SUSTAINABLE ACCESS TO ENERGY IN MOZAMBIQUE, GREENING THE CHARCOAL VALUE CHAIN IN THE LOWER ZAMBEZI RIVER BASIN

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OBJECTIVES OF THE STUDY & METHODOLOGY

Access to clean sustainable energy for cooking and other domestic uses remains a challenge in Africa, as most of the urban and peri-urban population rely on charcoal. These past few years, many countries attempted, more or less successfully, to regulate its production and trade.

Charcoal is often produced miles away from where it is consumed, in rural areas where wood is still readily available and where communities are seeking additional sources of income. Most charcoal is produced, processed and transported informally, outside existing legal frameworks. This is one of the factors that explains the difficulty of working on the sustainability and regulation of this sector, and the often-incomplete knowledge of Charcoal Value Chain (CVC) actors.

The Government of Mozambique is already well advanced in its work to map, update, and promote renewable energy sources, especially in the south of the country. In order to complete this diagnosis, Enabel has commissioned SalvaTerra to carry out this study with the aim to assess the potential for developing an efficient and diversified CVC that promotes sustainable sourcing, production, transportation, distribution, and use of charcoal in the Lower Zambezi River Basin (ZRB). It has been carried out between November 2021 and January 2022 in the three provinces of the Lower ZRB, i.e. Tete, Zambezia and Manica.

The results of this study will complement the data collected by the Ministry of Natural Resources and Energy. The aim is also to provide the Enabel teams with keys to understand the local sector of charcoal production, so that they can formulate a larger programme in the ZRB, to address the complex problems inherent in finding sustainable solutions to the energy question and its interface with food and water challenges.

The approach adopted is a mixed methodology combining literature review, interviews with key informants and meetings with CVC stakeholders in order to understand:

- Lessons learned from the numerous projects carried out in Africa, and an in-depth analysis of the projects already carried out in the South of Mozambique;

- CVC's characteristics in the Lower ZRB, on the basis of interviews with key informants and the main actors involved in traditional and alternative charcoal production, visits to charcoal production sites and main markets, etc.

More than 40 producers and charcoal traders were interviewed, as well as the main institutions at local and national level.

MAIN RESULTS

Interviews of key local actors enable to confirm that charcoal production is a labour-intensive activity, with low entry barriers since the process of assembling and managing traditional kilns is simple and easily mastered, even by inexperienced producers.

At small-scale, charcoal production generates small profit margins for most value chain actors, with particularly low benefits to the producers. This is all the more the case when production areas move away from urban markets, thus generating increased transport costs and additional logistics costs.

However, it is an important additional source of income for local communities, who are looking for a complement to their often seasonal and unprofitable agricultural activities.

In order to generate a minimum of profit, CVC actors who are not organized or structured in associations must adopt strategies for proper business performance. These strategies include movement based on access to natural resources, ad hoc mutual aid, and very low initial investment costs.

Despite an interest in reducing the drudgery of the work and improving the ratio of wood to charcoal (currently low) to improve their profits, producers are very risk averse. This is an important criterion to take into account when introducing new production practices.

Although communities and producers recognize that initiatives for sustainability in the production and use of charcoal are necessary, the use of wood fuel remains so far inevitable due to the low income of many families and the lack of competitive energy alternatives.

It is necessary to aim for a transformation of the value chain from its base, i.e. forest management. Indeed, the current production system is mainly based on uncontrolled and unlimited access (or at least perceived as such by producers) to forest resources. This leads to an expansion of charcoal production areas in the lower ZRB, affecting fragile forests with a slow renewal rate. In addition, conflicts between producers from local communities and producers from other districts/provinces are emerging (e.g. Zambezia).

According to the structure of the CVC and the production and marketing patterns in the study area, the potential for improvement lies more in the upstream part of the value chain (forest management and production techniques), as well as in the end-use (cooking solutions and fuel alternatives).

The mapping of initiatives at national level established that there are currently few projects in operation or in the pipeline in the ZRB. Most of the efforts so far have been concentrated in the south of Mozambique, due to the high demand for clean fuel and cooking solutions in the urban area of Maputo, where the high prices of charcoal and wood logically lead to a better competitiveness of alternative fuels.

However, this trend is spreading throughout the country, including the centre, as urban areas become denser and forest resources scarcer. The ZRB area has been relatively understudied by the scientific community to date, and the structure of the CVC is rather poorly documented.

Nevertheless, this does not prevent from learning some lessons from projects in the south, and identifying initiatives and approaches that could be scaled up in the Lower ZRB provinces.

- The main challenge is to take a cross-cutting view when dealing with the CVC: to focus on each link in the value chain and to coordinate the value chain as a whole;
- New technology adoption by producers and users is very difficult and one of the key factors of success is the adaptation to local context and producers/users' constraints;
- Complex kiln designs are hardly adoptable by charcoal producers, instead, improved kiln designs with slightly less efficiency but that are more suitable to local practices have a higher probability of adoption and replication;
- "Top-Down" approaches did not prove to be successful when introducing a new kiln technology, whereas participatory methods, with a gradual increase in technicality have produced interesting results in terms of adoption and appropriation of practices;
- A secure supply source has proven to be more of a motivational factor for improved kiln adoption compared to efficiency and time savings. This is all the more important as very few projects focus on securing forest resources and disseminating forest management practices in the country;
- Attempts that involve only producers and associations often fail when introducing new kilns, as there is a need to involve the formal private sector, which is currently not attracted to charcoal production;
- There is a need to provide for long-term state supervision to ensure the sustainability of activities undertaken by research organisations, and other actors in the CVC, as changing practices is a slow process that is greatly impacted by policies and legal framework.

The study of the licensing system reveals major shortcomings, insofar as it does not allow for detailed monitoring of the number of charcoal producers, the volumes produced, or the identification of production areas.

The institutions that regulate the activity lack various means, from finance, knowledge, training, human resources, tools, etc. which limits the full exercise of their obligations with a view to ensuring greater control and organization of charcoal production.

CONCLUSIONS

The issues of the CVC in the Lower ZRB can be summarized as: i) **No multisectoral coordination (forests and energy) and lack of leadership by any of the sectors**, ii) **Inefficiency and waste in production (traditional kilns) and consumption (low efficiency stoves)**, iii) **Indiscriminate logging** without respecting species or cutting zones, and iv) **Informal business with low incomes for producers, communities and the State**.

These issues imply an **extension of deforestation** further and further away from urban centres in an **uncontrolled and unmonitored** way. A lasting impact on ecosystems via the degradation of vegetation cover, with possible repercussions on water management, soil fertility, etc. is to be feared.

Charcoal production is an important complementary activity for the rural populations living in the ZRB area. It provides an important income supplement, particularly in case of major crop loss due to flooding, for example, which is becoming increasingly frequent in the ZRB. Indeed, IPCC (2009) has forecasted an intensification of cyclone features, increase in wind speeds and heavier rainfall discharges due to the increase in tropical sea surface temperature. Among the eight countries included in the ZRB, Zambia and Mozambique have the largest flooding area due to the Kafue flats and lower Shire region. The spread of inefficient carbonization techniques among the population, a potentially growing need for additional income after climatic disasters (cyclones, floods, droughts, etc.) combined with an increasing demand for fuel from urban centres will lead to **ever greater pressure on the forests**, and thus a **potential increase of GHG emissions, decrease in carbon storage as well as water and soil retention from trees**. Greening the CVC, and more generally the supply of biomass energy in the ZRB region would therefore contribute to both adaptation and mitigation of climate change effects.

The modernisation of the CVC and biomass sector for domestic use and small businesses (such as cooking stalls, restaurants, etc.) therefore requires a **multi-stakeholder approach** that include the central and local government entities, communities (charcoal producers and other forest product users), the private sector, development organizations partnering with Civil Society Organizations (CSOs) and Financing actors.

Based on lessons learned from CVC projects in Africa, the implementation of **demand-driven approaches** seems to be one of the ways to modernise CVC with the highest potential for sustainability. This means **stimulating demand and creating favourable conditions for the emergence of a market for competitive alternative fuels and efficient cooking equipment**. **The formal private sector** has a central role to play. The challenge will be to **extend the dynamics initiated in the south of Mozambique towards the centre**, by encouraging companies to set up in the main cities, and by supporting the development of new social businesses.

A trigger is needed to **open up a market opportunity**, that could take various forms such as **certification systems, incentive and technical support, financing**, etc., with **government institutions in the leading role**.

Researchers are also essential elements to be mobilised in order to **progressively improve knowledge on the potential risks of this particular area that is the ZRB** (climate, forest cover, associated agrarian systems, etc.), to contribute to developing a **clear vision of the dynamics at work in the CVC** and to **establish a relevant and efficient monitoring system** to follow the evolution of the situation over the long term.

In section 7 of the present report, **possible programmes to be developed, taking into account the objectives set by the government, pilot projects that have already been carried out and potential partners are outlined.**

Acronyms & key definitions

AECF	Africa Enterprise Challenge Fund
AICS	Italian Agency for Cooperation and Development, from the Italian *Agenzia Italiana per la Cooperazione allo Sviluppo*
ALER	Associaçao Lusofona de Energias Renovaveis
AQUA	National Agency for Environment Quality Control, from the Portuguese *Agencia da Qualidade Ambiental*
AVZ	Agência de Desenvolvimento do Vale do Zambeze
CAADP	Comprehensive African Agricultural Development Plan
COP	Conference Of Parties
CSO	Civil Society Organization
CVC	Charcoal Value Chain
DINAF	Direcçao Nacional da Floresta
DPREME	Direcça provincial dos recursos minerais e energia de Tete
Enabel	Belgian Development Agency
FLEGT	Forest Law Enforcement, Governance and Trade
GDP	Gross Domestic Product
GHG	Greenhouse Gases
GIZ	German Cooperation Agency from the German *Deutsche Gesellschaft für Internationale Zusammenarbeit*
ICS	Improved Cookstove
IPCC	Intergovernmental Panel on Climate Change
KUWUKA JDA	Juventude Desenvolvimento e Advocacia Ambiental
MADER	Ministry of Agriculture and Rural Development (former MINAG)
MIREME	Ministry of Natural Resources and Energy
MTA	Ministry of Land and Environment
MozFIP	Mozambique Forest Investment Program
Mt	Meticais
NGO	Non-Governmental Organisation
Norad	Norwegian Agency for Development Cooperation
REACT SSA	Renewable Energy and Adaption to Climate Change Technologies in Sub-Saharan Africa

RVI	*Reboisement Villageois Individuel*
SARDC	Southern African Research and Documentation Centre
SDC	Swiss Agency for Development and Cooperation
SIDA	Swedish International Development Cooperation Agency
SME	Small and Medium Enterprise
SNV	Netherlands Development Organisation
SPDTA	Provincial Services for Territorial Development and Environment from the Portuguese *Serviço Provincial de Desenvolvimento Territorial e Ambiente*
SSA	Sub-Saharan Africa
TaTEDO	Tanzania Traditional Energy Development Organization
UNCBD	United Nations Convention on Biodiversity
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
WEFE	Water-Energy-Food-Ecosystem
WFP	World Food Programme
ZAMCO	Zambezi Watercourse Commission
ZRB	Zambezi River Basin

1. Introduction

Whereas total fuelwood consumption has been declining or stabilizing in Asia and South America, in Sub-Saharan Africa (SSA) wood fuel demand continues to increase. In SSA, use of firewood dominates in rural areas, while charcoal is often the major source of energy, with about 90% of urban households depending on it for cooking and heating (Schure et al. 2013)[1]. The demand for charcoal is expected to increase, as population grows and urbanisation proceeds.

Mozambique has a great diversity of forest resources, which are extremely important for economic, social and environmental development through the generation of employment, fuelwood and many other benefits. Around 80% of the Mozambican population depends on fuelwood to meet its energy needs.

The actors in the charcoal value chain (CVC) are the producers, traders (wholesalers and retailers) and consumers. Producers are mainly men, while women are more involved in marketing. In Mozambique, charcoal is mostly produced using traditional methods which are costly, both in terms of volume of wood required for burning, as well as time spent in the production process. These production methods also often have significant impacts on the health of producers.

Charcoal is often produced miles away from where it is consumed, in rural areas where wood is still readily available and where communities are seeking additional sources of income. Most charcoal is produced, processed and transported informally, outside existing legal frameworks (Owen et al., 2013; Schure et al., 2015). This is one of the factors that explains the difficulty of working on the sustainability and regulation of this sector and the often-incomplete knowledge of CVC actors. *Deutsche Gesellschaft für Internationale Zusammenarbeit* (GIZ, 2013)[2] resumes the common issues characterizing the charcoal production chain in many African countries such as: 1) unregulated/illegal resources, 2) rampant and systemic corruption, 3) inefficient conversion technologies, 4) a perception that it is a poor man's business, 5) considered 'dirty' and economically unattractive, 6) free access to wood resources, leading to deforestation and degradation, 7) the charcoal business is dominated by a few powerful individuals.

The scientific community agrees that formal recognition and support to the charcoal sub-sector would be essential to streamline the operating environment, especially for the actors along the value chain. However, there is a risk that policies follow a different direction. Indeed, the reaction from policymakers to the increasing charcoal use could result in policies to prohibit the production and trade of charcoal (the "charcoal ban" in Kenya for example) and increased protection of the African forests. This will be further strengthened if international agreements such as the Forest Pledge do not consider key needs among charcoal customers and producers.

Access to clean sustainable energy for cooking remains a challenge as most of the urban and peri-urban population rely on charcoal. These past few years, many countries attempted, more or less successfully, to regulate its production and trade. To this end, the Government of Mozambique is already well advanced in its work to map, update, and promote renewable energy sources, especially in the south of the country. In order to complete this diagnosis, this study aims to assess the potential for developing an efficient and diversified CVC that promotes

[1] Schure J., Ingram V, Sakho-Jimbira MS., Levang P., Wiersum KF., 2013. Formalisation of charcoal value chains and livelihood outcomes in Central-and West Africa. Energy for Sustainable Development, V17, 95-105.

[2] GIZ HERA, 2013. Cooking Energy compendium. A practical guidebook for implementers of cooking energy innovation. Charcoal production. [Online] Available: https://energypedia.info/index.php/GIZ_HERA_Cooking_Energy_Compendium.

sustainable sourcing, production, transportation, distribution, and use of charcoal in the Zambezi River Basin (ZRB).

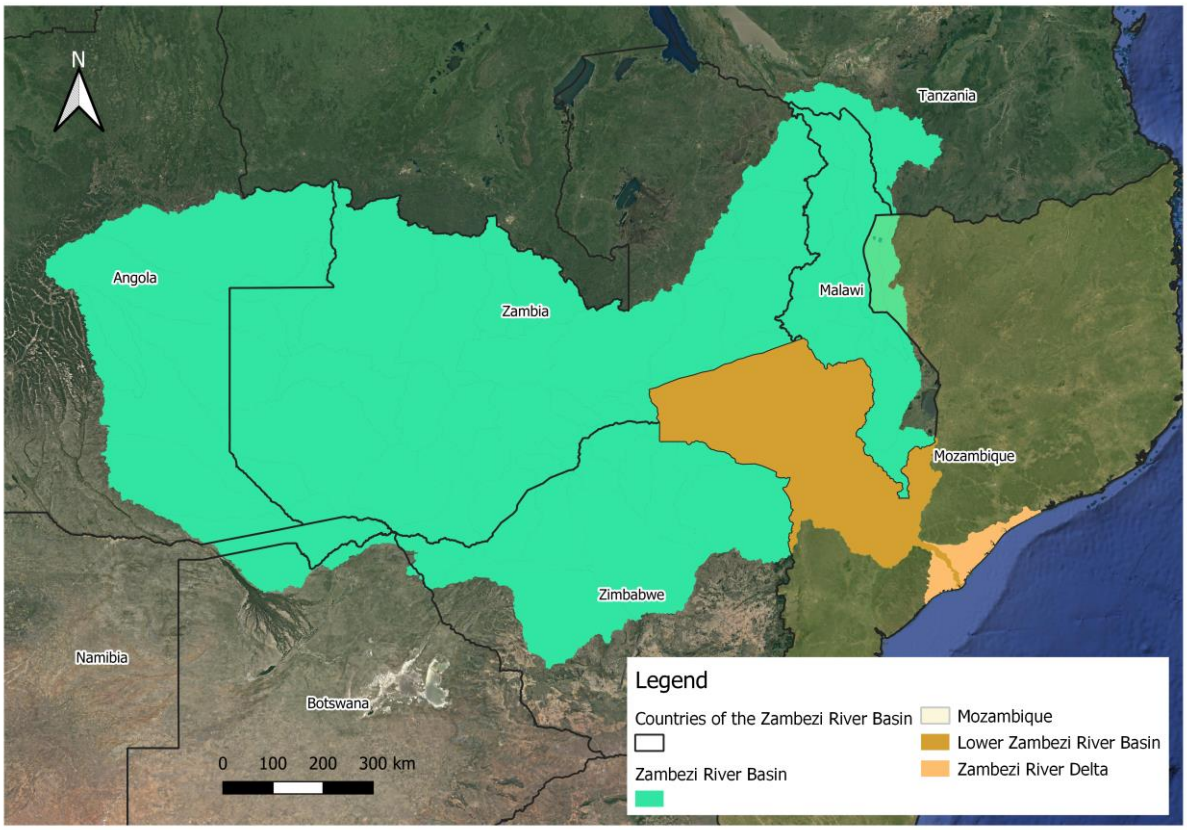

Figure 1: Zambezi River Basin (Authors, 2022)

The Lower ZRB is particularly complex because of its transboundary nature and its strategic importance for the country, both in terms of energy production, agriculture, water supply, etc. In this context, it is of major importance to place the CVC within a complex ecosystem of forest systems, agricultural systems, and wetlands, in and upstream of the study area, particularly the Middle ZRB. ZRB is characterized in details in **Annex 1**.

Enabel has therefore commissioned SalvaTerra to carry out this study between November 2021 and January 2022. The results of this study will complement the data collected by the Ministry of Natural Resources and Energy (MIREME). The aim is also to provide the Enabel teams with keys to understanding the local sector of charcoal production, so that they can formulate a larger programme in the ZRB, to address the complex problems inherent in finding sustainable solutions to the energy question and its interface with food and water challenges.

2. Methodology

2.1. Approach and objectives of the study

The objective of the study is to identify interesting solutions to be implemented for greening the CVC which may serve as a basis for the development of the Enabel programme, based on:

- Lessons learned from the numerous projects carried out in Africa, and an in-depth analysis of the projects already carried out in the South of Mozambique;

- A practical analysis of the CVC in the Lower ZRB, on the basis of interviews with key informants and the main actors involved in traditional and alternative charcoal production, field observation, etc.

The approach adopted is a mixed methodology combining literature review, interviews with key informants and meetings with CVC stakeholders as well as visits to charcoal production sites and main markets.

2.2. In-depth literature study

In-depth literature review was conducted, with study of over 50 international and country-specific reports and documents on CVC structure and options to make it more sustainable.

Documentation and data on charcoal production was also gathered thanks to the key informants interviewed, when it was available in electronic format.

2.3. Sites visited

Fieldwork took place in three provinces in the Lower ZRB region namely Tete, Manica and Zambezia.

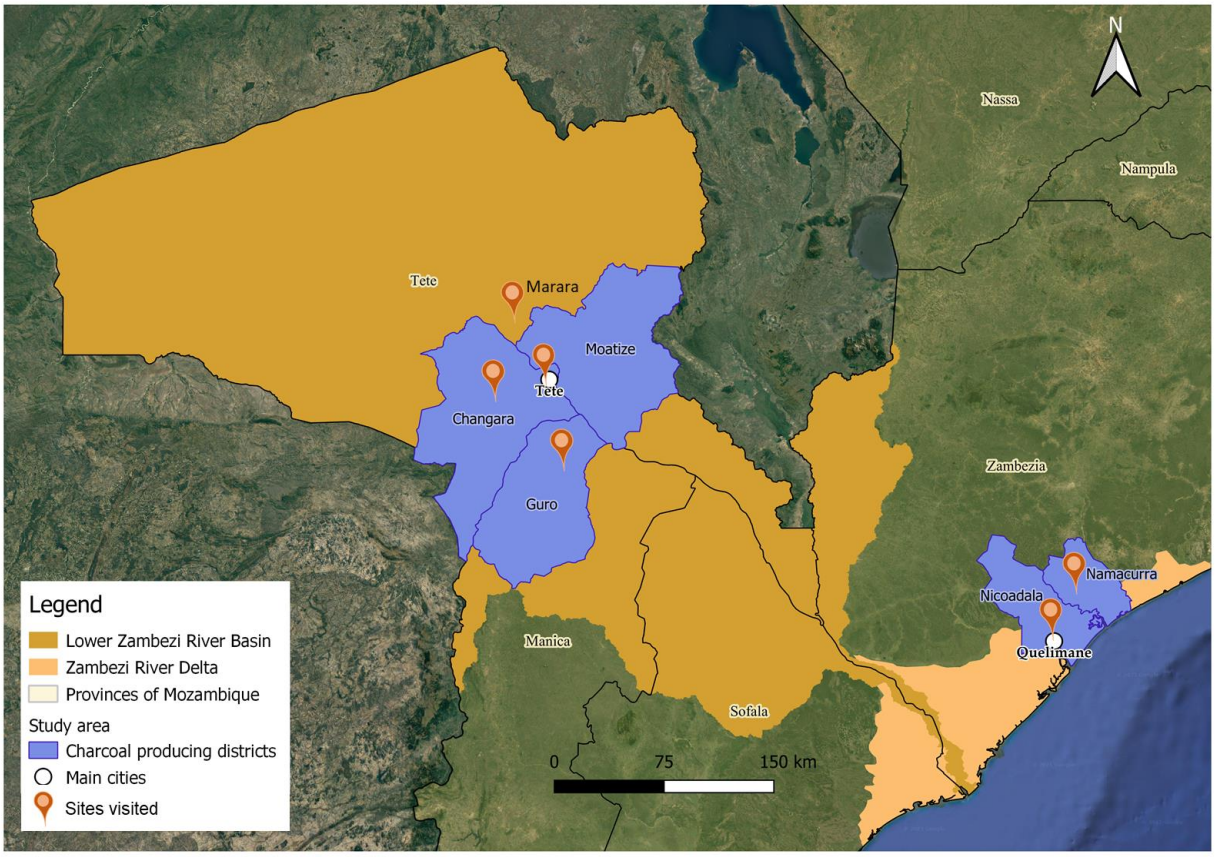

Figure 2: Lower ZRB and sites visited (Authors, 2022)

Data were collected for each province in the district with the highest charcoal production, according to information obtained from the Provincial Services for Territorial Development and Environment (SPDTA). In Tete the district of Changara was visited, in Manica the district of Guro and in Zambezia the districts of Namacurra and Nicoadala.

In the province of Tete, the district of Marara was also visited, where the Provincial Directorate of Energy, currently designated as Provincial Infrastructure Services, which includes the Directorate of Energy, implemented an improved cookstove (ICS) project.

The capital markets with the greatest trade in Tete (Kambinde Market) and Quelimane (Manhaua Market, Fai Market, Aquima Market and Garbage Market) were also visited in order to understand the origin of charcoal.

NB: No survey was carried out on charcoal marketing markets in Chimoio, the capital city of Manica, as they are mostly supplied by charcoal from districts that are not covered by the ZRB region.

2.4. Key informants at national and regional scale

The interviews were addressed to three target groups:

- **Central government institutions** involved in renewable energy projects and policies at national level: MIREME, FUNAE
- **Decentralized government institutions** with the role of regularizing and supervising forestry activity at provincial level: SPDTA, Agencia da Qualidade Ambiental (AQUA) and district governments
  as well as institutions linked to the Energy area: Provincial Directorates of Energy-DPE
- **Academic actors and CSOs** involved in the CVC in Africa and Mozambique: World Agroforestry (ICRAF), CIFOR, CIRAD, Greenlight Africa, and Eduardo Mondlane University.

Interview guidelines are available in **Annex 3**.

One of the main objectives of this phase was to:

1) Complete the list of projects and actors involved in the CVC in order to obtain a clear mapping;
2) Have a broad understanding of regulations and control means put in place by local institutions;
3) Refine the analysis of projects in neighbouring countries.

2.5. Local CVC actors interviewed in the ZRB area

Charcoal producers, producers 'Associations, wholesalers and resellers were also interviewed in the three provinces. Interview guidelines are available in **Annex 3**.

Province	District	Producers	Wholesalers	Resellers
Tete	Changara	6	4	6
Manica	Guro	2	*	*
Zambezia	Namacurra	5	12	10

*Generally, in this district, the producers are also in charge of selling the charcoal produced locally, or it is sold to production or is sold to wholesalers and resellers passing through to the South or the border, and therefore difficult to reach. Moreover, production in this area is still incipient with little commercial impact.

One of the main objectives of this phase was to:

1) Refine the understanding of the practices implemented in the area, particularly in the carbonisation process and to trace the CVC for the main production sites, from sourcing to the main consumption sites;
2) Understand to what extent they are aware of new production technologies and estimate their willingness/availability to access them;
3) Study the level of organisation in the CVC, identify the main actors and the power relations at work within the value chain.

2.6. Limitations

Due to the emergence of a COVID 19 variant, the mission workplan had to be adapted. Indeed, as of 26 November 2021, France has decided to close its borders with Mozambique and other countries in the Southern African region as a security measure. The field work has therefore been carried out by the national expert and mission leader, with remote monitoring by the international expert.

3. The CVC in Mozambique and in neighbouring countries

3.1. Charcoal production in Mozambique

Wood fuels in Mozambique are obtained from natural forest trees, mangroves, the remains of felling for new agricultural areas, dead trees and forest plantations as well as from tree pruning in cities (shade and ornamental trees) and residues from sawmills (Brouwer and Falcão, 2002). Given the demand in terms of physical effort in the production of charcoal, there is a greater participation of men while women lead their participation in the sale of the product (Chavana, 2014).

According to Pereira et. al. (2002), the production of wood fuels for commercialization, namely the manufacture of charcoal, is generally carried out around large cities and along the main roads to supply the urban market. The technology for making charcoal is simple and based on traditional earth kilns, whose yields range from 8-20%. Brouwer and Falcão (2004) stated that the efficiency of charcoal production in Mozambique, Malawi, Tanzania and Zambia varies in a range of 10% to 25%. This variable depends on the kilns used, which, although similar in design, are generally different because of the size of trees, and the composition of the wood used, as well as the time required for carbonization. The variety of charcoal kilns is described in **Annex 2**.

There are two types of charcoal producers. The first corresponds to local resident producers, directly involved in the production of charcoal, as a family, hiring acquaintances or as part of community sharing work, with small productions, often without licenses and with sales in the same location or near the roads of the production areas. The second type includes non-resident producers in the production area who hire workers for the activity. These producers, with a larger production, usually have the exploration and transport license, in addition to owning the truck and, sometimes, warehouses and stores in the city (Martins et al., 2016).

The country annually exploits about 17 million m^3 of wood for energy generation, mainly for domestic consumption (Pereira et. al., 2002). Many of the species used for the production of charcoal belong to the fourth class based on the Forestry and Wildlife Law Regulation (1999). Producers typically use the entire tree for charcoal production, and the species used depends on availability in the region, the quality of the charcoal produced, and customer preference. Traditionally, the main species used are chanato (*Colophospermum mopane*), Xivondzuane (*Combretum sp*) and micaias (*Acacia sp*.) due to their greater availability.

However, currently, more species are used due to the unavailability of the preferred species (Puna, 2008). For example, species such as: *Lonchocarpus capassa, Ornithogalum sp. Androstachys johnsonii, Terminalia sericea, Combretum imberbe, Ziziphus mucronata, Guibourtia conjugata* and *Combretum molle* are also being used for charcoal production, and first and third-class species. Sometimes, even precious woods are being used illegally for charcoal production. After production and bagging, only few people are able to identify the species that were used for charcoal production.

The charcoal production areas are generally located in natural forests whose access roads are mostly precarious and sometimes impassable during the rainy season, which consequently causes a rise in prices in city markets. In these areas are found firewood and charcoal producers who generally do not have exploration licenses. In addition to production, they are also dedicated to the sale of the same products to wholesalers or transporters near production areas or by roads or trails.

Very few studies have been carried out in Zambezia and Manica Provinces. However, Tete's case is better documented (see box below).

Data from Sedano et al. 2016 – Tete case study

In Tete, charcoal producers normally apply a selective logging system based on tree size (trees above 15 cm diameter) and tree species. They have preference for mopane, which is highly suitable for charcoal making operations with its straight trunk and its dense timber (1.02–1.14 $g.cm^3$) that produces charcoal with high caloric power. Trees used in the kiln are felled around the kiln location from an average cutting area of 0.31 ha., depending on the density of suitable trees.

Once the wood stock is exhausted, the kiln is moved to another forest area. The kiln, which was first established close to the towns, tends to move away over the years, along the transport routes and sometimes even deep into the forest. This trend is becoming even more pronounced with the increasing scarcity of the resource and the growing demand for firewood.

No correlation between agriculture expansion and charcoal production in the Tete Province. Sedano et al. showed that comparison between kiln locations and the global forest change 2000–2014 product (Hansen et al 2013) stated that only 0.22% and 0.90% of the kilns built in Changara and Moatize respectively overlaid land deforested in the last 15 years. The rest of the kilns being built on non-converted forest areas. Sedano et al. show a strong correlation between kiln volumes and number of sacks produced.

<u>Average kilns characteristics (2014):</u>

Dimensions - Length – 8,1m / width – 2,2m / height 1,2m

Production – 104 sacks of 15kg

Density of kiln/ha – 2-2,4

Charcoal production area	Number of kilns identified between 2011 and 2014
Moatize	3911
Changara	4650

3.1. Charcoal transporting

As charcoal is produced in rural areas but mainly used in cities, transport is an essential part of the value chain. Although transport distances vary by location, they generally tend to increase as neighbouring forests are cleared (Schure et al, 2014).

Charcoal transport can be done in three ways: from production areas to areas with better access by tractors, animal-drawn carts, or directly by people; then from areas with better access to city markets in trucks, bicycles or trucks, generally old (often with more than 15 years of use). It can also be carried out by train, which according to MIREME (2012), allows greater control compared to transport by truck. Transport costs depend on the distances travelled and are therefore variable. Carriers can be either wholesalers or retailers. Some are holders of operating licenses and others are only dedicated to car rental.

One of the issues associated with transport is the loss of charcoal in the form of charcoal dust during packaging and transport. Siedel (2008) estimated that this loss accounts to 20% of the total charcoal produced.

United Nations Development Programme (UNDP, 2013) estimated loss to 5–15 percent at production sites and 5–20 percent at retail areas (in Uganda).

3.2. Charcoal retailing and distribution

The distribution of woody biomass in the country does not follow the same pattern of demand, resulting in areas with a deficit of woody biomass and others with abundant woody biomass. In areas with high population concentration, such as urban centres and in the valleys of the main rivers, there is, in general, a deficit in the supply of woody biomass. This phenomenon has increased pressure on districts around large cities and along roads to supply firewood and charcoal (Sitoe et. al., 2008).

Wholesale charcoal is sold in markets or shipyards. Wholesalers, in addition to selling charcoal to retailers, also supply it to other sectors, namely kiosks, restaurants etc. Retailers sell charcoal in cans or piles in markets or along city walks.

The price structure in the commercialization of charcoal according to Manso (1993) is made up of different components that contribute to the determination of the final price to the direct consumer, namely:

• *Acquisition cost to the cutter/producer*: represents the cost for the labour involved in both cutting and burning to produce charcoal;

• *Transport cost*: is the cost that covers the freight of the vehicle for transporting charcoal;

• *Transit and marketing fees*: fees charged by local administrations to transporters and by municipalities to market sellers;

• *Storage Costs*: costs involved in storing the product before placing it on the market; and

• *Costs of Forest Exploitation License*: paid to the State to obtain the right to exploit the resource.

Contribution of the charcoal value chain to the economy

The commercialization of charcoal in Mozambique is a multi-million-dollar business, which covers the value chain from production, transport and commercialization. Forests annually contribute about 2% of Gross domestic product (GDP), 2% of direct jobs and US$200 million in foreign exchange in exports. Forest exploration is concentrated in 2 major products: wood fuels (92%) for the internal market only, and wood (8%) for internal consumption and export (DINAF, 2021).

In relation to charcoal sold in the country's cities, consumption is estimated at 1 million tons of charcoal per year, corresponding to 15 million bags, with a growth projection in 2025 to 20 million bags of charcoal, which it is mostly purchased by the domestic sector (DINAF, 2021). It is also estimated that the annual turnover of charcoal is around 250 - 300 million dollars, equivalent to more than 2.2% of GDP. In the supply of charcoal in the cities of Maputo, Matola, Beira and Nampula, this industry generates around USD 125 million every year (MIREME, 2012).

However, part of this activity is informal, which makes it difficult to account for the amounts involved, causing the Government to lose large amounts of currency. According to MIREME (2012), with a VAT of 17%, the potential level of revenue that is lost by not regulating the industry is at least US$50 million per year. Additionally, to this data must be added the loss of license revenue due to the lack of law enforcement, estimated at around 4.8 million dollars per year. According to the Direcçao National da Floresta (DINAF, 2021), the sector only manages to control about 4% of the charcoal that is destined for the urban supply of the country and that only about 10% of the biomass sold is licensed.

The regularization of this industry would generate more revenue for the State that could be used to promote the sustainable use of forests for the production of charcoal. In this sense, there is a need for a significant increase in control by the law authorities, namely the Ministry of Land and Environment (MTA), in particular DINAF and AQUA, in relation to production data as well as marketing data. Currently, the forestry sector only licenses about 250 thousand bags per year, which corresponds to 1.6% of what should be licensed, which means that almost all charcoal sold in the cities is illegal. Formalizing and regulating the charcoal value chain is one of the sector's challenges (DINAF, 2021).

As it is a very informal activity and with little official information available, it is difficult to design policies and strategies that allow the sustainable use of biomass energy in the country.

According to MIREME (2012), the charcoal value chain provides full-time jobs to 214,000 people who support a total of around 1.2 million dependents, equivalent to more than 5% of the population in Mozambique, the which makes the charcoal trade a clearly significant area of employment in the informal sector.

3.3. Profile on the household energy

Mozambique has a great potential in terms of energy, however only a small part of its potential is exploited. It is considered that the country has an abundant water potential, large deposits of mineral coal (in the province of Tete), as well as large deposits of natural gas in Pande, Temane (Inhambane), Búzi (Sofala), Palma (Cabo-delgado), among others (Matsinhe & Soto, 2011). According to Atanassov et. al. (2012), the profile of domestic energy follows a sort of ladder of energy sources in urban areas: from firewood at the bottom, passing through kerosene, charcoal and gas, to electricity at the top. Climbing the energy access ladder is related to rising household incomes. According to the ONG ByC (2014), in low-income households, different energy sources are used for lighting and food preparation, while charcoal consumption prevails as a fuel for cooking, followed by firewood.

Firewood consumption is more widespread in rural households, while charcoal is the most used fuel in urban areas, due to its high energy density and the economy it represents in terms of transport. In rural areas, the only two widely used energy sources are firewood (for cooking) and kerosene (for lighting). Electricity consumption is very low even in urban areas and nil in rural areas.

In this context, the patterns of use of both traditional (woody) and commercial fuels are quite complex and characterize the domestic sector (mainly in big cities). The reasons why there is use of various fuels vary from family to family and city to city, but reflect the balance made by consumers in fuel preferences and their costs. For example, the use of charcoal when compared to the use of gas or electricity is more costly for the user, but the low incomes of the

majority of the population and the initial costs associated with the use of other sources, make charcoal a great alternative for the population. Additionally, users can buy small amounts, which allow them to make better use of their low incomes (DNERN, 2006 in Puná, 2008).

It should be noted that, in the medium and long term, the trend is to change fuel use patterns towards commercial fuels and away from biomass fuels. In the short term, there will be upward and downward movements in the transition of fuels in response to changes in the relative price and availability of different fuels.

The FAO study (2017)[3] of the traditional charcoal value chain clearly shows that, of the four stages in the value chain, the majority of GHG emissions occur at the carbonisation stage.

[3] FAO. 2017. The charcoal transition: greening the charcoal value chain to mitigate climate change and improve local livelihoods, by J. van Dam. Rome, Food and Agriculture Organization of the United Nations. 185p.

4. The experience of greening the CVC in Mozambique and neighbouring countries

4.1. Initiatives in Africa

In its review of CVC greening projects in Africa, FAO (2017) recommends the promotion of the following seven technical interventions to achieve a greener CVC:

1. Sustainable Forest management practices;
2. Alternative sources of biomass (e.g. waste, residues and trees outside forests);
3. Agglomeration processes to increase the use of charcoal dust in briquettes;
4. The improved management of traditional kilns and the introduction of improved kilns;
5. Cogeneration, in the case of industrial-scale production;
6. Reducing fossil-fuel consumption in transportation; and
7. The use of improved cookstoves.

These recommendations also match the operations that have been identified as promising by the World Bank (2018)[4]. The bulk of the proposed interventions therefore concerns the first two stages of CVC, namely fuelwood sourcing and carbonisation.

Forest management practices: Traditional plantation development projects, launched in many countries since the 60s for forestry product including fuelwood supply, have often proved only partially successful, or have failed like in Mozambique (community conflict with large-scale commercial plantation forestry operators, etc.), leading for a long time to a negative view of these kind of projects.

New management options that combine agroforestry, plantations and improving energy efficiency among both producers and consumers can provide opportunities for sustainable future energy supplies. The establishment of plantations, the restoration of natural and degraded forests, introduction of trees in agricultural lands and sustainable fuelwood collect and peri-urban zones etc. can all contribute to sustainable sourcing. Many of these practices have been tested throughout Africa (ex. The Makala project in Democratic Republic of the Congo, Reboisement Villageois Individuel (RVI) initiatives in Madagascar, etc.).

The success of these initiatives depends largely on the legal and institutional context. The security of land tenure, the existence and application of forestry policies, and the means of control put in place greatly influence the sustainability of reforestation and afforestation actions. This was one of the lessons learned from plantation projects in Mozambique. De Almeida and Delgado (2019)[5] highlight the importance of building a long-term relationship between local communities, forestry operators, and government. They also state that, if not properly structured and conducted, conflicts between the three entities may be difficult to overcome.

[4] World Bank, 2018. Mozambique Country Forest Note. Report No: AUS0000336. 33p.

[5] De Almeida LS., Delgado C. The Plantation Forestry Sector In Mozambique: Community Involvement and Jobs. WB group. 47p.

Alternative sources of biomass and briquetting: Between 10 – 15 per cent of charcoal ends up as waste in the form of charcoal dust. This occurs during transportation and at wholesale and retail stalls. In Mozambique, civil society and small business already took actions to valorise this resource, which until now has been considered a waste product. This is the case of Verde Africa Lda[6] in Maputo, which makes briquettes out of charcoal wastes that is bought from wholesalers etc. Many examples have been found of briquettes production by local communities themselves, with a mixture of charcoal dust and soil in Kenya, for example (Njenga et al., 2014)[7].

UNEP (2014)[8] estimated that a company in Abidjan, Côte d'Ivoire, producing briquettes from wood and agricultural waste collected locally could produce sufficient briquettes to avoid harvesting 4 800 hectares of forest per year, reducing CO_2 emissions by more than 100 000 tonnes per year at full capacity.

Other biomass material can be used to make briquettes. In Cameroon, CIFOR supports a start-up company that transforms household waste (plantain peels and maize leaves) into ecological briquettes, contributing to urban waste management in the city of Douala.

Briquetting, in addition to offering a low-cost alternative to charcoal, is also an opportunity for job creation in both urban and rural areas.

However, attention must be paid to the quality of the final material produced, which varies greatly depending on the raw material and the manufacturing process used (Njenga, 2013)[9].

Efficient kilns: Over the years, many improved kilns have been developed and promoted by international institutions (PNUD, GIZ, SNV, etc.) in order to improve the conversion rate of wood into charcoal, to limit the release of Greenhouse Gases (GHG) and toxic fumes for producers. These kilns can be classified into five categories, each presenting advantages and disadvantages: 1) earth kilns, 2) metal kilns, 3) brick kilns, 4) cement or masonry kilns and 5) retort kilns. Some of these improved kilns are described in Annex 2.

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[6] https://verdeafrica.com/en/about-verde-africa/

[7] Njenga M., Karanja N., Karlsson H., Jamnadass R., Iiyama M., Kithinji J., Sundberg C. 2014. Additional cooking fuel supply and reduced global warming potential from recycling charcoal dust into charcoal briquette in Kenya. Energy, Volume 64, 2014, pp. 557-566.

[8] UNEP, 2014. Information Note by the secretariat on illegal trade in wildlife: the environmental, social and economic consequences for sustainable development. UNEP/EA.1/INF/19. First Session of the United Nations Environment Assembly.

[9] Njenga M., Karanja N., Jamnadass R., Kithinji J. 2013. Quality of Cooking Fuel Briquettes Produced Locally from Charcoal Dust and Sawdust in Kenya. Journal of Biobased Materials and Bioenergy 7(3):315-322.

Kiln type	Description	Efficiency (% mass yield)
Earth-pit	Wood in pit, covered with grass in soil.	12-30
Earth-mound	Wood piled on surface, covered with leaves and soil.	9-30
Casamance Earth-mound	The surface earth kiln, equipped with chimney for improved pyrolysis and quicker carbonisation.	17-30
Metal	Mobile metal kilns with chimney.	12-30
Brick and orange	Stationary brick kiln.	13-32
Retort	Kiln with retort technology that returns wood gases to the carbonisation chamber for more complete pyrolysis and reduced emissions. Option to integrate a modified chimney to recover oils and tars.	22-35
CML plant Ex (industrial)	A cyclical process of twelve carbonisation entities and an external combustion chamber. Each kiln is start one after the others to permit the collection and incineration of the carbonisation gases. Options to use heat for drying or to produce heat and power.	30-32 (plus heat or power)
VMR oven (industrial)	A cyclical process of two carbonisation entities and an external combustion chamber. While carbonisation takes place in one canister, the wood in the other canister is being dried.	30-32
The Degussa (Reichert)	Batch-fed retort where pyrolysis gasses are fed back to the retort and excess gasses are burnt to operate the heat exchanger and pre-dry the feedstock.	34
Carbonex	A cyclical process of eight carbonisation entities and an external combustion chamber. Each kiln is started one after the others to permit the collection of carbonisation gases. The combustion provides heat for drying or producing power with high efficiencies.	30-32 (plus heat and power)
Continuous operation retort	Continuous carbonisation process retort such as the Lambiotte and SIFIC process, where biomass is conveyed through continuous stages of heating and drying, carbonisation and cooling, in which pyrolysis gases produced sustain the process and emissions are largely mitigated.	30-35

Adapted from FAO, 2017a, complemented by authors.

Figure 3: Comparison of the main characteristics of charcoal kilns (Schure et al. 2019)[10]

Improved kiln's adoption rate is still low in sub-Saharan Africa. Although the improved kilns have proven to be more efficient than traditional kilns, some barriers to broad adoption remain.

In Cameroon, uptake and interest for improved kilns proposed by GIZ (2016)[11] remained low due to needed technical skills and professionalization of the charcoal operators. Making these new kilns work and maintaining them to maximise their lifespan is sometimes difficult for charcoal producers, who are often poorly educated.

Another issue commonly raised is the lack of appropriate materials and need for upfront investments, that are often out of reach for informal charcoal producers, who mainly rely on labour-force to produce charcoal with traditional kilns. In Rwanda, materials such as chimney were hardly available in the charcoal production area.

Schure et al. (2019) highlight the importance of adapting the kilns to local needs and context. Many initiatives trying to introduce new stationary charcoal kilns did not succeed, precisely because of the lack of mobility of the structures. This resulted in additional transport costs for the raw material once the resources within reach were used. In Kenya, transportation limits

[10] Schure J., Pinta F., Cerutti PO., Kasereka-Mutsavi L. Efficiency of charcoal production in Sub-Saharan Africa: Solutions beyond the kiln. ois et Forêts des Tropiques Volume 340 – 2e trimestre – Avril 2019 – p. 57-70. 14p.

[11] GIZ, Eco Consult, 2016. Programme d'appui à la mise en œuvre de la stratégie de développement du secteur rural volets forêts environnement. État des lieux de la chaîne de valeur du charbon de rebuts de bois de scierie à l'est Cameroun. 95 p.

and sizes of wood/ branches harvested were not considered enough when introducing new kiln technologies, which also led to deceiving adoption rates.

As for Improved Cookstoves (ICS), kilns must be adapted to local context and uses, as much as possible. This includes to weather conditions. In Senegal, the need for proven efficiency or quality enhancement before introducing the technique and its adaptation to weather conditions were also two important lessons learned.

Improved stoves: Despite years of promotion in some African countries (in particular in East Africa, a pioneer in dissemination initiatives), the dissemination of improved cookstoves remains a challenge. According to GIZ (2015)[12], a large number of technical, socio-cultural and economic parameters have to be considered.

The Stockholm Environment Institute (SEI, 2016)[13] identifies several key success factors for ICSs initiatives: i) stove quality and features (efficiency, reduced emissions, design that meets the diverse needs of users, accessibility, ease of use), ii) finance for both end-users and stove enterprises; iii) an enabling policy and regulatory environment including the establishment of standards for cookstoves; iv) and a strictly commercial approach (and not only distribution of ICSs).

The World Health Organization (WHO, 2018)[14] completes these analyses by recommending a differentiation of financial mechanisms according to the distribution of the working population in urban and rural areas: “market-based interventions might be targeted to urban areas and subsidized or non-governmental organization interventions to rural areas. Cross subsidies could offset the costs of transport and distribution in poor rural communities in remote areas”.

Regarding the stove technologies themselves, the CARE II Kenya project (GVEP, 2015) confirms the importance of the design and delivery systems to the end-user, recommending that ICS should not be selected on engineering principles and laboratory experiments only, but should endeavour to improve the local technologies that are already known and accepted among local communities. Moreover, it is noted that the involvement of target groups that will be producing, promoting and using the stoves is a key input for success. Stevens et al. (2019) note that in several cases, stoves given free of charge were left unused because the designs did not fit with local cooking practices.

Based on an integrated approach to household energy issues, key learning from EnDev Project (GIZ, 2013)[15] were:

i) to mobilise the public sector in order to create a favourable business environment by developing supportive policies, enforcing standards development, and make adoption funds available over a limited period of time to raise awareness;

ii) to establish long term partnerships with already implanted companies/stakeholders from the private sector in order to ensure supply (helping them access legal status, capacity building both administrative and technical to keep enterprises in business and ensure growth, facilitating access to financial support on the long term);

[12] GIZ, 2015. Towards sustainable modern wood energy development. Stocktaking paper on successful initiatives in developing countries in the field of wood energy development. 92p.

[13] SEI, 2016. Policy brief Bringing clean, safe, affordable cooking energy to Kenyan households an agenda for action. 6p.

[14] WHO, 2018. Opportunities for transition to clean household energy in Kenya. 60p

[15] GIZ, 2013. Catalysing Rural Energy Access. 13p.

iii) to work on the demand side by ensuring the sustainability, quality and functionality of ICSs, raising public awareness and establishing long term partnership with other stakeholders to build a functioning market system since consumer subsidies have not been effective.

In addition to the points developed above, the experience gained from all the projects carried out by the CP-EU Energy Facility (DEM, 2019)[16] highlights the success of initiatives that have focused on one technology only, biomass cookstoves. It has proven to be successful in reaching a large target group with high rates of adoption. Moreover, sustained feedback between cookstoves developers and the end-users is also mentioned as a factor of successful uptake of new technologies.

- ➔ Interventions from governments, development agencies and civil society organisations should not only address individual elements of the value chain (production and harvesting of fuelwood, production of lump charcoal and direct fuel substitutes, modernisation and professionalisation of the charcoal trade, and charcoal end-use). Modernisation of the charcoal sector is needed across the entire value-chain. Isolated interventions (reforestation, sustainable forest management, dissemination of improved stoves, etc.) fail to exploit adequately possible synergies that would, if combined, make them sustainable. Many of the least successful interventions have been those that addressed a single issue or constraint, without considering wider structural challenges.

World Bank also recommends strengthening Mozambique forest sector governance by increasing transparency on data about logging, wood transport, processing and export, control of logging and charcoaling operations, that are not currently well documented.

Legal framework: The success of large-scale interventions on the CVC depends largely on the legal and policy context. Thus, the FAO's review (2017) recommends five actions that address governance issues that should be complementary to technical and organisational innovations:

"*1. Simultaneously initiating multiple interventions for reducing greenhouse gas emissions, targeting the entire charcoal value chain.*

2. Increasing the financial viability of a green charcoal value chain by reforming tenure, increasing legal access to land and resources, providing evidence-based evaluations of the benefits of the charcoal sector for national economies, putting a fair price on wood resources, incentivizing sustainable practices, and attracting investment for a transition to a green charcoal chain.

3. Developing comprehensive national policy frameworks for the sustainable management of the charcoal value chain and integrating charcoal into wider efforts across sectors to mitigate climate change, including by making the charcoal value chain a specific component of nationally determined contributions.

4. Supporting national governments and other stakeholders in their efforts to green their charcoal value chains through research and the provision of reliable data.

5. Disseminating the lessons learned from pilot projects, success stories and research that take into account the entire charcoal value chain".

No international initiatives focused on the ZRB area could be found in the literature.

[16] DEM, 2019. Best practices for promoting Improved cook stoves in the ACP Region. 20p

4.2. Projects in Mozambique

CVC activities are unevenly distributed across Mozambique.

Most of the research and projects to introduce new charcoal kiln or improved cookstove technologies have taken place in the south of the country, particularly the province of Maputo, as the first area of consumption of biomass fuels and an important area of production. It is also the region that has seen fuel prices rise in recent years, due to population growth and the scarcity of available wood resources. Alternative fuels were therefore more competitive in this area.

Between 2000 and 2015, there were several promising initiatives undertaken by civil society and academic actors with government support. However, in the last 8-10 years, it seems that international funding has shifted away from biomass towards solar and other energy alternatives. This also coincides with a period when projects to disseminate ICSs through carbon funds have been heavily criticised. As a result, many pilot projects have not been scaled up.

It is only recently that international community renewed its interest in biomass and forest conservation (recently marked by Conference of Parties, COP 26's Global Forest Finance Pledge), which may lead to new financing opportunities.

A summary table of past and current projects in Mozambique and ZRB can be found in **Annex 6**.

4.2.1. Renewable energies support programs

Several cross-cutting support programmes for renewable energy development are being implemented in Mozambique. Most of them are financed by the international community, especially from European countries. Although the bulk of the support is for electrification systems (grid development and improvement, as well as off-grid technologies), parts of these programmes are oriented towards biomass. The most important on-going programmes are cited below.

The **BRILHO** – Energy Africa Mozambique programme[17] was launched with support of the British Government through UKAid and implemented by SNV. BRILHO's objective is to improve and increase energy access for people and businesses, leverage the private sector's innovation and investment capacity, resulting in market growth of clean cooking solutions, solar home systems, and mini-grids. It is a five-years programme, implemented from 2019 to 2024, designed to provide technical assistance, grants and capacity building to the government (SNV, 2019)[18].

In 2021, the Swedish International Development Cooperation Agency (SIDA) has joined donors, enabling an up-scale of the programme that now targets 975,000 people with access to improved cooking solutions.

The **EnDev programme**, funded by the German cooperation (GIZ), the Norwegian Agency for Development Cooperation (Norad), the Swiss Agency for Development and Cooperation (SDC) has renewed its commitment in Mozambique. In addition to the activities for the development of off-grid energy access, EnDev promotes the introduction, promotion of higher tier industrially produced stoves and good quality, standardised, locally produced stoves.

[17] https://brilhomoz.com/

[18] SNV, 2019. Accelerating sustainable energy markets. SNV in Energy. [Online] Available: https://brilhomoz.com/assets/documents/energy-sector-brochure-web_1.pdf

EnDev supports awareness raising activities to ensure that consumers are aware of and are able to identify and purchase quality products.

In the past two years, EnDev supported the cooking technology businesses, increasing their number from 4 to almost 20. It is also in line with the GET invest programme, also funded by GIZ. EnDev Mozambique also collaborates with the World Food Programme (WFP), promoting institutional cookstoves for schools (EnDev, 2021)[19].

REACT SSA (Renewable Energy and Adaption to Climate Change Technologies in Sub-Saharan Africa)[20] is a SIDA and Africa Enterprise Challenge Fund (AECF) funded programme with the aim to catalyse the access to low-cost, high-quality energy in poor households especially in rural areas in nine Sub – Saharan countries, including Mozambique. Launched in 2017, it mostly provides grants and support to renewable energy businesses, such as ICS and alternative fuels businesses.

The **ILUMINA project**, funded by AVSI Foundation and co-funded by the Italian Agency for Cooperation and Development (AICS), also supported ICS dissemination from 2019 to 2021, particularly targeting women (*Associaçao Lusofona de Energias Renovaveis*, 2021)[21].

What all these programmes have in common is that they adopt a "demand driven" dissemination approach, supporting the development of social enterprises to meet the demand of urban populations for more efficient and healthier cooking technologies and alternatives to traditional fuels whose prices are fluctuating with a global upward trend.

4.2.2.Forest management

In recent years, most of the effort from the government and international community has been centred in improving forest governance. Plans of actions have been designed, such as the National Forest Programme 2019-2035 that includes specific actions related to the CVC organisation and regulation, as well as the government objective to reduce charcoal use by 1% per year from 2025 (MTA, 2019) [22].

So far, very few projects have actually been carried out in the field of forest management with a specific focus on charcoal.

A majority of projects at national scale focus on reducing illegal logging. It is the case, for example of the FAO-EU Forest Law Enforcement, Governance and Trade (FLEGT) Programme. Through strengthening the private sector in sustainable forest use and supporting the role of local communities in the management and monitoring of forest resources, these projects can contribute to make the CVC more sustainable, although direct impact is not monitored.

Two community forest (CF) initiatives established in 1999–2000 were studied and reported as successful in Sofala and Manica Province (in the South of the province) (Sitoe & Guedes,

[19] EnDev, 2021. Energising Development Programming Report 2021 Update. 565p. [Online] Available: https://endev.info/wp-content/uploads/2021/07/EnDev_Programming_Report_2021_Update.pdf

[20] http://www.aecfafrica.org/portfolio/renewable_energy/react_ssa

[21] ALER, 2021. Renovaveis em Moçambique, 2021. Briefing. [Online] Available: https://www.lerenovaveis.org/contents/lerpublication/aler_mar2021_resumo-renovaveis-em-mocambique-2021.pdf

[22] MTA, 2019. Agenda Estrategica 2019-2035 e Programa Nacional de Florestas Moçambique. 162p.

2015)[23]. The case of CF in Sofala was especially designed to provide resources for charcoal production.

Forest management committees were organized, with the responsibility to pursue and manage the logging license, to liaise with private operators—who actually do the logging, buy bulky charcoal and bamboo poles— to protect the forest from fires, and check forest products transported through the community. Operators pay taxes for forest products and a quota is applied. 20% of revenues are returned to local communities and used for social investments. Charcoal producers from these forests could organize themselves to transport and sell the production at a better price and in larger quantities.

These forestry management systems, established initially with support of the FAO continued to be implemented after the end of international support. The NGO ADEL Sofala was implicated in punctually supporting the communities to ensure the sustainability of activities.

Devolution of forest resources and responsibilities to local communities with support from Forestry services is often considered a key factor of success, which proved to be efficient in those cases. It was made possible by **clear land delimitation and the forest management plan,** prepared by the project in partnership with provincial forestry agents. The **enforced knowledge** about forests and land certificate allowed communities to prevent outsiders from exploiting the community forests. The system is based on **close cooperation between the committee, the local authorities and the forestry services**.

The success of these projects must be balanced, however, because although these systems help to curb forest degradation, the overall forest area tends to decrease over time.

Still little is done to promote forest growth, replanting, management, and conservation to date.

However, from 2019 to 2021, the Mozambique Forest Investment Programme (MOZFIP), financed by the World Bank with technical and strategic support from FAO, was implemented in two selected landscapes in the provinces of Cabo Delgado and Zambezia. This programme was structured around five components that include:

Component 1 - Forest policy development and implementation strategy, legal and regulatory framework;

Component 2 - Sustainable Forest management - review of the institutional framework for forest concessions;

Component 3 - Development and implementation of the Forest Information System;

Component 4 - Institutional Capacity Development;

Component 5 - Project management and dissemination of results.

In the ZRB, the national initiative "A Leader, a Forest" has been implemented from 2009 to 2014 in a number of communities across the provinces. No concrete results have been obtained, due to the lack of monitoring and technical assistance to communities especially in the provision of seedlings or establishment of a community nursery (Interview O.N. Zalimba, Director of SPDTA Tete).

In line with this initiative, the government is setting up the "Florestas em Pé" programme, from 2016 to 2026 and coordinated by the Fundo Nacional de Desenvolvimento Sustentavel (FNDS). One of the expected outputs is the funding for the certification of 50 forestry concessions.

One important project is directly involving charcoal producers in Zambezia Province, that is part of the “Florestas em Pé” programme is Mozambique Forest Investment Program

[23] Sitoe A.A., & Guedes B.S., 2015. Community Forestry Incentives and Challenges in Mozambique. Forests 2015, 6, 4558-4572. 16p.

(MozFIP). A key component of the project is the promotion of small-scale forest plantations for commercial purposes through performance-based grants to smallholders. The Project aims to stimulate entrepreneurial programs through the planted forest grant scheme, agroforestry systems that are linked to the market, community-based forest management, and smallholder charcoal production. No concrete results have been published yet by the World Bank.

EDEN Reforestation projects, an international NGO based in Maputo, has been working on a project proposal to reforest the districts of Angónia and Tsangano, in Tete Province. From the information that could be gathered, no funding source have been secured to begin the activities yet in Tete Province. On the other hand, mangrove rehabilitation is being conducted in Quelimane district, but there is no direct impact measured on the local CVC.

4.2.3.Improved kilns projects

In term of new carbonisation technique introduction, very few projects proved to be successful, with high adoption rates by the local producers.

In the 70s, the Eduardo Mondlane University (UEM) has studied and installed metal kilns for the industrial production of charcoal and, more recently, it has also installed brick kilns inspired from Brazilian technology for research purposes (Interview Prof. Sá Nogueira Lisboa, UEM, 2021).

Training to use preferably Casamance kilns has been provided to charcoal producers by the Ministry of Agriculture in partnership with local NGOs (KULIMA and ADEL) in southern and central part of the country.

A common feature of all these projects was that they selected a comparatively better technology than the traditional kiln and presented it to the charcoal producers for adoption. No particular attention was paid to the suitability of these techniques to the producers' means, either in terms of investment or practices.

For family production of charcoal, these kilns were often unsuitable: they were fixed models and therefore generated additional costs for the assembly and transport of wood as well as for logistical organisation (brick kiln), requiring good technical knowledge and more supervision on the part of the producers (Casamance type kiln), as well as a significant investment at the start and for the maintenance of the equipment (metal kilns).

If these projects are not replicable as they stand, one solution would be to use actors with a greater investment capacity than simple family producers. For example, by targeting large-scale producers, it would be possible to develop platforms for the demonstration and testing of the above-mentioned technologies, and thus promote a "learning by testing" approach.

Among the pilot projects in the south of the country, the one carried out in Gaza province by Greenlight Africa, in partnership with UEM, has been the one with the most interesting results. This is partly due to the change in approach, i.e. the adoption of a participatory method for technology selection.

This project is part of the Nationally Appropriate Mitigation Actions for Mozambique Project in Mozambique, funded by the Belgian government and implemented from 2014. It aimed to explore the possibility of implementing sustainable charcoal projects that could be covered by climate finance mechanisms.

The kiln model selected the Improved Basic Earth Mound Kiln (IBEK), inspired from a kiln promoted by the Tanzanian NGO Tanzania Traditional Energy Development Organization (TaTEDO).

The main difference between a traditional kiln and the IBEK is the addition of a chimney and the internal structure of the kiln (see figure 4 below).

Figure 4: Construction stages of the IBEK kiln (Martins, 2016)[24]

In term of efficiency, the IBEK shows similar thermal efficiency to traditional kilns, but is quicker, allowing a reduction of the carbonisation process from three to two days.

The results of this pilot project are encouraging in the sense that they show that participatory methods enable producers to assimilate the technical improvement process and allow a good adoption rate.

It also emphasizes that rather than the technology itself, capacities of the charcoal producers and the operating conditions really make a difference with regard to efficiency. Working on implementing good practices and knowledge exchange with producers would be a good start to federate CVC actors, improve production efficiency, allow for technology to be further developed by charcoal producers themselves and even introduce alternatives to charcoal production (Martins, 2016).

The prospects for scaling up this project are to be explored for the ZRB area, where the main challenge is to federate the actors in order to change practices. The approach that has been developed could be replicated and extended to other type of technologies.

In the ZRB, International Organization for Migration (IOM) is working together with Greenlight Mozambique in order to minimize impact of migrant resettlements on natural resources, including forest due to high demand of domestic fuels for cooking. This work is in progress and results have not been yet released. It could include components on charcoal production and promotion of clean cooking technologies (Interview B. Atanassov, Greenlight Mozambique, 2022).

[24] Martins, R., 2016. Produção Sustentável de Carvão vegetal. Teoria e pratica na definição, implementação e avaliação de fornos de terra melhorados IBEK no Distrito de Mabalane – Província de Gaza. 63p.

4.2.4. Alternative fuel sources projects

Charcoal briquettes

The southern region of the country has seen the emergence in recent years of initiatives to provide alternative sources of fuel, mainly toward Maputo market.

Among the projects developed is the production of briquettes from charcoal dust and agricultural residues by Verde Africa Lda., a company established in 2016 (Verde Africa, 2018)[25]. Based in Maputo, this company is able to produce 17 tonnes of biobriquettes/month, and sells to Maputo consumers.

In the same line of action, start-ups are proposing briquettes from different agricultural residues such as Eco-Planet Mozambique, and its product "Eco-carvão" made from wastes and coconut shells. Since the beginning of the project in 2015, the factory based in Maputo kept growing from a capacity of 12 tonnes a month to 200 tonnes (Eco-Planet Mozambique, 2016)[26].

Larger industrial companies have also recently taken interest in briquettes production. Cotton producers such as SAN-JFS have recently been producing briquettes from cotton stalks at a small scale (World Trade Organization, 2020[27]). Some studies have also been carried out to transform cashew cakes into charcoal briquettes, but not yet implemented by industrials (Nitidae, 2020[28]).

The growing interest of the private sector in the production of briquettes should lead to the emergence of significant supplies in the coming years. As for now, however, this product remains rather marginal and its distribution is concentrated in the urban markets of the South, where the price of traditional fuels is high.

"Bio-coal briquettes"

As part of the JOGMEC's Clean Coal Town Project, the Japan Coal Energy Center (JCOAL) has been working together with JICA, the Mozambique government, local government, and the local community to produce bio-coal briquettes in Tete Province. The objective is to enhance the local consumption of coal for domestic use. After a pilot project that has proved to be successful, a new phase of the project is soon to be launched to set up processing units. Theses briquettes will be made from agricultural residues (cassava, maize) and coal dust. (Interview Dr. Sive, MIREME, 2022).

Given the importance of coal mining in the Tete region, and particularly in the Moatize district, the establishment of these production units could have a significant impact on the charcoal market. Details of the potential selling price have not been published, so it is difficult to say at this stage whether the final product will be competitive with vegetable charcoal.

[25] Arisaka J., 2018. Recycled charcoal briquettes in Mozambique - Affordable and quality energy for all. Presentation 18/01.19.

[26] Eco-Planet Mozambique, 2016. Eco-carvão. Carvão eco-amigável fabricado com cascas de Coco reciclados em Moçambique. 23p.

[27] The Cotton by-products Project: Unlocking the hidden value in Mozambique. Presentation of Cunguara B. 20/11/12, Maputo.

[28] Nitidae, 2020. Competitiveness of the cashew nut industry in Mozambique. 99p.

The Agência de Desenvolvimento do Vale do Zambeze (AVZ) have also been associated to the project experimental phase as a facilitator. Indeed, AVZ's prerogatives include:

- Carrying out of studies and presentation of strategies for economic and social development in the national part of the ZRB;
- Technical-financial assistance to the economic and social development initiatives in the national part of the ZRB, including the mobilisation of resources and channelling them to the beneficiaries;
- Assistance to Local Governments in incorporating the planning and land-use planning and local socio-economic development components.

Pellets

Until very recently, there has been no technology available on African markets for using biomass pellets. Over the last decade, the private sector has developed gasifier cookstoves, that can work with pellets and briquettes fuels. With the increase of charcoal and wood fuel in the southern part of the country, start-ups are currently developing pellets manufacture, with support of Research & Development actors (including Greenlight Mozambique).

4.2.5.Clean cooking solutions

Biomass ICS

Over the last decade, most ICS projects have been carried out in Maputo province. Quite a number of civil society organizations (CSOs) and social businesses are actually involved in the dissemination of ICSs.

In recent years, BURN Manufacturing, the Kenyan company that has been selling the Jikokoa ICSs (charcoal model, labelled by Gold Standard), implanted distribution shops in the main cities of Mozambique (Maputo, Matola, Beira, Tete, Inhambane, Chimoio e Nampula). With Greenlight Africa's support, BURN is actually implementing an assembly line in Maputo.

Mozambique Carbon Initiatives Lda. (MozCarbon) is implementing a project including the distribution of improved cookstoves in Maputo and Matola to replace the traditional cookstoves. Several models are being distributed, including Mbaula models.

Through the BRILHO programme, 7,706 improved cooking solutions were distributed since 2019.

CSOs have also been distributing ICSs in many districts around Maputo. Livaningo, ADEL and KULIMA are among the many NGOs that provide ICSs models to urban populations.

Figure 5: ICS disseminated in Tete Province (Authors, 2021)

In the ZRB, one ICS project was identified in Tete Province. Implemented by the CSO Juventude Desenvolvimento e Advocacia Ambiental (KUWUKA JDA) in Marara and Moatize districts, the project aimed at training rural communities and technicians to build fixed ICS (Direcçao Provincial dos Recursos Minerais e Energia de Tete, 2019)[29].

This project was developed with support of SDAE and SDPI in Marara and Moatize districts. These ICS have been developed for wood fuel, but not for charcoal use.

This project is no longer being developed due to lack of funding. In 2019, 203 community members were trained to build ICS and an awareness campaign on sustainable forest resource management was conducted in Moatize (KUWUKA JDA, 2019)[30]. Results to date could not be assessed with precision, but the ICS promoted is still being used by local populations.

Ethanol cookstoves

Project Gaia[31], with support of SNV, FUNAE and the City of Maputo has been working since 2012 for the commercialization of ethanol fuel and Clean Cookstoves in the capital city. They now support “Ndzilo”, a local company that sells ethanol stoves and supply consumers with ethanol.

Through the “Garner Sustainable Biomass and Renewable Energy Programme”, the private company Green 66 Innovations intends to distribute 100,000 ethanol stoves by 2025 to households in Maputo and Matola. The plan is to sell ethanol stoves made in South Africa and commercialised by the Swedish company Cleancook. Phase 2 of the business envisages to incorporate a re-usable bottle system that will cut down on the need to use new plastic bottles for fuel. This collection and redistribution system is envisaged to be rolled out once infrastructure is in place to collect, clean and rebottle locally (Gold Standard, 2017[32]).

There is no data available as to the success of these initiatives.

Gas

According to Dr. Sive (MIREME), an initiative will be launched in March of the current year for the massification of domestic gas use in five cities, namely Tete, Sofala, Quelimane, Nampula and Pemba. In this initiative, equipment for the use of gas is expected to be made available on the market at an affordable price, with special emphasis on the diversification of the size of the gas bottles, that is, the introduction of cylinders weighing less than those currently sold on the market (9 and 11 kg), in order to facilitate the acquisition by low-income families. On the other

[29] Direcçao Provincial dos Recursos Minerais e Energia de Tete, 2019. Projeto de Fogoes melhorados (ecologicos). 20 p.

[30] KUWUKA JDA, 2019. Relatorio Semestral, 2019. Cidadania, boa governaçao e desenvolvimento sustentavel.

[31] https://projectgaia.com/projects/mozambique/

[32] Gold Standard, 2017. Gold Standard for the Global Goals Stakeholder Consultation Report. 73p.

hand, it is expected that through awareness-raising actions and market research, current charcoal wholesalers/retailers will start to resell domestic gas.

4.2.6.Partial conclusion

Although several initiatives have been identified at national level, there are currently few projects in operation or in the pipeline in the ZRB. Most of the efforts so far have been concentrated in the south of the country, due to the high demand for clean fuel and cooking solutions in the urban area of Maputo, where the high prices of charcoal and wood logically lead to a better competitiveness of alternative fuels.

However, this trend is spreading throughout the country, including the centre, as urban areas become denser and forest resources scarcer.

The ZRB area has been relatively understudied by the scientific community to date, and the structure of the CVC is rather poorly documented.

Nevertheless, this does not prevent from learning some lessons from projects in the South, and identifying initiatives and approaches that could be scaled up in the ZRB provinces.

- The main challenge is to take a cross-cutting view when dealing with the CVC: to focus on each link of the value chain and to coordinate the value chain as a whole;
- New technology adoption by producers and users is very difficult and one of the key factors of success is the adaptation to local context and producers/users' constraints;
- Complex kiln designs are hardly adoptable by charcoal producers, instead, improved kiln designs with slightly less efficiency but that are more suitable to local practices have a higher probability of adoption and replication;
- "Top-Down" approaches did not prove to be successful when introducing a new kiln technology, whereas participatory methods, with a gradual increase in technicality have been more successful;
- A secure supply source has proven to be more of a motivational factor for improved kiln adoption compared to efficiency and time savings. This is all the more important as very few projects focus on securing forest resources and disseminating forest management practices in the country;
- Attempts that involve only producers and associations often fail when introducing new kilns, as there is a need to involve the formal private sector, which is currently not attracted to charcoal production;
- There is a need to provide for long-term state supervision to ensure the sustainability of activities undertaken by research organisations, and other actors in the CVC, as changing practices is a slow process that is greatly impacted by policies and legal framework.

5. Main study findings/results

5.1. Mapping of actors involved in CVC

	International	National	ZRB
Academic	Swedish University of Agricultural Sciences Stockholm Environment Institute (SEI) World Agroforestry CIRAD CIFOR	University Eduardo Mondlane University Lúrio	
(Inter) Governmental organizations	SIDA Norad SDC SNV UKAid GIZ WFP World Bank AICS AECF IOM Multi-donors platform PROFOR	Ministry of Natural Resources and Energy (MIREME) Ministry of Agriculture (MINAG) Ministry of Land and Environment Energy Fund (FUNAE) Fundo Nacional de Desenvolvimento Sustentavel (FNDS)	SDAE SPDTA AQUA
NGOs	AMER - Mozambican Renewable Energy Solidaridad Nitidae EDEN Reforestation	Livaningo ADEL Sofala KULIMA	ADEL (extended activities) KULIMA KUWUKA JDA
Private sector	Greenlight Africa (consulting) JCOAL BURN Manufacturing	Green 66 Innovations Eco-Planet Mozambique JFS Verde Africa Lda. Mozambique Carbon Initiatives Lda.	
CVC Actors	Producers' associations (in Zambezia: VURUKA; MICAMA) Independent producers Wholesalers Resellers Business holders End-users		

Figure 6: Mapping of CVC actors (Authors, 2022)

Apart from some international and local NGOs, very few actors are currently working on the sustainability of CVC.

5.2. CVC in the lower ZRB

The common structure of the charcoal value chain follows the flowchart elaborated from local actors mapping, presented in figure 7 below:

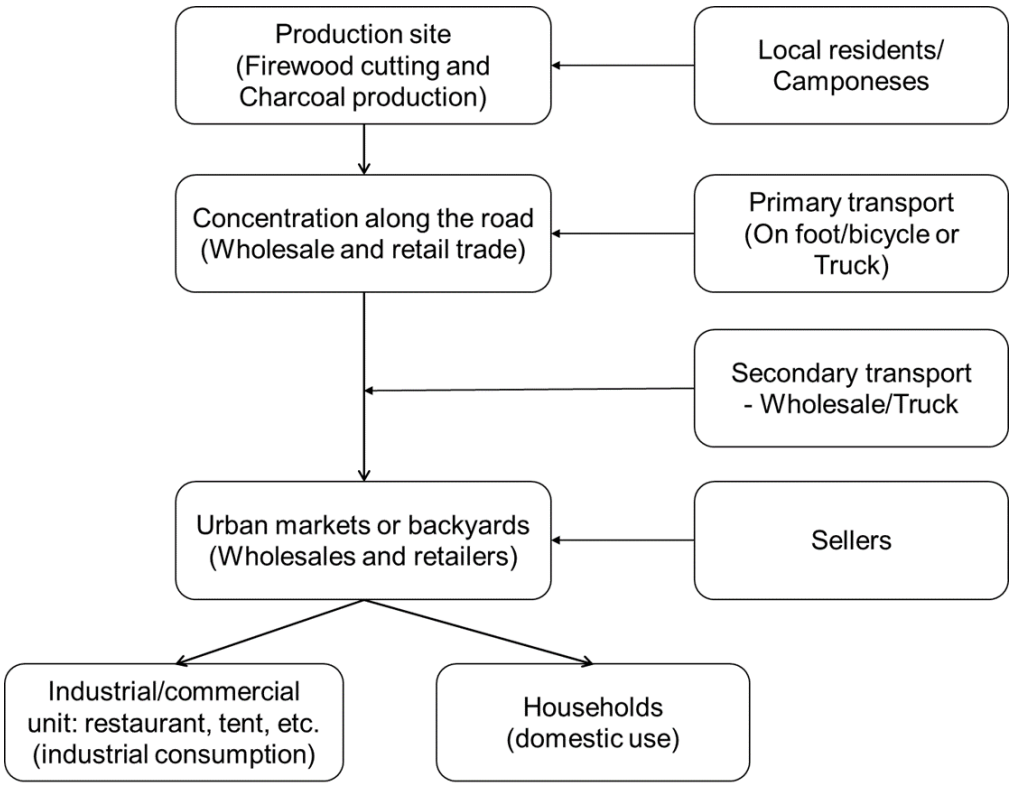

Figure 7: Common pattern of the charcoal value chain in the three provinces (Authors, 2021)

5.2.1. Main production sites and markets

The production basins are located on the outskirts of the main cities (Tete, Quelimane) and then move according to the deforestation line, deeper in the countryside. The production areas change according to access (along the roads) and according to the forest areas available.

In the city of Tete, the charcoal sold comes from the administrative post of Kambulatsitsi, District of Moatize and in the districts of Marrarra and Chiuta. However, the ranking of districts with the highest charcoal production in decreasing order is Changara, Moatize, Marara, Chiuta and Cahora Bassa.

The charcoal produced in this province also supplies the cities of Beira and Maputo, and some neighbouring countries such as Malawi, Zambia and Zimbabwe. However, there are no records of the quantity and volumes that leave the province.

In Manica, the district of Gondola stands out, but it is outside the study area. In the district of Guro (part of the lower Zambezi region), charcoal production began two years ago and was promoted by populations from the district of Changara (Tete). In that district, the populations dedicated themselves to mining activities. Currently, charcoal production is spreading to other districts in the province of Manica, namely Bárue and Catandica. Among the possible reasons for that phenomenon:

- Scarcity of the wood resource;
- Increase of the market with the growth of the city of Tete;
- Increase in the number of producers;
- Lack of diversification of income sources for local populations (especially in arid areas such as the north of Manica province).

In Zambezia province, the districts with the highest production are Namacurra (in the localities of Vuruka and Naciaia) and Nicuadala (in the locality of Licuar). All the charcoal produced is absorbed by the Quelimane market.

5.2.2.Production practices and outlooks for improved kiln technologies

In the lower ZRB, charcoal production is mostly informal, with mainly small-scale producers without operating licences.

Producers are mainly two types:

1) Small scale producers, either from local communities (family networks) or from other provinces/migrants, with few means of transport who sell mainly on the roads or directly at the production site to wholesalers;

2) Larger producers who produce and collect charcoal from smaller production units, who own trucks and are more likely to be licensed (facilitates the movement of large quantities of charcoal to urban markets). None of this type of producers could be interviewed.

For the producer, charcoal production minimizes the severity of poverty, but does not ensure a stable recovery from this condition. Charcoal production has little influence on the quality of housing and durable goods and a positive effect on food security and small purchases (soap, clothing, shoes and toothbrush).

Production practices

In the older logging areas such as in Tete province, carbonisation know-how is more developed among producers, who have been practicing for several years. With the scarcity of resources and a better notion of yield, producers are more likely to select the species and size of trees to be felled. Although no forest management plan is applied in the areas visited, the concept is known to producers.

In places where charcoal production is recent, such as in the Guro district, producers have little technical background, and no notion of sustainable forest management. They cut all species and diameters without distinction (“corto razo” i.e. clear-cutting in most of the sites visited).

On the other hand, in the three provinces of the Lower ZRB, carbonisation practices are similar.

The most commonly used technology is the traditional earth kiln, as shown in figure 8 below.

Figure 8: Steps of charcoal making using traditional earth kilns (Authors, 2021)

Charcoal production takes around two weeks, the first seven days being dedicated to tree cutting and gathering, followed by construction of the kiln and the remainder for combustion and bagging.

According to producers, traditional earth kilns have the advantage of enabling a phased extraction of charcoal. New producers could manage to learn the traditional kiln techniques quite easily as it does not require complex training to build. On the other hand, several disadvantages have been identified by producers:

- Slow Ignition time;
- It takes time for the fire to spread to the whole pile;
- Low yields (10 to 14%);
- A lot of waste is generated at charcoal extraction.

On average, each producer manages one kiln per month, and one kiln at a time.

Considering a maximum efficiency of wood conversion into charcoal situated at 14%: 86% of the weight of biomass collected and assembled in the kiln by the producer is lost; partly by dehydration and consequent greater energy concentration, and also by combustion where some of the wood becomes ash, without any commercial use.

Producers are often gathered in small groups, members of the same family or friends in the community. There is mutual help between them to build kilns. The production of charcoal is continuous, that is, when a kiln has been exploited, they build a new one, often as close as possible to the wood resource.

Once the charcoal is produced, it can be sold directly to wholesalers on site or transported to the points of sale on the public road by the charcoal workers themselves (figure 9).

Figure 9: Charcoal sale on public roads (Authors, 2021)

When the sale is made directly to the wholesaler, the latter is responsible for transport from production site to the main market.

In the sites visited, it was not reported by respondents the existence of intermediaries in the business, between the producer and the wholesalers.

From the data collected from the interviews, production costs include:

- Packaging costs: empty bag at 23 to 30 Mt per unit, material used to tie the bag costing 100Mt;
- Transport to the road: 20Mt per bag in case the wholesaler does not cover the costs;
- Equipment: axe purchased at 500 Mt (life of 1 year), machete (150 Mt) and hoe (200 Mt) both with an estimated useful life of two years.

The distribution of income is very uneven within the CVC, with most of the benefits collected by the actors at the end of the chain who have direct access to the market, to the detriment of the small producer. The sale price of charcoal to wholesalers at the production site varies from 60 to 80 Mt per bag (in Tete) and 100 to 120Mt (in Zambezia).

Structure of production

In Tete and Manica provinces (i.e. Guro district), there is no organization of the production, no producer associations are known to institutions or local authorities. Production is structured by working group and communities.

It is different for Zambezia province, where two associations have been identified: VURUKA association in the district of Namacurra, and MICAMA association in the district of Mocuba.

These two recognized associations of charcoal producers were created as part of initiatives for the sustainability of the CVC many years ago (no precise record). These associations exist mainly to prevent producers from other provinces to settle and produce charcoal. Producers are being represented by local leaders, but no formal status and member registration, and no production/sales organization yet.

Improved kiln technologies

There is a great lack of knowledge about alternative charcoal production technologies among charcoal producers, but also among government officials. Although there is interest in new technologies from all parties, producers have low investment capacities and are reluctant to take the risk to change practices without insurance of immediate and substantial benefits (time spent working, significant increase of yields, minimum disturbance in practices and easily assimilable changes, etc.).

5.2.3.Trade

Two types of actors were identified in the charcoal marketing chain: wholesalers and resellers.

Wholesalers

In most cases, wholesalers buy charcoal directly from small producers from the roadside in the interior. They own the means of transport and take the production to the main markets in urban areas.

The inquired wholesalers stated that they transport an average of 120 to 200 bags per trip using road transport. The results of the answers regarding the costs involved in the chain from production, transport and marketing are different for each province, district and city, so they cannot be considered conclusive.

However, as an example, wholesalers in Zambezia province (who are mainly supplied from the Namacurra district) report that the cost of transporting bags to Quelimane ranges from 120 to 135 Mt per bag.

Bags are sold between 170 to 200Mt per 25 kg bag and at 250 to 350 for the 50 kg bag in the city of Tete, while in the city of Quelimane the price of charcoal resale by wholesalers varies from 380 to 450Mt for the 50 kg bag (figure 10).

Figure 10: 25 kg bag (left) and 50 kg bag (right) sold by wholesalers (Authors, 2021)

Resellers

Retailers sell charcoal in small piles at a price ranging from 5 Mt (most requested, see figure 11), 10 and 20 Mt to 10-liter buckets sold at 70 Mt. Most resellers are women. They buy an average of one to two bags per day from wholesalers on the market itself.

Figure 11: Retail sale of charcoal in mounds (Authors, 2021)

5.2.4.Partial conclusion

Charcoal production is a labour-intensive activity, with low entry barriers since the process of assembling and managing traditional kilns is simple and easily mastered, even by inexperienced producers.

At small-scale, charcoal production generates small profit margins for most value chain actors, with particularly low benefits to the producers. This is particularly the case when production areas move away from urban markets, thus generating increased transport costs and additional logistics costs.

However, it is an important additional source of income for local communities, who are looking for a complement to their often seasonal and unprofitable agricultural activities.

In order to generate a minimum of profit, CVC actors who are not organized or structured in associations must adopt strategies for proper business performance. These strategies include movement based on access to natural resources, ad hoc mutual aid, and very low initial investment costs.

Despite an interest in reducing the drudgery of the work and improving the ratio of wood to charcoal (currently low) to improve their profits, producers are very risk averse. This is an important criterion to take into consideration when introducing new production practices.

Although communities and producers recognize that initiatives for sustainability in the production and use of charcoal are necessary, the use of wood fuel remains so far inevitable due to the low income of many families and the lack of competitive energy alternatives.

It is necessary to aim for a transformation of the value chain from its base, i. e. forest management. Indeed, the current production system is mainly based on uncontrolled and unlimited access (or at least perceived as such by producers) to forest resources. This leads to an expansion of charcoal production areas in the Lower ZRB, affecting fragile forests with a slow renewal rate. In addition, conflicts between producers from local communities and producers from other districts/provinces are emerging (e.g. Zambezia).

According to the structure of the CVC and the production and marketing patterns in the study area, the potential for improvement lies more in the upstream part of the value chain (forest management and production techniques), as well as in the end-use (cooking solutions and fuel alternatives).

5.3. Regulation of the CVC in the lower ZRB

5.3.1.Licensing system

The charcoal licensing process follows the same stages as the licensing process for construction materials (piles) and non-wood forest products.

Description of the licensing stages for charcoal

- Identification of site with forestry potential (Proponent);

- Request to the District Government to undertake community consultation of such a site (Proponent);

- Conduct community consultation (District Government, Proponent and other intervening parties); it should be noted that prior to this phase, the area, suitability of the applicant, proof of technical capacity and other aspects for the implementation of the proposed activity are verified (SDAE);

- Issuing of opinions (SDAE and District Administrator);

- Issuing of opinions (DPDTA);

- Dispatch from His Excellency the Governor of the Province;

- Issue of licence under a simple regime (DPDTA), mention that the licence is annual and with a quota of 1000 bags/year, (from 1st April to 31st December) in accordance with the forestry legislation in force.

It should be noted that licensing process has two modalities, one per license and the other per authorization for transport. The main difference is that authorizations only serve to transport charcoal from the place of production (informal production) to the market or consumption within the province, while in the License modality (formal production), the product can be sold outside the province.

The entity responsible for issuing licenses for the production of charcoal and forestry management is the SPDTA. In turn, AQUA is responsible for monitoring/supervising the exploitation and transport of forest and wildlife resources.

In the case of charcoal, inspection consists of checking (in the act of transport) the number of licensed bags, but does not observe the size of the bags, meaning that the actual volume of charcoal produced is far from being estimated and known.

However, the maximum quota of licensed charcoal is 1000 bags per year for each operator. Charcoal transport incurs a charge of 60 Mt per bag to be paid at AQUA. The approximate total value for issuing a charcoal license is around 100 thousand Mt or more, as in addition to the 60 Mt fee for a quota of 1000 licensed bags (which totals 60000 Mt), it includes other fees such as emission expenses of the topographical map of the place, costs of carrying out the community consultation, purchase of a guidebook, etc.

5.3.2.Licenses in the ZRB

Licensing databases are not available over a long time period (in Tete only over the past two years, whereas it is recorded for the last five years for Manica Province), due to the lack of centralized database and archive transfer.

For Tete province, DPDTA estimates the number of licenses emitted in 2020-2021 as shown in figure 12 below.

Type of document	Product	2020		2021		Growth rate (%)		Unit
		Nº	Quant.	Nº	Quant.	Nº	Quant.	
Licences	Charcoal	12	4864	13	5686	8.3	16.9	Bags (50 Kg)
Total		**12**	**4864**	**13**	**5686**	**8.3**	**16.9**	
Transport Permits	Charcoal	109	7940	259	12920	137.6	62.7	Bags (50 Kg)
	Wood fuel	291	4121	674	6624.6	131.6	60.8	Steres
Total		**400**		**933**				

Figure 12: Charcoal licenses at national level for 2020-2021 (DPDTA, 2021)

As for Manica Province, data shows that volume traded is increasing from 14,781 bags in 2017 to 29,088 bags in 2021, for a total of 79 licences emitted. In Guro district, no licences have been emitted over the last five years, as production is recent and mainly informal (interview Dir. C.M. Chiutano, Forestry and agroforestry plantations department in Manica).

It was not possible to obtain charcoal licensing data from the province of Zambezia due to the reasons mentioned above.

AQUA services report an increase in the number of products to be controlled without the provision of the human and financial resources necessary for effective control.

In practice, licenses apply very little to producers, the vast majority of whom are not controlled either on the areas of production or on the total volumes produced. Most of the production in the lower ZRB is therefore undocumented and unchecked by local authorities.

5.3.3.Partial conclusion

The study of the licensing system reveals major shortcomings, insofar as it does not allow for detailed monitoring of the number of charcoal producers, the volumes produced, or the identification of production areas.

Although it was not possible to obtain a database from the institutions that contains information on the number of charcoal licenses existing in the last 10 years that could serve to demonstrate the evolution of license requests, the informants stated that there is a growing trend of license requests.

At the district level, there are no data on the number of existing charcoal production licenses despite the fact that the licensing process starts in the district. Communication between services issuing licenses and local authorities is not well established, which does not allow for district representatives and communities to have a clear understanding and view of the production.

Most of the licenses issued relate to the transport of charcoal. Simple licenses for charcoal production must be redesigned to introduce the formal register of forest resources used for this purpose.

Forest associations should be promoted to enable simple licensees involved in charcoal making to benefit from economy of scale effects and sustainable forest management.

The institutions that regulate the activity lack various means, from finance, knowledge, training, human resources, tools, etc. which limits the full exercise of their obligations with a view to ensuring greater control and organization of charcoal production.

6. Conclusions

The issues of the CVC in the Lower ZRB can be summarized as: i) No multisectoral coordination (forests and energy) and lack of leadership by any of the sectors, ii) Inefficiency and waste in production (traditional kilns) and consumption (low efficiency stoves), iii) Indiscriminate logging without respecting species or cutting zones, and iv) Informal business with low incomes for producers, communities and the State.

These issues imply an extension of deforestation further and further away from urban centres in an uncontrolled and unmonitored way. A lasting impact on ecosystems via the degradation of vegetation cover, with possible repercussions on water management, soil fertility, etc. is to be feared.

Charcoal production is an important complementary activity for the rural populations of the ZRB area. It provides an important income supplement, particularly in cases of major crop loss due to flooding, for example, which is becoming increasingly frequent in the ZRB. Indeed, IPCC (2009) has forecasted an intensification of cyclone features, increase in wind speeds and heavier rainfall discharges due to the increase in tropical sea surface temperature. Among the eight countries included in ZRB, Zambia and Mozambique have the largest flooding area due to the Kafue flats and lower Shire region (Sanchez, 2018)[33]. The spread of inefficient carbonisation techniques among the population, a potentially growing need for additional income after climatic disasters (cyclones, floods, droughts, etc.) combined with an increasing demand for fuel from urban centres will lead to ever greater pressure on the forests, and thus a potential increase of GHG emissions/ decrease in carbon storage. Greening the CVC, and more generally the supply of biomass energy in the ZRB region would therefore contribute to both adaptation and mitigation of climate change.

This study highlights four very important points to take into account before considering operationalising field projects to improve the sustainability of the CVC in the Lower ZRB:

1. There are no CVC focused projects implemented at the Lower ZRB level. The projects implemented are at best province-wide, but more generally developed on the scale of a restricted agro-ecological zone or on a few districts. There is therefore currently no integrated 'territory' vision for the whole basin with regard to forest resource management and charcoal production. This is the result of a wider problem at national level, which is the lack of a transversal entity to coordinate all the actions undertaken to green the CVC.

2. Very few projects are still being implemented regarding the CVC in the three provinces considered. This follows a general trend at country scale: there is an important disparity between the south and the centre of the country in terms of the CVC structure and also in terms of the dynamics of CVC projects. Some pilot projects were identified, but either results are not well documented, or projects quite old, or they were implemented in other parts of the country, i.e. in the southern area near Maputo. This implies that it will be necessary to "start from scratch" or nearly so (since almost none of the few practices that may have been introduced are still applied) for the development of a sustainable value chain. The replicability of the projects will also have to be questioned before implementation, as there are some major differences in CVC structure between the ZRB area and the South.

3. Statistics for the charcoal production in the study areas are scarce and imprecise and the development potential of these chains is unknown and underused (domestication, efficiency, green seal and product of controlled origin). Representatives of government institutions at provincial and district levels do not have reliable information on the production, marketing and even use of charcoal. They are aware of the depletion of forest resources but are powerless to change this trend. In that regard, there is a strong interest from Provincial representatives

[33] Sanchez GS, 2018. The Zambezi River Basin: water resources management Energy-Food-Water nexus approach. Stockholm University, 61p.

in working on CVC sustainability. But there is a lack of training, knowledge, human and material resources to monitor effectively the CVC in these areas.

4. In the study area, the structure of the CVC may be a barrier to effective action in the first instance. In contrast to the south of the country, where producers are federated into associations and therefore have well-identified interlocutors, the particularity of the Lower ZRB is the lack of organised producer groups. The aim will therefore be to document the extent and structure of the CVC in each of the provinces in a more precise and exhaustive manner, but also to make producers aware of the need to join forces in order to be able to contribute effectively to the reorganisation and modernisation of the sector.

On this basis, it is clear that there are no turnkey solutions for the development of green CVC. The process is inevitably a long one, with a necessary first step of mobilisation and capacity building of local actors, both at the productive level and at the level of the institutions supposed to support them.

When asked about the possibilities to support a sustainable charcoal sector in Africa, researchers from Sweden, Kenya and Niger summarise the challenges as follows: “It is about understanding the big picture – and the details”. This is one of the major lessons learned from the various experiences on the continent, i. e. that actions that focus on one link in the chain are rather ineffective when implemented alone. It is necessary to develop coordinated action across the whole CVC to hope to see sustainable results.

The modernisation of the CVC and biomass sector for domestic use therefore requires a multi-stakeholder approach that include the central and local government entities, communities (charcoal producers and other forest product users), the private sector, development organizations partnering with CSOs and Financing actors.

Based on lessons learned in Africa, the implementation of demand-driven approaches seems to be one of the ways to modernise CVC with the highest potential for sustainability. This means stimulating demand and creating favourable conditions for the emergence of a market for competitive alternative fuels and efficient cooking equipment. Private sector has a central role to play. The challenge will be to extend the dynamics initiated in the south of the country towards the centre, by encouraging companies to set up in the main cities, and by supporting the development of new social businesses.

A trigger is needed to open up a market opportunity, that could take various forms such as certification systems, incentive and technical support, financing, etc., with government institutions in the leading role.

Researchers are also essential elements to be mobilised in order to progressively improve knowledge on the potential risks of this particular area that is the ZRB (climate, forest cover, associated agrarian systems, etc.), to contribute to developing a clear vision of the dynamics at work in the CVC and to establish a relevant and efficient monitoring system to follow the evolution of the situation over the long term.

In section 7 below, possible programmes are outlined to be developed, taking into account the objectives set by the government, pilot projects that have already been carried out, and potential partners.

7. Recommendations: Partners, initiatives, programme design, timeframe

7.1. Timeframe

In view of the situation as described in this report and summarised in section 6 above, it can be stated that the steps towards sustainability of CVC in the Lower ZRB are bound to be long term. It is in this long-term perspective that national plans are being developed, such as the various stages of the National Forestry Strategy 2019-2035 developed by the government.

This long period of time is absolutely necessary insofar as, as underlined above, it is a question of strengthening and developing each of the aspects of CVC, of strengthening the legal and institutional framework, of federating the actors around a project for the development of a sustainable CVC, etc. It is therefore a large-scale project, which must aim at a transversal and in-depth action and cannot bear fruit in just a few years.

The time step envisaged is therefore at least ten years.

7.2. Partners

As mentioned in the conclusion of the report, it is essential to adopt a multi-stakeholder approach to the development of a greener CVC.

This is only possible if a government entity is identified to coordinate the actions of donors, researchers, the private sector and NGOs.

Currently, CVC projects are not identified and coordinated at the national level. MADER, MIREME and MTA are the main ministries involved in the charcoal value chain. MADER and MTA for forest management and carbon emissions, deforestation, etc. mainly, MIREME for energy issues (production, consumption, etc.). There is currently no established or signed coordination between these three ministries, and there is no longer an inter-ministerial committee to manage/coordinate actions on these issues. Any coordination between these institutions occurs sporadically depending on their needs.

In order to federate technical and financial partners around an action plan focused on the CVC, it would be necessary to designate or create an entity to oversee all activities related to the CVC and re-establish an inter-ministerial committee to make informed decisions at national level. FUNAE could be an interesting candidate to lead the actions on CVC.

The legal framework has been established in recent years through the development of strategies that set out the challenges and the main objectives to be achieved with regard to charcoal. A new forestry law is under consultation, which will include elements on biomass energy management (SalvaTerra, 2021)[34]. It is now a question of putting in place the political framework for their operationalisation.

Some local partners have been identified, according to their respective fields of expertise. It will be necessary to further explore the possibilities of partnerships and specific support needs according to the projects implemented.

The AVZ is a key partner in the development process of CVC projects in the region. Indeed, it plays a facilitating role and can bring a territorial vision that is currently missing from biomass energy initiatives. Although charcoal is not currently at the heart of the programmes developed by the AVZ, it is part of their prerogatives, particularly via the component "Support to local governments through the creation of energy transformation stations for domestic and industrial use".

[34] SalvaTerra, 2021. Sustainable Access to Energy in Mozambique, Greening the CVC in the Lower ZRB – Inception report.

The Eduardo Mondlane University remains a key player in the academic field. The expertise of the researchers accumulated over the years and the projects in the south of the country make them privileged interlocutors who will be able to advise and support the implementation of projects in the lower ZRB. In addition, the collaborative links forged with research centres and consultancy firms will also be useful for the successful implementation of the programmes.

It will be necessary to integrate companies from the private sector, from Mozambique or from other African countries. Some have also been identified as potential partners, but this is a dynamic sector and the possibilities of partnerships should also be further explored when implementing the programmes.

7.3. Initiatives to develop and up-scale

None of the initiatives identified in this study are replicable "as is". In terms of initiatives to be replicated or scaled up, there are two options:

- A few successful initiatives in the Lower ZRB can be taken up and developed, but they necessarily require strong financial, technical and organisational support;

- Initiatives developed in the southern part of the country are interesting to import into the ZRB, but they imply ensuring their potential for application according to the specific context of this zone in terms of CVC structure, actors, territorial objectives, commercial opportunities and potential market, etc.

Project description and partners	**Period and area of implementation**	**Key elements of success**	**Need for adaptation / potential development**
Project: Improved cookstoves project "Projeto de Fogoes melhorados (ecologicos)" Obj: - To build ecological or improved cookstoves in all selected households and schools; - To contribute to the sustainable use of these woody resources, taking the student/community as an active participant in the project; - To seek actions that aim to contribute to mitigating the negative impact on woody/forest resources; - To make available more accessible ecological cookstoves to schools and households. Implemented by: KUWUKA JDA, Direcça provincial dos recursos minerais e energia de Tete (DPREME), UEM Funds: Government funds	2007-2021 Tete Province	• Mobilisation of qualified technicians; • Raising awareness in households and schools.	• Integrate other, more efficient improved stove designs; • Conduct a wider awareness campaign; • Expand the target audience to urban areas; • Support the development of social and women's entrepreneurship; • Integrate community-based agroforestry or forest management practices in targeted rural villages; • Develop a business model for the dissemination of ICS; • Implement tests of the disseminated model (effectiveness, emissions, etc.).

Project: part of the Nationally Appropriate Mitigation Actions for Mozambique Project in Mozambique. Obj: To explore the possibility of implementing sustainable charcoal projects that could be covered by climate finance mechanisms. The kiln model selected the Improved Basic Earth Mound Kiln (IBEK), Implemented by: Greenlight Africa, in partnership with UEM Funds: Belgian government	2014-2015 Gaza Province	• The approach adopted: participatory method with gradual involvement of charcoal producers in kiln design; • Kiln design chosen adapted to local practices; • Strengthening scientific knowledge; • Good example of cooperation between several actors: local CVC actors, local authorities, decentralised services of ministries, researchers and private sector.	• Maintain the approach adopted and strengthen it by including a training centre for a gradual improvement of the technical level of producers and offer the possibility to test other improved kiln models; • Encourage producers to form associations, provide organisational support for start-up. • Include a pilot phase of testing business models with charcoal producers, including community production and state-supervised production (based on supply from state forest plantations); • Strengthen the understanding of the value chain in order to refine the strategies to be developed for each of the CVC actors. • Integrate the upstream and downstream phases of charcoal production, namely the supply of sustainable wood and the use of unprocessed plant residues left over from the carbonisation process.
Project: Coastal restoration Obj: To restore of mangroves in the coastal area of Quelimane Implemented by: EDEN Reforestation projects	2021 Zambezia Province	Although results are not yet published, this project for sure takes a step in the right direction in term of forest management. It is essential to learn from the activities carried out and ensure their continuity.	• Include a dimension on charcoal production; • Scaling up to the whole coastal area of the lower ZRB territory; • Consider reforestation of areas in the interior of the country (see other projects carried out by EDEN)

Project: Mozambique Forest Investment Program (MozFIP) Obj: To promote sustainable biomass energy; land delimitation, planning and tenure regularization; and establishment of new planted forests and agroforestry areas. A key component is that MozFIP will promote small-scale forest plantation for commercial purposes through performance-based grants to smallholders. The Project aims to stimulate entrepreneurial programs through the planted forest grant scheme, agroforestry systems that are linked to the market, community-based forest management, and smallholder charcoal production. Implemented by: Government of Mozambique Funds: World Bank / Government of Mozambique	2017-2022 Zambezia & Cabo Delgado Province	Although results are not yet published, this project for sure takes a step in the right direction in term of forest management. It is essential to learn from the activities carried out and ensure their continuity.	• Include a dimension on charcoal production; • Scaling up to the whole of the lower ZRB territory.

7.4. Programme design

The table below summarises the potential programmes that could be implemented, as well as an indicative timeframe and the main actors who could take ownership and leadership for follow-up and implementation.

Objectives	Potential partners	Timeframe	Type of support/tasks
Encourage and massify the creation of associations and cooperatives for the planting, handling and production of charcoal and implementation of community charcoal production instead of isolated producers. Progressively develop and introduce new kiln technologies using participatory methods and structure a monitoring and evaluation platform in order to verify the levels of acceptability. Propose innovative business models that give more control to producers / allow a better distribution of risks and production costs.	Government actors: MADER, MTA, FUNAE, FNDS Potential partners: AVZ, UEM, Greenlight Africa, EDEN reforestation, ADEL SOFALA, KULIMA, RADEZA (Zambezia)	2023-2027	Mobilisation of Financial support with cooperation agents (e.g. WB, JICA, etc.) Technical assistance Capacity building /Training of Trainers
Elaborate development and management plans for identified forest areas, ensure the sustainability of the vegetation cover; empower local populations in the sustainable management of forest resources; preserve the genetic heritage and improve the biological diversity of the forest; improve knowledge of the resources; promote the use of non-timber forest products; promote local development, apart from charcoal activities.	Government actors: MADER, MTA, FUNAE, district and provincial authorities Potential partners: AVZ, UEM	2023-2033	Mobilisation of financial support Technical assistance Capacity building/Training of Trainers
Encourage the development of a state plantation model for energy purposes and establish new biomass fuel production models.	Government actors: MIREME, MADER, MTA, FUNAE, FNDS and district and provincial authorities	2023-2033	Mobilisation of financial support Technical assistance

	Potential partners: AVZ, UEM, Greenlight Africa, forestry experts		Capacity building/Training of Trainers
Ensure capacity building of the decentralised departments of the Ministries of Energy and Environment on CVC management issues and development of local project proposals.	Government actors: local departments of MIREME, MTA, AQUA, Charcoal producing district and provincial authorities Potential partners: AVZ, UEM	2023-2027	Capacity building/ Training of Trainers
Modify the licensing system to: - take into account the entire value chain, from harvesting and production to marketing. Structure, - Ensure the steering of taxation activities coordinated at national level with sufficient means available to carry out effective control, - Structure an information system that is regularly informed by centralised databases and ensures a good circulation of information collected in the field at the different decision-making levels (central and decentralised).	Government actors: MIREME, AQUA, DINAF Potential partners: UEM	2023-2027	Capacity building/Training of Trainers Technical assistance Mobilisation of financial support
Implement a policy to encourage the development of social entrepreneurship for the marketing of certified ICS to urban centres and competitive alternative fuels from charcoal wastes (briquettes, pellets, etc.). This could take the form of creating a local label based on international labels, training actors and setting up efficient distribution models, etc.	Government actors: FUNAE & MIREME Potential partners: Private sector (BURN Manufacturing, MozCarbon, Verde Africa Lda, Greenlight Africa), local CVC actors (charcoal producers and associations, local community representatives, etc.)	2023-2033	

Define and implement awareness raising strategy among potential consumers and relevant ministries and institutions within government institutions in order to: i) Increase awareness and understanding among consumers on clean cooking technologies and alternatives / green charcoal in order to stimulate demand. ii) Increase capacity among the government institutions to make informed decisions affecting charcoal sector, not only in the 3 most concerned ministries but also in Industry, Planification, etc.	Government actors: FUNAE in close collaboration with MIREME, FNDS, MTA Potential partners: ALER, EnDev,	2023-2027	Capacity building/Training of Trainers Financial support

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Annexe 1. ZRB area characterization

The ZRB spans eight countries including Angola, Botswana, Malawi, Mozambique, Namibia, Tanzania, Zambia and Zimbabwe. It is the most shared river system in Southern Africa, and it ranks in fourth position as the largest river basin in Africa.

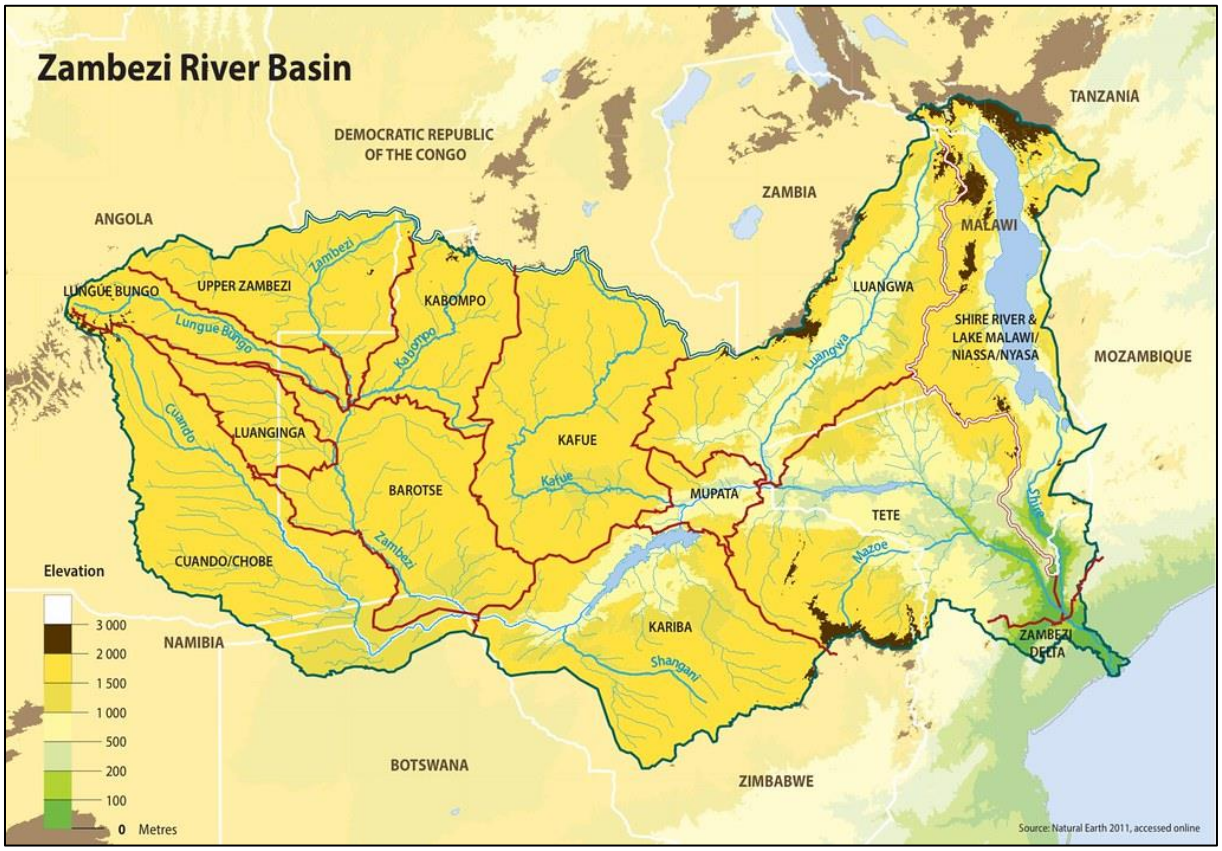

Figure 13: Zambezi River Basin (Southern African Development Community - SADC/SARDC et al., 2012)[35]

Zambezi river mostly receives its water from Zambia (40,7%), Angola (18,3%), Zimbabwe (15,9%) and Mozambique (11,4%). The ZRB is commonly split into three main regions:

- Upper Zambezi: characterised by steep slopes and large wetlands;
- Middle Zambezi: Victoria falls area;
- Lower Zambezi: Lake Malawi and the Cahora Bassa dam and reservoir, in Mozambique.

[35] SADC, Southern African Research and Documentation Centre (SARDC), Zambezi Watercourse Commission (ZAMCO), GRID-Arendal, United Nations Environment Programme (UNEP). 2012. Zambezi River Basin – Atlas of the changing environment. Ed. Gaborone, Harare and Arendal. [Online] Available: https://www.sardc.net/imercsa/zambezi/zambezi/The_Zambezi_River_Basin_Atlas.pdf

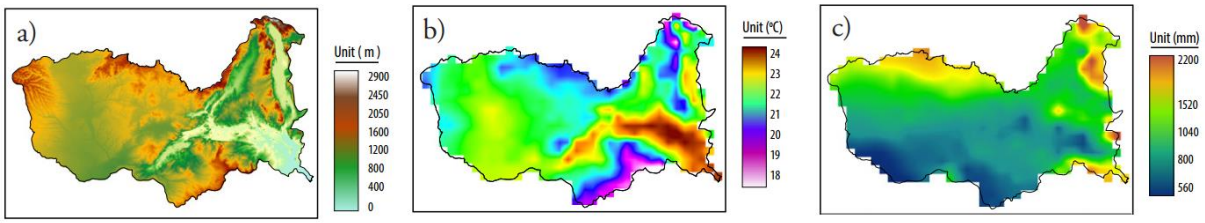

Figure 14: Map showing a) elevation, b) historical 30-year return mean temperature, and c) mean precipitation across the ZRB (CODESRIA, 2020)[36]

The climate within the basin varies greatly from its Delta in Mozambique at sea level, to its highest point at 2 900 m above sea level in Tanzania. This wide range in elevation across the ZRB results in wide spatial variations in temperature and precipitation (See figure 14 above).

The basin includes large areas of fertile land, thus making it a key agricultural area supporting large populations. Indeed, in 2008, the ZRB population accounted for 40 million people, including 7,5 million living in urban areas. This already large number is likely to increase further in the coming years, given that all the countries concerned have an annual population growth rate between 32‰ and 15‰ annually (UN, 2019)[37].

ZRB is also a critical area for both water provision (supporting agriculture, providing ecosystem services, but also used for energy production, etc.) and biodiversity conservation. The basin therefore concentrates multiple uses which implies many challenges to be met from the perspective of the WEFE nexus[38], particularly in a transboundary context (Senzanje & Dirwai, 2020)[39].

In recent decades, scientists have observed ecological changes in the ZRB, resulting from a complex set of drivers and pressures among which climate change and other non-climate drivers: poverty, water pollution, flow alteration, expansion of irrigated agriculture, etc.

These changes affect precipitation patterns, that are already affecting populations “The floods of the Zambezi River in Mozambique in 2008, for example, displaced 90,000 people, and along the Zambezi River Valley, with approximately 1 million people living in the flood-affected areas, temporary displacement is taking on permanent characteristics” (IPCC, 2014)[40].

The Intergovernmental Panel on Climate Change (IPCC) projected major impacts of climate change in the ZRB. At the regional scale, there is evidence of change in annual runoff, with some areas experiencing an increase in runoff (high latitudes) and others experiencing a

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[36] Council for the Development of Social Science Research in Africa, 2020. Ndebele-Murisa M., Kimirei IA., Mubaya CP., Bere T. Ecological Changes in the Zambezi River Basin. 260p. Dakar, Senegal.

[37] World Population ProspectsUnited Nations. 2019.

[38] “The water-energy-food-ecosystem (WEFE) nexus has emerged as an increasingly prominent global policy, governance and research agenda. The WEFE nexus presents an opportunity for policymakers, researchers and development agencies to integrate the sectors in order to optimise the use of the resource base, maximise synergies and minimise trade-offs and conflicts. Since the Zambezi River Basin is transboundary and there is competition for natural resources by sector (water, energy, agriculture) and by country (ZRB riparian countries), the WEFE nexus presents itself as a viable tool for resources management.”

[39] Senzanje A. & Dirwai TL., 2020. Characterization of Current Agriculture Activities, Future Potential Irrigation Developments and Food Security to Face Climate Variability in the Zambezi River Basin. A Report Submitted to the EU-Joint Research Commission on Assessing Water-Energy-Food-Ecosystem (WEFE) Interdependencies Across the Zambezi River Basin: Agriculture and Water. 75p.

[40] IPCC, 2014: Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Field, C.B., Barros, Dokken, Mach, Mastrandrea, Bilir, Chatterjee, Ebi, Estrada, Genova, Girma, Kissel, Levy, MacCracken, Mastrandrea, and White (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 1132 pp.

decrease. In the semi-arid and arid areas of the ZRB, rainfall is projected to decrease with a greater frequency of droughts expected, causing important water shortages in the area.

Flow alteration could have strong impact on energy production. IPCC's projections indicate that hydropower may fall by 10% by 2030, and by 35% by 2050 under the driest scenario, with lower generation expected in the upstream power stations and increases downstream (IPCC, 2014).

The basin area is therefore an area particularly threatened by climate change. The challenge is to implement concrete actions to preserve the key role of ecosystems in the region and the maintenance of the animal and human populations living there. This concerns many sectors, of which energy production is not the least, as it affects water management, land use, forest cover, etc. For instance, the impact of climate change on river flow threatens energy production based on hydropower plants. In order to ensure production, policy makers may turn to biomass-based energy production to offset this, increasing the pressure on forests and natural ecosystems.

Annexe 2. State of the art of carbonisation techniques

Traditional charcoal earth mound kiln (Schure, 2020)[41]

Traditional millstone construction techniques vary around the world. Sometimes the logs are elongated or stood upright, the kilns may be rectangular or conical in shape... the dimensions are largely dependent on the amount of wood to be carbonised. Its dimensions depend on the quantity of wood to be transformed and on the experience of the charcoal maker. However, there are certain features common to all traditional kilns, such as mulching, earth cover, vents and a chimney (in normal draught, i.e. from above).

Yields in traditional carbonization are also highly variable, but the scientific and technical community as a whole agrees that this set of techniques has the lowest yields. techniques have the lowest yields.

Fixed kilns made of bricks or metal (Altimara, 2017)

Unlike the earthen kiln, the fixed kiln requires the use of construction materials (bricks, metal, etc.) and therefore an initial investment. This cost varies greatly from one technology to another, depending on the materials, the dimensions of the kiln, but also on the patents or patents for use that may surround some of them.

These kilns are fixed, which means that they must be located close to the plantations to limit the costs of transporting the felled or processed wood, as well as the handling costs (loading/unloading).

This type of kiln also implies that the resource is renewed periodically, so that the kilns can be reused, subject to refurbishment (replacement of sheets, repair of chimneys, etc.).

[41] CIFOR, 2020. Moombe KB., Mwaanga BM., Gumbo D., Ihalainen M. and Schure J. Wood fuel production and trade in Choma District, Zambia. Brief info. No. 316. [Online] Available: 10.17528/cifor/007887

Oil drum kiln from the Mucombezi

Regulado, Mozambique (UEM, 2002)

These portable metal kilns are manufactured from standard 45 gallon oil drums.

Wood quantities transformed are quite low compared to earth mound kilns, althought, the conversion efficiency obtained in oil drum kilns is comparatively high with reported yields of up to 23% (dry basis).

The main disadvantage of the method is that the raw material must be less than 30 cm long, with a maximum diameter of 5 cm, to achieve satisfactory results. This means a considerable amount of labour in the preparation of the raw material. Also used oil drums are sometimes difficult and expensive to obtain. The drums tend to burn out rather quickly due to the thin metal used end have to be replaced fairly frequently.

Casamance kilns (GIZ, 2013)

"The Casamance kiln was developed in Senegal and is an earth mound kiln equipped with a chimney. This chimney, which can be made of oil drums, allows a better control of air flow. In addition, the hot flues do not escape completely but are partly redirected into the kiln, which enhances pyrolysis. Due to this reverse draft carbonization is faster than traditional kilns. and more uniform giving a higher quality of charcoal and efficiency up to 30 %. Comparative tests of the casamance kiln and traditional mound kilns confirmed the advantages in terms of efficiency and shorter carbonization times due to the enhanced hot flue circulation"

Box kiln (Forest Project, 2021)

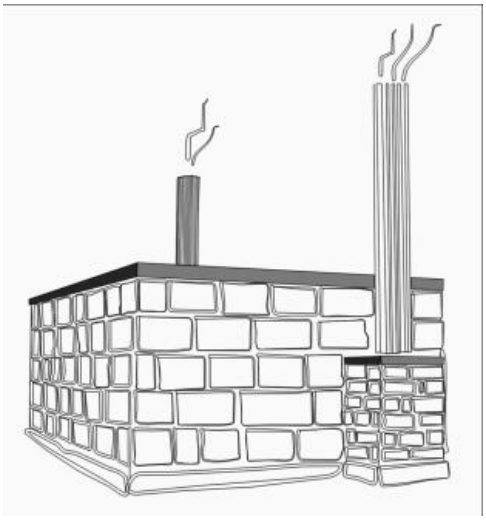
Simple transportable metal kiln, promoted by GIZ in Ghana, and many other donors.

Volume Box: 2m x 1m x 1,73m = about ~3,5m³

Effective volume of wood loaded: 1,9m x 0,9m x 1,6m = ~2,74m³

Weight of wood: about 650kg and about 20% humidity (~130kg of water)

Weight of wood oven dry: ~520kg



« Adam retort » kiln

The Adam Retort kiln is a metal and brick kiln with two chambers, one of which is a combustion chamber is used to heat the main chamber to initiate pyrolysis by burning biomass and biomass and biomass residues.

Charcoal received: about ~150kg

Efficiency: about ~29%

Operation time: about 12 hours

Cooling time: about 1 night and 1/2 day

Construction costs: about 500€ - 900€ depending on the country

When the load is hot enough and the moisture in the wood has evaporated, the pyrolysis gases, including methane, are released. the pyrolysis gases, including methane, are recovered for burning in the combustion chamber and accelerate the pyrolysis. Thus, not only does the process improve the efficiency obtained with conventional brick kilns, but it also conventional brick kilns, but it also helps to limit greenhouse gas emissions. greenhouse gas emissions. In addition, it has a much better effect on workers' health because more fumes are recovered. fumes are recovered.

Its manufacturer announces an efficiency of 35% to 40% on dry mass, which seems very high. which seems very high. The quantity of biomass burned to initiate pyrolysis is about 50 kg and it can be dry wood or charcoal residues, coconuts, etc.

Annexe 3. Interview guidelines

Interview guidelines for Institutions	
Institution, Name, position within the institution, number of years of service	Please state your name and position within the institution. How many years have you occupied this position? Previous position (if related to CVC)?
Description of role and key contribution in the CVC, human, financial and legal means available, person in charge;	What is the role of your institution in relation to the regulation of forestry/charcoal production activities? monitoring/census/data collection/policy proposal etc. If your institution has a regulation role, what are the means available in order to control the CVC? (Human, technical, financial, etc.)
Changes in landcover	What type of forests are the most common in the province? How are they managed? (Community level, state, private sector, etc.) Did you notice an evolution of the land cover in the district over the last decade? What are the impacts of the changes noted (if any)? Have your services noticed any particular difficulties with the supply of biomass fuel in recent years? Have any projects at state, provincial, district or community level been set in forest management area?
Charcoal production sites / Actors involved in the CVC in the province, location, type of activities;	What are the main charcoal production sites within the province? What is the trend in charcoal demand/production over the last decade? What type of actors are involved in the CVC within the province – at all levels: production, regulation, marketing and distribution, users, etc.? (State institutions, private companies, main producers' associations, etc.) What are the main markets in urban area and main sellers?

	In your opinion, what are the main difficulties when considering the CVC in the province? Do you have any suggestions to overcome those difficulties?
Charcoal volume licensing trends over the last decade	Is your institution involved in licensing process? If yes, how? How many licenses have been delivered over the last years (0 to 10 years) What are the main criteria to issue licenses? How is the production monitored by your services? (data available, collection methods, etc.) What are the main difficulties faced by your services in that matter? Suggestions to overcome these obstacles?
List of projects currently under implementation/in the pipe regarding the CVC (all stages): these projects will be described precisely specifying the location, population targeted, main objectives and outcomes, financing, organisations responsible for implementation, contact person, etc.;	Is there or do you know of any project implemented for the sustainability of charcoal production? (at national level/ in the province) Do you think such a project would be successful if implemented in your province (if implemented in other provinces)? What benefits/advantages do you think such an initiative/project would bring? (for the different actors involved, population, environmental impact, etc.)

Interview guidelines for charcoal producers	
Profile	Name, M/F, main activity How long have you been producing charcoal? Where do you come from originally? Where did you learn the technique from?
Characterization of the activity (quantity produced, technology used, equipment, number of workers, structuring, legal status, etc.),	How long does the charcoal production process last? Please describe this process? How many charcoal kilns do you manage? (pictures/capacity/dimensions) How many people (employees, relatives) are involved in the assembly these kilns? How much firewood is normally used in a kiln?

	How much charcoal / how many bags of charcoal are usually produced in each kiln? How do you earn money from this activity? To whom do you sell the charcoal? What measure do you use for selling charcoal (kg or in bags)? What are the prices for each measure? How much can you sell per day/week/month? Is there any regulation or licensing system in place for the exercise of your activity? Do you have a licence or have you applied for one? If not, why not? Are women involved in this activity? If yes, what has been their role?
The area of supply of raw materials (species, geographical area, etc.),	What species of tree do you usually use for charcoal production? What is the range of tree diameter mostly used? Do you have any preference of tree species to produce charcoal? Characterisation of forests exploitation mode (corto razo, corto selective, etc.)
Identified obstacles and levers	Have you personally experienced, or have you or your colleagues experienced, any health problems associated with coal production activity? Have you had any accident while doing this activity? Does the rainy season have any impact on your business? How does it? What difficulties do you face in charcoal production? How do you overcome these difficulties? Any additional suggestions?
Prospects and improvements desired by the producers	Have you heard of modern methods of charcoal production? If yes, which methods have you heard of? Would you be interested in adopting these modern technologies? Why would you be interested in doing so?

	Have you been contacted by institutions or associations offering this type of technology? Have you heard of a project to improve charcoal production in the region?

Annexe 4. Interview's minutes

Província	Instituição	Focal point	Função	Contactos	Papel da instituição	Projectos passados/ Potenciais	Ações para sustentabilidade	Principais constatações
Tete	Serviço provincial de Desenvolvimento Territorial e Ambiente (SPDTA) 06/12/21	- Oscar Nicolau Zalimba; - Eng. Romão	- Diretor provincial - Técnico Florestal e de Fauna Bravia	- 42222652/ 872222652 - 840757254/ 877757254	Licenciamento da actividade de produção florestal, combustíveis lenhosos e materiais de construção assim como do manejo florestal; O processo de licenciamento de produção de carvão vegetal, começa o requerimento do proponente ao administrador do distrito na qual pretende produzir o carvão. Este requerimento, deve ser acompanhado por um relatório de auscultação das comunidades favorável. Por sua vez, o distrito emite uma solicitação de autorização ao governador da província, este por sua vez remete ao SPDTA para emissão da licença. A cota máxima licenciada é de 1000 sacos de carvão por licença por ano	- Promoção de fogões melhorados em Angónia; - A Mozambique leaf tabaco promove o reflorestamento em Eucalypto para produção de estacas para secagem do tabaco; - Em 2009 a 2014 houve implementação do projecto "Um líder uma Floresta" mas teve fracasso devido à falta de monitoria e assistência técnica às comunidades sobretudo no fornecimento de mudas ou eventual estabelecimento de um viveiro comunitário;	- Organizar os produtores de carvão em associações, - Financiar o reflorestamento comunitário; - A EDEN Reforestation promoveu a produção de carvão de vegetal com base em resíduos de processamento primário em algumas comunidades; - Treinamento em técnicas para melhorar o rendimento dos fornos/fornos melhorados	- Os principais mercados de comércio de carvão são Cambinde e Cuachena (cidade de Tete) e Moatize (cidade de Moatize) mas o carvão vegetal produzido em Tete abastece as cidades da Beira e Maputo sendo transportado via terrestre; - A instituição foi criada em 2020 pelo que ainda não possui uma base de dados amplo sobre volumes de carvão escoado/produzido e licenças emitidas ao nível da província; - Possuem constrangimentos financeiros, de

						- A associação EDEN Reforestation (com sede em Maputo) tem um projecto desenhado para reflorestar os distritos de Angónia e Tsangano mas ainda não tem financiamento para iniciar.		conhecimento, treinamento, e de pessoal. Actualmente a instituição possui apenas 3 técnicos sendo que o número ideal para melhor prestar o serviço seria de 9, isto é, défice de 6 por que o governo não está a contratar devido a exiguidade orçamental; - Não existe na província plantações com fins energéticos; - O uso de combustíveis lenhosos é inevitável pois devido à baixa renda de muitas familias fica difícil ter outras alternativas energéticas uma vez que essas exigem algum tipo de investimento inicial mas reconhecem que iniciativas para sustentabilidade na produção e uso

								de carvão são necessárias;
	Serviço Distrital de Infra-Estrutura (Inclui a Direção de MIREME) 06/12/21	- Portásio Aurélio - Eng. Hermínio Cumbane	- Chefe de departamento de Energia; - Chefe de departamento recurso minerais	- 846189532 876189532 - 444775698	Monitoria/fiscalização da actividade mineira. Ex: extracção dos recursos minerais	- Projecto de fogões (mistos de barro) melhorados iniciado em 1996/7 e financiado pela DANIDA. Foi implementado primeiro em Moatize seguido de Angónia, Tsangano, Marávia e Marrara. Em 2021 esse projecto ficou paralisado por falta de financiamento; - Projecto de produção de Biobriquetes ensaiado em 2018 em parceria com a JICA em Moatize na zona de reassentamento. Este projecto visava produzir briquetes de finos de carvão mineral em mistura com biomassa como resíduos da planta de milho; - Submeteram uma proposta de projecto à ENABEL,	- Continuação de treinamento das comunidades para estabelecimento de pequenas fabriquetas de produção de fogões melhorados. O custo de treinamento para 20 a 30 famílias situa-se entre 370 a 500 Mil Meticais repetitivamente.	O projecto de fogões tem necessita de maior monitoria das comunidades pois findo o treinamento não há acompanhamento para verificar a continuidade de usos desses fogões pelas comunidades. O custo de um fogão melhorado de barro está abaixo de 500Mt. Este fogão pode ser fixo ou móvel; - O projecto de biobriquetes carece de financiamento, mas não pode ser implementado sem o conhecimento da JICA

						mas ainda não tiveram resposta		
	Agencia Nacional de Controle de Qualidade (AQUA) 06/12/21	- Alferes Simbi	Delegado da AQUA na província de Tete	-	Fiscalização de exploração e transporte de recursos florestais (Madeira, lenha e carvão vegetal) e faunísticos	Nunca ouviu falar de algum projecto		Reportaram défice de pessoal para melhor executar o trabalho de fiscalização. A província possui 43 fiscais distribuídos em 17 postos de controle. Em média cada posto tem ficado 1 fiscal sendo que o ideal seria 3. Os demais fiscais têm estado na floresta a fiscalizar a exploração madeireira; - A AQUA controla apenas o volume licenciado, mas não observa o tamanho dos sacos; - Os dados coletados pela AQUA em 30 dias no ponto de controlo da cidade de Tete, mostram que em média a entrada de 300 sacos de carvão

								de forma legal sem, no entanto, saber quanto da carvão entra nos mercados da cidade sem ser registado; - Reportaram tendência de aumento da produção de carvão com o agravar do custo de vida (falta de emprego e pobreza; - A fiscalização é somente dos volumes licenciado e ao longo do transporte, mas não é feita na área de produção; - A cadeia valor de carvão típica é: Produtores- Compradores- Grossistas e consumidores
	Serviços Distritais de actividades Económicas	- Ana Berissone	- Administradora do distrito		- Monitoria/fiscalização da actividade florestal, - Manejo florestal	Existiu um projecto de fogões melhorados nos anos 2010-2020	- Projectos de reflorestamento que incluiriam a componente de	- O distrito não tem dados de número de licenças de produção de carvão existentes porque quem

	(SDAE) de Changara 07/12/21	- Alcides Vicente Zacarias	- Diretor Distrital				produção de mudas; - Revitalização dos comitês de gestão de recursos naturais (CGRN); - Criação de associações de produtores de carvão para melhor fiscalização da actividade	emite é a direção provincial; - Os 20% da taxa descontada aos madeireiros e produtores de carvão não são canalizados às comunidades; não se faz nenhum Maneio florestal
	Produtores de Changara (Foram entrevistado um grupo de 6 produtores) 07/12/21					Houve tentativa de sensibilização dos produtores para aderirem ao licenciamento da actividade, mas sem sucesso devido à pouca colaboração dos mesmos		- A produção de carvão leva em torno de duas sendo 7 dias para abate, transporte e construção do forno e os remanescentes para combustão; - Não conhecem e nunca ouviram falar de técnicas modernas de produção de carvão, nunca foram contatados por nenhuma instituição a respeito e nem dum projecto ligado a melhoria

								da produção na região mas afirmaram que estão disponíveis/interes sados em aprender novas técnicas; - Os custos relacionados a atividade incluem: compra de saco vazio (23Mt), Molho de palha para amarrar o saco (100Mt), transporte até a estrada (20Mt por saco) caso seja feita pelo produtor; - O preço de venda do carvão para grossistas no local de produção é de 80Mt o saco e na estrada; - Em média cada produtor faz 1 forno por mês, mas há interajuda entre eles para construção de fornos (este facto pode facilitar a formação de associação);

								Tem trabalhado mais entre membros da mesma família
	Quatro Grossitas do mercado Kambinde.							O carvão é adquirido no posto admonistrativo de Kambulatsitsi Distrito de Moatize, No distrito de Marrarra e Chiuta; - O transporte é rodoviário que custa em média 6 Mil o transporte de 6 sacos mas dependendo da distância esse valor tem variado entre 10 a 12 Mil meticas; - O grossita compra cada saco no produtor a um preço de 60 Mt e revende ao preço de 170 a 200 o saco de 25 kg e a 250 a 350 o saco de 50 KG; conseguem vender 5 a 7 sacos de carvão por dia - A época chuva encarece o carvão devido à

								dificuldade na sua obtenção e as vendas aumentam; - A taxa cobrada pela AQUA que é de 60 Mt por saco é um constragimento
	6 Retalhistas Mercado Khambinde							A venda é feita em montinhos a preço de 5 (mais requisitado), 10 e 20 Mt (dá mais lucro). Eles compram por dia 1 saco aos grossistas no próprio mercado
Manica	SDAE de Guro 07/12/21	- Eng. Machubo - Angelina Guilaze	- Chefe dos Serviços - Administradora do distrito	- 827191490		Nunca houve nenhum projecto relacionado ao uso de combustíveis lenhosos, mas já ouviram falar de projectos de fogões melhorados implementados em outros locais	- Projectos sócias para diversificar a renda familiar como: Pecuária e Agricultura; - Sensibilização contra o abate sem reposição/reflorestamento	A produção de carvão no distrito iniciou a dois anos promovida pelas populações vindas do distrito de Changarra, Até o momento não se faz nenhum licenciamento de carvão (potencialmente seria ideal implementar esse projecto onde a produção é incipiente,

								facilitaria a organização); - O distrito já possui um viveiro, mas não operacional por falta de insumos (vasos e sementes); - O agravamento da taxa por saco de 1.5 para 60 Mt cria um constrangimento para grossistas
	Produtores de Guro (dois entrevistados)							- Alegam ter iniciado a produção de carvão a 6 meses, eles vinham se dedicando a produção agrícola e animal; Nunca ouviram falar de outra técnica de produção sustentável de carvão, não tem licença, nunca foram contatados por nenhuma instituição, mas estariam interessados em

								aprender novas técnicas; - A produção dura em média 15 dias - Vendem o carvão na via pública ao preço que varia de 200 a 250
	Serviços Provincias de Ambiente	Maquias Santos Chiutano	Chefe de departamento de florestas		Licenciamento da actividade florestal	Nunca houve projectos, mas que existe actualmente no distrito de Sussundenga uma fase piloto de projecto de reflorestamento	Fazer um estudo sócio-económico para entender a motivação para produção de carvão; - Projectos sociais de criação de renda extra alternativa à produção; - Projectos de reflorestamento	- A instituição não tem dados sobre produção de carvão vegetal; - A produção de carvão está a se alastrar para os distritos de Bárue e Catandica; - Há défice orçamental para compra de insumos
	Departamento de florestas dos Serviços Provinciais de Desenvolvimento Territorial e ambiente (SPDTA)	- Eng. Chibite - Eng. Dilton	- 844041205 - 845811293	-Chefe de Dpto - Director Provincial do SPDTA		A RADEZA, implementou um projecto de formação/capacitação dos produtores de carvão para melhor gestão do recurso florestal. Projecto implementado no distrito de Maganja da costa localidade	- Massificar as associações de produtores de carvão	- Verifica-se actualmente o uso de mangal para produção de carvão (de baixo custo), todavia a conservação do mangal está sob tutela do Ministério do mar águas interiores e pescas;

						de Cariua (contacto: 842975393 – Daniel Maula) - 2007/8 existiu o programa PRONEMAF com financiamento Finlandês e visavam o reaproveitamento de resíduos de processamento de madeira para produção de carvão		- há desafios de reflorestal essas essas de mangal
Zambézia	SDAE do distrito de Namacura	Betino José	-866089871	- Chefe do SDAE		- A Associção Eden Reforestation iniciou em 2021 no distrito, um projecto de reflorestamento com eucalupto na localidade de Malei, povoado de Modo; A FAO já interviu no distrito para questões de segurança alimentar	- Projecto para fomento de cultura de cajoeiro e de palmeiras. O SDAE já possuem um viveiro onde podem ser produzidas as mudas e fornecidas as comunidades. Essas culturas são estratégicas para servir de fonte alternativa de renda diferente do carvão. Outrora o distrito foi grande produtor	Existe uma associação VURUKA, cita na localidade de Mali, distriro de Namacurra (contacto do responsável- 849230150 –sr. Paulo). Esta associação carece de um estatuto. Todo jovem da localidade faz parte da associação, o líder nem sequer soube dizer o número de membro da "associação". Eles produzem carvão continuamente ao

							de coco mas devido a doença de amarelecimento letal do coqueiro, grande hectares dessa planta foram dezimadas - Também pode se treinar as comunidades na produção de mudas através de impelemtaçõ de viveiros comunitários	longo de todo ano mesmo em períodos de defeso florestal. Nenhuma autoridade de estado, ONG, etc já visitou a área de produção de carvão de Vuruka. A principal função dessa associação é de fazer o controlo de eventuais produtores invasores externos à localidade. Mostraram interesse em adoptar ou receber treinamento em técnicas modernas de produção de carvão mas ainda não tiveram nenhum contacto com alguma instituição seja pública ou privada a introduzir essa abordagem; Os custos envolvidos na produção incluem a compra de catana (150 Mt), enxada usada em média 2 anos (200 Mt); Machado usado

								em média 1 ano (500 Mt)Vendem o carvão a 100 Mt cada saco na fonte (o grossista traz o saco vazio) e a 140 na estrada (nesse caso compram o saco vazio a 40-45 Mt). Como dificuldade reportaram a necessidade de se estalar um viveiro comunitário para fazer o reflorestamento; enfrentam também a dificuldade de retirada do carvão dos locais de produção; Não há outra fonte alternativa mais rentável que o carvão na localidade, a agricultura pratica-se apenas para consumo familiar
	AQUA	Eng. Caetano josecaetanoeugênio@gmail.com	842379847	Chefe do Dpto de fiscalização Ambiental			Desenhar e financiar projecto para mapear as zonas de produção de carvão (dados	- A instituição tem técnicos qualificados para implementar esse projecto;

							como local, tipo de produção, fiscalização do tipo de epécies usadas etc); - Projecto que promove maior interação entre a AQUA e os comitéis de gestão de gestão de recursos ao niveil das comunidades	

Síntese do encontro com os representantes das delegações da Agência de Desenvolvimento do Vale do Zambeze abreviadamente designada por Agência do Zambeze

Principais áreas de atuação estratégicas da Agência:

1. *Educação* – Criação de centros de formação e financiamento a formação de docentes e estudantes;
2. *Agricultura* – Apoio aos governos locais no aprimoramento de técnicas de cultivo;
3. *Ordenamento Territorial* – Apoio aos governos locais na incorporação da componente de ordenamento territorial; e
4. *Infraestruturas* – Apoio na construção de infraestruturas socioeconómicas;
5. *Indústria* – Apoio à população do vale do Zambeze na construção de indústrias extrativas e de produção;
6. *Energia* – Apoio aos governos locais através da criação de estações de transformação de energia para uso doméstico e industrial;
7. *Comércio* – Organização de férias e fórum para a exposição e comércio de produtos agrícolas;
8. *Turismo* – Apoio na construção infra-estruturas turísticas ao redor do vale Zambeze.

Os objectivos de atuação incluem:

- A realização de estudos e apresentação de estratégias para o desenvolvimento económico e social na parte nacional da bacia hidrográfica do Rio Zambeze;
- A assistência técnica–financeira às iniciativas de desenvolvimento económico e social na parte nacional da bacia hidrográfica do Rio Zambeze, incluindo a mobilização de recursos e sua canalização aos beneficiários;
- Assistência aos Governos Locais na incorporação das componentes de planeamento e ordenamento territorial e do desenvolvimento socioeconômico local.

Delegação do Zambeze

- Charles Parreirão (878863334) – Coordenador da agência ao nível da Zambézia;

- Revés Meneses (865279106)

Principais constatações:

- Existe uma iniciativa piloto da empresa Pedra-Pedra LTD, para aproveitamento da serradura resultante do processamento da madeira de coqueiro para produção de briquetes, com arranque previsto para o mês de Março. A empresa situa-se junto à Universidade Licungo (Cidade de Mocuba) e encontra-se na etapa de importação dos equipamentos;
- A delegação da AvZ não tem nenhuma ligação com a empresa mas ajuda a empresa na logística para participação na féria nacional vulgo FACIM, através do apoio no transporte e alojamento;
- Há enorme preocupação com o corte de mangal para produção de carvão vegetal;
- Esta delegação é mais operativa, toda planificação estratégica e de ações é feita na delegação de Tete;
- O CVC é da prioridade da AvZ mas ainda não há estudos/projectos a vista;
- Até o momento, a AvZ não tem nenhuma intervenção na CVC apesar desta ter como uma das principais áreas de actuação a Energia conforme relatado acima;
- Como medida para melhorar o CVC sugere a organização de produtores em Associação, desenvolvimento e /ou introdução d novas técnicas/ métodos de produção de carvão;

- A agência trabalha com 14 comunidades na província de Zambézia, 4 Comunidade em Manica e 8 em Sofala;

Delegação de Tete

- Eng. Pedro Baúte (875273066) oficial de ligação entre o produtor e a industrias para facilitação de negócios

Principais constatações:

Houve uma recomendação para o envio da nota oficial à Direção geral de modo a obter mais informação estratégica sobre como seria o papel e intervenção da AvZ na CVC;

- Fez menção da existência do projecto de produção de biobriquetes liderado pelo MIREME. Nesee projecto, a AvZ fazia acompanhamento e auxiliava no zoneamento das áreas desmatadas pea extração mineira (carvão mineral);

- Considera a actividade de produção de carvão vegetal uma alternativa à produção agrícola e reconhece que esta actividade causa desmatamento que por sua vez impacta a agricultura com a ocorrência das mudanças climáticas;

- O papel da AvZ em um projecto na CVC seria de (i) coordenação das actividades e (ii) assistência técnica em agronegócios e todas áreas de desenvolvimento comunitário. Todavia, nunca houve iniciativa implementada pela AvZ para a sustentabilidade da CVC

Annexe 5. Contact list

Province	Institution	Ponto focal	Fuction	Contact
Tete	Provincial Territorial Development and Environment Service (SPDTA)	Oscar Nicolau Zalimba	Provintial director	42222652/ 872222652
		Eng. Romão Band	Forestry and Wildlife Technician	840757254/ 877757254
	District Infrastructure Service (Includes MIREME Directorate)	Portásio Aurelio	Head of Department of Energy	846189532 876189532
		Eng. Herminio Cumbane	Head of Mineral Resources Department	844775698
	National Quality Control Agency (AQUA)	Ensign Simbi	AQUA Delegate in Tete Province	
	Changara District Services for Economic Activities (SDAE)	Ana Berissone	District Administrator	
		Alcides Vicente Zacarias	District Director	876458188
	Agência de Desenvolvimento do Vale do Zambeze	Eng. Pedro Baúte	Liaison officer between the producer and the industry for business facilitation	875273066
Manica	Guro District SDAE	Machubo Engineer	Head of Services	827191490
		Angelina Guilaze	District Administrator	
	SPDTA	Santos Chiutano Machines	Head of Forest Department	842980490
Zambezia	Namacurra District SDAE	Benito José	SDAE Director	866089871
		Paul	Leader of the Vuruka Charcoal Producers Association	849230150
	District Infrastructure Service (Includes MIREME Directorate)	Almerino	Energy sector technician	879967525
	Zambezia SPDTA	Booth	Head of Forest Department	844041205
		Dilton Oliveira	Provincial Director	845811293

	AQUA	José Caetano	Head of Inspection Department	842379847
	Agência de Desenvolvimento do Vale do Zambeze	Charles Parreirão Revés Meneses	Agency coordinator at Zambezia level	878863334 865279106

Annexe 6. Past and Ongoing projects in Mozambique

CICS's micro-cluster Implemented by: FUNAE/ SNV/GIZ Period: 2012-2015 Targeted area: Province of Maputo Period:	Working in the development of CICS's micro-clusters within the Maputo Province, FUNAE and SNV are improving local capacity to produce and distribute JICO/Mbaula; Through a key partnership with GIZ, Livaningo and Kulima, SNV will leverage its ongoing activities in this sector promoting access to 20.000 CIC'S and benefiting over 100.000 people by 2015.
Sustainable biomass out-growers project Implemented by: Solidaridad Southern Africa Period: 2012 Targeted area: Sofala Province	One of the objectives is to create a value chain for the commercialization of renewable charcoal as a substitute for the conventional biomass fuels currently sold in the markets. 5 000 Households were targeted for the pilot phase,
Efficient and Clean Cooking for Mozambican Low-Income Households Implemented by: MozCarbon	The project aims to achieve four main goals: - Reduction of greenhouse gas emissions through decreased consumption of biomass from better combustion and energy efficient-stoves; - Decrease pressure on forests and thus diminishing forest degradation and deforestation due to reduced charcoal consumption by households; - Tackle household indoor air pollution and promotion of a safe and clean cooking environment thus reducing death rates from respiratory diseases such as asthma which kills approximately 13,000 people a year in Mozambique (mostly women and children). - Promotion of socio-economic benefits for the population due to reduced charcoal use (and cash) to meet cooking energy requirements and creating job opportunities for local people during the distribution of these stoves.
Improved cookstoves in Chamanculo C, Maputo Implemented by: CarbonSink / Co2balance Period: 2014 Targeted area: Maputo	Distribution of approximately **5,000 domestic fuel-efficient cook stoves** (Envirofit CH-2200 cookstoves) to households within Chamanculo C. The goal of the project is to improve energy efficiency, conserve natural resources and improve living conditions for the local population.

Mozambique Improved Cooking Solutions Initiative Funded by: SNV Period: 2015-2017 Targeted Area: Maputo P.	The objective of the project was to establish local production and commercially viable supply chains for selling improved cookstoves in Maputo province. 32 500 ICS have been distributed.
Mozambique Energy Development and Access Project [42]– Woodfuel sub-component Funded by: World Bank/MIREME Period: 2010-2017 Budget only for woodfuel sub-component: 4 M USD	The objective was to increase access to modern energy in peri-urban and rural areas, thereby facilitating improved quality of life of the respective communities and generating income. One of the project's three components is about investment on rural and renewable energy, which has a subcomponent on woodfuel, i.e. promotion and dissemination ofm improved wood fuel stoves for use in the household and small and medium enterprise (SME) sectors, introduction of improved charcoal kilns, and support to inter-fuel substitution for traditional biomass in households and institutions such as schools, clinics, etc. **Activities related to improved charcoal kilns and inter-fuel substitution for traditional biomass were cancelled. Demonstration projects to accelerate market penetration of renewable energy technologies were also cancelled. ICS distribution was downsized from 50,000 to 4,000 units.**

On-going initiatives

Mozambique Dedicated Grant Mechanism for Local Communities Project (MozDGM) Funded by: World Bank / WWF Period: 2018 – 2023 Amount:4.5M USD	The objective is to strengthen the capacity of target communities and community-based organizations to participate in integrated landscape management. Among other activities, MozDGM implement capacity building of communities and CBOs in integrated landscape management; grants to be awarded for community subprojects that include Non-Timber Forest Products (NTFP) production and business development, alternative incomes to illegal harvesting of trees or charcoal, etc.
"Florestas em Pé" Program Ministry of Agriculture and rural development / Fundo Nacional de Desenvolvimento Sustentavel Period: 2016 – 2026	The project provides funding for the certification of 50 forestry concessions, the training of 800 protection inspectors, the construction of 5 inspection camps, the distribution of 12,000 beehives to 800 beekeepers' associations, the installation of 20 honey processing units, the funding of 20 district carpentries, and the opening of 20 tree nurseries. *MozFIP is part of the program*

[42] https://documents1.worldbank.org/curated/en/157701526683577615/pdf/Mozambique-MZ-Energy-Dev-Access-Project-APL-2.pdf

R**enewable Charcoal Energy for Maputo (REFORMA)** Implemented by: Universidade Eduardo Mondlane (UEM), UK Funded by: Government's Foreign, Commonwealth & IDRC/CRDI (Development Office and the International Development Research Centre) Period: On-going Targeted area: Province of Maputo	O1: To learn how villages can proactively make the most of the opportunities offered by the wood fuel sector, and mitigate its environmental and social impacts. To do this, Activity 1 - will help three villages prepare for the arrival of the charcoal boom, by facilitating i) experiential learning with villages currently experiencing the "boom" or a recent "bust", and ii) participatory land use planning and the development of social capital at village and district level. The learning from this activity will be analysed to allow wider impact and upscaling. O2: To develop a regional plan for the wood fuel sector to ensure sustainable harvest and reduce deforestation and degradation and associated carbon emissions. Activity 2 will do this by building capacity at provincial and district level to use the tools ACES developed, to i) map the woody biomass resource, ii) estimate its sustainable harvest, and iii) develop a regional plan for permit allocation. Together with partners in national government, we will develop a long-term plan to learn from this and expand the approach to other areas in Mozambique with an active wood fuel sector.
Clean energies in the context of climate change" Project Implemented by: Livaningo Period: 2017-2021 Targeted area: Province of Maputo	Whin the framework of the Empowering Community programme sponsored by Naturvernforbundet, the project includes promotional actions and capacity building for the manufacturing of improved cook stoves. It targets six districts in Maputo Province (Boane, Moamba, Namaacha, Manhiça, Maputo City and Magude). Livaningo has also been acting as an intermediary/facilitator of Community Based Organisations and small craft industries on the sale of ICS. The NGO finds selling markets.

Very few projects have been developed in the Mozambican part of the ZRB. One important project is directly involving charcoal producers, in Zambezia Province:

Mozambique Forest Investment Program (MozFIP) Funded by: World Bank / Government of Mozambique Period: 2017-2022 Amount: 47M USD	MozFIP seeks to promote sustainable biomass energy; land delimitation, planning and tenure regularization; and establishment of new planted forests and agroforestry areas. A key component is that MozFIP will promote small-scale forest plantation for commercial purposes through performance-based grants to smallholders. The Project aims to stimulate entrepreneurial programs through the planted forest grant scheme, agroforestry systems that are linked to the market, community-based forest management, and smallholder charcoal production. The project targets 160 communities in nine districts in Zambezia and seven districts in Cabo Delgado.

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