Capacity Building in Energy Planning and Management
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MOZAMBIQUE URBAN BIOMASS ENERGY ANALYSIS 2012

MAPUTO – MATOLA - BEIRA – NAMPULA

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PROJECT BACKGROUND

This project is part of the Capacity Building in Energy Planning and Management programme funded by the European Commission (EuropeAid/127640/SER/MZ). The programme is duly implemented by Grontmij A/S of Denmark and Ceso CI of Portugal. The beneficiary organization is the Mozambique Ministry of Energy – Department of Studies and Planning.

The urban biomass energy analysis project has benefited from collaboration in implementation from the University of Eduardo Mondlane (UEM), the National Energy Fund (FUNAE) and the provincial services for lands and forests (SPTF) in Maputo, Beira and Nampula.

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EXECUTIVE SUMMARY

Biomass energy in the form of charcoal or firewood is used by over 85% of urban households in Mozambique. The charcoal commerce is a multi-million dollar industry, covering an extensive value chain from those in the production sites to those transporting and retailing it in the cities. Despite the dimension of this sector, it is a largely informal activity with limited recorded information. This has made it difficult to design policies and strategies that could foster sustainable use of biomass energy resources in the country.

The objective of this study is to generate a baseline of the biomass energy industry, by providing detailed information on the production, supply and consumption of biomass energy in selected regions of Mozambique.

The survey was administered to households of all socio-economic backgrounds, within most neighbourhoods of Maputo, Matola, Beira and Nampula cities. Within all cities, electricity connectivity rates are relatively high, whereby in Maputo and Matola over 90% of households have access to electricity. Within both Beira and Nampula the connection rate is at 80%. The large majority of these households use a pre-paid system locally called *credelec*.

Despite the high urban electrification rates, the predominant energy source used for cooking in the cities is biomass. Charcoal is used by 87% of households in Maputo and Matola; 85% of households in Beira city; and as much as 92% of households in Nampula. Fuel mixing is becoming a common trend in urban Mozambique. Households rely on multiple sources of cooking fuel to satisfy energy needs. Modern fuel penetration is becoming more prevalent in cities such as Maputo and Matola; whereby 50% of households use either LPG stoves or electric stoves in combination with biomass. In Beira the modern fuel penetration level is at 26% while in Nampula it is the lowest at 10%.

The level of modern fuel use can be associated with the price of biomass fuels. In Maputo and Matola where a greater number of people use LPG or electricity for cooking, it is where charcoal is most expensive. On average charcoal reliant households spend 775 Meticais (28 USD) a month for this fuel. At such high prices, it is economically viable to switch to modern fuel sources. In Beira city, households spend on average 465 Meticais (17 USD) per month for their charcoal. In Nampula however, charcoal prices are lowest. Households spend on average 381 Meticais (14 USD) per month for using this fuel. This is half the expenditure compared to those households in Maputo and Matola. This explains the lower level of modern fuel adoption rates in Nampula.

The quantities of charcoal used by households in the different cities also vary. In Maputo and Matola, an average of 2.64 kg of charcoal is used daily by charcoal reliant households. In Beira, they use 2.49 kg per day. In Nampula however, up to 3 Kg of charcoal is used daily. The larger quantities of charcoal used in Nampula may again be related on the lower price of charcoal in the city. People can afford to cook more meals and for a longer time. The results show that in Bothe Maputo/Matola and Beira, households spend an average of 2:24 hours cooking per day. In Nampula it is 3:25 hours.

The survey shows that over 70% of households in Maputo and Matola cities cook indoors. In Beira and Nampula, 69% and 54% respectively cook indoors during the rainy season. The health dangers associated with indoor air pollution are well documented and can pose serious health threats. Conditions such as acute respiratory infections, chronic obstructive lung disease as well as lung cancer are common amongst long time biomass users. This study revealed a 23% respiratory

disease incidence amongst the sample. Nampula was the city where most cases were reported (26%) followed by Beira (25%) and the lowest in Maputo and Matola (19%). With this in mind, households were asked whether they associate health impacts to cooking with charcoal. The results show that in Maputo, 83% of respondents said there was no health problem associated. In Beira and Nampula 58% and 67% respectively did not associate health problems with charcoal use. This highlights the need to increase awareness amongst households on the health dangers associated with indoor air pollution.

Similarly, respondents were asked whether they associate environmental problems with charcoal use. Only in Beira, did the majority of households agree with this association (68%). In Nampula 46% of respondents agreed; while in Maputo and Matola, only 23% of households associated a negative environmental impact with charcoal use.

The environmental impact associated with the mass consumption of charcoal in the urban areas is serious. This is most critical for the south of the country. Charcoal users in Maputo and Matola consume an equivalent of 1.8 million tonnes of wood per year. This translates to 141 985 hectares of forest destroyed annually just for charcoal production for domestic use. To produce charcoal for Beira, it is required on an annual basis 438 258 tonnes of wood. This means that 12 045 hectares of forest are removed each year in Sofala and Manica provinces. For the case of Nampula city supply, it is required 722 518 tonnes of wood per year. This translates to an annual deforestation rate of 23 360 hectares. In all study regions, no significant efforts of reforestation and sustainable forestry practices were encountered.

Many families are dependent on the charcoal industry for their livelihoods. The charcoal value chain is extensive and begins with the producers in the rural areas. They are either family based subsistence level producers or larger associations of producers and commercial loggers. This study estimates that the average producer supplying Maputo and Matola region earns around 6750 Meticais (241 USD) per month as revenue. Those producing for Beira city earn around 3330 Meticais (119 USD) per month, while those producing for Nampula city earn on average 4500 Meticais (161 USD) per month.

The second intermediary in the charcoal value chain is the transporter. They provide the service for transporting the charcoal from production site to sales point. This is largely done in the form of large trucks or like in many cases for Beira and Nampula cities, by bicycle. Those transporting charcoal by truck to Maputo and Matola city do so for extensive distance over 300 km. They can earn up to 54 360 Meticais (1 941 USD) per month. In Beira, the majority of charcoal is transported by bicycle. Cyclists can paddle for long distance and earn only 2400 Meticais (86 USD) per month. Similarly, in Nampula cyclists earn an average of 1680 Meticais (60 USD) per month.

At the point of sale, charcoal is either sold by wholesalers in bulk, or by retailers in smaller/daily quantities. Wholesalers in Maputo can earn up to 9000 Meticais (321 USD) per month, while retailers earn on average 8745 Meticais (312 USD) per month. Wholesalers in Beira can earn around 4600 Meticais (164 USD) per month and retailers around 5985 Meticais (214 USD) per month. Within Nampula, wholesalers can earn on average 3200 Meticais (114 USD) per month while retailers earn 2790 Meticais (100 USD) per month from revenue of sales.

It is estimated that just for household charcoal supply in Maputo, Matola, Beira and Nampula the industry generates around 125 million US dollars every year. Since this is a largely informal activity, the value of this industry is unaccounted for in the government tax structure. Regularising the

industry could generate income for the state, which in turn could be used to promote more sustainable use of forestry resources for charcoal production.

SUMMARY OF POLICY RECOMMENDATIONS

At production level:

1. To reduce informality of charcoal industry by designing better fiscal control policies;
2. Develop commercial models for renewable charcoal production;
3. Develop models for community forest management and sustainable charcoal production;
4. Study the possibility of introducing a certification system for sustainably produced charcoal;
5. Introduce improved charcoal production kilns in rural areas to increase wood to charcoal conversion efficiency;
6. Promote better logging practices – for example felling trees at correct height to ensure regeneration;
7. Promote for the production of third generation charcoal such as briquettes from waste material or specially planted feedstock.

At retail level:

1. Study options for introducing a licensing system for charcoal wholesale and retail;
2. Study options for introducing a certification system for the retail of sustainably produced charcoal.
3. Incentivise and facilitate for carbon financing in clean cooking energy projects. Opportunities exist within improved biomass stoves; other clean cooking fuels such as ethanol, bio-diesel and biogas; as well as sustainable forestry plantations for biomass fuel production.

At consumer level:

1. Promote for public awareness raising campaigns of dangers associated with indoor air pollution;
2. Consumers should be more aware of environmental impacts associated with the production and consumption of biomass fuels;
3. Scale up introduction of clean cooking fuels such as LPG, ethanol and electricity;
4. Promote and facilitate for more private sector investment in clean cooking fuels;
5. Ensure economic incentives for clean cooking fuel entrepreneurs such as possible tax exemptions, favourable tariffs and even subsidies. This is to ensure the economic viability of clean cooking fuels compared to biomass fuels;
6. Incentivise and promote the production of improved biomass stoves which are more energy efficient and fuel saving.

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1. INTRODUCTION

Mozambique is a relatively energy abundant country, with rich resources of hydro, coal and natural gas. Despite the mass export of such resources, over 80% of the local population is still dependent on traditional biomass fuels as their primary energy source. Such dependency becomes an environmental concern when looking into the urban area. It is in the cities that biomass has become a traded commodity, and in demand by millions. This biomass often originates from natural forested areas, which are being cleared at unsustainable rates as charcoal producers search for denser and more calorific wood.

Despite the visible impacts of the biomass energy industry, there is limited up-to-date and concise scientific information available to depict this sector. Data collection in the past has been concentrated into small sample sizes and limited geographic cover. Such has impeded for a thorough analysis of a baseline situation, as well as for the creation of models and scenarios to aid policy-making.

Policy-makers and researchers have often made use of national government databases to determine the amount of biomass energy consumed in urban areas. This data is compiled by considering the amount of licenses issued by the ministry of agriculture for the exploration of forests for the production of charcoal and/or firewood. The accuracy of these figures has however been questioned on various accounts. It is believed that the greater amount of biomass entering the urban areas is of an informal nature. Some experts estimate that only about 10% of the biomass is licensed (Sitoe *et al.* 2008, Falcão *et al.* 2012). Thus it is only this amount which is recorded in the national database.

With the fast growing rate of deforestation, the government of Mozambique has initiated the process of establishing the countries first biomass energy strategy and policy. As a means to ensure an accurate depiction of the biomass energy sector in Mozambique, this study has been commissioned by the Mozambique Ministry of Energy, and funded by the European Union, as a means to create a national energy use database, and guide the establishment of models and scenarios to be used towards designing the strategy.

The study looks at the energy use dynamics within the larger urban areas of Mozambique. As to account for the southern region, the cities of Maputo and Matola have been analysed. The centre of the country has been covered by the city of Beira, while within the northern region; the study was carried out in Nampula.

Within each city, three components have been analysed. The first looks at the urban energy use matrix of the city, both at household level as well as at institutional level. The second component is the analysis of biomass supply in this urban areas, taking into account the origin of the biomass, the means of transport used, the costs associated as well as the frequency travelled by each individual transporter. Daily counting of vehicles with biomass entering the cities was also done. The third component focused on the value chain of biomass. Intermediaries' ranging from charcoal producers to wholesalers and retailers have been interviewed to gain a deeper understanding of the structure of this largely informal business. These three components give us a thorough understanding of urban biomass energy use and production patterns.

2. METHODOLOGY

This study covered a range of components within the biomass energy field. Most notably;

1. Urban biomass energy consumption
2. Biomass energy supply dynamics
3. Biomass energy value chain analysis

Each one of these three components was studied within the different regions of Mozambique. To represent the southern region, Maputo and Matola cities were chosen. To represent the central region, the study took place in Beira city. And to represent northern Mozambique, the biomass energy dynamics in Nampula city were analysed. As a whole, a total of 1 980 respondents were sampled, subdivided into categories as depicted by the figure below.

Nampula:
-Date: 23/07/2012 to 2/08/2012
-Households Sampled: 448
-Institutions sampled: 56
-Value chain sample: 70
-Transporters sampled: 125

Beira:
-Date: 21/05/2012 to 3/06/2012
-Households Sampled: 420
-Institutions sampled: 46
-Value chain sample: 65
-Transporters sampled: 80

Maputo/Matola:
- Date: 10/12/2011 to 23/12/2011
-Households Sampled: 501
-Institutions sampled: 71
-Value chain sample: 63
-Transporters sampled: 75

2.1. URBAN ENERGY USE DYNAMICS

Baseline fuel surveys were administered to households within neighbourhoods of Maputo, Matola, Beira and Nampula. A total of 56 neighbourhoods were covered, of which 25 are in the Maputo and Matola cities; 16 in Beira and 15 in Nampula. Annex 1 shows a detailed table with neighbourhood names and respective sample size.

A random sampling technique was implemented within a proportional range to represent the population ratio of each neighbourhood. Every third household was enumerated, as to assure greater representativeness. Within each household, enumerators asked to survey the person responsible for cooking.

For the collection of institutional related energy use, surveys were administered to a sample of take-away canteens, restaurants, hotels, bakeries, hospitals and prisons. A list of such establishments was provided by the municipal council of each respective city. The sample size was determined by the concentration of such institutions within each city. Generally, not less than 10 establishments of each category were considered.

Within each city, the surveys were administered by a team of eight enumerators. These were university students, with a background in social sciences or economics. The surveyors underwent thorough two-day training, pilot survey implementation and subsequent data quality verification checks.

The household energy use survey was designed to collect a range of socio-economic data; household energy information, stove and fuel use statistics; as well as general cooking habits. Furthermore, a baseline fuel weighing procedure followed each survey to determine the weight of fuelwood used per household per day. The institutional energy use survey included questions about the number of daily cooked meals prepared; sources of cooking energy used; quantities of such fuels, as well as the costs associated with cooking energy.

Within the data analysis, the following equations were used to determine the consumption and expenditure patterns for household cooking energy use:

Charcoal and firewood consumption

$$Q = Wd \times Wm$$

Whereby;

Q – Monthly Quantity of charcoal or firewood consumed by the household (Kg/Month)
Wd – Average weight of daily charcoal or firewood consumption per household (Kg/month)
Wm – The conversion coefficient of the average daily household charcoal or firewood consumption (Wd) to the weight of the monthly charcoal or firewood use, with reference to frequency of use.

Household Charcoal expenditure (cost)

The monetary value paid by families for the monthly consumption of charcoal has been calculated as follows:

$$Vc = Q \times Pc$$

Whereby:

Vc – Value spent per households per month to purchase charcoal (Mts/month)
Pc – Unitary price per kilogram of charcoal.

Households Expenditure on Firewood, LPG or Kerosene

To calculate the monetary value spent per family per month for the acquisition of firewood, LPG or Kerosene, the following equation was used:

$$FLK = v \times p$$

Whereby:

FLK – Value spent per month for the purchase of firewood, LPG or Kerosene (Mts/month)
v – The value spent for each purchase of the stated fuel (Mts).
p – The conversion coefficient of the daily value spent (g) to the monthly value spent, in function with the frequency that the household buys their fuel:

-Every Day; p = 30
-Three times per week; p = 13
-Once per week; p = 4,3
-Once every two months; p = 2,15
-Once a month; p = 1

Consumption and cost of electricity used for cooking

In order to estimate the consumption of electricity for cooking, the following equation was used:

$$C = Ns \times Nd \times T \times Nm \times Wm \times C$$

Whereby:

C – Electricity consumed per month per electric stove within a given household (Kwh).
ns – Number of electric stoves used per household
nd – Number of times the electric stove is used per day
t – The average time the stove is under use per meal preparation (h)
nm – Number of days the electric stove is used per month
Wm – The conversion coefficient for the weekly use frequency to the monthly use frequency
C – The average electricity consumption of electric stoves (Kwh); for this study it was considered 1 Kwh.

The monetary value spent per month for electricity was obtained by multiplying the monthly consumption to the price of one Kwh, in accordance with the official price provided by the national utility company – Electricidade de Mocambique.

$$G = C \times Pe$$

Whereby:

Pe – Unitery price of electricity (Mts/Kwh). from 0 to 301 Kwh, 1 Kwh = 2.27 Mts; from 301 to 500 Kwh, 1 Kwh = 3,20 Mts

2.2. BIOMASS SUPPLY ANALYSIS

This component aimed to calculate the amount of biomass fuels which enter the urban centres on a daily basis. The provenance of these fuels as well as the tree species used was also determined through a system of surveys administered to those transporting the fuels.

All known biomass entry points to the cities (Maputo, Matola, Beira and Nampula) were monitored during a period of 10 days. The three main routes identified include main roads, secondary roads, as well as the railway terminal. These entry points were acknowledged by the National Directorate for Land and Forests (DNTF) as well as the provincial services of lands and forests (SPTF), for each respective city.

For Maputo and Matola, It was determined that the large majority of biomass enters through the following routes:

1. Matola Rio
2. Moamba
3. Marracuene
4. Gare de Mercadoria (Wholesale train station)

For Beira, the following routes were monitored:

1. Inhagau
2. Dondo weighbridge
3. ECMEP (Informal route 300 meter from Dondo weighbridge)

For Nampula, the following road checkpoints were used.

1. Checkpoint 1 (National road number 8 towards Nacala)
2. Checkpoint 2 (Exit road to Angoche)
3. Checkpoint 3 (Exit road towards Mogovolas)
4. Checkpoint 4 (Exit road towards Ribaue)

The daily vehicle counting and survey administration was done by officials from the Provincial Services of Land and Forests (SPTF). They remain stationed at road checkpoints, on a daily basis. It was possible to monitor the roads over 24 hours, due to a system of work shifts amongst officials. At the train station in Maputo, it was possible to count incoming charcoal and firewood loads, based on the train arrival schedule. The train arrives from the charcoal production regions every Thursday late afternoon.

In order to estimate the average charcoal sacks weight, several charcoal sacks were selected randomly from different trucks at all check points. The selection was dependent on the willingness of the transporter to participate in the study. A structured questionnaire was also administered to at least 7 transporters per day and per checkpoint. Categories of transporters include truck drivers, pickup van drivers, individual transporters as well as cyclists.

The amount of biomass that entered the cities was estimated based on the amount of charcoal sacks and amount of firewood registered at checkpoints. The data on charcoal was then converted into biomass, assuming the charcoal kiln efficiency of 13%. For the firewood, the amount of biomass was estimated based on the assumption that 1 ester is equal 0.7 m^3 of biomass. The following two formulas were used.

1. The efficiency of kiln charcoal production (E):

$$E = \frac{P_{ch}}{V \times \delta} * 100$$

Where,

P_{ch} = Total weight of charcoal produced (kg);
δ = Average Density of miombo wood in Mozambique (858 kg/m^3);

2. The volume of the timber in the kiln (V):

$$V = \frac{3.14 \times (D)^2}{4} * L * N$$

where,

D = Average diameter of logs in the kiln (m);
L = Average length of logs in the kiln (m);
N = Number of logs inside the kiln.

2.3. BIOMASS ENERGY VALUE CHAIN ANALYSIS

In the scope of this study, seven categories of intermediaries are identified, according to the role played in the charcoal chain; in sequential order of the process, these are (i) wood loggers, (ii) charcoal producers, (iii) packers or sack sorters, (iv) transporters, (v) wholesalers, (vi) hand-carriers and (vii) retailers.

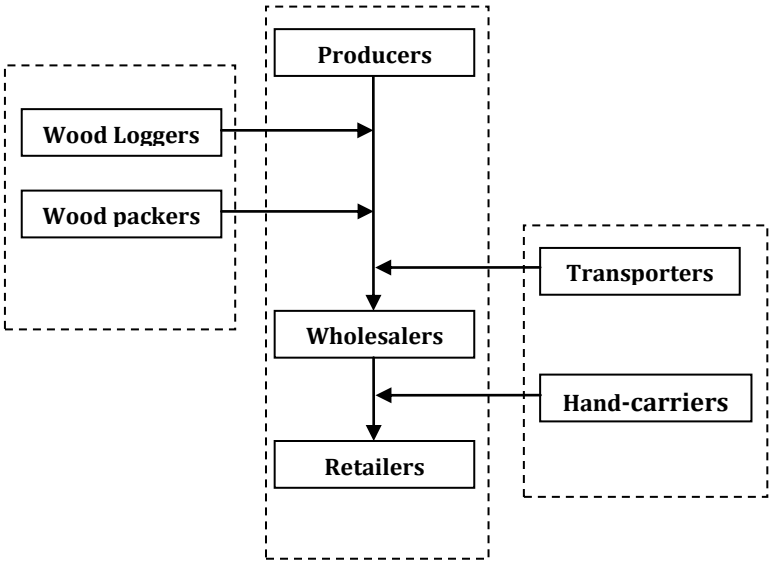


Figure 1: Structure of charcoal value chain

Qualitative interviews were conducted with the various intermediates within the charcoal value chain. The questionnaire structure was developed in a fashion that enables to capture as much relevant information as possible of a category, namely, the socio-economic profile, the activity of each of the interviewees in the charcoal chain, the cost structure within the activity and, whenever it was found relevant, the health and environmental perception of the interviewee in relation to his/her activity.

A pilot-test was conducted to fine tune specific aspects of the questionnaire. In general, at the end of each interview, the interviewee is given an opportunity to comment on any aspect not dealt with during the interview that, to his/her view, may be relevant for the study.

For analysis purposes, the collected information and data is entered into Excel in table format for each category surveyed. Thereafter, the collected answers are grouped with view to assess similarities or common answers, differences and any other personal views obtained from the interviewees.

All interviews were carried out within the urban boundaries of the cities with the exception those interviews targeted at charcoal producers. Such were carried out in Savane, Sofala province, as an indicator for producers catering for Beira city; as well as in Meconta, Nampula province.

3. RESULTS

3.1. HOUSEHOLD AND INSTITUTIONAL ENERGY USE

3.1.1. SOCIO-ECONOMIC DYNAMICS

Within Maputo and Matola city, there is an estimate of 449 343 Households. This study sampled 501 households within 25 neighbourhoods in this region, which amounts to 0.11% of all households in these two cities. For Beira city, it is estimated that 101 334 households reside. The study sample was 420 households, which is proportionate to 0,41% of the population. For Nampula, the sample size is proportioned to 0.35% of all households in the city. Figure 2 below compares the household number within the three cities studied. Average household size for the four cities is 5.8 members per Household.

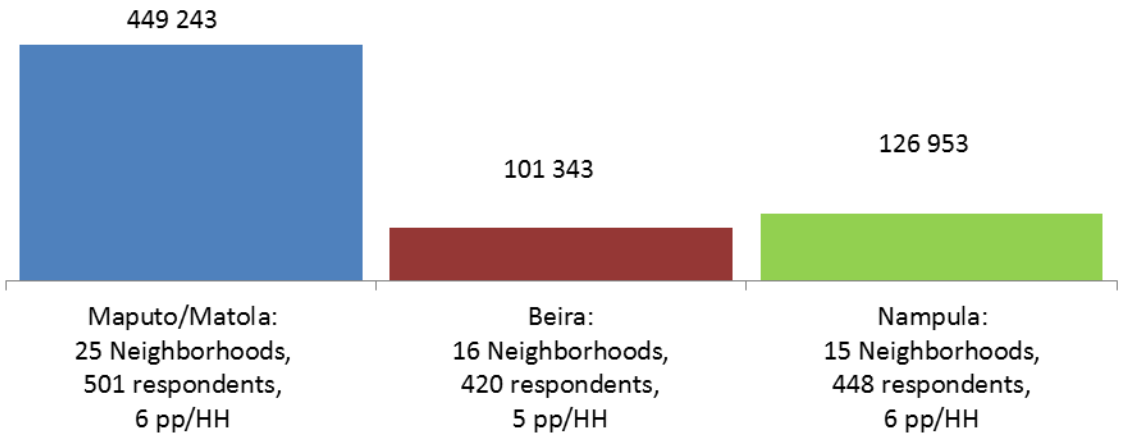
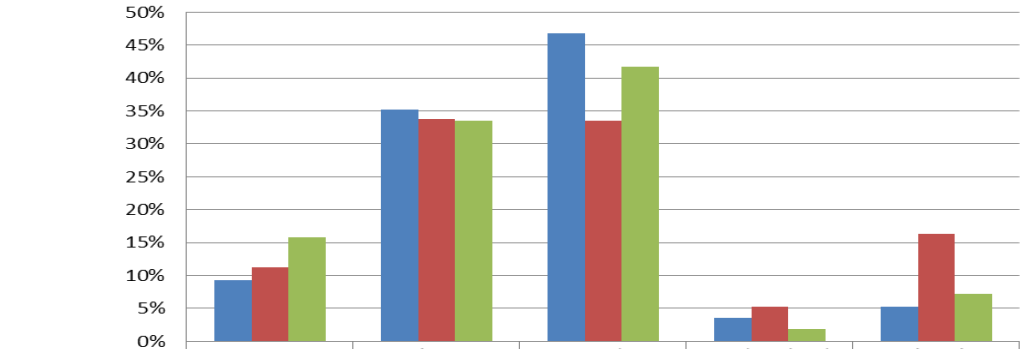


Figure 2: Total urban household size and sample size comparison

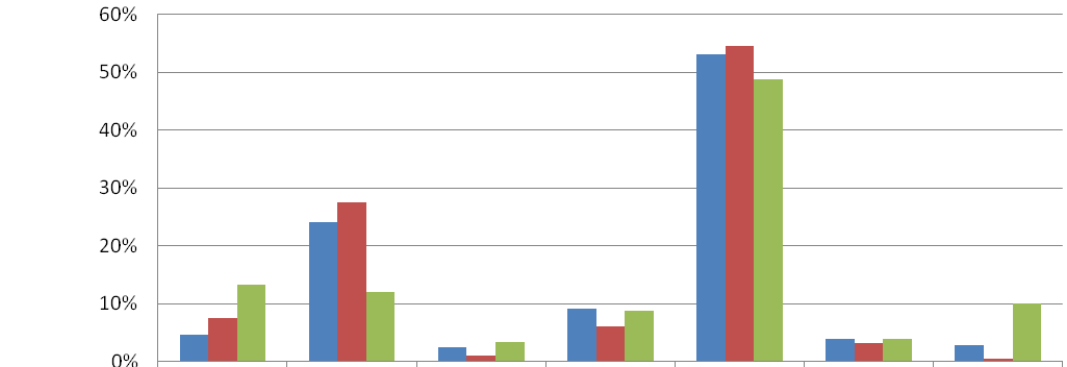
Within those households sampled, the large majority had attained primary or secondary school education. The figure below compares the education level of the sample amongst the three urban areas, whereby the results indicate similar trends. Those which have attained secondary school education are 47% for Maputo/Matola, 33% for Beira, and 42% for Nampula. It is notable however that in Beira, there are more households with a university education (16%) compared to the two other urban areas (5% for Maputo/Matola and 7% for Nampula).



	None	Primary	Secondary	Trade School	University
Maputo/Matola	9%	35%	47%	4%	5%
Beira	11%	34%	33%	5%	16%
Nampula	16%	34%	42%	2%	7%

Figure 3: Highest education level attained in household

Similarly to the trends noticed with education level, households within the three different urban centres share similar trends regarding the activities practiced to generate income. By far, most households receive a salary through employment (53% in Maputo/Matola, 54% in Beira and 49% in Nampula). The second most stated activity for income generation is self employment, practiced by 24% of households in Maputo/Matola and 27% of households in Beira. For Nampula however, farming constitutes of the second most common income generating activity, practiced by 13% of households. Figure 4 below highlights these trends.

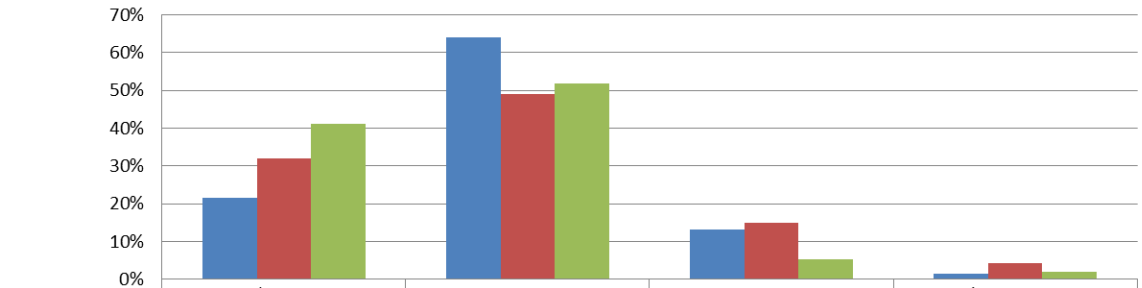


	Farming	Self-employed	Formal Business	Informal Business	Employed Salary	Temp employment	Unemployed
Maputo/Matola	5%	24%	2%	9%	53%	4%	3%
Beira	7%	27%	1%	6%	54%	3%	0%
Nampula	13%	12%	3%	9%	49%	4%	10%

Figure 4: Main income generating activity of household

The households within the sample are next divided amongst income groups. Four income segments are categorised within the Mozambican context. Those with monthly household income below 2500 Meticais (90 USD) are classified as "low income"; those with income between 2500 to 10 000 Meticais (90-360 USD) are classified as "middle-low income"; while those with income between 10 000 and 30 000 Meticais (360-1070 USD) are considered "middle income", and those with household income over 30 000 Meticais (1070 USD) are considered as "high income". Figure 5

below compares households within the different income groupings within the three urban areas studied. The majority of households fall under the middle-low income category, and few households can be considered middle or middle-high income. Within the Maputo/Matola sample there is a larger share of Mid-low income (64%) than Beira and Nampula (49% and 52%, respectively), while in Nampula, a larger share of Low income households (41%) were found compared to Beira (32%) and Maputo/Matola (21%).



	Below 2500 [Low income]	2500 to 10 000 [Mid-low income]	10 000 to 30 000 [Middle income]	Above 30 000 [Middle-high income]
Maputo/Matola	21%	64%	13%	1%
Beira	32%	49%	15%	4%
Nampula	41%	52%	5%	2%

Figure 5: Household monthly income classification (Meticais)

Irrespective of income level, most households are connected to the electric grid in all cities surveyed. Within Maputo/Matola, 90% have electricity access, of which 81% pay via a pre-paid system (locally called "credelec"). In the case of Beira and Nampula, they both have 80% grid connectivity, of which 77% is pre-paid in Beira and 69% pre-paid in Nampula.

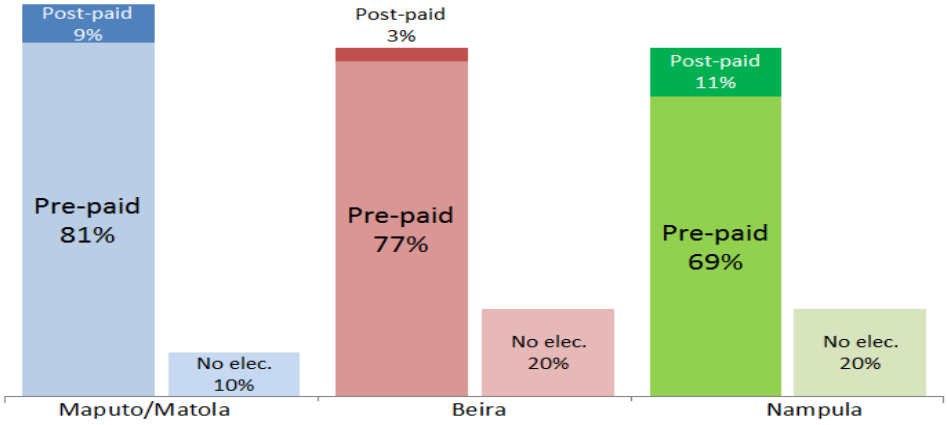
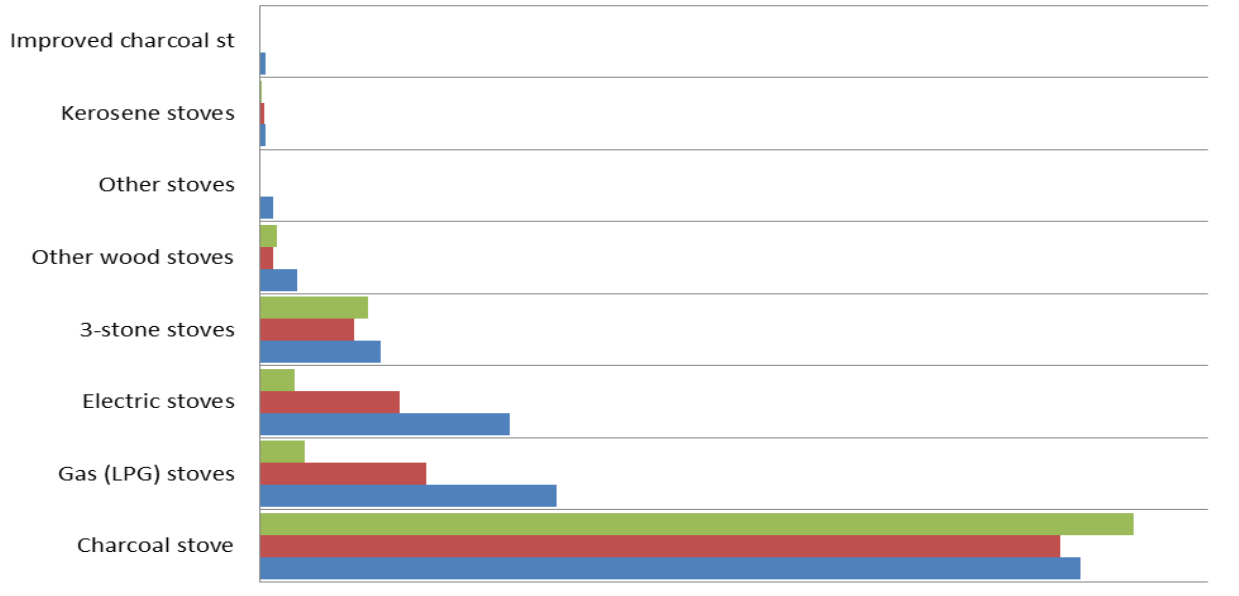


Figure 6: Electricity connection rate and form of payment

3.1.2. COOKING FUEL USE

This section looks at the cooking fuel sources used amongst households within the three urban centres studied. Figure 7 below illustrates the stove type ownership amongst households in Maputo/Matola, Beira and Nampula. The results show that the predominant stove type used by households in these cities is the charcoal stove. They are used by 87% of households in Maputo/Matola region, 85% of households in Beira city, and by as much as 92% of households in Nampula city. For Maputo/Matola and Beira city, the second most common stove type owned is the LPG (gas) stove. It is used by 31% and 18% of the sample respectively. In the case of Nampula, the second most common stove type used is the firewood stove (either 3-stone or improved model). This is used by 13% of the households. Electric stoves are used by 26% of households in Maputo/Matola; 15% of households in Beira and only 4% of households in Nampula city.



	Charcoal stove	Gas (LPG) stoves	Electric stoves	3-stone stoves	Other wood stoves	Other stoves	Kerosene stoves	Improved charcoal st
Nampula	92%	5%	4%	11%	2%	0%	0%	0%
Beira	85%	18%	15%	10%	1%	0%	0%	0%
Maputo/Matola	87%	31%	26%	13%	4%	1%	1%	0,6%

Figure 7: Stove type ownership amongst households in Maputo/Matola, Beira and Nampula cities

Fuel-mixing is a common trend in urban Mozambique. Households often rely on multiple fuel types to satisfy their cooking energy needs. Of the 87% of households in Maputo/Matola which cook with charcoal, only 35% exclusively use this fuel. Common fuel mixes include Charcoal-LPG (practices by 19%); charcoal-electricity (15%); and Charcoal-firewood (9%). It is also worth noting that in Maputo/Matola, of all the LPG users, only 3% exclusively rely on this fuel. Similar trends can be seen with electric stove users.

In both Beira and Nampula, charcoal is used more exclusively by a greater number of households. 64% of charcoal users in Beira rely only on this fuel, while as much as 77% of households in Nampula do so too. In Beira, the second most common fuel use strategy is charcoal-electricity. This is practices by 9% of households.

From the analysis it can be noted that in the Maputo/Matola region, there is a higher penetration of modern cooking fuels. 50% of households own and use either an Electric or LPG stove. Beira follows with 26% modern fuel use, while in Nampula the figure is 10%. Table 1 below illustrates the fuel use strategies in the three urban centres in more detail.

Table 1: Fuel use strategies amongst sample

Main fuel use strategies	Maputo/Matola	Beira	Nampula
#1 Charcoal only	35%	64%	77%
#2 *Charcoal-LPG*	19%	7%	6%
#3 *Charcoal-Electricity*	15%	9%	3%
#4 Firewood only	6%	8%	7%
#5 *Charcoal-Firewood*	9%	3%	7%
#6 *Charcoal-LPG-Electricity*	7%	2%	0%
#7 LPG only	3%	4%	0%
#8 *LPG-Electricity*	2%	3%	0%
#9 Electricity only	2%	1%	0%
#10 *Charcoal-Electricity-Firewood*	1%	0%	0%
#11 *Charcoal-LPG-Firewood*	1%	0%	0%

Since charcoal stoves are most commonly used, it is worth considering the type of charcoal stove used by households. The study shows that within Maputo/Matola, the majority of households (70%) use a double-burner charcoal stove. This trend is reversed in Beira and Nampula, where the majority (73% and 64%, respectively) use a single burner charcoal stove. Of these, only 6% and 8% of households in Beira and Nampula have two counts of these single burner stoves. Table 2 compares charcoal stove type usage amongst the three regions.

Table 2: Charcoal stove type ownership amongst charcoal users and number of stoves owned

	Maputo/Matola	Beira	Nampula
1 x One-Burner stove	27%	67%	56%
2 x One-Burner stove or +	3%	6%	8%
1 x Two-Burner stove	67%	21%	34%
2 x Two-Burner stove or +	3%	5%	3%

3.1.3. DAILY HOUSEHOLD FUEL USE QUANTITES

This section estimates the daily quantities of fuel used by households, with relation to their fuel use strategy. Units of fuel use are given in kilograms, for the case of charcoal, firewood and LPG; and in Kilowatt hours for electricity consumption.

Table 3, below, shows the quantities of fuel used by households in Maputo and Matola. For those using charcoal as their only cooking energy source, they consume 2.64 kg of charcoal per day. Firewood users consume 4.46 Kg of wood per day; LPG users go through 286 grams for the days cooking; while electric stove users consume 2.71 Kwh's worth of electricity per day. The table also specifies the different quantities used of the respective fuels when more than one energy source is used daily.

Table 3: Average daily fuel use quantities amongst households in Maputo/Matola

One energy source	**N**	**% of sample**	Charcoal (Kg/day)	Firewood (Kg/day)	LPG (Kg/day)	Electricity (Kwh/day)
Charcoal	175	35	2.640			
Firewood	28	5.6		4.456		
LPG	14	2.8			0.286	
Electricity	11	2.21				2.71
Total	**228**	**45.6%**				
Two or more energy sources	**N**	**% of sample**	Charcoal	Firewood	LPG	Electricity
Charcoal - Firewood	47	9.5	1.679	2.918		
Charcoal - LPG	95	19.2	1.844		0.3285	
Charcoal - Electricity	72	14.5	2.173			1.311
LPG - Electricity	10	2			0.3895	1.389
Charcoal - LPG - Firewood	3	0.6				
Charcoal - LPG - Electricity	34	6.9	2.000		0.3487	0.149
Charcoal - Electricity - Firewood	7	1.4				
Total	**268**	**54.1%**				

Table 4 shows the average daily fuel quantities used by households in Beira city. Of those using only charcoal, they consume 2.495 kg of charcoal per day; firewood users, make use of 2.9 kg of wood for the day; while those cooking exclusively with LPG consume 367 grams of LPG per day. Those cooking only with electric stoves use 1.65 Kwh of electricity. Further details on consumption levels of households using multiple fuel sources can be found in the table below.

Table 4: Average daily fuel use quantities amongst households in Beira

One energy source	N	% of Sample	Charcoal (Kg/day)	Firewood (Kg/day)	LPG (Kg/day)	Electricity (Kwh/day)
Charcoal	258	63,7	2.495			
Firewood	31	7,7		2.902		
LPG	15	3,7			0.367	
Electricity	5	1,2				1.65
Total	**309**	**76,3**				
Two or more energy sources	**N**	**% of Sample**	Charcoal	Firewood	LPG	Electricity
Charcoal - Firewood	12	3,0	1.633	1.120		
Charcoal - LPG	28	6,9	1.810		0.393	
Charcoal - Electricity	35	8,6	2.301			1.356
LPG - Electricity	11	2,7			0.367	0.194
Charcoal - LPG - Electricity	10	2,5	1.324		0.448	0.746
Total	**96**	**23,7%**				

Table 5 shows the average daily fuel quantities used by households in Nampula city. For those using only charcoal for cooking, an average of 3 Kg is consumed per day. Firewood users consume 3,94 kg per day; while electric stove users consume 0,68 Kwh per day. It can be noted that no households reported to using LPG as their only fuel source. Further details on consumption levels of households using multiple fuel sources can be found in the table below.

Table 5: Average daily fuel use quantities amongst households in Nampula

One energy source	N	% of Sample	Charcoal (Kg/day)	Firewood (Kg/day)	LPG (Kg/day)	Electricity (Kwh/day)
Charcoal	342	77,0	3,00			
Firewood	32	7,2		3,94		
Electricity	1	0,2				0,68
Total	**375**	**84,5%**	**Charcoal**	**Firewood**	**LPG**	**Electricity**
Two or more energy sources	**N**	**% of Sample**				
Charcoal - Firewood	29	6,5	1,24	2,22		
Charcoal - LPG	25	5,6	1,81		0.44	
Charcoal - Electricity	15	3,4	3,89			0,68
Total	**69**	**15,5%**				

3.1.4. HOUSEHOLD FUEL EXPENDITURE

The average money spent to purchase fuel per household is largely based on the fuel type purchased as well as the quantities purchased at one time. Fuel prices also differ within the different cities. For Maputo/Matola for example, households spend on average 431 Meticais (15

USD) a month to purchase firewood. In the case of Beira and Nampula, the monthly expenditure is 199 Meticais (7 USD) in both cases.

With regards to expenditure on charcoal, 75% of charcoal users in Maputo/Matola purchase this fuel by the sack (+/-70 kg). Doing so, they spend on average 559 Meticais (20 USD) per month on charcoal. It should be noted however that households which are reliant only on charcoal for all cooking needs, spend on average 775 Meticais (28 USD) for their fuel if purchased per sack. Those households which purchase charcoal in daily quantities (bundles), spend around 53% more than those who purchase sacks. Their monthly expenditure is at 854 Meticais (30 USD). Purchasing charcoal by the sack can therefore save households 3540 Meticais (126 USD) per year compared to those who purchase daily quantities. A reason for purchasing bundles may be because some households do not have the full amount of money up-front to pay for one sack of charcoal.

In the case of Beira, those which purchase charcoal sacks spend around 417 Meticais (15 USD) per month; while those which purchase daily bundles spend on average 579 Meticais (20 USD) per month. The charcoal price in Nampula is much lower than the two other regions. Households purchasing sacks, spend on average 271 Meticais (9.6 USD) for charcoal per month; while those purchasing in bundles spend almost double, at 300 Meticais (11 USD) per month. Both in Beira and Nampula, 17% of the households purchase daily quantities (bundles); while in Maputo/Matola, 25% purchase in daily quantities. This is possibly due to the higher price of a charcoal sack compared to the two other cities.

Monthly expenditure for LPG is similar amongst the three urban regions studied. Within Maputo/Matola, households spend on average 717 Meticais (26 USD) per month for LPG. In Beira and Nampula, households spend 680 Meticais (24 USD) and 750 Meticais (27 USD) respectively. The price spent for electricity is much lower compared to all other fuel types (average of 90 Meticais amongst all cities). This is possibly due to the fact that the electric stoves are primarily used for fast cooking, such as boiling water, re-heating food or frying.

Table 6: Average monthly expenditure per cooking fuel type (Meticais)

Fuel	*% of Maputo respondents*	Maputo/Matola	*% of Beira respondents*	Beira	*% of Nampula respondents*	Nampula
Firewood	*11%*	431	*7%*	199	*11%*	199
Charcoal in Sack	*55%*	559	*76%*	417	*84%*	271
Charcoal in Bundle	*13%*	854	*9%*	579	*8%*	300
Charcoal in a can	*2%*	821	*0%*	-	*0%*	-
Gas (LPG)	*22%*	717	*15%*	680	*5%*	750
Electricity for cooking	*24%*	130	*14%*	87	*3%*	52
Kerosene	*0,4%*	528	*0%*	-	*0%*	-

Cooking fuel monthly expenditure differs amongst the different cities. For Maputo/Matola, households spend on average 846 Meticais (30 USD) per month for their cooking energy. In Beira, this expense is less, at 551 Meticais (20 USD) per month. Household in Nampula city have the lowest monthly expenditure on cooking fuels. They need on average 441 Meticais (16 USD) per month. This difference is largely due to the low price of charcoal observed in Nampula. In Maputo and Matola, the price of a charcoal sack is currently reported to cost around 650 Meticais (23 USD). In Beira city, the charcoal sack is sold for an average price of 220 Meticais (9 USD). In Nampula, the

price of a sack of charcoal is the lowest, at 130 Meticais (4.6 USD). It should be noted that the average weight of the charcoal sack differs amongst the cities. An estimate of the charcoal sack weight for each city can be seen in section 3.2.5.

Table 7 below further analyses the average total monthly expenditure for cooking fuels by households in different income groups. The general trend is that with increased income, cooking energy expenses also increase. It is also worth noting that households in Maputo pay more than double for their cooking energy costs compared to households in Nampula. This again is largely due to the lower price of charcoal in Nampula.

Table 7: Average total monthly expenditure for cooking energy by income group

	Maputo/Matola	Beira	Nampula
Less than 2 500	745	504	347
2 500 - 10 000	823	539	421
10 000 - 30 000	1028	618	748
More than 30 000	772	761	618
ALL income groups aver	846	551	414

Table 8 below shows that average monthly expenditure by income group on charcoal, when it is the only fuel used within the household. For the case of Maputo/Matola, low income households spend more on bundles of charcoal compared to other income groups, however when buying in sacks, they spend less. 52% of households are within the middle-low income group and buy charcoal in sacks which costs them an average of 851 Meticais (30 USD) per month.

For Beira and Nampula, the table shows a substantial rise in charcoal expenditure with increased income level. This is true for both charcoal in sacks and charcoal in bundles. In Nampula for example, households in the middle and high income group spend almost double on purchase of charcoal in the form of sacks compared to low income households.

Table 8: Average spending on charcoal by households only cooking with charcoal

Income Level	Buying in:	% of Maputo/Matola respondents	Maputo/Matola	% of Beira respondents	Beira	% of Nampula respondents	Nampula
Low Income	Bundles	8,3%	**888**	11,3%	**709**	7,3%	**271**
	Sack	10,9%	**699**	30,0%	**421**	29,5%	**333**
Middle-Low	Bundles	15,5%	**812**	4,8%	**723**	3,0%	**345**
	Sack	52,2%	**851**	48,3%	**509**	52,3%	**429**
Midle and High	Sack	13,2%	**1079**	5,7%	**582**	7,8%	**714**

3.1.5. COOKING HABITS

Cooking habits such as time spent cooking, pots used, kitchen location and energy saving techniques are important to consider. Slight differences exist amongst the different cities analysed.

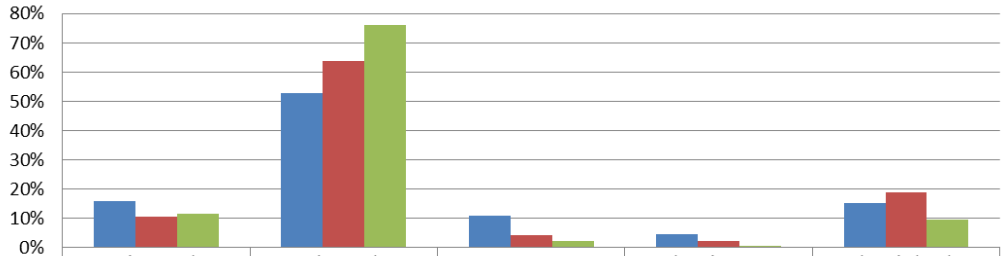
When considering the number of meals cooked per day, households in Maputo/Matola and Beira reported to cooking two meals a day. In Nampula however, households reported to cooking three times a day. Time spent cooking during the day also differs amongst the cities. For Maputo/Matola, households report to cook an average of 2:21 hours. In Beira, it is reported that households cook an average of 2:27 hours. Households in Nampula registered the longest cooking time amongst the different cities. They cook an average of 3:25 hours per day. Within all cities, households reported to using two pots every time they cooked. Generally, one pot for the stew and another to cook either rice or maize porridge.

Cooking location is also interesting to note for the different cities. Households were asked where the cooking generally takes place during the dry season (May-October) as well as during the rainy season (November-April). For Maputo/Matola cooking location did not vary much according to the different seasons. In general, 31% of households cook outdoors, either in the open space or on their balconies. 69% of households however reported to cooking indoors. In the case of Beira, cooking location varied during the two seasons. During the dry season, 68% of the households cook outdoors while 31% cook indoors. During the rainy season however, only 30% cook outdoors and 69% cook indoors. Similar trends were registered in Nampula, where during the dry season 60% of households cook outdoors and 39% cook indoors. Within the rainy season however, 34% cook outdoors and 64% indoors. Table 9 below compares cooking location between the three regions studied.

Table 9: Cooking location within the dry and rainy season

Cooking Location	Maputo/Matola	Beira	Nampula
Dry Season			
Indoors	69%	31%	39%
Outdoors	31%	68%	60%
Rainy Season			
Indoors	71%	69%	64%
Outdoors	29%	30%	34%

Boiling water is a daily task amongst households in Mozambique for various purposes such as making tea, warming bath water as well as treating (disinfecting) water for drinking. Figure 8 below shows the different fuel types used to boil water amongst households in the different cities. Charcoal is by far the most common energy source used for this purpose in all cities. It is worth noting that electricity is the second most common source of energy for heating water in Maputo and Beira; it is used by 20% and 21% respectively in the form of either electric stoves or electric kettles. Firewood is generally used to boil water by households which also rely on it as their primary cooking fuel.



	Firewood	Charcoal	LPG	Electric Stove	Electric kettle
Maputo/Matola	16%	53%	11%	5%	15%
Beira	11%	64%	4%	2%	19%
Nampula	11%	76%	2%	1%	9%

Figure 8: Fuel source used to heat or boil water

Since charcoal is the most common fuel type, it is worth considering the frequency of use amongst the sample. In Maputo/Matola, 65% of charcoal users make use of this fuel for all meals. The other households use it at least once a day or more sporadically throughout the week. In Beira and Nampula, a greater percentage of households rely on charcoal for all the cooking; 83% and 89% respectively. Table 8 below shows this distinction amongst the cities studied.

Table 10: Charcoal use frequency amongst households

Charcoal use habits	Maputo/Matola	Beira	Nampula
For all meals	65%	83%	89%
At least once a day	4%	5%	3%
At least 3 times/week	15%	3%	7%
Once a week	7%	9%	1%
Other	9%	0%	0%

With the rising price of cooking fuel in the cities, it was asked of households whether they make use of fuel saving technique. One of the most fuel consuming meals in Mozambique is cooked beans. It can take up to 3 hours of cooking time. One of the methods which can be used to reduce cooking time is soaking the beans in water a few hours before cooking. Households were therefore asked whether they practice this technique. The results show that in Maputo/Matola, only 20% of households soak the beans before cooking. This practice is even less in Beira and Nampula where 5% and 7% respectively, do so.

Another fuel saving technique involves lighting the charcoal stove only once and cooking all meals while the charcoal is hot. This is practised by 38% of households in Maputo/Matola, and only 8% of households in both Beira and Nampula. One of the reasons why more households practice fuel saving techniques in Maputo/Matola is probably due to higher fuel prices in this region compared to the other cities.

3.1.6. HEALTH AND ENVIRONMENT

Literature suggests that the frequent use of biomass fuels is related to a multitude of health problems. Impacts associated with Indoor Air Pollution (IAP) include: Acute respiratory infections, chronic obstructive lung disease and lung cancer. Also associated with high levels of smoke exposure is the increased susceptibility to Tuberculosis, Cataract and Asthma (WHO 2012).

With this in mind, households were asked whether the persons who generally do the cooking have suffered from respiratory health problems in the past year. The results show that throughout the sample, 23% of households reported respiratory health problems. Nampula was the city where most cases were reported (26%), followed by Beira (25%) and Maputo/Matola (19%). The table below shows the occurrence of respiratory disease amongst households by income level bracket.

Table 11: Occurrence of respiratory disease amongst households by income bracket

Family income	Maputo/Matola	Beira	Nampula	3-cities average
less than 2500 Mt. per month	**23%**	**32%**	**41%**	**32%**
% of the above who signal a respiratory disease in the Household	19%	23%	24%	23%
Between 2500 Mt. and 10000 Mt. per month	**62%**	**49%**	**52%**	**55%**
% of the above who signal a respiratory disease in the Household	20%	26%	25%	23%
Between 10000 Mt. and 30000 Mt. per month	**12%**	**14%**	**5%**	**11%**
% of the above who signal a respiratory disease in the Household	14%	36%	30%	26%
Above 30000 Mt. per month	**2%**	**5%**	**2%**	**3%**
% of the above who signal a respiratory disease in the Household	22%	26%	22%	24%
TOTAL	**100%**	**100%**	**100%**	**100%**
% of the city total who signal a respiratory disease in the Household	19%	26%	25%	23%

Table 12 below shows the incidence of respiratory health problems amongst household in relations to cooking place. A weak relation could be found amongst respiratory illness and cooking indoors versus cooking outdoors.

Table 12: Occurrence of respiratory disease amongst households with relation to cooking place (rainy season)

% of respondents	Maputo/Matola	Beira	Nampula	3-cities average
... cook in open air	**24%**	**10%**	**1%**	**12%**
% of the above who signal a respiratory disease in the Household	17%	33%	50%	22%
... cook on the balcony	**7%**	**21%**	**33%**	**20%**
% of the above who signal a respiratory disease in the Household	18%	42%	20%	27%
... cook in a separated closed kitchen	**21%**	**11%**	**21%**	**18%**
% of the above who signal a respiratory disease in the Household	21%	16%	35%	26%
... cook in a kitchen inside house	**41%**	**59%**	**45%**	**48%**
% of the above who signal a respiratory disease in the Household	18%	22%	23%	21%
... cook in another configuration	**7%**	-	-	**2%**
% of the above who signal a respiratory disease in the Household	26%	-	-	9%
TOTAL	**100%**	**100%**	**100%**	**100%**
% of the city total who signal a respiratory disease in the Household	19%	26%	25%	23%

Within the survey households were asked whether they think the use of firewood has an impact on health. Similarly household were also asked whether they think the use of charcoal has an impact on one's health. The results show interesting trends amongst the different cities. Regarding firewood, only 34% of households in Maputo agreed that there are health impacts associated with firewood. Within Beira, as much as 81% agreed and in Nampula 64% associated health problem to firewood use. When it comes to charcoal use and its impact on one's health, the majority of respondents in all cities disagreed about this link. In Maputo, only 17% associate health impacts to charcoal use; in Beira it is 42% and in Nampula 32% of respondents agreed. A further 13% of households in Both Beira and Nampula were not sure how to answer.

Table 13: Respondent perception to health problems associated with firewood and charcoal

Is there a relation between firewood use and health problems	Maputo	Beira	Nampula
Agrees	34%	81%	64%
Disagrees	38%	10%	24%
Doesn't know	27%	9%	12%

Is there a relation between charcoal use and health problems	Maputo	Beira	Nampula
Agrees	17%	42%	33%
Disagrees	83%	45%	54%
Doesn't know	0%	13%	13%

Similarly, households were asked whether they think firewood and/or charcoal use has negative impacts on the environment. Except for Beira, where the majority (68%) agreed about the negative impacts, the majority of respondents in Maputo (77%) and Nampula (54%) either disagreed or were unsure of any environmental problems associate with these fuels.

Table 14: Respondent perception to environmental problems associated with firewood and charcoal use

Do you think fuelwood use has a negative impact on the environment?	Maputo	Beira	Nampula
Yes	23%	68%	46%
No	47%	19%	31%
Doesn't know	30%	13%	23%

3.1.7. INSTITUTIONAL ENERGY USE

The following section looks at the cooking fuels used within the surveyed institutions such as informal food vendors, restaurants, hotels, bakeries and hospitals.

Table 15 shows the energy mix most commonly used amongst informal food vendors. These are people that provide cooked meals to the lower and middle income segment of the population which often work in the city-centres. The data shows that almost all informal food vendors use charcoal for cooking the meals. 41% and 17% in Maputo/Matola and Beira respectively use LPG as well. Vendors in Beira and Nampula use the greatest amount of charcoal, ranging up to 15 sacks a month.

Table 15: Cooking energy consumption for informal food vendors

Fuel type usage	Maputo/Matola	Beira	Nampula
Percentage Using charcoal	98%	100%	100%
Quantity of charcoal/month	2.85 Sacks	12 Sacks	15 Sacks
Expenditure on charcoal/month	1 852 Meticais	2 877 Meticais	1 950 Meticais
Percentage using LPG	41%	17%	0%
Quantity of LPG/month	13kg	13.75 kg	-
Expenditure of LPG/month	773 Meticais	876 Meticais	-
Percentage combining both fuels	59%	17%	-

Table 16 shows the energy sources used to prepare food in restaurants for the three urban regions studied. In Maputo/Matola, 14% of the restaurants surveyed use firewood, while 67% use charcoal. It is notable however that up to 90% use LPG for preparing food. In Beira and Nampula, all restaurants surveyed make use of charcoal for cooking, however in Beira, 90% use LPG. Only 47% of restaurants use LPG in Nampula. Electricity is used by 90% of restaurants in Maputo/Matola, 50% of restaurants in Beira and all restaurants in Nampula city.

Table 16: Cooking energy consumption for restaurants

Fuel type usage	Maputo/Matola	Beira	Nampula
Percentage using firewood	14%	0%	0%
Quantity of firewood/month	5 tones	-	-
Expenditure on firewood/month	2 833 Meticais	-	-
Percentage Using charcoal	67%	100%	100%
Quantity of charcoal/month	16 Sacks	18 Sacks	26 Sacks
Expenditure on charcoal/month	10 429 Meticais	4 742 Meticais	4 007 Meticais
Percentage using LPG	90 %	90%	47%
Quantity of LPG/month	145 kg	165 kg	25.3 Kg
Expenditure of LPG/month	5 734 Meticais	9 255 Meticais	1 536 Meticais
Percentage using Electricity	90%	50%	100%

With regards to Hotels, all use either LPG or electricity for cooking food. In Beira however, 20% of the hotels surveyed made use of charcoal for cooking. LPG quantities consumed vary from 675 kg per month for Maputo/Matola hotels, to 176 kg per month on average for those using in Beira.

Table 17: Cooking energy consumption for hotels

Fuel type usage	Maputo/Matola	Beira	Nampula
Percentage Using charcoal	0%	20%	0%
Quantity of charcoal/month	-	21 Sacks	-
Expenditure on charcoal/month	-	5 250 Meticais	-
Percentage using LPG	100%	20%	47%
Quantity of LPG/month	675 kg	176 kg	293 Kg
Expenditure of LPG/month	22 500 Meticais	5 250 Meticais	24 800 Meticais
Percentage using Electricity	100%	100%	100%
Electricity bill/month	29 803 Mets	-	152 650 Mets

All bakeries visited make use of firewood to bake bread. Quantities of firewood used vary amongst 2.5 tonnes a month for Maputo/Matola and 2.3 tonnes for Beira. Within Nampula, the bakeries reported to using on average 4.13 tonnes of firewood per month.

Table 18: Cooking energy consumption for bakeries

Fuel type usage	Maputo/Matola	Beira	Nampula
Percentage Using firewood	100%	100%	100%
Quantity of firewood/month	2.5 tonnes	2.3 tonnes	4.13 tonnes
Expenditure on firewood/month	15 280 Meticais	10 800 Meticais	8 333 Meticais
Percentage using Electricity	100%	0%	100%
Electricity bill/month	15 000 Mets	-	8 833 Mets

Hospitals were surveyed only in Beira and Nampula. The fuel types used vary within the two cities. Within Beira, all hospitals reported to using charcoal for preparing meals. On average they use 10 Sacks per month. In Nampula, 90% of hospitals reported to cooking with firewood. They use 3.75 tonnes of wood per month. Another 10% of hospitals reported to cooking with electricity.

Table 19: Cooking energy consumption for hospitals

Fuel type usage	Beira	Nampula
Percentage Using firewood	0%	90%
Quantity of firewood/month	-	3.75 tones
Expenditure on firewood/month	-	2 333 Meticais
Percentage using charcoal	100%	0%
Quantity of charcoal/month	10 sacks	-
Charcoal expenditure/month	2 387 Meticais	-
Percentage using Electricity	0%	10%
Electricity bill/month	-	4 328

3.2. BIOMASS SUPPY DYNAMICS

The main vegetation cover used by the households to produce charcoal in Mozambique is obtained from miombo woodlands, which are dry tropical woodlands. The harvesting of miombo woodlands and other forest vegetation types is essential for the livelihood of the rural dwellers (employment, income, consumption goods and services). The harvesting is stimulated by the purchasing power of urban dwellers. This can be seen in the growth in fuel wood and charcoal consumption substituting electricity and gas as alternative sources of energy, and the increased use of wood based products for building houses (Karekezi *et al*., 2003; Falcão, 2005; Luoga *et al*., 2000a).

Most of the charcoal in Mozambique is produced by the traditional earth kiln method. The method consists of the following steps: (i) locating suitable trees; (ii) choosing the right place to build the kiln i.e. flat and sandy soils and closer to the trees; (ii) cutting the trees and transporting them to the kiln site; (iv) gathering material necessary for kiln construction (grass, clay/sand, and stones when available); (v) constructing the kiln; (vi) operating the kiln; (vii) unloading the kiln; (viii) putting the charcoal into sacks. The process of charcoal production is labour intensive, mainly carried out by men and bears some similarities to that in Kenya, and Uganda (Luoga *et al*., 2000, Falcão, 2005)

Charcoal production efficiency in Mozambique, Malawi, Tanzania and Zambia varies between 10% to 25% (Lew and Kammen, 1997; Okello *et al.,* 2001; Stassen, 2002, Pereira and Joaquim, 2001; Falcão, 2005). Efficiency varied between kilns, which though similar in design, are usually different because the size, species and composition of wood used as well as the time taken for carbonisation, are different. Pereira and Joaquim (2001) found for Licuati and Chipango, Maputo Province (southern Mozambique) an average charcoal yield of 14.1% and 19.5% respectively, ranging between 6.1% and 35.5%. The efficiency of conversion of *Acacia drepanolobium* wood to charcoal in Laikipia, Kenya, ranged from 10.2% to 18.2%, with an average of 14.2% (Okello *et al.,* 2001). More technologically advanced kilns such as the Mark IV, Cusab Kiln, and Gayland Batch Charcoal Retort give higher efficiency rates of 25–32% (Cunningham, 1996; Lew and Kammen, 1997; Okello *et al*., 2001). These kilns could significantly improve charcoal production in the rural areas. However, some of these kilns have been tested in the South of Mozambique and the results showed that they are usually out of the financial reach of most charcoal burners and they use much more labour than the system applied now. This means they are unlikely to be implemented by the charcoal burners.

This section looks at the fuelwood supply dynamics in the three regions of Mozambique. It focuses on the areas from which the biomass is sourced for the production of charcoal, the transportation means and distances to the cities, as well as an estimate of the quantities of biomass fuels supplied.

3.2.1. REGIONS OF BIOMASS SUPPLY

Production areas are normally located away from the main urban markets where the charcoal is sold. Although charcoal production can be scattered throughout the rural area, this study has identified certain regions where production is more concentrated.

Although there is charcoal coming from 6 districts surrounding Maputo city (Moamba, Matutuine, Namaacha, Goba, Boane, Manhiça), the majority of charcoal that feeds Maputo urban markets is currently coming from further locations (>300km) such as Magude disctrict in Maputo, but mainly from Gaza Province, namely the districts of Mabalane, Massingir, Mapai, Chicualacuala, and Guijá.

Within the three road checkpoints covered in this study, it was analysed that charcoal entering through the Moamba checkpoint, comes largely from Moamba district (90%) as well as from Magude (10%). At the Matola Rio checkpoint, 98% of the charcoal was reported to come from Matutuine, while 2% came from Namaacha district. The charcoal which arrives through the Marracuene checkpoint, is to a large extend from Gaza province. 70% of vehicles survey reported coming from Mabalane; 15% said they are arriving from Massingir, while the rest mentioned areas such as Chigubo, Guijo and Combomune.

Charcoal which arrives by train to Maputo comes from forested areas along the railway line spanning from the border of Zimbabwe in the west of Gaza province to Maputo city. Identified charcoal production regions include Mabalane, Chicualacuala, Combomune, Mapai, Chókwé and Magude. With the exception of Magude, all other regions are within Gaza province.

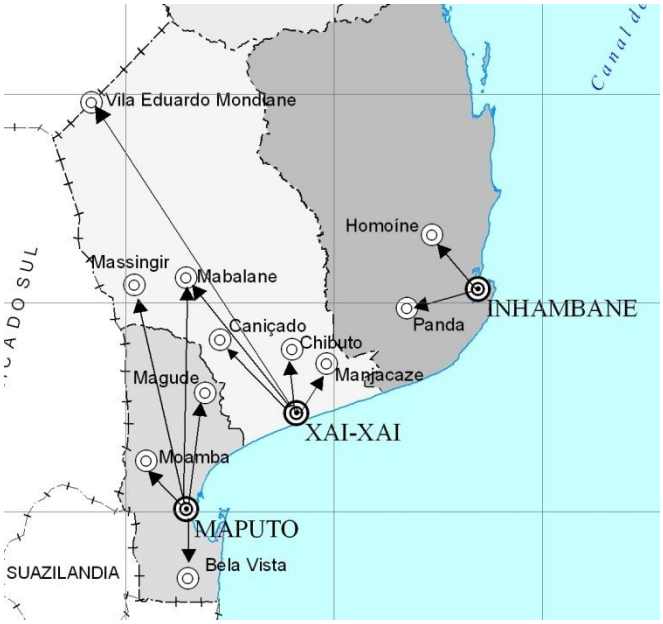


Figure 9: Maputo/Matola charcoal supply regions

Charcoal production regions which supply Beira city, include Dondo, Savane, Buzi, Chibabava and Nhamatanada. Increasingly however, charcoal is also coming from districts in Manica province such as Gondola and Sussundenga. The Dondo Weighbridge checkpoint registered the entry of charcoal via trucks and other motorized vehicles. These bring charcoal from further distances such as in Manica province, and Nhamatanda district. The Other checkpoints registered charcoal entry via bicycles, from near-by distances to the city such as Savane, Dondo and Buzi.

Figure 10: Beira charcoal supply regions

For Nampula city supply, the study found that charcoal is produced in districts such as Meconta, Mecuburi, Rapale, Murrupula, Anchilo, Monapo and Muecate. Within the checkpoints, it was reported that 21% of the charcoal originated in Meconta, 17% originated from Anchilo, 11% from Muecate, 6% from Monapo and the rest from other localities.

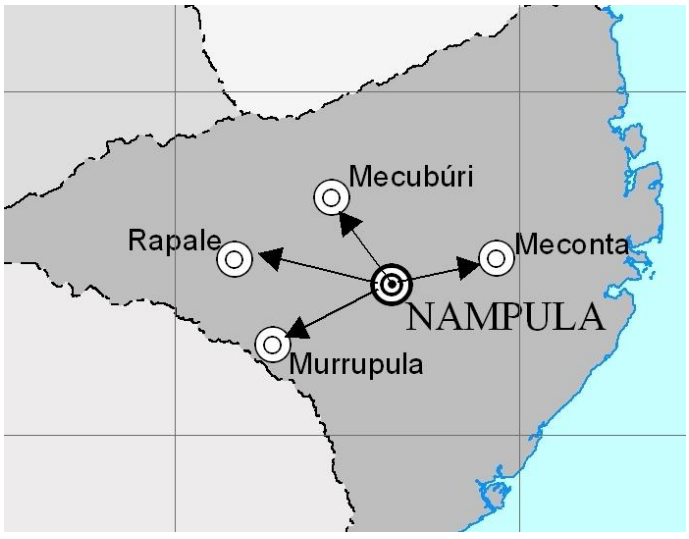


Figure 11: Nampula charcoal supply regions

3.2.2. TRANSPORT DYNAMICS

For Maputo there are different transportation means being used to transport charcoal from production regions to the city. Except for Chicualacuala, Mabalane and Magude, where there are train stations, the majority of Charcoal that is brought to Maputo city is being brought by either small or big trucks. Animals and push-carts are only used for transporting charcoal within small distances such as from production areas to the main road or from the market in the city to the retailing place.

Figure 12: Charcoal transported via truck

The amount of charcoal currently being brought by train is twice that of 2007. This increase can be attributed to the increases in petrol prices that led to a shift from the usage of trucks to trains. Trains are cheaper costing 50 Mt/sack and 70 Mt/sack for the cargo and passenger trains respectively while the truck costs may reach up to 260Mt/sack depending on the area and the truck capacity. Train allows for bigger quantities of charcoal (around 350 sacks/carriage) to be brought to Maputo at one time but has the inconvenience of only being available twice a month or in small loads using the passenger train.

Figure 13: Offloading charcoal sacks at the wholesale train station - Maputo

Data obtained at the train station, suggests that an average of 42 wagons of charcoal enter Maputo each month. Within each wagon, there are on average 350 sacks of charcoal. This amounts to 14 700 sacks of charcoal entering Maputo each month by train. This corresponds to 1102.5 tonnes of charcoal. The table below shows the estimated amount of charcoal which enters through the different checkpoints studied. The charcoal which enters Maputo via train is 38% of total supply.

Table 20: Estimated monthly supply of charcoal for Maputo/Matola according to different entry points

Checkpoint	Sacks of charcoal/Month	Total Weight (Tonnes)	Percentage of total supply
Marracuene Checkpoint	27980	1706,8	59%
Matola Rio Checkpoint	1293	72,5	2%
Moamba Checkpoint	571	32	1%
Garre de Mercadoria (Train S.)	14700	1102,5	38%
TOTAL	**44544**	**2913,8**	**100%**

Charcoal transportation in Beira and Nampula share similar characteristics and one key difference to Maputo/Matola. A large part of the charcoal is transported by bicycles from point of production to the urban areas. These cyclists often paddle for long distance, to deliver the charcoal sacks. In the case of Beira, many cyclists were interviewed which began their journey in Savane, 80 Km from the delivery point. Charcoal which is produced at further distance, arrives by truck or passenger cars, and can be found on the main roads leading to the city.

Figure 14: Bicycle transportation of charcoal sacks in Beira

Since the charcoal transported by bicycle, does not require a licence, as it is considered personal quantity by law (3 sacks or less); there is no official register of the quantity of charcoal which enters both cities this way. In Beira, of the total number of vehicles transporting charcoal, the bicycles made up 56% of them. In Nampula, bicycles comprised 88% of all vehicles counted. Table 21 below accounts for the average number of charcoal sacks which entered into the city of Beira and table 22 accounts for the average number of charcoal sacks entering Nampula city daily.

Table 21: Average daily charcoal quantity entering Beira

Checkpoint	Charcoal Quantity (sacks)	Charcoal weight (Kg)	Conversion to wood (Kg)	Quantity conversion to cubic meters (M^3)
ECMEP	132	7906,8	40269,2	53,7
Dondo WB	207	12399,3	96018,6	128
Inhangau	97	5810,3	29091,6	38.8
TOTAL	**436**	**26116,4**	**165379**	**181,7**
Monthly estimate	**13080 Sacks**	**783492 Kg**	**4961382 Kg**	**5451 M^3**

Table 22: Average daily charcoal quantity entering Nampula

Checkpoint	Charcoal Quantity (sacks)	Charcoal weight (Kg)	Conversion to wood (Kg)	Quantity conversion to cubic meters (M^3)
Checkpoint 1	306	17656,2	101383	135,2
Checkpoint 2	210	12117	63784,5	85
Checkpoint 3	416	24003,2	132593,4	176,8
Checkpoint 4	141	8135,7	42274,5	56,4
TOTAL	**1073**	**61912,1**	**340035,4**	**453,4**
Monthly estimate	**32190 Sacks**	**1857363 Kg**	**10201062 Kg**	**13602 M^3**

3.2.3. ESTIMATION OF AVERAGE CHARCOAL SACK WEIGHT

The weight of the charcoal sack is an important factor to consider when estimating the exact quantities of charcoal supplied into the city. This study shows that charcoal sacks supplied from different regions have different weights. This was determined by weighing a sample of charcoal sacks at each checkpoint. The table below summarises the findings.

For Maputo, the average sack of charcoal is registered at 60,9 Kg. This considers sacks measured at all checkpoints. However most charcoal registered (97%) comes through the Marracuene checkpoint and the train station (Gare de Mercadorias). If the average weight of charcoal at these two checkpoints is considered, then the average weight for charcoal sacks entering Maputo is 68.5 Kg*.

Table 23: Summary of average charcoal sack weight at different entry checkpoints for Maputo/Matola

	Matola Rio	Gare de Mercadorias	Moamba	Marracuene	MAPUTO AVERAGE
Average (Kg)	56,1	75,8	50,5	61,2	60,9 (68.5)*
Minimum (Kg)	40	50	40	50	45
Maximum (Kg)	70	100	65	80	78,75

Table 24: Average charcoal sack weight at different entry checkpoints for Beira

	ECMEP	Dondo WB	Inhagao	BEIRA AVARAGE
Average (Kg)	51,3	77,9	50,5	59,9
Minimum (Kg)	43	45	45	44,3
Maximum (Kg)	64	100	60	74,7

Table 25: Average charcoal sack weight at different entry checkpoints for Nampula

	Checkpoint 1	Checkpoint 2	Checkpoint 3	Checkpoint 4	NAMPULA AVERAGE
Average (Kg)	55,7	51,2	53,6	50,4	52,7
Minimum (Kg)	45	48	51	47	47,7
Maximum (Kg)	65	73	56	56	62,5

Figure 15: Weighing of charcoal sack at Dondo, Sofala province (Beira).

3.2.4. TREE SPECIES HARVESTED FOR CHARCOAL PRODUCTION

According to the survey administered to producers and transporters of charcoal, various tree species were identified as feedstock for charcoal production.

For the supply of Maputo and Matola, the main species used are Chanato *(Colophospermum mopane),* Xivondzuane (*Combretum sp)* and micaias *(Acacia sp.)* because they are readily available. However other species are also used when there is an absence of the preferred species.

Most of these species used for charcoal making belong to the 4th class according to the Forest Law and Forest regulation but there are some species that are not part of the 4th class and currently being used for charcoal production illegally, namely: *Lonchocarpus capassa, Ornithogalum sp. Androstachys johnsonii, Terminalia sericea, Combretum imberbe, Ziziphus mucronata, Guibourtia conjugata and Combretum molle.*

The main tree species used for charcoal production in Beira are: messassa (*Brachystegya spiciformis*), metongoro (*Uapaca kirkiana*), mucaucau (*Tabernaemontana elegans*) and mugonha (*Breonardia microcephala*). The use of these species is directly related to their availability in the regions of production. The large part of these species are however in the list of prohibited species for charcoal production by the national forestry regulation.

The tree species mostly used for charcoal production in Nampula are: messassa (*Brachystegya spiciformis*), Mpacala (*Julbernardia globiflora*), muroto (*Brachystegia sp.*), mukui (*Ficus sp*) and also the cashew tree. Similar to Beira, most of these species are deemed illegal for charcoal production under the forestry regulation. The cashew tree is used for charcoal production by some, because these trees are currently being substituted in Nampula province by new cashew trees due to their old age and low productivity.

3.2.5. ESTIMATED TOTAL CHARCOAL SUPPLY AND FOREST CLEARENCE RATE

In the past it has been difficult to determine the forest clearance rate as a result of charcoal production. This has largely been due to a lack of precise data on per capita charcoal consumption. Based on the information gathered through this survey, together with a charcoal-to-wood and wood-to-forest conversion equations, the following section focuses on the forest loss as a result of charcoal production.

Based on the household energy analysis, it is estimated that in Maputo and Matola, 849 357 Kg of charcoal are consumed daily. By considering the average efficiency rate (16,83 %) of traditional earth kilns in Mozambique (Pereira, 2002 and Falcão, 2005), It is possible to convert this charcoal into 5 046 684 Kg of wood.

The average density of native wood types in Mozambique is around 750 Kg/m^3. This means that on a daily basis, 6 729 m^3 of wood is consumed in Maputo and Matola for cooking purposes. Marzoli (2007) states within the National Forestry Inventory that the average density of the forests in the Maputo and Gaza provinces (source of charcoal for Maputo city), is 17,3 m^3/ha. This means that to satisfy the demand for charcoal in Maputo and Matola cities, 389 ha of forests are required on a daily basis. This translates to an annual forest clearance of 141 985 ha for the production of this biomass fuel.

Table 26: Estimate total charcoal quantity supply for Maputo/Matola and annual forest clearance rate

Indicator	Value	Source
Population – Maputo/Matola	2 021 596	INE (2007) 2012 projections
Household Number	449 243	INE (2007) – 4.5 pp/hh
% Using Charcoal	86.6%	HH Energy Analysis 2012
Average Kg Charcoal consumed/day	2.171 Kg	HH Energy Analysis 2012
Total Households Using Charcoal	391 291	HH Energy Analysis 2012
Total KG of charcoal consumed/day	849 357 Kg	HH Energy Analysis 2012
Charcoal conversion to wood	5 046 684 Kg	16,83% Kiln efficiency
Wood conversion into cubic meters	6 729 M^3	750 Kg/M^3
Wood conversion into Hectares of forest	389 ha	17,3 M^3/ha (for Gaza)
Annual forest clearance for charcoal	**141 985 ha**	

Following the results from the household energy survey in Beira city, it is estimated that 84,5% of the households use charcoal. This means that on a daily basis, 202 079 Kg of charcoal is consumed, which translates directly into 1 601 m^3 of gross wood that needs to be harvested. As a result, 12 045 ha of forest need to be cleared per year for the production of charcoal to satisfy urban demand.

Table 27: Estimate total charcoal quantity supply for Beira and annual forest clearance rate

Indicator	Value	Source
Population – Beira city	456 005	INE (2007) 2012 projections
Household Number	101 334	INE (2007) – 4.5 pp/hh
% Using Charcoal	84.5%	HH Energy Analysis 2012
Average Kg Charcoal consumed/day	2.354 Kg	HH Energy Analysis 2012
Total Households Using Charcoal	85 830	HH Energy Analysis 2012
Total KG of charcoal consumed/day	202 079 Kg	HH Energy Analysis 2012
Charcoal conversion to wood	1 200 707 Kg	16,83% Kiln efficiency
Wood conversion into cubic meters	1 601 M^3	750 Kg/M^3
Wood conversion into Hectares of forest	33 ha	48,3 M^3/ha (for Sofala)
Annual forest clearance for charcoal	**12 045 ha**	

Similarly, by following the conversion rate from charcoal to wood volume; 117 431 charcoal reliant households in Nampula city, consume an equivalent of 2 639 m^3 of wood per day. By following Marzoli's (2007) forest density estimate for Nampula province (41,4 m^3/ha), it is possible to calculate that 23 360 ha of forests are cleared annually to produce charcoal for the city.

Table 28: Estimate total charcoal quantity supply for Nampula and annual forest clearance rate

Indicator	Value	Source
Population – Nampula city	571 284	INE (2007) 2012 projections
Household Number	126 952	INE (2007) – 4.5 pp/hh
% Using Charcoal	92.5%	HH Energy Analysis 2012
Average Kg Charcoal consumed/day	2.837 Kg	HH Energy Analysis 2012
Total Households Using Charcoal	117 431	HH Energy Analysis 2012
Total KG of charcoal consumed/day	333 150 Kg	HH Energy Analysis 2012
Charcoal conversion to wood	1 979 501 Kg	16,83% Kiln efficiency
Wood conversion into cubic meters	2 639 M^3	750 Kg/M^3
Wood conversion into Hectares of forest	64 ha	41,4 M^3/ha (for Nampula)
Annual forest clearance for charcoal	**23 360 ha**	

3.3. CHARCOAL VALUE CHAIN ASSESSMENT

The charcoal value chain incorporates the different processes and actors involved before the charcoal is delivered to the end consumer. It follows from the sourcing of wood for production in rural areas to its retail in urban markets and other channels. The categories of intermediaries within the value chain include: Loggers, producers, transporters, wholesalers and retailers. In addition, various other actors can be involved within the process. These are people who are hired to sort the charcoal and fill sacks at production sites; those which are hired to carry the heavy sacks to and from the transport vehicles; as well as push-trolley transporters. All these actors represent a step within the value chain. At each step, the value of charcoal as a traded commodity increases. The following analysis considers costs associated with each intermediary and breaks them down to determine the profit at each stage.

There are contextual differences in the value chain between the regions sampled. For example, within Maputo/Matola, the charcoal value chain is more extensive in terms of actors and logistics compared to the other provinces. This is largely due to the scale of demand and ever-increasing distance of production. Within Beira and Nampula, much of the charcoal still originates from small-scale producers at subsistence level. At times, one individual is responsible for various stages in the value chain, such as own production, transportation and wholesale.

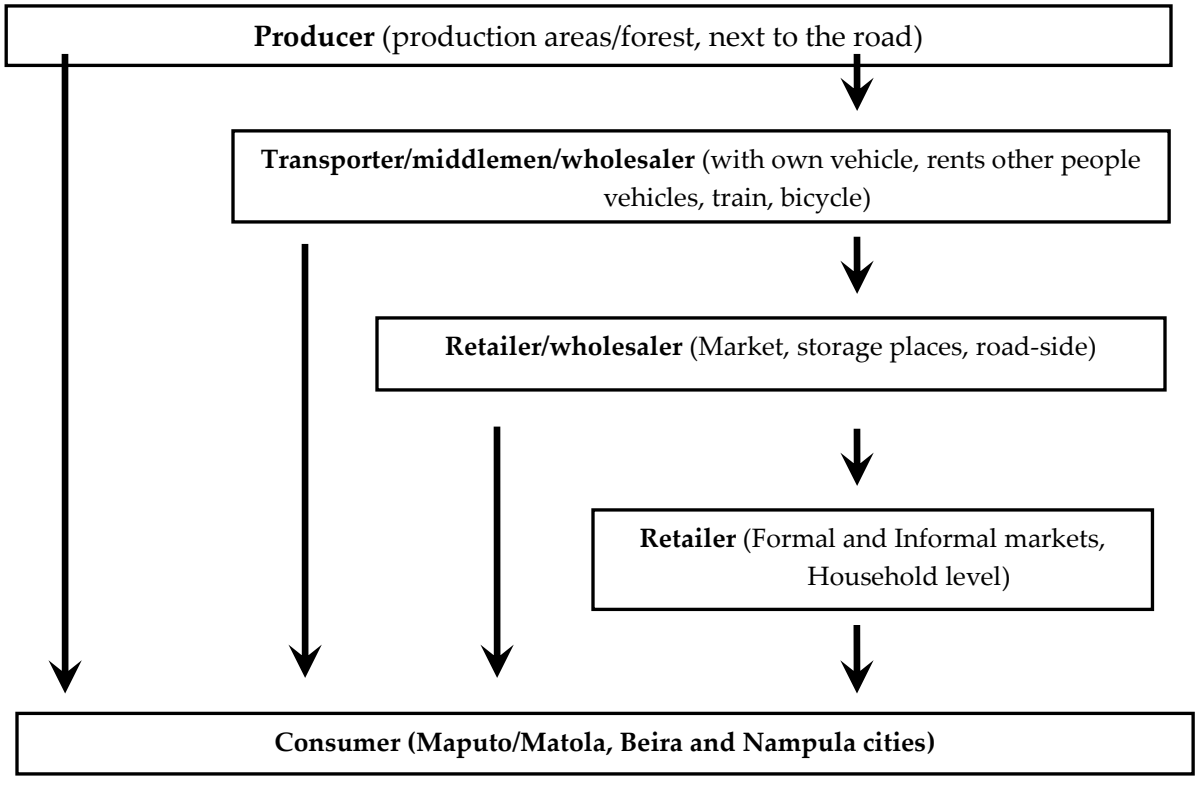


Figure 16: Structure of charcoal value chain

3.3.1. DESCRIPTION OF VALUE CHAIN

In general, the charcoal chain begins in the rural areas where forest resources are available. The first actors involved are loggers, which identify suitable trees and fell them. The logs are cut into suitable sizes and the step to follow is the construction of the kiln. Those involved in making the kiln could either be the loggers, or other individuals. The kilns are usually built near the site where the trees were cut. After the wood has been carbonized, those which built the kilns usually carefully remove the charcoal from within and sort it for sale. Producers catering for Maputo/Matola are generally involved in this sector on a full time basis, with large production levels. Producers are either involved as private individuals, or are hired by actors in the urban areas which control various stages of the value chain. Within Beira and Nampula, charcoal production is more subsistence oriented by rural communities.

Various options exist for purchasing charcoal from source of supply. In the case of Maputo/Matola, it is at times the wholesalers which travel to the production sites and directly buy sacks of charcoal. They rent their own transport (truck) or bring the charcoal to the city via train. Quantities are usually large (+100 sacks). Alternatively, the buyer sends a truck driver to collect charcoal directly from producers. Trucks can be privately owned or rented and usually make repetitive trips for the same buyers. It should be noted that charcoal producing regions are at distance over 300 km from Maputo/Matola. In the case of Beira and Nampula, a similar structure exists to some extent, however with closer distances of charcoal producing regions to the city. Much of the charcoal is also transported by bicycle. Those transporting the charcoal by bicycle are either the ones whom produce the charcoal, or could be those which purchase the charcoal directly from a producer and sell it with margin at the wholesale yards in the cities.

Once the charcoal reached the city, it is usually first sold at whole-sale yards which can be found at the larger market areas. Households can purchase charcoal sacks directly from the wholesalers, or alternatively opt to buy charcoal in smaller quantities from Retailers. These retailers are the final component of the charcoal value chain. They buy large sacks from the wholesalers and portion the charcoal into small quantities. Retailers can be found throughout formal and informal markers; street sides as well as at household level. The following section discusses each intermediary of the value chain in detail, including cost structure at each level.

LOGGERS

Wood loggers appear in the first step of the chain since they are the ones who source wood for charcoal production. They are generally male with the age between 20 – 40 years. Usually they are employed by charcoal producers. They normally cut trees and/or tree branches manually with machetes and axes to feed the kilns. There are also loggers who use chainsaws to harvest wood. One of the interviewed wood loggers has estimated that with 5 liters of gasoline it is possible to harvest wood enough to produce 35 – 50 charcoal sacks of 60 – 70 kg. In many cases, wood loggers are also involved in the charcoal production, especially in the Beira and Nampula supply regions.

"An electric chainsaw with 5 litre gasoline produces between 35-50 sacks of charcoal. Sacks vary around 60-70 kg. This quantity can be reached by only one person"
-Wood logger - Mabalane

PRODUCERS

Producers are households or individuals that carbonize wood to produce charcoal using mostly traditional sand kilns. In the case of Maputo/Matola supply, most producers live in rural areas within temporary camping sites with precarious living conditions. They do so to be close to the resources because there is little wood left around Maputo and Matola cities. In some cases they are locals from the production areas but there is a growing trend for producers to migrate from one area to another seeking for forest resources availability. Also there is an increased trend of getting "outsiders" working as full time producers, being paid by third persons who hold the charcoal production license for the volume produced. Two different scenarios can be observed, i) those who receive a monthly payment and ii) those who receive a payment according to their productivity. The second kind of arrangement incentivizes the increased production and may pose a threat to the environment as there is little attachment from these producers to the resources.

In the case of Nampula and Beira, most producers surveyed are rural community members which work in isolation or ask neighbors to help them with the construction of the kilns. In many cases, family members also help with the production process. Two types of producers were identified; those which are local residents to areas of production, as well as those which migrate to charcoal production regions in search of forestry resources. In both cases the reasons for partaking in this industry are (1) Subsistence base - to generate income for purchase of consumable goods (2) as a supplementary income generating activity when agricultural productivity is low. In the majority of cases, charcoal producers in these regions are also engaged in agricultural activities. None of the producers interviewed in Beira and Nampula region hold a license for using the forestry resources. None were also aware that such licensing processes exist. In the case of Nampula, respondents mentioned that the forestry areas used for charcoal production are controlled by the local traditional chief, which to an extent attributes the right to use of these resources.

Figure 17: Charcoal producer sorting and packing charcoal into sacks for sale – Dondo, Sofala

Most of the producers learned the activity through friends or seeing others doing it and have never benefited from any training on improved kiln making. This can be seen as a limitation because they have some problems with the kilns' failures (due to unburned wood or conversion of wood into ashes). Wood to charcoal conversion efficiency level is also very low when using traditional kilns.

A few producers have benefited from trainings in the usage of improved kilns however, there has never been a follow up on what was previously done and most of the trained producers are not using this knowledge allegedly because the introduced technology (Casamance) is time consuming. In this scenario, the introduction of improved charcoal production technologies that are cost effective in terms of time or the promotion of kilns that allow for the usage of timber scraps or agricultural residues for charcoal production would be an asset. For instance the promotion of the use of drum kilns could be a good option. This would promote reduction of wastes as well as promote the resources sustainability by reducing the amount of trees that are currently being cut.

Only a few women (less than one quarter) are involved in the production process because the activity is considered labour-intensive. Women are involved mainly to help their husbands to cover the kilns. There are, however, a few cases of women producers and this occurs often when the woman is the head of the household because the husband is absent or when they have become widows.

"I produce charcoal in Mabalane and sell it in Maputo. I am not personally involved in the production process, for this I have staff which I pay"
Guidion Tomas – Charcoal Producer - Maputo

For charcoal producers supplying the Maputo/Matola markets, the average number of kilns produced per month is one, whereby each kiln is reported to produce on average 30 sacks of charcoal. Each sack is sold at production site for an average of 225 Meticais (8 USD). It therefore can be estimated that the monthly income for producers is around 6 750 Meticais (241 USD). One of the people interviewed has a larger-scale business in the charcoal production industry. He hires workers in the rural areas to produce charcoal for him to sell in Maputo. On average, he produces 500 charcoal sacks a month, of which he transports himself to Maputo and sells for 550 Meticais (20 USD) each to wholesalers. His average monthly sales volume is 275 000 Meticais (9 821 USD).

"The charcoal production process takes more or less two weeks to complete. I produce about 500 sacks a month. On average each kiln can produce around 50 sacks"
Guidion Tomas – Charcoal producer - Maputo

Charcoal producers interviewed in Sofala province (for Beira) make on average one kiln per month. Each kiln can produce the quantity of charcoal to fill 45 sacks. Each sack is sold for an average price of 74 Meticais to wholesalers. This amounts to a monthly income of 3330 Meticais (119 USD).

"I can produce around 100 charcoal sacks from 10 trees"
Albino Abacar– Charcoal producer – Meconta, Nampula

Figure 18: Charcoal producers piling wood to make traditional kiln – Dondo, Sofala

In the case of those producing for Nampula city, the average number of kilns made per month is 1.5; whereby it is reported that 80 sacks can be produced per kiln. Each sack is then sold to wholesalers at 50 Meticais each (1.8 USD). Producers therefore have an average monthly income of 6000 Meticais (214 USD). It should be noted that the kilns produced by those interviewed in Nampula are larger than the ones seen in the case of the Maputo/Matola and Beira study. It should also be noted that producers reported to work an average of nine months per year, which would bring their average monthly income to about 4500 Meticais (161 USD) per month

"I have not heard of modern methods of charcoal production before. But I am interested in learning about these methods as now I take too long to make the charcoal"
Antonio Martins – Charcoal producer – Meconta, Nampula

Figure 19: Traditional charcoal earth kiln – Meconta, Nampula

TRANSPORTERS

Transporters normally function as middlemen and wholesalers. This category includes individuals that carry the charcoal from the production areas to the district headquarters using donkeys, tractors, trucks pushing trolleys and bicycles or that transport charcoal from the district headquarters to the main markets in the cities.

Within the Maputo/Matola study, the following 4 different groups of transporters were identified:

1. People who own one or more vehicles and transport their own products - normally licensed and having their own employees or buying from producers to resell in Maputo.

2. People who own one or more vehicles and transport third person products mostly for women that dedicate to the buying and reselling business. Not all of these vehicle owners have a license to produce charcoal. In these cases it is the responsibility of the charcoal owners to have all licenses and documents ready for inspection at checkpoints.

3. People who dedicate themselves to buying the charcoal in the rural areas and reselling it in the city of Maputo. They don't have their own transport and can use either rented trucks or train carriages for the charcoal transportation. Individuals that transport the charcoal from the inner production areas to the collection areas (e.g. for the train station), using trucks, tractor or animals.

4. People who transport the charcoal from the wholesalers to the retail outlets/ places.

Both sexes are involved differently in the activity but men are the main vehicle owners. Only 18% of the transporters are females and most of them fall under the category 3.

The bulk of charcoal commercialized in Maputo originates from Gaza province: truck-drivers mainly bring charcoal from Mabalane (230km), Combomune (300km), Macia (120 km), Motasse, Chókwe (150 km), Massingir (300 km). Once in Maputo, charcoal is delivered to the different market places including charcoal yards.

Main reasons for engaging in the transportation are: subsistence (32%), unemployment (21%) and the profitability of the business (21%). For those whom transport charcoal by truck from Production sites to Maputo, they generally charge from 100 to 180 Meticais (3.4 – 6 USD) per sack (depending on the distance traveled). It is reported that each truck can take an average of 150 Sacks per trip. This amounts to a value of 15000 – 27 000 Meticais (536 – 964 USD) per trip. If four trips are made per month, a transporter can generate as much as 108 000 Meticais (3857 USD).

"For transportation I charge per sack of charcoal carried. The distance is also taken into account. From Mabalane to the city I normally charge 150 Meticais per sack. It would be more expensive if the distance was larger. Generally I transport 130 to 150 sacks at each trip."

Gilberto Batine – Truck driver - Maputo

Within Beira and Nampula regions, the distances for charcoal transportation are much less compared to Maputo/Matola. Three transport categories were identifies, namely: Trucks of 10 and 20 tons, light weight vehicles and bicycles. For both cities, it was registered that bicycles were the most frequent means used to transport charcoal. The quantity of charcoal sacks carried per trip varies from 1 to 2 and bicycle transporters usually make 2-3 trips per week. In the case of Beira, these cyclists transport the charcoal at distances from 40 to 80 Km. With an average charcoal sack weight at 50 kg, cyclists normally paddle with an additional 100 kg weight. Within Beira and Nampula two types of bicycle transporters were identified:

1. Those which purchase charcoal at production sites and sale to wholesalers or end-users in the cities
2. Those which transport the charcoal which they themselves produced to wholesalers or end users in the cities.

In the case of Beira, the sale price from transporter to wholesaler is at average 100 Meticais (3.6 USD) per sack. Those which transport the charcoal they personally produce will therefore earn this for themselves. In this case, if they make 3 trips a week, with two sacks per trip, they would earn a monthly income of 2400 Meticais (86 USD). For Nampula, this trend is similar; however bicycle transporters sell their charcoal to wholesalers at 50-70 Meticais (1.8 – 2.5 USD). In this case, their monthly revenue would be between 1200 and 1680 Meticais (43 - 60 USD).

WHOLESALERS

Wholesalers are individuals engaged in the commerce of charcoal at bulk. They usually sell charcoal sacks either to retailers or end-consumers such as households and institutions. It is mainly women which are engaged in this activity, with ages between 20 to 60 years.

Within Maputo/Matola, four sub-categories of wholesalers were identified:

1. those who take the train to production sites and bring back charcoal to Maputo, at the station, *Gare de Mercadorias*;
2. The second sub-category, travel to production sites and bring their merchandise to Maputo by trucks;
3. Those who have suppliers and get charcoal from truck-drives at the market; and finally
4. Wholesalers coming to Maputo, generally from places such as Manhiça and Macia. This last sub-category was found in Volcano Market and travel exclusively to sell charcoal sacks and return to their places of origin once they finish selling their load.

"I travel to Mabalane on Tuesdays with the train, once I know the charcoal has been produced. There I find people who can help me pack and carry the charcoal sacks for a fee. The sacks are first carried to a truck and thereafter transported to the train station. The sacks arrive in Maputo on Thursday night, and are unpacked Friday morning at the station. I sell some sacks at the train station, and the rest I sell from home"

Isabel Amaral – Charcoal Wholesaler

The revenue made by wholesalers depends on the price which they buy the charcoal and that which they sell it for. In the case of Maputo, wholesalers generally purchase the charcoal sack at 425 Meticais (15 USD) - including producer and transporter costs - and resell it for an average of 650 Meticais (23 USD). They profit on 225 Meticais (8 USD) for each sack sold. Wholesalers can sell between 30 to 50 sacks per month, making a profit between 6750 and 11 250 Meticais (241-402 USD) per month.

Within Beira, wholesalers acquire each sack of charcoal for an average price of 100 Meticais (3.6 USD) and sell it for an average price of 215 Meticais (7,7 USD). If wholesalers can sell up to 40 sacks a month, they will make revenue of 4600 Meticais (164 USD). Similarly in Nampula, the wholesalers acquire each sack of charcoal for 50 Meticais (1,8 USD) and resell it for 130 Meticais (4,6 USD). If they sell 40 Sacks per month, their revenue will be at 3200 USD (114 USD).

Figure 20: Charcoal wholesaler yard at Mucurreano market - Maputo

RETAILERS

Retailers buy the charcoal in sacks from the transporters or wholesalers and resell it in small cans or piles. They can be found in all markets and along the roads in the city. Retailers can also be individuals whom sell charcoal in small quantities from their homes. Due to the informality of the activity, it is difficult to estimate the numbers of people that are involved in it. But one may assume there are large numbers of individuals involved. As with other stakeholders in the supply chain, the main reasons for entering in this business are subsistence means and unemployment.

Retailers sell the charcoal all year as there is always demand for this source of energy. One sack may be divided into various different smaller quantities. The table below shows the different quantity types found at retail points in Maputo with respective price. The most common form of retail charcoal purchase is in bundles (called “molhinos” locally). On average each bundle weighs 500 grams and is sold for 9 Meticais (0.3 USD). If retailers purchase a 68.5 kg sack of charcoal from wholesalers at 650 Meticais (23 USD), it is possible to resell this quantity for 1233 Meticais (44 USD) in the form of bundles. This gives a revenue of 583Meticais (20,8 USD) per sack sold in retail form. On average, retailers can sell half a sack per day, which equates to monthly revenue of 8745 Meticais (312 USD).

Figure 21: Charcoal retailers in Maputo

Table 29: Retail charcoal prices for various markets in Maputo

Charcoal Prices (Mt) for different charcoal retail quantities							
		20 litre can (13 kg)	10 litre can (6.5 kg)	5 litre can (2.5 kg)	2 litre can (1.5 kg)	Bundle (0.5 kg)	Sack (70 kg)
	Markets						
1	Malanga	130	70	.-	.-	10	650
2	Xipamanine	130	70	25	13	10	600
3	Vulcano	140	70	25	.-	5	600
4	Xiquelene	180	100	.-	13	10	650
5	Mucorreano	180	100	.-	.-	.-	700
6	Adelina	180	.-	.-	.-	10	700
7	Museu	200	.-	.-	20	.-	800
Average Price (Mt)		163	82	25	15	9	671

For the case of Beira, retailers purchase a 59.9 Kg sack of charcoal for an average price of 200 Meticais, this they sell in small bundles at 5 Meticais each. Considering that the average weight of a bundle in Beira is 500 grams, retailers can profit on 399 Meticais per sack sold in bundles.

Similarly, within Nampula, retailers purchase a 52.7 kg sack of charcoal for 130 Meticais and resell it in bundles for 3 Meticais each. Doing so, earns them revenue of 186 Meticais per sack sold in the form of bundles.

OTHER INTERMEDIARIES

Various other intermediaries can be identified within the charcoal value chain. These are individuals which offer services to the main actors within the charcoal trade business.

The first category identified are charcoal sack sorters. They are usually employed by charcoal producers and are based at production sites. Their work involves packing charcoal pieces into the 50 liter sacks (usually reused maize or rise sacks). They either receive payment per sack packed, or a daily wage for the work done. This category is more commonly found in regions where large volumes of charcoal are produced, such as those supplying Maputo/Matola cities.

"I work at the charcoal production location for a monthly wage of 500 Meticais. Ideally I would like to be studying; however I am in this business because I was unable to enrol at school this year"

Helton – Charcoal packer

Others in the charcoal value chain include hand-trolley drivers. They typically transport small amounts of sacks, usually 1 to 10 sacks at the time, and for short distances. They can be hired by wholesales or retailers to move the charcoal sacks from one location to another. Consumers might also hire their services, to transport the charcoal bought at the wholesale yards to their homes. Usually the price charged depends on the number of sacks carried and distance. It varies between 10 Meticais to 100 Meticais per sack.

Complimenting the work of hand-trolley drivers are those people paid to carry the heavy charcoal sacks either to or from the transport vehicles. Such people were interviewed within the Maputo train station terminal and wholesale yards. Their role, at the train station, consists of carrying charcoal sacks from train carriages to the trucks or to hand-trolleys for the wholesalers. At the markets, they carry charcoal sacks from trucks for wholesalers and, in some cases, for retailers operating in markets, or else, to hand-trolleys for those wholesalers operating out of the markets.

"Once the train arrives full of charcoal, I am paid to carry the charcoal sack from the train to the truck which will distribute charcoal to the markets. At the charcoal production sites I do the same, however I carry the sack from the location of production to the trucks."

Alfredo – Charcoal sack carrier

In general, charcoal carriers are employed by wholesalers; while only few are self-employed. The highest wage of employed carriers is 2500 Meticais (90 USD) a month, these are generally carriers working in charcoal yards located in market places. Self-employed carriers charge their service per sack of charcoal carried and the price varies according to the distance and demand. At the train station, they charge 5Mt per sack to carry from the train carriage to the trucks or to hand-trolleys. At the markets they charge between 10 – 50 Mt, depending on the distance. On average, they carry 30 sacks per day, earning them from 150-300 Meticais (5-10 USD) per day.

3.3.2. VALUE OF THE INDUSTRY AT DIFFERENT LEVELS

The following section summarises the added value of charcoal at each level of the value chain. Furthermore, it highlights the average revenue gained by each intermediary in the charcoal business.

Table 30 shows the value added on a 68.5 Kg sack of charcoal at each intermediary level of the Maputo/Matola supply chain. It is most notable that those transporting the charcoal from production sited to the city by truck, make the highest revenue per month. They can earn around 54 360 Meticais (1941 USD) from this service if they profit on 90 Meticais on each sack carried. Transporters usually charge by the sack carried. The average price stated is 140/sack. For this analysis it was considered that 50 Meticais of this value goes towards petrol and driver salary expenses.

Those earning the lowest are charcoal producers. They earn on average 6750 Meticais/month. This however is more than double the minimum wage in the agricultural sector. Wholesalers and retailers earn similar incomes (8745 and 9000 Meticais respectively).

Table 30: Maputo/Matola charcoal supply value chain summary

Maputo value chain	**Per sack sold (68.5 Kg)**			**Monthly Revenue**	
Intermediary	Unit Price (Meticais)	Expenses (Meticais)	Revenue (Meticais)	Monthly quantity(Sacks)	Monthly revenue (Meticais)
At production site	225	0	225	30	6 750
Transporter (Truck)	140	50	90	604	54 360
Wholesaler	650	425	225	40	9 000
Retailer	1233	650	583	15	8 745

Table 31 shows the value added at each intermediary in Beira. In this case, the revenue stream for transporters using bicycles is depicted. This is the most common form of charcoal transportation in the region. The analysis shows that in this case, it is the retailers which earn the most from the industry. They earn on average 5985 Meticais (214 USD) per month. Conversely, those transporting charcoal by bike, purchased from producers, earn the least. They only have a margin of 26 Meticais (0,93 USD) per sack transported. If producers chose to transport their own charcoal to the city, it increase the value of their product and earns them an additional 26 Meticais per sack produced.

Table 31: Beira charcoal supply value chain summary

Beira value chain	**Per sack sold (59.9 Kg)**			**Monthly Revenue**	
Intermediary	Unit Price (Meticais)	Expenses (Meticais)	Revenue (Meticais)	Monthly quantity(Sacks)	Monthly revenue (Meticais)
At production site	74	0	74	45	3 330
Transporter (Bicycle)	100	74	26	24	624
Bicycle (own charcoal)	100	0	100	24	2 400
Wholesaler	215	100	115	40	4 600
Retailer	599	200	399	15	5 985

The case of Nampula is similar to that of Beira. Revenue margins are however less, as the charcoal production price is much lower. In this case, it is the producers which earn the highest margins. They can make on average 4500 Meticais (161 USD) per month. It should be noted that the producers interviewed in Nampula had a larger productivity than those in Beira. Both due to higher forest density and larger kilns built.

Table 32: Nampula charcoal supply value chain summary

Nampula value chain	Per sack sold (52.7 Kg)			Monthly Revenue	
Intermediary	Unit Price (Meticais)	Expenses (Meticais)	Revenue (Meticais)	Monthly quantity(Sacks)	Monthly revenue (Meticais)
At production site	50	0	50	120	4 500
Transporter (Bicycle)	70	50	20	24	480
Bicycle (own charcoal)	70	0	70	24	1 680
Wholesaler	130	50	80	40	3 200
Retailer	316	130	186	15	2 790

4. DISCUSSION AND POLICY RELEVANCE

The following section discusses the significance of the results gathered in this analysis, and proposes recommendations to improve upon the situation.

4.1. DOMINANCE OF CHARCOAL

Various reasons can be suggested to why charcoal is the most dominant fuel throughout urban areas in Mozambique. The results show that in Maputo, the capital of the country, 87% of households use charcoal at least once a week. For Beira, it is 85% and in Nampula, as much as 92% of the population relies on this fuel.

Reasons for this dominance span from cultural factors, to economic considerations and lack of awareness issues. Perhaps the most stated cultural reason for cooking with charcoal is related to the taste of food. Many believe that food prepared with charcoal or firewood tastes better than that prepared with modern fuels. Attached to this, is the habit of cooking with charcoal and the tradition of using this fuel. It has become a norm to cook certain dishes such as traditional stews using biomass fuels. This can be observed even in the higher income families (Atanassov, B. 2010).

Perhaps the most prevalent reason why households choose charcoal is related to the accessibility of the fuel. Charcoal is perceived as both “economic” and “available” compared to other cooking fuels. As a result of the continuous supply of this commodity and extensive wholesale and retail network,

charcoal is made readily available and accessible to households. One only needs to walk a few meters to find someone selling charcoal on the street side or from a neighbour's home.

With regards to price, charcoal is perceived to be the most affordable fuel. Both in Beira and Nampula, it is the most affordable cooking energy source after firewood. The monthly expenditure on charcoal for Beira is 551 Meticais, while in Nampula it is 414 Meticais. Within Beira and Nampula the monthly household expenditure on LPG is at 680 Meticais and 750 Meticais respectively. For Maputo/Matola however, there has been a sharp increase in the price of charcoal within the past four years. Currently households relying exclusively on charcoal for cooking spend on average 846 Meticais per month. The average household expenditure on LPG is 717 Meticais per month for Maputo/Matola region. Possible reasons why more households have not adopted LPG include:

1. Lack of public awareness that LPG could be more economical fuel source;
2. Difficulty in obtaining LPG fuel supply, as distribution networks are not yet extensive throughout the city;
3. A higher start up cost compared to charcoal. Households need to purchase an LPG stove, together with the initial canister and connecting equipment. This can range up to 100 USD or more depending on the stove. One can buy a charcoal stove for 3 to 20 USD.
4. Currently only 11kg LPG canisters (tanks) are sold, which are reported to contain one month's worth of fuel. Smaller quantities are not available for households which do not have the up-front cash to purchase the larger canister.
5. Some households are concerned about the safety of using LPG at home. They consider this fuel as being dangerous and with risk of explosion.

4.2. ADOPTION OF MODERN COOKING FUELS

Fuel-mixing is practiced by many households within the three urban regions studied. Despite the mass use of charcoal, households often also use modern cooking fuels such as LPG and electricity to supplement their cooking needs. Within Maputo/Matola this trend is most prominent, whereby modern cooking fuels have the highest penetration. As much as 50% of households own either an LPG or electric stove. Within Beira, 26% of households make use of a modern stove type, while in Nampula it is only 10% of households.

This trend can be further analysed according to income. In general, households with a higher monthly income are more likely to own a modern stove type, as opposed to those with a lower income. The figure below shows two graphs, one which illustrated biomass stove ownership according to income level; and another illustrating modern stove ownership. The energy ladder trend is most visible for Beira city. The higher the income, the less likely households are to own a biomass stove, and more likely to adopt modern cooking fuels. Within Maputo/Matola, one can see an increase trend of modern stove ownership with a rise income; however the biomass stove ownership is constant throughout the different income groups. This indicates a higher level of fuel mixing for Maputo/Matola residents. In the case of Nampula, the data shows the least level of modern stove penetration; however a similar trend of modern fuel use with higher income exists.

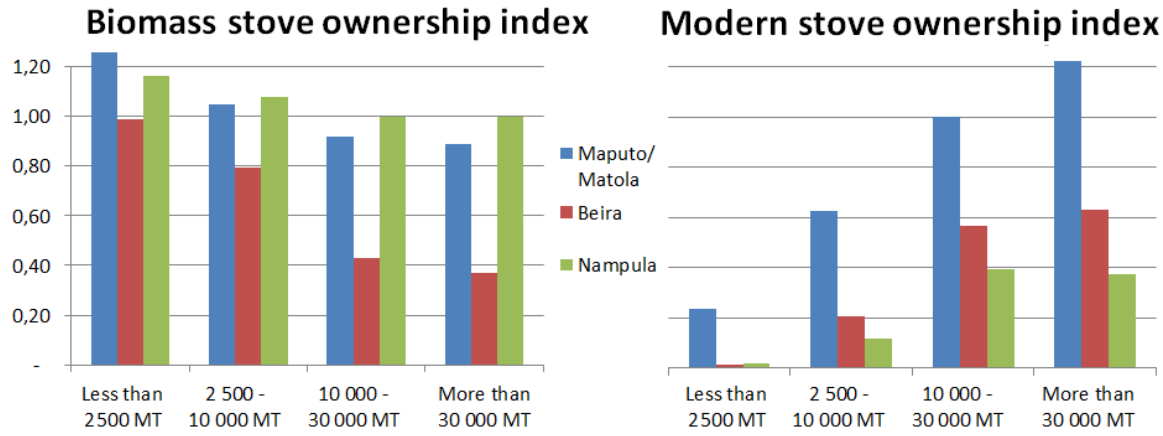


Figure 23: Energy ladder for Maputo/Matola, Beira and Nampula

One of the main reasons why more households have adopted modern cooking fuels in Maputo, as opposed to those household in Nampula is due to the price of charcoal. Fuel mixing has become a necessity in Maputo/Matola, as the price of charcoal is much higher. Households have adapted to this by cooking some dishes using charcoal, while others using modern fuels. This decision is not only culturally driven, but to a higher degree economically driven. Traditional stews for example, take long time to simmer. For this it becomes more economic to use charcoal, as once the stove is lit, the same charcoal can burn for hours. However when it comes to faster dishes such as fried food, pastas and rice, it no longer is economical to light the same charcoal amount for a short use. For these instances households prefer to use LPG or electricity.

It can be concluded that the price of fuel is a decisive factor in cooking energy choice. Adoption of modern fuels can occur at a larger extent if the price becomes competitive with that of charcoal. However the case of Maputo/Matola also shows that biomass fuels will continue to be used within the households energy mix. This may either be culturally or economically driven (in the case of long simmering stews).

4.3. HEALTH AND ENVIRONMENT

Health problems associated with biomass energy use are well documented. The effects of indoor air pollution on respiratory health and general well-being are a serious concern amongst health practitioners. According to the World Health Organization, up to 2 million people a year die prematurely from illness attributable to indoor air pollution due to solid fuel use (WHO 2012).

This study shows that 23% of respondents had suffered from respiratory health problems within the month before the survey. The highest incidence was in Nampula, whereby 26% reported health problems. Within Maputo/Matola and Beira it was 19% and 25% respectively.

It is interesting to note that those cities which rely more exclusively on biomass fuels (such as Nampula and Beira), have a higher incidence of respiratory health illness compared to Maputo/Matola

The study also shows a weak public awareness on the health impacts associated biomass energy use. Only 17% of households in Maputo said that cooking with charcoal can have negative health impacts. For Beira, 42% of households were aware; while in Nampula 33% associated health impacts to charcoal use. It can therefore be concluded that more awareness raising campaigns are needed to educate people about the health impacts associated with biomass fuels. This in turn may promote the transition to more modern and clean energy sources.

The environmental problems associated with this mass dependency on biomass fuels are equally concerning. The charcoal quantity consumed in one year just for Maputo and Matola translates into 1.8 million tones of wood. The forest density index for the Maputo and Gaza province is 17,3 M^3/ha. This means that 141 985 hectares of forest are cleared every year just to supply these two cities. Households in the city of Beira, consume an equivalent of 438 258 tones of wood per year. This translates into 12 045 hectares of forest cleared annually for charcoal production (48,3 M^3/ha). Similarly, those consuming charcoal in Nampula go through an equivalent of 722 518 tones of wood per year. This is an estimated 23 360 hectares of forest which is cleared for charcoal in Nampula province.

When comparing these figures to the data from the national forestry inventory (2007); one can determine the percentage of total forest clearance which is just for the production of charcoal. The forest inventory specifies an annual deforestation rate for Maputo and Gaza province to be 29 000 hectares/year (estimated between 1990 and 2002). Considering that just to meet the current demand for Maputo/Matola charcoal supply, it is required 141 985 hectares of forest per year. This means that the actual forest clearance rate for charcoal is five times above the estimated average given by the national forestry inventory.

The national forestry inventory specifies that the annual deforestation rate for Sofala province is 20 000 hectares/year. For the supply of charcoal for Beira city, it is required 12 045 hectares/year of forest. This means that just over 60% of the forestry resources annually depleted in Sofala go towards charcoal production. Similarly, by considering the annual deforestation rate for Nampula, which is 33 000 hectares/year. It can be concluded that the 23 365 hectares/year needed for charcoal production constitutes 71% of total forest resources extracted.

It can therefore be concluded that for the studied regions, a large percentage of the forestry resources exploited each year goes towards charcoal production. It should be noted that no significant examples of sustainable forest management or plantations for charcoal production were encountered in the studied regions. It is therefore recommended to promote such initiatives, as the figures show that forest clearance for charcoal production is happening at a highly unsustainable rate.

4.4 THE INFORMAL CHARCOAL INDUSTRY

The charcoal value chain analysis shows the informal nature of the charcoal industry. Yet, much capital is generated annually from this business. By considering the price of charcoal for Maputo/Matola, and the quantities consumed on an annual basis; it can be estimated that just for Maputo/Matola, the charcoal industry generates 105 062538 USD (105 million USD) on an annual basis. It can also be calculated that to supply Beira city, the value generated by the charcoal industry is 9 455133 USD (9.5 Million USD). Similarly, the value of the charcoal business in Nampula is 10 712908 USD (10.7 Million USD).

This annual generated value of approximately 120 million USD from the supply of charcoal to four cities is to its greatest part tax free. Regularising the industry could generate income for the state, which in turn could be used to promote more sustainable use of forestry resources for charcoal production.

Some attempts have however been made to regulate the industry. Procedures to licence charcoal production exist, and are controlled by the ministry of agriculture. Only a few producers are however currently licensed. Mainly the transporters or the wholesalers who buy from the producers hold licenses. Although the forest law and its respective regulations state that the producers should be the licensed ones, this in practice is difficult to implement due to the governments limited capacity to control the vast forest areas. Thus it is transporters or wholesalers which hold licenses to a limited quantity of charcoal which they can transport on a monthly basis. This is controlled at the road-checkpoints on entry to the cities. However it should be noted that only a small fraction of transporters or wholesalers hold licenses. The bulk of the charcoal which enters the cities is not registered. This is most notable for Beira and Nampula, whereby a larger part of the charcoal enters via bicycle. Since the transport of three or less sacks of charcoal is considered as personal use by the law; cyclists do not need to account for the amount they carry (generally two or less sacks).

When by truck, most of the charcoal is transported during the night period (8pm to 5am) and this seemed to be purposefully so because the law enforcement agents are more vulnerable to corruption and also are in many cases tired of the work shifts. It is possible to see that some trucks do pass the check posts without any documents or declaring a smaller quantity than the reality. To avoid the problem of underestimation of charcoal quantities in loaded trucks, law enforcement trainings should include modules in this regard and more supervision of agents should be in place. Additionally an incentive system should be put in place so that they feel motivated to accurately register the information. Part of these incentives could be provided by the 50% benefit sharing mechanism that ought to be approved by responsible entities. Additional measures include the reduction of night transportation to avoid corruption problems.

5. CONCLUSION

From the information gathered through the study, it can be concluded that biomass energy plays an important role for the livelihoods of many in Mozambique. It is a major income generating activity for both those producing in the rural areas, as well as those commercialising it within the cities. It is also a secure and available source of cooking energy for millions dependent on it.

Yet, the environmental and social impacts are concerning, and threaten to amplify within the coming years. Policy-makers and development agents have a delicate decision to make regarding the interventions chosen for this sector. On the one hand, the livelihoods of many are dependent on this largely informal industry, while on the other hand, this informality is leading to uncontrolled and unsustainable depletion of natural resources and ill health of numerous biomass users.

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