforestation and reforestation activities	80	70	70	90	70	80	
2.Reducing deforestation and forest degradation	40	60	60	90	60	40	
3. Coastal/mangrove forest restoration activities	70	70	50	90	80	80	
4. Agroforestry	80	80	60	90	70	70	
5. Value addition for tree/forest products	90	90	50	60	20	70	
6. Monitoring and satellite imaging	40	40	20	70	50	50	
Scoring scale	0=very high cost --> 100=very low cost	0= Very low --> 100= Very high	0= Very low --> 100= Very high	0= Very low --> 100= Very high	0= Very low --> 100= Very high	0=Very Difficult -->100=Very Easy	
Criterion weight	15	20	10	30	10	15	100

Table 13: Sensitivity analysis scores - Forestry sector

Sensitivity Decision Matrix - Weighed Scores									
			Benefits					Other	Total score
Technology	**Costs**		**Economic**	**Social**		**Environmental**	**Climate related**	**Ease of implementation**	
	Criterion A	**0**	**Criterion B**	**Criterion C**	**0**	**Criterion D**		**Criterion F**	
1. Afforestation and reforestation activities	1200	0	1400	700	0	2700	700	1200	7900
2. Reducing deforestation and forest degradation	600	0	1200	600	0	2700	600	600	6300
3.Coastal/mangrove forest restoration activities	1050	0	1400	500	0	2700	800	1200	7650
4. Agroforestry	1200	0	1600	600	0	2700	700	1050	7850
5. Value addition for tree/forest products	1350	0	1800	500	0	1800	200	1050	6700
6. Monitoring and satellite imaging	600	0	800	200	0	2100	500	750	4950
Criterion weight	15	0	20	10	0	30	10	15	100

Table 14: Sensitivity analysis -decision matrix for the forestry sector

From the foregoing, for the forestry sector, stakeholders gave more importance to the criterion on environmental and economic benefits of the technology. Other important criteria include ease of implementation and costs of the technology. The ranking of the technologies was not affected by sensitivity analysis. Afforestation, agroforestry and coastal forests restoration were selected as priority technologies. Development of relevant legislation and policy framework was selected as a priority to facilitate the implementation of the other key technologies across the sector.

CHAPTER FIVE: SUMMARY AND CONCLUSIONS

The TNA process (mitigation focus) plays an important role in identifying priority technologies, with multiple sustainable development benefits for deployment in the priority sectors of Energy and Forestry. The TNA process was highly consultative process and utilised multicriteria analysis to identify priority technologies. The active support of the TNA Coordinator, the MoECC, the Working Groups and all the stakeholders was indispensable in fulfilling this assignment.

The results of the TNA assessment and the priority technologies selected through the MCA process are consistent with national development priorities and climate change goals for the sectors.

Priority mitigation technologies in the sector; include energy efficient cook stoves, portable solar lanterns and distributed solar PVs. These technologies respond to the needs of the majority rural population of Somalia, contribute to economic, social, health and have climate mitigation benefits. These technologies are relatively cheap for majority of the population and could help create job opportunities.

Forestry is a key source of Somalia's emissions, primarily from deforestation, where forests are cleared for fuelwood and charcoal production. The sector provides the highest mitigation potential to achieve the country's NDC target. Mitigation technologies in the sector will contribute to emissions reductions and achievement of country's NDC goals while contributing to broader sustainable development objectives. The priority technologies for the sector include afforestation and restoration of forests on degraded lands include coastal forests, agroforestry and development of necessary regulatory frameworks.

To implement the priority technologies in the sectors, Somalia will need to put in place enabling policy and strengthen institutions frameworks, attract significant international climate finance and investments across sectors, receive support in terms of capacity development and awareness creation for various institutions and stakeholders to achieve the desired results at scale.

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ANNEXES 1: TNA SOMALIA STAKEHOLDERS

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Fatuma Mohamed	TNA Mitigation Consultant
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Annex 1.2 National Climate Change Committee (NCCC) Somalia

	NAME	INSTITUTION
	Representative of Permanent Secretary	Office of the Prime Minister
	Director General	MoECC
	Representative	Federal level Sectoral Ministries
	Representative	State level Sectoral Ministries
	Representative	Directors of Governmental Agencies
	Representative	civil society organizations
	Representative	private sector.

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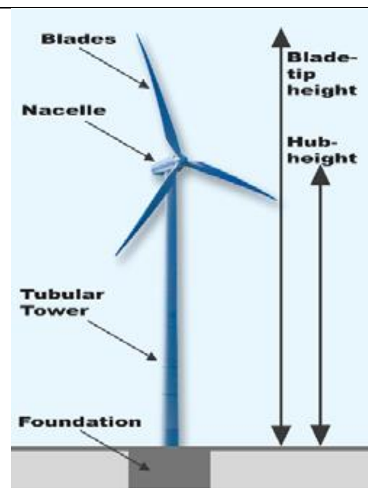
ANNEX 2: TECHNOLOGY FACT SHEETS

Technology Fact Sheets for the Energy Sector

i) SOLAR HOME SYSTEMS (SHS)	
Introduction	Somalia lies in the Horn of Africa at 10 00N and 49 00N thus exposed to abundant sunshine all year through. Solar lamps and solar home systems are increasingly seen as a route to electrification in rural areas of sub-Saharan Africa and Asia. Standalone off-grid solutions i.e. Solar Home Systems (SHS) and solar lamps are therefore a viable complement to mini-grids. SHS typically include solar panels, a rechargeable battery, and LED lighting arrays, and many include mobile phone charging capabilities. Larger systems include an interface for connecting appliances such as efficient DC radios, televisions, fans, and other small appliances. Replacing traditional fuel-based energy sources (kerosene, candles, diesel generators) with quality solar products has a major positive impact on the local environment and household health, as well as disposable income. In Somalia, solar energy devices including Solar Home Systems are now readily available for importation and are commercially viable for private sector investment and can provide household lighting and power household devices depending on the capacity. If fully adopted in Somalia, solar powered electricity could also power wireless communications technologies that are linked to processes of economic integration and greater rural-urban connectivity.
Technology Characteristics	Solar electricity is the electric power generated from sunlight using devices called *solar cell modules*. Electric devices transform solar energy into electricity for lighting, pumping water, powering radios, etc.
Country Specific Applicability and Potential	Solar Home Systems has very high potential given the fact that the country has all year sun exposure and is close to the Equator with 2500 to 3000 hours per annum solar irradiation.
Status of technology in country	Solar Home Systems and solar lamps are the main source of electricity is some municipalities of Somalia and other rural off grid areas. In spite of the high initial costs of investment and insecurity of solar panels, investment in solar power remains the most viable renewable energy source in most parts of the country.
Benefits to economic/Social and environmental development	Employment creation Social and health benefits include: i) Better health as the technology does not emit any pollution as opposed to use paraffin lamps ii) Good learning opportunities for students in the evenings iv) Improved health. Traditionally families in rural areas use paraffin candles and lamps as source of light. These candles and lamps produce fumes which are harmful to human health

Climate change mitigation benefits	SHS can replace use fossil fuels for lighting and powering electrical appliances
Financial requirements and costs	On average a 20 Watt-peak system costs approximately USD 200 while a 100 W panel SHS costs about USD 800-100 depending on the quality.
ii) ENERGY EFFICIENT COOKSTOVES	
Introduction	Biomass energy – mainly charcoal and firewood is the main source of energy for domestic and commercial cooking at 80 percent energy usage. Acacia bussei is the most common wood for charcoaling and in Puntland, it is estimated that the annual rate of Acacia bussei decline is about 5 and this rate is validly applicable across Somalia. The output of charcoal in north-eastern Somalia was estimated to be 4.8 million bags (about 25-30kg each) and most of it is for export to the Gulf States and for domestic usage. Introduction of Energy Efficient Cook Stoves also known as Improved Cook stoves (ICS) 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. The ICS will reduce global greenhouse gas emissions by reducing the quantity of non-renewable biomass consumed as cooking fuel. Further, the end users of the ICS provided will benefit from having improved access to the ICS market by spurring growth of private sector in sale, repair and maintenance of the ICS stoves. ICS also have the potential to reduce indoor air pollution levels and the various health risks associated with breathing polluted air, thus resulting in a range of social and economic benefits to users. ICS can therefore deliver a long- term, secure and simple contribution to sustainable development in Somalia and such an initiative can be attractive to investors in Carbon Finance through the International Carbon Market Mechanisms since a rich history exists globally under the Clean Development Mechanism on ICS. Introduction of ICS in the rural and urban areas for both charcoal and fuelwood usage can support to reduce the negative impacts due to fuelwood and charcoal withdraw for consumption at the household level.
Technology Characteristics	There are various types of improved cookstoves globally and in the East Africa for both firewood and charcoal usage. Compared to the replaced traditional cooking stove used by the end-users, ICSs are more efficient while providing the same service. They allow better heat retaining, i.e. quicker heating-up and longer cooking times with less wood fuel (and combustion fumes), curbing deforestation. Current ICS in the market have a thermal efficiency of 20 to 50 percent. Currently the common systems used for cooking are the traditional open fire (3-stone) system and traditional stoves which are still dominant in most of the households. The ICS model reduces fuel use and the emissions reductions by improving heat transfer and combustion efficiency compared to the three-stone or tin cookstoves.

Country Specific Applicability and Potential	Somalia's population mainly uses firewood and charcoal for cooking and thus the ICS technology is a viable and applicable technology to be introduced in the country.
Status of technology in country	Although Somalia does not the widespread usage of energy efficient cookstoves, the technology is widely available in the neighbouring countries for importation and distribution. Since biomass (charcoal and firewood) is the main source of cooking energy, efficient energy cookstoves are well suited for usage of either fuel source.
Benefits to economic/Social and environmental development	Social: The ICS has the capacity to reduce indoor air pollution providing a safer method for combusting biomass for cooking, helping to reduce burn injuries. Through improved thermal efficiency, ICS reduce energy needs and the associated household expenditures on cooking fuel. In addition, considerably less time will need to be spent collecting wood fuel for the family home thereby reducing the work burden on rural families and presenting alternative opportunities for economic development, as saved household labour can be diverted to more productive economic activities. Economic: Purchasing or collecting firewood or fossil fuels to boil the water constitute a significant expense for the very poorest households and communities. Due to high fuel costs, boiling water for drinking is often not done. ICS will improve access to clean drinking water by enabling households to boil drinking water using limited biomass energy, which will reduce cost for families and thereby reduce child and adult morbidity and mortality, improve attendance at school, increase productivity, and more generally give a sense of hope and opportunity. Poverty reduction, by lowering households' expenditure for charcoal, fuelwood or kerosene, and improving engagement in education by permitting more evening study time for students. • Marketing of ICS will help strengthen the employee base of implementing organizations and create direct local employment opportunities in operational and/or management roles, as well as possible future assembly, manufacturing, distribution and sales activities. The use of ICS will require capacity building to ensure the strengthening of the ICS value chain to contribute to future local economic development and technological self-reliance • Environmental well-being: The use of charcoal and fuelwood has been documented as one of the major causes of deforestation. The introduction of ICS would reduce the dependency on woody biomass for cooking and reduce the pressure over the remaining forest resources. The ICS technology reduces greenhouse gas emissions over its lifetime. The use of inefficient cooking stoves and three-stone fires in homes has been found to cause considerable disease and death, particularly among women and children.
Climate change mitigation benefits	There is documentary evidence that use of ICS contributes to decrease of GHG emissions caused by the burning of non-renewable biomass by use of

	improved cooking devices. The associated adaptation co-benefits and sustainable development benefits include energy access, improved health, improved education standards, improved resilience, among others.
Financial requirements and costs	The average cost for a household ICS ranges between 30 to 50 dollars depending on the energy efficiency rating and the brand. Noting that over 69 percent of the Somalia population lives below of the international poverty line of USD 1.90, the best model of introduction of ICS in the country could be through carbon finance where households are supplied with the cookstoves, and they pay small amounts over time through a microfinance arrangement with the carbon buyers or a local microfinance intermediary
iii) WIND POWER TECHNOLOGY	
Introduction	Wind power energy use is growing globally and its share in the renewable energy sector is growing exponentially. Wind turbines are used as main renewable energy sources for supply to national or sub-national grid systems or as auxiliary and supplemental power sources in various sectors. By design, a wind turbine is a machine that converts energy in wind into mechanical energy to electricity.
Technology Characteristics	 Wind turbine technology by design is composed of 3 rotating blades and a tubular tower as shown in the diagram above. The tubular tower height ranges between 50-80 meters with a diameter of 47-80 meters. The wind turbine generator is installed at such heights so that high wind velocities can be easily harnessed without being affected by turbulence caused by obstacles on the ground such as trees, hills and buildings[34]. When correctly installed, the power ratings vary and could range between 660kW to 1.8MW[35].
Country Specific Applicability and Potential	Limited data exists on Somalia's wind potential. However, it is generally known that the country has strong winds, and the African Development Bank has estimated that the county has an annual average wind speed of 1.5 to 11.4 m/s depending on the area. The Federal Government of Somalia

[34] United States Environment Protection Agency,. August 2013. Renewable Energy Fact Sheet: Wind Turbines.

[35] Renewable Energy Research Laboratory. University of Massachusetts at Amherst. Wind Power: Wind Technology Today. Community Wind Power Fact Sheet. #1.

	has indicated in its draft Energy Policy (version of September 2018) that it shall support investment and use in wind energy.
Status of technology in country	Somalia has limited use of wind power energy with its contribution to the energy generation mix estimated at 0.1 percent and is only currently in use in certain areas in the country. However, according to the World Bank[36] (2018), the wind model for Somalia is very "encouraging "but bankable wind projects able to attract private investment in the sector require higher level of certainty. Wind power site mapping will have to be undertaken along with other pre-feasibility studies.
Benefits to economic/Social and environmental development	Social: • Wind power facilitate generation of sustainable electric power • Provides local employment during plant construction and operation of the wind power plant Environmental: • Wind power is a sustainable and renewable energy source. It is non-polluting to all environmental media (land, air, water) and does not generate hazardous waste). Land below medium or commercial wind farms can be used for animal grazing and farming. Economic: • Wind energy contributes to the local economy through creation of employment • Improves power security of the country • Displaces electric power generated using fossil fuels thus resulting in a reduction of fossil fuel importation
Climate change mitigation benefits	Wind generated energy reduces generation of electric power using fossil fuels, thus resulting in reduced GHG emissions.
Financial requirements and costs	The cost of wind turbine power technology is very competitive when compared to conventional power sources but the environmental and climate change benefits far outweigh the costs. Depending on the size of the wind farm, energy production is affordable when compared to conventional power production technologies. The cost of generating electricity per kilowatt hour reduces as the size of the wind farm and size of turbines increases. Key cost drivers for wind power include annual capacity factor, location of the wind farm, wind quality and installation and maintenance costs. Pre-requisite assessment of the wind speeds at a potential site is indispensable in addition to other pre-feasibility studies before investment. Average global indicative large scale wind farm installation costs vary from USD 1,000 to 1,200 kilowatt per hour.[37]
iv)	**PORTABLE SOLAR LIGHTING DEVICES/SOLAR LANTERNS**

[36] World Bank. Somali Electricity Access Project. (P165497). Combined Project Information Documents/ Integrated Safeguards Datasheet (PID/ISDS) 2nd October 2018.

[37] IRENA, 2016 The power to change: solar and wind cost reduction potential 2025

Introduction	Solar energy is the cleanest, most abundant renewable energy source available in Somalia. Portable solar lanterns are an affordable and convenient alternative to solar home systems in off-grid areas in many developing countries including Somalia. Portable solar lanterns provide higher quality light than the use of candles or kerosene lamps. They are also used to provide street lighting in rural areas
Technology Characteristics	Current technologies of solar lanterns use Light Emitting Diode (LED) thereby providing quality 4-5 hours of quality lighting before requiring recharge[38]. A portable solar lantern is mainly composed of the LED bulb, internal battery and an inbuilt or separate solar PV panel for charging the lantern. Photovoltaic (PV) panel directly converts energy from sunlight into electricity. When sunlight strikes the PV module, made of a semiconductor material, electrons are stripped from their atomic bonds. This flow of electrons produces an electric current.[39] The Glowstar lantern developed by Practical Action Kenya and now marketed by Sollatek is a good example of a robust version of a solar lantern, which can withstand harsh African conditions. It uses a PV panel to charge up a 12-Volt lead-acid gel cell battery located in the base of the lamp which is designed to withstand many charge/ discharge cycles. Other manufacturers may have different battery specifications. The light source is a compact fluorescent tube which should last four years in normal operation.[40]
Country Specific Applicability and Potential	Solar Lanterns are commercially available globally through a range of companies. In Somalia, portable solar lanterns are already in use in off-grid areas and are best suited for nomadic pastoralists and small-scale traders in the market centres. Research documented by the CTCN notes that solar PV is suitable where the cost of grid extensions is high, insolation levels high, and the receptor communities geographically scattered as is the case in Somalia thus making the technology viable for off-grid rural areas.
Status of technology in country	Communities in off-grid rural and urban areas of Somalia are already using solar lanterns to a limited degree. Upscaling usage of the technology can be achieved since the enabling policy for both the NDC and the draft Energy policy advocate for use of renewable sources of energy to enhance energy security.
Benefits to economic/Social and environmental development	Social: • Portable solar lanterns are convenient for use for nomadic pastoralists, small scale traders in market centres thus giving convenience of mobility • Enhanced security provided through provision of lighting in off grid areas • Displacement of kerosene lamps which are often expensive and dirty will lead to enhancing education by expanding time for studying.

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39 Solar Energy Industries Association. Solar Energy Technologies. (www.seia.org)

40 https://www.ctc-n.org/technologies/solar-lamps

	• Improve lighting output Environmental: • Improved indoor health due to displacement of kerosene lanterns thereby reducing indoor air pollution and fire hazard associated with flammable fuels such as kerosene • Contribution to implementation of several Sustainable Development Goals Economic: • Generate savings on the energy spending • Use of the lanterns will enhance national economic development through facilitating a widespread access to sustainable energy services in the form of improved lighting • Improved access to sustainable energy services is a necessity in creating income and employment generating activities • Proper lighting in rural areas and other off-grid areas has significant positive impacts on productivity broadly and income-generating activities specifically
Climate change mitigation benefits	It is estimated that the average solar lantern can achieve 0.08 tCO_2e/solar lantern greenhouse gas emissions reduction. The technology displaces use of kerosene or other biomass fuels for lighting.
Financial requirements and costs	Costs will relate to uptake of the solar off-grid portable lighting system across off-grid urban and rural areas as well as awareness raising campaigns, training and maintenance services. The current market price for one portable solar lamp ranges from USD 20 upwards depending on size and quality.
v) ENERGY EFFICIENT LED BULBS	
Introduction	The light-emitting diode (LED) is today's most energy-efficient and rapidly developing lighting technology. Quality LED light bulbs last longer, are more durable, and offer comparable or better light quality than other types of lighting. They are a highly energy-efficient lighting technology that use at least 75% less energy, and last up to 25 times longer, than incandescent lighting. In a country where electricity is mainly from thermal sources through inefficient technologies with documented energy losses, widespread use of LED energy efficient bulbs has a large potential to displace the incandescent bulbs and impact on energy savings and reduce greenhouse gas emissions.
Technology Characteristics	Light Emitting Diodes (LED) are electronic devices that emit visible light when electric current flows through them. LEDs are manufactured using semiconductors, like silicon and germanium. The semi-conductors are alloyed or doped with small quantities of a chosen impurity. According to the impurities chosen, a distinction is made between p-type or n-type, where the letters p and n stand for positive and negative respectively. The semiconductor alloy therefore contains half of p-type and half of n-type semiconductors and together they make a junction called a pn junction. When the LED is switched on, electric current passes through the pn

	junction and charge carriers, both negative (electrons) and positive (holes), are created. When electrons recombine with holes within the device, they release energy in the form of photons. This effect produces the colour of light that corresponds to the energy of a photon. The light produced depends on the semi-conductor material used in the LED. Semi-conductor material such as gallium arsenide produces mainly red light. Synthetic materials such as p-phenylenyinyl can produce light of any colour.[41] The use of LED lighting technology has grown over the years and is currently available in many countries in a wide variety of home and industrial products. This growth has resulted in increased product availability, improved manufacturing efficiency, and lower prices than originally priced. LED lamps can therefore affordably and effectively replace 40, 60, 75, and even 100-Watt incandescent bulbs. Their useful life is defined differently than that of incandescent or compact fluorescent lighting (CFL) since LEDs typically do not “burn out” or fail. Instead, they experience ‘lumen depreciation’, wherein the brightness of the LED dims slowly over time. Unlike incandescent bulbs, LED “lifetime” is established on a prediction of when the light output decreases by 30 percent[42]
Country Specific Applicability and Potential	Somalia in its NDC has prioritized the following actions, among others, in for its energy sector: • Development of renewable energy electricity • Promotion of distributed renewable lamps • ***Promotion of use of energy efficient light bulbs*** • Promote energy efficiency in electricity transmission Somalia already has an enabling policy and legislative framework for the application and adoption of energy efficient LED lamps. A combination of use of renewable energy coupled with use of energy efficient bulbs will yield multiple benefits in energy savings, economic savings for users/return on investment, reduced greenhouse gas emissions and related benefits.
Status of technology in country	Energy efficient LED lamps are available for importation and distribution within Somalia especially in the urban areas.
Benefits to economic/Social and environmental development	Social: • Improved lighting – LED lamps produce directional bright and intense light thereby giving better lighting experience while using less electricity • Job creation in various aspects of importation, sale, distribution, assembly of luminaries, lighting installation, maintenance services, and monitoring services • Contribution to the national energy efficiency objectives of Somalia thereby assisting with improving energy security for the country • Positive impact associated with green technology transfer

[41] Barefoot Power Lighting Programme.
[42] https://www.energystar.gov/products/lighting_fans/light_bulbs/learn_about_led_bulbs

	Environmental: • The introduction of energy efficient LED lighting technology in Somalia in areas with access to electricity in both commercial and domestic buildings will reduce the consumption, and hence generation electricity from fossil fuel. • Reduction of greenhouse gas emissions from reduced usage of fossil fuel powered electricity • Reduction of air pollutants associated with fossil fuel including particulate matter produced during the burning of fossil fuels to produce electricity • LED lamps do not contain mercury. The aluminium heat sinks can be recycled therefore making them environmentally friendly Economic: • Return on investment. Continuous usage of LED lamps yields significant energy savings. The lamps have a long lifespan thus saving costs for frequent lamp replacement as is the case for incandescent bulbs • Reduction of the overall cost associated with lighting use electricity consumption for commercial, residential and public building owners and occupiers
Climate change mitigation benefits	Reduction of greenhouse gas emissions with continuous and widespread usage of energy efficient LED lamps associated with the energy savings.
Financial requirements and costs	Financial requirements will be associated to the initial installation, where absent, of compatible electric fittings suitable for use for energy efficient LED lamps. However, there are several LED lamps that are compatible with electric fittings of incandescent or compact florescent lamps. The average cost for an LED lamp for domestic usage with a 5-year lifespan ranges from USD 1 to over USD 20 for commercial and industrial usage. Additional costs relate to capacity building of technicians for installation and awareness creation on the benefits of the technology

TECHNOLOGY FACT SHEETS FOR THE FORESTRY SECTOR

i) Agroforestry	
Introduction	World Agro forestry Centre defines agroforestry as an integrated approach to the production of trees and of non- tree crops or animals on the same piece of land[43]. It is a dynamic, ecologically based, natural resource management system that, through the integration of trees on farms and in the agricultural landscape, diversifies and sustains production for increased social, economic and environmental benefits for land users at all levels[44]. The crops can be grown together at the same time, in rotation, or in separate plots when materials from one are used to benefit another. Agro-forestry systems take advantage of trees for many uses: to hold the soil; to increase fertility through nitrogen fixation, or through bringing minerals from deep in the soil and depositing them by leaf-fall; and to provide shade, construction materials, foods and fuel.
Technology Characteristics	Agroforestry involves three main types of systems, and all these can be practiced in appropriate regions of Somalia. 1. Agrisilvicultural systems which are a combination of crops and trees, such as alley cropping or home gardens 2. Silvopastoral systems which combine forestry and grazing of domesticated animals on pastures, rangelands or on-farm 3. Agrosylvopastoral systems which entails combining the three elements, namely trees, animals and crops integrated on a farm[27].
Country Specific Applicability and Potential	Land restoration, reduction of deforestation and provision and conservation of livestock fodder is a top national priority for Somalia. According to the draft National Determined Contribution Financing Strategy[45], agroforestry is a mitigation option with the greatest emission reduction potential in Somalia. This will be appropriate in high rainfall areas and where irrigation is practised and these can benefit both large- and small-scale farmers. Agroforestry is also appropriate for all land types and is especially important for hillside farming where agriculture may lead to rapid loss of soil. Agroforestry technology is relatively well known and practiced by local farmers though at low scale. If adopted effectively implementation, capacity building to farmers would be essential especially on tree species selection, tree seed collection and propagation, fodder harvesting among other useful skills. Working through farmer associations, community organizations or cooperatives can help reduce initial investment costs by sharing the cost of seedling production. Maintenance can be done by farmer beneficiaries themselves.

[43] World Agroforestry web page: (https://www.worldagroforestry.org/about/agroforestry)
[44] FAO web page: (https://www.fao.org/forestry/agroforestry/80338/en/)
[45] Somalia, Federal Republic of., 2021. Nationally Determined Contribution Financing Strategy. Directorate of Environment and Climate Change. Office of the Prime Minister. Mogadishu.

Status of technology in country	Agroforestry is already being practiced in Puntland by the World Agroforestry Centre in collaboration with World Vision and the community under the Re-greening Africa Project. Scaling up of this project and or the lessons and skills learned in appropriate areas can yield multiple benefits. Possible areas for agroforestry in Somalia's include the alluvial plains in the South that are the country's most fertile soils together with the inter-riverine area of Bay. The main agricultural products sold in the domestic market include sugar, bananas, sorghum and corn as well as gums and resins making it ideal for the technology. Somalia's agricultural sector is largely dependent on rain-fed agriculture. This dependency by the majority of farmers on rain-fed agriculture and pastures has made the economy extremely vulnerable to the vagaries of weather. As a result, failure of rains and occurrence of drought during the growing season has regularly contributed to severe food shortages and loss of animals. Further, the main source of energy in the country is biomass – firewood and charcoal. Therefore, the introduction of agroforestry technology will be able to meet multiple needs including enhancing food production through soil nutrient enrichment and harvesting of fruits from fruit trees, fuel wood, fodder production for livestock, reduction of soil erosion and land degradation, among other benefits of the agroforestry technology. One major disadvantage of agroforestry is it is labour intensive at the onset, and these could lead to farmer aversion. However, the benefits are significant and diverse and therefore the Federal Government may need to provide a national agroforestry strategy and action plan for adoption at local levels.
Benefits to economic/Social and environmental development	Social: It increases the income earned and inputs saved through improvements in the farm resource base and products for sale. Through increased yields, it provides significant savings for households on firewood, forage and fertilizer purchase. Health: It can improve medicinal plant conservation, domestication, and propagation; provides nutritious agro-forestry foods, including fruits and leaves; promotes changes in ecosystem structure and function that affect disease risk and transmission[46]. Economic: Purchasing or collecting firewood or fossil fuels to boil the water constitute a significant expense for the very poorest households and communities. Due to high fuel costs, boiling water for drinking is often

[46] Agroforestry technology fact sheet

	not done. ICS will improve access to clean drinking water by enabling households to boil drinking water using limited biomass energy, which will reduce cost for families and thereby reduce child and adult morbidity and mortality, improve attendance at school, increase productivity, and more generally give a sense of hope and opportunity. Poverty reduction, by lowering households' expenditure for charcoal, fuelwood or kerosene, and improving engagement in education by permitting more evening study time for students. • Marketing of ICS will help strengthen the employee base of implementing organizations and create direct local employment opportunities in operational and/or management roles, as well as possible future assembly, manufacturing, distribution and sales activities. The use of ICS will require capacity building to ensure the strengthening of the ICS value chain to contribute to future local economic development and technological self-reliance • Environmental well-being: Agroforestry is agricultural and forestry systems that try to balance various needs including to produce trees for timber and other commercial purposes and to ensure the protection of the natural environment so that it continues to provide resources and environmental services to meet the needs of the present generations and those to come. Ago-forestry also increases water infiltration and slows runoff flow, stabilizes and protects stream banks from erosion, filters pollutants from runoff water and stabilizes riverbanks.
Climate change mitigation benefits	Agroforestry has the potential to restore degraded lands, provide a broader range of ecosystem goods and services such as carbon sequestration and high biodiversity, and increase soil fertility and ecosystem stability through additional carbon input from trees, erosion prevention, and microclimate improvement. Agroforestry systems could greatly contribute to global soil carbon sequestration if used in larger areas[47].
Financial requirements and costs	Somalia targets to introduce agroforestry in its arable land of 8.1 million hectares. The cost of agroforestry per hectare has been calculated by Stiebert et al at an average of US Dollars 13.25 per hectare per year assuming equal estimates during that period. These values are standardized using the capital recovery factor of 0.15 and the operational costs at 10 percent Therefore the financial costs of implementing agroforestry in Somalia depends on the land acreage that will be put under this technology.
ii) AFFORESTATION AND REFORESTATION	

[47] World Agroforestry web page: https://www.worldagroforestry.org/publication/agroforestry-systems-metaanalysis-soil-carbon-stocks-sequestration-processes-and-future

introduction	The Afforestation and reforestation technology uses conventional forest planting techniques such as plant planning, plant selecting, land preparation, fertilizer application, irrigation, protection and other associated technologies, such as creating new species, tissue culture, seeding to afforest new areas and reforest previously deforested areas. As described in Chapter 1 of this TNA, Somalia has a very high rate of deforestation mainly driven by charcoal demand for export and domestic usage as a fuel source. However, the government in its national policies such as the NDC, National Development Plan, the NAPA among others have prioritized afforestation.
Technology Characteristics	
Country Specific Applicability and Potential	Afforestation and reforestation is a widely used technology globally and also in Somalia. It has a high potential in forestry and can be further developed and localized to use indigenous knowledge systems for seed collection, generation, propagation into seedlings and planting and nurture.
Status of technology in country	Somalia forests and scrublands cover over 23 percent of the total land mass and even though the country has faced massive deforestation over the years, it has a huge potential to restore its degraded forests and scrublands though a combination of afforestation and reforestation while at the same time allowing natural forest and scrub regeneration through control of drivers of deforestation.
Benefits to economic/Social and environmental development	High economic efficiency, especially from material plantations Economic: • Afforestation/reforestation is a labour-intensive technology and therefore creates several job opportunities for planting, weeding, pruning and general forest management leading increased income • Seed collection and seedling propagation is a viable income generating activity in many countries and easily replicable in Somalia • Forests provide non timber forest products such as honey, gums and resins that are highly commercially viable as income sources Environmental: • Afforestation and reforestation covers barren and degraded lands and increases vegetation cover. It also ensures local and national ecological security for climate change adaptation

	• Reduction of soil erosion, protecting water sources, resisting pests and diseases, provision of biodiversity habitat, climate amelioration created by well forested areas among other multiple benefits of forests.
Climate change mitigation benefits	The role of forests in climate change mitigation are well known and documented and associated climate change adaptation co-beneifts. Forests are carbon dioxide sinks through carbon sequestration and the potential for sequestration varies depending on species and agro climatic zones.
Financial requirements and costs	Afforestation and reforestation technology is a labour and skill set intensive technology. Cost drivers include training of foresters and technicians and other skilled labour, seed collection, seedling propagation, planting, weeding, pruning and forest management. Costs can be leveraged through enhanced public education, awareness and training on the benefits of tree planting so that afforestation and reforestation initiatives are citizen driven through "adopt a forest initiative", national tree planting days among others. International support for afforestation and reforestation for large-scale measures will be needed
	iii) MANGROVE FOREST RESTORATION
introduction	Somalia has a long coastline enriched by a wide belt of mangrove forest. However, this strong buffer belt has faced deforestation over the years. Mangroves are one of the most rehabilitated coastal wetlands for shoreline protection. Mangrove ecosystems played a vital role in buffering the force of the strong sea waves and in protecting the human inhabitations. Mangroves provide vital ecosystem functions and are instrumental in supporting the livelihoods of the local coastal communities. These mangrove systems also perform vital hydrological functions and serve as breeding grounds for fish & other marine species[48]. Evidence from the 12 Indian Ocean countries affected by the 2004 tsunami disaster suggested that coastal areas with dense and healthy mangrove forests suffered fewer losses and less damage to property than those areas in which mangroves had been degraded or converted to other land use (Ibid). Somalia with its very long coastline, and in view of climate change and related impacts can benefit greatly from mangrove restoration.

[48] Technology fact sheet for adaptation: Mangrove restoration. (www.ctcn.org)

Technology Characteristics	Mangrove restoration/ reforestation involves various measures. This includes the following: • Collection of plant propagules from a sustainable source • Preparation of the restoration site for planting and directly plant propagules at regular intervals at an appropriate time of year • Establish nurseries to stockpile seedlings for future planting • Mangrove re-establishment can also be achieved by planting dune grasses as these grasses are known to provide a stable, protective substrate for mangroves to establish their root systems and after the establishment of mangroves they over grow the sea grasses allowing mangroves to be dominant[47]
Country Specific Applicability and Potential	Technology for mangrove restoration has been successfully implemented in many countries including in the Western Indian Nations of nations of Kenya, Tanzania and Mozambique among others. When the drivers of mangrove deforestation are controlled or removed, mangrove forests have been known to naturally regenerate and this can be applicable in Somalia.
Status of technology in country	Indigenous knowledge technology for mangrove restoration is available in Somalia. This in combination with scientific methods of mangrove restoration available across the world in both Africa, Asia and South America and documented in literature can be utilized to restore the Somalia mangrove forest ecosystem. Capacity building, training and exchange visits in successful nations can serve as good building block for sustainable mangrove restoration initiatives. Locally available mangrove species should be propagated since they are best suited to the range of soil and hydrological conditions and thus most appropriate species for mangrove reforestation.
Benefits to economic/Social and environmental development	Social: • Employment provision – mangrove restoration is labour intensive for managing of seedling nurseries, planting and management of the mangrove forests Economic: • Improved fish catch through improved breeding sites thereby increasing income for local fishing communities and also for export • Research has shown that a reduction in installation and maintenance costs of sea defences may occur when such structures are located behind large areas of mangroves which absorb the energy and slow the water flow of storm surges(ibid) • Sustainable harvesting of mangrove is a source of timber and other non-timber products Environmental: • Shoreline protection

	• Mangroves are breeding and nursery ground for a variety of birds, fish, shellfish and animals Mangrove systems provide water quality and climate regulation • They are valuable accumulation sites for sediment, contaminants, carbon and nutrients. • Tourism attraction yielding multiple social economic benefits
Climate change mitigation benefits	Mangrove systems among other wetland ecosystems are large reservoirs of carbon dioxide. Except for tundra and peatlands, mangroves store more organic carbon per unit area than any other ecosystem[49]. A combination of terrestrial afforestation and reforestation measures combined with mangrove restoration and rangeland restoration can yield significant carbon sequestration for Somalia.
Financial requirements and costs	Mangrove restoration is a labour-intensive technology for both skilled and unskilled workers. Cost drivers include undertaking field surveys to decide the sites for mangrove restoration; training, travelling transportation costs to planting sites, maintenance of nurseries and labour costs for planting, monitoring and management per hectare
iv) VALUE ADDITION FOR TREE/FOREST PRODUCTS	
Introduction	Value addition is enhancement added to a product or service before offering to the user. It is the additional valued added to a product in addition to the original cost of production. It is to economically add value to a product to form characteristics more preferred in the marketplace and when applied in the forest sector especially for non-timber products, it creates a market economy that reduces pressure on the forest products. Somalia has over the years been one of the rich sources of frankincense and gum Arabica that has been exported globally. Other forest / tree products include fruits, honey among others.
Technology characteristics	Value addition of forest and tree products entails various aspects. These include: • Transformation of the raw material into lucrative products. This includes improved methods or practices for harvesting, processing, packaging, branding and marketing of the forest wood and non-wood forest products

[49] Daniel M. Alongi. 2020. Global Significance of Mangrove Blue Carbon in Climate Change Mitigation. Sci 2020, 2, 67; doi:10.3390/sci2030067

	• Adding desired specific traits to a product at domestic level can lead to development of local enterprises to meet demand for value added products • Value can be added to timber products by ensuring that when producing timber logs for sale, the log is cut properly to the correct length so more products can be produced from straighter, less tapered material. For lumber products, Value can be added to lumber by processing more efficiently or manufacturing for special niche markets. However, since Somalia is currently having high rates of deforestation, the key value addition shall be concentrated on promotion of non-wood forest products (NWFP). These include gums, resins, mushrooms, honey, medicinal plants, food, and spices, among others. • Promotion of NWTP as a technology is mainly by increasing value of forests in their intrinsic natural state through increasing awareness biodiversity conservation and sustainable protective use of forest resources • Training on value addition of communities or organized groups on NWFP noting that NWFP yield higher incomes over time from the same species thereby generating income for rural forest dependent communities • Value addition of forests can also be achieved through involving people living near forests in sustainable management of forest resources thereby reducing pressure on the forest
Country Specific Applicability and Potential	Value addition of forest/tree wood and non-wood products is a viable and applicable technology in Somalia. Already the country is exporting these products and there is thus need to add value to the gums, resins and fruit products originating from the country’s forests and reduce the burden for wood products in order to conserve the forests, reduce pressure on deforestation and increase income for the rural forest dependent communities.
Status of technology in country	Somalia already a source for various wood and non-wood forest products. In this post-civil war era, the local industry is growing gradually and investment in technology for value addition of these products is achievable at both local level through organized community groups (youth, women, CBOs), private sector investment etc. Government has created an enabling policy for sustainable forest management and conservation of Somalia’s terrestrial and coastal forests.

<table>
<tr><td>Benefits</td><td>Social:
There is increasing demand for natural products, bio-products and Somalia has been a leading producer of such. Value addition through improved harvesting, processing, packaging and branding can enhance the social economic benefits of the country’s products
Economic
Value addition of non-wood forest products can contribute significantly to improving rural households through additional income for rural people
Contribute positively to economic growth, both at the local, regional and national levels
Environmental:
Value addition of forest non-wood forest products leads to significant reduction of deforestation by addressing the drivers of deforestation such as poverty</td></tr>
<tr><td>Climate change mitigation benefits</td><td>Reduced pressure on forests leads to reduced deforestation thereby enhancing forest carbon stocks and carbon dioxide sinks.</td></tr>
<tr><td>Financial requirements and costs</td><td>Investment in value addition of forest wood and non-wood products can be done at local, state or national level. Key cost drivers include training on value addition, research and innovation, technology and technical skills for extraction of gums, resins, perfumes, medicines, essential oils, dried fruits etc. Costs also relate to the unique processing of finished products, packaging, branding and marketing to meet specific user needs.</td></tr>
<tr><td colspan="2" align="center">V) MONITORING AND SATELLITE IMAGING</td></tr>
<tr><td>Introduction</td><td>Mapping of forests and forests degradation is an important step towards effective forests management. Globally there has been a growing pool of remote sensing and satellite imaging methods that have been progressively developed to detect and map forest degradation.
In the African region, several countries have invested and collaborated with global mapping centres to monitor forests. However, there is no one single method that can be applied to monitor forest degradation, largely due to the specific nature of the degradation type or process and the timeframe over which it is observed. Somalia can use remote sensing and other satellite imaging technologies to monitor and sustainably manage its forests.</td></tr>
</table>

Technology characteristics	"Remote sensing (RS) refers to a technology that employs active or passive sensors that can scan the Earth's surface and process the data captured to infer spatially continuous, meaningful data, and information that is directly usable for understanding and monitoring (at various scales) many of the natural and anthropogenic activities taking place on our planet."[50] . There is no one size fits all remote sensing technology for above ground biomass stock monitoring and mapping, but various types are available for meeting set needs. The methods for remote sensing to be used will depend on user requirements, such as the geographic extent, the type of vegetation, the above ground biomass (AGB) densities under consideration, and the objective of the report, for instance, whether the need is for the most recent up-to-date AGB estimate, or for a long-term AGB trend for establishing baselines. Remote sensing systems are usually defined depending on the source of the energy they detect. Passive sensors detect the radiation that objects naturally emit or reflect. Active sensors emit their own source of energy, and thus operate independently of solar illumination, which is then scattered from the target and received back at the sensor. Examples of active sensors include Synthetic aperture radar (SAR) which emits microwave pulses, and LiDAR, which emits laser beams. These active sensors are key to monitoring forests because they have the capacity to penetrate the forest canopy, and in some cases clouds. SAR can penetrate clouds and provide volume and height estimates to measure biomass and LiDAR instruments are able to accurately map the 3D structure of stands of trees, identifying the size and shape of individual trees but it however cannot penetrate clouds like SAR. Remote sensing technology is vital for forest monitoring and can be either mounted on an aeroplane or on unmanned aerial vehicles (drones) or as space bone sensors on board satellites (Ibid). As a technology, aerial monitoring of forests using remote sensing and satellite imagining has existed for many years and increasingly, there is a vast amount of optical satellite imagery now available for many forest types globally and these in many cases is free of charge and thus has the potential to contribute to management of forests.
Country Specific Applicability and Potential	Forest monitoring through satellite imaging is applicable in Somalia with the right investment in capacity building of the requisite skill-set and technology.

[50] World Bank, 2021. Assessment of Innovative Technologies and Their Readiness for Remote Sensing-Based Estimation of Forest Carbon Stocks and Dynamics. The World Bank.

Status of technology in country	Regular and accurate monitoring of forest cover, forest cover change and drivers of change provides the necessary information to support policies and management practices to protect, conserve and sustainably manage forests. Somalia lacks forest monitoring and remote sensing capacities which is essential to quantify forest degradation. There is no documented information on the use of remote sensing for management of forests in Somalia. However, an enabling policy exists on its use as a technology for managing the countries forests.
Benefits	• Use of aerial digital imaging can reduce the cost of national or subnational-wide ground-data surveys by a fraction of the original cost • When used for purposes of greenhouse gas accounting, use of satellite imaging in combination with remote sensing techniques, it can improve deforestation and afforestation estimates, and therefore GHG emissions and removals through satellite-based Above Ground Biomass stock measurements, and information about the associated uncertainty.
Climate change mitigation potential	Remote sensing technology can be used to measure above ground forest carbon stocks to thereby establishing the amount of greenhouse gas sequestered by a forest block.
Costs	Monitoring of forests through use of satellite imaging through remote sensing is an expensive technology. However, there is an increasing pool of open access remote sensing data of various forests globally and in the African region that can be used for forest monitoring in Somalia. In order to downscale these data, the need for investment in training of skilled manpower in remote sensing and geographic information systems and other geostatistical skills, data capture and storage, imaging and interpretation to track deforestation or regeneration trends will be needed. Investment will be needed in the equipment for data capture, imaging and storage. Somalia can leverage on increasing demand for international partnerships that foster free and open access to data, algorithms, and centralized cloud services through sustainable funding. Somalia can also seek support for forest inventory updates and new initiatives that seek to build a Global Forest Biomass Reference System that will allow access to data at lower costs.
(VI) DEVELOPMENT AND IMPLEMENTATION OF FOREST LEGISLATION AND NATIONAL CHARCOAL POLICY	
Introduction	Somalia country lacks effective policy and legislative framework for the management of forests both at national and federal levels. As a soft measure, the development of national forestry legislation and finalisation of national charcoal policy is a great step towards Somalia's effort to curb deforestation and a mitigation measure under the sector. Such measures should also be implemented at the six federal states.

	Charcoal constitutes the primary urban fuel in Somalia and the main illegal export commodity that is a major source of income and environmental degradation in the country. The production, transport and combustion of charcoal constitutes a critical energy and economic cycle in the economy of Somalia that has led to rapid forest degradation for many years. This unsustainable trend necessitated the UN Security Council passed Resolution 2036 which banned the export and import of charcoal from Somalia[51]. Far from decreasing, the illegal trade and use of charcoal has remained constant and thus the need to formulate a forest legislation and policy that also regulates charcoal.
Technology characteristics	The role of the legislation and policy is to influence forest management activities. Through a participatory process involving all stakeholders in the Country, formulate and implement a comprehensive Forest Legislation and Charcoal Policy. Key characteristics of this technology include: • various stakeholder groups interests in the governance of forests and trade of forest products are addressed and well guided • Capacity building and regional cooperation • Development and promotion of alternative livelihoods • Supporting the shift to alternative livelihoods for beneficiaries of the charcoal value chain • Clear governance structures. Key features of good forest governance to be delivered through this legislature include adherence to the rule of law, transparency and low levels of corruption, stakeholder inputs in decision making, accountability of all officials, low regulatory burden, and political stability[52]
Country Specific Applicability and Potential	Somalia lacks a comprehensive forest legislation for the sustainable management of forests and charcoal policy. The 9th National Development Plan, NDC, NAPA and Draft Energy Policy all document the need for sustainable management of forests and implementation of the UN Security Council Resolution 2036. The formulation of a forest legislation and charcoal policy in Somalia therefore is highly applicable as a technology and has potential to address the drivers of deforestation in the country.

[51] Programme for Sustainable Charcoal Reduction and Alternative Livelihoods (PROSCAL). Joint Programme between the Federal Government of Somalia and United Nations that seeks international cooperation to stop the illegal export of charcoal from Somalia.

[52] Kishor, Nalin and Kenneth Rosenbaum. 2012. Assessing and Monitoring Forest Governance: A user's guide to a diagnostic tool. Washington DC: Program on Forests (PROFOR)

Status of technology in country	*"We need a holistic response to address the issues of charcoal in Somalia. Both the demand and supply side have to be tackled. To do this we need cooperation to implement the UN Security Council Resolution and ensure the environmental, economic and human losses that happen because of illegal charcoal trade are curbed." Mahdi Mohamed Guled Deputy Prime Minister of Somalia Conference on Charcoal in Mogadishu.*[50] The above quote is a testimony that the Federal Government of Somalia is committed to address the environmental, human and economic challenges associated to charcoal production through setting in place comprehensive measures. The Federal Government of Somalia, in collaboration with various partners established the Programme for Sustainable Charcoal Reduction and Alternative Livelihoods (PROSCAL). Among the key objectives of this program is a comprehensive response strategy to support the Security Council's Resolution. The objectives of this programme, which form important building blocks for the development of a forest policy and national charcoal policy. The programme objectives included: • To mobilize key stakeholders in the region and build institutional capacities among government entities across Somalia for effective monitoring and enforcement of the charcoal trade ban, energy security and natural resources management • To support the development of alternative energy resources • To facilitate a transition towards livelihood options that are sustainable, reliable and more profitable than charcoal production • To begin reforestation and afforestation throughout the country to rehabilitate degraded land • To build Regional Economic Partnerships to curb the unsustainable use, trade in, and production of charcoal in Somalia
Benefits	A comprehensive forest legislation and charcoal production policy will have the following benefits: Environmental: • Reduced deforestation and curbing of land degradation and associated benefits reduced soil erosion, increased soil fertility, increased water percolation, reduced flooding and associated siltation during rainfall seasons, reduced aridity and eventually reduced desertification • Control of biodiversity loss and improved microclimate associated with well conserved forests Social: • Improved security. The PROSCAL report documents that charcoal is one of the key commodities exported from Kismayo, Somalia's most southerly port by Al-Shabaab. As is the case with other commodities smuggled overland from Al-Shabaab-

	controlled areas to neighbouring countries, the maritime charcoal trade ultimately benefits armed insurgencies. A comprehensive forest and national charcoal policy will contribute reduction of insurgencies. • Reduction of inter-clan disputes over depleted forest and natural resources especially during dry seasons. PROSCAL report indicates that charcoal production fuels land tenure disputes and interclan fighting, and the resulting resource depletion is a key factor driving the recruitment of marginalized youth by militia groups Economic • Contribution to national economic growth and wellbeing including poverty reduction and associated avoided vulnerabilities that result from deforestation and land degradation
Climate change mitigation potential	The role of well managed forests, reduced land degradation and avoided negative impacts associated avoided deforestation and land degradation are invaluable carbon sinks. The NDC documents an ambition of 6.0 MTCO2 eq by 2030 from comprehensive forest management measures.
Costs	Policy and legislative formulation is an expensive but necessary endeavour. Key cost drivers include technical policy formulation workshops, stakeholder engagements, national validation forums, secretariat work, printing and production works, approval by the legislature at various levels of governance and publication. Costs will also be needed continuously for implementation of the legislation and policy in accordance with the implementation action plans and monitoring of progress.