Supplementary materials 1

1.1. Quantitative assessment of the environmental dimension

1.2. Climate change impact category

1.2.1. Description of the charcoal sector

We used southern Mozambique (Mabalane, Chicualacuala, Guijá, and Massingir districts) as a study area to describe the charcoal sector because southern Mozambique is the central supplying region of charcoal to the Mozambican capital, Maputo, one of the biggest markets for charcoal in the country. In the studied area, mainly Mabalane and Chicualacuala districts, there are local villager operators producing charcoal on a small-scale with household labor and sales to wholesalers and large-scale operators producing and commercializing charcoal on a large-scale using migrant labor who are selling their production to wholesalers [1]. The provided description of the charcoal production process is about large-scale operators due to their potential of harvesting large amounts of charcoal (Figure 1), which are more likely to cause forest degradation.

The large-scale operators exploit the forest resources under the simple license regime granted by the government. In 2014, 156 people officially held a production license for the district of Mabalane. Of these, 81% were non-residents and 35% were female [1]. The large-scale operators set up charcoal production camps in the communities' woodlands and transport the charcoal to urban markets in Maputo. These large-scale charcoal productions are often poorly monitored.

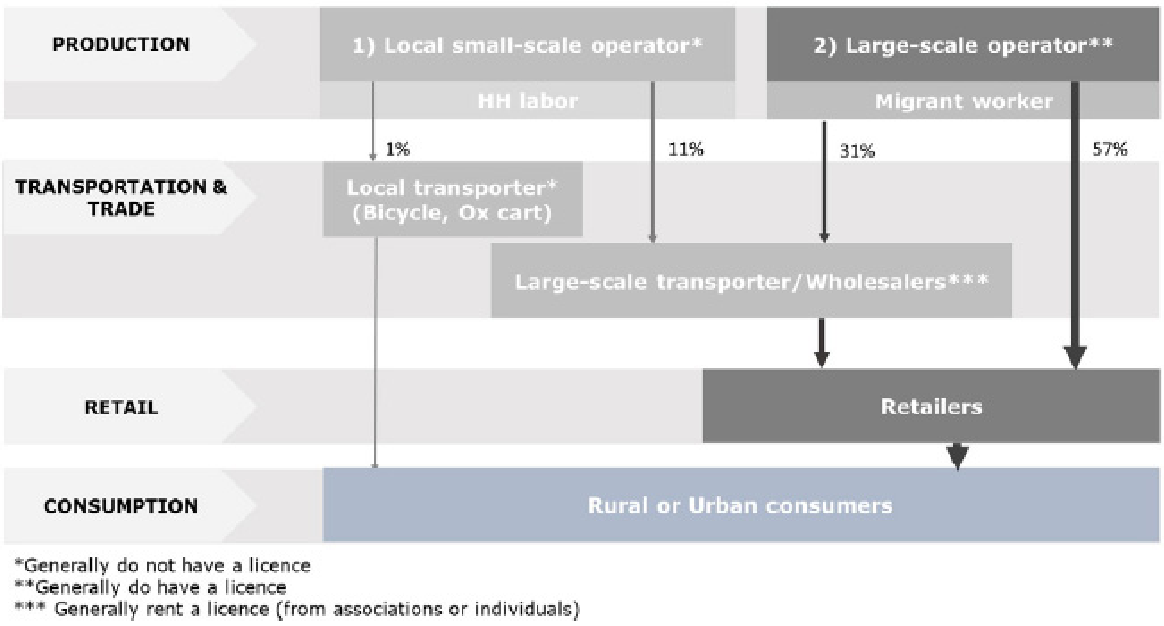

Figure 1: Charcoal production chain identified in Mabalane District and percentage of production volume. Source: Baumert et al. [1].

The charcoal production process is on average operated with 1 to 5 workers, mostly (> 80%) outsiders mainly from Inhambane province who work during the dry season (mainly March to November), and some keep working during the rainy season. The workers are mostly between 19 and 30 years of age (60%), and many abandon the activity to pursue other opportunities after one year of work, which means that most of the workers in the activity have less than a year of experience. It was found that few of the natives of the province of Gaza and specifically of the study area, agreed to work in the activity of charcoal production. The following were identified as the main reasons for the predominance of migrant workers in the charcoal production camps: First, most of the migrant workers have better technical knowledge on how to produce charcoal than the local's ones, and secondly, they have long-standing relations with their employers and tend to relocate with them to new production frontiers. Thus, mutual trust has been established [1]. In terms of gender, it was observed that there are no women involved in the production process because this activity requires more significant physical effort. However, most of the workers use to bring their wife to the camping site for cookies and water provision while the man is involved in charcoal production.

The tree species type used is only *Colophospermum mopane,* and they expand the production area every year, looking for forest patches with big standing trees [2]. The main reason for selecting the new production site is that there are no mopane trees with diameters required for felling, in areas where there has been a recent charcoal production. Although they stated that they had cut trees selectively with diameters ranging from 20 to 40 cm, some tiny mopane trees (diameter < 20cm) that had been felled have been observed. These are mainly used to put the last wood cover of the kiln before the final cover is made of leaves, grass, and sand. The type of kilns is exclusively of land of the "boat" type with an average of the following dimensions: length = 14.1 m, width = 3.8 m, and height = 1.3 m, which are constructed with local material, as shown in Figure 3. The charcoal process begins with the crosscutting and sectioning into about 1.2 to 3 m long billets, piled into the stack, and then thatched with grass before plastering with earth, except for a small window through which the fire is set. Once the fire has been established, the window is plugged with soil to ensure controlled partial combustion (carbonization) of the logs into charcoal. Each kiln is fed with felled wood that requires 3 to 7 days of work utilizing a chainsaw, consuming 5 to 10 liters of fuel for the whole process depending on the dynamics of the chain operator. Afterward, the kiln is prepared in about 7 to 15 days, but in some cases, it can vary from 15 to 40 days. This is followed by the pyrolysis process, which takes an average of 15 days, and finally, it takes an average of 2 days for harvesting the charcoal. It is therefore estimated that the total time of production of charcoal is about 45 days.

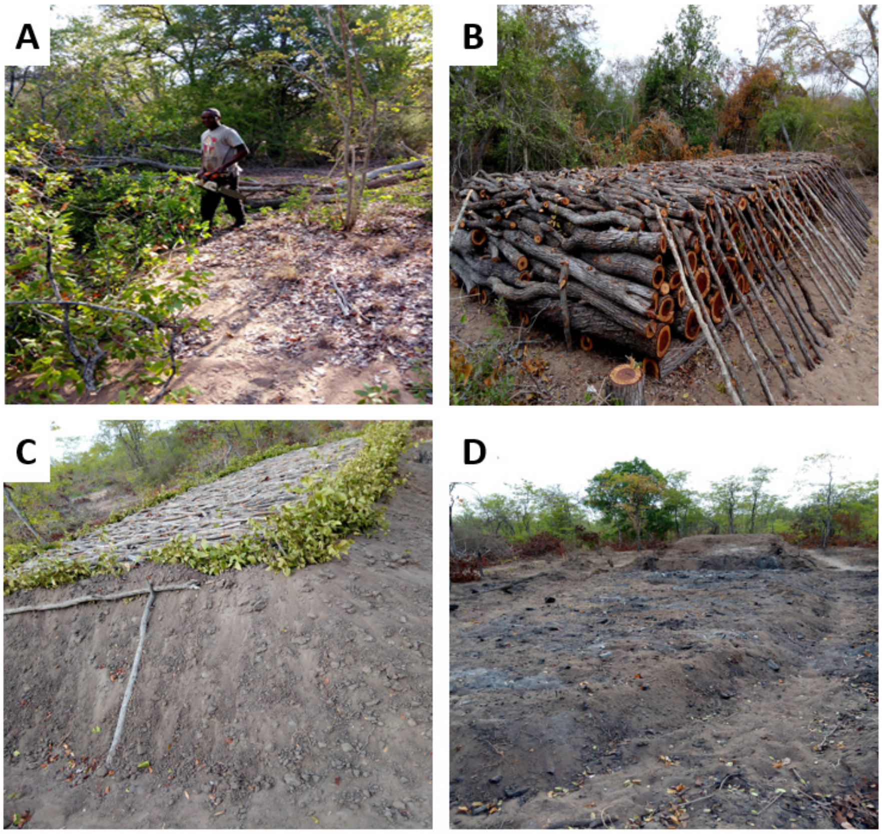

Figure 2: A: Tree felling using chainsaw; B: kiln set up with large stems at the base and small branches on the top; C: kiln almost covered; D: kiln ready for harvesting, Mabalane district, Mozambique. Photos: Sá Nogueira Lisboa.

The workers are paid according to the number of sacks (sack size = 50kg) produced per kiln, being distributed to 50% with the boss who pays the sacks of the workers to a value of 350 MT per sack, and of this amount are discounted the expenses of food, chainsaw, and the fuel used for the felling the trees. According to [1], of the local producers, 91% sell charcoal to wholesalers, whereas 9% supply local markets directly, with selling prices varying between 250 and 300 MZN per sack. Estimating the number of wholesalers is difficult, as anybody with good relations to charcoal producers and connections to license holders can enter this business. Some of the former charcoal-producing large-scale operators switched entirely to the wholesaler business using their license to buy charcoal from different areas. Most of the profits generated through charcoal production do not revert to communities. The fragile or absent organization and the lack of marketing capacity in these communities make it difficult to claim a more significant share of the charcoal value from the value chain [1].

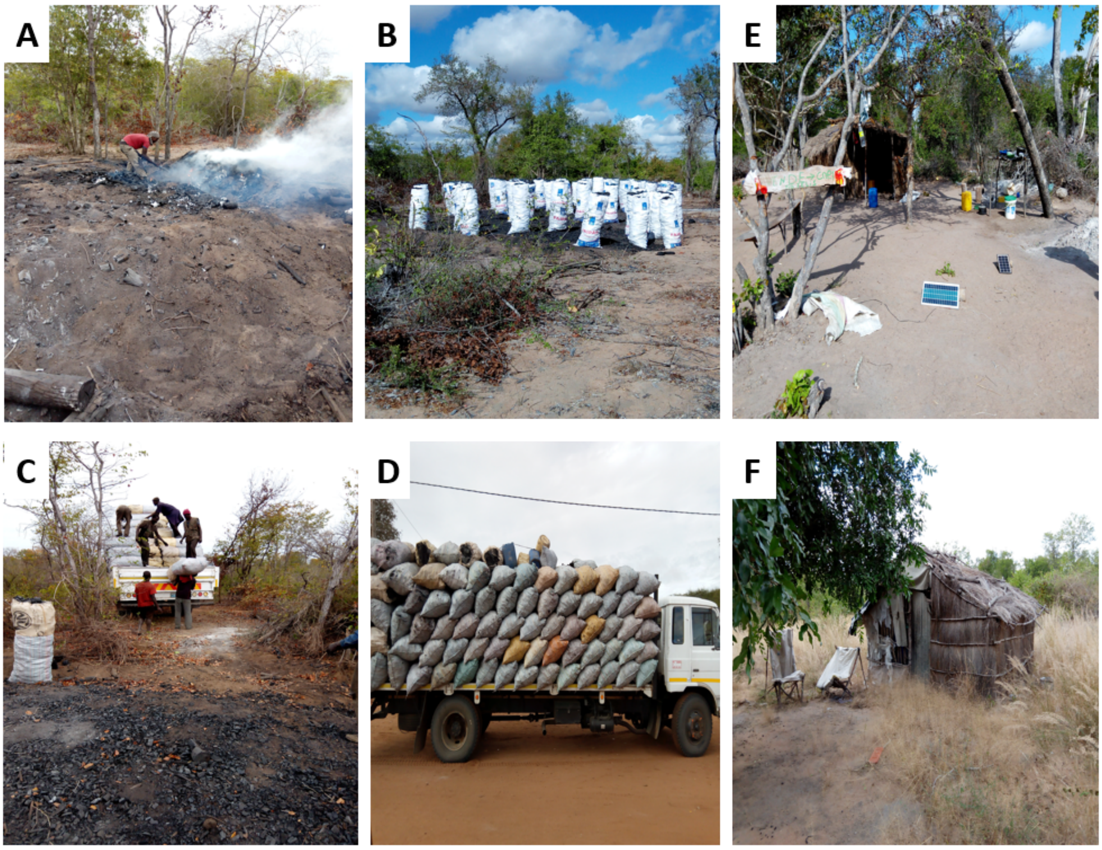

Figure 3: A: charcoal harvesting process, B: charcoal in the sack, C: workers packing the charcoal sacks in the truck, D: Truck taking charcoal to Maputo-city, E: camping side in active, F: abondoned camp, Mabalane district, Mozambique. Photos: Sá Nogueira Lisboa

1.1.3. Estimation of business-as-usual of GHG emission and GHG removal in the charcoal production process

The identification of baseline GHG emissions and removals was established through forest surveys. The baseline scenario is defined as the business as usual (BAU). The emission source is the carbon content of the cut tree for charcoal production, and the source of the removal is regeneration through seeds and regeneration of the stumps in the area that charcoal production has been performed. Before computing the baseline scenario, the emission factor of charcoal production was computed. In this study, the emission factor was estimated using the 2006 IPCC [3] Guidance. The baseline scenario considers that future charcoal production will happen with the same traditional technology as used today. Before establishing the emission factor, the average biomass extracted in charcoal production was estimated with the process, as explained below.

1.1.4. Estimation of the average biomass extracted in the charcoal production process

The biomass used in the charcoal production process was estimated based on [4] computed through the difference between the biomass of the supposed standing tree and the biomass of the stump obtained based on the multiplication of its volume and the density of the species. Basal diameters (BDs) of the stumps were converted to the diameter breast height (DBH) of standing trees before harvesting using a linear relationship developed for *C. mopane: DBH = 1.171BD + 4.0646* ($r^2 = 0.9$) (DBH = diameter breast height; BD = basal diameter). The biomass of the supposed standing tree corresponding to the measured stump was estimated through equation of *Colophospermum mopane* [5]: $B = 0.204 \times DBH^{2.275}$ (B = above-ground biomass (kg); DBH = diameter breast height (cm)). It should be noted that the allometric equation of the Japanese Agency for International Cooperation-JICA [6] for the Gaza mopane should be ideal, however, it was not possible to use it since it is a double input, Diameter at Breast Height (DBH) and height as the independent variable.

1.1.5. Estimates of removals source in the charcoal production areas

The CO_2 fixing capacity of the Mopane forest was estimated by summing the biomass of the remaining trees in the areas of charcoal production with DBH equal or greater than 5 cm and total height, where the DBH and height and estimated biomass were measured through the allometric equation fitted by the Japanese Agency for International Cooperation-JICA [6] for the mopane of Gaza (Equation 1), and the biomass of those non-mopane tree species was estimated using the allometric equation from Miombo woodland [7] with the biomass of natural regeneration, either by stem regrowth or not.

$$AGB_{Kg} = 0.03325 * DBH^{1.848} * H^{1.241} \quad \textbf{(Equation 1)}$$

Were: AGB is above-ground biomass (kg), DBH is diameter breast height (cm), H is total tree height (m).

The natural regeneration biomass was estimated based on the product of the mean volume (obtained by multiplying the mean cross-section and the mean height) with its specific density, according to Equations 3 and 4.

$$Vol_{medo} = \sum gi \times hi \times ff \times N / ha \quad \text{(Equation 2)}$$

Were: Vol_{medo} is tree volume (m^3), gi is basal area of regeneration i (m^2), h is total height of regeneration i (m), ff is form factor (unless unit), N/ha is number of regeneration trees per hectare.

$$AGB_{seq.} = Volume_{medium} * \rho_{mopane} \quad \textbf{(Equation 3)}$$

Were AGB_{seq} is above-ground biomass, ρ_{mopane} is wood density of mopane species.

After the biomass determination, the carbon was determined based on default value 0.5 of the total biomass, thus obtaining the carbon stock in tons Mg ha^{-1}, and this converted into CO_2 by multiplying carbon with default value (3.67 equivalent CO_2) from 2006 IPCC [3], performed as is showed on Equations 4 and 5.

$$C_{stock} = AGB_{seq.} * 0.5 \quad \textbf{(Equation 4)}$$

$$CO2_{seq.} = C_{stock} * 3.67 \quad \textbf{(Equation 5)}$$

1.1.6. Estimation of charcoal production emission factor

According to 2006 IPCC [3] Guidance, the change in the annual carbon stock in remaining forests can be estimated based on the stock difference method or the method of losses and gains. However, in this study only the loss and gain method were applied since it is suitable for the estimation of emission factors from forest degradation, especially selective cutting of wood, extraction of firewood, and charcoal production [8]. The gains-and-loss method consists of accounting for biomass gains through tree growth rates after charcoal production, and biomass losses from charcoal production, firewood removals, and transfers of live products to dead organic matter [9]. In this case, it was the balance of removals and CO_2 emissions. Thus, the emission factor from charcoal production was estimated based on IPCC [3], Equation 6. It should be noted that it was impossible to estimate the emissions of gases other than CO_2 due to the lack of appropriate equipment for the measurement of these gases, thus using IPCC standardized emissions [3].

$$EF = (\Delta G_C - \Delta P_C) \times \frac{44}{12} + E_{oth} \quad \text{(Equation 6)}$$

where: EF: emission factor (t CO_2e ha^{-1}); ΔG_C: carbon gain after charcoal production (t $CO_2 ha^{-1}$); ΔP_C: carbon lost during charcoal production (tCO_2 ha^{-1}); 44/12: carbon conversion factor for C to CO_2; emissions of gases other than CO_2 such as CH_4 and N_2O released during burning (t $CO_2e.ha^{-1}$).

Figure 4: measuring stumps and coppice regrows. A: stump diameter measurement; B: stump height measurement; C: coppice diameter measuring and counting coppice; D: coppice diameter measurement, Mabalane district, Mozambique.

1.2. Scenario development and assumptions

In East and Southern Africa, clear-cut during charcoal production, at least at small spatial scales, appears to be more prevalent than selective cut. Mozambique, charcoal production in a dry forest is characterized by a "clear-felling system" since almost all species are used [10]. Charcoal production occurs widespread in large forest areas; production sites are nomadic as a dependent of the occurrence of targeted tree species. However, in mopane woodland, the most dominated woodland in southern Mozambique, the charcoal production is characterized by a selective cut of *Colophospermum mopane* species [11,12]. Therefore, charcoal production contributes to forest degradation, compromising ecosystem services and rural livelihoods [13,14].

The baseline emission scenario of charcoal production was performed using forest degradation area (activity data) of charcoal production. It mapped kilns of Mabalane district using very high-resolution images (Figure 5), which were accurate data exists from 2008 to 2018 [2]. The rate of forest degradation from Mabalane was used to extrapolate the activity data to other districts (Chicualacuala, Massingir, and Guija). According to the provincial government, charcoal production in Massingir and Guija has currently been banned, and the activity data and all assumptions to these districts were more conservative compared to Mabalane district.

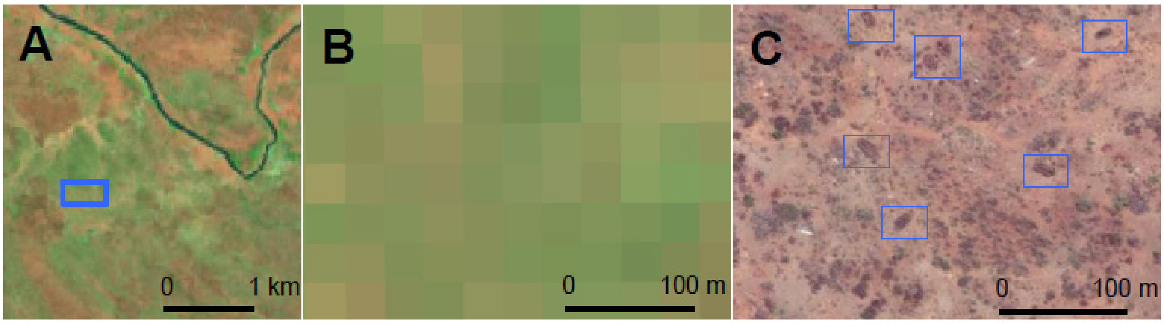

Figure 5: *Example of kiln detection at various spatial resolutions: A) Landsat 8 false color composite (457) (June 2014); B) Close view of box area in Plate A: C) Multispectral very high-resolution of same area (December 2014). Blue polygons mark charcoal kiln locations (from Sedano et al. 2016*[15]*).*

The activity data of Chicualacuala, Massingir, and Guija were performed from African Land Cover 2016 (Sentinel 2, 20 m spatial resolution, http://www.un-spider.org/links-and-resources/data-sources/cci-land-cover-s2-prototype-land-cover-20m-map-africa) and NDVI map from Google Earth Engine extracted to the study area. The GPS coordinate of the kilns was collected in the field to validate the NDVI map of charcoal production. The timeline considered in the charcoal NAMA for the pilot study is up to 2020, but in this study, a timeframe from 2015 until 2030 was considered for the pilot to be aligned with NDC and SDGs timelines. Therefore, the emission from forest degradation (charcoal production) in the study area were computed from 2008 to 2018 and then extrapolated to 2025 assuming that the forest degradation area will decrease by 245.65 ha yr^{-1} if charcoal production happens as business-as-usual (e.g. mopane species will become scarce because of high intensity of charcoal extraction). The emission from 2015 to

2025 was estimated multiplying the emission factor of charcoal production by activity data computed in the previous section. The scenarios were calculated for the pilot project for the study area (Massingir, Chicualacuala, Guija and Mabalane districts) and at the national level as the charcoal NAMA applies to the entire country.

2.1.1. Estimation of emission reduction potential of identified mitigation technologies in the charcoal NAMA

The potential reduction of GHG emission from charcoal production from different identified mitigation measures was estimated using combined methods from the following CDM registered methodologies, which were developed concerning to charcoal production sector.

- AMS-III.BG: Emission reduction through sustainable charcoal production and consumption.
- AMS-III.K: Avoidance of methane release from charcoal production.
- ACM0021: Reduction of emissions from charcoal production by improved kiln design and/or abatement of methane.

However, the general applicability and suitability of the methodologies for Mozambique has been assessed in the context of the charcoal NAMA, showing that the selected measures in the charcoal NAMA do not fulfil all requirement of CDM methods, and some assumption and proxies were used. Therefore, in this study, the mitigation measures selected are the same as the ones identified in the charcoal NAMA project, which are more likely to be implemented. This meant that the potential emission reductions were estimated only for (i) briquetting of charcoal waste material and agricultural waste material, (ii) introducing efficient kilns and sustainable forest management of charcoal production, and (iv) torrefaction by the private sector (and replanting). According to De Koning et al. [16], no methodology fully applicable account for avoided emissions due to the implementation of improved kilns in combination with forest management. Therefore, the scenario of avoided emissions from introducing efficient kilns and sustainable forest management were addressed, combining approach from CDM methodology and IPCC (2006) guidance [3].

2.1.1.1. Briquetting charcoal waste materials

Flue gas emissions from biomass combustion refer to the gas product resulting from the burning of solid biomass fuel. As the briquetting of charcoal, waste materials substitutes the production of other charcoal, and the emissions related to this substituted production are avoided. Therefore, the only applicable methodology to calculate for these emissions is AMS-III.BG. The scenario created in this study considers that briquetting of charcoal waste material partially substitutes for regular charcoal. Therefore, fewer trees will be logged, and less CO_2 will be emitted while producing the same amount of charcoal.

The charcoal producer produces 200 kg of waste material per kiln, next to 60 bags charcoal. When production is at the license maximum of 1000 bags, this means yearly 3.3 tons of charcoal waste material is available for briquetting. On the other hand, the assumption was extrapolated for all charcoal producers and kilns from the entire study area. The total kilns were obtained from the Mabalane district [2] and extrapolated to the entire study area. There are on average 6 to 10 kilns per hectare, and produce around 8 096 tons of charcoal waste material per year in all districts. This means that if the charcoal waste materials are converted to briquetting it will replace about 2 460 bags charcoal from 41 kilns. The potential emission reduction computed here is only for Briquetting assuming that: only the charcoal waste material will be used because the traditional manner of charcoal production has emission itself added the emission from charcoal waste material, applied here as a business-as-usual scenario (BAU) considering the scenario assumptions described in Table 2. The following equations and values apply here:

Equation 7

$$ER_y = \sum_i Q_{CCP,i_y} \times \left[\left(CF \times NCV_{wood} \times \frac{NCV_{charcoal,i}}{NCV_{charcoal,default}} \times f_{NRB,BL,wood} \times EF_{proj} + (SMG_{y,b} - M_d) \times (1 - f_{NRB,BL,wood}) \times GWP_{CH4,y}\right] - PE_{y,fugiti} - PE_{y,flaring} - PE_{FF,y} - PE_{EL,y} - PE_{BC,y}$$

Table 1: Parametrization of model of emission reduction from briquetting of charcoal residues

Parameter	Description	Value	Source / explanation
ER_y	Emission reductions in year y[1] (t CO_2e/yr)	-	Calculated
Q_{CCP,i_y}	Quantity of charcoal type i produced and used in year y (t)	8096 ton per year	Sedano et al. (2019)
CF	Default wood to charcoal conversion factor	0	No charcoal production
NCV_{wood}	Net calorific value of wood (TJ/t)		
$NCV_{charcoal,i}$	Net calorific value of the charcoal type i produced during the project (TJ/t)	29.5 GJ/ton	Default value
$NCV_{charcoal,default}$	Default net calorific value of charcoal (TJ/t)		
$f_{NRB,BL,wood}$	The fraction of biomass of type i used in the absence of the project activity that can be established as non-renewable biomass; determined as per the procedure found in the latest version of "AMS-I.E: Switch from non-renewable biomass for thermal applications by the user" or on the basis of the published DNA endorsed default values available on the UNFCCC website[2]	91%	UNFCCC http://cdm.unfccc.int/DNA/fNRB/index.html

1 Project emissions on account of transport are assumed to be negligible.

2 Default values of fraction of non-renewable biomass can be retrieved at: <http://cdm.unfccc.int/DNA/fNRB/index.html>.

Parameter	Description	Value	Source / explanation
$EF_{projected\_fossilfuel}$	Emission factor for the substitution of non-renewable woody biomass by similar consumers (t CO_2/TJ)	81.6 t CO2/TJ	Default value
$GWP_{CH4,y}$	Global warming potential of methane applicable to the crediting period (t CO_2e/t CH_4)	21 t CO2e/t CH4	Default value
$SMG_{y,b}$	Specific methane generation for the baseline charcoal generation process in the year *y* (tonnes CH_4/t charcoal product)	0.030 t CH4/t charcoal	Default value
M_d	Factor to account for any legal requirement for capture and destruction of methane in the charcoal production facility (tonne of CH_4/tonne of raw material)	0	Policy context
$PE_{y,flaring}$	If applicable, emissions due to the flare inefficiency in the project charcoal manufacturing plant in the year *y* (t CO_2e) determined in accordance with the procedure provided in AMS-III.K. In case captured pyrolysis gas is gainfully used (e.g. as fuel for pre-heating the facility, or for wood drying, or used for production of heat and/or power as in the case of micro-gasifier), then it can be taken as zero	0	No flare
$PE_{FF,y}$	Project emissions due to fossil fuel consumption in charcoal production facilities in year *y* (t CO_2)	1.072 t CO_2 yr^{-1}	5 to 10 litres of fuel is used for chainsaw.
$PE_{El,y}$	Project emissions due to electricity consumption in charcoal production facilities in year *y* (t CO_2)	0	No electricity use
$PE_{BC,y}$	Project emissions due to biomass cultivation in year *y* (t CO_2)	0	No biomass cultivation

2.1.1.2. Introducing efficient kilns and sustainable forest management

In the same logics as briquetting, the simplest methodology AMS-III.BG was used for introducing efficient kilns. Since the charcoal NAMA has not as a requirement to be developed in a CDM context and be designed as a CDM Program of Activities, the limitation (described in delivery 1) to only account for biomass residues does not apply here. This makes the methodology AMS.III.BG *Emission reduction through sustainable charcoal production and consumption* under a NAMA framework suitable for this project opportunity. The assumption is that modern kilns are efficient and modern kilns allow for more efficient charcoal production e.g. a brick kiln has a 3:1 (wood input/charcoal output) ratio instead of 7:1 by the current earth kilns.

Therefore, the assumption is that through the use of more efficient kilns, less wood will be needed to produce the same amount of charcoal, resulting in less wood being harvested, leading to reduced CO_2 emissions. In addition, since less trees are logged, there is also a positive impact on the conservation of biodiversity. The assumption for national scale is that moving from earth kiln to brick kiln means 2.5

times less wood for the same amount of charcoal: From using 2.4 million tonnes of wood to 1 million tonne wood. This means 3.3 million trees are saved on an annual basis. According to MITADER annual forest report [17], the average amount of charcoal production in Gaza province is about 18 803 Mg yr^{-1}, and this means that 131 634 Mg yr^{-1} of wood is used for charcoal production in Gaza province. At the national level, MITADER annual report [17] from 2015 to 2017 states that Mozambique has produced 26 861 Mg yr^{-1} of charcoal. This figure was used to perform the scenario at the pilot level (the targeted districts) and the national level.

The inclusion of sustainable forest management (SFM) in the NAMA should safeguard the applicability criterion of renewable biomass feedstock. Taking in consideration to Table 2, the scenario created here is rather optimistic which is believed that charcoal NAMA will promote sustainable forest management in the charcoal area of all targeted districts while at the same time is being implemented the improved kilns. We believe that sustainable forest management can increase the natural regeneration of trees, and in this way, increase the source of removals of GHG from baseline or BAU scenario. Therefore, the estimated emission removals from natural regeneration (1.73 t CO_2 ha^{-1}yr^{-1}) computed in the preview section was added to the emission reduction of improved kilns, and the potential reduction emission from improved kilns and sustainable forest management was computed all together. Currently, the charcoal comes from areas that are unsustainably used and become degraded. To produce the above amount with brick kilns, 354,000 ha of land (assuming a 5 yr rotation) would be needed under SFM practices.

Within the methodology, AMS-III.BG a standardized baseline, has been registered for Uganda[3]. Among others, this standardized baseline defines a positive list of technology which are automatic additional. This is very practical for a sector-wide NAMA as it avoids the demonstration of additionality for every improved kiln installed, although additionality is not a direct requirement for NAMAs. The positive list includes the Casamance kiln, the Adam retort, sedimentary kiln, the Carbo twin retort, and the Pyro 7 retort sedimentary kiln with or without briquetting process [16]. This positive list can be adopted for the NAMA in Mozambique.

For the project activity not equipped with the capture and destruction of the pyrolysis gases, emission reductions are calculated as follows:

$$ER_y = \sum_i Q_{CCP,i,y} \times \left[\left(CF \times NCV_{wood} \times \frac{NCV_{charcoal,i}}{NCV_{charcoal,default}} \times f_{NRB,BL,wood} \times EF_{projected_{fossilfuel}}\right)\right] - PE_{FF,y} - PE_{EI,y} - PE_{BC,y}$$

Equation 8

Table 2: Parametrization of emission reduction model from modern kilns and sustainable forest management

Parameter	Description	Value	Source / explanation
ER_y	Emission reductions in year y[4] (t CO_2e/yr)	-	Calculated
$Q_{CCP,i,y}$	Quantity of charcoal type i produced and used in year y (t)	18 803 ton per year	
	Default wood to charcoal conversion factor	0	No charcoal

[3] Standardized baseline: Fuel switch, technology switch and methane destruction in the charcoal sector of Uganda Version 01.0

[4] Project emissions on account of transport are assumed to be negligible.

Parameter	Description	Value	Source / explanation
CF			production
$NCV_{charcoal,t}$	Net calorific value of the charcoal type *i* produced during the project (TJ/t)	29.5 GJ/ton	Default value
$NCV_{charcoal,default}$	Default net calorific value of charcoal (TJ/t)		
$f_{NRB,BL,wood}$	Fraction of biomass of type *i* used in the absence of the project activity that can be established as non-renewable biomass; determined as per the procedure found in the latest version of "AMS-I.E: Switch from non-renewable biomass for thermal applications by the user" or on the basis of the published DNA endorsed default values available on the UNFCCC website[5]	91%	UNFCCC http://cdm.unfccc.int/DNA/fNRB/index.html
$EF_{projected\_fossilfuel}$	Emission factor for the substitution of non-renewable woody biomass by similar consumers (t CO_2/TJ)	81.6 t CO2/TJ	Default value
$GWP_{CH4,y}$	Global warming potential of methane applicable to the crediting period (t CO_2e/t CH_4)	21 t CO2e/t CH4	Default value
$SMG_{y,b}$	Specific methane generation for the baseline charcoal generation process in the year *y* (tonnes CH_4/t charcoal product)	0.030 t CH4/t charcoal	Default value
$PE_{y,flaring}$	If applicable, emissions due to the flare inefficiency in the project charcoal manufacturing plant in the year *y* (t CO_2e) determined in accordance with the procedure provided in AMS-III.K. In case captured pyrolysis, gas is gainfully used (e.g. as fuel for pre-heating the facility, or for wood drying, or used for production of heat and/or power as in the case of micro-gasifier), then it can be taken as zero	0	No flare
$PE_{FF,y}$	Project emissions due to fossil fuel consumption in charcoal production facilities in year *y* (t CO_2)	1.072 t CO_2 yr^{-1}	5 to 10 litres of fuel is used for chainsaw.
$PE_{El,y}$	Project emissions due to electricity consumption in charcoal production facilities in year *y* (t CO_2)	0	No electricity use
$PE_{BC,y}$	Project emissions due to biomass cultivation in year *y* (t CO_2)	0	No biomass cultivation

5 Default values of fraction of non-renewable biomass can be retrieved at: <http://cdm.unfccc.int/DNA/fNRB/index.html>.

2.1.1.3. Torrefaction of Biomass

Torrefaction is a thermal process that enhances the properties of biomass through its thermal decomposition at a temperature between 200 and 300 °C [18]. Torrefied biomass is hydrophobic or moisture-free fuel resists biological breakdown and does not emit CH_4 or CO_2 [19].

According to the Charcoal NAMA documentation available the torrefaction technology should be introduced in regions with (a) high level of charcoal production with producers that already produce the maximum amount, and (b) lower levels of organizational capacity and thus fewer opportunities for the above-mentioned projects, and (c) especially in regions close enough to urban markets but too far for producers to transport charcoal to the market at this moment. However, the higher distance of the market will lead to high diesel fuel consumption. Due to the lack of additional data and methodology for estimating the emission from torrefaction, the scenario emission estimated in this study used the assumption from De Koning et al. [16].

The way torrefaction will be handled in the NAMA is not clear; even the feasibility study approached the torrefaction in a very pragmatic way with no clear idea on which approach will be used either waste material from the native forest or from forest plantation. Although, according to De Koning et al. [16], torrefaction has a positive effect on sustainable charcoal production. Nevertheless, for torrefaction to be economically viable, it should be used at an industrial production scale. An average commercially viable scale for a company is estimated at 50 000 tons charcoal per year. This implies 125,000 tons of wood or 412,500 trees. For a Sustainable Exploitation Block with a rotation scheme of 5 years, 42,142 ha of supply area would be needed. This amount of land is not available in the Maputo region for a single company. Therefore, the supply area includes both the company land as well as individual suppliers (out grower-plantation model). It is assumed that the charcoal will replace unsustainable charcoal in the market, and implies a potential of GHG emission reduction in 112.4 tCO2eq/yr. In this work, we used the national strategy of forest plantation, which states that the country aims to plant 1 million ha by 2030. We combined this value with 64 237 ha of planted area in 2015 all over the country and get the annual area needed to reach 1 million ha by 2030. The annual area was used to compute the rate of forest plantation growth from 2015 to 2030 and combining with the viable amount of charcoal (50 000 tons per year) for torrefaction. After that, we retrieved the same equation of briquetting to estimate the potential of emission reduction of torrefaction (see Equation 9). In the pilot area, we were more conservative in forest plantation growth for woodlots as the site is not suitable for forest plantation on a massive scale. The current context of the biomass energy sector in Mozambique becomes the main challenge of the implementation of torrefaction technology as there is no policy of forest plantation for energy supply. Therefore, taking into consideration the information above and the lack of parameters to access the whole torrefaction process in this study, the potential emissions from the torrefaction process were estimated only considering the viable amount of charcoal per year produced from the torrefied wood from either native forest or plantation forest. For the project activity not equipped with the capture and destruction of the pyrolysis gases, emission reductions are calculated as follows:

The following equations and values apply here:

Equation 9

$$ER_y = \sum_i Q_{CCP,i,y} \times \left[\left(CF \times NCV_{wood} \times \frac{NCV_{charcoal,i}}{NCV_{charcoal,default}} \times f_{NRB,BL,wood} + (SMG_{y,b} - M_a) \times (1 - f_{NRB,BL,wood}) \times GWP_{CH4,y}\right] - I$$
$$- PE_{y,flaring} - PE_{FF,y} - PE_{EI,y} - PE_{BC,y}$$

Table 3: Parametrization of model of emission reduction from briquetting of charcoal residues

Parameter	Description	Value	Source / explanation
ER_y	Emission reductions in year y[6] (t CO_2e/yr)	-	Calculated
$Q_{CCP,i,y}$	Quantity of charcoal type i produced and used in year y (t)	50 000 ton per year	Sedano et al. (2019)
CF	Default wood to charcoal conversion factor	0	No charcoal production
NCV_{wood}	Net calorific value of wood (TJ/t)		
$NCV_{charcoal,i}$	Net calorific value of the charcoal type i produced during the project (TJ/t)	29.5 GJ/ton	Default value
$NCV_{charcoal,default}$	Default net calorific value of charcoal (TJ/t)		
$f_{NRB,BL,wood}$	Fraction of biomass of type i used in the absence of the project activity that can be established as non-renewable biomass; determined as per the procedure found in the latest version of "AMS-I.E: Switch from non-renewable biomass for thermal applications by the user" or on the basis of the published DNA endorsed default values available on the UNFCCC website[7]	91%	UNFCCC http://cdm.unfccc.int/DNA/fNRB/index.html
$EF_{projected\_fossilfuel}$	Emission factor for the substitution of non-renewable woody biomass by similar consumers (t CO_2/TJ)	81.6 t CO2/TJ	Default value
	Global warming potential of methane	21 t CO2e/t	Default value

[6] Project emissions on account of transport are assumed to be negligible.

[7] Default values of fraction of non-renewable biomass can be retrieved at: <http://cdm.unfccc.int/DNA/fNRB/index.html>.

Parameter	Description	Value	Source / explanation
$GWP_{CH4,y}$	applicable to the crediting period (t CO_2e/t CH_4)	CH4	
$SMG_{y,b}$	Specific methane generation for the baseline charcoal generation process in the year y (tonnes CH_4/t charcoal product)	0.030 t CH4/t charcoal	Default value
M_d	Factor to account for any legal requirement for capture and destruction of methane in the charcoal production facility (tonne of CH_4/tonne of raw material)	0	Policy context
$PE_{y,flaring}$	If applicable, emissions due to the flare inefficiency in the project charcoal manufacturing plant in the year y (t CO_2e) determined in accordance with the procedure provided in AMS-III.K. In case captured pyrolysis gas is gainfully used (e.g. as fuel for pre-heating the facility, or for wood drying, or used for production of heat and/or power as in the case of micro-gasifier), then it can be taken as zero	0	No flare
$PE_{FF,y}$	Project emissions due to fossil fuel consumption in charcoal production facilities in year y (t CO_2)	1.072 t CO_2 yr^{-1}	5 to 10 litres of fuel is used for chainsaw.
$PE_{El,y}$	Project emissions due to electricity consumption in charcoal production facilities in year y (t CO_2)	0	No electricity use
$PE_{BC,y}$	Project emissions due to biomass cultivation in year y (t CO_2)	0	No biomass cultivation

2.2. Estimation the GHG emission and carbon stock from charcoal production and tree regrowth.

The average above-ground (AGB) biomass extracted in the charcoal production areas between the different periods of charcoal production (2008-2010, 2011-2014, and 2015-2018) in Mabalane district was 69.34 ± 3.00 Mg ha^{-1} (± standard error), corresponding to 34.67 ± 1.5 Mg ha^{-1} of carbon stock. These values were extrapolated to all four districts of the study area, combining the activity data of forest degradation at provincial level. The emission factor to the entire study area is 12.72 tCO_2-eq ha^{-1} yr^{-1}.

The charcoal production period had a significant effect on the average AGB extracted in the study area (ANOVA, $p < 0.05$, Figure 7), with significantly lower biomass in the period from 2008 to 2010 with 41.09 ± 4.24 Mg ha^{-1} than the periods of 2011 to 2014 and 2015 to 2018, which were not statistically different from each other, with mean biomass extracted of 74.44 ± 3.36 Mg ha^{-1} and 70.44 ± 2.55 Mg ha^{-1}, respectively. The low biomass extracted from 2008 to 2010 can be explained by the use of rudimentary techniques (machetes and axes) for the harvesting of trees since it is the first years of exploitation, where charcoal production was carried out by local communities only. Also, it can be explained, for a long period of fallow (10 years), that some stumps have probably been decomposed.

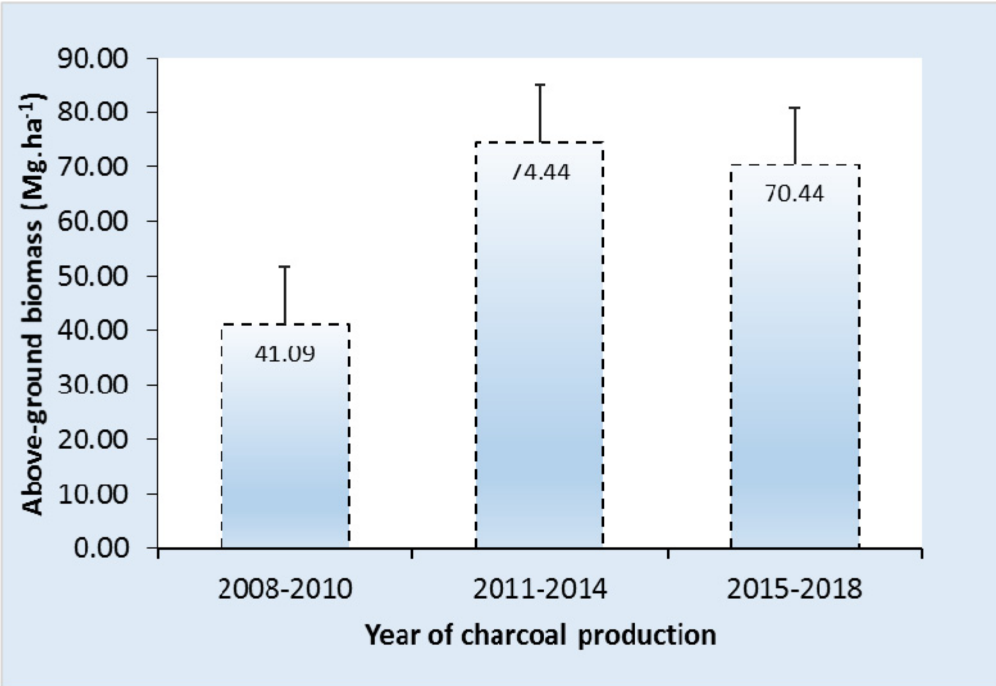

Figure 4: Above-ground biomass extracted through charcoal production process along three time period.

The average biomass stored by forest growth in the charcoal production areas of mopane woodland in Mabalane was 9.43 ± 2.34 Mg $ha^{-1,}$ corresponding to 4.71 ± 1.17 Mg $ha^{-1,}$ equivalent to one removal of 17.30 ± 4.29 t CO_2-eq ha^{-1}. From the 9.43 ± 2.34 Mg ha^{-1} of the AGB stored in the areas of charcoal production, 2.78 Mg ha^{-1} was from sprouts, and 7.15 Mg ha^{-1} was from the remaining biomass. It is imperative to note that the biomass of the sprouts reported in this study may have been overestimated because it was calculated based on the specific density of *C. mopane* (736 g cm^{-3}, Bunster, 2006) for adult trees.

The period of charcoal extraction had a significant effect on the CO_2 removals in the study area (Figure 8). The charcoal production area from 2011 to 2014 had higher biomass of sprouts (3.78 ± 0.83 Mg ha^{-1}) and was statistically different about the production areas from 2008 to 2010 and from 2015 to 2018, which had mean CO_2 removals not statistically different from each other (Figure 8). Sprouting biomass from the 2008 to 2010 period was assumed to be higher due to the long fallow period (10 years) compared to the production areas from the period 2015 to 2018, which has only less than three years of fallow. However, this was not observed in the area of charcoal production from 2008 to 2010, which likely is due to poor soil quality, which affects the mopane growth as a result in that area is mostly dominated by shrub mopane. Figure 6 also revealed that the AGB of remaining trees in the charcoal production area from 2008 to 2010 was statistically lower amongst the periods, with about 4.25 ± 0.09 Mg ha^{-1}. The AGB of remaining trees was 7.64 ± 0.37 Mg ha^{-1} and 7.29 ± 0.55 Mg ha^{-1} for the period from 2011 to 2014 and 2015 to 2018, respectively. The AGB of remaining trees from the last two periods was not statistically different of each other.

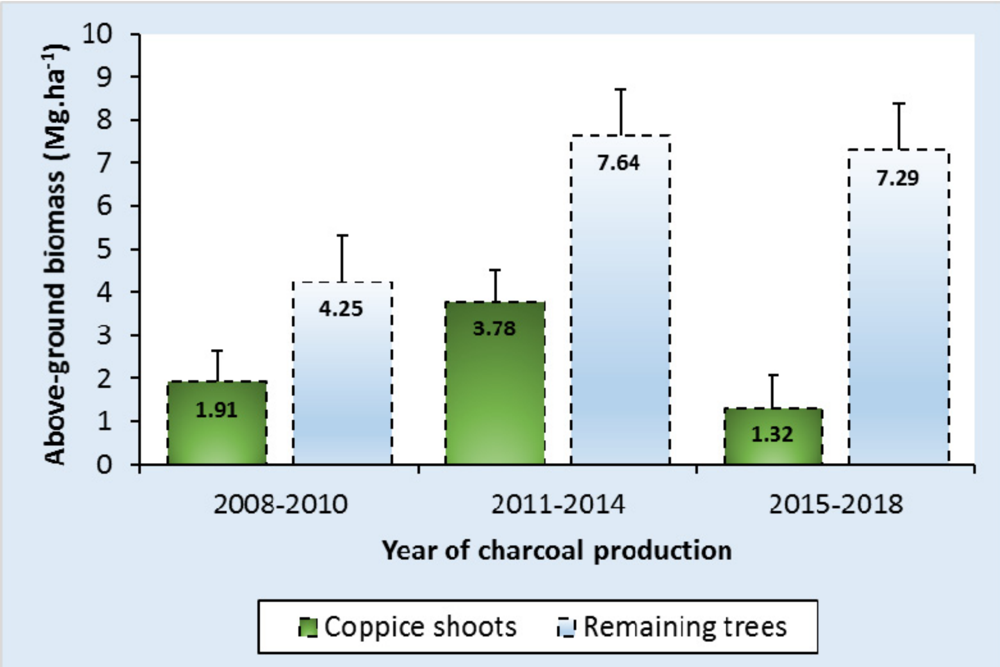

Figure 5: GHG removals through coppice after charcoal production process

Supplementary material 2

1. Social and economic impact categories

1.1. Description and Identification of specific impacts within each impact category

An initial matrix was developed, including the identified specific impacts within each impact category, based on the literature review and the ICAT Guidance. The effects identified were validated by key stakeholders in a consultation workshop in Maputo, in April 2019. Each specific impact was characterized in relation to its baseline or business-as-usual scenario (what will happen if the NAMA is not implemented) to inform the changing scenario (impacts from NAMA implementation). The qualitative impact assessment was done on a national scale. However, some impacts were validated using a questionnaire in the pilot area (the five districts, namely: Chicualacuala, Massingir, Mabalane, and Guijá).

Each NAMA technology such as improved kilns and sustainable forest management, briquetting of charcoal waste material, and torrefaction from forest plantation, were assessed in the three dimensions, environmental, economic and social, and impact categories (air, soil, land, forest, and biodiversity, jobs, energy, health, etc.) were identified and assessed within each dimension. The results of the assessment provide the following information, which can be found in the following sections.

(i) Impact categories included in the assessment,
(ii) specific impacts identified,
(iii) in-or out-of-jurisdiction,
(iv) magnitude,
(v) significance,
(vi) summary of qualitative and quantitative assessment results for each impact category,
(vii) methods or source used,
(viii) feasibility to quantify,
(ix) included to quantitative assessment boundary,
(x) justification of exclusion or other comments.

As indicated above, some impacts were possible to quantify, while others were not, so the assessment is both qualitative and quantitative. It is worth mentioning that the qualitative evaluation covers all impact categories that were identified as potential impacts. Still, the quantitative assessment only includes quantifiable impact categories when relevant data were available. The time series of impact assessments considered in this study are short-term (up to 5 years), medium-term (5 to 15 years) and long-term (greater than 15 years). According to the stakeholders, each impact has a specific effect, and its magnitude and significance can change with time and space.

2. Qualitative impact assessment of social and economic dimension

Having identified the specific impacts, these are analysed qualitatively and characterized based on the probability of occurrence, magnitude, and nature of the change (positive or negative). Table 2 shows the category of likelihood classification of each impact.

Table 4: Assessing significance of impacts

Likelihood	Description	Approximate likelihood (rule of thumb)
Likely	Reason to believe the impact will happen as a result of the policy or action.	≥ 90%
Likely	Reason to believe the impact will probably happen as a result of the policy or action	< 90% e ≥ 66%
Possible	Reason to believe the impact may or may not happen as a result of the policy or action. About as likely as not. Cases, where the likelihood is unknown or cannot be determined, should be considered possible.	< 66% e ≥33%
Unlikely	Reason to believe the impact probably will not happen as a result of the policy or action.	< 33% e ≥ 10%
Very unlikely	Reason to believe the impact will not happen as a result of the policy or action	<10%

Source: ICAT [20]

Magnitude represents the degree of change from the result or expected of the policy or action. According to the ICAT [20], if there is no data or evidence to estimate the relative magnitude, experience, and consultation with interested and affected parties can be used to rate the impact as a major, moderate, or minor. If this is not possible, this impact should be classified as "uncertain" or "cannot be determined." In this study, the magnitude of impact was assessed together with stakeholders during the workshop in Maputo, and also with some results from questionnaires in the field. The table below shows the relative magnitude of sustainable development impacts, according to ICAT [20].

Table 5: Estimating the relative magnitude of sustainable development impacts

Relative Magnitude	Description
Major	The change in the impact category is expected to be substantial in size (either positive or negative). The impact significantly influences the effectiveness of the policy or action with respect to that impact category.
Moderate	The change in the impact category is expected to be moderate in size (either positive or negative). The impact somewhat influences the effectiveness of the policy or action with respect to that impact category.
Minor	The change in the impact category is expected to be insignificant in size (either positive or negative). The impact is inconsequential to the effectiveness of the policy or action with respect to that impact category.

Source: ICAT [20]

3. Quantitative impact assessment for social and economic dimension

3.1. Quantitative impact assessment for Social dimension

Social impact categories identified are hunger, nutrition, and food security, education, access to land and its resources, poverty reduction, gender equality, and equity. An increase in income in the charcoal value chain will have a spillover effect on household wellbeing. The NAMA will positively contribute to poverty reduction and thus improved access to food that will ultimately contribute to reduced hunger and food insecurity, and malnutrition. The increased income is also expected to lead to investment in child education. No data on gender and household economy profile is systematically collected at the district level with a detailed disaggregation level, which limits the assessment of other potential impacts. Therefore, only the following quantifiable has implications of the NAMA are presented: education and gender/equity (Table 4).

Table 4: Key parameters and indicators for tracking the social impacts of NAMA

Parameter	Key Performance Indicator	Entity responsible for measuring	Entity responsible for Reporting	Entity responsible for data sharing	Monitoring frequency
Education	Number of children enrolled in school	District Education Directorate	District Services of Planning and Infra-structure (SDPIs)	Ministry of Education,	Annual
		National bureau of Statistics (INE), from the regular based national statistics			
	Number of workers in the charcoal value chain using more efficient and sustainable charcoal production technologies, and forest management practices	District Services of Economic Activities (SDAE) Charcoal associations	Provincial Forest and Wildlife Services (SPFFB)	National Directorate of Forests (DINAF)	Quarterly
Gender equity	% of women in different sectors and activities in the charcoal value	SDAE	SDPI	DINAF (disaggregated by gender)	Quarterly

	chain				

A database of charcoal producers or associations in the NAMA target areas should be established. From the technical assistance side at the pilot stage, surveys should be conducted in order to track the NAMA implementation. It will be beneficial if records charcoal producer's income and expenditures are also collected. It will allow having clear NAMA benefits without the uncertainty of attribution of impacts to other activities.

Improved access to education for local children

Number of Children enrolled in school

The potential positive impact of NAMA technologies options on income generation includes increase investment in education at the local level, thus increasing literacy level as illiteracy still high around 60% in rural areas [21]. The number of children enrolled in schools in different areas is regularly collected. It can easily be used to access the progress of NAMA contribution to households involved in the charcoal value chain, even though attribution of this impact to the NAMA activities can be discussed. In the BAU, it is assumed that the Education Strategy 2012-2016 [22] aims at maintaining the increasing rate of children enrolled in schools. Table 7 shows a variation pattern of children enrolment and the equations used. It is expected that an increase of 20% and 16.5% will be achieved as NAMA income opportunities allow parents to invest in education.

Improving income and opportunity equity

Increased gender equality promotion and women empowerment by created association

Several groups have different vulnerability levels based on gender and age. Social exclusion and access to opportunities are also based on social context or culture. Additional access opportunities to resources and benefits are observed. The charcoal producers profile raises the need for looking at gender relations and create a balance between genders [23]. Women's participation is meager in the NAMA pilot area, close to 10%. The socio-economic context makes the women less Martengaged in charcoal production, as they are more engaged in household activities and farming. The need for increased income is in general, regardless of gender and social group. Job opportunities that can be easily performed without affecting the current women responsibilities will be created, such as:

i) forest management activities and honey production that can be performed in areas close to agriculture fields,

ii) briquette packaging and labeling,

iii) production and trade of efficient stoves.

It is as well expected that additional economic activities can be developed as an application of income from charcoal in commercial activities, the opening of small shops, or stimulation of local industry. Table 8 shows the variation pattern of the expected change in women proportion involved in charcoal activities.

Charcoal consumers using sustainably produced charcoal

An increase in charcoal sustainably produced and an increase in awareness of consumers on the impacts of charcoal production will provide a shift from unsustainable to sustainably produced charcoal. Increasing amounts of sustainable charcoal in trade places or markets will be accessible to consumers as the value chain develops. **Table 6** presents the impact of quantification or expected variation of the consumer using sustainably produced charcoal from 2020 to 2030 due to NAMA implementation. Currently, less than 2% of charcoal is produced sustainably in Mozambique, as the adoption of efficient technologies is limited.

3.2. Quantitative impact assessment for impacts in the Economic dimension

The identified specific impact categories for the economic dimension are economic diversity, labour, income, and sector revenue. Due to data limitations for quantification, scenario development for economic impact are labour and revenue. Effects assessed are related to a positive increase in new long-term employment opportunities and a negative effect on the reduction of employment where traditional and unsustainable technologies are used.

Increased number of employed people in the charcoal value chain (green jobs)

Number of people working in the sector

New employment opportunities and training are expected to offset the potential negative impacts. The forest sector has been reported to employ 600,000 people [24], and the charcoal sector around 1,500,000 [25]. Statistics data shows a decrease in employment from 2015 to present, within average about 87,000 people. NAMA implementation will contribute to increased employment locally and at the national level. The organization of charcoal associations along the value chain will allow better statistics on employment benefits for local and external people. The increase will be due to the formalization of the charcoal value chain as it will open new opportunities along the chain from where people may choose where to take benefits, either from production and trading or transporting and distribution. As formal contracts will be required, the security of employment will be ensured, thus attracting more people and allowing more comprehensive coverage of NAMA efficient technologies or practices. Table 9 presents the basis for the expected variation in people benefiting from employment.

Increasing the benefit (revenues) of the local communities

According to Nhancale et al. [25], only 4% of charcoal producers are licensed, and about 96% are illegal producers (the local community holds a customary right on local resources). This means that currently, the communities only get 0.8% of the charcoal revenues, instead of 20%, which should be the actual share for the communities. With the NAMA, this scenario will be reversed, as the formalization of the sector will induce the current producers to formalize their charcoal activity by requesting a license, thus contributing to the increase in the percentage margin that remains with the communities. On the other hand, the NAMA intends to allocate a percentage of the increased profits to the producers, to compensate them for the increased activities (i.e., forest management), and to make them aware of the value of the standing tree, thereby encouraging them to value the regeneration of the forest and waste minimization. We assume that the number of people or producers willing to get a license and formalize their charcoal activity will increase by 8% per year (Table 10). This is an optimistic scenario, and to realize this scenario many issues must be solved, such as corruption, governance, building infrastructure, promotion of local community charcoal institutions, etc.

Increase in total revenue in the sector (% GDP)

According to Nhancale at al. [25], only 4% of charcoal was officially recorded and accounted for in the sector statistics. According to [24,25], the GDP from the charcoal sector varied between 4-9%. Studies have reported that almost 50% of harvested wood goes unrecorded as a result of illegal logging [26]. It is expected that sector GDP might have decreased at the same proportion to 2-5%. The formalization of the charcoal value chain will benefit from better control of the charcoal produced and an increase in sector revenue from licensing. Table 11 presents the basis for the equation development to express the expected changes in forest sector revenue as the charcoal value chain is formalized.

Table 6: Quantification of availability of sustainable charcoal

The energy produced in a sustainable manner												
Specific impact	Increase in complementary biomass and charcoal waste used, which will increase access to charcoal and other energy carriers (briquettes, terrified material) produced in a sustainable way											
Indicator	Number of charcoal consumers using sustainably produced charcoal											
Assessment method	Scenario method											
Equation	• $\%Ch = \begin{cases} Ch_f = Tc_1 * Ch_o \text{ de 2018 à 2025} \\ Ch_f = Tc_2 * Ch_o \text{ de 2026 à 2030} \end{cases}$ $Tc_1 = 1.6$ $Tc_2 = 1.3$											
Parameters needed	The initial value of unsustainably used charcoal and evolution rate											
Assumptions	By 2025 the intake rate will be high, and after that slow and stabilizing rate will be observed as sustainable charcoal and briquettes will be replacing the traditional charcoal as low production of the later take place.											
Assessment period	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
With NAMA (%)	0	2	3	5	8	13	21	27	35	46	60	78
Base scenario (%)	0	2	3	3	4	5	6	8	10	12	15	19
Increase (%)	0	0	1	2	4	8	15	20	26	34	45	59

Table 6: Quantification of the improved access to education for children, due to improvements in income

Education												
Specific impact	Improved access to education for local children											
Indicator	Number of children enrolled in school											
Assessment method	Scenario method											
Equation	$E = \begin{cases} E_f = E_o + 6340 \; de \; 2018 \; à \; 2025 \\ E_f = E_o + 5971 \; de \; 2026 \; à \; 2030 \end{cases}$ Ef = Next year's student's MOo = Student's year's before											
Parameters needed	Student population growth rate over time/ school infrastructure capacity, the ratio of school-aged children that going to school, to total school-age children,											
Assumptions	By 2025, the rate of intake will be high as a result of the improvement of charcoal actor's income as NAMA is fully implemented. From 2025, a slow down as almost all children at schooling age will not be much left.											
Assessment period	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
With NAMA (%)	164060	177137	190213	203290	216367	229443	242520	248491	254463	260434	266406	272377
Base scenario (%)	164060	170400	176740	183080	189420	195760	202100	208440	214780	221120	227460	233800
Increase (%)	0	6737	13473	20210	26947	33683	40420	40051	39683	39314	38946	38577
Increase	0	4	8	11	14	17	20	19	18.5	18	17	16.5

Table 8: Quantification of the share of women participating in charcoal production

Gender equity	
Specific impact	Increased gender equality promotion and women empowerment by created association
Indicator	% of women involved in activities in the charcoal value chain
Assessment method	Scenario method
Equation	$\%W = \begin{cases} \%W = 10\%T \text{ year} \leq 2018 \\ \%W_n = an * W_{n-1} \text{ } 2019 < Anos \leq 2025 \text{ with } a_n = 1.025 + 0.075n \\ \%W_n = 1.075W_{n-1} \text{ for year } \in]2025, 2030] \end{cases}$ Onde: W = Percentage of women before 2019 (10%) T = Total Workers Wn = Percentage of women in year n an = Annual growth rate in the years 2019 to 2025 0.075 = Annual growth rate in the years 2026 to 2030 n = values ranging arithmetical from 1 to 7 with one corresponding to 2019 and 7 corresponding to 2025
Parameters needed	Historical data of the level of women's participation in charcoal production,
Assumptions	Until 2025 the female population entering the charcoal production chain will grow at a progressive rate against the actual 10%, tending to stabilize at a constant rate from 2025.

Assessment period	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
With NAMA (%)	10	11	12	15	19	25	35	36	37	38	38	39
Base scenario (%)	10	10	10	10	10	10	10	10	10	10	10	10
Increase (%)	0	1	2	5	9	15	25	26	27	28	28	29

Table 7: Quantification of the increased number of people in the charcoal value chain

Labour													
Specific impact	Increased number of employed people in the charcoal value chain (green jobs)												
Indicator	Number of people working in the sector												
Assessment method	Scenario method												
Equation	$MO = \begin{cases} MO_f = Tc_1 * MO_o \text{ from 2018 to 2015} \\ MO_f = Tc_2 * MO_o \text{ from 2026 to 2030} \end{cases}$ MOf = Next year's workforce MOo = Workforce year's before $TC_1 = 11\%$ $Tc_2 = 5\%$												
Parameters needed	The average rate of change in the sector's labor force, excluding outlier, the ratio of total labor introduced by NAMA												
Assumptions	Up to 2025 will be a greater increase in the number of employed people as a result of new activities (briquettes, torrefied briquettes or pellets), that are not currently performed, and forest management, which is presently not very intense. However after 2025 demand will be reduced as some activities will have been properly established.												
Assessment period	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**
With NAMA	117286	129609	143228	158277	174907	193285	213594	236037	233227	245480	258377	271951	286238
Base scenario	95743	105803	116921	129206	142782	157784	174363	192683	202806	213461	224675	236479	248903
Increase	21542	23805	26307	29071	32125	35501	39231	43353	30420	32019	33701	35471	37335
%	22.5	22.5	22.5	22.5	22.5	22.5	22.5	22.5	15	15	15	15	15

Table 10: Quantification of economic benefits to the communities

Income													
Specific impact	20% of charcoal licensing revenue delivered to the community												
Indicator	Amount of revenues from charcoal's licensing delivered to the community												
Assessment method	Scenario method												
Equation	$VN_{n+1} = \frac{(V_n - 7\%V_n) * P_{n+1}}{4} \cap V_{n+1} = V_n - 7\%V_n$ Vn: the amount of earlier year V_{n+1}: next year's amount of business as usual scenario VN_{n+1}: the amount of year (n+1) with NAMA P_{n+1}: percentage of charcoal produced with a license in the year (n+1)												
Parameters needed	Percentage of revenue gathered with and without NAMA, average license fee, number of licenses awarded.												
Assumptions	The amount of license will increase by 8% per year with NAMA, and without NAMA, the current revenue caught by the SDAE is about 4%. This means that with NAMA, the number of licenses will increase. The number of licenses will increase 8 % per year, because we assume that the formalization or licensing of illegal charcoal production will increase gradually.												
Assessment period	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**
With NAMA (MZN)				32248125	39206250	47190000	55860000	64968750	74255625	83557500	92651250	102813750	111101250
Base scenario (MZN)				19845000	18450000	17160000	15960000	14850000	13815000	12855000	11955000	11115000	10335000
Increase (MZN)				12403125	20756250	30030000	39900000	50118750	60440625	70702500	80696250	91698750	100766250
%				62.5	112.5	175	250	337.5	437.5	550	675	825	975

Table 11: Quantification on the impacts on the revenue from the charcoal sector

REVENUE													
Specific impact	Increase in total revenue in the sector (% GDP)												
Indicator	% change in the forest sector revenue as a result of NAMA												
Assessment method	Scenario method												
Equation	$\% \, Of \, PIB = \{\%PIB_f = Tc_1 * \%PIB_o$ de 2018 à 2030 PIBf = Next year's PIB PIBo = PIB year's before $TC_1 = 1.10$												
Parameters needed	Average change rate in the sector's GDP, Average change rate in the national GDP												
Assumptions	In the period 2020-2025 is expected a constant increase rate. However, an exponential increase in GDP will be experienced in the sector as charcoal value chain is modernized and revenue captured more efficiently.												
Assessment period	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**
With NAMA	2.6	2.6	5.5	5.7	6.0	6.3	6.6	7.0	7.3	7.7	8.1	8.5	8.9
Base scenario	2.6	2.6	2.7	2.9	3.0	3.2	3.3	3.5	3.7	3.8	4.0	4.2	4.4
Increase	0.0	0.0	2.7	2.9	3.0	3.2	3.3	3.5	3.7	3.8	4.0	4.2	4.4
%	2.6	2.6	5.5	5.7	6.0	6.3	6.6	7.0	7.3	7.7	8.1	8.5	8.9

Validation of the impact

A questionnaire was applied to gather responses from charcoal producers, drivers of charcoal transportation, local institutions, and local traders. The result of the interview at the district level was used to make the last judgment of the significance and magnitude of each selected impact. For the description of the specific impact, the current scenario (baseline) was considered and compared to a description of the expected future scenario. It is also likely that unintended, specific impacts will occur, i.e., impacts that do not contribute to the achievement of NAMA objectives. An unintended impact is the emissions in transport that will increase with the NAMA since the NAMA will result in increased production of charcoal, and consequently, increase the transport of this charcoal from the place of production to the cities.

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