AFRICAN DEVELOPMENT BANK GROUP

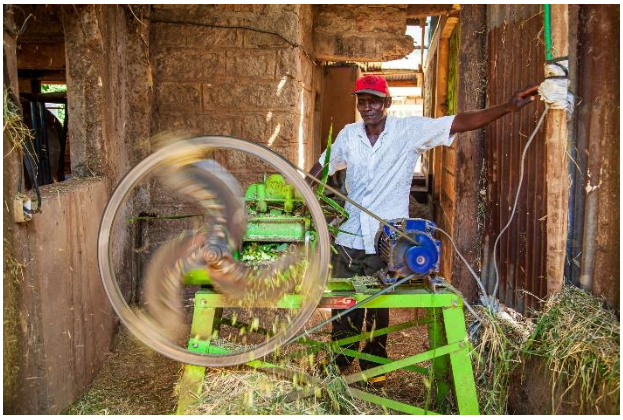
GREEN CLIMATE FUND

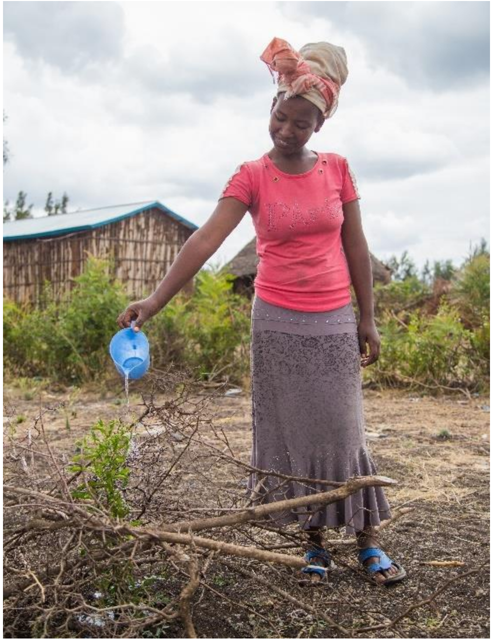
BUILDING CLIMATE RESILIENCE FOR FOOD AND LIVELIHOODS IN THE HORN OF AFRICA (BREFOL)

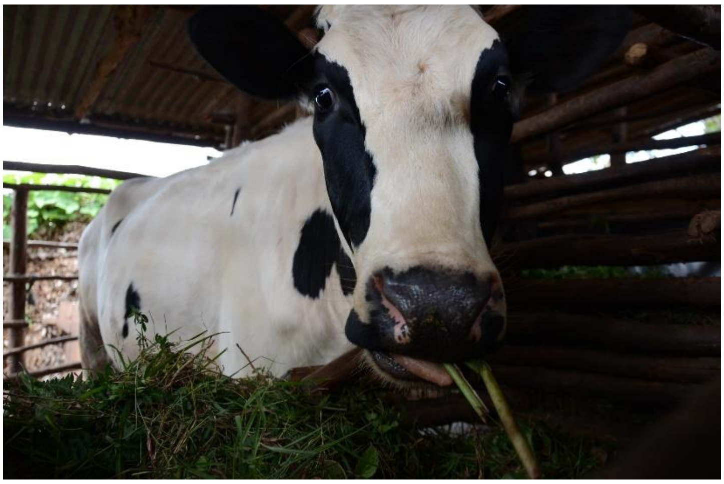
Djibouti, Ethiopia, Kenya, Somalia, and South Sudan

Annex 22b. GHG Emissions Reduction Methodological Note

Annex 22 b - Program to Build Resilience and Food Security in the Horn of Africa (BREFOL).







GHG Emissions Reduction Methodological Note

African Development Bank

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Contents

1. Objective of the BREFOL and summary of expected GHG emission reductions

The objective of the GCF- AfDB funded Activity (BREFOL - Program to Build Resilience and Food Security in the Horn of Africa Region) is to help mainstream climate change and variability considerations in the Horn of Africa (HoA) including Djibouti, Ethiopia, Kenya, Somalia, and South Sudan). The HoA region is one of the most vulnerable regions to the impacts of climate change and is prone to highly variable rainfall patterns, with differing intensity and distribution. The frequency of extreme weather events has increased considerably owing to climate change and variability. Some of the most pronounced weather events have resulted in production losses/failure, emergence of crop and livestock diseases, and livestock deaths. The effects are humanitarian emergencies, food insecurity and damages to infrastructure and the environment. The BREFOL program will support interventions including: (i) construction/rehabilitation of 578 water mobilization infrastructure; (ii) full operationalization of 3 cross-border memorandums of understanding to better control transboundary animal diseases and zoonoses in border areas; (iii) establishment of 3 cross-border veterinary laboratories to facilitate cost-effectiveness analysis of integrated pest management technologies to fight against fall armyworm, arboviruses in transhumant cattle, and locust's invasion; (iv) 102,000 ha of degraded agro-pastoral rangeland/pastureland placed under sustainable land management practices; (v) 1,160,000 smallholder farmers, herders and communities provided with access to digital and non-digital climate-resilient innovations and technologies; (vi) adoption of climate risk finance and insurance that directly benefits over 1.6 million farmers and pastoralists; and (vii) strengthened operational capacity for resilience building to climate change at the community, national and regional levels. BREFOLS will also support mitigation benefits through reduced emissions resulting from the use of renewable energy for energy access and power generation. The technologies include solar PV for lighting, irrigation and processing (4.8 MW and 3,890m3 of biodigesters) while forestry and land use will also contribute to GHG emission reduction during the project lifetime. Under the Programme and in line with the principles of demonstrating mitigation impact per GCF Board decision B.33/12 (Annex VI), GHG emissions will be avoided through the following activities:

1. Provision of 4.8 MW of solar PV in the 5 countries to be installed for solar irrigation, solar lighting and processing systems. The solar systems will support MSMEs that operate off grid and the solar PV will replace diesel.
2. Provision of the 3,690m3 of biodigester in Ethiopia, Kenya and South Sudan
3. Agroforestry activities in Ethiopia, Djibouti and Kenya
4. Grassland management in all 5 countries

The distribution of the GHG emission activities per country and the summary of the GHG emission reductions per activity under the BREFOL program are tabulated below:

Table 1: Proposed GHG emission activities per country

Country	Capacity of PV to be installed (kW) Activity 2.2.2	Capacity of biodigester to be installed (m3) Activity 2.2.2	Area of land under Agroforestry practices (ha) Activity 1.2.2	Area of rangelands under management (ha) Activity 1.2.2
Djibouti	300	n/a	25,000	2,000
Ethiopia	1,000	3500	800	63,000
Kenya	1,500	120	4,000	20,000
Somalia	1,000	n/a	n/a	7,000
South Sudan	1,000	270	n/a	13,000
Total	**4,800**	**3,890**	**29,800**	**102,000**

Table 2: Summary of projected GHG emissions under the HoA BREFOL program

GHG reduction activity	Capacity / Unit	Yearly GHG emissions tCO2	GHG emissions avoided at mid term tCO2	GHG emissions avoided by end of programme tCO2	GHG emissions avoided over lifetime tCO2
Off grid solar PV for irrigation Systems , Lighting and Processing Systems - MW	**4.8**	6,046	9,686	26,614	135,434
Installation of Biodigester units - m3	**3,890**	6,737	10,105	30,316	90,949
Rehabilitation of rangelands ha	**102,000**	320,405	274,287	1,226,939	8,010,125
Land under agroforestry - ha	**29,800**	236,513	183,941	806,312	5,912,829
Total		**569,701**	**478,025**	**2,090,182**	**14,149,337**

2. Alignment of proposed activities with the countries' NDCs and national policies

The proposed project interventions are aligned with the country's NDCs as per the table below:

Table 3: Alignment of proposed activities with NDCs of the country

Country	NDC provision on solar PV	NDC provision on biodigester	NDC provision on rangeland/ agro forestry	Source
Djibouti	• Objective is to reach 100% RE by 2030 using solar geothermal and other RE technologies (pg 15.) • Use of solar PV for irrigation purposes as a means of building climate resilience (pg. 140)	Djibouti does not have specific search results indicating a national strategy on the use of biogas for energy generation. However, there are broader strategies and initiatives in the region and globally aimed at increasing renewable energy sources like bioenergy, which could indirectly influence Djibouti's energy policies. The Pan-Arab Renewable Energy Strategy 2030 focuses on increasing renewable energy targets in the Arab region	The Government of Djibouti has been diversifying local agricultural production by introducing agro-forestry practices. Additionally, programs supported by the United States aim to enhance rangeland rehabilitation and soil conservation techniques in Djibouti	https://unfccc.int/documents/366858
Ethiopia	Ethiopia aims to achieve net zero emissions by 2050 and has set a target to expand renewable electricity from 5% to 15% by 2030, primarily using wind and solar PV	In terms of biowaste or biogas, Ethiopia has been actively promoting clean cooking solutions through the National Biogas Program, aiming to install more than 35,000 biogas digesters by 2025 and a total of 98,000 by 2030 in rural areas. This initiative is part of Ethiopia's efforts to diversify its renewable energy mix and reduce dependence on traditional biomass for cooking, aligning with its Climate Resilient Green Economy (CRGE) Strategy	The contribution of land use change and forestry (LUCF) in Ethiopia's Nationally Determined Contributions (NDC) is significant, promising the largest mitigation potential within the NDC The country has set ambitious targets for reforestation and restoration, aiming to plant	https://unfccc.int/sites/default/files/NDC/2022-06/Ethiopia%27s%20updated%20NDC%20JULY%202021%20Submission_.pdf https://www.un.org/sites/un2.un.org/files/sdg7_ethiopian_energy_compact_1st_final_draft_.pdf https://cdkn.org/sites/default/files/files/NDC-Highlights-Volume-_2_No-5-1.pdf

			trees on 3 million hectares through tree planting and restore 5-6 million hectares through natural forest regeneration. These efforts align with Ethiopia's long-term forestry sector goals and the country's Forest Sector Development Plan, with the aim of increasing forest cover to 30% of the national territory over the long term	
Kenya	The renewable energy targets for Kenya as per its Nationally Determined Contributions (NDCs) include an aim to expand geothermal, solar, and wind energy production, along with other renewables and clean energy options. Kenya plans to develop 5.5 GW of geothermal, 3 GW of hydro, 1.5 GW of wind, and 1.2 GW of solar PV by 2030	The Government of Kenya is actively promoting the use of biogas in various sectors, including agriculture and farming. The Kenya National Domestic Biogas Programme (KENDBIP) was established to promote the installation of biodigesters in agricultural smallholdings across the country. The programme aims to reduce dependence on firewood, improve the environment, and provide a smokeless fuel for households. The programme also seeks to create jobs in the new market of biogas-related services, such as installing and maintaining biodigesters	Kenya aims to increase forest cover to 10.6 million hectares by 2050, with agriculture being the leading source of emissions followed by land use and land use change and forests. The country's NDC emphasizes mitigation efforts in the LUCF sector to achieve emissions reductions and enhance carbon sequestration, highlighting the importance of sustainable forest management and reforestation initiatives	https://faolex.fao.org/docs/pdf/KEN210108.pdf https://www.iied.org/sites/default/files/pdfs/migrate/16588IIED.pdf https://climateactiontracker.org/countries/kenya/
Somalia	The renewable energy targets for Somalia as per its Nationally Determined Contributions (NDCs) include a commitment to develop renewable energy electricity, specifically solar and wind power. Somalia aims to promote clean and energy-efficient solutions, distributed renewable lamps, and energy-efficient light bulbs in the energy	N/A	Somalia's NDC outlines a range of strategies to reduce deforestation, land degradation, and increase carbon sequestration through sustainable land use practices like agroforestry and conservation agriculture. The NDC emphasizes the	https://unfccc.int/sites/default/files/NDC/2022-06/Final%20Updated%20NDC%20for%20Somalia%202021.pdf

	sector. The country also plans to invest in renewable energy sources like solar and wind to achieve emissions reductions and avoid greenhouse gas emissions. However, the specific share of photovoltaic (PV) energy in the energy mix is not explicitly mentioned in the NDCs		importance of promoting sustainable land management to mitigate climate change effects and enhance resilience to its impacts. Additionally, the NDC includes goals to reduce greenhouse gas emissions by 31% by 2030 compared to a business-as-usual scenario, highlighting the country's commitment to addressing climate change through sustainable land use practices and forestry initiatives	https://ice.simad.edu.so/2023/03/03/nationally-determined-contribution-ndc/
South Sudan	The renewable energy targets for South Sudan as per its Nationally Determined Contributions (NDCs) include a focus on increasing the share of renewable energy in the total energy mix. South Sudan aims to enhance its energy mix by incorporating solar, wind, hydro, and other renewable sources. However, the specific share of photovoltaic (PV) energy in the energy mix is not explicitly mentioned in the provided sources	The specific share of biowaste or biogas in South Sudan's energy mix is not explicitly mentioned in the provided sources. However, the country's focus on utilizing renewable and regenerative energy sources suggests that biowaste or biogas could play a significant role in contributing to the renewable energy targets outlined in its NDCs. The current status of biogas production in South Sudan indicates that there is potential for utilizing biogas as an energy source, particularly from biomass resources like animal wastes, agricultural residues, and sugar cane.	South Sudan's NDC aims to reduce emissions from land use, deforestation, and forest degradation through sustainable forest management practices. The country recognizes the importance of forests for socio-economic development, environmental protection, and livelihood support, especially for the rural and nomadic population that heavily depends on forests for their needs. Despite facing issues like deforestation and conversion of forestlands into other land uses, South Sudan is committed to mitigating greenhouse gas emissions from the land use sector by implementing measures to enhance forest carbon stocks,	https://www.undp.org/south-sudan/publications/south-sudans-second-nationally-determined-contribution-climate-promise https://climatepromise.undp.org/what-we-do/where-we-work/south-sudan https://www.afdb.org/sites/default/files/documents/publications/afdb_south_sudan_final_2018_english.pdf

			reduce deforestation, and promote sustainable land management practices	

3. Cost of PV and bio digestor systems.

The beneficiaries of the PV systems will be agro pastoralists and farmers not connected to the grid and using mostly diesel to support lighting, irrigation, and processing. It is assumed that the average size of the of the PV kit required (modules with inverters, mounting, and metering) per beneficiary is 5kW.

The average of small-scale off-grid solar PV plants in Africa has been on a decreasing trend, making solar energy more accessible and cost-effective across the continent. The cost per watt for the installation and operation of small off-grid PV systems in the Horn of Africa varies by country but with costs becoming more competitive and affordable, especially with the support of government incentives and programs aimed at promoting renewable energy adoption in the region. The average price per watt for small-scale off-grid systems in Africa has significantly decreased in recent years. According to a report by IRENA (2016), the installed costs for power generated by utility-scale solar PV projects in Africa have decreased to as low as USD 1.30 per watt[1]. In order to account for the MRV requirements which will be passed on to the installer of the PV system, and average cost of **USD1.5 per watt** is considered for the programme and the lifetime of the equipment is expected to be 25 years

The relevance of biodigesters for smallholders in rural areas in Africa is high. Biodigesters contribute to the intensification of farm production, access to fertilizers and energy, savings on fuel and fuelwood, and the reduction of indoor air pollution. Fixed dome type biodigesters are the most commonly used in Africa[2]. They strengthen the resilience and the prospects of households. Yet, access to biodigesters is severely limited by its costs and the household's socio-economic position. The implementation of the Africa Biogas partnership Programme[3] including in Ethiopia, the practicability of use of biogas for cooking and electricity generation has been demonstrated. The average size of biodigester units[4] installed in African countries under the programme (including in Ethiopia and Kenya) was around 4-6$m^3$with an average cost of USD130/ m3 for either in-situ constructed or prefabricated (becoming more popular now). A cost of **USD 300 per cubic meter** for a biodigester (including civil works, maintenance, monitoring and reporting on performance) and associated accessories for electricity generation [5] was considered for the program. The lifetime of the equipment is expected to be 15 years

In terms of disbursement rate, the deployment of the PV systems will echo the disbursement schedule outlined in Annex 4, i.e., 30% in year 1, 25% in year 2, 20% in year 3, 10% in year 4, 10% in year 5 and 5% in year 6. For the bio digester units, since there are only about 780 units (of approximately 5m3) to be installed, it is assumed that 50 % will be in place by end of year 2 and the totality will be in operation by end of year 3

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[1] https://www.irena.org/publications/2016/Sep/Solar-PV-in-Africa-Costs-and-Markets
[2] https://www.sciencedirect.com/science/article/pii/S0973082618302497
[3] https://www.snv.org/project/africa-biogas-partnership-programme-abpp
[4] https://a.storyblok.com/f/191310/b8ca144d18/snv-20biodigester-20status-20brief-20-28final-29.pdf
[5] Amigun B., Von Blottnitz H. Capacity-cost and location-cost analyses for biogas plants in Africa. *Resour. Conserv. Recycl.* 2010;55(1):63–73

4. Summary of methodologies used for GHG calculations

In line with GCF Board Decision B.3/12 and annex VI thereto, specific methodologies were used to determined the GHG emissions avoided per project supported intervention as indicated in Table 4 below:

Table 4: Summary of methodologies used for GHG calculations under BREFOL programme

GHG mitigation activity	Capacity / Unit	Methodology and reference	Description of Methodology
Off Grid Solar PV	**4.8 MW**	CDM – AMS-I.L Small-scale Methodology Electrification of rural communities using renewable energy – version 4.0 9N0MH2D8XJL1R5IYC3ZPGK7UBQVSTF (unfccc.int)	Refer to Section 5 of the methodological note
Installation of Biodigester units	**3890 m3**	IRENA's methodology for measuring small -scale biogas capacity and production IRENA_Statistics_Measuring_small-scale_biogas_2016.pdf	Refer to Section 6 of the methodological note
Rehabilitation of rangelands	**102,000 ha**	Module 4.1.2 of the FAO EX-Ante Carbon Balance tool (version 9) EX-ACT | Economic and Policy Analysis of Climate Change | Food and Agriculture Organization of the United Nations (fao.org)	Refer to Section 7 of the methodological note
Land under agroforestry	**29,800 ha**	Module 5.1 of the FAO EX-Ante Carbon Balance tool (version 9) EX-ACT | Economic and Policy Analysis of Climate Change | Food and Agriculture Organization of the United Nations (fao.org)	Refer to Section 7 of the methodological note

5. Estimation of emissions avoided using PV for solar irrigation system, lighting and processing.

The Small-scale methodology for Electrification of Rural Communities using renewable energy developed by the Clean Development Mechanism (CDM) was used to estimate the GHG emissions avoided through the use of PV for lighting, irrigation, and processing6. This methodology is applicable to electrification of a community achieved through the installation of renewable electricity generation systems that displace fossil fuel use, such as in fuel-based lighting systems, stand-alone power generators, and fossil fuel based mini-grids.

This methodology was deemed appropriate as it enables calculation of GHG emissions resulting from displacement of fossil fuel use in rural communities in rural communities are supplied with electricity from renewable-based systems.

Furthermore, this methodology is applicable in situations where consumers that were not connected to a national/regional grid prior to project implementation are supplied with electricity from the project activity, where the total installed capacity is less than 15MW, and where the end users (consumers) include households

[6]https://cdm.unfccc.int/UserManagement/FileStorage/9N0MH2D8XJL1R5IYC3ZPGK7UBQVSTF

and/or small, medium micro enterprises requiring electricity for interior lighting, street lighting, refrigeration, or agricultural water pumps.

As per the methodology, the two parameters required to determine the baseline include:

a) The amount of renewable electricity utilized by the consumers served by the project renewable electricity generation systems;
b) The number of consumers supplied with renewable electricity by the project activity;

Based on the installed capacity, the yield per kW per year and the assumption that the average size connection (kit size) is 5kW with a daily load factor (utilisation factor of 0.75), the total number of beneficiaries and energy produced per year per connection is established as per Table 5 below:

Table 5: Number of consumers per country and green energy consumed per consumer

Country	Installed Capacity (kW)	Yield per kW per year kWh/KwP[7]	Yearly yield MWh/ yr	Average size of connection (kW)	Number of beneficiaries	Annual energy generated per beneficiary (MWh)
Djibouti	300	1835	413	5	60	6.881
Ethiopia	1000	1750	1,313	5	200	6.563
Kenya	1500	1700	1,913	5	300	6.375
Somalia	1000	1875	1,406	5	200	7.031
South Sudan	1000	1600	1,200	5	200	6.000
Total	**4800**				**960**	

The following are the baseline emission factors for each tranche of annual amount of renewable electricity consumed per consumer during the crediting period:

a) For the first 55 kWh of electricity supplied to the user by the project electricity generating system in a given year, the emission factor is 2.72 kg CO_2/kWh (i.e. 2.72 t CO_2/MWh). This is equivalent to a constant of 0.1496;
b) For the electricity supplied to the user by the project electricity generating system in a given year that is above 55 kWh, the emission factor is 0.9 kg CO_2/kWh[8]

The detailed GHG emission reductions is computed in the attached spreadsheet.

As per the AMS-I.L methodology, the baseline emissions for consumers that consumed more than 55kWh baseline emissions the entire project are calculated as:

[7] https://globalsolaratlas.info/
[8] https://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-33-v2.0.pdf

$$BE_{55\,plus,y} = \sum_{z}^{M} \left[\left(EG_{z,y} - 0.055 \right) \times EF_{CO2,55\,plus} + C \right]$$ Equation (3)

Where:

$EG_{z,y}$	=	Electricity delivered by project renewable electricity generation system to consumer *z* in year *y*, where the electricity delivered to the facility is more than 55 kWh (kWh)
$EF_{CO2,55\,plus}$	=	A default emission factor value as specified in Table 1 of TOOL33 based on the diesel generator capacity and the load
z	=	Consumer supplied with renewable electricity from operating project renewable electricity generation systems consuming more than 55 kWh in year *y*
c	=	A constant calculated as multiplication of 55 kWh electricity supply and a default emission factor value as provided under section 5.2 of TOOL33 (t CO_2)
m	=	Number of facilities in the project activity consuming more than 55 kWh

The overall project emission is computed by deducting the project emissions and leakage emissions from the baseline missions as per the formula hereunder:

$$ER_y = BE_y - PE_y - LE_y$$

Where:

ER_y	=	Emission reductions in year *y* (t CO_2e/y)
BE_y	=	Baseline Emissions in year *y* (t CO_2/y)
PE_y	=	Project emissions in year *y* (t CO_2/y)
LE_y	=	Leakage emissions in year *y* (t CO_2/y)

In the current context, the Emission reductions is equal to the baseline emissions as it is assumed that there is no project and leakage emissions.

Using the above, the overall annual yearly emissions avoided at the end of the programe is 24,966 tCO2 as per Table 6 below:

Table 6: Annual overall emissions avoided through the use pf PV

Country	**GHG Emissions avoided from PV at mid term tCO2 (end of year 3)**	**GHG Emissions avoided from PV at end of project tCO2 (end of year 7)**	**GHG Emissions avoided from PV during lifetime tCO2**
Djibouti	604	1,661	8,458
Ethiopia	1,922	5,286	26,908
Kenya	2,744	7,522	38,237
Somalia	2,057	5,657	28,798
South Sudan	1,760	4,840	24,640
Total tCO2	**9,087**	**24,966**	**127,042**

6. Estimation of emissions avoided using Biodigesters.

The methodologies for the analysis of the biogas energy generation are at two levels. At the level of the biodigester plants and at the level of the use of the biogas directly for transport, cooking, cooling or for electricity generation.

Baseline 1: Abatement from biowaste

In the absence of bio-digesters, feedstock and waste will be randomly dumped in the nature, generating methane. Having bio-digesters in place is a better way of collecting this methane contained in waste and feedstock that would have otherwise ended up directly disposed in the atmosphere. The baseline is the amount of CO2eq that would have been discharged directly in the atmosphere, in the absence of digesters. In the case of the BREFOL program, it is estimated that around 780 units will be deployed to beneficiaries who have the necessary infrastructure to collect the animal waste and other organic waste for use in the biodigester at its rated capacity.

Baseline 2: Abatement from the use of biogas for electricity generation

In the absence of this activity, energy (MWh) for additional electricity needs would be generated using Diesel engines, resulting in emissions. By using Biogas instead of Diesel for generating this energy, the emissions that would have resulted from Diesel combustion are avoided. The baseline emission is the amount of CO2eq that would have then been produced through generation of same amount of energy (MWh) by the Diesel generator as with the substituted capacity by the renewable energy system.

Calculating Baseline 1:

a) Evaluating volume of direct discharge of methane in the atmosphere: This was done through assessing the amount of feedstock and waste (feedstock-m3/yr) that would be produced and disposed annually in the nature instead of being used in digesters based on the biodigester volume to be installed in the 5 countries (3,890 m^3). According to a 2016 study from IRENA[9], the production of $1m^3$ of biogas per day using fixed dome plants requires a biodigester volume of $2.5m^3$ on average (or 1m3 of biodigester produces 0.4 m^3 of biogas daily. Based on this, the total volume of biogas generated per year in the programme is $567{,}940m^3$ and with $1m^3$ of biogas containing 0.65 m^3 of methane, the total yearly volume of methane available is 369,161 m^3

b) Evaluating the mass of methane: Given that climate mitigation is measured by the mass of CO2eq and not the volume of CO2eq in the atmosphere, to make things comparable we have assessed the mass of the methane that corresponds to the volume of methane that would have been discharged directly in the atmosphere without the activity. This simple exercise is achieved by multiplying the volume of the gas (m^3) by its density (kg/m^3), where the density of methane is a chemical known constant which is 0.67 kg/m3. This resulted in assessing the total mass of methane that would have been without the activity dumped in the atmosphere and that amount is 247 tCH4.

c) Evaluating the corresponding CO2eq emission: The latest IPPCC report provides the 100-year GWP of methane which is 28 times CO2e. The NDCs of the 5 beneficiary countries was however based on 100-year GWP of the 4th assessment, which is more conservative. To evaluate the corresponding CO2eq emission we have used the conservative factor 28 times CO2eq to align with countries NDCs. Formula is: Resulting Emission (tCO2eq) = methane mass (tCH4) * 28 (tCO2eq/tCH4) which resulted annual direct discharge of 6,925 tCO2). This amount is the baseline emission on this item.

d) Deducting emissions from the activity itself: Once methane is collected in the digesters, it will not be released in the atmosphere as in the baseline, rather it will be used to generate electricity. The

[9] https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2016/IRENA_Statistics_Measuring_small-scale_biogas_2016.pdf

conversion of methane to electrical energy necessitates combustion of methane first which is achieved through the chemical reaction:

$$CH_4 + 2O_2 \rightarrow CO_2 + 2\ H_2O$$

The mass of CO_2 that results from this reaction is known since the chemical law of Lavoisier discovered in 1789, also known as “The Law of Conservation of Mass”. Lavoisier discovered that mass is neither created, nor destroyed in chemical reactions. It is therefore known since then that 16 grams of methane when completely burned produces 44 grams of CO_2. This means that 247 tCH_4 when completely burned will produce 247 * (44/16) tCO_2, which is equal to 680 tCO_2 as emissions from the activity itself.

Mitigation Baseline 1 from biodigester: without the activity, there would have been 6,245 tCO_2eq released in the atmosphere (6,925 – 680) annually.

Calculating Baseline 2:

The amount of emission reduction on this item is estimated ex-ante using the Diesel emission factor (tCO_2eq/MWh) that provides the amount of GHG emission (tCO_2eq) per unit of Energy (MWh) produced. The formula is :

Emissions by Diesel (in tCOeq) = Energy Generated by Diesel (in MWh) x Emission Factor of Diesel (in tCO_2eq/MWh). The Emissions Factor of Diesel used in 0.9 tCO_2eq/MWh similar to the factor used for the GHG emissions avoided through the use of solar PV in the previous section.

Mitigation Baseline 1: Using biogas instead of diesel, 350 tCO_2 is avoided yearly.

Table 7: GHG emission through biowaste generated and use of biogas for electricity

Country	**Volume digester (m3)**	**Emissions avoided year 1 tCO2**	**Emissions avoided year 2 tCO2**	**Emissions avoided year 3 tCO2**	**Emissions avoided year 4 tCO2**	**Emissions avoided year 5 tCO2**	**Emissions avoided year 6 tCO2**	**Emissions avoided year 7 tCO2**	**Emissions avoided year 8 - 15 tCO2**
Ethiopia	3,500	0	3,031	6,062	6,062	6,062	6,062	6,062	48,492
Kenya	120	0	104	208	208	208	208	208	1,663
South Sudan	270	0	234	468	468	468	468	468	3,741
Total yearly emissions avoided	**3,890.0**		**3,368**	**6,737**	**6,737**	**6,737**	**6,737**	**6,737**	**53,895**
Cumulative emissions avoided			**3,368**	**10,105**	**16,842**	**23,579**	**30,316**	**37,053**	**90,949**

7. Rangeland rehabilitation and Agroforestry

The GHG emissions avoided through rangeland/ pastureland rehabilitation of agroforestry practices has been computed using the FAO EX-Ante Carbon Balance tool (version 9)[10]. This tool can be used to calculate greenhouse gas emissions using IPCC methodologies (refer to Annex 22 C).

Rangeland rehabilitation:

Rangeland restoration in the Horn of Africa will enhance livestock production by improving forage quality and quantity, soil fertility, and water retention, thus ensuring a consistent and nutritious food supply for animals. It will reduce soil erosion and desertification, conserves biodiversity, and supports sustainable grazing practices, leading to long-term land productivity. Restoration efforts in the region will also provide economic benefits to pastoralist communities by increasing livestock productivity and market value, while mitigating climate change impacts through carbon sequestration. By engaging local communities in restoration activities, the programme will empower them with sustainable land management skills, fostering resilience to drought and other climate-related challenges.

Module 4.1.2 of the tool is used (Grassland systems remaining grassland systems- total area remain constant) and for all 5 countries, it is assumed that the baseline scenario is that the grassland/ rangelands under consideration for project intervention are severely degraded and will get even more severely degraded without and intervention while the rehabilitation will improve the quality of the grassland.

Based on these entries in the worksheet of each country, the following amount of GHG is sequestrated over the lifetime of the investment (25 years) and assuming a gradual rehabilitation (as described above) is undertaken is tabulated overleaf

Agro Forestry abatement

The agro forestry activity under the programme consists of planting adapted trees (e.g. leguminous trees) with high potential of nitrogen fixation to convert degraded lands into fertile croplands (agroforestry). This therefore account as a Land Use Change activity and under the FAO Ex-Ante tool, Modules 2.3 (other land use changes) and is linked to module 3.2 (perennial systems from other LU or converted to other LU)

Converting degraded lands to cropland through agroforestry can significantly enhance soil fertility through several mechanisms:

1. Organic Matter Addition

Agroforestry systems introduce trees and shrubs into agricultural landscapes, which can increase the amount of organic matter in the soil. The leaf litter, root biomass, and decaying wood from these plants add organic material to the soil, enhancing its structure and fertility. Organic matter improves soil texture, water retention, and nutrient availability.

2. Nutrient Cycling

[10] https://www.fao.org/in-action/epic/ex-act-tool/en/

Trees and deep-rooted plants in agroforestry systems can access nutrients from deeper soil layers that annual crops cannot reach. When these plants shed leaves or when roots die back, these nutrients are brought back to the soil surface, becoming available to crops. This process helps recycle nutrients within the ecosystem, reducing the need for external fertilizers.

3. Nitrogen Fixation

Some trees and shrubs used in agroforestry, such as legumes, have the ability to fix atmospheric nitrogen through their symbiotic relationship with Rhizobium bacteria in their root nodules. This biological nitrogen fixation can significantly increase the nitrogen content of the soil, providing an essential nutrient for crops and enhancing overall soil fertility.

4. Soil Erosion Control

The presence of trees and shrubs in agroforestry systems can reduce soil erosion by stabilizing the soil with their root systems. This is particularly important on degraded lands where erosion may be a major problem. Reduced erosion means that more nutrients and organic matter are retained in the soil, which contributes to better soil fertility.

5. Microbial Activity Enhancement

The diverse plant species in agroforestry systems can promote a more diverse and active soil microbial community. These microorganisms play crucial roles in decomposing organic matter, cycling nutrients, and improving soil structure. Enhanced microbial activity can lead to increased availability of nutrients for plants.

6. Improved Soil Structure

Tree roots in agroforestry systems can help to break up compacted soils, improving soil aeration and water infiltration. Better soil structure enhances root growth and increases the soil's capacity to hold water and nutrients, which can improve the growth conditions for crops.

7. Microclimate Regulation

Trees and shrubs in agroforestry systems can modify the microclimate around them by providing shade and reducing wind speed. This can lead to more stable soil temperatures and moisture levels, which can positively affect soil microbial activity and plant growth, indirectly enhancing soil fertility.

By incorporating trees and shrubs into agricultural landscapes, agroforestry can restore degraded lands, improve soil health, and increase the productivity and sustainability of these ecosystems.

Based on these entries in the worksheet of each country, the following amount of GHG is sequestrated over the lifetime of the investment (25 years) and assuming a gradual rehabilitation (as described above) is undertaken is displayed in Table 9

Table 8: GHG abatement from rangeland rehabilitation under BREFOL program

Country	Rangeland rehabilitation (ha)	Cumulative tCO2 emissions avoided through rehabilitation Y1	Cumulative tCO2 emissions avoided through rehabilitation Y2	Cumulative tCO2 emissions avoided through rehabilitation Y3	Cumulative tCO2 emissions avoided through rehabilitation Y4	Cumulative tCO2 emissions avoided through rehabilitation Y5	Cumulative tCO2 emissions avoided through rehabilitation Y6	Cumulative tCO2 emissions avoided through rehabilitation Y7	GHG abatement from rangeland rehabilitation (tCO2)- 25 years
Djibouti	2,000	444	1,331	2,663	4,438	6,657	9,320	12,426	76,334
Ethiopia	60,000	29,578	88,735	177,470	295,783	443,675	621,144	828,193	5,087,469
Kenya	20,000	9,859	29,578	59,157	98,594	147,891	207,048	276,064	1,695,823
Somalia	7,000	1,553	4,660	9,320	15,533	23,300	32,619	43,492	267,168
South Sudan	13,000	5,136	15,407	25,678	35,950	46,221	56,492	66,763	883,331
Total	**102,000**	**46,570**	**139,711**	**274,287**	**450,298**	**667,743**	**926,624**	**1,226,939**	**8,010,125**

Table 9: GHG abatement from agro foresrty under BREFOL program

Country	Agro forestry (ha)	Cumulative tCO2 emissions avoided through agro foresrty Y1	Cumulative tCO2 emissions avoided through agro foresrty Y2	Cumulative tCO2 emissions avoided through agro foresrty Y3	Cumulative tCO2 emissions avoided through agro foresrty Y4	Cumulative tCO2 emissions avoided through agro foresrty Y5	Cumulative tCO2 emissions avoided through agro foresrty Y6	Cumulative tCO2 emissions avoided through agro foresrty Y7	GHG abatement from agro forestry (tCO2) - 25 years
Djibouti	25,000	25,449	76,347	152,693	254,488	381,733	534,426	712,568	4,377,201
Ethiopia	800	1,488	4,464	8,928	14,880	22,320	31,248	41,664	255,938
Kenya	4,000	7,440	22,320	22,320	52,080	37,200	81,841	52,080	1,279,690
Total	**29,800**	**34,377**	**103,131**	**183,941**	**321,449**	**441,253**	**647,515**	**806,312**	**5,912,829**

8. Provisions for Monitoring, Reporting and Verification (MRV)

The status of the MRV system in place in each country to track progress of the NDC targets:

- Ethiopia has a Measurement, Reporting, and Verification (MRV) system in place to track greenhouse gas (GHG) emissions for reporting purposes. The MRV system is designed to measure the amount of GHG emissions reduced by specific mitigation activities, such as reducing emissions from deforestation and forest degradation, over a period of time. The system involves measuring emissions, reporting the findings to an accredited third party, and verifying the results to ensure the accuracy and transparency of the data. Ethiopia's MRV system is based on the International Consultation and Analysis (ICA) and International Assessment and Review (IAR) processes under the UNFCCC. The country is required to report on the receipt of and need for climate finance, as well as draw lessons from various experiences of financial instruments used, such as grants, loans, export credit, and guarantees[11]
- There is an MRV (Monitoring, Reporting, and Verification) system in Kenya to track progress against the Nationally Determined Contributions (NDCs). The Integrated MRV system in Kenya includes an Integrated MRV tool for monitoring and reporting both mitigation and adaptation actions, along with their results. This system is coordinated from the Climate Change Directorate and is embedded in the Climate Change Act,[12] obligating all State and Non-State climate change actors to report on their activities annually. The reports generated through this system provide input for both national and international reporting, addressing various reporting obligations
- It is not clear if there is a system for monitoring, reporting, and verification (MRV) in Djibouti to track progress against the Nationally Determined Contributions (NDCs). The Medium-Term Work Plan between the Ministry for the Environment, Land, and Sea of Italy and the Ministry of Habitat, Planning, and Environment of Djibouti aims to support the development of a clear and transparent MRV system for monitoring, reporting, and verification of actions enacted within the framework of the INDCs(2016)[13]. However, the 2021 NDC does not mention about any MRV system in place in the country.
- Somalia does not have a functional MRV system in place and as stated in the 2021 NDC it requires support to establish national measurement, reporting and verification (MRV) system and strengthen its institutional set-up with adequate infrastructure and human resources to track climate actions.

To ensure that the mitigation results are properly recorded during the implementation period and during the lifetime of the programme, necessary resources has been allocated to track progress track progress on the mitigation goals and policies outlined in Nationally Determined Contributions (NDCs) of the 5 countries. The project support operationalisation of a project specific Monitoring Reporting and Verification (MRV) mechanism during the project implementation period and will provide support

[11] https://transparency-partnership.net/sites/default/files/mrv_101_0.pdf

[12] https://climateactiontransparency.org/wp-content/uploads/2021/07/1D_Needs-and-Gap-Assessment-Report-for-Kenya.pdf

[13] https://www.mase.gov.it/sites/default/files/archivio/allegati/sviluppo_sostenibile/medium_term_work_plan_Djibuti.pdf

to the necessary institutions to capture the necessary information post project period. For the PV and biodigester units, the responsibility of reporting on the operation of the installed systems will be under the responsibility of the private contractors to whom the contract will be allocated. As indicated in Section 3 of this document, to cater for the added services, the price per watt for the PV system and price per m3 of bio digester will also include the responsibility of monitoring the system parameters (installed capacity, energy generated and used) and reporting same to the Project Implementation Units who will be trained on the Reporting. For the agro forestry and rangeland rehabilitation abatement, the PIUs will be trained on the use of the FAO EX Ante tool (version 9 or latest) to be able to track the amount of GHG emissions avoided during the reporting period.

The capacity building activities will ensure that the countries with an already established MRV system (Ethiopia and Kenya) are able to streamline the results of the project specific activities in national reporting and will assist countries without an established MRV system to ensure that the project results are still captured and eventually reported in national MRV to be setup.