NL Agency
Ministry of Economic Affairs, Agriculture and Innovation

Sustain-able Biomass

Making charcoal production in Sub Sahara Africa sustainable

>> Focus on energy and climate change

Making charcoal production in Sub Sahara Africa sustainable

Colofon

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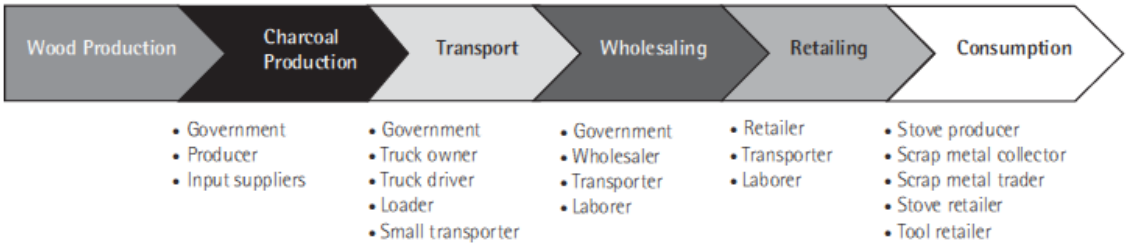
Executive summery

Between the countries in Africa there are many similarities in the way the charcoal sector is structured. This report analyses how charcoal production in Africa can be made sustainable, by assessing bottlenecks and possible solutions.

Characteristics of the charcoal sector
The charcoal value chain is complex, comprising a wide range of actors and operators with varying interests and stakes (illustrated in the Figure below).



Beneficiaries in the charcoal value chain - example from Tanzania

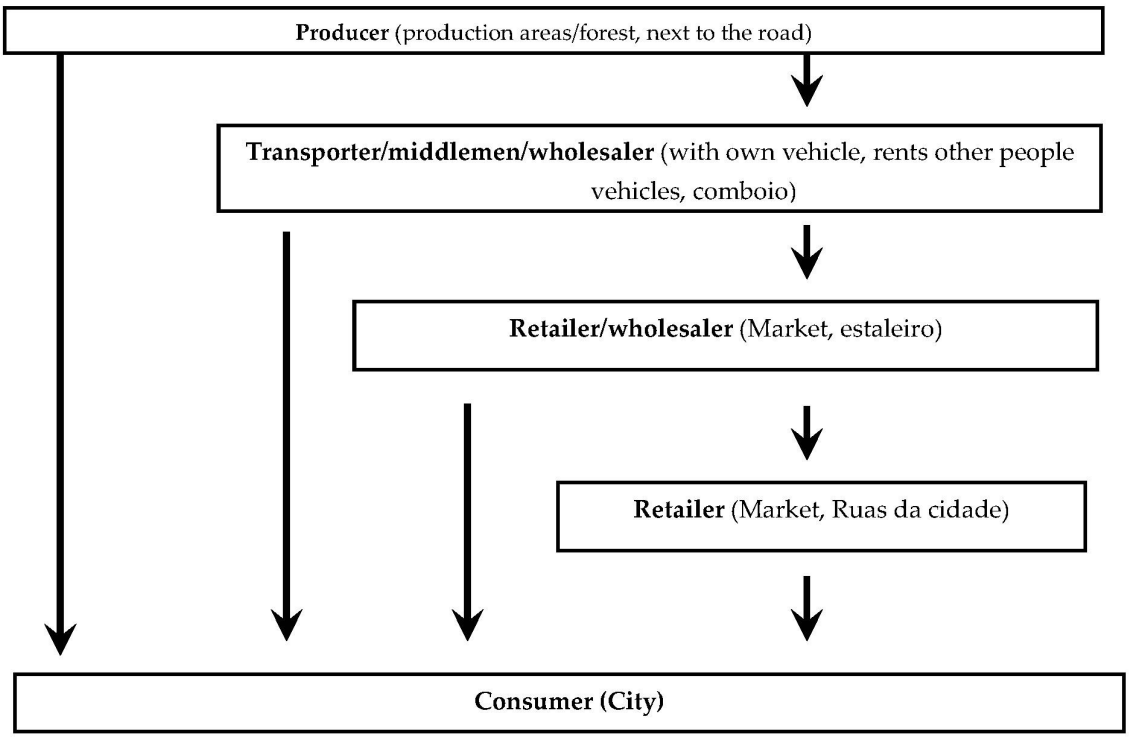
The main technical, socio-economic and environmental issues in each step of the charcoal value chain have been described: fuelwood production and harvest, charcoal production, charcoal logistics and trade (comprising transport, wholesaling and retailing), and charcoal uses (in particular as household fuel for cooking and heating).

Charcoal is primarily produced in forested areas surrounding urban centres. Wood is harvested from these areas through clear felling, selective cutting or from purposely grown plantations. The harvested wood is converted into charcoal in a batch-type process. Traditionally, earth or mound carbonisation kilns with relatively low efficiencies are applied. Often some sort of charcoal licensing system is in place but in practice in many countries the bulk of charcoal production is undertaken without official licensing, and charcoal is transported and traded clandestinely.

In general the charcoal producer (which can be either a professional or occasional producer) brings the charcoal in bags to the roadside from where the charcoal is transported by truck, other motorized vehicles or by bicycle to urban centres. Depending on the local situation there will be different degrees of vertical integration in the charcoal supply chain. The figure below illustrates the supply chain for Maputo (Mozambique).

For many of the operators across the value chain, charcoal offers a meagre income, which may not reach the minimum (urban) wage. Even most of the wholesalers (the category that tends to earn the most in the charcoal business) don’t always earn very high incomes.

Charcoal supply chain for Maputo, Mozambique



For many urban households, even those that are not poor, charcoal provides a reliable, convenient and accessible source of energy for cooking at a stable cost, and in many African countries the majority of urban households depends (at least partly) on charcoal for their daily energy needs. Continuous urbanisation and population translates in ever increasing charcoal demand, and the economic importance of the charcoal sector is substantial. In the larger African countries, hundreds of thousands of people earn their livelihoods to charcoal.

(Sustainability) issues in the charcoal sector

Charcoal production has far-reaching impacts extending across a range of social and environmental issues. These include health problems of charcoal producers associated with air pollution, environmental change associated with greenhouse gas emissions and the depletion of local forests and woodlands, and social problems related to migration, labour and gender. The table at the end of chapter 3 (reprinted below) links the charcoal sector issues with the Cramer Criteria for sustainable biomass production.

The problems identified in the charcoal sector rarely arise as a result of charcoal production alone. Rather, they are the result of complex relationships between charcoal producers and consumers, the environment, and the larger political economy.

Since charcoal cannot be easily replaced in the short term with alternative energy sources that are comparably affordable, policy measures are needed that aim at making charcoal production and use more sustainable while avoiding to push the

price of the product to a level that is prohibitive for poorer consumers. Since the environmental and social impacts of charcoal production, trade and consumption are extensive and intertwined the issues in the charcoal sector need to be addressed in a holistic manner, looking beyond a single intervention along the value chain. Isolated interventions (reforestation, sustainable forest management, improved stoves) will fail to exploit adequately possible synergies that would, if combined, make them sustainable.

Issues related to the charcoal sector classified along the Cramer sustainability themes

Step	Sustainability theme	Issues
Step 1: Forest resources production and harvest	GHG balance	Unsustainable harvest leads to increased GHG-emissions.
	Biodiversity	Over-exploitation of species with good charcoal properties and of forest resources especially near urban centres
	Environment	Deforestation; in low-rainfall areas over exploitation can accelerate desertification
	Food versus fuel	In general no competition with land for food. Possible if plantations are employed on agricultural land
	Local prosperity	Low income from wood collection, often performed by women
	Local welfare	Hard work for low income; serves as extra alternative income
Step 2: Charcoal production	GHG balance	Low conversion efficiency increases environmental impact incl. GHG balance of whole supply chain.
	Environment	Emissions of smoke: local air pollution and low greenhouse gas balance; low conversion efficiency increases environmental impact of the whole supply chain
	Local prosperity	Low income, weak negotiation position toward traders
	Local welfare	Poor labour conditions: inhalation of toxic smoke and charcoal dust
Step 3: Transport and trade	GHG balance	Increased transport distances, leading to higher energy use and GHG emissions
	Environment	Increased transport distances, leading to higher energy use and emissions
	Local prosperity	Most benefits in transport and trade (on the costs of other beneficiaries in the supply chain)
	Local welfare	Charcoal dust emissions
Step 4: End use	GHG balance	Efficiency charcoal stove sub optimal, leading to higher demand for charcoal and subsequent GHG emissions
	Environment	Ash is not recycled (however, this happens almost nowhere in the world)

	Local prosperity	Changing charcoal price affects the poor more than the rich.
	Local welfare	Reliable source of energy for the poor and less poor users

Note: Biodiversity and food-versus-fuel issues mainly relate to Step 1 and therefore are not covered in Step 2-4.

Lessons learnt intervening in the charcoal sector

Based on literature analysis and interviews with actors in the field, lessons can learnt from past interventions of governments, development agencies and civil society organisations aimed at making charcoal production across Africa more sustainable. A special effort has been made to focus on the more successful interventions. The lessons learnt are discussed along the steps of the charcoal value chain, as follows:

- Production and harvesting of fuelwood
- Production of lump charcoal and of direct substitute fuels
- Modernisation and professionalisation across the entire value chain
- Reduction of charcoal end-use
- Policy interventions

For each step, the lessons learnt are first introduced, followed by several illustrative examples and case studies, and rounded off with short conclusions and recommendations.

On the production of fuelwood, the report presents forest management examples covering Senegal, Madagascar, Rwanda and South Africa respectively. One of the key lessons is that security of tenure (property rights) is a key factor that determines whether participatory forest management succeeds or fails.

Regarding the production of lump charcoal, it is concluded that the efficiency of the traditional earth kiln, if properly tended, is comparable to that of improved kilns. Critical factors are the operational and supervision skills of the charcoal producer, the moisture content of the utilized wood, and the woodfuel species used. The development and promotion of low-cost improvements to the traditional earth kiln design and the training of charcoal kiln operators aimed at applying these improvements is called for.

Concerning the production of direct substitute fuels, the main challenge is of an economic nature. The viability of producing direct substitute fuels for lump charcoal strongly depends on the prices for charcoal. Business prospects are the best when woodfuel is in shortage and woodfuel prices are high. Another approach is the development of non-biomass fuels such as paraffin and LPG. The latter is of particular interest when countries have their own natural gas sources, as is e.g. the case in Mozambique and Tanzania.

Modernisation and professionalisation of the charcoal value chain requires stakeholders to move into the formal sector. Formalisation will provide greater security for producers and traders, which will in turn encourage longer-term investments designed to increase efficiency and sustain supply. As experience from Sudan shows, the charcoal sector can be formalised by the creation of professional charcoaling groups in the form of self-regulatory associations,

cooperatives or private firms. To be effective, strong political support -both within government and the political system – is a must for formalisation.

Reduction of charcoal end-use can be achieved by promoting more efficient charcoal stoves. Across Africa, the introduction of improved charcoal stoves has also often failed to achieve the intended result of dramatically reducing charcoal consumption. For a wide range of varying reasons (including political, social and economic obstacles), few improved charcoal stove programmes have been successful. A positive exception to the rule and deserving multiplication is the improved Kenya Ceramic Jiko (KCH) stove. As recent experience in Tanzania and Chad has confirmed, the outright banning of charcoal is a counter-productive practice that should not be replicated. Rather than reducing charcoal demand the only sustainable effect has been a steep increase in charcoal price.
Over and above the measures discussed above, policy measures are needed that aim at making charcoal production and use more environmentally sustainable while avoiding to push the price of the product to a level that is prohibitive for poorer consumers. Since the environmental and social impacts of charcoal production, trade and consumption are extensive and intertwined an integrated view is essential in policy making. Isolated interventions fail to exploit adequately possible synergies that would, if combined, make them sustainable.

The report concludes with recommendations in which areas NL Agency's Netherlands Programs Sustainable Biomass could support making charcoal production in Africa more sustainable. It presents some ideas for pilot demonstration projects demonstrating that sustainable charcoal production can be practiced, for field studies and for information exchanges.

1 Introduction

1.1 Background

The Global Sustainable Biomass Fund supports developing countries in making their biomass production for energy uses sustainable. The Sustainable Biomass Import programme aims to stimulate, support and facilitate the promotion of sustainability of the production, processing and import of biomass produced abroad, leading to the application of biomass for energy, transport or chemical purposes in the Netherlands. NL Agency (formerly SenterNovem) implements both programmes.

In 2009 and 2010 some 45 pilot biomass sustainability projects have been awarded grants with a total value of 20 M€. An accompanying programme aims to feed these pilot projects with information, to learn from the experience gained in pilot projects, and to fill up possible gaps in the overall programme coverage.

An assessment of the stock of pilot projects contracted to date by NL Agency learnt that there are indeed a number of such gaps. One gap concerns making charcoal production in Africa more sustainable. Although the topic was covered in some of the proposals applying for a programme grant, the proposals were considered of insufficient quality to warrant their approval. Therefore NL Agency has commissioned BTG to carry out this study on making charcoal production in Sub-Sahara Africa sustainable.

1.2 Purpose and scope

To assess the bottlenecks and the possible solutions with regard to making charcoal production in Africa sustainable (with a special focus on South Africa, Mozambique and Tanzania).

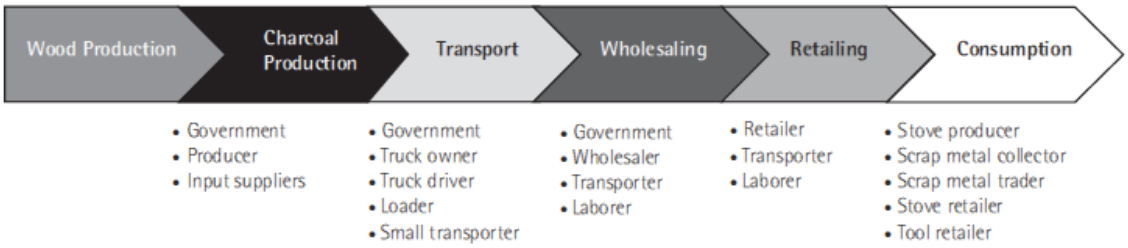
1.3 Guidance for the reader

The reports starts with a general introduction (chapter 2) describing the general characteristics of the various steps in the charcoal value chain, from fuelwood harvest, via charcoal production and transport & trade to end-use. Attention is paid to the main technical, socio-economic and environmental aspects. The chapter also includes a discussion of the economic relevance of the charcoal sector across Africa. In chapter 3 the main (sustainability) issues related to the charcoal sector are described. These issues are subsequently linked with the Cramer Criteria for sustainable biomass production. Chapter 4 is devoted to discussing the lessons learnt from past interventions of governments, development agencies and civil society organisations. The emphasis is on presenting a selection of the more successful interventions, and the lessons that have been drawn from these interventions. Based on the lessons learnt recommendations for future involvement of NL Agency are formulated in chapter 5.

2 Characteristics of the charcoal sector

The structure of the charcoal value chain (see Figure 1) is complex, comprising many different actors with varying interests and stakes.

Figure 1: Beneficiaries in the charcoal value chain. Example from Tanzania. Source: WB 2009.



This chapter describes common elements of the charcoal sector that apply in most Sub Sahara African (SSA) countries, from fuelwood production and harvest up till final charcoal consumption. Attention is paid to technical, socio-economic and environmental aspects.

2.1 Fuelwood production and harvest

In Africa almost all charcoal is produced in rural areas, especially in forested areas surrounding the urban centres. The radius of the area from which the raw materials are collected is steadily increasing with charcoal makers needing to travel progressively further to obtain the resources needed. However, travel distances to these sources vary significantly between regions and locations (Beukering et al 2007).

Three main types of wood harvesting can be distinguished of which the first two dominate:

I. Clear felling of forestland for agriculture purposes and subsequent carbonization of the felled trees
II. Selective cutting done by the charcoal makers who aim at generating income from charcoal.
III. Harvesting from dedicated plantations, which is not common in most Sub Saharan countries with the exception of South Africa.

2.1.1 Clear felling of forestland for agricultural purposes

The production of charcoal is often a by-product of other economic activities, such as the clearance of land for agriculture. A common practice when a farmer wishes to clear a new area for agriculture is to invite charcoal producers to clear all woody biomass in a given area in return for the rights to produce and market charcoal resulting from the clearance process (WB, 2009).

2.1.2 Selective cutting

Selective cutting means that certain trees that provide good quality charcoal are selected and cut for charcoal production. Preference and suitability of trees used for charcoal production varies with size, availability and accessibility of the tree species. Large tree species (>20cm diameter) with high caloric values are the

most preferred, due to the large quantity of dense and hard charcoal they produce (Beukering et al, 2007).

2.1.3 Harvesting from plantations

Harvesting biomass from dedicated plantations is the most sustainable option to acquire the raw materials needed for charcoal production. However this is also the most expensive option compared to clear felling and selective cutting in which cases the biomass is available at (close to) zero opportunity costs.

2.2 Charcoal production

Charcoal can be produced from wood and other biomass types in a process called carbonisation. Carbonisation is the method of burning wood or other biomass in the absence of air after which it breaks down into liquids, gases and charcoal.

Charcoal is traditionally produced in earth, brick or steel drum kilns in batches from about 1 to 5 tons. Common kiln types and production methods are detailed in e.g. (FAO, 1983) and (Foley, 1986) and more recently in (UNDP, 2010). Fuelwood is gathered and cut to size, and placed in an underground or above ground kiln. The kiln is fired and the fuelwood heats up and begins to pyrolyse. The kiln is mostly sealed, although a few air pockets are initially left open for steam and smoke to escape. As the kiln emissions change colour, the charcoal producer may seal some air pockets. The production process may take up to a few weeks. About half of the energy in the fuelwood is typically lost in the process (but the charcoal produced has higher energy content per unit mass). When the process has ended, the kilns are opened or dug up and the charcoal is removed. The resulting charcoal resembles smaller, lighter pieces of blackened wood. These will have higher energy content by weight than fuelwood (Kammen and Lew, 2005).

Figure 2: Female charcoal producer in Zambia (b) Traditional mound kiln in Liberia
Sources: (a) Climate Interchange (b) BTG Biomass Technology Group BV

In Africa, a limited number of people consider charcoal production to be their main economic activity, while a majority engage only occasionally as a means to generate income, particularly in times of financial stress, such as when making large payments for things such as medical costs, funeral expenses, food supplies

in the event of poor harvests, marriage ceremonies, or school fees. Cash income from charcoal may act as a form of insurance against crop failures (FAO, 1983).

2.3 Charcoal marketing

In general the charcoal producer brings the charcoal in bags to the roadside from where it is transported by truck, other motorised vehicles or by bike to the urban centres. Charcoal producers are often contracted by wholesalers or transporters, but they also work and sell their products individually. The majority of charcoal is sold to large- or small-scale transporters. Some large-scale transporters are also wholesalers. These wholesalers then pass the charcoal on to smaller-scale retailers and consumers (WB, 2009). The retailing of charcoal offers trade opportunities for many people, in particular women.

Figure 3: Charcoal picked up at the roadside (b) Charcoal retailers in Accra, Ghana
Source: Wisdom Ahiataku-Togobo (Ministry of Energy, Ghana)

Depending on the local situation there will be different degrees of vertical integration in the charcoal supply chain. Figure 4 illustrates the charcoal supply chain for Maputo.

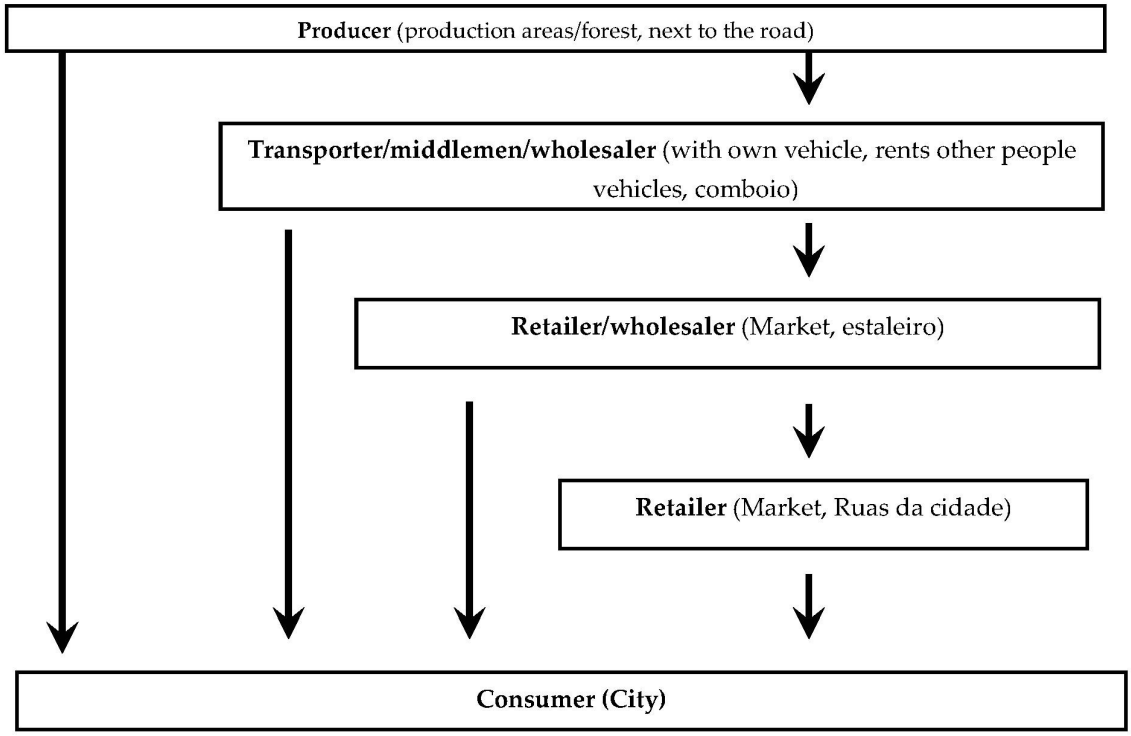
In general the charcoal supply chain in African countries is very reliable, typically much more reliable than e.g. electricity supply (TaDEDO, 2010).

2.3.1 Formal versus informal supply chains

Charcoal logistics and trade can be divided into a formal and an informal commercialisation chain:

- The "formal" commercialization chain begins with the harvesting of wood to produce charcoal. The product is transported and traded by officially licensed transporters and traders, who pay the necessary duties and taxes.
- The "informal", usually much larger, commercialization chain is undertaken without official licensing. Charcoal produced through the informal chain is transported and traded clandestinely in an attempt to avoid authorities, taxation, and penalties. Both in Tanzania and Mozambique the fast majority of charcoal arriving in the country's capital is believed to follow this second path (Malimbwi et al, 2007; Puná, 2008).

Figure 4: Charcoal supply chain for Maputo, Mozambique.
Source: Puná, 2008.

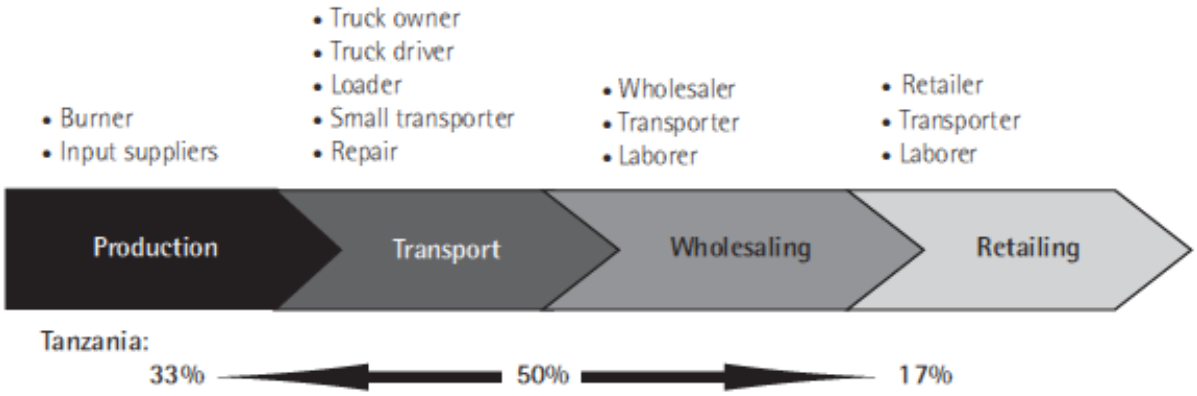


2.3.2 *Income distribution among the charcoal supply chain*

Case studies carried out in e.g. Tanzania, Mozambique, and Malawi looked at the sales prices and profit margins captured by the various operators across the value chain.

- In Tanzania, on average, producers are able to capture around one-third of the final end price of charcoal, with transporters-cum-wholesalers capturing around half. Retailers capture only one-sixth of the retail price (WB, 2009), see Figure 5.
- In Mozambique, the charcoal business proves to be likewise more profitable for transporters than for producers and retailers. Producers' net income can be between 2400 and 3600 Mt/month (~100-150 USD/month), or about two times the minimum wage in Mozambique. Wholesalers may get incomes between 3650 and 12,200 Mt/month (~ 150-750 USD/month), which is (substantially) more than producers' net income. Retailers get an income that varies between 480 and 1350 Mt/month (~ 19-54 USD/month). Thus, the profit margin for retailers may not exceed or not even reach the minimum urban daily wage (Puna, 2008).
- In Malawi, the distribution seems somewhat more equal, with values accruing to producers ranging from 20% to 33% of charcoal retail price, to transporters from 20% to 25% and to retailers from 25% to 33% of final selling price, according to (Kambewa et al, 2007).

Figure 5: Distribution of profits along the charcoal value chain
Source: WB, 2009.



The distribution of income along the charcoal chain can vary considerably between countries. (Ribot. 2007) investigated the distribution of benefits from charcoal from its origin to end-use in Senegal. He found that how profits are distributed over the various stakeholders depends strongly on the degree of market access control that stakeholders command. At the time of his research, urban merchants held a tight grip on the market, and their average annual profit was at least a factor 9 higher than that of other stakeholders in the commodity chain. According to (Ribot, 2007), factors that contributed to the oligopolistic position of urban merchants included: control of labour opportunities, control of market access and leverage over prices.

2.4 Charcoal end uses

For many urban poor, charcoal provides a reliable, convenient and accessible source of energy for cooking at a stable cost. While electricity and gas may be considered the most desired cooking fuels in urban areas, even if these are available most poor households cannot afford both the energy resource and the devices required to use these forms of energy. Many households, therefore, turn to using kerosene or charcoal. Since kerosene is not always available or too costly for many this leaves charcoal as the most readily available fuel (Mugo and Ong, 2006).

Charcoal has also unique cooking properties that make households to go for it even when other fuels are also available (Seidel, 2008):

- It has double the energy content of fuelwood;
- It is lightweight and thus easy to transport and store;
- It easy to store over long period of time, without risk of insect or fungal attack;
- It produces less fumes and noxious compounds when burned;
- In most cities it is cheaper compared to kerosene, LPG or electricity.

Or in the words of a Mozambique retailer: "it sells well, it doesn't go rotten and children don't steal it" (Pereira, 2001). The case discussed in Box 1 illustrates the convenience of charcoal.

Box 1: Why is charcoal a widely accepted fuel in Southern Countries? (Seidel, 2008)

In Malindi (Kenya) a lady wants to cook beans. She needs about 20€ cents to buy some charcoal to cook her beans. Once the charcoal is burning, she puts the pot with beans on the stove and she can leave the place and take care for other things. The charcoal stove does not need regular attention. After 1.5 hours the beans are readily cooked.

Much different however, if she would use a wood fire. She regularly needs to attend and feed the fire. If she does not carefully and constantly feed the fire with wood in a proper stove, she may use and burn more wood- compared with the wood which is needed to produce the charcoal used.

Even as affluence increases and households shift to using electricity, gas (LPG) and kerosene, households continue using charcoal in significant amounts, as a result of its attractiveness and convenience. In addition, even in cases where petroleum fuels are used, charcoal is often used as a backup fuel or the main fuel for preparation of certain foods. In Senegal, where LPG penetration is increasing, households using LPG are still using as much or more charcoal than households which only use charcoal (Kammen and Lew, 2005). And when gas (LPG) prices fell to a third of that of charcoal in the early 2000's many households in Sudan still went for charcoal (Ibrahim, 2003).

2.4.1 *Trends in charcoal consumption*

In many African countries the majority of urban households (often 80% or more) and a considerable number of rural households depend on charcoal for their energy needs. Unfortunately, reliable information and estimates of charcoal production, trade and use or its impact on forest and woodland cover are not available in most African countries, and can only be obtained from detailed field surveys.

A recent FAO Forestry Paper (FAO, 2010) estimated 2007 global charcoal consumption at 43.6 million tones. Developing countries accounted for nearly all this consumption, and Africa alone consumed more than half of total world production. Charcoal production increased by about 160% between 1992 and 2007 and is expected to continue to grow as populations expand, especially in low-income countries. See Table 1.

Table 1: Charcoal consumption patterns by region, 2003–2007 ('000 tonnes)
Source: FAO, FAOSTAT (available at faostat.fao.org)

Region	2003	2004	2005	2006	2007
Africa	20 496	21 500	22 143	22 756	23 550
Americas	15 674	16 522	16 815	13 506	12 568
Asia	7 114	7 357	6 180	6 369	6 599
Europe	615	699	814	720	888
Oceania	24	23	21	21	21
World	**43 923**	**46 101**	**45 973**	**43 372**	**43 626**

(Kammen and Lew, 2005) note that FAO estimates domestic charcoal consumption using constant charcoal consumption per capita factors for each country. Because these factors are not changed for extensive periods of time, the changes in charcoal production shown are due entirely to population increases.

It is expected that even in Sub Sahara African (SSA) countries already consuming large volumes of charcoal demand will increase further for the following reasons:

- Population increase (often 2-3% per year, which leads to a doubling of the population in about 20 to 25 years).
- Increased urbanisation, as worldwide people continue to flock from the countryside to urban centres in search of jobs and a better standard of living. Increasing urbanisation will lead to increasing demand for charcoal.
- Rising prices for alternative fuels such as LPG, natural gas, or electricity also cause people to continue using charcoal, despite rising incomes.

2.5 Economic contribution of the charcoal sector

Charcoal production and trade contributes to the national economy by providing rural incomes, tax revenue and employment. Charcoal is particularly important as a means of generating income for some of the poorest members of society. It also saves foreign exchange that would otherwise be used to import fuel.

A large number of people are employed in the various phases of the charcoal value chain, including: collection and sizing of wood; preparation of charcoal kilns; loading the wood into kilns and unloading charcoal after conversion; unloading, bundling, packaging and transportation; and marketing. Additional indirect employment is generated by the activities that use charcoal.

In Tanzania, revenues generated by the charcoal industry for Dar es Salaam alone amount to 350 billion Tsh (USD 350 million). The charcoal business generates employment for more than hundred thousand workers (Van Beukering, 2007). In Malawi, the estimated value of the charcoal industry in the four largest urban areas is about MK 5.78 billion (roughly USD 41 million). This figure is slightly less than the value of Malawi's tea industry. It is estimated that nearly 93,000 people owe their livelihoods to charcoal (Kambewa et al, 2007). In Kenya, the charcoal industry employs about 200,000 persons in production alone. In Uganda, charcoal production provides 20,000 jobs and generates more than Ush 36 billion (USD 20 million) a year for rural people. The pattern is similar in other countries across Africa (Mugo and Ong, 2006).

World Bank/ESMAP estimates for the generation of employment per TJ Energy consumed indicate that charcoal creates between 200 and 350 jobs per TJ, electricity 80-110 jobs, LPG 10-20 jobs and kerosene only 10 jobs. The figures suggest that promoting charcoal can create more jobs than the other forms of energy. In addition, planting trees for charcoal can be a profitable enterprise as shown in the case of Kakuzi (Kenya), where it costs Ksh 159 (60%) to produce a bag of charcoal that is sold at Ksh 260, earning a net revenue of Ksh 101 or 40% of the retail price (Kakuzi, 2003).

3 Issues associated with the charcoal sector

Charcoal production has far-reaching impacts extending across a range of social and environmental issues. These include health problems associated with air pollution, environmental change associated with greenhouse gas emissions and the depletion of local forests and woodlands, and social problems related to migration, labour and gender. Nevertheless, such problems rarely arise as a result of charcoal production alone. Rather, they are the result of complex relationships between charcoal producers and consumers, the environment, and the larger political economy. Therefore, understanding the problems associated with charcoal production requires an understanding of the social, political, economic and environmental contexts in which they arise (FAO, 2010). In this chapter, the main (sustainability) issues related to the charcoal sector are described. The chapter is concluded with a table linking the issues in the charcoal sector issues with the Cramer Criteria for sustainable biomass production.

3.1 Fuelwood production and harvest

The continued use of natural forests for charcoal production represents a threat to the future of the resource, especially in situations where there is high demand (such as in the periphery of large urban zones) and a lack of sustainable forest management (Hosier, 1993). In low-rainfall areas, where regenerative capacity is relatively low, unplanned and unmanaged charcoal production can accelerate desertification processes. The impacts of woodfuel production and harvest for charcoal production also depend on the production and harvest methods employed.

Clear cutting

Clear cutting, or clear felling, is a forestry/logging practice in which most or all trees in a harvest area are cut down. It is a destructive form of forest management. The term "slash-and-burn" is used when the permanent conversion of forests for agricultural purposes is intended. Slash-and-burn entails the removal of all stems in a particular area. This is a form of deforestation, because the land is converted to other uses. Although there is an obvious link with charcoal production, the need for agricultural land is a main driver.

Selective harvesting

In selective cutting only a portion of the trees are harvested, leaving all others. The (young) trees that are left as residuals will, if ecological conditions permit, reseed the space that has been created. However, due to poor forestry management skills young trees are often also cut and used to cover the charcoal kilns, adding to forest destruction. The opportunistic harvesting of wood results in a gradual degradation of forest resources over time, rather than clear-cutting over a large area, finally leading to real deforestation.

Charcoal producers prefer tree species that yield dense, slow-burning charcoal. These tree species are slow growing and are therefore particularly vulnerable to overexploitation. The concentrated exploitation of a few species with a high density can adversely affect biodiversity. Some dense tree species have a high economic value e.g. as a source of timber, unrecognised by the charcoal producers (TaTEDO, 2010); some of the species are protected and cutting them is illegal.

Plantation wood
In the fuelwood production methods discussed above (clear cutting and selective harvesting) very little, if anything, is paid for the harvested forest stands. In economic terminology, the biomass is available at zero opportunity costs. As a result, despite growing scarcity of wood, charcoal generally remains under-priced by more than 20 to 50%, relative to its economic cost in most African countries (WB, 2009). This is mainly due to insecure land-tenure, which leaves many forest areas open to free and unregulated access and use.

In the third production method wood is harvested from purposely-established plantations. Charcoal that is produced in this manner will be more expensive as plantation establishment and management costs will need to be factored into the charcoal price. Some examples of charcoal production from plantation wood are discussed in chapter 4.

3.1.1 Fuelwood collection for charcoal production versus direct fuelwood use

The charcoal-making process is resource-intensive as the harvesting of the feedstock is an intensive process, concentrated in as small an area as possible over as short a period of time as possible. In some cases, wood is taken illegally from state land, and producers are under pressure to harvest the wood to make the charcoal as fast as possible. In contrast, fuelwood users typically collect relatively small quantities of wood on a regular basis and thus the forest impact is more dispersed and less intensive. Moreover, fuelwood-users usually collect twigs, branches and dead wood, which has less impact (at least in the short term) on forest productivity while wood for charcoal is usually made from stemwood (FAO, 2010).

3.1.2 Forest Stewardship Council (FSC) certification

The Forest Stewardship Council (FSC) is an international non-governmental organisation supporting environmentally appropriate, socially beneficial, and economically viable forest management. Forest certification according to FSC is based on ten general principles for forest management covering environmental, economic and social issues elaborated in a set of more detailed criteria (Vis et al, 2007).

FSC certification of charcoal is an elaborate, time- and resource-consuming process, and goes beyond the certification of the wood from which it is produced. An example of the documentation involved in FSC charcoal certification (describing the Namibian charcoal producer Jumbo Charcoal) can be found at the website of the Soil Association[1].

In the United Kingdom, nearly all charcoal purchased is imported, and a high proportion of it is FSC-certified. This holds for example for charcoal imported from South Africa. However a significant portion (>20%) of UK supplies comes from -other- tropical countries, including Ghana, Nigeria, Brazil, Indonesia and Brazil, and little of this is FSC-certified (FOE, 2004). For other EU member states the situation is likely to be much the same.

Charcoal that is sold across Africa is rarely FSC-certified (with the possible exception of South Africa), as few charcoal users demand for it.

1 http://92.52.112.178/web/sa/saweb.nsf/librarytitles/29512.HTMl/$file/RT-FM-001-12%20Jumbo%20FM%20RA%20report%20FINAL.xls

3.2 Charcoal production

The critical factors in the production of charcoal appear to be the operational and supervision skills of the charcoal producer, the moisture content of the utilized wood, and the woodfuel species used. The production technology used is also important, but less so than often believed. The efficiency of the traditional kiln, if properly tended, appears comparable to that of improved kilns (Kammen and Lew, 2005). The more efficient the conversion process, the fewer the associated emissions to air, soil and water, and the subsequent impacts on the environment and labour conditions. Generally speaking, higher charcoal yields and lower emissions go hand in hand.

3.2.1 Charcoal production efficiency

The efficiency of charcoal production determines the amount of charcoal that can be made per unit of wood biomass, and thus affects the impact of fuelwood harvest practices. Efficiencies of conventional kilns are normally low, ranging from 10-20 (Wiskerke, 2008). The following factors directly or indirectly affect charcoal production efficiency:

- Relatively high efficiencies can be reached if an experienced producer follows best practice, even when traditional kilns are used.
- It is to be expected that occasional charcoal producers will achieve lower efficiencies than full-time charcoal producers.
- Illegal charcoal production might need to be performed in a quick way, not allowing optimising the charcoal production process.
- Improved stationary kilns (like beehives) can be applied if the charcoal production takes place at a fixed location, as is the case when plantations are used as a source of wood.

3.2.2 Emissions

The by-products of charcoal production are pyroacids, primary acetic acid and methanol, tars, heavy oils and water, the majority of which is emitted into the environment with the kiln exhaust. The emissions into air include gaseous emissions of carbon monoxide (CO), carbon dioxide (CO2), methane, ethane and volatile organic compounds (VOC); emissions of the particulate matter (PM) coming from the uncombusted tars and charcoal dust, and pyroacids that may form aerosol emissions. The level of emissions depends highly on the technology used for the production, the temperature developed during the pyrolysis as well as on the moisture content of the wood.

(Domac and Trossero 2008) presents a comparison of air pollutant emissions for different types of charcoal production. For example, emissions from traditional charcoal production methods in several African countries expressed in g per kg of charcoal produced are given as 450 to 550 for CO2, 700 for CH4, 450 to 650 for CO and 10-700 for NMHC (non-methane hydrocarbons). Such emission levels, especially that of methane, which has a high global warming potential (GWP), can be perceived as significant environmental impact on both regional and global level. The main reason for these rather high levels of air emissions is the incomplete combustion of wood and gaseous by-products of charcoal production, which are directly emitted into the atmosphere.

In Africa, the emissions are usually released as part of the smoke into the atmosphere, posing an air-pollution problem. When inhaled the smoke can result in serious health issues of the charcoal producers. The local impacts of air

pollution may be reduced by locating charcoal production sites at least 100 metres from villages (Mugo and Ong, 2006), although few data are available on the effectiveness of such a measure. The use of cleaner, more efficient technologies in charcoal production could also have huge health benefits (FAO, 2010).

Air emissions from industrial charcoal production technologies, using batch kilns and continuous operated multiple hearth retorts, are considerably lower. These technologies allow the collection of the gaseous and liquid smoke arising from charcoal production, which can be used as energy source or to increase the efficiency of charcoal production. These technologies, however, have high initial investment costs.

Another pollutant produced in charcoal making is charcoal dust, a black powdery residue that disperses quickly into the air and can cause respiratory illnesses. Many rural households use the dust for medicinal purposes, as an insect repellent and as a soil conditioner on farms, thus increasing their exposure to it (FAO, 2010).

Box 2: charcoal production and the greenhouse gas reduction
Measurements of kiln emissions carried out in the early 1990's suggest that the global warming impact of charcoal production may be much greater than the benefits of biomass charcoal use replacing fossil fuels. (Kammen and Lew, 2005) stress that it is crucial to assess the entire carbon balance of the charcoal cycle for impact on global warming, and conclude that when charcoal is produced in poorly operated kilns it is among the worst, if not the worst, cooking energy source in terms of global warming. The use of cleaner, more efficient technologies in charcoal production could significantly cut pollutant emissions, and at the same time bring huge health benefits

3.3 Charcoal logistics and trade

3.3.1 Physical structure of the charcoal supply chain

Like is the case for many other commodities, there are many different ways in which charcoal is being transported. Basically anything that moves can play a role: tractors, lorries, trucks, trains, bicycles, pushing carts, donkeys, head loads et cetera. In Mozambique part of the charcoal shipped to the capital Maputo is transported by freight train (Puná, 2008). In Tanzania a combination of lorries and bicycles is used (WB, 2009).

What modes of transport are applied depends not only on the availability of vehicles and the existence and condition of the (road and rail) network. The cost associated with the use of a certain type of transport also plays a major role. And the possibility to forego detection of illegal charcoal also comes into play. At the Dar es Salaam city border, charcoal transported by lorry is taxed, but charcoal transported by bicycle is not, as in the latter case it is assumed to be for private use. The result of this regulation is that a few kilometres beyond the city border charcoal is trans-loaded from trucks to bicycles on a massive scale, with the sole purpose to avoid taxation (Van Beukering, 2010).

The average distance between rural charcoal production centres and urban consumer centres is increasing gradually. This parameter can be affected by many

factors, the most important one being the existence and condition of the road (or as is the case in Mozambique: rail) network. Increasing hauling distance results in higher fuel consumption by trucks and associated emissions.

Like charcoal producers, charcoal haulers are exposed to charcoal dust, a black powdery residue that disperses quickly into the air and can cause respiratory illnesses.

Figure 6: (a) a bicycle packed with charcoal (b) charcoal retailing in small quantities
Source: (a) WB, 2010 (b) WB, 2009

3.3.2 Organizational structure of the charcoal supply chain

Charcoal supply takes largely place in the informal sector. Consequently, next to the reduced tax income from this sector, there is there is lack of official data on this sector, and it will be difficult to take proper policy measures.

Some authors point out that, when the charcoal industry is informal this often means that rural communities do not reap the full benefits of the industry. Corruption is rampant and systemic in many cases, leaving many charcoal producers vulnerable to unscrupulous trading practices and economic exploitation.

In countries that have made an effort to apply legal restrictions to the charcoal trade, these restrictions are frequently ignored, and much of the trade is unlicensed.

3.4 Charcoal end users

In general, end users are satisfied with the use of charcoal. Compared to the use of fuelwood, indoor levels of toxic air pollutants during use are much reduced. However, when charcoal is used for heating purposes, special care is needed to avoid exposure to dangerous carbon-monoxide emissions (FAO, 2010).

The efficiency of charcoal stoves is often sub-optimal; an increase in efficiency of charcoal stoves could potentially lower charcoal consumption and thus reduce charcoal production and its impacts.

3.5 Socio-economic considerations

Various observations can be made regarding the socio-economic aspects of charcoal production, trade and consumption:

- Fuelwood production and harvest: a community whose forest areas are being harvested may receive no benefits whatsoever, as wood is generally harvested illegally or without direct payment. Fuelwood collection typically generates low income and is often performed by women.
- Charcoal production is a poor man's business. Landless, uneducated or otherwise disadvantaged people provide a cheap source of labour. For lack of other options, they can be easily exploited. Poverty forces them to sacrifice long-term considerations (health, livelihood security etc.) for meagre short-term income. The poor are also powerless in the sense that they cannot defend their vital interests vis-à-vis more powerful stakeholders of the charcoal supply chain. They are not organised in most cases, and thus avail of little - if any - bargaining power, and virtually no access to investment capital.
- Charcoal traders are often seen as the ones benefiting most in the charcoal supply chain. A common observation is that there is no equitable revenue sharing along the entire value chain. (WB, 2009) observes that "… Despite the involvement of a great number of people in the charcoal business, profits are usually concentrated in the hands of a few intermediaries, mainly engaged as transport agents or wholesalers, that exercise tight control over the charcoal trade and often have close linkages with political elites, who use their power as a means to efficiently circumvent legal fees and levies. The decidedly oligopolistic structure is heavily biased against women, who often bear the heaviest workloads (wood harvesting/collection, kiln operation, small-scale retailers)". Such oligopolistic structure is for example visible in Senegal (Ribot 2007). However, other authors point out that it is very common in any value chain that traders have high profit margins. Transporters/traders may have their own truck for charcoal transport, but most are not particularly rich.
- Charcoal retailers have often a low of income from charcoal sales. The profit margin for retailers may not exceed or not even reach the minimum urban daily wage (Puná, 2008).
- Although consumption levels do not always differ much between poorer and richer end users, in terms of disposable income poorer households spent a much higher proportion than richer households. Furthermore, richer households are able to buy charcoal in bulk, where unit prices are significantly lower than for smaller quantities. As a result of their limited cash flow and low purchasing power, poorer households buy charcoal more frequently and in much smaller quantities, but at a much higher unit price (WB, 2009).

3.6 Policy issues

In many countries, charcoal is largely a "hidden" sector, getting little policy attention. Its role in the national economy is almost always overlooked, and as a result its actual and potential contribution to economic development is systematically underestimated. When considered in energy policies by Governments at all, woodfuel (including charcoal) is often deemed a "backward" and ecologically risky energy source, which use should be discouraged - despite

the fact that in many cases it may provide energy for more than 80% of a country's population.

With regard to the coverage of the charcoal sector in forest policies the situation is not much better. National forest policies tend to emphasise forest use for timber production, not for charcoal production. With woodfuels escaping official statistics, the forest sector's contribution to the national economy is often marginal (2-4%) and as a result forest governance receives little attention and meagre budgetary allocations. In consequence, local branches of the forest service display low human, technical, and enforcement capacities. This problem is often exacerbated by half-hearted or arbitrary decentralization of forest governance, which leaves local administrators ill prepared for the challenge of promoting community involvement or investment by the private sector. Such institutional weaknesses lower the morale of local staff, and invite corruption. Corruption coupled with unclear policy and legal frameworks is seen as a major cause of unregulated or even illegal charcoal businesses.

Finally, in many countries, land tenure is a key issue that must be addressed because only when land-use rights are clear can resource management be undertaken effectively (FAO, 2010).

3.7 Conclusions

For each step in the charcoal value chain the main sustainability aspects as discussed in this chapter are summarised in Table 2.

The Cramer Criteria constitute a framework for sustainable biomass production (Cramer 2007). The criteria provide an overview for the assessment of sustainability issues for biomass production, addressing the following six themes.

- Greenhouse gases: Calculated across the entire chain, the use of biomass for biofuels must emit 35 percent net fewer greenhouse gases than the fossil fuel average. For electricity production, 50 percent.
- Biodiversity: Biomass production shall not harm any protected or vulnerable biodiversity, but shall reinforce biodiversity where possible.
- Environment: The use of pesticides or artificial fertilisers, or the effects of biomass culture on the soil, air and water, may not disturb the environment.
- Food versus fuel: The production of biomass for energy must not endanger the food supply or other local applications (such as medicine or construction materials).
- Contribution to the local prosperity: The production of biomass must contribute to the local prosperity.
- Contribution to the local welfare: The production of biomass must contribute to the welfare of the employees and local population.

Although the framework is originally focussed on biomass production, most of the themes can be applied in all steps of the charcoal supply chain[2]. The table below links the main charcoal issues discussed in this chapter with the Cramer Criteria for sustainable biomass production. Note that policy issues are not part of the Cramer sustainability themes.

2 Except for the themes biodiversity and food versus fuel, which only relate to biomass production and harvest.

Table 1 Summary of issues related to the charcoal sector

Step	Sustainability Aspect	Issues
Step 1 Forest resources production and harvest	Environmental	High demand for charcoal leading to over exploitation of forest areas especially near urban centres; In low-rainfall areas over exploitation can accelerate desertification Over exploitation of species with good charcoal properties
	Social	Low income from wood collection, often performed by women
	Economic	Wood for charcoal economically not taken into account; making sustainable alternatives like plantations impossible.
	Policy/Other	Lack of clear land ownership structure leads to unplanned and unmanaged harvesting. Illegal cuttings.
Step 2: Charcoal production	Environmental	Emissions of smoke: local air pollution and low greenhouse gas balance; Low conversion efficiency increases environmental impact whole supply chain.
	Social	Poor labour conditions: inhalation of toxic smoke and charcoal dust Low income, weak negotiation position toward traders
	Economic	Low conversion efficiency leads to lower yields
	Policy/Other	Charcoal production informal sector, partly illegal Often no fixed location for charcoal production: difficult to employ high efficiency production technologies Part time charcoal producers and illegal setting complicate efficient charcoal production practises.
Step 3: Transport and trade	Environmental	Increased transport distances, leading to higher energy use and emissions
	Social	Exposure to charcoal dust
	Economic	Most benefits in transport and trade (on the costs of other beneficiaries in the supply chain)
	Policy/Other	Majority of transport in informal sector; lack of control
Step 4: End use	Environmental	Efficiency charcoal stove sub optimal, leading to higher demand for charcoal and subsequent emissions
	Social	Reliable source of energy; poor and less poor use charcoal

	Economic	Changing charcoal price affect the poor more than the rich.
	Policy/Other	Informal sector.

Table 3 Summary of issues related to the charcoal sector following the sustainability themes of Cramer

Step	Sustainability theme	Issues
Step 1: Forest resources production and harvest	GHG balance	Unsustainable harvest leads to increased GHG-emissions.
	Biodiversity	Over-exploitation of species with good charcoal properties and of forest resources especially near urban centres
	Environment	Deforestation; in low-rainfall areas over exploitation can accelerate desertification
	Food versus fuel	In general no competition with land for food. Possible if plantations are employed on agricultural land
	Local prosperity	Low income from wood collection, often performed by women
	Local welfare	Hard work for low income; serves as extra alternative income
Step 2: Charcoal production	GHG balance	Low conversion efficiency increases environmental impact incl. GHG balance of whole supply chain.
	Environment	Emissions of smoke: local air pollution and low greenhouse gas balance; low conversion efficiency increases environmental impact of the whole supply chain
	Local prosperity	Low income, weak negotiation position toward traders
	Local welfare	Poor labour conditions: inhalation of toxic smoke and charcoal dust
Step 3: Transport and trade	GHG balance	Increased transport distances, leading to higher energy use and GHG emissions
	Environment	Increased transport distances, leading to higher energy use and emissions
	Local prosperity	Most benefits in transport and trade (on the costs of other beneficiaries in the supply chain)
	Local welfare	Charcoal dust emissions
Step 4: End use	GHG balance	Efficiency charcoal stove sub optimal, leading to higher demand for charcoal and subsequent GHG emissions
	Environment	Ash is not recycled (however, this happens almost nowhere in the world)

	Local prosperity	Changing charcoal price affects the poor more than the rich.
	Local welfare	Reliable source of energy for the poor and less poor users

4 Lessons learnt intervening in the charcoal sector

This chapter looks at the lessons learnt from past interventions of Governments, development agencies and civil society organisations aimed at making charcoal production across Africa more sustainable. Although some failures are also discussed, a special effort has been made to focus on the more successful interventions. It should be noted, however, that generally speaking the overall success of interventions in the charcoal sector across Africa has been mixed, at best, and few interventions would seem to have achieved a long-lasting impact (WB, 2009).

Like in the previous chapters, interventions are discussed along the steps of the charcoal value chain. For each step, the lessons learnt are first introduced, followed by several illustrative examples (when available), and rounded off with conclusions and recommendations.

4.1 Production and harvesting of fuelwood

4.1.1 Introduction

Across Sub Saharan Africa, the past two decades have witnessed a growing movement to empower rural communities with the rights and responsibilities to manage local forest resources. Participatory or community forestry has taken root, using a range of different models. One of the key lessons learnt is that security of tenure (property rights) is a key factor that determines whether participatory forest management succeeds or fails - both from a forest management perspective, and from the perspective of securing and maintaining participation over the long term. Below four examples are given illustrating the lessons learnt regarding fuelwood production and harvest:

- Community forest management in Senegal
- Individual reforestation schema Madagascar
- De-linking charcoal production and deforestation in Rwanda
- Plantation-based charcoal production in South Africa.

4.1.2 Example: community forest management in Senegal

In Senegal, the forest law creates opportunities for rural communes to formally claim possession of hitherto state controlled forests adjacent to their community, and to manage them in accordance with a publicly approved forest management plan. Additionally, state forests may be allocated to communes for co-management. Communes, in turn, enter into contracts for the purpose of granting use rights on the village level. Detailed, inventory based management plans are prepared, which also reflect and harmonise locally perceived needs and expectations. Each village establishes a management committee, and households interested in utilization of certain forest products form respective user groups (WB, 2009). Key elements of this community forest management system include (GTZ, 2010):

- Directives for sustainable management of state and community forests
- A regional plan for the sustainable management of forests
- Production of management plans
- Capacity building, enabling local communities to enter partnership agreements with the forest services.

4.1.3 Example: individual reforestation schema Madagascar

The case of Madagascar may be cited as a promising example where tenure rights in respect of marginal public lands have been granted to individuals of local communities for the purpose of creating energy plantations. The village-based approach places local people at the centre of planning and implementation of plantation management for sustainable charcoal production. It is based on voluntary participation of communities eager to rehabilitate degraded lands by means of voluntary reforestation. As a first step, an afforestation area is identified by the community and legally registered as a "Réserves Foncières pour le Reboisement". A village-based participatory approval process allocates individual woodlots to interested households, along with defined use rights and obligations. Each plot is demarcated, mapped, and documented with the community's approval. Technical assistance is provided by specially trained NGOs. Aside from institutional and technical support, the only substantial external input is mechanized soil preparation. Tractors must be used to break up compact layers in degraded soil, to increase percolation of rainwater and ensure higher survival rates of seedlings. Nursery operation, planting, and maintenance are the plantation owners' responsibilities. An overall GIS-based monitoring system provides data for every plantation plot, including productivity figures, income generated, etc. More than 4500 ha have been planted, providing an annual increase in income of more than 20% for more than 1500 rural households. The monitoring system further revealed that 34% of the poorest and landless people became involved, and 22% of women enrolled as woodlot holders. In addition, the uncontrolled exploitation of natural forests in the vicinity of the villages substantially decreased, as did the incidence of fires (Sepp 2008a) (GTZ-ECO 2006). Key elements of the individual reforestation scheme in Madagascar include (GTZ, 2010):

- Limiting afforestation to marginal land (with zero opportunity costs)
- Voluntary decision of community members to participate
- Allocation of responsibilities to all community actors
- Individual ownership of plots and products (secured land/tenure rights)
- Capacity building, creation of rural energy markets
- Monitoring of plantation growth and quality.

4.1.4 Example: de-linking charcoal production and deforestation in Rwanda

Rwanda is one of the few examples of an African country with increasing forest cover, growing about 7% from 2000 to 2005 primarily due to large numbers of forest plantations. This success comes at the expense of Rwanda having previously lost two-thirds of its natural forest cover and, along with it, much of its biodiversity. Today, practically all charcoal in Rwanda is derived from trees that have been planted on government, private or community land. There are indications that private woodlots, using planted fast growing eucalyptus, are providing an increasing part of the firewood and charcoal market in Rwanda. Charcoal production from natural forests is almost non-existent. Additionally, remnant rainforests are conserved by way of expanding the network of federally-protected areas. Farmers have become aware that with secure land tenure and rising wood fuel prices, it is profitable to invest in tree planting, and to produce poles for construction, fuelwood and wood for charcoal making. Furthermore, due to rising income, the position and social standing of farmers in rural society has improved. Farmers are able to engage traders –who formerly held most of the

power within the woodfuel value chain– on an equal footing, and to negotiate prices as is common in a free market economy (De Miranda et al, 2010). In conclusion, Rwanda may well be the only country in Africa where the relation between charcoal and deforestation no longer exists[3].

A factor that has contributed to the success is that Rwanda as one of the few countries in Africa applies private land ownership on a large-scale. As a result of allowing private land ownership, trees can be seen everywhere. People have an incentive to plant trees when they know that the tree will still be their property when it matures, which is not the case on common lands. Trees form a sort of security for farmers, which they can cash in case of need (MARGE, 2009).

Main elements of the charcoal production system in Rwanda include:
- High timber and woodfuel prices due to massive prior deforestation
- Targeted efforts to conserve remnant rainforests
- Establishment of private plantations
- Secure land tenure
- Improved market control and negotiation power of farmers/ charcoal producers
- Due to rising income, improved social standing of farmers in rural society

4.1.5 Example: plantation-based charcoal production in South Africa

In South Africa, charcoal is primarily made from tree plantations; established in the first place to provide pulp, wattle extract, and construction timber. Commercial plantations (mainly of pine trees, gum trees and Black wattle) cover almost 1.2 million ha. Charcoal production is concentrated in the general area of Dalton, Ahrens and Greytown in the Natal Midlands, in the Northern Kwazulu-Natal forestry areas between Paulpietersburg and the Mpumalanga border, and in the south-eastern parts of Mpumalanga. These areas have good railway connections with the port of Durban. Much of the local charcoal production is exported, e.g. to Europe. Therefore South Africa needs to import charcoal from neighbouring countries to meet the domestic demand. For example, part of the charcoal marketed in South Africa is produced in Namibia[4]. Domestic demand is confined to wealthier middle-income households who use charcoal for cooking as part of social events (the Sunday "braai"). Charcoal use is not common in South African low-income households in South Africa (Stassen, 2010).

Main elements of the charcoal production system in South Africa include
- Long history of establishing tree plantations
- Few alternative value-added applications for plantation wood and processing waste
- High level of organisation in the charcoal supply chain
- Good transport links with export markets
- Relatively well-off middle-income charcoal users can afford paying "Western" prices.

4.1.6 Recommendations

Based on the lessons learnt from the presented examples the following recommendations can be formulated:

3 Except the charcoal supply for Antananarivo, Madagascar, which also mainly comes from farmers' eucalyptus plantations; in much of the rest of the country, charcoal still comes from natural forests.

4 The website http://namibiaafricawwf.blogspot.com/2009/10/charcoal-burning.html gives some insight in charcoal production making in Namibia.

- Increase supplies of wood for charcoal through plantations and woodlots. Address the unchecked harvesting of trees without replacement. Develop and implement short- and long-term plans for massive tree plantings.
- Develop woodfuel management and harvesting plans for forest areas administered by national and district governments. The aim of national and district level woodfuel plans is to increase progressively the market share of commercial woodfuels that are sustainably produced, and to generate significant and long-term tax revenue for local and national forestry management funds. The plans can address rehabilitation, better management and exploitation of state and district plantations, as well as tree planting and increasing the productivity of private small-holder tree farms. If managed properly, plantations, woodlots, and trees outside forests (such as in agroforestry systems, along roads, and around fields) can play a substantial role in supplying raw material for charcoal production, and reduce the pressure on natural forests. Annex A discusses the role these forest resources can play.
- Secure forest tenure ("property rights") for rural producers by scaling up community-based forest management in urban catchment areas. For example, a community may be granted exclusive control over natural woodlands growing on their territory, and the exclusive right to sell wood-based fuels harvested/produced thereon. In return, the community would be bound to enter into a formal agreement with the forest service to manage the woodland sustainably and to use improved kiln technologies (e.g. Village VERT approach in Chad). Without a more effective forest and land tenure policy in place, it is difficult to expect major changes towards forest management practices.
- In countries with significant areas of marginal and/or degraded public land, privatisation of land for the purpose of tree-farming may be an option. Such schemes have the potential to preserve/ameliorate land and to augment wood-fuel supplies at the same time.
- Stop illegal cutting and completely ban the production of charcoal from public forests and plantations, set up management plans for restoring public national and district plantations, develop and promote adapted tree management and rational cutting methods, train local bodies and professionals.
- Develop and promote silvicultural practices among private plantation owners, in order to preserve and improve their standing stock, increase forestry productivity and favour rational and sustainable tree-cutting.

4.2 Production of lump charcoal and of direct substitute fuels

4.2.1 Lessons learnt improving carbonisation efficiency

The conversion of wood into lump charcoal plays a small but crucial role in the charcoal value chain. In most instances, charcoal production takes place using traditional earth or pit kilns, where wood is cut and stacked before being covered in earth and carbonized.

Due to the assumed low conversion rates of traditional kilns, many projects have been carried out aimed at introducing more efficient carbonization technologies. Improved technologies can be broadly classified into five categories, namely (i) earth kilns, (ii) metal kilns, (iii) brick kilns, (iv) cement or masonry kilns and (v) retort kilns. Earth and metal kilns are transportable; the other kiln types are stationary.

Earth and brick kilns are simpler, lower-cost designs deemed particular suitable for developing countries. A well-known example is the Casamance kiln, developed in Senegal. It is equipped with a chimney that can be made of oil drums. The chimney allows a better control of airflow. In addition, the hot flue gases do not escape completely but are partly redirected into the kiln, which enhances pyrolysis. Due to this reverse draft carbonisation is faster and more uniform giving in theory a higher quality charcoal and efficiency up to 30% (Seidel, 2008).

Although the use of improved kilns can be considered as a crucial step in achieving sustainable charcoal production, efforts to introduce improved mobile charcoal production techniques often have had limited success[5]. (Feinstein and Van der Plas 1991) observe that improved charcoal production techniques are often adopted for brief periods only and then discarded: evidence of this is found by the remains of metal kilns and metal pit covers scattered in the Senegalese forest. (Kammen and Lew, 2005) may provide an important explanation why charcoal producers abandoned the metal kiln and components. Their field measurements show a large amount of scatter in yields, indicating that the yield is highly dependent upon the skill of the producer. They claim that very good traditional kilns can compete with very good Casamance kilns.

Other countries where efforts to introduce improved kilns were made in the past show similar low adoption rates. Improved kilns were introduced in Uganda in the 1960s but they are virtually still unknown in the country today. In Kenya more than 90% of charcoal producers use inefficient traditional kilns (Mutimba, 2005). (Seidel, 2008) and (WB, 2009) present several reasons for the low adoption rate of improved carbonisation kilns, including:

- Brick and concrete kilns are stationary, whereas charcoal is frequently produced in a manner which requires mobile kilns or kilns constructed on site for the duration of production.
- Investment costs for many improved kilns (especially for metal kilns which are transportable) may be prohibitive for small scale producers
- Special skills are required to construct and to operate improved kilns.
- It has appeared hard to achieve improved carbonization efficiencies (25-30%) under field conditions.
- Due to the informal (and often illegal) nature of charcoal production, producers have no secure and long-term access to wood resources, limiting their willingness to investment in more efficient conversion methods.
- The efficiency of the traditional earth kiln, if properly tended, appears comparable to that of improved kilns, critical factors being the operational and supervision skills of the charcoal producer, the moisture content of the utilized wood, and the woodfuel species used.

4.2.2 Lessons learnt developing direct charcoal substitutes

In addition to producing charcoal form hardwood species, it can be made from a wide range of alternative feedstocks, including (i) newly introduced and/or previously unused tree species, (ii) agro-residues, (iii) invasive aquatic weeds, or (iv) charcoal fines[6]. Some examples of experience gained with the production of substitute fuels include:

5 Semi-industrial and industrial kilns have met with some success, but only under intensive production systems (such as in a plantation setting or with significant external investments by a private sector enterprise dedicated exclusively to charcoal production.

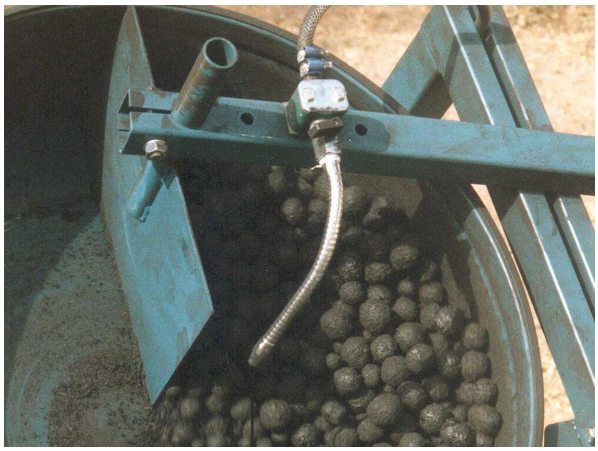
6 The use of substitute fuels like bio-ethanol, gelfuel, biogas, LPG, kerosene (paraffin) and electricity has no direct impact on the sustainability of the charcoal value chain, and are not further discussed here.

- **Newly introduced an/or previously unused tree species**: Ethiopia has more than one million hectares of fast growing bamboo trees. In 2009 a project started in Ethiopia and Ghana to develop bamboo as an alternative to timber charcoal for poor households. The EC funded project will develop at least 1,000 enterprises producing bamboo charcoal and train over 6,000 people in bamboo cultivation, best bamboo firewood practices and bamboo charcoal production, set up 3 bamboo charcoal technology centres and develop marketing strategies for bamboo charcoal (Y. Seboka, personal communication 2010). In Kenya, MakaaZingira Enterprise produces eco-charcoal briquettes from fast growing indigenous shrubs, which are sustainably harvested, carbonised, mixed with waste cassava and coconut fibre and then compressed. The charcoal briquettes are eco-friendly and ethically produced, and the first in East Africa to be FSC-certified. In 2009 the company was awarded the SEED Award for entrepreneurship in sustainable development (SEED Initiative, 2009).
- **Agro-residues** such as cotton stalks, risk husks, coconut shells, peanut shells, sawdust, and the residues of the coffee, tea and floriculture industries. Carbonised cotton stalks can be used to produce agglo-briquettes, spherical balls consisting of charcoal powder glued together with a binder, e.g. molasses, a technology developed by BTG Biomass Technology Group B.V. Already in the late 1980s the Rahad Energy Products Corporation Ltd in Sudan gained commercial experience with this technology. More recently, Biomasse-Mali applied the technology in Mali. Bioterre Senegal has gained experience producing substitute charcoal from rice husk (PISCES, 2009). Diligent (Eindhoven) is demonstrating the production of charcoal from Jatropha press cake (Peters, 2010). And Carbo (Almelo) supplied industrial 'twin retort' carbonization technology to produce charcoal on a commercial scale in Ghana and Senegal from coconut shells and peanut shells respectively[7].
- **Invasive aquatic weeds**, such as typha, papyrus and water hyacinth. Typha is a type of reed that covers large parts of four shared water bodies of West Africa, including the Senegal river causing irrigation canals to be blocked and rendering access to the river difficult. After a successful pilot, ALCD/Biomasse-Mali aims to produce synthetic fuel logs and green charcoal from blending Typha weed and rice husks (CASCADe Africa, 2010). In Senegal, typha is used neat to produce charcoal briquettes (PISCES, 2009).
- **Charcoal dust and fines**: The production of charcoal briquettes from fines is well established in Kenya. Nairobi-based Chardust Ltd. pioneered the development of innovative techniques to convert biomass wastes into low-cost charcoal briquettes. It has been involved in this business for nearly a decade, and now sells more than 200 tonnes of briquettes per month[8]. Recently, Mr. Patrick Mwangi has started making briquettes using charcoal dust and water in Nyeri[9], and women from the districts of Nakuru, Kisumu and Kibera produce charcoal balls in a similar way (PISCES, 2010). Other countries where charcoal briquettes are made using charcoal fines and a binder include Mali (Visser, 2010), Tanzania (Peters, 2010) and Senegal. (PISCES, 2009).

7 www.p-plus.nl/artikel.php?IK=592
8 www.chardust.com
9 kenya-chat.com/tag/using-charcoal-dust-and-water/

Figure 7: Charcoal substitute production (a) from bamboo (b) at MakaaZingira
Sources: (a) Ethiopian Rural Energy Development and Promotion Center (b) SEED Initiative

Figure 8 (a) Agglomerator for briquette production (b) Chardust briquettes for sale
Sources: (a) BTG Biomass Technology Group BV (b) Chardust Ltd./ HEDON.



4.2.3 *Recommendations*

Regarding lump charcoal production, several decades of efforts to improve the performance of charcoal production by adopting improved kilns have shown little pertinent and positive results (with the possible exception of (semi-) industrial kilns under intensive production systems). Because the results of using capital-intensive improved kilns under African field conditions has been so disappointing, in recent years the focus has shifted towards the promotion of low-cost improvements to the traditional earth kiln design.

Charcoal producers should however be encouraged, and capacitated, to achieve higher conversion efficiencies using cheap and better charcoal-making technologies. They should be provided with a range of technical solutions from which to choose, rather than a "single best" technical solution. Market pressures

alone are unlikely to lead to efficiency opportunities being exploited (UNDP, 2010). Research that would lead to the development of efficient and affordable kilns should be facilitated (World Agroforestry Centre). Targeted training support to charcoal producers groups on improvement of traditional practices is warranted. Those working with larger tree plantations should be assisted to identify and invest in improved kilns (WB, 2009).

The Tanzania Traditional Energy Development and Environmental Organization (TaTEDO) has pioneered this approach with a range of simple adaptations to traditional designs that can achieve significant savings at a low cost. These include the introduction of a chimney, as well as ensuring that wood used in the kiln is adequately dried and cut into approximately similar sizes (WB, 2009) (Sawe, 2010). It is recommended to evaluate the success of the TaTEDO effort with a view of establishing replication potential.

Figure 1: (a) Charcoal training at Kisangara (b) Improved basic earth mound kiln
Source: E.N Sawe (TaTEDO, Tanzania)

Another approach to boosting charcoal production from the current biomass resource base is the use of alternative feedstocks. As has been illustrated above, these initiatives are usually small-scale and can generate a modest income for those involved. Their economic viability strongly depends on the prices for woodfuels. The best chances of success are found in areas with severe woodfuel shortage and higher charcoal prices.

A third approach is the promotion and development of on-biomass substitute fuels such as paraffin and LPG. The latter category is of particular interest when countries have their own natural gas resources, as is e.g. the case in both Mozambique (Falcon, 2010) and Tanzania (Van Beukering, 2010).

4.3 Modernisation and professionalisation across the entire value chain

4.3.1 Introduction

As explained before, in most African countries a large share of charcoal production and trade is informal and unregulated. In many cases corruption is rampant and systemic. Wholesalers may hold a tight grip on the market and wield leverage over charcoal prices. Regulation and professionalisation of the charcoal sector is adamant to reduce the tight grip of specific stakeholders. Poor governance and ineffective regulation of the charcoal sector also means that government misses out on tax income and that charcoal continues to be sold at a price well below its true (economic) value, as the cost of the resource itself (wood) is rarely factored into the final price.

4.3.2 Moving charcoal production and trade into the formal sector

Introducing fiscal measures that encourage illegal charcoal producers to move into the formal sector will have a range of positive and negative spin-off effects. On the positive side, formalization will provide greater security for producers and traders, which will in turn encourage longer-term investments designed to increase efficiency and sustain supply. On the negative side, however, encouraging producers and traders to engage in legal and regulated business will necessarily result in price increases for the end user, as the final market prices reflect the true value of not only processing and transport costs, but raw materials and licensing as well. However, experience would suggest that these price increases will in turn encourage efficiency savings across the whole production-trade-consumption chain.

Given the tight control exercised over the charcoal trade by a limited number of influential businessmen in many countries (e.g. Senegal), efforts to reform the sector are often strongly resisted. Linkages between large-scale charcoal traders and political leaders are often close. If the strong and vested interests operating in the charcoal sector are to be overcome, it will require strong political support - both within government and the political system - but also among the users and consumers of charcoal within urban centres. Otherwise, failure to address the challenges of formalization will ultimately undermine efforts to address the problems of charcoal trade elsewhere along the production marketing chain (WB, 2009).

4.3.3 Sustainable charcoal trade

To encourage charcoal producers to invest in sustainable charcoal trade, they will need to be sure that they can operate competitively against other producers (often operating illegally). This can be achieved in a variety of ways, such as:

- Reducing the scale of illegal trade to a level where it does not impact significantly on the formal charcoal trade. This can typically take place through a targeted investment in regulation and control to ensure that the costs of trading in illegally produced charcoal are higher than the costs of trading in charcoal that is licensed and regulated;
- Providing subsidies or fiscal incentives for sustainably produced charcoal that compensate for price differences when compared to illegally produced charcoal
- "Eco-labeling" charcoal so that despite higher prices, consumers buy it based on the knowledge that they are contributing to sustainable development and improved producer prices. This process of product differentiation, however, does not address the widespread and dominant trade in unregulated charcoal.

All three of these measures have been attempted, with varying degrees of success. Perhaps the best-known example of fiscal incentives comes from Niger, which introduced a variable tax regime to incentivise sustainable production and penalise unsustainably produced charcoal (discussed in more details in Section 4.5.2 below).

4.3.4 Example: professionalisation of the charcoal sector in Sudan

Unlike most other SSA countries, Sudan has such well-articulated charcoal policy and legislation. This has not only ensured professional and profitable management of the country's forests, but has also enabled sustainable production from plantations.

The Sudanese government has recognized charcoal as an important source of energy and vested the power to regulate it in the Forest National Corporation. The agency is responsible for planning and organizing production from natural and planted forests (covering 68% and 32% of the forested area respectively). The corporation has a management plan for natural forests. Forestland is first leased to farmers for five years. At the beginning, charcoal producers are contracted to clear the land for crop production and use the wood to make charcoal. The land is then farmed for five years after which it is left to regenerate for 14-20 years.

For planted forests, the department sets aside land and funds to plant and manage over 100,000 ha of trees annually. The trees take about 14-17 years to mature for harvesting. The government has recognized charcoal producers to whom it sells the trees by tender at officially set prices.

While most of the charcoal is produced by large-scale contractors that are members of the Sudan Charcoal Producers Association, individuals also produce limited amounts. The charcoal is sold to merchants who transport it to wholesalers in urban centres for distribution to retailers and users.

The Sudan Charcoal Producers Association was started to negotiate with the government on behalf of traders. Grouping producers, transporters and traders, the association has set up its own rules in addition to those laid down by the government. For example, the association expels members who fail to pay taxes or engage in corruption. The expulsion means one cannot trade in charcoal. The organization has paid off, with some members producing between 2,000-5,000 bags of charcoal and earning up to US$50,000 a season. The association is not problem-free, however. Members complain of high taxes, unclear boundaries and conflicts due to animal routes through contracted land. They are pressing for the government to allocate them forest land to manage (Mugo and Ong, 2006).

Considering what is happening elsewhere in East Africa and the way the charcoal industry is run in Sudan, the following lessons can be drawn. In Sudan:

- Charcoal is recognized as a key source of energy.
- There is a specific institution, a parastatal, to implement wood energy policies.
- Production of charcoal from plantations and natural woodlands is well planned.
- Resources are allocated yearly for establishment of plantations.
- There is strong public and private sector participation.
- Charcoal is a formal and lucrative industry.
- There are clear marketing arrangements and rules.
- Traders are organized into a formal association recognized by the government.

- The government is paid royalties and taxes, which are reinvested in establishing plantations.

Other countries in eastern and southern Africa could use some of these ingredients to establish dynamic charcoal industries of their own (Mugo and Ong, 2006).

4.3.5 Recommendations

To achieve modernisation across the entire charcoal value chain, the following is recommended:

- Official recognition of charcoal production and trade
- Creation of professional charcoaling groups
- Promote market integration
- Improvement of charcoal transport
- Packaging and labelling of sustainable charcoal

Presently, the charcoal industry is organised informally, but it is an integral part of the national economy and it makes a substantial contribution to the livelihoods of the poor. Those involved in the industry want charcoal to be recognized as a legal economic activity (Mutimba, 2005). The notion of professional charcoal producers should be developed and a move should be made away from individual and occasional charcoal producers (UNDP, 2010). The charcoal sector can be formalised by the creation of professional charcoaling groups in the form of self-regulatory associations, cooperatives or private firms. Such producer groups can be more commercially-oriented, eventually gaining access to more up to date information about sources of wood available for carbonisation and obtaining access to credit (MARGE, 2009a). Vertical and horizontal integration of fuelwood and charcoal markets to overcome current problems associated with isolated markets for these commodities should be promoted (UNDP, 2010).

In order to make the supply chain more sustainable, illegal trade should be discouraged. Licensing of charcoal production and trade is required to encourage its commercial production in a sustainable manner (UNDP, 2010). Incentives could be provided to compensate for the price difference between illegal charcoal.

The transport of charcoal should be allowed in just the same way as any other commodity may be transported without problem. A simple permit system should be set up to guide transporters to zones with sustainable charcoal production. To assist professional charcoal producers to obtain better prices, charcoal depots could be instrumental. The depots would be staffed by people from the charcoal producer associations (or an alternative institutional solution). If organised in this fashion, the transportation system would operate in a more efficient way according to prevailing market dynamics (MARGE Malawi, 2009).

Packaging and labelling of sustainable charcoal shall allow differentiating it from illegal charcoal production (Mutimba, 2007). In addition eco-labelling could be promoted in order to improve the recognisability of sustainable charcoal for consumers that can afford a price premium.

4.4 Reduction of charcoal end-use

In this section two different kinds of interventions aimed at reducing the demand for charcoal are discussed. The first type of intervention, banning charcoal, has been tried by several African countries but in all cases proved to be counter-

productive. By lack of alternative fuel, low urban income households will continue using huge amounts of charcoal, whether its production, trade or consumption has been declared illegal by the government or not. The only relevant impact of banning charcoal is an abrupt price hike.

The second type of intervention, the introduction of improved stoves, has also often failed to achieve the intended result of dramatically reducing household charcoal consumption. For a wide range of varying reasons (including political, social and economic obstacles), few of the improved stove programmes initially implemented across Africa achieved their objectives. Improved stove programs have failed in areas were fuel is not purchased or fuel is easy to collect. The high purchase price of an improved stove can also be a formidable barrier to its adoption. Although in the long run improved fuel stoves save money, the initial cash outlay required may prevent poorer people from affording the stove. After a difficult start-up period, the improved Kenya Ceramic Jiko stove -which has been around since 1982- is now considered an exception to the rule that deserves multiplication.

4.4.1 Ban on charcoal use

Sudden interventions are certainly not working. This can be illustrated by several examples where governments decided to ban charcoal. Banning charcoal is counter-productive, as it leads to price hikes:

- Although energy policy in e.g. Ethiopia and Kenya favour the development and promotion of improved charcoal cookstoves and sustainable farm forestry for fuelwood, charcoal-making actually remains illegal in these countries. The ban does not stop charcoal production or trade, but, instead, has served to drive the industry further into the informal sector, escaping public regulation and revenue collection, fuelling illegal payouts to officials along transit routes, damaging the wholesale and retail business of those unable to secure charcoal supplies, and most importantly, causing an inflationary spike in the price of charcoal nationwide (UNDP, 2010).
- Tanzania introduced a ban on charcoal in 2006. The ban had little impact on charcoal production. Producers continued to manufacture their product. The ban's only impact was to deprive the government of revenue for licensing production while brisk trade carried on illegally. Prices for charcoal went up – and stayed up – as did corruption of officials. The ban lasted only 2 weeks (WB, 2009)
- In Chad, the Government banned charcoal in the capital N'djamena in January 2009. It created "explosive" conditions as families desperately sought the means to cook. With the government blocking all entry of charcoal into the city, and reportedly confiscating any found in the city, charcoal became nearly impossible to come by. And when found, a bag that used to cost about 6,000 CFA francs (US$ 12) was sold, clandestinely, at about four times that (Nelson, 2009).

Although energy policy in e.g. Ethiopia and Kenya favour the development and promotion of improved charcoal cookstoves and sustainable farm forestry for fuelwood, producing charcoal actually remains illegal in these countries. The ban does not stop charcoal production or trade, but, instead, has served to drive the industry further into the informal sector, escaping public regulation and revenue collection, fuelling illegal payouts to officials along transit routes, damaging the wholesale and retail business of those unable to secure charcoal supplies, and

most importantly, causing an inflationary spike in the price of charcoal nationwide (UNDP 2010).

4.4.2 Improved charcoal stoves

Although the benefits of improved charcoal stoves are obvious, their adoption rates vary a lot across Africa and to date they have not been as successful as one would expect. One reason is that the price of an improved stove is about 2-10 times the price of a traditional one. Since charcoal is usually rather cheap, the payback rate due to charcoal savings is at least 1-3 months (for a stove with a lifetime of approx. 1 year). The influence of the charcoal price may be illustrated by the case of **Rwanda**. Like in other African cities households in Kigali rely on charcoal. The charcoal price is higher compared to other countries, which is an incentive for the use of charcoal saving stoves. In 1990 ESMAP has trained artisans to produce an improved charcoal stove and in 1991 it was estimated that between 20.000 and 30.000 stoves had been sold. A recent survey showed that about 40 % of the households in Kigali are using an improved charcoal stove, which uses 33% less charcoal than traditional stoves. It was calculated the payback period is only two weeks and thus much shorter than in other countries. Charcoal savings amounted to about 113 US$ per year for an average family. (Seidel, April 2008)

The experience of promoting improved charcoal stoves in Tanzania is a case in point of the cumbersome process to induce innovations through a top-down project approach. In Tanzania, the improved stoves were introduced almost two decades ago but still diffusion has reached a mere 4%. The route chosen was to train artisans operating in the informal sector. The bottlenecks identified for further market uptake are related to volumes and quality of production. The artisans were incapable and uninterested to invest in modern production methods allowing for quality control and upscaling. Hence from a job creation perspective the project was fairly successful but from the consumer's point of view to access fairly cheap stoves of high quality, the experience tells us that the model for diffusion is critical to reach a sustainable market (WB 2009).

One of the most successful stove projects in Africa is the development of the improved Kenya Ceramic Jiko (KCJ; also known as Jambar) charcoal stove. See section 4.4.3 for more information. The KJC is not the only improved charcoal stove on the market. In the late 1980s/early 1990s the all-metal Rondereza was field-tested in Rwanda. The Rondereza was introduced with some success but due to the civil war the stove dissemination initiative collapsed. However, in 2007 a similar stove appeared available in Kigali (Visser, 2010). The GTZ ProBEC project recently tested an all-metal charcoal stove from Lusaka that looks like a promising option as it is cheap to produce and achieves 15-20% energy savings over the KCJ through a design that pre-heats incoming air (MARGE Malawi, 2009) and (Van Beukering, 2010) observe that the highest need is not for new stove designs but for successful business models.

4.4.3 Example: Kenya Ceramic Jiko improved stove

One of the most successful stove projects in Africa is the development of the improved Kenya Ceramic Jiko (KCJ; also known as Jambar) charcoal stove. It is made of metal cladding with a wide base and a ceramic liner (safer to use - cooler on the outside) and can reduce charcoal consumption by some 30%. It is used in almost all urban households in Kenya (as well as in 16% of rural homes). In Kenya

alone, some 2.6 million stoves are in use (cumulative production now over 15 million), where KCJ production is now a fully self-sustaining business using locally produced materials and skills, generating jobs and new enterprises (Source: AFREPREN/FWD, undated).

Figure 10: (a) Toyola (KCJ-type stove) in Ghana (b) KCJ stoves at the market

The KCJ has been disseminated across Africa, initially supported by CARE and later by many other (local) organisations. The stove is quite popular and users think it looks nice (Visser, 2010). KCJ-type improved stoves are widely used in Uganda, Tanzania, Rwanda, Burundi, Sudan, Ethiopia, Malawi, Zambia, Burkina Faso, Ghana, Mali, Niger and Madagascar. The improved stove is known under different local names (e.g. Sewa in Mali).

The success story of the KCJ in Kenya can be attributed to the long-term commitment by both the private and public sector in its development, and specialised focus on the KCJ and sustained support from local champions. In addition, through the piggy back principle, the KCJ developed around the existing artisanal industry which reduced the costs of setting up a whole new network. This initiative has led to increased income generation to all the parties involved in its production (GTZ, 2007).

4.4.4 *Use of carbon credits to promote improved stoves*

A recent development to make improved stoves with a relatively high purchase price more affordable to low-income African households is the use of carbon credits. In the Basa Magogo project in South Africa, the Fair Climate Fund applies income from voluntary emission reductions to help finance the purchase of energy-efficient household coal stoves[10]. In Lusaka, Zambia, the German power utility RWE has launched a Clean Development Mechanism (CDM) project to promote climate protection by way of highly efficient biomass stoves. The RWE project aims at the full replacement of the charcoal consumption of 30,000

10 http://www.fairclimatefund.nl/

households by introducing highly efficient "Save80 cooking systems". In the first stage of the project, 1500 urban households will be using the stove (RWE, 2009).

No examples of improved charcoal stove projects financed from carbon credits could be identified.

4.4.5 Recommendations

Outright banning of charcoal production or trade is not recommended. The ban does not stop charcoal production or trade, but, instead, has served to drive the industry further into the informal sector, escaping public regulation and revenue collection, fuelling illegal payouts to officials along transit routes, damaging the wholesale and retail business of those unable to secure charcoal supplies, and most importantly, causing an inflationary spike in the price of charcoal nationwide (UNDP 2010).

Regarding improved charcoal stoves, depending on their current uptake, one or more of the following support activities may be considered:

- In less saturated markets, active and aggressive promotion of fuel-efficient charcoal stoves[11]
- Introducing entirely new charcoal stoves if they have the potential to result in further efficiency improvements (MARGE Malawi, 2009).
- Creating an enabling environment for stove producers (GTZ, 2007)
- Capacity building among informal artisans and importers (a) to make available quality improved stoves and (b) to develop commercially attractive business models (including carbon financing) (Van Beukering, 2010)
- Energy conservation among large non-domestic charcoal users (MARGE, Rwanda, 2009)
- Develop a mechanism based on energy efficiency labelling to promote the use of improved charcoal stoves (MARGE, Rwanda, 2009)
- Launch a long-term awareness and popularisation campaign to convince households, institutions and firms to adopt improved stoves.

Ideally, the focus of the activities should not be a particular model of stove -as is often the case now- but on all equipment able to carry out the desired task and meeting defined energy efficiency standards. Stove manufacturers need to be convinced to produce more energy-efficient models for which, as result of associated promotional activities, market growth can be expected. What is needed is not another improved stoves programme, but a mechanism to promote the use of higher efficiency equipment similar to that used in the USA and Europe for consumer appliances and cars (MARGE, 2009a) (Van Beukering, 2010). Carbon credits could be part of the solution.

4.5 Policy interventions

4.5.1 Introduction

Over and above the measures discussed above, policy measures are needed that aim at making charcoal production and use more environmentally sustainable while avoiding to push the price of the product to a level that is prohibitive for poorer consumers. Since the environmental and social impacts of charcoal production, trade and consumption are extensive and intertwined an integrated view is essential in policy making, looking beyond a single intervention along the

11 e.g. the ubiquitous improved ceramic-lined metal stove, known as the Kenya Ceramic Jiko

value chain (Sepp, 2008). Isolated interventions (reforestation, sustainable forest management, dissemination of improved stoves) fail to exploit adequately possible synergies that would, if combined, make them sustainable (GTZ, 2010).

Governments need to improve the framework in which the charcoal sector operates. To operate efficiently and effectively, at the national level a single department or ministry shall be assigned responsibility for the entire charcoal value chain (production, distribution and marketing) and held accountable for all the issues affecting the industry. Institutional capacity needs to be developed at different levels within Government organisations (State, district, community) to effectively regulate the sector, to enforce regulations, and to monitor and control charcoal flows.

In many countries (e.g. Angola, Senegal, Madagascar) the supply and demand side of energy is handled by different ministries. While the Ministries in charge of forestry set framework conditions for a sustainable management of a country's forests (and among other things license charcoal manufacture and trade), they do not deal with aspects of demand and end-use. However, as sustainable harvesting is inseparably linked with demand for biomass as fuel, a combined view covering both "upstream" and "downstream" in an integrated way is essential.

In short, charcoal production is denied the comprehensive treatment it deserves in both the forestry and energy sectors (let alone other policy areas including environment, health, rural development, poverty alleviation etc.). Clear, integrated policies are needed to enable the development of urgently required, coordinated approaches to sustainable charcoal production. National energy, forest and environment policies should be harmonised to foster inter-institutional collaboration, the transfer of technology and capacity building. In addition, a coherent wood energy policy coordinated by a central institution could be developed. In Ghana´s "Strategic National Energy Plan (2006-2020)" the decade-long disregard for wood-based fuels is openly recognised, and recommendations are made to institutionalise the wood energy sector as a sub-sector in its own right. It is proposed to establish a National Woodfuel Office as a coordinating body, so as to improve management efficiency, promote charcoal-industries, and ensure a sustainable wood supply (Energy Commission Ghana, 2006).

4.5.2 *Example: fiscal incentives for sustainable charcoal production in Niger*

The first African country to attempt to use fiscal incentives as a tool to regulate charcoal production was Niger[12], where in 1989 the government created "rural markets," or well-marked locations where firewood had been sold by villages from locally managed wood resources. Harvesting regimes were based on long-term sustainable harvesting plans. The two key elements for success were:

- Villages operating a rural market were allowed to levy a tax, which remained largely in the village. This was additional, fixed revenue for the village and belonging to the whole population, rather than just those involved in the wood fuel business; and
- The tax level depended on a number of variables: (a) how far the market is from the capital Niamey, with higher tax levels the closer the market is; (b) whether it is sustainably produced wood near the rural market (lower taxes); (c) if it is from a zone with excess wood where wood harvesting is allowed; or (d) if the wood illegally cut (highest tax level).

12 Similar systems were introduced somewhat later in Chad and Mali

In this way, transporters had an incentive to visit rural wood markets rather than open access areas. At the same time, villages had an incentive to obtain approval for operating a rural wood market, for which several conditions existed: (i) delineation of village borders; (ii) drawing a map of wood resources, including dead wood; (iii) developing simple wood fuel harvesting management plans; and (iv) establishment of a management committee. Once all conditions were fully satisfied, villages were allowed to sell wood and levy the tax. Coupons were used as a mechanism to indicate the origin of the wood and the quantity transported. Around Niamey, a control system was set up verifying whether wood transporters had already paid their taxes. If not, they were assumed to have obtained wood from a non-managed zone and paid tax accordingly. Even though the tax payment compliance mechanism no longer exists in Niger, the rural markets still function, and a tax is still levied, but now directly by the village. (Van der Plas, 2008) (Chomitz and Griffiths, 1997).

4.5.3 Recommendations

Policy and regulatory framework

The following recommendations are made regarding the policy and regulatory framework:

- Ensure that national energy policies include charcoal as part of the future energy mix
- Develop wood energy strategies analysing the different options on how to reach national energy goals. Biomass energy strategies propose the appropriate intervention lines and set out concrete actions by which the goals will be achieved
- Create the right climate ands a more enabling framework for profitable and sustainable charcoal production and use through enacting sound policies and legislation.
- Put in place a suitable regulatory framework and practical standards: (i) outline standards and guidelines for the production of sustainable charcoal, (ii) develop simple licensing procedures and (c) recognise charcoal associations
- Create incentives for sustainable charcoal sector management by allowing districts to retain a portion of licenses and fines collected from licensing charcoal
- Support districts to retain and reinvest charcoal revenues in revenue collection and sustainable forest management

Fiscal and pricing framework

The following recommendations are made regarding the fiscal and pricing framework:

- Introduce a simple charcoal taxation system based on the principle that sustainably produced charcoal is taxed at a lower rate and all other (i.e. non-sustainably produced) charcoal is taxed at a higher rate. Such a tax replaces all individual and semi-legal tax systems and provide funds to all involved, including the charcoal depots, district and village administrations. The taxation system would have the following characteristics: (a) decentralized but under national guidelines; (b) unique control and tax collection systems at transport level; (c) with a level around 10% of the product retail prices.
- Build fixed trading sites (charcoal depots) for the transport and trade of charcoal. Identify suitable sites for trading around the large cities and support the construction of charcoal depots

- Establish a comprehensive efficient system to collect taxes and verify compliance.
- Set up a tough charcoal monitoring and control body that oversees charcoal flows and collects data at the regional level. Increase the number and effectiveness of fixed checkpoints. Train and supervise the staff of the monitoring body and the checkpoints.
- Set-up a sustainable charcoal or forest fund or levy. This fund would be generated from taxation of charcoal and fines on illegal producers. Such a fund could operate like the Road Levy Fund or the Rural Electrification Fund (both examples from Kenya). Any money collected should be re-invested into the creation of a more sustainable charcoal industry. Such investments include setting up tree nurseries and efficient community kilns at the community and district level

4.6 Conclusions

Interventions from governments, development agencies and civil society organisations need 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.

In addition to supply-side and demand-side measures, such as the establishment of wood plantations, the promotion and development of energy-efficient conversion and end-use technologies, and the introduction of substitute (biomass and fossil) fuels, a charcoal sector policy[13] would need to include:

- The regulatory, fiscal and pricing framework
- Initiatives aimed at the professionalisation of the entire charcoal value chain
- Institutional capacity of Government organisations to regulate charcoal production, to enforce regulations, and to monitor and control charcoal flows

The broader regulatory and tax framework around which the charcoal sector operates shall be a central element of charcoal policy. Unless the market cost of charcoal reflects its true value - which includes raw materials, labour, transport, and all taxes and licenses - any efforts to develop sustainably produced charcoal will always be undercut by illegal charcoal, which bypasses many of these key costs. Achieving greater compliance of the informal illegal sector will necessarily result in an increase in prices to consumers, but this will in turn stimulate investments by both consumers and producers that are designed to achieve greater efficiency savings.

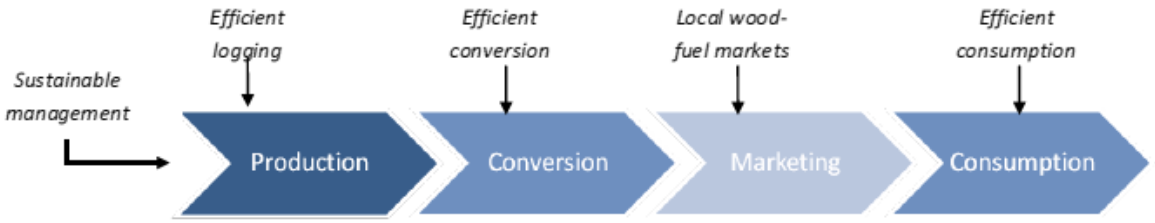
Formalising and regulating an important sector like charcoal requires strong levels of political support and willingness to challenge powerful and vested interests, often with strong links to the political establishment. It is perhaps for this reason that the overall success of interventions in the charcoal sector have met with

13 Typically as part of a larger woodfuel sector, or bio-energy, strategy

mixed success. But those countries that have taken these bold steps appear to have made the greatest progress.

(GTZ, 2010) summarizes activities in each step of the value chain (Figure 11) that for improved leverage need to be implemented and synthesised.

Figure 11 Interventions are needed across the entire value-chain (GTZ, 2010)



Step 1: Wood-fuel production
- Devolution of secure, long-term tenure to rural communities (e.g. Niger, Mali, Chad, Senegal, Madagascar)
- Promotion of private plantations on marginal sites (e.g. Madagascar, Rwanda)
- Energy contracting by small and medium-sized commercial consumers to private farmers (Brazil, Nicaragua)

Step 2: Harvesting
- User-group organisation
- Optimisation of logging technology
- Streamlining of logging and transport
- Harmonising harvesting with consumption patterns

Step 3: Conversion
- Dissemination of improved technologies (e.g. kilns)
- Further research and development (efficiency, environmentally-sound processes)
- Introduction of alternative wood energy products (e.g. wood-chips, briquettes, or pellets)

Step 4: Marketing
- Establishment of formalized local energy markets
- Introduction & enforcement of a proof of origin for sustainably produced charcoal
- Standardisation and improved product quality
- More equitable benefit sharing

Step 5: Consumption
- Dissemination of improved stoves
- Research & development for cleaner and safer combustion
- Streamlining wood-fuel products with consumption technologies
- Kitchen management

5 Recommendations for NL Agency involvement

NL Agency's 'Netherlands Programs Sustainable Biomass' are exploring in which areas it could support making charcoal production in Sub Sahara Africa more sustainable. It has indicated that it considers setting-up one or more pilot projects in the focus countries Mozambique, Mali and/or Tanzania. If relevant, more in-depth studies into specific charcoal issues could be an integral part of such pilot projects.

In principle, the pilot projects could cover any part of the charcoal value chain including the regulatory framework. Examples include:

1 Setting up of sustainable woodfuel plantations
2 Training in the use of energy efficient carbonisation kilns
3 Promotion of energy efficient charcoal stoves
4 Development of direct substitute fuels
5 Regulation, modernisation, taxation and professionalisation of the charcoal sector

NL Agency has indicated that it considers the development of direct substitute fuels (option 4) of particular relevance. This concerns the production of charcoal form alternative feedstocks, including (i) newly introduced and/or previously unused tree species, like bamboo or indigenous shrubs, (ii) agro-residues such as cotton stalks, risk husks, coconut shells, peanut shells, sawdust, and the residues of the coffee, tea and floriculture industries, (iii) invasive aquatic weeds, such as typha, papyrus and water hyacinth, or (iv) charcoal dust and fines.

Pilot projects in this area are typically small-scale and can generate a modest income for those involved. Their economic viability strongly depends on the prices for woodfuels. The best chances of success are found in areas with severe woodfuel shortage and higher charcoal prices.

The pilot projects supported by NL Agency can be implemented by, or in cooperation with, local civil society organizations. To get an understanding of what can be achieved in this area a good reference is (Practical Action Consulting, 2009) which contains brief description and preliminary lessons learnt on livelihood impacts from 2 charcoal pilot projects, both implemented in Senegal. The first pilot concerns a project targeted at charcoal dust collection and household fuel production in Saint Louis city. The second pilot concerns the transformation of pest invasive species (Typha Australis) into marketable charcoal in Saint Louis region.

It is recommended that when developing these pilot projects the relevant lessons learnt as summarised in chapter 4 of this report are taken into consideration. Furthermore, it is recommended that NL Agency actively promote information exchange between pilot projects. This information exchange should not be limited to the pilot projects that NL Agency intends supporting, but should also cover pilot projects and commercial initiatives with similar scope initiated by entrepreneurs and sponsored by other donor organisations in the three focus countries or elsewhere in Africa.

A study into the market potential for substitute charcoal fuels and the experience gained (in project and market initiatives) producing substitute charcoal fuel could also be part of the pilot project. Thus, to summarise, the pilot project could cover substitute charcoal production and promotion in the host country, combined with international market potential assessment and information exchange covering various relevant African countries.

Additionally, NL Agency could also support a pilot project aimed at developing and implementing new business models for the promotion, production and adoption of energy-efficient charcoal stoves (option 3). Such pilot could be of particular interest if carbon financing (the Kyoto-type Clean Development Mechanism or voluntary emission schemes) would be used to bring down the costs per charcoal stove.

Some further ideas for studies that can be carried out standalone or as part of a larger pilot project include:

- Assess existing involvement of development organisations and civil society organisations. This study aims to identify what activities are already being carried out by development organisations and CVO's to help making the charcoal sector more sustainable. It makes sense to limit the geographical scope of this assessment to NL Agency's focus countries (Mali, Mozambique, and Tanzania).
- What factors help determining the charcoal yield? This report has shown that in terms of charcoal yield improved kilns not always outperform traditional kilns (see also Kammen and Lew, 2005). There are various other factors than the technology used that help determine the charcoal yield achieved by a charcoal producer. This study will investigate what these factors are and how these can be "controlled", so that "high" yields can be achieved consistently with traditional kilns.
- Environmental assessment of carbonisation kilns: Make an assessment of available traditional and improved charcoal production kilns in terms of their environmental impacts (emissions to air, soil and water), with the aim to identify the cheapest carbonization technologies that limit the emissions of gaseous and liquid smoke.

Finally, NL Agency could bring together different stakeholders in the charcoal value chain. This can include stakeholders of different background from the same country, or stakeholders form "similar" background from different countries. Examples include:

- An Expert Meeting could be held in the Netherlands, to validate and/or help set priorities in NL Agency's programming priorities in the field of sustainable charcoal.
- A sustainable charcoal conference could be organized in Africa (building on the IMBAR conference held in Maputo, Mozambique in June 2008). Ideally this would be done in close collaboration with other development agencies or existing charcoal support projects.

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Annex: Increasing woodfuel supply from forests, plantations, woodlots and trees outside forests

Across Sub Saharan Africa, the vast majority of charcoal comes from natural forests. To date, plantations, woodlots, or trees outside forests (such as in agro-forestry systems, along roads, and around fields) play only a negligible role in supplying raw material for charcoal production. Increasing supply from these forest sources can reduce pressure on natural forests.

Management of Natural Forests and Woodlands: Across Sub Saharan Africa, the past two decades have witnessed a growing movement to empower rural communities with rights and responsibilities with which to manage forest resources. Participatory or community forestry has taken root across many countries on the continent and uses a range of different models, including community-based forest management (CFM) and joint forest management (JFM). One of the key lessons learnt is that security of tenure is a key factor that determines whether participatory forest management (PFM) succeeds or fails - both from a forest management perspective, and from the perspective of securing and maintaining participation over the long term.

Tree Plantations and Woodlots: Considering natural forests will not be able to meet growing demands for charcoal in a sustainable manner, PFM approaches in natural forests need to be reinforced through developing complementary tree plantations. Planted forests can play a very positive role in: (a) provision of renewable and environmentally friendly energy resource, (b) provision of ecosystem services (e.g. erosion control, carbon storage, etc.); (c) reduction of pressure on natural forests; (d) restoration of marginal or degraded land; and (e) provision of rural employment and development.

Two main principles must be followed to fully capture the potential of plantations for sustainable charcoal production: (i) No natural forest area should be converted into plantations, and (ii) Plantations have to provide direct pecuniary benefits to rural households in order to divert pressures from natural forests. Preferably, plantations should be established on degraded lands. Furthermore, rural people should not be forced to engage in plantation establishment.

Development of plantations and woodlots at the community level can also be promoted through outgrower schemes. A possible business model would see a private entity investing in modern, industry type carbonization technology, but sourcing its raw material through contractual relationships with smallholders. Such a setup would provide adequate benefit-sharing incentives to rural households that are necessary to motivate households to engage in tree planting instead of alternative land uses.

(ESMAP, 2010) presents a set of guiding principles for sustainable community-based production of commercial woodfuel, drawing on and reflecting lessons learnt in various Sub Saharan African countries. These guiding principles conceptualize the priority measures necessary for creating the minimal framework that will support sustainable production of wood-based fuels (Box A.1).

Box A.1: Guiding principles for sustainable production of commercial woodfuel (ESMAP, 2010)

1. High-level, cross-sectoral recognition of woodfuel as a renewable, environmentally friendly and socio-economically sound source of energy, playing a part in integrated energy supply policy frameworks.
2. Decentralization of forest governance and devolution of management authority, so as to allow for local, evidence-based forest management planning, and exercise of resource property rights by forest-dependent communities.
3. Formalisation of woodfuel value chains, including provisions for transparent and closely monitored marketing and transport.
4. Establishment and harmonization of supportive regulatory frameworks, including (i) simplified management regulation; (ii) transparent revenue collection; (iii) differentiated taxation in favour of sustainably-sourced woodfuel; and (iv) equitable revenue sharing for the benefit of rural communities engaged in sustainable forest management.
5. Targeted strengthening of decentralized forest authorities, with a view to building capacity for effective law enforcement and provision of public support to stakeholders engaged in CBWP.
6. Harnessing the potential of civil society organisations for post-project follow-up and replication of best practices.
7. Establishment of provisions for PES (Payment for Environmental Services), with a view toward valorising intangible ecological and social benefits of sustainable forest management.
8. Targeted measures to ease social hardships for end-users when woodfuel prices increase (e.g. by promoting efficient conversion and combustion technologies).

Trees outside Forests: In the African context, the contribution of trees outside forests (TOFs) to the energy supply still remains largely underestimated. Statistics on woodfuel supply do not adequately capture this resource, and existing policies concerning rural development still neglect TOFs as one of the most important wood fuel supply resources. Trees outside forests include all trees found on non-forest and non-wooded lands, i.e. trees on agricultural lands, in urban and settlement areas, along roads, in home gardens, in hedgerows, scattered in the landscape, and on pasture and rangelands. Although TOFs fulfil a multipurpose function and are part of an integrated land-use system, wood fuel can be a main product. According to the FAO, over two-thirds of the energy demand in the Asia-Pacific region is supplied by woodfuels from non-forest sources.

TOFs for charcoal can occur in various places and ways: in home gardens or as replacement or enhancement of natural fallow vegetation. To control soil and water erosion, trees and shrubs can be planted along the contour lines on slopes or on terraces. Living fences planted as tree lines on farm boundaries or on pasture plots, animal enclosures, or around agricultural fields, can also contribute to the energy supply of local households.

The major constraint to wider dissemination of agro-forestry approaches often arises from complex land tenure systems in Africa.

Source: (WB, 2009).

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